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FOREWORD

GREDIT2018, dedicated to Green development, Green infrastructure and Green technologies, is a Second International Conference and overall a third scientific event of the GREDIT Family in Skopje. The preparations for GREDIT2018 Conference begun just after the conclusions of GREDIT 2016 were drafted on April 1st, 2016. It came clear that there are mayor issues that need to be addressed concerning the impact on the environment from human activities in several fields. Skopje, the host city of GREDIT2018, as several other cities in the world, is challenged to urgently implement green development, green infrastructure and green technologies so it can provide healthy urban environment.

GREDIT2018 Conference is a place where scientific research is shared among fellow scientists but also with the local and regional stakeholders and representatives from the industry.

The aim of the GREDIT2018 International Conference is to contribute to sustainable development in a multidisciplinary way, exploring the following topics:

- Air – water – soil pollution
- Risk assessment
- Sustainable development, renewable energy resources and management of natural resources
- Agriculture, Forestry, Agro-ecology, Food quality safety
- Management of urban and industrial waste and waste water
- Climate change – biodiversity – energy efficiency
- Green smart cities/societies – green architecture, landscape design and transport
- Health and environment

As a preparation for the Conference, two round tables were organized in the fields of: "Unregulated landfills" and "Urban air pollution".

This Conference has been organized as a joint effort of the Ss. Cyril and Methodius University in Skopje, Balkan Environmental Association BENA, the Chamber of certified architects and certified engineers of Macedonia, PAKOMAK, FUEL and 6th Star.

We are grateful for the mutual cooperation of the International Scientific Board members of the Conference, the members of the honorary presidency of the Conference and the Organization Board with the authors and researchers present at GREDIT2018.

All of our efforts were supported and sponsored by the Organizers and Sponsors of the Conference who have shown high social responsibility. The support from the sponsors and contributors of the Conference is highly appreciated.

GREDIT2018 Organization Committee

ПРЕДГОВОР

Конференцијата GREDIT2018, посветена на зелен развој, зелена инфраструктура и зелени технологии, е втора во низата конференции под брендот GREDIT и трет научен настан под истиот бренд. Подготовките за GREDIT2018 започнаа веднаш по завршувањето на Првата меѓународна конференција и донесувањето на заклучоците од неа на 1 април 2016 година. Уште тогаш стана јасно дека има мнигу прашања поврзани со влијанието на човековите активности врз животната средина, на кои треба да се посветиме. Скопје, градот домаќин на GREDIT2018, како и неколку други градови во светот, приоритетно работи на имплементација на принципите на зелен развој, зелена инфраструктура и зелени технологии, за да може да обезбеди здрава урбана средина.

Конференцијата GREDIT2018 е настан каде научните истражувања се споделуваат со научната јавност и индустријата и со претставници на јавниот сектор.

На конференцијата беа презентирани 127 труда од автори од 16 земји. Еден дел од трудовите од конференцијата се објавуваат во списанието Машинско инженерство – научно списание.

Теми на конференцијата беа:

- Загадување на воздух, вода, почва
- Процена на ризик
- Одржлив развој, обновливи извори на енергија и управување со природните ресурси
- Агро-екологија
- Управување со урбан и индустриски отпад и отпадни води
- Климатски промени, биодиверзитет, енергетска ефикасност
- Зелени паметни градови/општества, зелена архитектура и транспорт
- Животна средина и јавно здравје

Како подготовка за оваа конференција се одржаа две рабтни средби на темите: „Нерегулирани депонии“ и „Урбано загадување на воздухот“.

Конференцијата беше организирана заеднички од Универзитетот „Св. Кирил и Методиј“ во Скопје, Машинскиот факултет, Балканската асоцијација за животна средина, Комората на овластени архитекти и овластени инженери, ПАКОМАК, Центарот за истражување и развој ФУЕЛ од Скопје и 6. Ѕвезда.

Благодарни им сме за меѓусебната соработка на членовите на Интернационалниот научен одбор, членовите на почесното претседателство и Организацискиот одбор на Конференцијата, како и на истражувачите и авторите кои презентираа свои трудови на GREDIT2018.

Кон нашите подготовки за одржување на конферецијата се приклучија и нејзините поддржувачи и спонзори кои покажаа висока социјална одговорност. За нивната поддршка GREDIT2018 е многу благодарен.

Организациски одбор на GREDIT2018

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CHALLENGES OF MACEDONIAN ENTREPRENEURIAL ECOSYSTEM

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A b s t r a c t: This paper presents the principles for formation, development and sustainability of entrepreneurial ecosystems, with the focus on the Macedonian ecosystem. It includes the analysis of the theory of entrepreneurship and start-up ecosystems and, in addition, their role in economic growth, both locally and nationally, is explained. From the theoretical analysis, the definitions and explanations for entrepreneurship and start-up ecosystem are presented in detail. Within the practical part, a significant number of interviews have been conducted in order to obtain information on how people perceive the process of opening their own business, and to highlight the problems that entrepreneurs faced when opening a business. The research shows that there is an active entrepreneurial ecosystem in Macedonia, but it is necessary to unify and upgrade the offered services. The paper ends with number of recommendations for strengthening the Macedonian entrepreneurial eco-system.

Key words: ecosystem; entrepreneurship; Macedonia; start-up; entrepreneurial ecosystem

ПРЕДИЗВИЦИ НА МАКЕДОНСКИОТ ПРЕТПРИЕМАЧКИ ЕКОСИСТЕМ

А п с т р а к т: Овој труд ги презентира принципите на воспоставување, развој и одржливост на претприемачките екосистеми со посебен фокус на македонскиот екосистем. Во трудот е вклучена анализа на теоријата за претприемништво и за старт-ап екосистемите, а презентирана е и нивната улога во развојот на економијата како на локално така и на државно ниво. Од теоретски аспект детално се презентирани дефиниции на претприемачки и старт-ап екосистеми. Во рамките на спроведените практични анализи беше спроведен значителен број интервјуа со голем број акционери и претприемачи со цел да се осознаат проблемите и пречките со кои се соочуваат лицата кои започнуваат нови бизниси. Истражувањето покажа дека во Македонија постои активен претприемачки екосистем, но дека е неопходно тој да се обедини и да се надгради тековната понуда на услуги. Трудот завршува со низа препораки за зајакнување на македонскиот претприемачки екосистем.

Клучни зборови: екосистем; претприемништво; Македонија; старт-ап; претприемачки екосистем

1. INTRODUCTION

The latest data from the Global Entrepreneurship Monitor for 2015/2016 show that in the Republic of Macedonia most of the newly created businesses are opened from necessity, not from perceived opportunity [1]. The number of businesses open from necessity, as opposed to businesses started as a result of a certain opportunity, is twice as big. However, looking on 10 years scale in the Republic of Macedonia, in the last couple years, a socio-economic environment (ecosystem) is conducive to creating (opening) new businesses, which would be opened from a perceived opportunity, not necessity (as is the current situation).

Researchers and policy makers are increasingly applying the concept of entrepreneurial ecosystems to understand and explain why in certain regions, the concentration of fast growing companies is much higher in relation to other regions /

cities. Although the concept of entrepreneurial ecosystem in the past 5–10 years is analyzed more intensively by researchers, historically, these analyzes have their roots first in biology [2], then in geography [3, 4], sociology [5] and economic research [6, 7]. This basic research builds on modern research on the entrepreneurial ecosystem, among which the most popular are the Start-up Communities of Feld [8], as well as the work of Katz and Bradley [9] for matching metropolitan policies in the function of economic development.

The **entrepreneurial ecosystem** is an economic, social and political environment that supports the entrepreneurship process, providing support and resources that enable start-up companies to rapid growth and development [10, 11].

In this system there are numerous stakeholders who in various ways are involved in supporting the formation of new businesses. Figure 1 shows one possible approach to define the entrepreneurial ecosystem, which shows the complexity of the issues that are the subject of study in this paper [12].

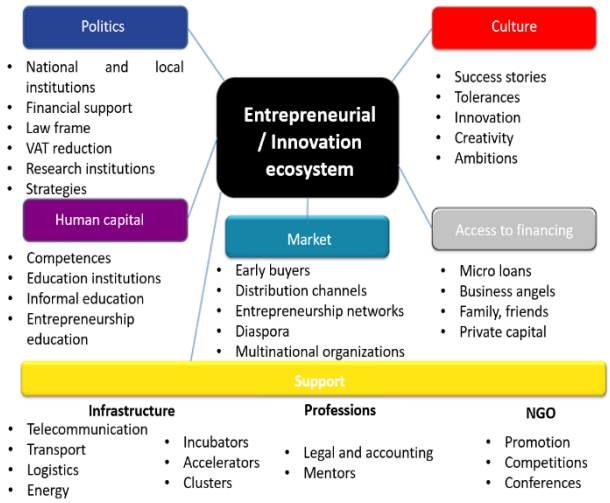

Fig. 1. Stakeholders of entrepreneurial ecosystem (Source: Polenakovikj M., 2017)

In order this ecosystem to develop sustainably, it is necessary to fulfill many conditions, such as: appropriate culture – which supports risk taking, innovative thinking, etc.; access to finance necessary for the development of new products and/or services; support institutions (which will provide appropriate, quality training and mentoring for start-up companies); and other preconditions [13, 14].

In order to better understand Macedonian entrepreneurial ecosystem, beside theoretical analysis of literature from the area, the "on-site" analysis consisted of a survey of a broad population and interviews with representatives of ecosystem stakeholders was realized. The survey of the general population covered over 200 respondents, while over 40 stakeholders were interviewed in order to obtain relevant information that can better describe the Macedonian ecosystem.

2. LITERATURE OVERVIEW

Defining the concept of entrepreneurship is a difficult task because among the many theorists and practitioners there is still no generally accepted definition, or approach in explaining entrepreneurship. According to Robert Price, "there are very few words in the lexicon of business terms that are so badly and differently defined as the case with the word entrepreneurship. The concept of entrepreneurship in modern society has been perpetuated for thousands of years, and in some cases the word has been overused, and many times misused" [15]. There are hundreds of different definitions and clarifications in the literature. Although the notion of entrepreneurship first appeared in Cantillon's works as early as 1730, where he introduces the concept of entrepreneurship by analyzing the work of sellers, farmers and craftsmen of that time [16], then Say in 1803 [17], the first serious analysis of entrepreneurship was made by Austrian-American economist Schumpeter in 1934 [18]. In the last three to four decades, entrepreneurship has been seen as the driving force of economic development, structural changes and the creation of new jobs, and thus as a key tool in the fight against global poverty. Not going in depth analysis of different approaches in understanding entrepreneurship, the authors of this paper are adopting European Commission definition of entrepreneurship: "*An individual's ability to turn ideas into action. It includes creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives. This supports individuals, not only in their everyday lives at home and in society, but also in the workplace in being aware of the context of their work and being able to seize opportunities, and is a foundation for more specific skills and knowledge needed by those establishing or contributing to social or commercial activity. This should include awareness of ethical values and promote good governance*" [19].

As it is the case for the entrepreneurship, also terms ecosystem, or entrepreneurial ecosystems, have number of different approaches, explanations and definitions. One possible approach in definition

of these terms has regional development approach. In that direction Roger R. Stough, Robert J. Stimson, and Peter Nijkamp [20], in analyzing different theories and models for securing regional development, introduce the term sustainable innovative development as the basis for regional development. Such sustainable innovative development is based on 5 critical success factors:

1. availability of productive capital,
2. the presence of human capital,
3. access to social capital (communication and interaction between people, business networks, trust-based relationships),
4. use of creative capital, and
5. existence of ecological capital.

From their analysis and research, it is noted that the responsibility for securing regional development is not only in the hands of one stakeholder, but more and more partners come from different organizations, who at times have even completely different goals and intentions. All these stakeholders are an integral part of a network that is dominant and through which Brad Feld [8] distributes positive energy, activities and innovations in society. He says that in the physical world most of that energy, activities and innovations appear in small geographical regions that he calls "start-up communities", while scientists call them micro-economic clusters, and more recently the word **entrepreneurial ecosystem** is used.

Again, there are numerous approaches of defining key factors of entrepreneurial ecosystem. One of the most influential structure of entrepreneurial ecosystem was provided by World Economic Forum – WEF [21]. Their research surveyed over 1,000 entrepreneurs from around the globe with the goal of better understanding how successful entrepreneurial companies speed access to new markets and become scalable, high-growth businesses. WEF experts suggested 8 pillars of an entrepreneurial ecosystem (Figure 2).

Analyzing the role of the university in the entrepreneurial ecosystem, Davey and Galan-Muros recognized four key elements of a systematic entrepreneurial ecosystem [22]:

1. Cultural and intellectual capital, including contributions to knowledge and experience;
2. Strategic capital, related to improvements in reputation and authority;
3. Network capital, comprising support from networks and relationships; and
4. Economic capital, consisting of increases in finances or resources.

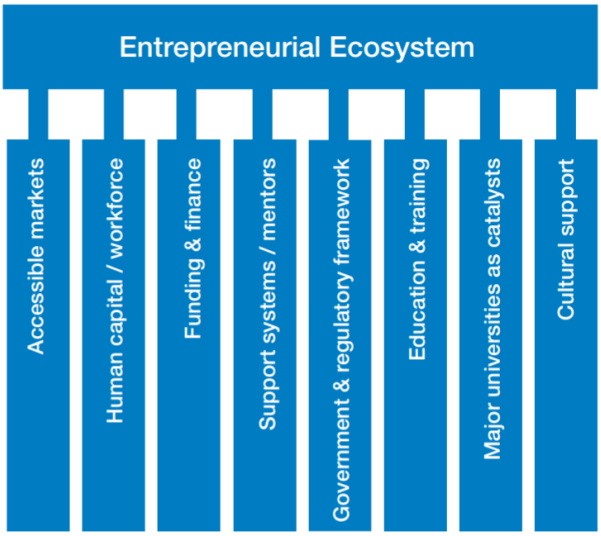

Fig. 2. Eight pillars of an entrepreneurial ecosystem (Source: World Economic Forum, 2014)

This effective ecosystem was not created overnight nor through a purposeful effort by the state or an individual. Rather, numerous actors and factors have contributed to creating an ecosystem that supports innovative, high-growth entrepreneurship which in turn has helped the region avoid the decline and population loss that commonly afflicts old industrial regions in the new knowledge-based economy. The entrepreneurial ecosystem approach provides a framework for integration of insights from the academic literature on regional entrepreneurship and the approach includes several valuable novel contributions to our understanding of the entrepreneurship process and its impact on regional economic development [23].

3. ENTREPRENEURIAL ECOSYSTEM IN THE REPUBLIC OF MACEDONIA

The development of a local and regional entrepreneurial ecosystem is an important link in the chain of providing long-term economic growth and development at local, regional and national level. Analyses show that although there are various stakeholders of the Macedonian ecosystem, they still do not function in synchronization in securing regional development when it comes to regional level. Therefore, more than ever, we need the development of a local and regional entrepreneurial ecosystem that can be initiated, stimulated and supported by a variety of stakeholders: municipalities, universities, development agencies, centers for development of the planning regions, strong non-governmental institutions, venture capitalist, etc.

This ecosystem should foster the competitiveness and innovation of the private sector in the region. Given that entrepreneurs, and the private sector has the leading role in the design and development of such an ecosystem, it is crucial to encourage all stakeholders of the ecosystem to continuously be active and support their activities for strengthening the ecosystem.

Responsibility in developing such an ecosystem is not just in the hands of one stakeholder, but rather on several stakeholders from different organizations. According to the experience of the developed countries, a different types of entrepreneurial ecosystem is needed at the regional level, since the energy, activities and innovations themselves appear in smaller geographical regions. This entrepreneurial ecosystem is being developed by local entrepreneurs, but it is appropriate to encourage all stakeholders to engage in it.

In order to review Macedonian entrepreneurial ecosystem in 2016–2017 "on-site" research was conducted that included the survey of the general population covered over 200 respondents, while over 40 stakeholders of the ecosystem were interviewed.

The realized research showed [12]:

1. In the Republic of Macedonia there is an entrepreneurial ecosystem that is dispersed in various locations throughout the country. At least 20 micro-entrepreneurial ecosystems in the state can be recorded.
2. Unfortunately, Macedonia is lagging behind its closest neighbors when the innovations are in question, especially in the part of newly formed start-up companies, but now more than ever before, there is interest and potential that entrepreneurs can encourage in creating new innovative companies.
3. Skopje, as a center of socio-economic life, as the capital of the state, and as a concentration of businesses and universities dominates the rest of the country from the aspect of most-developed ecosystem.
4. In each of the existing ecosystems there is no element that is a pillar of ecosystem development.
5. The role of the leader in the ecosystem is problematic. Although the theory suggests it to be a business sector, this is not the case in Macedonia, except in the example of the SEAVUS Incubator.
6. Most often, the ecosystem is run by institutions that have been earmarked for donor assistance, and they manage to continue to exist even after the completion of the initial donor projects.
7. The analysis showed that the main problems that our ecosystems face (not all factors are relevant for the different ecosystems) are:
   - Lack of financing in the initial phase (start-up capital);
   - Lack of financing in the middle phase of start-up development (venture capital);
   - Lack of support from the local community in the development of the ecosystem;
   - There are not enough experienced leaders who would lead and manage the ecosystem;
   - Poor interest among the entrepreneurs and the business community for the development of the ecosystem and their involvement as mentors and advisers;
   - Problems with the legislation in certain areas such as: payment abroad, the need to follow all regulations and for a company of 3 employees and a company of 50 employees (e.g. Law on protection at work);
   - Insufficiently developed system for start-up support in terms of training and mentoring and initial training;
   - Insufficiently developed networking (connections and connectivity), especially with foreign countries;
   - Insufficient pre-knowledge about the functioning of the domestic legal-economic system and the way the start-ups function at the beginning of their development;
   - Lack of entrepreneurial education in the formal education system, especially at the university level.

4. CONCLUSIONS AND RECCOMMENDATIONS FOR IMRPOVING MACEDONIAN ENTREPRENEURIAL ECOSYSTEM

Macedonian entrepreneurial ecosystem should be driven by the market and fine-tuned by culture and local customs, while main pillars that are cornerstone of the ecosystem are: business sector, state institutions, policy and legislation, financial sector and non-governmental sector.

The recommendations for strengthening of each of these pillars and overall Macedonian entrepreneurial ecosystem are [12]:

• **Policy and legislation**

– Further implementation of reforms such as tax guillotine where simplification of procedures for opening and running a business will be simplified;

– Simplify procedures for closing a business;

– Tax incentives when purchasing equipment intended for research and development, i.e. for the development of innovative products and services;

– Development of municipal strategies for promoting and supporting the entrepreneurial ecosystem.

• **State institutions**

– Development of infrastructure to support start-up companies at all levels – state, regional and local levels (incubators, hubs, accelerators, co-working space, more technology parks, etc.);

– State subsidies, but implementation at the local level;

– Strengthening the capacities of the local administration responsible for regional / local development;

– Trainings of teachers and teachers on topics of incentives and entrepreneurship at all levels of education;

– Introduction of subjects related to entrepreneurship at all faculties in the Republic of Macedonia;

– Stimulating competitions related to entrepreneurship.

• **Business sector**

– Greater involvement of chambers and other associations in support of start-ups (in the form of mentoring and transferring their experiences);

– Development of clubs of young entrepreneurs within the chambers and associations;

– Development of specific sectors within the chambers and associations that would take care of the start-up community (special funds for initial financing).

• **Non-governmental sector**

– Strengthening of entrepreneurship development, business angels, youth entrepreneurship campaigns;

– Strengthening the capacities of non-governmental educational institutions in the areas of competitiveness of micro, small and medium-sized companies, innovation management, management with new product development, entrepreneurial education;

– Monitoring and suggestions for improving state policies related to entrepreneurship.

• **Financial sector**

– Banks to provide simpler procedures for obtaining loans – start-up credits;

– Establishment of venture capital funds;

– Extending FITD (Fund for Innovations and Technology Development) activities (in terms of size of funds and support palette for start-ups and small and medium-sized companies);

– ESA to decentralize programs at local level for municipalities to be more responsible for the support and development of local entrepreneurial ecosystems;

– Attracting funds from expatriates (diaspora) and from the aspect of finance and from the aspect of knowing how to manage investment funds;

– Develop alternative ways of financing such as crowd-financing;

– Strengthening and increasing the networks of business angels in the Republic of Macedonia.

• **Culture and local customs** (as a community where all the previous factors exist):

– Promote activities that involve taking calculated risk;

– Focus on activities that will fail to perceive the collapse of the business as something terrible, but as an opportunity to learn from mistakes and give a second chance;

– Greater media coverage of all activities related to innovation and entrepreneurship (fairs, business plan and start-up competitions, etc.);

– Development of specialized educational TV shows that will address topics – How to start a business? How to finance a start-up business?

– Displaying successful entrepreneurial stories of domestic and world-renowned entrepreneurs, etc.

• **Market**

– The market is the beginning and end of each ecosystem. It is the reason for the existence of any business.

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DEVELOPMENT OF MODEL FOR MAINTENANCE OF RAILWAY ROLLING STOCKS

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A b s t r a c t: This paper proposes modern railway rolling stock maintenance model. The maintenance of railway rolling stock is a key factor for successful and safe operation of the railway system. The paper research shows in detail the key maintanace quality indicators, such as: reliability, availability, efficiency, functional capability and capability to maintain the railway rolling stock. The key maintenance quality indicators mostly depend on the selection of the basic conceptual maintenance models, preventive maintannace and the corrective maintenance concepts. The new concept which is used more often, is condition based maintenance (CBM). The main purpose of this paper is to create a most convenient concept for railway rolling stock maintenance. The selection of the concept is focused on the definition of the existing maintenance concepts and their comparison with the concept of condition based maintenance. The paper shows examples of condition based maintenance, and by analyzing the results from the examples it comes to a conclusion that the most appropriate maintenance model is the condition based maintenance. Also, according to the costs analyses it can be concluded that from economical point of view the preferred selection of a modern railway rolling stock maintenance model is the preventive maintenance model, i.e. condition based maintenance.

Key words: modern maintenance models; railway rolling stock; maintenance concepts; preventive maintenance; corrective maintenance; condition based maintenance

РАЗВОЈ НА МОДЕЛ ЗА ОДРЖУВАЊЕ НА ЖЕЛЕЗНИЧКИ ШИНСКИ ВОЗИЛА

А п с т р а к т: Во овој труд се предлага современ модел за одржување на железничките шински возила. Одржувањето на железничките шински возила е клучен фактор за успешно и безбедно функционирање на железничкиот систем. Истражувањата детално ги прикажуваат главните индикатори на квалитетот на одржувањето: надежноста, расположливоста, ефективноста, функционалната способност и способноста за одржување на железничките шински возила. Главните индикатори на квалитетот на одржувањето во голема мера зависат од изборот на концепциските модели на одржување. Основните концепции на одржување на железничките шински возила се превентивно и коративно одржување. Новите концепти кои сè повеќе се користат се базирани на примена на одржување според состојба (CBM). Главната цел на овој труд е да се создаде најпогоден концепт на одржување на железничките шински возила. Изборот на концептот се фокусира на дефинирање на постојните концепти на одржување и нивна споредба со концептот на одржување според состојба. Во трудот на реален случај е прикажана примена на одржувањето според состојба. Од анализа на резултатите од случајот се добива заклучок дека најсоодветен концепт на одржување е одржувањето според состојба. Од анализа на трошоците може да се заклучи дека и од економска гледна точка изборот на современ модел на одржување на железничките шински возила е моделот на превентивно одржување, односно одржувањето според состојбата.

Клучни зборови: современи модели на одржување; железнички шински возила; концепти за одржување; превентивно одржување; коративно одржување; одржување според состојба

1. INTRODUCTION

The maintenance concept implies the principles under which the plan and the maintenance program are implemented, but the rapid development of technology is a process that leads to a change in the approach to the maintenance process. The greatest significance of every maintenance strategy is the concept of maintenance, since the overall quality of the maintenance depends on the conceptual solutions [1].

The rapid development of high performance technical systems that should fulfill their function in general, technical, safety, environmental and other requirements demands an essential need for a modern way of control and maintenance. The maintenance, although not main activity of many companies, today, many organizations often place it on the margins of the governance process and often consider it costly (especially preventive and basic maintenance).

On the other hand, until now, there are evident obstacles that prevent the fulfillment of all conditions for modern transport, such as: the low level of interoperability between the railway infrastructure, the railway vehicles and the systems for managing and regulating the railway traffic. In order to overcome the compatibility problems of the various systems, generally in the rail system, the European Union has introduced a series of legal solutions and specifications that regulate the interoperability of all stakeholders of the railway system, regardless of which producer, product or for which country are intended. These standards that govern the compatibility of the rail system are referred to as the Technical Specification for Interoperability (TSI) and cover the areas of infrastructure, rail vehicles, energy, management and maintenance subsystems, railway subsystems, signaling, exploitation and others. However, despite the defined standards and specifications for interoperability, some of the characteristics of railway vehicles can not be controlled, measured or managed in the most efficient manner by applying the existing methods, since the speed of development and the complexity of the technical systems determines the need of more responsible and higher level of control and maintenance.

Modern maintenance approaches require action to the maintenance procedures and their preventive character, i.e. the actions to be carried out before the appearance of the defect, in order to prevent or delay the occurrence of the defect [2]. The constant development of railway vehicles requires finding new modern maintenance models. The essence of the modern approach to the maintenance of railway vehicles lies in the safe diagnostics and processing of systematized measurement data.

2. LITERATURE RESEARCH REVIEW

Several definitions are used to define the term maintenance itself. From all these it can be concluded that the main purpose of the maintenance is to maintain the functional ability of the means of work according to their purpose, according to the requirements of the production function under given conditions and with certain costs [1, 3].

The quality of the maintenance depends greatly on the choice of the maintenance strategy. In order to move towards the selection of a maintenance strategy, it is necessary to clearly understand what are the goals to be achieved and what are the maintenance activities.

The three main objectives that need to be achieved with the maintenance are [4]:

1) Minimizing the costs due to a halt in work caused by unplanned defects of railway rolling stock.

2) Prevention or slowing down the process of aging of railway vehicles.

3) Reduction the cost of operations which arise as a result of increased failures and delays in their work process.

There are other maintenance objectives that can be considered from a technical and technological point of view, but also from an economic point of view, and all of them are further presented and analyzed in this paper.

The main task of the technological process of maintenance consists of the organization of operations that provides high quality repair, the shortest time of retention of the railway vehicle in the process of repair and the lowest costs of its execution. The main maintenance activities are [5]: checking, adjusting, calibrating, measuring, service / lubricating, repairment, replacement, overhaul and recovery.

From the point of view of the very process of maintenance of the rolling stock, any rail vehicle can be considered as a whole or a system composed of separate parts, devices and elements [6]. In both cases, the basic indicators of the quality of railway vehicles can be defined as: reliability, availability, effectiveness, functional capability, maintenance ability and safety. The definition of these indicators does not only apply to railway vehicles, but also

applies to the entire railway system. In international professional literature these indicators are also known under the name of the standard RAMS, that is the acronym comprised of: Reliability, Availability, Maintainability, Safety. The RAMS's goal is that the rail system reaches a defined level of rail traffic at a given time under security conditions [7].

The constant recording and rapid response in case of detected defects substantially reduces the possibility of greater damage as well as a longer disturbance of the railway timetable [8]. Compared with the maintenance of production systems, researches on maintenance of railway vehicles are relatively low and rare. The researchers Dipark Chaudhuri and P. V. Suresh (1995) developed in their work an algorithm for determining the best maintenance model, the length of the period and the replacement policy using the probability theory [9]. This study does not take into account the safety when forming the maintenance model, which is a key factor in maintaining the rolling stock.

Regarding the spare parts, the researchers Chelbi and Ait-Kadi (2001) propose a common optimum periodic replacement and a spare parts delivery model. The work of this model is evaluated in terms of total average cost per time unit for an indefinite period [9].

The authors Yun and Ferreira (2003) described in their study a model for simulation which assesses the conditions for alternative models for replacing parts of the railway vehicles [9]. The main purpose of the model is to determine the optimum replacement model, given the replacement cost and the operating costs for an appropriate rolling stock. Replacement costs consist of fixed and variable costs depending on the units that need to be replaced. As a criterion for comparing the proposed measures, the period and the total projected costs are taken. In doing so, it is very difficult to accurately determine the amount of spare parts that needs to be purchased at a certain time. This is the main research thesis considered in the research of Almeida (2001). The researcher Almeida presented the decision-making models on the basis of a number of criteria, mainly for two maintenance issues: the selection of a contract for the repair and procurement of spare parts [9]. The problem with choosing a repair contract is a model that contains the consequences that are presented through the function of using more choices. The consequences are the price of the contract and the time of execution, represented by the time lag of the system. Also, in the case of the decision model for the procurement of spare parts through the function of using more choices, they are assessed with the two criteria: risks and costs [10].

The researchers Chaudhri and Suresh (1995), Cassady et al. (1998) and Nakagawa (1989) conducted their research on the principle of reducing maintenance costs in order to find the best method for replacement [9]. They considered the maintenance costs including the costs for preventative maintenance and maintenance costs for damaged facilities [11].

The authors Huang et al. (1995), Sarker and Haque (2000) suggested that the rates of the impairment system increase with a depreciation rate [9]. When the maintenance costs of the defect will be greater than the cost of preventative maintenance, the appropriate time period for preventive maintenance will reduce the total maintenance costs. To obtain a more realistic outcome, we can apply the "Weibull" allocation of depreciation to the components of the rolling stock. Most researches on maintenance models and replacement policies are aimed at developing a model that takes into account total costs. The model for maintenance of railway vehicles should not rely solely on a model that takes into account the costs only. When choosing a model, safety must be included as a key factor as well as the adoption of a decision-making model by experts (for example, using the ANP method - an Analytical Network Process [9]), that is, a way to select an appropriate maintenance model for railway vehicles [12].

3. CONCEPTUAL MAINTENANCE MODELS

The maintenance concept can be defined as a long-term plan that covers all aspects of maintenance. This sets the direction of the maintenance management and precise action plans to achieve the desired future state of the maintenance function. The maintenance concept is part of the hierarchical maintenance process in which decisions are made on the selection of recommended concepts and models based on the strategy and priorities of the company.

In accordance with the European standard EN 13306, the basic concepts of maintenance of the railway vehicles are preventive and corrective maintenance (Figure 1).

In addition to the basic division there are other modern concepts of preventive maintenance [13]:

1. Reliability Centered Maintenance – RCM.
2. Total Productive Maintenace – TPM.
3. Proactrive maintenance.
4. Maintanance type „operation until failure“.

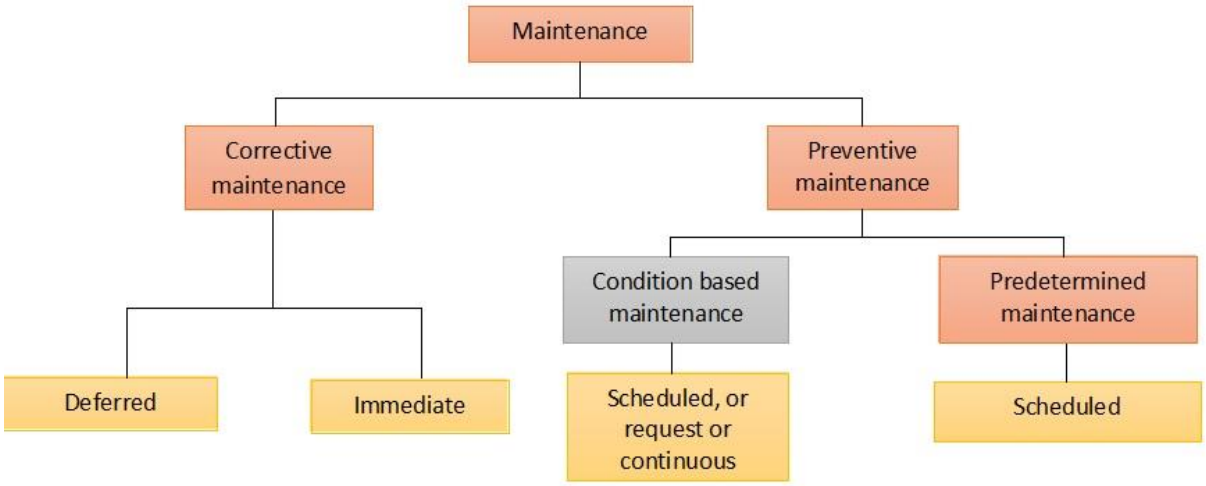

Fig. 1. Concepts of maintenance according to European standard EN 13306 (Maintenance –Terminology) [1]

4. APPLICATION OF THE DEVELOPED MAINTENANCE MODEL BY CONDITION

On time detection of the defects of the railway wheels, or the introduction of a system for defects detection during the exploitation is more cost effective for the railway operator, but also for the railway infrastructure manager. The deformation of the railway wheels leads to occasional damage to the railroad tracks, but also to the railway vehicle itself, which directly affects safety, stability and comfort of traveling with it. Any replacement of the railway wheels or the repair of damaged railway tracks, in addition to maintenance costs, also cause disturbance to the railway traffic on the trains, as well as the shortage of railway vehicles. The costs of purchasing and replacement of new wheels as well as repairing the dimensions of their wreaths are very high. In order to reduce the costs, it is necessary to plan well the process of maintenance of the railway vehicles. Efficient maintenance of railway vehicles requires effective and timely forecasts of the possible number of defected rail vehicles based on various rail wheel defects that may occur during a certain period of exploitation [2].

The preventive maintenance of the underframe of the railway vehicles has a very important role in the timely detection of failures, which could cause an increased percentage of immobilization of the railway vehicles. The timely and proper preventive tracking of the railway wheels prolongs their service life and it minimizes the need for corrective maintenance. The data obtained as a result of regular monitoring and measurements of their parameters are used as statistical data in the process of planning and forecasting of their age of exploitation and the need for change of the wheels. Certainly, consideration should be given to the recommendations made by railway wheel manufacturers for their predicted duration (wheel wear), which is expressed in passed kilometers until the next regular repair.

4.1. *The occurrence of defects on the railway wheels*

The reason for the defects on the railway wheels may be different, most often referring to [2]:

- mechanical abrasion caused by friction,
- defects caused by low quality and non-humogenic material, and
- defects caused by cyclic and overheating thermal nature influence.

All imperfections and defects that appear along the rolling surface of the wheel are arranged in groups. Each of these groups is classified and has its own code in accordance with the recommendations given in the GCU (General Contract of Use), Appendix 9, OUK / AVV [14].

Figure 2 presents statistical data about the average number of defects caused on the rolling stock related to flat bed on the rolling surface of the wheel (49%), which are the highest types of defects, and the lowest number of defects are those which are caused by traffic related cavitatios, scaled and cracked spots (1.36%). The European standard EN 13262, which sets out the basic standards and recommendations for the production of wheels for railway vehicles, defines the following designations of the steel materials from which they are made: ER6, ER7, ER8 and ER9.

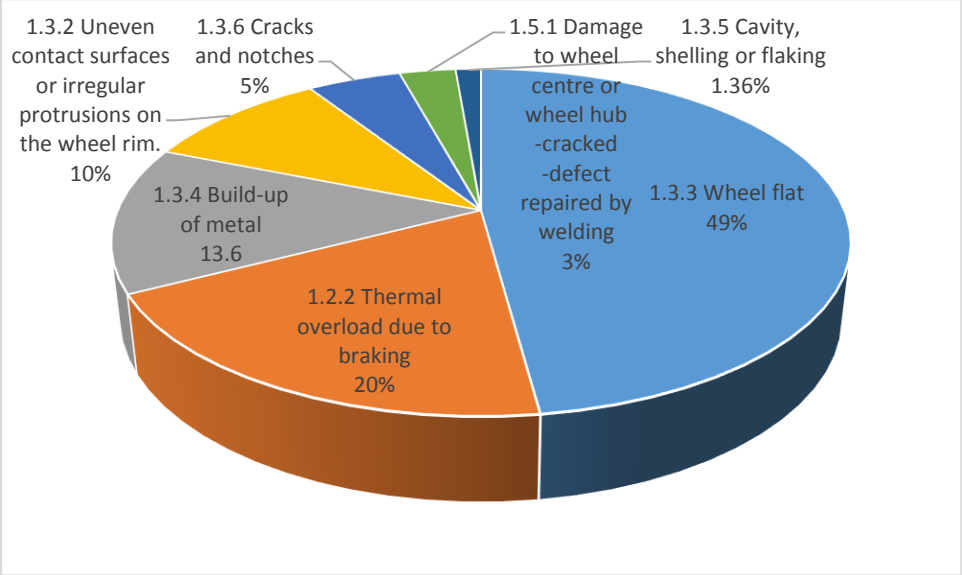

Fig.2. Imperfections and defects that appear along the rolling surface of the wheel [2]

The minimum hardness values expressed in the Brinell (HB) unit are given in Table 1. They are presented in two categories (K1 and K2), and the data refers to the hardness of the material from which the railway wheels are made, and the size that needs to be with the same value in measurements at a depth of up to 35 mm from the rolling surface of the wheel.

Table 1

Minimum hardness values of the rail wheel [2]

Mark of the material from which the railway wheels are made	Minimum hardness values per category	
	K1 (> 200 km/h)	K2 (< 200 km/h)
ER6	/	225 HB
ER7	245 HB	235 HB
ER8	245 HB	245 HB
ER9	/	255 HB

The defective construction of the wheels can also cause defects of the railway wheels (expressed through the characteristic of the longitudinal connection of the axle assembly and the frame of the rotary stand) as same as the low quality of the material from which they are made can affects the damage of the railway wheels. Another type of defects that occur from a mechanical-thermal nature are the formations of annular depressions along the rolling surface of the railway wheel [2].

The condition monitoring of the railway wheels on the Diesel Multiple Units (DMU) series 711 and the Electric Multiple Units (EMU) series 411, owned by MZ Transport AD Skopje is categorized according to the CBN model. The monitoring of the situation is prescribed by regularly measuring their safety assessment indicators. During the exploitation as part of the CBN, the following changes in the main parameters of the railway wheels are measured: the diameter of the railway wheel D, the thickness of the crown Vd, the height of the crown Vv and the curvature radius q_r. The Table 2 presents the allowed deviations of those measurments.

Table 2

Permissible deviations of the geometric measurements of the wheels on EMU 411 and DMU 711 (mm)

Parameter	Wheels diameter (*D*)	Minimum value	Maximum value
Thickness of the crown Vd	$780 < D \leq 850$	25	32,5
Height of the crown Vv	$780 < D \leq 850$	27,5	32
Curvature radius q_r	$780 < D \leq 850$	6,5	10

During the exploitation of the railway wheels there is a change in the safety assessment parameters, because the change in the shape of the wheel from the wheel. In that case it is necessary to perform machining – re-profiling the crown of the railway wheels. With this processing, the wheels will be brought back into the permitted safety measures, which will allow prolongation of the life and the exploitation of the railway wheels and will prevent the occurrence of derailment.

With regular preventive maintenance according to the condition, various anomalies can be observed in the direction of the aforementioned defects along the rolling surface of the wheel. If the railway wheels are made of insufficient quality material and with poor technological processing or from material that has inadequate physical characteristics, i.e. hardness, in this case, the appearance of the porosity of the material on the railway wheels can be noticed. In the event of such a situation, the railway wheels will be subjected to more frequent machining in order to prolong their exploitation period.

Table 3 presents the changes in the diameter of the railway wheels during their exploitation on DMU 711 003-004, and in Table 4 for EMU 411 101-102. The date of commencement or the placing of the railway wheels in exploitation, the dates when the machining of the railway wheels during the exploitation has been carried out, and the date when the railway wheels according to the value of the safety assessment indicator are not in use (when DMU 711 003-004 and EMU 411 101-102 are excluded from the rail traffic), are clearly recorded.

The comparative analysis of the change in the diameter of the railway wheels in the two sets (DMU 711 003-004 and EMU 411 101-102) is graphically depicted on the diagram on Figure 3.

Table 3

Change in the diameter of the railway wheels during the period of exploitation of DMU 711

Axle	DMU 711 003				DMU 711 004				Elapsed distance km	Processing date
	1	2	3	4	1	2	3	4		
Wheel diameter after processing, *D* (mm)	850	850	850	850	850	850	850	850	0	14.03.2016 (start of exploitation)
	838	838	838	838	838	838	838	838	71.366	30.06.2016
	820	820	820	820	820	820	820	820	102.000	04.08.2016
	800	800	800	800	800	800	800	800	117.000	16.09.2016
	790	790	790	790	784	784	790	790	160.000	22.11.2016
	785	785	785	785	**779**	**779**	785	785	185.000	26.12.2016 (end of exploitation)

Table 4

Change of the diameter of the railway wheels during the period of exploitation of EMU 411

Axle	EMU 411 101				EMU 411 102				Elapsed distance km	Processing date
	1	2	3	4	1	2	3	4		
Wheel diameter after processing, *D* (mm)	850	850	850	850	850	850	850	850	0	08.02.2016 (start of exploitation)
	833	833	830	830	833	833	833	833	145.000	25.01.2017
	822	822	820	822	820	823	820	823	180.000	12.04.2017
	805	807	807	808	801	802	807	806	215.000	05.07.2017
	791	792	794	795	786	788	792	790	220.000	25.07.2017
	789	788	788	788	784	788	**780**	783	227.227	28.07.2017
	785	784	784	784	**779**	**779**	**775**	**775**	242.185	04.09.2017 (end of exploitation)

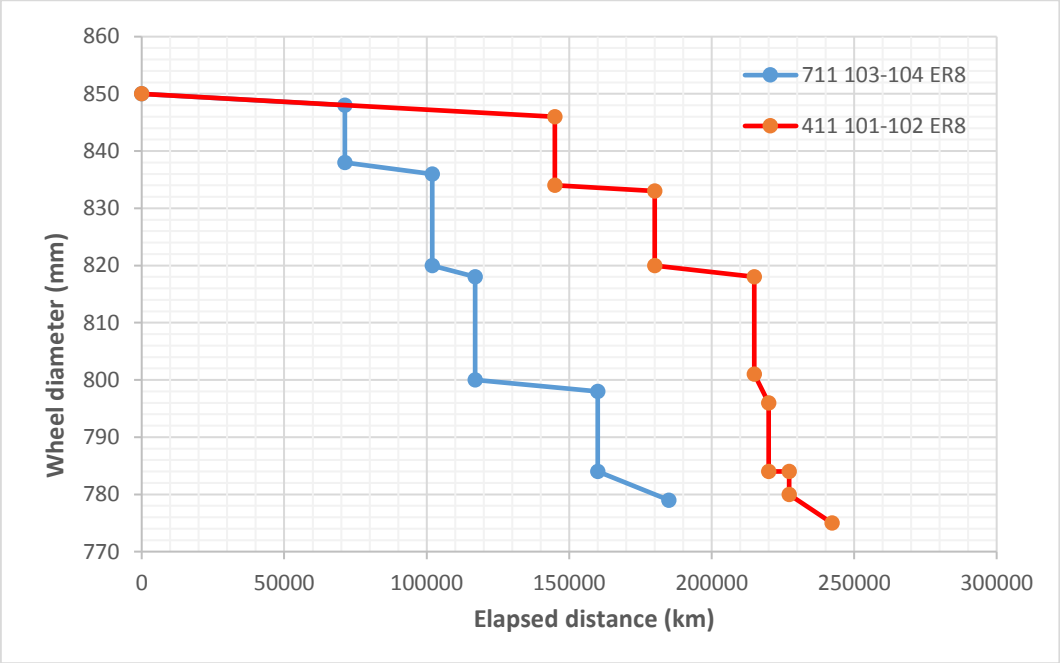

Fig. 3. Diameter change wheel diameter for DMG 711 003-004 and EMG 411 101-102

The passenger multiple units 711 003-004 and 411 101-102 given in Figure 4 are composed of three units, each end unit is powered unit, and the middle one is a free or drawn unit.

Fig. 4. Diesel multiple unit (DMU) 711 003-004

Regarding the weight of the powered units, there is a difference of 1.765,3 kg and based on this, it should be expected that the degree of friction on those rail wheels on the DMU is higher, which means that the wear, i.e. wheel wear should be higher.

EMU 411 operates on a repaired railroad along Corridor X, and DMU 711 operates on a far worse old railroad from the Corridor Xd. The condition of the railway track in this case plays a very important role in the part of the wear and tear of the railway wheels. The sharp curvatures of the rail track also contribute to the damage to the railway wheels, and such a track with high number of curves represents large portion of the Corridor i.e. where the DMU droved.

As previously mentioned, the material from which the railway wheels are made (with an appropriate designation according to Table 1) is a very important indicator of the level of their spending. The completed replacement of the wheels on the DMU at 185,000 km of elapsed distance and at 240,000 km on the EMU, occurs relatively early and is much erlier then the forecasted prescription for such an replacement, especially if we are taking into account the statistics of the standard UIC 510-2 and TSI 2006 / 861 / EC.

By analyzing the above reasons that show very fast spending, it was decided that during the first replacement of the railway wheels on the DMU 711 003-004 new railway wheels shoud be installed, new wheels which are made of a stronger category of material marked as ER9, in order to increase their exploitation lid.

The comparative analysis of the railway wheels of DMU 711 003-004 and EMU 411 101-102 made of material marked as ER8 and newly installed rail wheels made of material marked as ER9 is given in Figure 5. It can be concluded that the railway wheels with the ER9 mark has considerably less spending than the ER8 wheels.

4.2. *Affecting factors to the wheels spending on DMU 711 and EMU 411*

The main factors greatly contribute to the increased spending of the rail wheels of both trainsets (DMU and EMU) refer to [2]:

- the weight of the powered units,
- the condition and quality of the railway track,

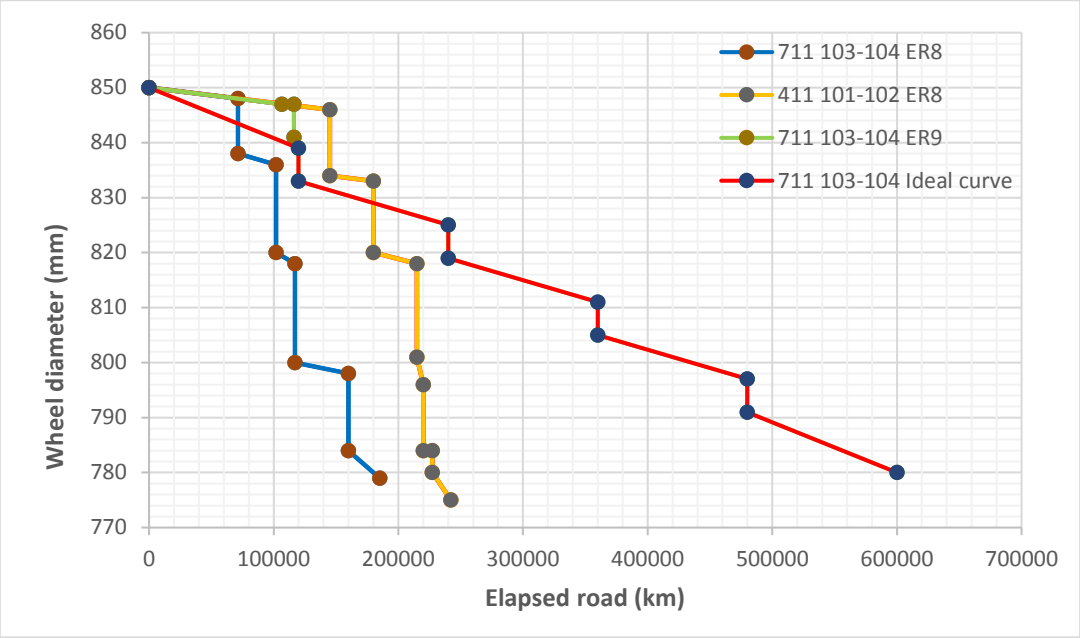

Fig. 5. Change diagram of the wheels dimeter at 711 003-004 and 411 101-102 in respect of the markings ER8 and ER9

- the quality of the construction of the railway wheels,
- the type of material from which the wheels are made,
- exploitation conditions and
- the impact of weather conditions.

Acordingly, if the trainset is with a lower weight of the powered units, and operates on a newly build or repaired railway track, it will have a longer exploitation life of the wheels.

Having in mind that the basic parameters which are defining the contact of the wheel and the track, are: adhesion, slipping and wear, then the abrasion and plastic leakage are closely related to the geometry of the profile of the wheel and the rail and this significantly influences the dynamics of the railway vehicle. The surface of contact between the wheel and the rail as a geometric characteristic depends on the radius of the curvature of the contact surface. The nature of the force of contact depends on the conditions of the surface and the environment, which include roughness, the presence of water, snow, oil, impurities. The characteristics of the material and the profile of the wheel and rails define its interaction, and the most important are the hardness, toughness and thermal conductivity of the materials.

If the wheels are with high quality, the appearance of porosity of the material is lower, and the need for machining is less, or with other words, the need for corrective maintenance is lower. Also, if the material of the wheels is with greater hardness performance, the lifetime of the wheels is longer. The standards and norms of UIC members stipulate that the optimum strength and hardness ratio of the steel material from which the wheel is made need to be 10% stronger and stronger than the material from which the rail is made. The research on rail track and railway rolling stock investment shows that the ratio of the lifetime of the rails to the wheels should be 2:1 in favor of the rails, considering that wheels with a 10% higher fortress than the rail tracks are used [1]. In this regard, it is a fact that the repairment of the rail track and the replacement of the rails is far more biger investment than the change of the wheels of the railway vehicles.

The conditions under which the exploitation takes place are the most important factor when it comes to the wearing of the railway wheels, which includes:

- the difference in wheel diameters on the same axle,
- the difference in wheel diameters on the same boogie,
- non-parallelism of the axles on the same boogie,
- non-grinding of the crowns on the wheels and similar.

The lifespan of the wheels depends on the dynamics of the wear of the hoop or the crown of the wheel. It is certain that by reducing the friction between the crown of the wheel and the rail it will increase the durability of the wheel.

Also, the errors in the geometry of the track directly affect the increased wear on the wheels.

In addition, the influence of the weather conditions has an important role in the wheel wearing. If there is more wet weather, the side friction and wear of the wheels are lower. This can not be influenced, but it must be kept in mind when experimenting or data is analyzed.

5. ANALYSIS OF THE OBTAINED RESULTS

The analysis of the practical application of the developed maintenance model according to the conditions shows that the defects which occur during the exploitation of railway vehicles are very easily identified and detected. The results obtained from a technical point of view gave a clear deduction that the basic objective of preventive maintenance by condition (CBM) is achieved, and activities are created to timely perform the process with appropriate maintenance.

In the analyzed case, it is shown how through the regular control and measurement of the wheels of the DMU and the EMU, the condition of the crowns on the railway wheels can be monitored. With the timely preventive maintenance according to the condition, that is, reprofiling of the crowns, the life of the wheels is prolonged and the occurrence of derailments is prevented. By analyzing the consumption of the railway wheels an information indicating when there would be a change of wheels is generated. This means that it will be predicted when the trainset would be out of traffic due to the change of the railway wheels. On this basis, the indicators which are influencing the consumption of the railway wheels are created.

5.1. *DMU 711 wheels replacement costs analysis*

The inadequate selection of the wheels for the DMU can contribute to profile wheel wear, and thus higher costs for companies owning railway vehicles. This *state of the art* maintenance model allows daily monitoring and measurement (tracking of wheels). It gives a clear indication of timely machining – reprofilling of the railway wheels. With the timely reprofiling, the reliability and safety of the railway vehicle increases, the life of the railway wheels continues, and the main goal to reduce the costs arising from the early change of the railway wheels is achieved.

Table 5 shows the analysis of the costs that occur during one change of the railway wheels of the trainset DMU 711 in the company MZ Transport AD Skopje. Costs are devided in 4 items:

- Financial losses caused by the non-exploitation of the trainset, expressed in euros.
- Necessary working hours for workers to carry out railway wheel replacement operations, expressed in euros.
- Handling costs for the use of consumables, working machines and equipment, special tools, etc., expressed in euros.
- Purchase of new railway wheels, expressed in euros.

Table 5

Wheels replacement costs for DMU 711

Number	Cost description	Price (EUR)
1	Financial losses caused by the non-exploitation of the DMU (average waiting time of 15 days for carrying out the change of the railway wheels)	25.500,00
2	Costs for working hours for performing workers' operations (average 10 workers)	23.040,00
3	Handling fees for the use of materials, machinery, equipment and special tools	3.000,00
4	Supply of 16 sets of railway wheels	22.400,00
Total:		73.940,00

The estimated total cost for one replacement of the railway wheels on the trainset DMU 711 is shown in Table 5. Considered the economic point of view, for the trainset DMU 711 with wheels made of material bearing the mark ER8 and for elapsed distance of at least 600,000 km, it should be foreseen that at least 3 wheel changes will be made.

In the second case, when the wheels of the DMU 711 are made of material bearing the designation ER9, there would be a one-time replacement cost and would be within the regular plan repair.

In this particular case of the analysis on the DMU 711 trainset, it can be concluded that the inadequate selection of the railway wheels during the design carried out by the manufacturer of the trainset has created increased maintenance costs to the owner of the trainset.

6. CONCLUSION

In the case stady analyzed in this paper, the application of the model for preventive maintenance according to the condition is specifically shown.

The application of this model gives a concrete indication for the timely discovery of the reasons for increased wearing of the railway wheels.

Using the experiential practices and recommendations based on the railway norms (UIC 510-2 and TSI 2006/861 / EC), an ideal curve for maintenance and exploitation of the railway wheels has been developed and defined. The developed ideal curve is in full correlation with the application of the model for preventive maintenance according to the condition. By modifying it and adjusting it to the maintenance needs of railway operators, it is possible to use it as a guide in the process of procurement and maintenance of railway vehicles. It actually defines the time terms and parameters of machine processing – reprofiling, as well as the deadlines when the change of the railway wheels needs to be made. Taking into account the above, railway operators will be able to make better programs and maintenance plans, while at the same time having satisfactory achievement and fulfillment of the quality indicators in the maintenance of the railway wheels.

Inadequate selection of the maintenance model, but also improper choice of the type of railway wheels leads to their rapid spending. The rapid change of the railway wheels, from an economic point of view, means an increased financial burden to the owners of railway vehicles. In the case of the Diesel Multiple Unit series 711 owned by MZ Transport AD Skopje, the improper choice of the type of railway wheels caused financial loss of the company. Certainly the calculation of the loss was made on the basis of data and forecasts, but it can be used with minor corrections and modifications for further detailed calculation of the company's real costs, which in any case could be expected to be different from the analyzed.

The results of the research for the selection of a proper maintenance model showed economic justification, i.e. with the achievement of efficient and effective maintenance, the costs are reduced. The final results show that economically the most cost-effective is the model of preventive maintenance according to the conditions.

Finally, it can be concluded that: there is no universal ideal model for the modern maintenance of railway vehicles, but the most favorable one is proposed model of preventive maintenance according to the conditions.

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INSPECTION BODIES MANAGEMENT OF DOCUMENTATION PROCEDURES AND STANDARDS

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A b s t r a c t: This work is composed from the document Management Procedure for inspection bodies. Purpose and goals are covered as the subject and scope of application. Also the therms, responsibilities and description of the procedure and standardizing the document are given.

Key words: ISO 17 020; standard; inspection bodies; documents procedure

УПРАВУВАЊЕ СО ПОСТАПКИТЕ ЗА ДОКУМЕНТАЦИЈА И СТАНДАРДИЗАЦИЈА НА ИНСПЕКЦИСКИТЕ ОРГАНИ

А п с т р а к т: Во трудот е претставена постапката за користење (управување со) документи на инспекциските тела. Намерата и целите се опфатени како предмет и опсег на примена. Исто така се дадени и термините, одговорностите и описот на постапката, како и стандардизирање на документите.

Клучни зборови: стандард ISO 17 020; инспекциски тела; процедура за документација; начин на користење документи

INTRODUCTION

The quality system and its proper implementation in everyday activities make the difference in the quality recognition offered by the company. Designing an appropriate system contributes to the effective and efficient operation of the company, as well as improving the quality of services.

The following bodies operate in the scope of the ISO 17 000 standard:

– product certification bodies MKC EN ISO / IEC 17065;

– testing and calibration laboratories, MKC EN ISO / IEC 17025;

– inspection bodies, MKC EN ISO / IEC 17020.

Depending on the activities that the body will perform in the standard itself, the type of document that is to be issued by him is specified. Testing laboratories issue test reports, certification bodies, certification of the product, while inspection bodies certify from inspection / verification from check. Inspection bodies perform their activities on the basis of the defined requirements contained in the standard MKS EN ISO / IEC 17020.

Accreditation as a status provides a hint that a particular institution / program meets the standards set by an already accredited institute / agency.

Accreditation reflects the fact that after the realization or implementation of the mandatory points of the standard, the institution does not cease to aim only for maintenance, but also for its

continuous upgrading. This involves the design of documentation that corresponds to the standard.

The Quality Manual as an essential tool for navigation will need to be a shortened program, but also a basic document for the staff. The staffer, by accepting and realizing the points of the manual, increases his safety at work, while the process of obtaining the final product will be recognizable for the company.

MATERIALS AND METHODS

1. *Document management procedure for inspection bodies*

1.1. *Purpose and goal*

The purpose and goal of the document management procedure is to standardize the documents from the quality management system and to prescribe the method of preparation, control and approval.

By standardizing the documents (formal appearance and content), a permanent layout and form of documents is established.

The goal is to enable unequivocal identification and simple handling of documents.

1.2. *Subject and scope of application*

The documentation management procedure refers to documents from the quality management system.

1.3. *Responsibilities and competencies*

Responsible for the implementation of the document management procedure is the quality manager.

The competencies for certain activities regarding the preparation of the documentation are given in the following Table 1.

Table 1

Activities competence

	Initiative (proposer)	Preview of the proposal	Preparation*	Control	Approval	Responsible for the record of documents	Responsible for distribution of documents
Head	**X**	**X**		**X**	**X**		
Deputy head	**X**						
Quality manager	**X**	**X**	**X**			**X**	**X**
Administrator	**X**						
Technical officer	**X**						

* The quality manager defines which individuals will be involved in the respective activity.
X – Bearer of the activity

1.4. *Terms and definitions document – a means of support and information*

- **Quality management system** – part of the management system aimed at introduction and development of environmental policy and environmental aspects.
- **Organization** – company, joint stock company, institution or part, or a combination thereof, public or private, which has its own functions and administration.
- **Procedure** – logical sequence of implementation of activities and processes.
- **An entry** – a document in which results or activity are recorded.

1.5. *Description of the procedure*

A request / proposal for a new document / document amendment (Figure 1).

The request (written or oral) for the preparation of a new document (or document amendment) may be submitted by all employees, explaining the reasons for the proposed document / amendment of the existing document. The request for a new document/amendment is submitted to the quality manager.

Review of the request / proposal

The request / proposal is jointly reviewed by the quality manager and the head of the inspection body.

In case the request is justified, the document is prepared and released into trial run, and then it is re-examined and approved. If the proposal is not in the function of the quality management system, it is rejected.

The approval for acting upon the request / proposal is given by the head (Figure 1).

Preparation of the document / amendment

The quality manager together with the head reviews the document / amendment. The quality manager (or another person authorized by the manager) prepares the document. The first version of the document is always version 0, and each subsequent amendment has the next number of the modified version (Figure 1).

Document / amendment control

All users of the document are reviewing the new document / amendment. The control performed by the quality manager and the head gives an approval for the implementation of the document. If there are any objections, the document is given for further development / processing to the expert team / the creator (Figure 1).

Receiving, recording and distributing documents

All valid documents are recorded by the quality manager in the Document Records List. The quality manager informs employees of the amendments in the documents, withdraws the invalid and distributes the valid documents to the employees (Figure 1).

Document storage

An original copy of the documents is kept by the quality manager. The original always has the number 01. The users have numbered working copies.

The quality manager takes care not to lose or damage any document. The documents are stored in a register (Figure 1).

Issue of documents

The documents are issued through the Documents Distribution List by signing by the users.

The documents are issued by the quality manager with a recorded copy number.

Except for the needs of the employees, the quality manager with authorization from the head, may also issue a document to another person outside the company, but sample must be marked *for information purposes only*.

The Documents Record List and the Documents Distribution List apply to all documents, i.e. the internal and external documents (Figure 1).

Implementation of the amendment (introduction) and replacement of invalid documents

When making an amendment (introducing a new document), the whole document changes.

If a chapter in the Quality Manual was changed, the whole chapter also changes.

In the Documents Record List and in the Distribution Documents List, a new or revised document is entered in the amended version and it is submitted to the users.

Documents are in use with the data approved by the head. They are distributed through a Distribution Documents List.

Upon submission of a new document, the user is obliged to return the previous copy of the document. In the quality manager archive, one copy of the invalid documents is kept for a minimum of 5 years, which have "not valid" mark and the other copies are destroyed (Figure 1)

1.6. *Standardizing the documents*

All the quality system documents have a standardized layout. The documents are written with the font *courier new* with the size of the letters and numbers in the texts is 12, and in titles, tables, images and schemes another font size or other font is used as needed.

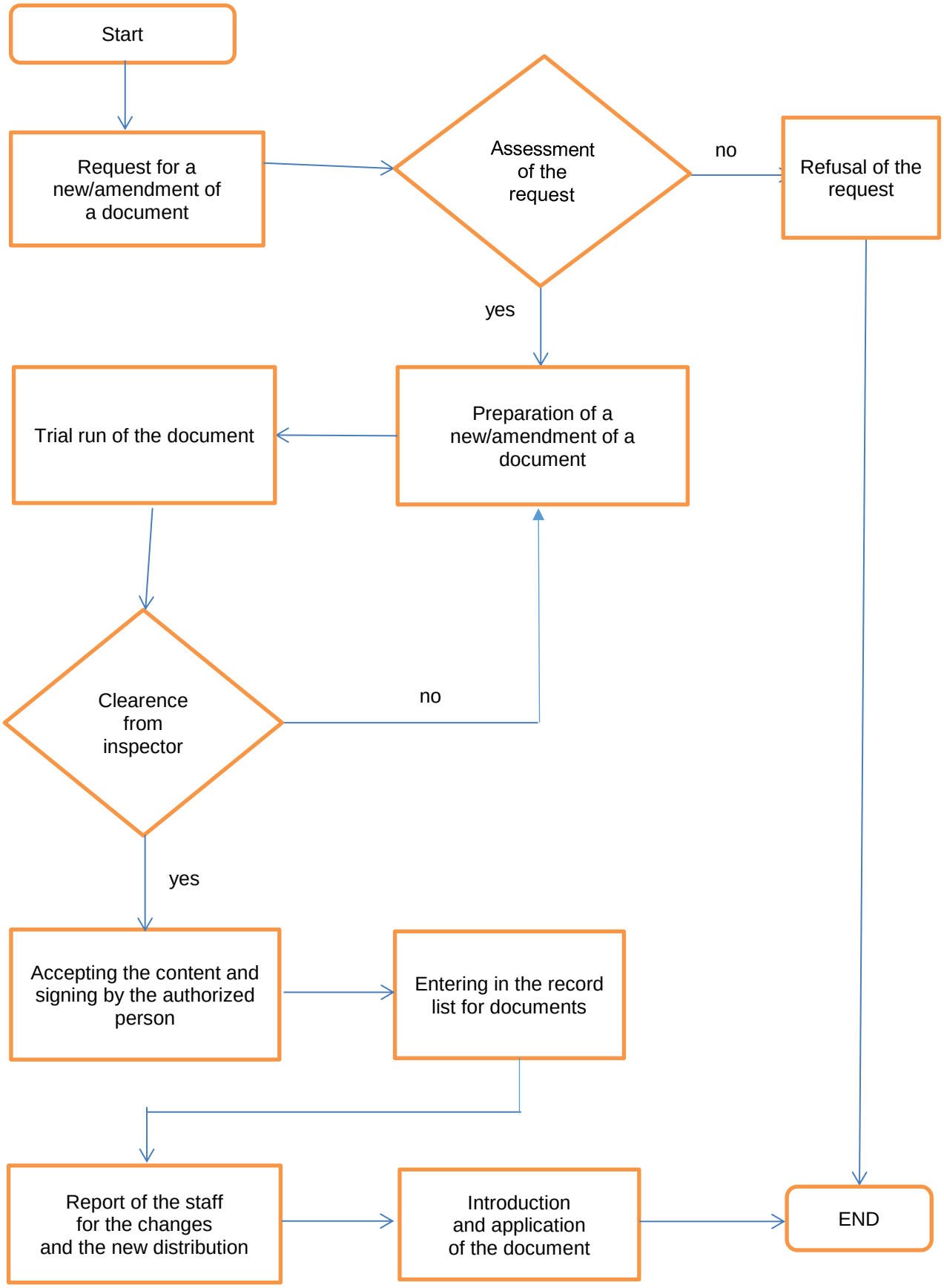


Fig. 1. Algoritham for preparation/amendment of a document

1.6.1. *Quality Manual*

- **Front page:** The front page of the Quality Manual contains:
- the logo and name of the inspection body: NAME of inspection body, Skopje,
- document name: Quality Manual,
- the number of the sample,
- the label if the document is subject or not to modification,
- Information purposes only copy or not.

The front page is changed only in the case of changing the name and logo.

Chapters of the Quality Manual

The front page chapters in the Quality Manual contain:

- header,
- content,
- footer.

The header of the Quality Manual chapters contains the following informations:

- the inspection body logo,
- name of the inspection body,
- Quality Manual.

The **footer** on the first page of the Quality Manual has the following form (Table 2).:

Table 2

Footer of the Quality Manual

	Name and surname	Position	Date	Signature
Copy no.				
Prepared by				
Controlled by				
Approved by				

The footer on the following pages contains the label on the document, the version, and the number of page.

1.6.2. *Standardization of documents (procedures, guidelines, forms, plans, check lists)*

These front pages of these documents contain:

- **header,**
- **content,**
- **footer.**

Each page of the procedures and instructions has a **header** and it contains the following informations:

- the logo and name of the inspection body,
- document name: Procedure (manual),
- document code: UU.X.X.X (U-letters, X*-numbers),
- version number,
- page number in the document,
- *X, depending on the chapter, can have two digits (Table 3).

The **footers** have the same layout as the chapters in the manual.

On the inner sides of these documents there is no defined footer.

The first page of these documents is given in Appendix 1.6.3.3.

Table 3

Method of encoding documents

УУ.	Х.	Х.	Х	
				Two letter abbreviation for certain document
				Chapter number according to the standard and the manual
				Point number according to the standard and the manual
				Document number linked with the chapter

Document management procedure

The documents will have the following abbreviations:

- PK – quality manual,
- PR – rulebook,
- PO – procedure,
- UP – manual, instructions,
- PL – plan,
- ChL – check list,
- OB – forms, i.e. abbreviation used for other documents that are not listed.

Appendix 1.6.3.6 gives the format of the entry outlook.

Description of the procedure

The description of the procedure for the course of the activities execution, contains only the activities that are compulsory. The activities are listed according to the order of their execution. The procedure description can only be with text or with a graphic representation of the course of the activities. The graphic presentation of the activities course in the procedure is applied as much as possible. The layout of the graphic presentation of the procedures is shown in Appendix 1.6.3.4.

1.6.3. Appendixes

Appendix 1.6.3.1. *Front page of the manual*

QUALITY MANUAL

SERVIS ZA TAHOGRAFI I TAKSIMETRI
TAHO · Skopje d.o.o.e.l

Sample no.	
Submitted to changes	
"Information purposes only" copy	

The Quality Manual is made by the working team members.

_

Photographs, photocopies, magnetic copy or any kind of copy and transfer to third parties are prohibited in compliance with the Law on Copyrights.

Appendix 1.6.3.2. *First page of the manual*

QUALITY MANUAL
INSPECTION BODY

SERVIS ZA TAHOGRAFI I TAKSIMETRI
TAHO · Skopje d.o.o.e.l

Content

Copy no.	**Name and surname**	**Position**	**Date**	**Signature**
Prepared by				
Controlled by				
Approved by				

Photocopies and transfer to third parties are prohibited in compliance with the Law on Copyrights.

Appendix 1.6.3.3. *Front page of the document*

Document title

INSPECTION BODY

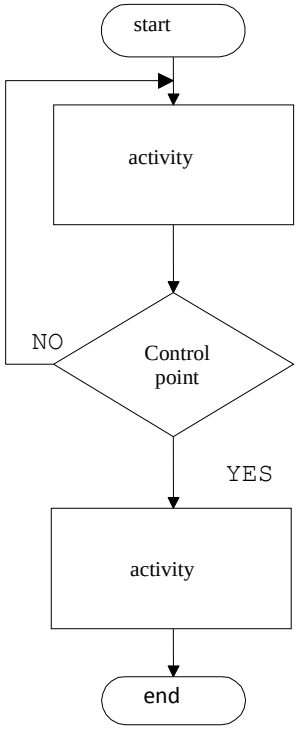
SERVIS ZA TAHOGRAFI I TAKSIMETRI
TAHO · Skopje d.o.o.e.l

Content

	Name and surname	Position	Date	Signature
Prepared by				
Controlled by				
Approved by				

Photocopies and transfer to third parties are prohibited in compliance with the Law on Copyrights

Appendix 1.6.3.4. *Description of the course of the activities in the procedures*

Chart	**Text description**	**Responsible for:**		**Documentation regarding the activity**
		I	**K**	
				

Appendix 1.6.3.5. *Inside page of all documents*

DOCUMENT TITLE
INSPECTION BODY

SERVIS ZA TAHOGRAFI I TAKSIMETRI TAHO · Skopje d.o.o.e.l

UU.X.X.X/Version X Page m of n

Appendix 1.6.3.6. *Records*

Record title
INSPECTION BODY

SERVIS ZA TAHOGRAFI I TAKSIMETRI
TAHO · Skopje d.o.o.e.l

OB X.X.X/VersionX Page m of n

1.6.4. *Records*

The documents which are an objective evidence of the conducted activity or the achieved results are entered in the records (Table 4).

1.6.5. *Reference documents*

Documents implemented in the procedure:

- МКС EN ISO / IEC 17020: 2006,
- Quality Manual.

1.6.6. *Appendixes*

- OB 7.6.1. Documents Record List;
- OB 7.6.2. Documents Distribution List;
- OB 7.6.3. Form for Documents amendments

Traceability of data is on the highest level from start to finish of the complete procedure of inspection. Certificates are with minimum faults, and the measured data is reliable and traceable. Documents are standardized, equipment that measures has accredited certificates of reliability and all of that lead to final result of the highest level of conformity.

Table 4

Records

No	Record	Storage place	Storage time	Person in charge
1.	OB 7.6.1, Documents Record List	Quality manager	5 years	Quality manager
2.	OB 7.6.2, Documents Distribution List	Quality manager	5 years	Quality manager
3.	OB 7.6.3, Form for Documents amendments	Quality manager	5 years	Quality manager

EXPECTED RESULTS

Accreditation, as the basic guideline for obtaining a licence for work, should not be seen as a criterion to be fulfilled but as a tool that the company should maintain and complement. Continuous maintenance of the system makes the company competent, recognizable in quality and successful in the activity it performs. Correct installation and upgrading of procedures, instructions and rulebooks generates an uninterrupted flow of information.

The work of a new version of the quality system should always be in the mind of the management and the person responsible for maintaining the quality system manager. Implementing new versions brings new challenges, i.e. new ideas that the company will incorporate into the system in order to improve it. The quality of the services represents a basic aspiration for the company's operation, and it is maintained by improving and systematizing the documentation from the quality system.

USED LITERATURE

[1] www.stoneridge-electronics.com

[2] www.tachomaster.co.uk/documentation

[3] www.iarm.gov.mk

[4’ http://eur-lex.europa.eu

[5] Law on working hours, obligatory vacations of mobile workers and drivers in road traffic and devices for enrollment in road transport, *Official Gazette of R.M.,* No. 161/09)

[6] Rulebook on the technical characteristics of the tachograph and the manner of use, installation, repair, inspection and control of the tachograph, *Official Gazette of R.M.,* No. 102/10)

[7] Rulebook on the form and content of the application for issuance or extension of the authorization for installation, inspection, control and repair of tachographs as well as the necessary documentation, space and equipment of the workshop, *Official Gazette of RM.*, No. 18/10).

[8] ISO/IEC 17020:2012 Standard

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REVERSE ENGINEERING AND ADDITIVE TECHNOLOGIES IN CIRCULAR ECONOMY

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A b s t r a c t: The opportunity to redesign various parts for production has developed techniques that are in continuous use, including the Reverse Engineering (RE). RE encompasses a variety of approaches to reproduce a physical object with the aid of drawings, documentation, or computer model data. RE is the process of obtaining a geometric CAD model from 3-D points acquired by scanning existing parts. Recently, the acceleration of machining parts design and applying the CAD for RE has resulted in the need for their rapid production, now known as Additive Technologies (AT). Additive Technologies is defined by a range of different production processes that are capable of translating virtual solid model data into physical models in a quick and easy process. AT can be used to remove or at least simplify many of multistage processes. With the addition of some supporting technologies it can be possible to manufacture a vast range of different parts with different characteristics and with economic reasoning. The economic aspect is always present in engineering analyses in various forms by advancing access to all sectors of production. Circular economy (CE) is one of them and considered as an alternative to a traditional linear economy in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. Circular economy is part of the ongoing narrative on industrial sustainability covering resource efficiency, reduced energy, and increasing the efficiency. The idea of circular economy applied in large industrial constellations where companies exchange resources and have alternative forms of access to products and services that can increase the efficiency of use of already manufactured products and thus reduce the demand for new production. In this paper we explain the improvements of circular economy in reverse engineering and additive technologies during they use in industrial sector, their impact and efficiency in implementation. This paper analyzes the benefits and barriers of circular economy during applying in RE and AT.

Key words: circular economy; reverse engineering; additive technologies; CAD; efficiency

РЕВЕРЗНО ИНЖЕНЕРСТВО И АДИТИВНИ ТЕХНОЛОГИИ ВО ЦИРКУЛАРНАТА ЕКОНОМИЈА

А п с т р а к т: Можноста за редизајнирање различни делови на производство има развиено техники кои постојано се користат, вклучувајќи го и реверзното инженерство (RE). RE опфаќа различни пристапи кон репродукција на физички објект со помош на цртежи, документација или податоци од компјутерски модел. RE е процес на добивање геометриски CAD модел од 3-D точки добиени со скенирање на постојните делови. Забрзувањето на развојот на дизајнот на делови за машини и примената на CAD за RE неодамна резултираа во потреба од нивно брзо производство, сега познато како адитивни технологии (AT). Адитивните технологии се дефинирани од голем број различни производни процеси кои се способни да преведат виртуелни цврсти модели во физички модели во брз и лесен процес. AT можат да се користат за отстранување или барем поедноставување на многу мултифазни процеси. Со додавање на некои придружни технологии може да се овозможи производство на широк спектар различни делови со различни карактеристики и со економска оправданост. Економскиот аспект секогаш е присутен во инженерските анализи во различни форми преку унапредувањето на пристапот до сите сектори на производството. Циркуларната економија (CE) е една од тие форми и се смета за алтернатива на традиционалната линеарна економија, во неа ги чуваме ресурсите да се користат што е можно подолго, за од нив да извлечеме максимална вредност додека се во употреба, а потоа да ги обновуваме и

регенерираме производите и материјалите на крајот на нивниот работен век. Циркуларната економија е дел од секојдневието на индустриската одржливост покривајќи ја ефикасноста на ресурсите, намалената енергија, како и зголемувањето на ефикасноста. Идејата за циркуларна економија се применува во големите индустриски констелации, каде што компаниите менуваат ресурси и имаат алтернативни форми на пристап до производи и услуги кои можат да ја зголемат ефикасноста на користењето на веќе готовите производи и со тоа да ја намалат побарувачката за ново производство. Во овој труд ги објаснуваме предностите на циркуларната економија во реверзното инженерство и адитивните технологии во текот на нивното користење во индустрискиот сектор, нивното влијание и ефикасноста на нивната имплементација. Овој труд ги анализира придобивките и препреките што ги има циркуларната економија при примена во реверзното инженерство и адитивните технологии.

Клучни зборови: циркуларна економија; реверзно инженерство; адитивни технологии; CAD; ефикасност

AIMS AND BACKGROUND

Sustainable aspects and clean technologies have begun to change in recent years and nowadays the investments in those directions are very high. The idea of incorporating the Circular Economy (CE) has continued to exist as a potential part of the review. The greatest interest is presented in improvement of production processes, field of energy reduction and the use of raw material.

The CE, by contrast is defined by Ellen MacArthur Foundation shown in Figure 1 as a definition of technical and a biological cycle, the so-called "butterfly" diagram illustrating how in a CE products are designed to enable "cycles of disassembly and reuse" and thus reducing or eliminating waste [1].

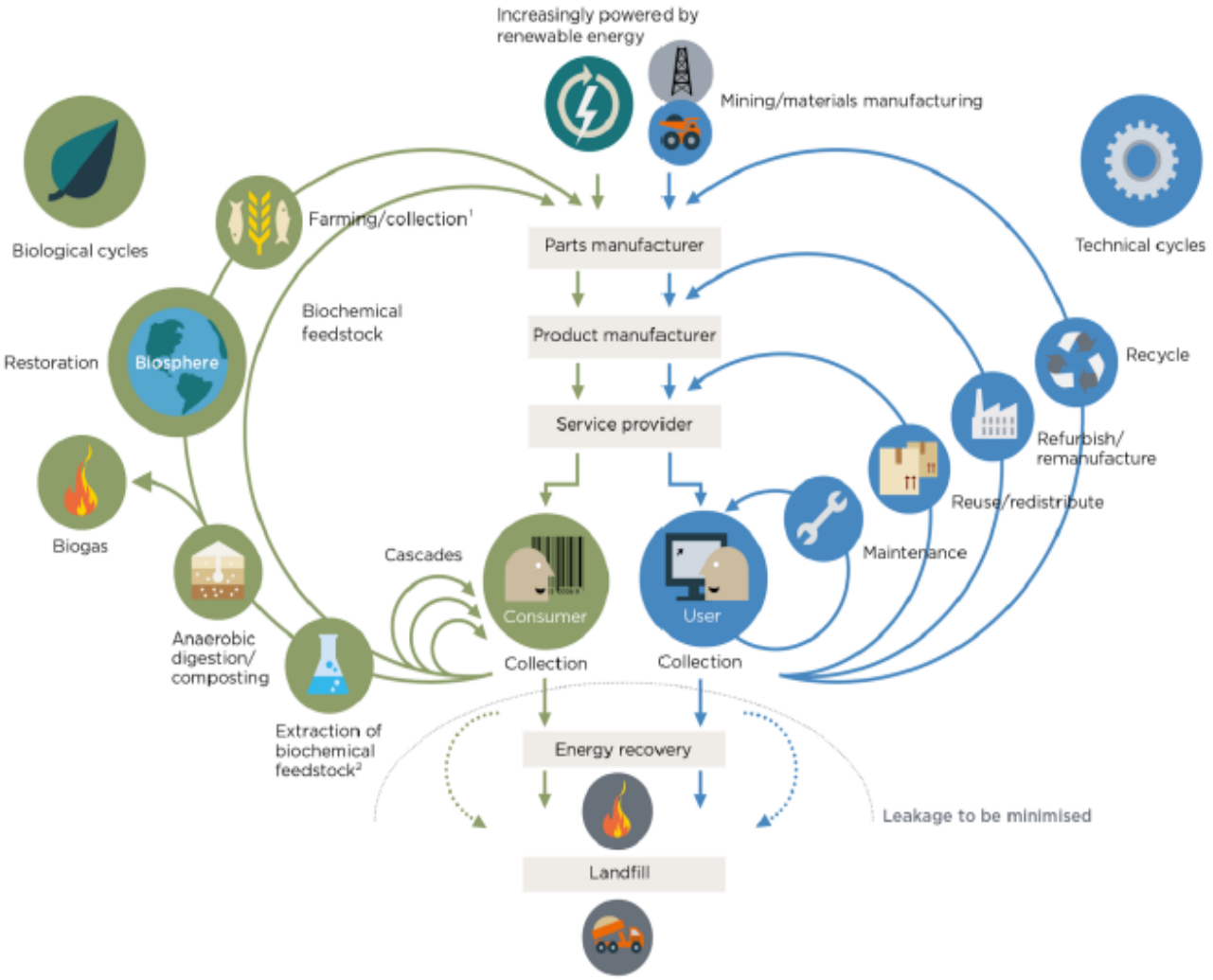

Fig. 1. Circular economy model (biological and technical) cycles [1]

The incorporation of the CE in the field of industry has begun to be an indication by enhancing the technical aspects especially with reverse engineering (from 3D scanning to 3D CAD model) to production technologies like additive manufacturing (FDM, SLS, etc.). Reverse engineering (RE) (Figure 2) is one of the methods which companies applied to accelerate their product evolution process and this method is desire for access to the technology with minimum cost, risk and time [2]. RE is no longer just about bringing old technology back to life, but it is also about using that technology as a launch pad into the future.

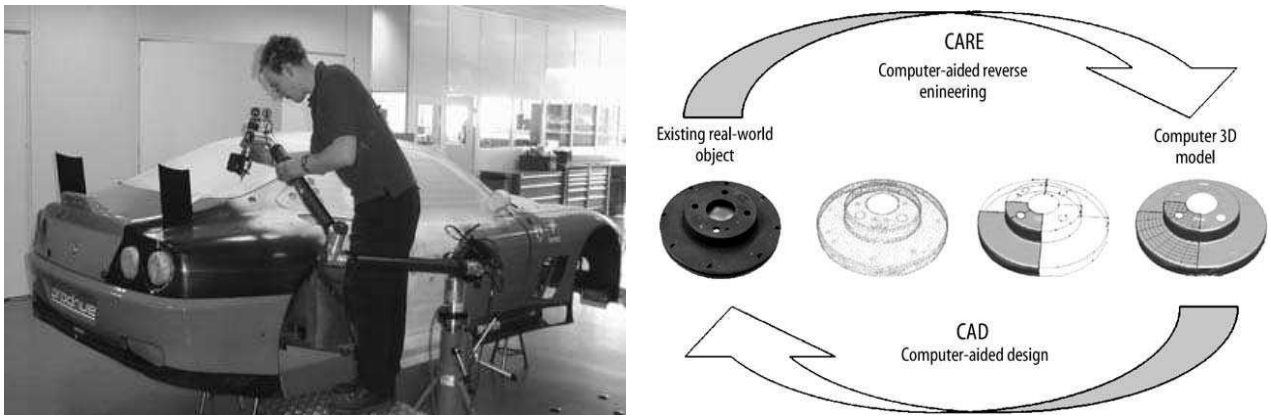

Fig. 2. 3D scanning and computer-aided reverse engineering (CARE) process [3]

Digitalization of production processes now reached very high in terms of interconnection lines between themselves. Additive technologies (AT) now are creating wholly new opportunities in design of complex structures, material selection, making products lighter, new product functions and new opportunities with lower cost production.

A digitally transferred product file and printing close to the user would move part of the logistics online, and enable the easy creation of channels inside places and systems.

In addition to providing new design possibilities, digital spare parts which are sold partly as a service rather than simply as a product involve local manufacturing units. This keeps manufacturing expertise close to users, over more dispersed areas.

The possibilities of digitalization, 3D CAD design and local production are highlighted by this transshipment. Likewise, the length of the product, the reliability and permissibility of the repaired products are in harmony with the principles of the CE.

IMPLEMENTATION OF CIRCULAR ECONOMY USING RE AND AT

The application “Circular Economy” as a concept requires collaboration between the companies, especially in the industry sector. Its interdisciplinary form provides the possibility of multi-factor interconnection between itself. In addition to collaboration, the need for companies to be in close proximity to one another in order to aid the implementation of the CE could lead to the formation of clusters, although waste exchange networks.

The complexity, new design mentality and the required collaboration make it important for organizations to apply systems thinking, which can also be referred to as systems theory to the CE and it good explaned in Figure 3 [5].

According to the Figure 4, we have analyzed in particular manufacturing sector integrated with different sectors with inside subsector like RE and AT and process of implementation in the CE.

RE techniques have been developed to convert point cloud data, obtained through digitization into CAD models either in STL format. These CAD models can be subsequently used for fabrication by using material incremental methods, AT. This relationship between RE and AT has many advantages over their integration into the CE. In this paper we explain four steps that are possibility to implement the Circular Economy using Reverse Engineering and Additive Technologies.

The first step gives positive indications for the possibility of shortening the time during dimensioning process of a part. Using 3D scanners enables to get data in a very fast and accurate way. At the same

time, improvements can be made while using the CAD model and send it for fast production with AT. This line can be circulated when we need to create closed loop system to check the produced part with 3D scanning and compare with original one.

The second step concerns the possibility of reducing the cost of production by having efficient use of the raw material. The efficiency of the various manufacturing processes shifting towards AT instead of the existing ones, dramatically reduces the loss of the raw material and the possibility of using different flexible designs gives excellent results for the production process in general as it presented in Figure 5 [7]. In metal additive manufacturing more than 95% of the unused powder can be locally filtered and reused directly, while the other 5% can be sent to a centralized recycling facility to produce virgin powder. Plastics like ABS, PLA and PET are recycled and the filament itself often has recycled content, ecocycle cube uses 25% recycled rPET in its cartridges and recyclebot produces filament from 100% householder polymer waste [8].

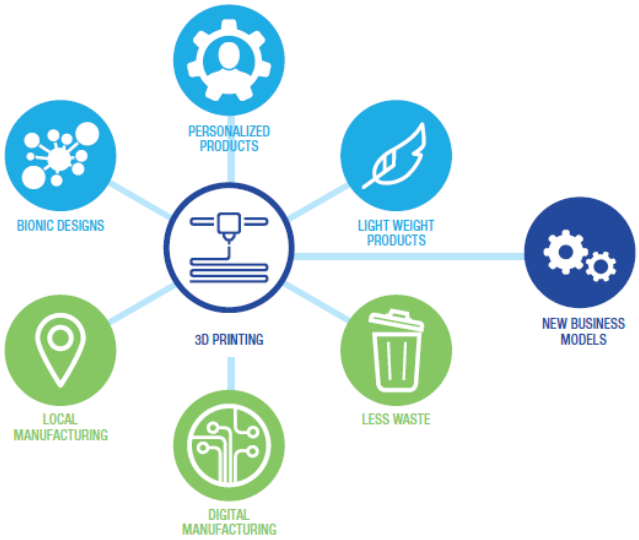

Fig. 3. 3D printing in circular economy [4]

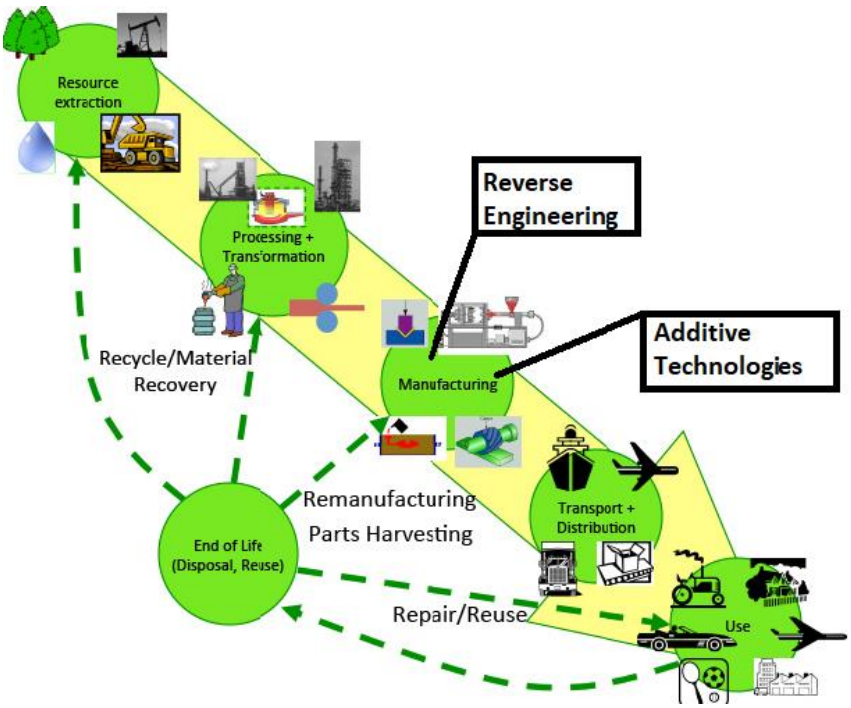

Fig. 4. Circularizing an economy using RE and AT [6]

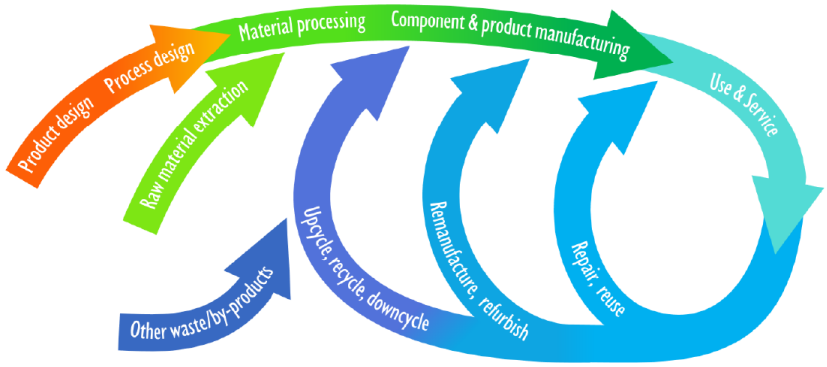

Fig. 5. The product and material life cycle [8]

The third step explains the improvement quality of product during using RE and AT. The digital scanning brings us the quality of any surface that we need to measure, especially industrial parts. When we have the model we can resurface and redesign according to technical requirements. The direct link from software to machine gives us the safe data, especially from credible CAD/AM software. Using the AT for executing the parts is very efficient and flexible for different complex shapes.

The fourth step explains the improvement of service to clients. Possibility to connect the requirements from different clients in online form using technics RE and AT. Digital cloud data will store the raw material, possibility of digitalization of measurements, 3D printed parts by online order. This will be the shorts line from costumer to manufacturer.

All of these four steps outlined above are related to aspects of the CE when attempts are made to create a functional concept. They are positive indications for relation presented in this paper.

CASE STUDY EXAMPLES

Case study 1: Kazzata [9]

The kazzata offer the manufacturer to keep inventory of spare parts only in digital form. This means no longer need to mass produce and store spare parts not knowing when or from which part of the globe and order will come. From now it's on, only 3D print the part on demand.

Scenario of use: When a customer enters web site, may enter 'Spare Parts' page and finds the spare part needed, order it and pay online and, in a short time will get the real spare part delivered. The spare part will be 3D printed via global network of specialized industrial grade 3D printing service bureaus. The one who will 3D print it will be the one closest to the customer. Ship the part to customer on behalf after quality control. Platform and technology carry out all the above mentioned activities in all their aspects.

The manufacturers are operating the "back office" of the platform, so have to upload a CAD file and all related data of the part itself. This includes information related to the material and the 3D printing technology needed.

This case study explain us the possibility of using the RE and AT for repair and remanufacturing and the step towards to the CE.

Case study 2: Fila-Cycle [10]

Research and development have taken place over several years and the company was formed in 2014 in recognition of the potential global impacts additive technologies will have on business and people.

Fila-Cycle focuses on material research and development, consultancy, impacts on businesses and the environment alike. Fila-Cycle brand specializes in 100% recycled plastic materials such as rABS, rHIPS, rPET, rPLA and rNylon filaments suitable for FDM/FFF 3D printing. In context of recycling there are some barriers about capacity for recycling. The capacity of current machines is around 30 kg/hour and it is not enough for application using in any AT. Also diversity of additive technologies makes some challenges for adapt the materials for each needed technology.

There are different parts that are remanufactured with recycled material that we can see in Figure 6.

Fig. 6. rPLA and rABS – 100% recycled [10]

Case study 3: "Standard Products" [11]

In "Standard Products" joints are 3D printed parts supported with RE to collect the data from model and to make CAD design. Those joints are to create furniture from wood (Figure 7). This project shows the ability of AT to combine design for standardization with design for adaptability.

Several standard designs are offered, but through the digital customization, joints can be adjusted to local standards or personal preferences.

Case study 4: Volvo [12]

Volvo cars is engaged in several remanufacturing activities for its vehicle parts, operated by Volvo Reman. One example is a worldwide system for remanufacturing diesel particle filters.

The logistics of an exchange system with central inventory in Maastricht is facilitated by different subcontractors and unites over 2500 Volvo car resellers, parts OEMs and Volvo car workshops. The responsible remanufacturer is UBD Cleantech in Höör Sweden, which is able to restore up to 95% of filters technical capacity. Remanufacturing of particle filters reduces the demand for virgin rare metals, which have significant environmental loadings and require large amounts of raw materials and energy. It also offers considerable economic gains for Volvo clients.

Although markets for new and remanufactured filters are separate, there strong demand for remanufactured filter due to their much lower price and performance identical to new particle filter. A small share of used filters is still not captured and is recycled by materials recyclers.

Fig. 7. The stool and three ways to production [11]

RESULTS AND DISCUSSION

The production phase of the CE starts with better product design using optimization and new ideas for design of the parts, possibility to include recycled materials that helps saving resources and in other way creating inventive for products that can be easily reused in different applications.

Already a large number of different materials have the potential to improve the output of the producer through the RE and AT relationship, and also with a cycle of use that are fully restorative.

According to the US Department of Energy, AT uses 50% less energy on average, and saves up to 90% on materials costs compared to traditional manufacturing [13] and this is indication of well incorporated with CE.

The improved production process and innovative industrial processes will be two crucial points of CE for investment in the future.

Industry will be crucial for transition to a Circular economy with implementation of reverse engineering and additive technologies. Many of companies now are investing on it.

CONCLUSIONS

RE and AT are changing the technology approach. These affect the production processes, manufacturing organization and all stakeholders.

The relation between RE and AT and other manufacturing technologies and systems, such as Industry 4.0, Internet of things and different materials are changing the whole picture of the industry.

The features that are RE and AT are very suitable for incorporation of the CE as a new opportunity for improvement of production processes and sustainable developments in the future.

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RECORD MANAGEMENT PROCEDURE FOR INSPECTION BODIES

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A b s t r a c t: Record management procedure for inspection bodies is covered, goal and purpose as scope and responsibilities. Description and authorities for records management as Direction for satisfying the requirements.

Key words: MKC EN ISO/IEC 17 020 : 2012 standard; inspection bodies; documents procedure; manager of using documents; record management

ПОСТАПКА ЗА УПРАВУВАЊЕ СО ЗАПИСИТЕ НА ИНСПЕКЦИСКИТЕ ТЕЛА

А п с т р а к т: Опишани се постапката за управување за инспекциските тела, целта и намерите, како и обемот и одговорностите. Опишани се овластувањата и е дадено упатство за задоволување на барањата и овластувањата за користење на документите.

Клучни зборови: стандард МКС EN ISO/IEC ISO 17 020: 2012; инспекциски тела; процедура за документи; начин на користење документи; управување со записи

INTRODUCTION

The management team and the staff are responsible for the continuous improvement of the record management process. Technical personnel, administrators and other staff in a company are part of the system and a cart without which it can not function properly.

Managed by quality manager and properly targeted and familiar with the system and record management contribute to meeting the goals that the company strives. Such objectives are not only related to the inspection activities, but also to safety, the code of conduct, monitoring the quality policy that the firm will elevate to a level other level with a recognizable quality mark of an accredited body.

MATERIALS AND METHODS

1. *Record management procedure for inspection bodies*

1.1. *Goal and purpose*

The purpose and goal of the record management procedure is to define the activities for keeping records as an objective evidence of quality assurance.

1.2. *Scope of application*

The record management procedure applies to the inspection body.

1.3. *Responsibilities and competencies*

The administrator is responsible and authorized for the implementation of the record management procedure

1.4. *Terms and abbreviations*

Record – A document describing the results.

Quality records – Records referring to quality.

1.5. *Description and authorities for records management*

The use of the procedures and instructions by the staff and the location in which it is responsible for execution is indicated in Table 1.

T a b l e 1

Description and authorities for records management

Activity	Description of activity	Records	Person in charge	Documentation regarding the record
External mail	Acceptance of the external mail	Letters Contracts Orders Offers	Administrator	Manual for archive operation Archive operation provision
Quality system	Recording the records of the quality system		Quality manager	
Record creation	Record creation	Record form	Quality manager	420001 Documents administration procedure
Implementation process records	Records registration		Employees	
Records distribution	The records are distributed to the people, they are addressed to the persons in charge of recording, analyzing and keeping of the record.		Head	Archive operation manual Archive operation provision OB 432 Distribution list
Archive	Archiving and ensuring keeping and damage protection in the defined term		Administrator	Archive operation manual Archive operation provision PO 431 Documents management procedure
Destruction	The person in charge performs a check. Destruction through record.		Head (State Archive Committee)	Record

Direction for satisfying the requirements

All documents are entered in the records that are objective evidence of the performed activity or the achieved results.

Quality records are all templates and reports prepared through the development, procurement, service, control, examination and quality system verification process.

The records contain details of a particular activity, product or service, including at least the following:

- record title;
- who prepared the record;
- date and place of preparation.

Any inconsistency is stated in the quality record.

The records are legible, easy to group and identify.

The company keeps records of the following areas:

- quality records;
- procurement records;
- training and verification records;
- records for the performed control

Keeping records

The records are legible, easy to group and identify. The records are kept in a place where they are accessible, protected from damage and loss. The places where the records are kept, the time period for storage and the person in charge are precisely defined. All specified time periods for storage are considered as minimal. The quality records and records for the production performance are given in each procedure. All of the documents are traceable, easy to use (Tables 2 – 9).

The accredited inspection bodies according to the ISO 17020: 2012 standard perform their procurements through companies that are listed in the list of suppliers. Suppliers through the entry Vendor Criteria are assessed according to prescribed criteria such as delivery time, quality of service, quality certificates held by them, price of the service and other values that are important for the inspection body. The three best-rated ones are taken into account, the best bid being chosen (Table 2).

In each inspection or verification it is important to inform the user according to which the Inspection is conducted. The data and information referring to the users are managed in accordance with the positive legal regulations and are of a confidential character (Table 3).

All relevant regulatory laws and regulations related to the work of inspection bodies as well as the ISO standard itself are kept in the classrooms as long as they are valid. With the entry into force of new laws, changes the quality manual and all other records related to that law or regulation (Table 4)

Table 2

Procurement records

No.	Record title	Storage place	Storage time	Person in charge
1	Letter	Archive	1 year	Administrator
2	Suppliers list	Archive	1 year	Administrator
3	Suppliers' offers	Archive	1 year	Administrator
4	Contract	Archive	5 years	Administrator

Table 3

Archive operation records

No.	Record title	Storage place	Storage time	Person in charge
1	Archive register /request for inspection / verification	Archive	Pursuant to the regulation for office and archive operations	Administrator
2	Business communication documentation (letters, contracts etc.)	Archive	Pursuant to the regulation for office and archive operations	Administrator

Table 4

Laws

No.	Record title	Storage place	Storage time	Person in charge
1	Laws register	Archive	Until they are valid	Administrator

The plan for supervision and maintenance plan of the equipment is done once a year mostly at the end of the calendar year in order to start the new with the already laid out plan. The training phases in which the inspectors are located also enters the annual planning. Annually, the management's assessment and supervision of how well planned activities have been successfully made (Table 5)

The quality manager is responsible for the quality manual. The organizational structure is described in the manual, whereby the manager must have a direct link with the head of the inspection body.

Feedback and corrective measures are an important factor in getting users' feedback and tool where the firm should be improved (Table 6)..

Table 5

Plans

No.	Record title	Storage place	Storage time	Person in charge
1	Report on plans materialization	Archive	3 years	Administrator
2	Plan on maintenance	Archive	3 years	Administrator

Table 6

Quality records

No.	Record title	Storage place	Storage time	Person in charge
1	Decisions	Quality manager	Permanently	Quality manager
2	Systematization and organization of the job positions	Quality manager	Permanently	Quality manager
3	Report on the results of the assessment of the users' satisfaction	Quality manager	2 years	Quality manager
4	Questionnaire	Quality manager	2 years	Quality manager
5	Report of surveys	Quality manager	2 years	Quality manager
6	Assessment of the re-examination of the quality system	Quality manager	3 years	Quality manager

The complete equipment used for inspection is certified by accredited laboratories. In the process of inspection, the already prescribed process of safety at work must be followed by the inspectors (Tabe 7).

Continuous upgrading of inspectors on a technical plan and monitoring recent trends is an important part of the quality policy for the inspection body. It directly affects the quality of the service for which the inspection body strives to be on the highest level.

The training is performed with certified bodies or bodies recommended by the device manufacturer (Table 8).

The financial arrangement may be granted to outsourcing company or to a department of the inspection body in charge of it. If the inspection body has its own department, the administrators are responsible for monitoring the latest valid rules and laws according to financial performances (Table 9).

Table 7

Verification/inspection records

No.	Record title	Storage place	Storage time	Person in charge
1	Minutes for overtaking the equipment	Archive	5 years	Administrator
2	Measurement cards of the equipment	Archive	5 years	Administrator
3	Minutes for the equipment check	Archive	5 years	Administrator
4	List of equipment	Archive	5 years	Administrator
5	Minutes for calibration	Archive	1 year	Administrator
6	Minutes of the handing over	Archive	3 years	Administrator

Table 8

Training and assessment records

No.	Record title	Storage place	Storage time	Person in charge
1	Certificates for seminars and professional improvement	Archive /record for each employee	Permanently	Archive

Table 9

Financial operation records

No.	Record title	Storage place	Storage time	Person in charge
1	Orders for business trips	Archive	Within the legal time limit	Administrator
2	Calculations for business trip	Archive	Within the legal time limit	Administrator
3	Invoice	Archive	Within the legal time limit	Administrator
4	Receipt note	Archive	Within the legal time limit	Administrator

1.6. *Reference documents*

Documents implemented in the procedure:

- MKS EN ISO / IEC 17020: 2012;
- Quality Manual.

1.7. *Appendixes*

Instructions and provision for archive operations.

EXPECTED RESULTS

Having the experience of the past, and the implemented position of the company as an accredited inspection body for analogue and digital tachographs, one of the factors that bounce on the accredited bodies is access to information. The simple yet efficient system, makes the flow of information fluid and easy to manage and understandable. Such an implemented system is fully processed from the highest to the executive level and is the framework around which the company gravitates and exists.

The archiving of objects and services performed later through the annual analyses and assessments of the management give a clear picture of the position and direction of the company's movement. Feedback and corrective measures undertaken are crucial for the future of the company that builds the external image through these standardized forms and the perception of the client towards the company itself.

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Original scientific paper

KINEMATIC MODEL ANALYSIS OF A PARALLEL MANIPULATOR WITH SIX AND THREE DEGREES OF FREEDOM

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A b s t r a c t: Model analysis of mechanism with parallel structure with revolute kinematic pairs by six and three degrees of freedom is presented. An analytical method for solving the direct kinematics is analyzed by using analytic equations of the plane in which the movable platform of the manipulator is placed. The obtained solutions cannot be physically realized from a constructive aspect, therefore a method is proposed by simulation modelling in Matlab/Simulink and SolidWorks where certain constrains can be made. Respectively, this apples to the angles of rotation of kinematic revolute pairs and changes in certain dimensions, specifically the kinematics and also following the operation functionalities of the manipulator in 3D workspace. Additionally, as well through conducted PID control, the related difficulties in the analytical solution of nonlinear equations can be overcome.

Key words: manipulator; parallel structure; direct kinematics; mechanism; platform parallel structure

КИНЕМАТСКИ МОДЕЛ НА АНАЛИЗА НА ПАРАЛЕЛЕН МАНИПУЛАТОР СО ШЕСТ И СО ТРИ СТЕПЕНИ НА СЛОБОДА

А п с т р а к т: Во трудот се анализира модел на просторни механизми со паралелна структура со ротирни кинематски парови со шест и три степени на слобода. Анализиран е аналитички метод за решавање на директната кинематика со користење на аналитичките равенки на рамнината во која лежи подвижната платформа на манипулаторот. Решенијата кои со тоа се добиваат не можат коректно физички да се реализираат од конструктивен аспект, затоа е предложен метод со формирање на имитационен (симулациски) модел во Matlab/Simulink и SolidWorks. Соодветно, може да се направат одредени ограничувања во ротациите на зглобовите и менување на одредени димензии односно на кинематиката и функционално следење на работата на манипулаторот во 3Д работен простор. Дополнително е прикажано управување со ПИД контролен закон, начин на кој би се избегнале тешкотиите при аналитичкото решавање на нелинеарните равенки.

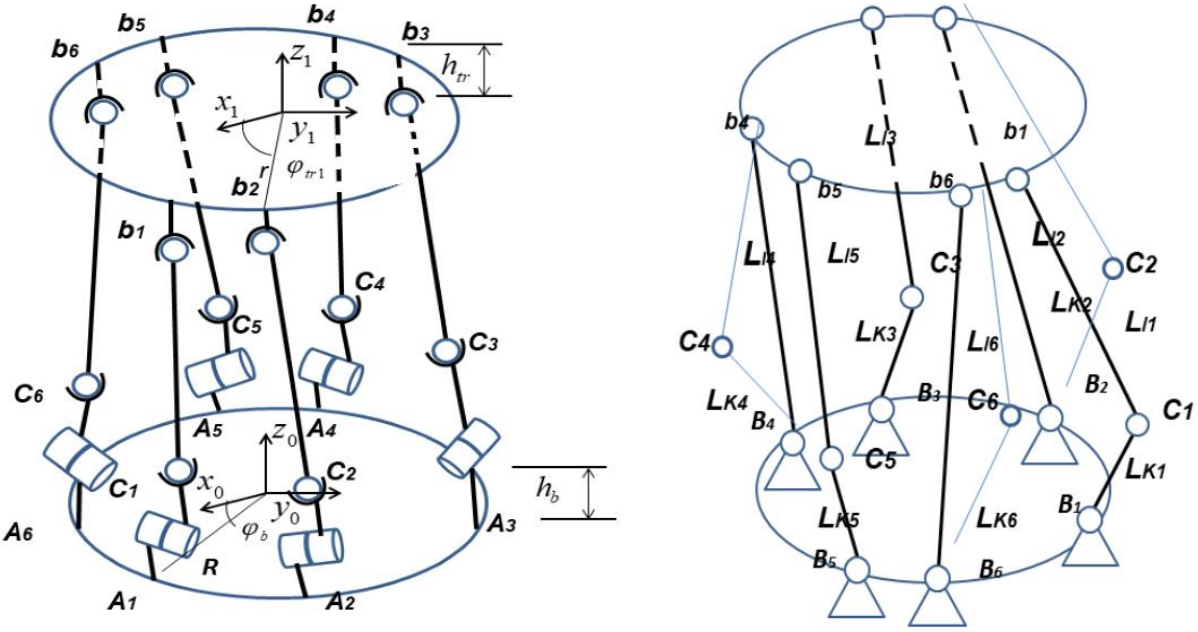
Клучни зборови: манипулатор; паралелна структура; директна кинематика; механизам; платформа на паралелна структура

INTRODUCTION

It is well known that compared with traditional serial mechanisms, parallel mechanisms have potential advantages: high rigidity, evenly distributed effect of forces through all the construction, accuracy of positioning of the manipulator platform, higher loads, possible velocity and acceleration of the platform, etc. However, some disadvantages of the parallel structure such as small workspace and complex forward kinematics also limit their applications.

Some dynamics problems of parallel mechanisms are about the over-determinate inputs. In practice, there are many machines that work with over-determinate input, i.e. their input-number is much bigger than their mobility number. How to set the inputs to be accordance and optimum distribute and to obtain the expectant motion acceleration is a challenge [1].

Answering direct kinematics is an important stage in exploring mechanisms with a parallel structure and the same time is necessary for determining of the work space and motion modelling. Two things need to take in account when direct (forward) kinematic problems are solving, difficult to calculate and obtaining nonunique solutions [2]. Therefore, in following is present a teachings in terms of analytical solution direct kinematics of parallel manipulators and model analysis by Matlab/Simulink and SolidWorks programming packages. For analytical approach of direct kinematics, parallel manipulators with six (Figure 1a) and three degrees of freedom (Figure 1b) are considered.



a) b)

Fig. 1. Parallel manipulators: a) six and b) three degrees of freedom

METHODS FOR SOLVING FORWARD KINEMATICS

Forward kinematics can be defined as finding the position and orientation of the mobile platform for known generalized coordinates. The position and orientation of the mobile platform can be represented in the form of a homogeneous matrix *T*.

$$T = \begin{bmatrix} R(\alpha,\beta,\gamma) & p(x,y,z) \\ 0 & 1 \end{bmatrix}, \qquad (1)$$

where $R(\alpha, \beta, \gamma)$ is the rotational matrix (3×3) with function of Euler angles, $p(x, y, z)$ is displacement vector (3×1) and 0 is zero vector (1×3).

Solving forward kinematics of parallel robots is a highly difficult problem, and up to date, no method has been found to obtain a precise unique analytical solution of direct kinematics. Nowadays, the most common used method is the equation assembling of connections by which is describe the distances between the points of the stationary and the movable platform or some other points [3]. This method does not lead to solving 18 nonlinear terms, which it is quite difficult. Three virtual points [4] will be introduced to reduce the number of steps on the upper mobile platform, by which the coordinates of the kinematics pairs of the mobile platform are defined.

Mobile platform with three virtual points V_{T1}, V_{T2} and V_{T3} is given in Figure 2, also shows the moving kinematic pairs in points b_1, b_2, b_3, b_4, b_5 and b_6 in case for six legs and angle between pairs is given by φ_b. Virtual points V_{T1}, V_{T2} and V_{T3} make an equilateral triangle, from where it can be analytically determined the surface on which is placed the kinematic pairs of the movable platform, and then the coordinates of the position of kinematic pairs on the mobile platform are expressed with the coordinates of the virtual points V_{T1}, V_{T2} and V_{T3} for case of parallel manipulator with six (Figure 1a) and three (Figure 1b) degrees of freedom.

$$
\begin{aligned}
b_1 &= \left[x_{V_{T1}} + K(x_{V_{T3}} - x_{V_{T1}})\, y_{V_{T1}} + K(y_{V_{T3}} - y_{V_{T1}})\, z_{V_{T1}} + K(z_{V_{T3}} - z_{V_{T1}})\right]^T \\
b_2 &= \left[x_{V_{T2}} + K(x_{V_{T2}} - x_{V_{T1}})\, y_{V_{T1}} + K(y_{V_{T2}} - y_{V_{T1}})\, z_{V_{T1}} + K(z_{V_{T2}} - z_{V_{T1}})\right]^T \\
b_3 &= \left[x_{V_{T2}} + K(x_{V_{T1}} - x_{V_{T2}})\, y_{V_{T2}} + K(y_{V_{T1}} - y_{V_{T2}})\, z_{V_{T2}} + K(z_{V_{T1}} - z_{V_{T2}})\right]^T \\
b_5 &= \left[x_{V_{T2}} + K(x_{V_{T2}} - x_{V_{T3}})\, y_{V_{T3}} + K(y_{V_{T2}} - y_{V_{T3}})\, z_{V_{T3}} + K(z_{V_{T2}} - z_{V_{T3}})\right]^T \\
b_6 &= \left[x_{V_{T2}} + K(x_{V_{T2}} - x_{V_{T3}})\, y_{V_{T2}} + K(y_{V_{T1}} - y_{V_{T3}})\, z_{V_{T3}} + K(z_{V_{T1}} - z_{V_{T2}})\right]^T
\end{aligned}
\tag{2}
$$

where

$$
K = \frac{r \sin\left[\dfrac{\varphi_b}{2}\right]}{2r \sin\left[\dfrac{\varphi_b}{2}\right] + r \sin\left[60^\circ - \dfrac{\varphi_b}{2}\right]} \tag{3}
$$

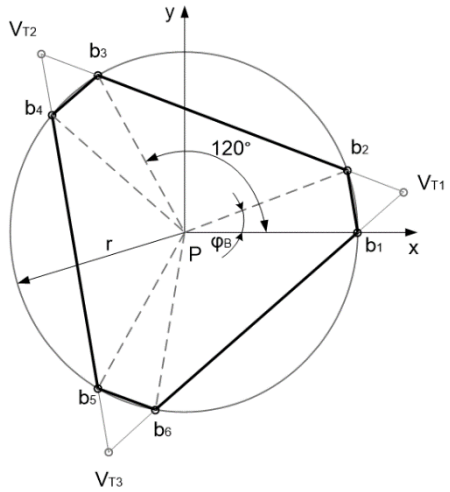


Fig. 2. Virtual points on the upper-moving platform

From obtained ratios, the matrix of the homogeneous coordinates of the joints of the platform is defined.

$$
D = \begin{bmatrix} b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \tag{4}
$$

To determine the coordinates of the points (coordinates of rotary kinematic pairs), as far as they are in the legs (Figure 1a [5] and Figure 1b [6]), rotational matrices are used. A case of a parallel manipulator with six degrees of freedom is presented in [5] and [6]. A parallel structure is analyzed where the legs are performed as a knee-lever mechanism with three degrees of freedom. The analysis gives the procedure for formation of the rotational matrices whose members are expressed by the rotational variable coordinate around the axis *Oz*. For case of parallel manipulator with three degrees of freedom (Figure 1b) follows:

$$
\begin{aligned}
C_1 &= \left[R L_k \sin(\alpha_1) \quad L_k \cos(\alpha_1)\right]^T \\
C_3 &= R_Z \left[R L_k \sin(\alpha_3) \quad L_k \cos(\alpha_3)\right] \\
C_5 &= R_Z R_Z \left[R L_k \sin(\alpha_5) \quad L_k \cos(\alpha_5)\right]^T
\end{aligned}
\tag{5}
$$

where

$$
R_Z = \begin{bmatrix} \cos(120°) & -\sin(120°) & 0 \\ \sin(120°) & \cos(120°) & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{6}
$$

and α_i is angles of rotation of the kinematic pairs C_i relative to the O_z axis.

For case of parallel manipulator with six degrees of freedom (Figure 1a) follows:

$$
C_i = T_{ROT}(\psi_i) C_0 \tag{7}
$$

$$
T_{ROT}(\psi_i) = \begin{bmatrix} \cos(\psi_i) & -\sin(\psi_i) & 0 & 0 \\ \sin(\psi_i) & \cos(\psi_i) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{8}
$$

$$
C_0 = \begin{bmatrix} R - l_1 \sin(\theta_i) \\ 0 \\ h_b + R\cos(\theta_i) \\ 1 \end{bmatrix} \tag{9}
$$

where θ_i is angle between A_iC_i and the normal to the base, ψ_i is angular coordinate of the i input kinematic pair, h_b and h_{tr} are distances of the kinematic pairs from the static platform and the upper movable platform, respectively shown in Figure 1a, and also:

$$
\begin{aligned}
&\psi_1 = \varphi_b, \quad \psi_2 = \frac{2\pi}{3} - \varphi_b, \quad \psi_3 = \frac{2\pi}{3} + \varphi_b, \\
&\psi_4 = \frac{4\pi}{3} - \varphi_b, \quad \psi_5 = \frac{4\pi}{3} + \varphi_B, \quad \psi_6 = -\varphi_b
\end{aligned}
\tag{10}
$$

$$
l_1 = A_i C_i \tag{11}
$$

The next step is to assemble a system of equations in which the unknown coordinates x_{VT1}, y_{VT1}, z_{VT1}, x_{VT2}, y_{VT2}, z_{VT2}, x_{VT3}, y_{VT3} and z_{VT3} with nine equations are expressed through the lengths of the sides of the equilateral triangle and the lengths of the legs. For case of parallel manipulator with three degrees of freedom (Figure 1b) follows:

$$\begin{aligned}
&\left[(x_{V_{T1}}-x_{V_{T2}})^2+(y_{V_{T1}}-y_{V_{T2}})^2+(z_{V_{T1}}-z_{V_{T2}})^2\right]=V^2\\
&\left[(x_{V_{T2}}-x_{V_{T3}})^2+(y_{V_{T2}}-y_{V_{T3}})^2+(z_{V_{T2}}-z_{V_{T3}})^2\right]=V^2\\
&\left[(x_{V_{T3}}-x_{V_{T1}})^2+(y_{V_{T3}}-y_{V_{T1}})^2+(z_{V_{T3}}-z_{V_{T1}})^2\right]=V^2\\
&(X_{b1}-X_{C1})^2+(Y_{b1}-Y_{C1})^2+(Z_{b1}-Z_{C1})^2=L_l^2\\
&(X_{b2}-X_{C2})^2+(Y_{b2}-Y_{C2})^2+(Z_{b2}-Z_{C2})^2=L_l^2\\
&(X_{b3}-X_{C3})^2+(Y_{b3}-Y_{C3})^2+(Z_{b3}-Z_{C3})^2=L_l^2\\
&(X_{b4}-X_{C4})^2+(Y_{b4}-Y_{C4})^2+(Z_{b5}-Z_{C5})^2=L_l^2\\
&(X_{b5}-X_{C5})^2+(Y_{b5}-Y_{C5})^2+(Z_{b5}-Z_{C5})^2=L_l^2\\
&(X_{b6}-X_{C6})^2+(Y_{b6}-Y_{C6})^2+(Z_{b6}-Z_{C6})^2=L_l^2
\end{aligned} \tag{12}$$

For case of parallel manipulator with six degrees of freedom (Figure 1a) follows:

$$\begin{aligned}
&\left[(x_{V_{T1}}-x_{V_{T2}})^2+(y_{V_{T1}}-y_{V_{T2}})^2+(z_{V_{T1}}-z_{V_{T2}})^2\right]=V^2\\
&\left[(x_{V_{T2}}-x_{V_{T3}})^2+(y_{V_{T2}}-y_{V_{T3}})^2+(z_{V_{T2}}-z_{V_{T3}})^2\right]=V^2\\
&\left[(x_{V_{T3}}-x_{V_{T1}})^2+(y_{V_{T3}}-y_{V_{T1}})^2+(z_{V_{T3}}-z_{V_{T1}})^2\right]=V^2\\
&(D_1-C_1)^2+(D_1-C_2)^2+(D_1-C_3)^2=L^2\\
&(D_1-C_1)^2+(D_1-C_2)^2+(D_1-C_3)^2=L^2\\
&(D_2-C_1)^2+(D_2-C_2)^2+(D_2-C_3)^2=L^2\\
&(D_3-C_1)^2+(D_3-C_2)^2+(D_3-C_3)^2=L^2\\
&(D_4-C_1)^2+(D_4-C_2)^2+(D_4-C_3)^2=L^2\\
&(D_5-C_1)^2+(D_5-C_2)^2+(D_5-C_3)^2=L^2\\
&(D_6-C_1)^2+(D_6-C_2)^2+(D_6-C_3)^2=L^2
\end{aligned} \tag{13}$$

where,

$$L = b_i C_i,\ L_l = b_i C_i,$$

and

$$V = V_{T1}V_{T2} = V_{T2}V_{T3} = V_{T1}V_{T3}$$

are sides of the equilateral triangle.

By solving equations (12) and (13) the coordinates of the virtual points are obtained by which can be determine the coordinates of the center of the movable upper platform $p(x_p, y_p, z_p)$. Then the directional cosines of O_x, O_y and O_z axes are defined and through this the matrix is assemble which determines the position and orientation of the upper floating platform in the space. Through this procedure, the direct kinematics of the parallel manipulators in a matrix form is solved.

$$Tr=\begin{bmatrix}
\cos\alpha_{ox} & \cos\alpha_{oy} & \cos\alpha_{oz} & x_p\\
\cos\beta_{ox} & \cos\beta_{oy} & \cos\beta_{oz} & y_p\\
\cos\gamma_{ox} & \cos\gamma_{oy} & \cos\beta_{oz} & z_p\\
0 & 0 & 0 & 1
\end{bmatrix} \tag{14}$$

It has been proved by calculation that the system of equations (12) and (13) has 40 different solutions, which is confirmed by the research [5], [7] and [8]. The calculations have shown that some of the solutions are real and partly complex and depend on the system parameters and the initial conditions. From the model analysis of the manipulator it can be concluded that the choice of generalized coordinates does not provide a uniquely determined position of the mobile platform without considering the conditions of the connections, linear and angular velocities, which is also contained in the paper [3]. Consequently some constraints on the parameters should be made for example limiting the angles of rotation of the joints proposed in [6]. Therefore, in following a simulation model is presented and these constraints can be introduced in 3D working space and examine it functionally by observing the movements of the mobile platform or its centre. Considering a case for parallel robot with six degrees of freedom whose legs are knee-lobe and by knowing the matrix T_r that define position and orientation of the platform, consequently the position of the knee driven by the servo-motor can obtained, that is the angle of rotation α_i. The knee-lever mechanism lies in one plane (Figure 3) and knee and lever have constant length, the following equations can be set:

$$\left(X_{Ci}-X_{Bi}\right)^2+\left(Y_{Ci}-Y_{Bi}\right)^2+\left(Z_{Ci}-Z_{Bi}\right)^2=L_l \tag{15}$$

$$\left(X_{bi}-X_{Ci}\right)^2+\left(Y_{bi}-Y_{Ci}\right)^2+\left(Z_{bi}-Z_{Ci}\right)^2=L_k \tag{16}$$

$$X_{Bi}\left(X_{Ci}-X_{Bi}\right)^2+Y_{Bi}\left(Y_{Ci}-Y_{Bi}\right)^2+Z_{Bi}\left(Z_{Ci}-Z_{Bi}\right)^2=0_l \tag{17}$$

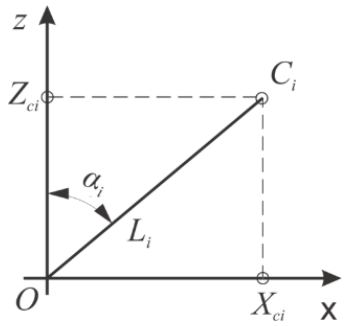


Fig. 3. Knee L_k in the ZOX plane

Knowing the coordinates of C_i, the angle of rotation α_i can determine with the following expressions:

$$\begin{aligned}
\alpha_1 &= \arccos\left(\frac{Z_{C1}}{L_{kp}}\right),\\
\alpha_2 &= \arccos\left(\frac{Z_{C2}}{L_{kp}}\right),\\
\alpha_3 &= \arccos\left(\frac{Z_{C3}}{L_{kp}}\right)\\
\alpha_4 &= \arccos\left(\frac{Z_{C4}}{L_{kp}}\right),\\
\alpha_5 &= \arccos\left(\frac{Z_{C5}}{L_{kp}}\right),\\
\alpha_6 &= \arccos\left(\frac{Z_{C6}}{L_{kp}}\right)
\end{aligned} \tag{18}$$

Modelling and simulation of manipulator with six legs knee-lever type

In order to explore the kinematics of the parallel manipulator, as case study is manipulator with parallel structure as shown in Figure 4 above, with following parameters: l_l = 0.7 m, l_k= 0.35 m for time t = 2 s.

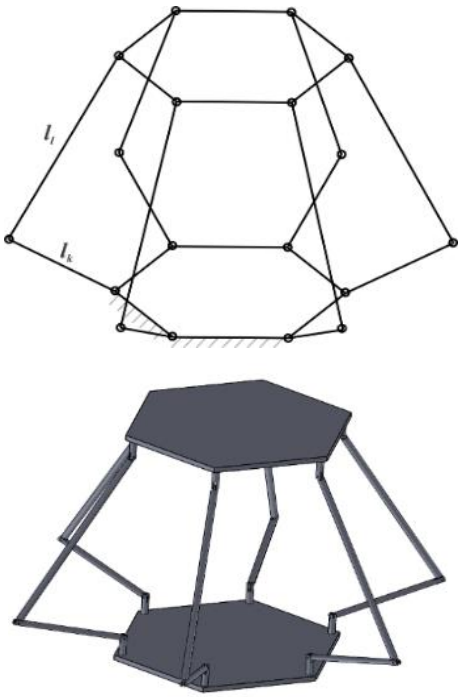


Fig. 4. Manipulator with parallel structure (above) and parallel manipulator constructed in SolidWorks (below)

Parallel robot manipulator in 2D working environment

Figure 5 presents a simulation model from which can be determine the dynamic characteristics, as displacements, velocity and acceleration of the joints and members of the parallel robot manipulator in the 2D environment for the given movements of the knees.

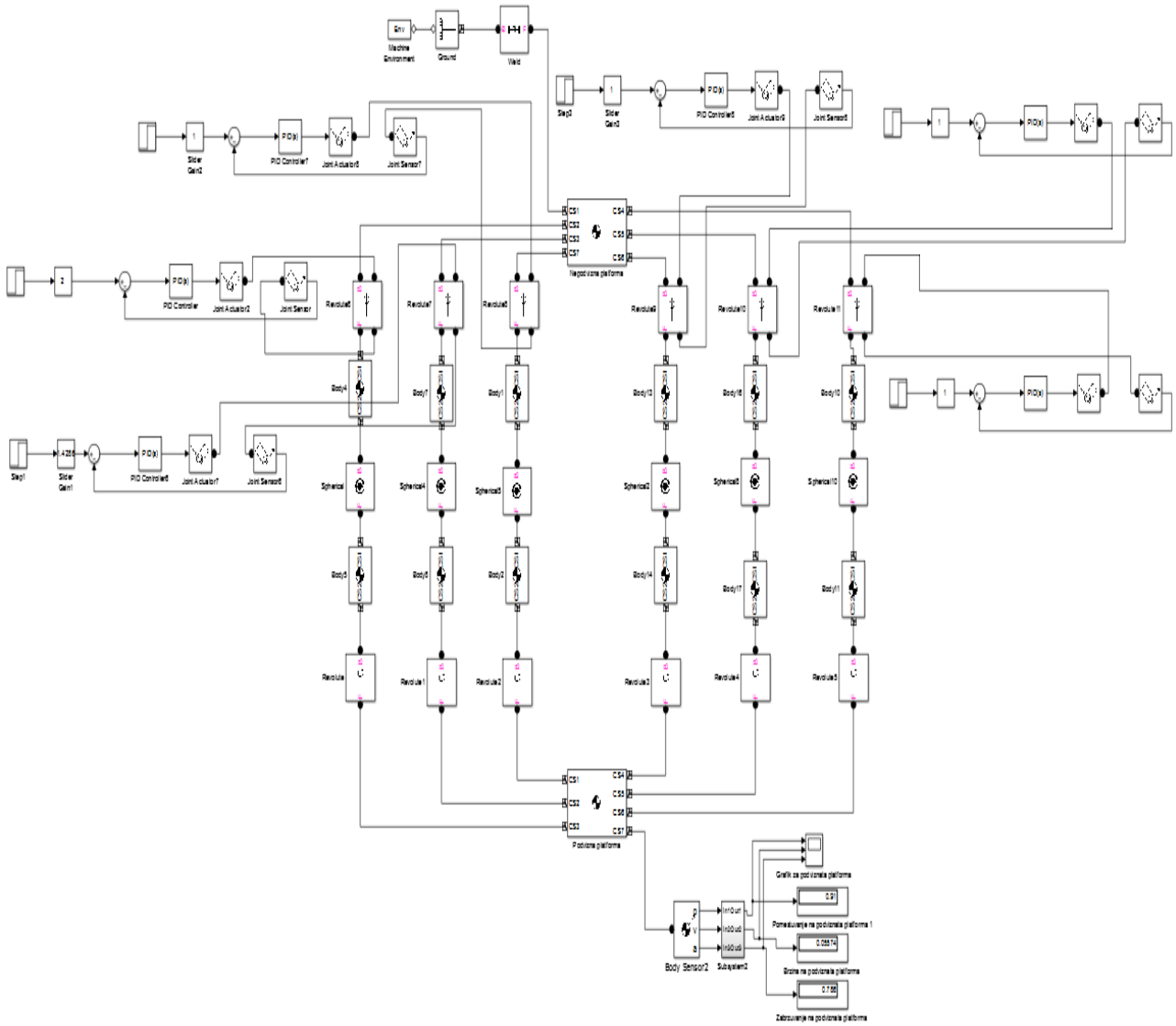


Fig. 5. Parallel manipulator with six legs

The diagram in Figure 6 gives the curves of displacement, velocity and acceleration of the center of gravity of the mobile platform, where the first curve represents the displacement, the second is velocity variation and the third curve refers to the acceleration.

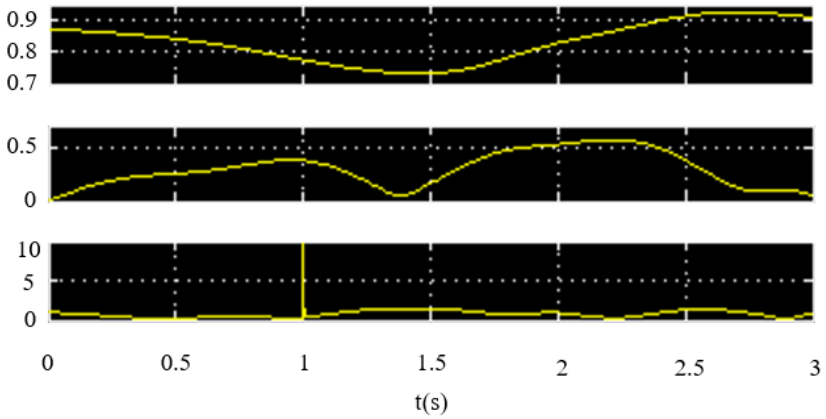


Fig. 6. Curves of displacement, velocity and acceleration of the center of the mobile platform

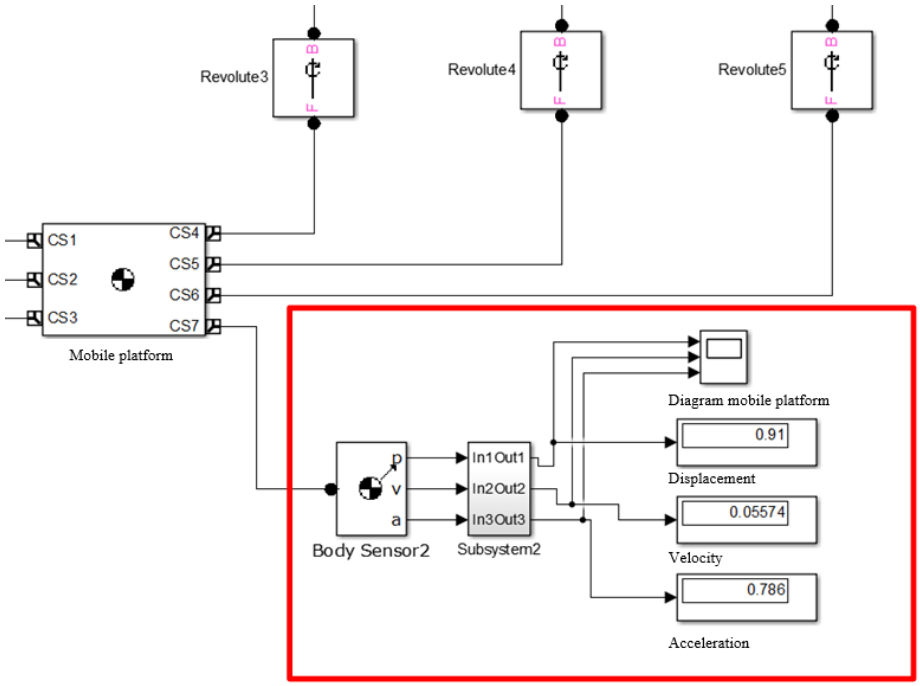


Fig. 7. View of the blocks for calculating the displacement, velocity and acceleration of the mobile platform

Parallel robot manipulator in 3D working environment

In the software 3D CAD package SolidWorks, the parallel manipulator is constructed through the appropriate tools. Individually construct all its parts and with appropriate functions the connection is carried out to eventually function. In our case, we have six knee-lever legs through which the mobile (upper) platform is shown in Figure 4 below. After finishing the construction of the parallel manipulator with six knee-lever legs in SolidWorks, by using the Simscape Multibody Link tool saved file is export from SolidWorks to Matlab Simulink. After the proper input of the already saved SolidWorks file and its activation in Matlab Simulink, the model of the parallel manipulator is created in Matlab Simulink (Figure 8).

Each leg has a PID control that manages its movement and Figure 9 presents PID control for one leg.

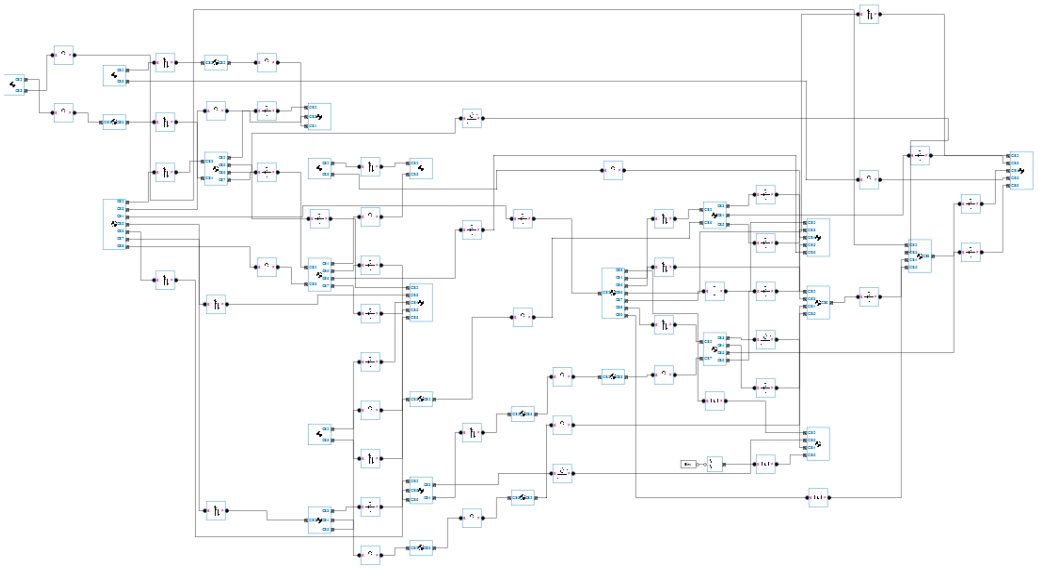


Fig. 8. Simulation model of a parallel manipulator obtained by transferring the file from SolidWorks to Matlab Simulink

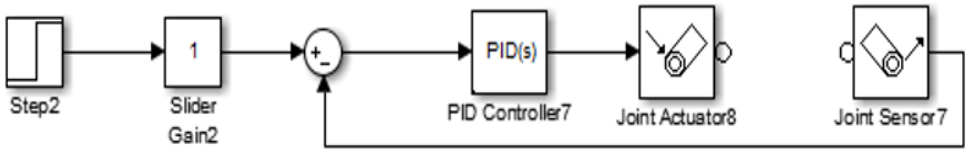


Fig. 9. View the blocks that constitute the PID control

CONCLUSION

It has been proved by the presented analysis and calculation that the system of equations (12) and (13) can have up to 40 different solutions, which is proven also by the research in [7] and [8]. Previous researches have shown that part of the solutions are real or complex and depend on the parameters of the system and the initial conditions.

From the simulated model of parallel manipulator, it can be concluded that the choice of the generalized coordinate does not provide a unique determined position on the mobile platform without taking into account the conditions of the kinematic joints, linear and the angular velocities. Generally, some parameters need to be constrained, in [6] it is proposed to limit the angles of rotation of kinematic revolute pairs, therefore in the presented analysis the solution of direct kinematics is through simulation model where constraints are added. Furthermore, in the 3D work space can be observed the movements of the mobile platform, respectively the functionality of the manipulator. The model also allows to control the movement of each leg of the manipulator. Additionally, as well through conducted PID control, related difficulties in the analytical solution of nonlinear equations (12) and (13) can be overcome.

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DESIGN FOR BETTER LIFE QUALITY AND MENTAL HEALTH

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A b s t r a c t: In this paper, a research process for obtaining a creative solution which will help for the general improvement of people's mental health is presented. This goal is achieved by following the design thinking methodology. Theoretical analysis on the subject "positive design" and detailed interdisciplinary research and application of modern methods and principles in the field of industrial design were performed. In addition, this paper contains the following ethnographic methods: observation of the target group, collecting photo-materials, analysis of different situations, informative polls, and analysis and systematization of data. As a result, an innovative, urban pavilion was designed, a pavilion which would reduce the stress and alleviate everyday life of the residents of the modern cities. With this done, the need for increasing awareness about the significance of positive design and social designing the modern lifestyle was promoted, since it can be used as a tool to improve general wellbeing and society advancement.

Key words: mental health; design thinking; ethnography; pavilion; urban design

ДИЗАЈН ЗА ПОДОБАР КВАЛИТЕТ НА ЖИВЕЕЊЕ И МЕНТАЛНО ЗДРАВЈЕ

А п с т р а к т: Во овој труд е презентиран спроведениот истражувачки процес за добивање креативно решение кое ќе помогне за генерално подобрување на менталното здравје. Целта е постигната преку следење на методологијата „дизајнерско размислување". Направени се теоретска анализа на тема „позитивен дизајн" и детално интердисциплинарно истражување и апликација на модерни методи и принципи на полето на индустриски дизајн. Дополнително, овој труд ги содржи и следниве етнографски методи: набљудување на таргет-група, собирање на фотоматеријали, анализа на различни ситуации, информативно анкетирање, како и анализа и систематизација на податоците. Како резултат на истражувањето е дизајниран иновативен урбан павилјон кој би го намалил секојдневниот стрес и би го олеснил животот на граѓаните во модерните градови. Преку овој дизајн е нагласена потребата од подигање на свеста за значењето на позитивниот дизајн и социјалниот дизајн во модерните општества, бидејќи тој може да се користи како алатка за подобрување на општата благосостојба и напредок на општеството.

Клучни зборови: ментално здравје; дизајнерско размислување; етнографија; павилјон; урбан дизајн

1. INTRODUCTION

In this paper, emphasis is placed on designing for positive emotions in terms of improving the way people live and having a positive impact on their mental health. Lately, a number of factors in people's everyday life have begun to trigger a rapid stress growth that results with a block in the quality of work and social activities, as well as the emergence of different degrees of mental health disorders. These risk factors include: increasing work hours, lack of free time, lack of engagement in stress-relief activities, hectic way of life in cities, dynamic every day habits, etc. Therefore, a commonly raised question is: how to help people avoid, or at least reduce, the negative impacts that modern communities have on them. This is especially important because happy people contribute more to the development of societies.

Today, when more than half of the worlds' population lives in cities, urban design has an exciting potential in terms of positive influence on citizens.

Having this said, from a designer perspective, this issue is addressed by following the design thinking methodology. In this paper, research was conducted to gain insight into the emotions and behaviors of citizens in order to pinpoint their most important needs. Serious analysis of the emotional and mental connection between users and their surroundings helped to generate an idea for a solution to this very complex challenge – improving the general wellbeing and increasing positive moods and mental health.

The design thinking process took place as follows:

Table 1

Description of the design thinking process

EMPATHIZE	• Detail studying of the main causes of stress, negative moods, unproductiveness and depressive thoughts. • Studying of the impact of urban design on the moods and behaviors of citizens. • Ethnographic research: ➢ independent observation, ➢ quantitative examination in a structural form.
DEFINE	• Analysis and systematization of data – pinpointing an exact way in which the issue can be solved. • Analysis of existing forms of solutions to the same or similar issues. • Idea – establishing hypothesis. • Defining designer goals that the design (solution) needs to meet.
IDEATE	• Gathering inspiration (positive design, natural systems, eco design, ergonomics, etc.) • Generating concepts. • Grading concepts.
PROTOTYPE	• Developing a 3D model. • Building a prototype.
TEST	• Testing the provided solution by presenting the idea to potential users. • Conducting an additional survey in order to receive feedback.

The result of this process was a design of an urban pavilion – a location that unities the key elements of positive design, based on the principles of modularity, bionics, ecology and ergonomics. The purpose of this design is to provide a creative solution that will contribute to solving the problems in people's lives created by "the urban jungle", to suggest a concept space/facility that could be placed across multiple network locations in the city. This space would be a partial compensation for the lack of free time and relaxation methods and would help stimulate creativity and positive moods.

The main goal of this design and paper is to emphasize that designers need to accept their social responsibility and explore ways to gradually improve the mental health and wellbeing of people by creating products that encourage them to engage in activities that help them feel good.

2. URBAN DESIGN AND MENTAL HEALTH

A. *Impact of good mental health on society progress*

Only individuals with good mental health are able to reach their own full potential. This means they are able to use their skills and talents fully in favor of social and economic development of the society. They express positive emotions and attitudes toward their assignments, deal better with stress, are more creative and more likely to implement their good ideas. All these points are evident in everyday life situations, but also shown as results from various conducted researches on this subject.

Lyubomirsky, King and Diener in their research present the conclusion that "happy workers enjoy multiple advantages over their less happy peers" [1]. Not only the individuals who have higher subjective wellbeing do better at interviews, but they also get better evaluations from their supervisors when they get the job due to showing better performance and productivity and are more likely not to show outbursts at the work place. Even before they start searching for jobs, people with positive attitudes are more likely to graduate collage, and later work on better work positions with greater autonomy, meaning and diversity of tasks. In addition, Frisch shows that people with a general satisfaction in most valued areas of life and greater happiness are more initiative, productive and satisfied with their jobs [2].

Another detailed research titled "Employee Positive Emotion and Favourable Outcomes at the Workplace" [3] shows similar results. The researchers Staw, Sutton and Pelled described several specific relationships in order to define their hypothesis about the favorable outcomes of positive emotions on productivity.

What this model of relationships showed, basically was that positive emotions have desirable ef-

fects on the person himself and not only on his relationship with others. This includes grater activity at given tasks, persistency and cognitive functioning. Also, their pleasant vibes and reactions help them cooperate better with colleagues because they appear more likeable to them. This is closely related with favorable responses and reactions from the people they communicate with who easily consider and accept their ideas and leadership. In addition, they enjoy higher ranking on different desirable criteria connected with the work position.

Having in mind the facts mentioned above it could be stated that there is a loop connection between good mental health and positive thoughts, progress of companies and progress of societies. Therefore, it is crucial to understand the outcome of different positive emotional attitudes at the work place and explore ways to encourage them and channel them towards development and innovation (Figure 1).

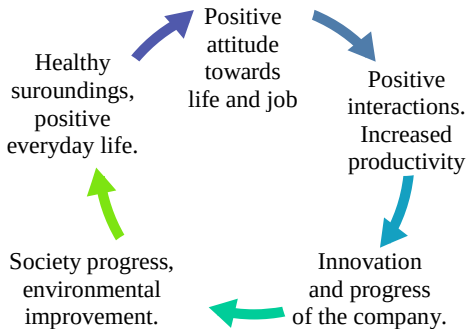

Fig. 1. Chain connection between positive attitudes and development of societies

B. *The influence of life in cities on mental health*

As previously mentioned, today more than 50% of the global population lives in cities, and it is expected that this percent will increase up to 70% by the year of 2050 [4]. People migrate to larger cities in search for better opportunities, such as availability of work, better and wider choice of education and healthcare institutions, better services, more places for entertainment etc. However, with the constantly increasing trend of urbanization, more and more people are exposed to factors that increase the levels of stress, which has a negative influence on mental health. Such factors can originate from the urban social environment (low socio-economic status, low social support, social segregation, minority status), but mostly from the urban physical environment. The second category includes problems such as grater pollution – of earth, air, water; noise – traffic; urban design – tall oppressive buildings, big density of objects; other physical threats – accidents, violence.

A simple research by observation was done in order to understand the existing factors of risk in the city of Skopje. After analyzing the urban environment, it became clear that the citizens are constantly exposed to sights that contribute to increase of stress and anxiety. Examples are shown on the images below. They illustrate the main issues in big cities, such as pollution (Figure 2), physical threats (Figure 3), small streets crowded easily with heavy traffic during rush hours (Figure 4) and densely placed new buildings (Figure 5). All of which trigger feelings of insecurity and tension.

Fig. 2. Pollution, eyesores

Fig. 3. Physical threats

Fig. 4. Density of buildings

Fig. 5. Busy streets, traffic.

C. *The role of urban design in mental health improvement*

In order to reduce the factors of risk a specific approach is necessary when designing the urban environment. Design is a key element in all our surroundings and a meaningful factor in our everyday lives, so a question is raised – how design of urban environments can improve the physical, mental health, positive mood and help with stress reduction.

According to a policy brief published by the Centre for Urban Design and Mental Health (May 2016) [5], four main principles need to be followed in urban design in order for it to have a positive impact: *Green areas; active zones; pro-social places and safe places.*

1. *Green areas*

The benefits from spending time in nature are numerous. Nature is good for the general wellbeing because it promotes physical activity, social interactions, it allows the mind to rest from everyday tasks, and it enables aesthetic enjoyment.

For these reasons, green areas need to be integrated in all kinds of urban planning. Large green areas where people can go for a walk, socialize or exercise have the greatest effect, however, it is very important that the citizens are constantly and regularly exposed to natural elements during their daily routines (such as trees and flowers, fountains, views to parks from office rooms, gardens for lunch breaks etc.). Charlotte Collins, in her summery of the WHO report on "Urban Green Spaces and Health" **[6]**, talks about the quality versus the quantity of natural environments in a city. She emphasizes that frequent, even if smaller, natural surroundings are more useful because the sight of horticultural elements mixed with the urban equipment reduce mental tiredness, aggression and stress. On this same subject, Jonce Walker, urban planner and sustainability professional, talks about Biophilic Urban Acupuncture *(BUA)* **[7]**, which is a theory that knots of biophilic interventions in specific urban locations in dense cities can help to improve the mood and connect people.

2. *Active zones*

It is already well known that regular physical activity has plenty of positive effects not only on physical, but also on mental health, since exercise reduces depression, anxiety and stress and improves the general wellbeing.

Urban design has a potential to influence the daily physical activity of people by changing their everyday paths as they move through the city. For example, a research [8] shows that in the USA daily bike rides of kids and adults consist of only 1% of total means of travel, in comparison with the Netherlands and other European cities where bike travels are 20% to 30% from the total daily means of travel. This situation is mainly due to the proper pedestrian and cyclist conditions, restrictions on vehicle speeds, expanded sidewalks, longer-lasting green traffic lights for pedestrians, etc.

When starting any urban project, consideration should be given to its impact on health and the environment. Such changes will be essential for making physical activity a regular and natural part of everyday life.

3, *Pro-social places*

One of the most important opportunities for promoting good mental health is achieving natural, positive social interactions between people in a social community. Urban places need to have locations that encourage positive social interaction.

In a research conducted as a part of the "Center for Welfare Program" [9] professionals from different sectors were surveyed about the welfare of the community. Out of a total of 317 respondents, more than 60% believed that community wellbeing was based on "strong networks of relationships and support between people in the community", as well as "close relationships and friendships between neighbors and acquaintances". Additionally, most of them shared the view that "well-being is a result of a sense of belonging in a community, a sense of security in it and an opportunity to take action in order to influence its improvement". The results show why the welfare of the community creates the best places to live in.

4. *Safe places*

The feeling of safety and security is integral to good mental health and well-being. Urban dangers include traffic, being lost in space, environmental pollution and danger from other people. The feeling of insecurity increases chronic stress and levels of anxiety, and people living in less secure neighborhoods are less likely to go outside for a walk or engage in any other physical or social activity.

In this paper, besides the four previously discussed principles published by the UD/MH Centre, two others are suggested and taken into consideration as important for improving the mental health: *personal space* and *variety of outdoor activities*. *Personal space* is the need for including secluded and peaceful areas in urban design projects that allow quiet introspection and individual relaxation. In addition, urban spaces should be enriched with equipment that enables people to engage in a *variety of outdoor activities* such as: lounge chairs for relaxation, benches that can be used for coffee breaks, lunch areas with tables and benches, reading zones in well-lit spaces, etc.

All the mentioned principles are branched out later on in the research to lists of ideas and attributes that can be used for good, user-centred urban design.

3. ETHNOGRAPHIC RESEARCH

In order to develop a better understanding of the way people live in big cities and the factors that interfere with their mental health an ethnographic research was conducted using the following methods: *method of observation* and *method of examination.*

A. *Observation method*

The *method of observation* is usually performed by observing and recording the behavior of a target group in different situations from a point of view of the subject of research [10]. This method was used by independent monitoring of the behavior of the residents of Skopje, in their natural, everyday environment. Choosing an observation method of an independent type, with a present researcher without his/her active participation, rather than a participative one, with an included social interaction between the researcher and the respondents, and choosing the natural environment over an artificially created one, allowed the observed individuals to act naturally since they were not aware they are being observed. This means the collection of data was simple, but accurate and it didn't require additional costs. The source of information was everything included in the surroundings: the physical environment, physical activities, frequencies of interaction and communication, etc.

The observation process was done following the suggestions of Whitehead. He, states in his paper "Basic Classical Ethnographic Research Methods" [11] that in order for the observation process to be successful and complete, it is important, when implementing it, to take into account relevant categories for obtaining data amongst which are: the space of the social setting, objects that are used, characteristic of the individuals, their behaviors, the patterns of interaction, emotions, physical environmental elements present in the setting and so on.

The research data collection, according to these relevant categories, is consisted of 3 elements:

- descriptive part – description of the participants, their surroundings and the event;
- reflective notes – personal thoughts related with the observed situation;

- demographic information – data about the time and place of the conducted research.

Characteristic situations that reflect the behavior of the residents of Skopje during the working days were pointed out. All these situations were demonstrated through several photographs, analyzed in detail and commented on. Some of them are presented as cases in Table 2.

Table 2

Description of 3 studied cases

CASE	DISCUSSION
	The photograph captures several employees from a sales company spending their breakfast break together around 9:30 am. They stood in front of the entrance of their offices, ate their breakfast out of plastic bags, and after that they finished their morning coffee. The total time they spent outside was about 20 minutes due to favourable weather conditions. They didn't have a place to sit or a table so they used the side wall of the building for leaning, placing their mugs and ashtrays.
	This photographed case shows the employers of a company for import and distribution of food products who are spending time out of their office around noon for their lunch break. They had their lunch, talked for a while and got back to work inside. Since there was no suitable sitting area around the object they used a couple of pallets as benches for sitting and rest. They ended their break early.
	This photograph is taken during working hours on a rainy day, in front of a mall. The employees went out of the building for coffee breaks, being careful to stand under the covered part in front of the entrance so they wouldn't get wet. Their breaks were very short – 5 to 10 min maximum. They had a few sips, talked to each other and on their phones, than they went back inside.

The drawn conclusion from the observation method is the following:

The employed citizens of Skopje do not have enough appropriate places where they can rest from work during the day. Unfortunately, most companies and municipalities do not invest in adequate external space that would stimulate the creativity and productivity of the employees and citizens.

Since the focus in the performed observation is mainly on the external behaviour, the motives, attitudes and other inner conditions are not obvious and all the collected data is not standardized. That is why this type of research was combined with a survey as an additional method in order for the results to be complete.

B. *Examination method*

The *examination method* is the most commonly used method, since it is most suitable for collecting qualitative information. It allows data collection from the interviewed individuals related with their opinions, attitudes, intentions, preferences, feelings, ideas, as well as information related with their behaviour and their demographic characteristics [10]. The method was used as a quantitative technique – through a survey. The questions were in a structural form, 21 in total, and 50 male and female respondents answered it. They are all of different age, employed in institutions in public administration and the private sector (media; software development companies; trade companies for import, export and distribution of goods). The main goal of the survey was to examine the way people think and what they feel during their daily routines. More precisely, to think of ways that could help for stress reduction, that is, to see how the daily habits of people can be influenced in order to improve their mental health, productivity and creativity.

The main conclusions from the performed survey are:

- Adult, employed residents of Skopje feel stressed out, insufficiently rested and overwhelmed most hours of the day. Life in Skopje increases their anxiety. An estimated 48% of respondents answered with “often” to the question “How often do you feel overwhelmed with work and under stress during the day?”, 30% answered “sometimes”, 12% – “all the time” and only 10% – “rarely”. In addition, most chose the answer “It makes me stressed out” (66%) to the question “Do you believe the way of life in Skopje increases your everyday stress levels?”.
- They need better use of the free time they have during the day and appropriate activities for reducing stress and stimulating their creativity. Results show they mostly spend their free time eating, drinking coffee, in front of the TV or browsing the Internet.
- They need a suitable space where they can engage in such activities on breaks during the working day as well as in their private spare time. When asked “In what kind of space do you spend your breaks?” most answers were:

"lunch area" 38%, and "space inadequate for spending breaks" 38%. Moreover, top responses to the survey question "Are you satisfied with the space where you spend your free time during the day?" were: 42% "a little" and 38% "not at all".

- They are likely to enjoy using such spaces. This conclusion originates from the answers to the question "If there is a suitably designed space close to your home/work would you spend time there – relaxing, reading, working etc.?" which were: 78% "yes", 16% "I don't know" and 6% "no".

The conclusions drawn from the conducted analysis through observation and examination are indicators that in the city of Skopje there is a problem of lack of adequate urban space where people could engage in everyday activities that contribute to the maintenance and improvement of their mental health. This problem, if left neglected, would eventually evolve into an even more complex social situation – a society that can not progress because its inhabitants are massively affected by urban stress, irritable, prone to depression, incapable of establishing positive social relations and with significantly reduced creativity and productivity.

4. ESTABLISHING HYPOTHESES

All the research carried out and analysis of collected data resulted with an idea to design a product that would help solve the previously defined problems – ***urban pavilion***.

The idea for this pavilion is to be designed as an urban space that would be a source of positive vibes and emotions for the citizens and would complement the deficit of adequate space for spending free time. This pavilion, as a product, is intended to be a structure that can be incorporated in different city locations. On the other hand, companies could invest in this structure and place it next to their main buildings, as an additional space meant to be used by employees, so that they can step away from the dynamic surroundings and closed office space several times a day. This pavilion is imagined as a place where citizens can spend time alone or in company, to have coffee or a meal, read books, newspapers and magazines, work on their computer, have a relaxed working meeting, or simply have a few minutes for individual relaxation. This way of functioning would allow reduction of the stress that everyday life brings to people. That is the reason why this pavilion should be created using the principles of positive design.

Based on the theoretical and ethnographic researches, as well as a local and global market analysis, according to the perceived needs of potential users that need to be met, and generated idea for a product, the following hypotheses can be defined:

1) If there are adequately equipped urban pavilions in the big cities, they would solve the problem of lack of space for spending time on break, overtime, meetings, socializing, etc. and it would be a pleasure for the citizens to use them.
2) If there are adequately equipped urban pavilions in the big cities, they would have a significant impact on the reduction of the stress of citizens in their everyday life and on the long-term improvement of their mental health.

5. PRODUCT DEVELOPMENT FOLLOWING THE PRINCIPLES OF POSITIVE DESIGN

Becoming aware of a social issue and mulling over an idea that could solve it was only the beginning phase of the used design thinking methodology. The following step was to clearly define the goals that the designed solution needs to follow in order to satisfy customer needs. There were 10 main designer goals defined:

1) Exploitation of the pavilion at temperatures from 12 to 35°C.
2) Exploitation of the pavilion at least 14 hours a day (07:00–21:00).
3) Exploitation of the pavilion 7 months a year (March – June; September – November).
4) Durable construction, at least 10 years without need of serious repairs.
5) Use of positive and warm materials (wood).
6) Possibility of adapting space size according to number of users (10, 10–20, 20–30, more than 30).
7) Sufficient number of tables and desks according to the number of users (comfort and safety, applied ergonomics).
8) Incorporating a lot of horticultural units.
9) Unique and modern design, following the latest trends.
10) Eco design, not threatening the local eco system and performing at least 3 eco functions.

Following these directions, and seeking inspirations in nature for the functionality of the design, several concepts were developed. The chosen concept evolved in a detailed 3D computer model (Figure 6), and a 3D-printed model (Figure 7).

Fig. 6. 3D computer model of the pavilion.

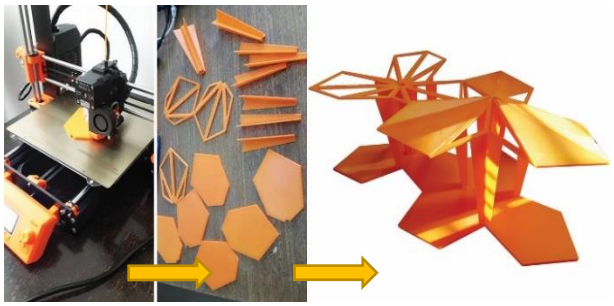

Fig. 7. The process of creating a physical 3D-printed model.

The designed pavilion satisfies the designer goals and follows the principles of positive design in more than one way, predented in Table 3.

Besides following the positive design principles, the strong side of the pavilion is its modularity. It has a playful, modern structure, following the "origami" design trend, which not only looks attractive, but also allows simple upgrading of the object. The entire pavilion is made out of basic modular segments that can be connected for easy adaptation to different spaces and different number of users (Figure 8). This also means reduced costs for development and easy repairing with simple replacement.

Another strong point are the ecological functions:

- solar power generation to supply the plugs for electrical devices in the interior;
- collecting rain water for irrigation of the surrounding park through a specially designed angle of inclination of the roof panels (Figure 9);
- environmentally friendly and recyclable materials (wood and plastic).

In order to achieve maximum comfort regardless of external conditions, and escape costs for heating or cooling the space, the side walls of the pavilion have an option for installing rotating panels. They can be placed on sides exposed to sun and wind which will allow the space to be closed during unfavorable weather conditions (Figure 10). These panels are designed as semi-transparent, matte, in order to provide shading, but also let natural light to enter the space.

Table 3

Description of how the positive design principles are applied to the design of the pavilion

P.D. PRINCIPLE	APPLICATION
GREEN AREAS	• Design that provides a biophilic intervention by integrated plants in the interior and natural surroundings. • Sun roof for obtaining a beautiful sky view. • Enabled connection with nature and enhanced sense of relaxation.
ACTIVE ZONES	• Pavilion that initiates spending time outside of the office/home/car. It encourages movement and taking action.
PRO-SOCIAL PLACES	• Well organized benches for 2 and more people that encourage spontaneous social interactions. • Space that can be used to gather people for workshops, events, volunteering, picnics etc.
SAFE PLACES	• Open-space design without objects that block the sight. • Abundant amount of natural light. • Structure with user-friendly, safe and recyclable materials (wood, polycarbonate, acrylic, polypropylene). • Applied ergonomic measurements. • Modular design, adding or removing modules to increase/decrease the space and adapt it to the number of users.
PERSONAL SPACE	• Allowed privacy in some segments. • Separate benches, tables and lounge chairs for 1 person.
VARIETY OF ACTIVITIES	• Rest areas (relaxing lounge chairs, quiet surroundings, park). • Work zones (tables, plugs, wi-fi). • Reading zones (separate benches for 1 in a well-lit place). • Lunch break areas (lunch tables). • Coffee break areas (benches for 2 and more people with coffee tables).

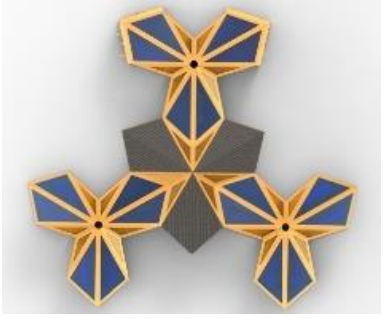

Fig. 8. Pavilion made of 4 connected modules

Fig. 9. Roof close-up
(solar panels, pipes for rain water collection)

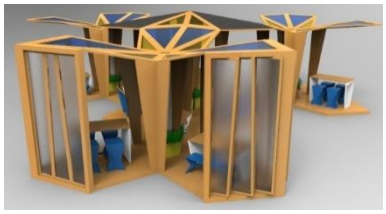

Fig. 10. Close-up of the rotating side panels.

For the color choice, a separate research on color and emotion was made [12, 13, 14, 15, 16], and the conclusions (Table 4) helped to define the ideal color combination: blue, yellow and white – colors related with happiness, socializing, activity, relaxation, calmness, patience and creativity.

Table 4

Effects of colours on human emotions

	yellow	red	blue	green	orange	purple	brown	grey/black	white
positive	X	X	X	X	X	X			X
happy	X	X	X						
excited	X	X							
entertained	X	X			X				
social	X	X			X				
active	X	X			X				
hungry		X			X				
attentive		X							
creative			X						
patient			X	X					
calm			X	X		X			
neutral									X
frightened								X	
sad							X	X	

6. EVALUATION

In order to determine the way people would respond to the pavilion and whether the design confirms the given hypotheses, a test was conducted involving a focus group of 30 adult, employed citizens of Skopje. They were shown images of 3D models of the designed pavilion and they were asked to check one option from a given list of words, each describing different types of emotion. The interview were supposed to check the emotion that they felt strongest when viewing the visuals from the pavilion.

The given list of emotions is the following:

anger	sadness/depression/ coldness		irritation/disturbance	
safety	calmness	relaxation	creativity/ imagination	
joy	fun/excitement	boredom	tiredness/sleepiness	
	neutrality	love	hate	

This kind of testing is visual and simple, answered by choosing and checking an option from a given list. There are no detailed questions that require writing or explaining so that the respondents do not feel annoyed when responding. They can answer according to the first thoughts and emotions that emerge when looking at the pictures.

This test was necessary in order to receive feedback and determine if this pavilion would have a positive effect on. The results of the survey are shown below by a column chart (Diagram 1) showing the most commonly expressed emotions among the examinees when viewing the pavilion.

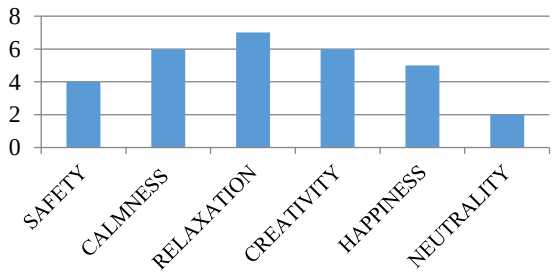

Diagram 1. Most common emotions associated with the pavilion

None of the negative emotions were chosen, and feelings of relaxation, calmness, creativity and happiness dominate in the answers. From this, it can be concluded that the previously defined hypotheses are **confirmed**.

7. CONCLUSIONS AND DISCUSSION

The steady following of the design thinking methodology allowed getting close to the users and creating a design that has a potential to improve their life. During the theoretical research, the importance of designing for mental health improvement was emphasized. Through the conducted ethnographic research by a detailed survey about the habits of adult, employed residents of the city of Skopje, as well as the observation of their daily behavior, the lack of dedicated attention to this important topic was realized.

Therefore, the direction in which the practical research headed was designing a space that would improve the quality of life of the citizens of Skopje. The ecological, modular pavilion, based on the principles of natural systems, and above all of positive design, offers a lot of possibilities for its simple modification and use in the urban environment of Skopje. Regardless if the object would be placed in public parks of municipalities or as an additional object to the companies' main facility buildings, this pavilion would be a step forward in designing for positive emotions and raising awareness about the importance of improving mental health.

The final conducted evaluation regarding the product showed a positive response from the focus group which is an indicator that citizens would like to use this space and that it would increase their positive mood, but in order to determine with certainty that the pavilion would influence the long-term improvement of mental health, further experimental analysis with a sample of such a pavilion should be done. This remains a suggestion for further research and completion of this topic.

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Original scientific paper

SUSTAINABLE ASPECTS OF ADDITIVE MANUFACTURING

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A b s t r a c t: Improvement of the sustainability of products seems like constant battle between the production companies and the society, in order to preserve the environment for the future generations. New opportunities are on the horizon with the additive manufacturing technologies. Additive manufacturing, known as 3D printing, encompass different processes under one name. Each of these processes is unique, but they are all based on the same principle for layer-by layer building of the product. The versatility of these processes may seem challenging but on the other hand, it gives a wide range of opportunities for different application in product design and production. Companies worldwide are already using these benefits and redesigning their products.In this paper, we want to show that design can make huge impact. We can achieve that by using the topology optimization tools and the additive manufacturing in order to create lightweight parts. We use topology optimization to achieve best solution for the design of the part and the additive manufacturing to produce it.

Key words: sustainability; additive manufacturing; design process; lightweight parts

ОДРЖЛИВИ АСПЕКТИ НА АДИТИВНОТО ПРОИЗВОДСТВО

А п с т р а к т: Подобрувањето на одржливоста на производите изгледа како постојана битка помеѓу производните компании и општеството, со цел да се зачува животната средина за идните генерации. Нови можности се на хоризонтот со адитивните производствени технологии. Производството на адитиви, познато како 3D печатење, опфаќа различни процеси под едно име. Секој од овие процеси е уникатен, но сите тие се базираат на истиот принцип за градење слој по слој на производот. Разновидноста на овие процеси може да изгледа како предизвик, но од друга страна, таа дава широк спектар на можности за различна примена во дизајнирањето и производството на производи. Компаниите во светот веќе ги користат овие придобивки и ги редизајнираат своите производи. Во овој труд сакаме да покажеме дека дизајнот може да направи огромно влијание. Тоа можеме да го постигнеме со користење на алатки за оптимизација на топологија и производство на адитиви со цел да создадеме лесни делови. Ние ги користиме оптимизацијата на топологијата за да постигнеме најдобро решение за дизајнот на делот и производството на адитиви за да го произведеме.

Клучни зборови: одржливост, производство на адитиви, процес на дизајн, лесни делови

1. AIMS

The overall situation with the pollution superimposes need for intense regulations in every aspect of our living. Consequently, that implies to the manufacturing sector. The engineers and designers must have the sustainability aspects in mind when designing a new product. These aspects take account of the material used for the product, the production process, distribution and end of life. Having in mind all those elements can be off-putting when designing.

Optimistic thing for the engineers and designers is the development of the technology. New technologies such as additive manufacturing give them freedom of form that no other technology can offer. Additive manufacturing (AM) can help engineers

and designers in the design process, allowing them to create complex geometries. The freedom of forms that AM technologies enable is also of great significance for the topology optimization. With that in mind creating optimized lightweight parts with complex geometries, it is not a problem anymore. On the other hand, there are numerous benefits of the lightweight parts: use of less material, weight reduction, shorter time for production, fuel efficiency and less carbon footprint (in transportation systems).

In this paper, we will focus on the lightweight parts because as mention above they play important role in the sustainability process. Redesigning the parts in order to make them lightweight does not necessarily mean that they cannot withstand pressure or perform heavy-duty applications. Parts are optimized in order to maintain their application, but with the use of less material. Lightweight parts are created after analysis for load and weight distribution using topology optimization.

The aim of this paper is to prove that with less material more effect can be achieved.

2. BACKGROUND

Additive manufacturing

Additive manufacturing is a general term that is used for a group of process where parts are created layer by layer, which means by adding material. This is completely opposite to the subtractive process in which parts are created by removing material. The manner in which parts are created is the reason why these processes have so many advantages in comparison to the subtractive processes [1].

Topology optimization

Topology optimization is a computational approach for optimizing the distribution of material in a given design domain, such that a certain objective is minimized subject to design and response constraints [2]. In the Topology optimization monograph [3] extensive reviews of different formulations and implementation techniques are presented. Even though topology optimization was intended initially for optimizing load-bearing structures, it is currently applied in various engineering and science fields, like buildings, aircraft, automotive, acoustics, photonics, fluid motion, heat transfer and medicine, among others [2]. The vast application possibilities of the topology optimization are the reasons that this principle is considered for further analysis in this paper.

Topology optimization and additive manufacturing overview

Topology optimization is not a new approach in the product design. The advancements in the AM technologies are the reason that topology optimization has become popular again. Marchesi and colleagues [4], propose using topology optimization with AM to produce diesel engine support. Brackett and colleagues [5] propose a method to eliminate the need for support material all-together by taking advantage of the maximum printable overhang angle, which requires no support. Mass and Amir [2] work on similar problematic, creating overhangs with no support material, using virtual skeleton. Saadlaoui and colleagues [6] in their study test and compare the validity of three engineering approaches from the topology optimization computations to the SLM manufacturing.

Of particular concern for this paper are studies that use topology optimization for weight reduction, e.g. creating lightweight parts. The number of such studies is not for underestimation and some of them are mentioned in the following text. Gardan and Schneider [7] optimize the volume of material to be used and the global mass. They propose a methodology to minimize the inner material. The methodology for weight gain is tested in more than ten parts with different AM process: FDM, SLS and SLA. Salonitis and Al Zarban [8] examine the principles of additive manufacturing, design guidelines, capabilities of the manufacturing processes and structural optimization using topology optimization. They propose a redesign methodology, which they explain through a redesign case study of an existing bracket. Nimbalkar and colleagues [9] compared the production of an aircraft ventilation assembly produced via FDM (0.040 kg) and injection molding (0.043 kg) as well as a topologically optimized aerospace bracket manufactured by EBM (0.38 kg) and conventional machining (1.09 kg). The main benefits shown in both case studies are achieved during the use phase (15 million miles in a short-haul aircraft and 19 million miles in a long-haul aircraft, respectively) of the lightweight components. The total energy savings are quantified to be around 233 MJ/part and 70 GJ/part, respectively. Reiher and Koch [10] used topology optimization for weight and waste reduction in the design of link

lever. The waste reduction of the optimize link lever is of factor 15 while the weight is reduced by 36%. They also presented example of part created within the project "COMPOLIGHT" where weight reduction was from 20 kg to 1 kg and a pressure loss reduction by factor four. European Aeronautic Defense and Space Company (EADS), owner of Airbus is conducting studies of the effect of weight reduction on their planes. The process that is used is Direct Metal Laser Sintering (DMLS). In their study, they redesigned the hinge for jet-engine cover. The result of the study is that the optimized part (Figure 1) weighs half as much the initial part [11].

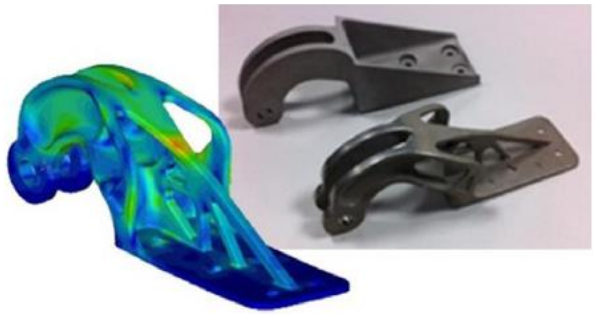

Fig. 1. Airbus A320 Nacelle Hinge Bracket (back) and the Optimized Design (front). Courtesy of EADS and ALTAIR [7]

Additionally, lightweight parts when used as part in complex systems such as aircraft despite increase of fuel efficiency but also reduce carbon emissions. This has been topic for several studies who have defined the carbon footprint reduction of additive manufacturing technologies [12]. In one of their studies, EADS compared cast steel nacelle hinge brackets produced with rapid investment casting and optimized design of the titanium nacelle hinge bracket produced with DMLS. In the comparison, following aspects were considered: energy consumption for the life cycle of the bracket, including raw material manufacture, the production process and the end-of-life phase [13]. Their study shows that it is possible to cut material consumption by 75% and CO_2 emission by 40% [14].

3. EXPERIMENTAL

From the literature review presented in section 2 it is evident, that topology optimization is mostly used for metal parts. That makes sense because the weight reduction are more evident there and at the same time cost for the material is lower.

We wanted to try something different, to create part with ABS. The ABS part is intended to be produce on fused deposition modeling (FDM). The reason that we chose FDM as a process and ABS as material is that now they are increasing in number of users. This can be backed up by the information provided by Wohlers Report from 2016 [15], where it is stated that the number of sold personal FDM machines (under 5000 UDS) is 278,385 units. As comparison in the same year, the number of sold industrial AM machines is 12,558 units. Most users do not have engineering education, so the parts that they print are with basic design focusing on the functionality. Something that is popular in the community of FDM printing is robotic arm. This is why for the experiment we choose to optimize robotic arm, actually one part of it, the gripper (Figure 2).

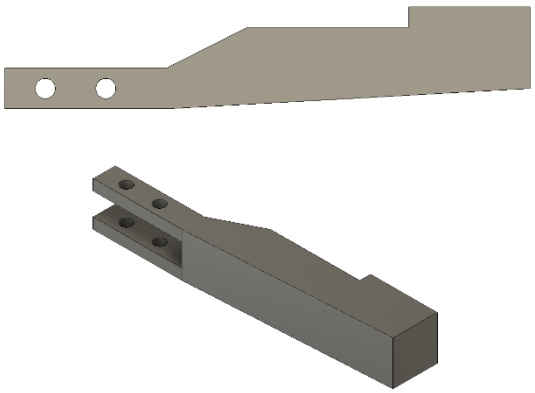

Fig. 2. Part of the robotic arm, the gripper that is subject to topological optimization

For the finite elements (FE) analysis, the cylindrical holes were chosen as pin constraints. The force was applied to the rectangular area that comes in contact with the object that is picking up. The area around the holes is defined as design restriction (Figure 3), which means that in that area no changes of the topology are permitted.

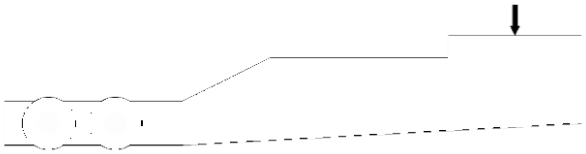

Fig. 3. Position of the design constraints

4. RESULTS AND DISCUSSION

The result of the FE analysis is shown in Figure 4. The dark areas are where there is most stress.

The light area means that there is no stress and there is more than needed material.

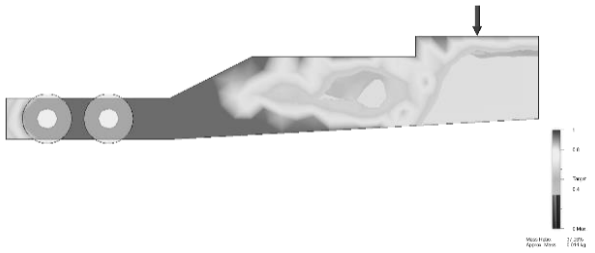

Fig. 4. Result of the FE analysis

The optimized part has less material than the initial part (Figure 5), actually half of it. The mass of the initial part was 38 g, and of the optimized part is 19 g. The optimized part has also filleted edges, which is important for better stress distribution.

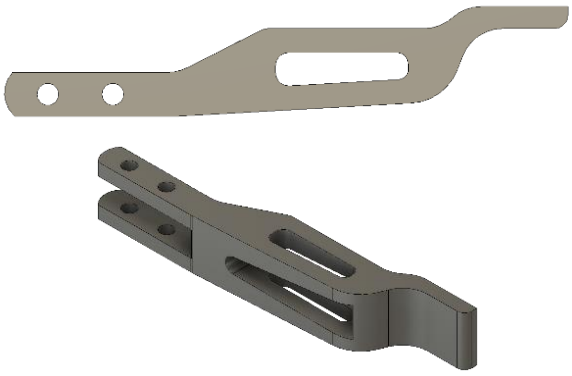

Fig. 5. Optimized gripper

One thing has to be mention in the analysis and that is that generic ABS was used. The FDM process uses ABS, which may differ from the generic in some characteristics. The main reason for this was for the initial and optimized part to be from the same material. This way it is clear that the weight reduction is result only of the topology optimization and it cannot be accounted for the material. With this example, everything previously stated is confirmed.

5. CONCLUSION

It can be concluded that AM's main advantage, freedom of form can be used for creating not only pleasing to eye parts, but more importantly sustainable. One approach of using AM's advantages, which was presented in this paper, is by topology optimization. With the topology optimization, lightweight parts are created. Primary benefit of the lightweight parts is use of less material and shorter production time, so that means less electrical energy. Secondary benefit of the lightweight parts is evident by their use in bigger systems. For example, airplanes that weight less use less fuel and emit less carbon footprint.

In addition to this is the constant research in the field of materials used in AM. By creating new composite materials or metamaterials, new opportunities arise for creating lightweight parts.

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Original scientific paper

INFLUENCE OF CONDENSATION TEMPERATURE AND FLUID PROPERTIES ON THE ORGANIC RANKINE CYCLE EFFICIENCY

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A b s t r a c t: The Organic Rankine Cycle (ORC) is becoming a popular choice for the exploitation of limited heat sources, where air and water cycles fail to provide satisfactory results. This paper gives a theoretical overview of the organic rankine cycle and lists a number of its uses, highlighting its application in geothermal reservoirs, most commonly providing geothermal fluids in the liquid state. The advantages and disadvantages of this cycle are analyzed, followed by the criteria for fluid selection. Furthermore, a method for calculating the cycle efficiency of a specific geothermal ORC plant is presented, as well as an analysis of the impact that the condensation temperature and choice of working fluid have on the cycle efficiency

Key words: Organic Rankine Cycle; condensation temperature; efficiency

ВЛИЈАНИЕ НА ТЕМПЕРАТУРАТА НА КОНДЕНЗАЦИЈА И КАРАКТЕРИСТИКИТЕ НА РАБОТНИОТ ФЛУИД ВРЗ ЕФИКАСНОСТА НА ОРГАНСКИОТ РАНКИНОВ ЦИКЛУС

А п с т р а к т: Органскиот Ранкинов циклус (ОРЦ) станува популарен избор во експлоатацијата на ограничени извори на топлина, каде што воздушните и водните циклуси не можат да обезбедат задоволителни резултати. Овој труд дава теоретски преглед на органскиот Ранкинов циклус и ги набројува неговите примени, потенцирајќи ја неговата примена во геотермалните резервоари кои најчесто располагаат со геотермални флуиди во течна состојба. Анализирани се предностите и недостатоците на овој циклус, проследени со критериумите за избор на работен флуид. Дополнително е претставен метод за пресметка на коефициентот на полезно дејство на циклусот за определена геотермална ОРЦ-постројка, како и анализа на влијанието кое температурата на кондензација и изборот на работен флуид го имаат врз ефикасноста на циклусот.

Клучни зборови: органски Ранкинов циклус; температура на кондензација; ефикасност

1. INTRODUCTION

While most of today's power generation is based on air and water cycles, there is an abundance of heat sources that cannot be exploited using these conventional cycles due to their low thermal power. In these cases, the Organic Rankine Cycle (ORC) is a more attractive alternative on account of its use of an organic working fluid, characterized by a lower boiling point and higher molecular mass than water.

These qualities make the organic Rankine cycle a technically and economically viable solution and allow it to take advantage of limited heat sources with low to medium temperatures, such as liquid dominated geothermal reservoirs.

Geothermal heat sources are especially convenient for ORC applications, since they are extremely reliable and available. Unlike solar or wind power plants, geothermal plants do not depend on any weather conditions, apart from the condensation

temperature which changes according to the seasons.

2. THEORETICAL BASIS OF THE ORGANIC RANKINE CYCLE

The organic Rankine cycle is a thermodynamic cycle used to convert heat into mechanical work, whose working principle is based on the conventional Rankine cycle.

As seen on Figure 1, heat is introduced through heat exchangers, where the working fluid is vaporized and possibly superheated. Then, the fluid is fed into an expander, where part of its thermal energy is converted into mechanical. The power output of the expander depends on the amount of heat what was successfully converted, i.e. the fluid's enthalpy drop.

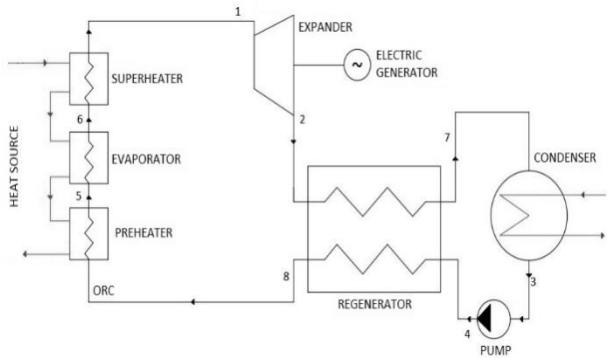

Fig. 1. Layout of an ORC plant

Following the fluid's phase change in the expander, it is condensed in a condenser and then pumped. However, it is sometimes attractive to install a regenerative heater between the expander and the condenser in order to increase the cycle's efficiency.

Traditional Rankine cycles use water as the working fluid of choice. However, in the exploitation of limited heat sources, where sometimes the temperature is not high enough to even vaporize the water, there is a need for an alternative choice of working fluid.

The organic Rankine cycle replaces water with an organic fluid, with a much lower boiling point and a higher molecular mass than water. These qualities are crucial to harnessing the heat from low temperature sources. Therefore, the essential distinction between the traditional and the organic Rankine cycle is the working fluid in question.

3. COMMON APPLICATIONS OF THE ORGANIC RANKINE CYCLE

ORC technology is quite versatile and has a wide range of applications in heat sources with low to medium temperatures. As of December 31st, 2016, it is estimated that ORC technology makes up for a total of 2.7 GW of the world's installed capacity, accounted for by 1754 ORC units [1].

ORC power generation has the largest potential in three sectors. The electricity and heat generation sector produces a significant amount of waste heat that can be utilized with an ORC unit. Furthermore, the industrial and transportation sectors have considerably high energy consumption levels; however the former has lower levels of waste heat than the latter [2].

3.1. *Waste heat recovery*

The organic Rankine cycle offers a solution for low-grade waste heat recovery in different kinds of industrial or production processes. Sources of waste heat are diverse – exhaust gases from furnaces, turbines and engines, inter-cooling of compressors and power plant condensers. Utilizing waste heat is becoming a trend due to the environmental benefits, as well as the possibility of reducing fossil fuel consumption [3].

3.2. *Solar thermal power*

In terms of solar energy, ORC technology mainly focuses on concentrated solar power (CSP). Most of the installed CSP systems use steam cycles to generate power. However, steam cycles require high temperatures and are therefore inadequate for small scale and domestic units. Replacing the steam cycle with an organic cycle eliminates this problem and shows a much higher performance.

Although photovoltaic collectors are the main competitor for solar ORC units regarding power generation, solar ORCs have the possibility to produce hot water as well as power [4].

3.3. *Biomass CHP plants*

ORC technology offers several advantages for biomass plants. Using water as a working fluid warrants high pressures in the plant's boiler. However, replacing the water cycle with an organic Rankine cycle eliminates the need for such high pressures

and therefore, the investment cost for the boiler is significantly reduced.

Additionally, ORC biomass plants have low maintenance costs and longer life service [5].

It is important to note that an intermediate thermal oil cycle which transfers the heat released during the biomass combustion to a closed organic cycle is common in biomass ORC plants.

3.4. *Geothermal power plants*

Geothermal power plants produce 73% of the electricity generated with ORC technologies. Geothermal energy sources are characterized by their diversity and their reliability for electricity generation. When the geothermal field in question is vapor dominated, then it is practical to use a direct cycle. However, liquid dominated fields are much more common, so binary cycles, and ORC specifically, are predominant in generating electricity from these sources [6].

Since every geothermal reservoir has different chemical and thermal conditions, geothermal fluids are not uniform. Consequentially, to ensure the plant's stable operation, thorough analysis of the geothermal reservoir must be performed. This results in a diverse range of ORC plants, using different pressures, temperatures, equipment and working fluids to maximize the plant's efficiency.

4. ADVANTAGES AND DISADVANTAGES OF THE ORGANIC RANKINE CYCLE

The organic Rankine cycle is a binary cycle, which means that fluids from the heat source do not come in direct contact with the plant's equipment, such as the expander, condenser and pump, lowering the risks of corrosion.

However, the main advantage of ORC technology comes from the utilization of an organic working fluid which has three main qualities:

1) low boiling point;
2) high molecular mass;
3) 'leaning' saturation curve, as depicted in Figure 2.

Evaporating at lower temperatures than water allows for use in low to medium temperature sources, while high molecular mass ensures lower enthalpy drops, thus simplifying the design of the expander. Furthermore, the shape of the organic fluid's saturation curve makes possible for the expansion to occur in dry conditions, decreasing the possibility of corrosion in the expander and allowing for a cycle without superheater [7].

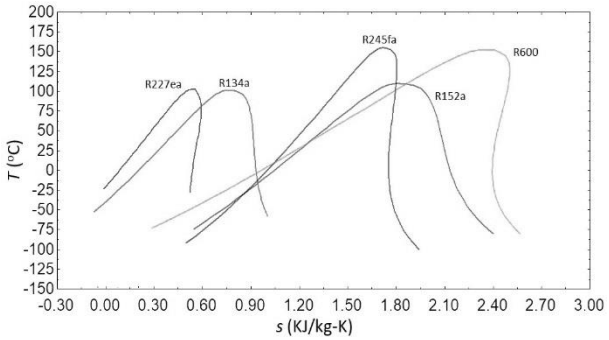

Fig. 2. Saturation curves of different working fluids

Compared to classic air or water cycles, the organic Rankine cycle performs much better in limited heat sources. Air or gas cycles have negative efficiency in sources with temperature lower than 250°C, while at 450°C the cycle efficiency barely reaches 8%. Water cycles make up for some of the air cycle's shortcomings, however, the application of a water cycle calls for a steam turbine with multiple stages, complex plant design and wet expansion, which increases the costs of the plant [8]. For these reasons, water cycles are inadequate for application in low temperature sources.

While the organic Rankine cycle provides a viable solution for the exploitation of geothermal sources, there are some disadvantages that must be taken into consideration, such as high investment costs for the plant, especially in applications in geothermal reservoirs.

Every geothermal reservoir has different properties, such as thermo-physical and chemical qualities of the geothermal fluid and availability and quantity of the fluid. Detailed examinations of the reservoir must be performed in order to obtain crucial information needed to evaluate whether and in what way the heat source can be exploited. Thanks to the non-uniform nature of geothermal reservoirs, each reservoir requires different ORC design, from the duration of the plant's operation to the selection of working fluid and cycle parameters. Due to these circumstances, it can be concluded that ORC plants have high investment costs.

Moreover, the organic working fluids are often flammable or toxic and consequentially the costs are even further increased due to the need for additional safety equipment.

The fluids' high molecular mass results in relatively high electricity consumption of the pump,

while the characteristically large amount of heat disposed of through the condenser demands additional electricity consumption for the ventilators used for cooling. These two factors significantly impact the cycle efficiency.

5. WORKING FLUID SELECTION

The type of working fluid selected for the given plant impacts the complete thermodynamical cycle, cycle efficiency, cost of the equipment, safety measures, etc. Since the choice of working fluid plays an important role in the plant design, there are a number of important criteria that should be fulfilled.

Starting from the thermo-physical properties of the fluid, lower critical pressures are preferred. Thermal stability in the given temperature range is another important aspect, since organic fluids are more prone to chemical decomposition at higher temperatures of the heat source. Good heat transfer of the working fluid decreases the surfaces of the heat exchangers, therefore reducing the cost. Moreover, to minimize the power consumption of the pump, fluids with lower viscosity should be used.

Working fluids with boiling temperatures between 0°C and 100°C and critical temperatures lower than 200°C are easier to handle than others. The critical temperature also plays an important role in the enthalpy drop in the expander. To ensure higher power output of the cycle, higher enthalpy drops are required.

Additionally, the working fluid should have an isentropic or positive saturation curve. Fluids with negative saturation curves have 'wet' expansions, leading to the formation of droplets at the end of the expansion [9]. Figure 3 shows three different types of saturation curves.

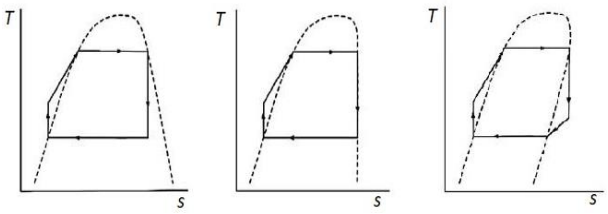

Fig. 3. T-s diagrams of fluids with different saturation curves: a) wet, b) isentropic and c) dry

To avoid the implementation of added safety measures, the fluid of choice should be non-flammable and non-toxic. Although it is possible to operate with flammable and toxic fluids, it is not recommended since it further increases the cost of the plant.

Lastly, to determine whether the fluid is environmentally acceptable, two indices are used. Global Warming Potential (GWP) is an index that shows the relationship between the amount of heat retained due to a certain amount of the fluid in question and the heat retained due to the same amount of carbon dioxide. On the other hand, Ozone Depletion Potential (ODP) is an index that shows the relationship between the global loss of ozone due to different substances and the global loss of ozone due to the specific working fluid in question.

A number of working fluid types are available for use in ORC plants: CFC, HCFC, HFC, FC, HC and HFO. From a technical point of view, all of these groups are acceptable. However, CFCs and HCFCs are banned due to their high ODP, while HFCs are phased out due their GWP [10].

6. CYCLE EFFICIENCY

An ORC plant utilizing heat from a geothermal source is examined. It is determined that the heat input is 26,145.7 kW.

All calculations are done with the help of Engineering Equation Software (EES) developed by F-Chart Software. This software contains thermodynamical data for a variety of fluids, including the organic fluids used in ORC technology.

The organic working fluids considered for this plant are R227ea, R134a and R152a.

Figure 4 shows the organic Rankine cycle in a T-s diagram. The fluid enters the heat exchangers after it has been pumped to 28 bar (3-4). The fluid accepts the heat from the geothermal fluid (4-5-6-1) and is superheated to 105°C with a given 3 bar pressure drop through the heat exchangers. The cycle efficiency is compared with and without the use of a regenerative heater before the heat exchangers.

The expansion (1-2) occurs in dry conditions. The power output depends on the condensation temperature. Lower condensation temperature entails greater expansion, and with that, higher cycle efficiency.

Part of the condensation is done with a regenerative heater (2-7), while the rest of it happens in a condenser (7-3), as shown in Figure 4. Introducing a regenerative heater lowers the amount of heat rejected through the condenser, thus decreasing the fan consumption for the condenser's air cooling. Additionally, regenerative heating is provided (8-4).

Equation (1) gives the fluid's enthalpy after exiting the regenerator.

$$i_8 - i_4 = i_2 - i_7 \quad (1)$$

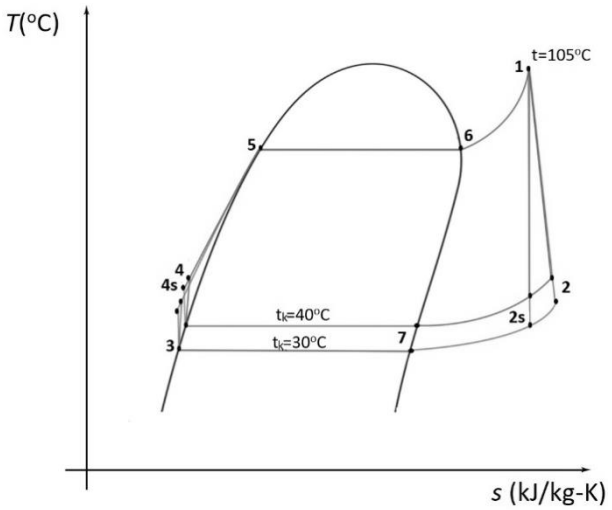

Fig. 4. ORC in T-s diagram

Given a condensation temperature of 35°C, the fluid's enthalpy difference at the entrance and exit of the heat exchangers can be calculated. The fluid's mass flow can be determined using Equation (2), where Q represents the heat transferred from the geothermal fluid and m_f is the mass flow.

$$m_f = \frac{Q}{(i_1 - i_8)} \text{ kg/s} \quad (2)$$

To calculate the amount of heat converted into mechanical work in the expander, it is necessary to determine the fluid's enthalpy drop (i_1–i_2) as seen in Equation (3), where η_{ex} = 85% is the expander efficiency [11], and (i_1–i_{2s}) represents isentropic expansion.

$$i_1 - i_2 = \eta_{ex}(i_1 - i_{2s}) \quad (3)$$

Equation (4) shows that multiplying the enthalpy drop with the fluid's mass flow will result in the expander's work.

$$W_{ex} = m_f(i_1 - i_2) \text{ kW} \quad (4)$$

However, after this work is converted into electricity, a significant amount of it is used to power the pump and the air-cooled condenser's fans. In order to calculate the cycle's efficiency, these two consumptions must be determined.

The pump's work is calculated through Equation (5), where the pump's efficiency is η_p=70% [12], while v_3 represents the fluid's specific volume following the condensation.

$$W_p = m_f \frac{(P_4 - P_3)v_3}{\eta_p \cdot 10^3} \text{kW} \quad (5)$$

For the calculation of the fan consumption, it is established that for every kilowatt of rejected heat, the fans require 8 W of electric energy. Heat rejected through the condenser Q_c and the power consumption of the fans W_{ACC} can be calculated with Equation (6) and Equation (7) respectively.

$$Q_c = m_f(i_7 - i_3) \text{ kW} \quad (6)$$

$$W_{ACC} = \frac{8 \cdot Q_c}{10^3} \text{ kW} \quad (7)$$

Finally, the efficiency of the organic Rankine cycle can be calculated using Equation (8).

$$\eta_{ORC} = \frac{W_{ex} - (W_p + W_{ACC})}{Q} \cdot 100\ \% \quad (8)$$

7. EFFECT OF THE CONDENSATION TEMPERATURE ON THE CYCLE EFFICIENCY

The cycle's efficiency largely depends on the condensation temperature, since it determines the enthalpy drop, i.e. the amount of successfully converted heat. Therefore, lower temperatures result in higher efficiency, whereas higher temperatures lower the efficiency. Furthermore, the condensation temperature, i.e. condensation pressure, affects the pump's work, which in turn impacts the efficiency.

This can be clearly seen in Table 1, where different condensation temperatures (T_c) between 20°C and 40°C are given and the efficiency of the cycle is accordingly calculated. It is evident that with lower condensation temperatures, the cycle displays higher efficiency.

Table 1

R227ea cycle efficiency for different condensation temperatures

T_c °C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC} %
20	3436	399.6	231.1	10.73
22	3359	403.5	231.9	10.42
24	3283	407.3	232.7	10.11
26	3206	411.1	233.5	9.79
28	3130	414.8	234.4	9.48
30	3053	418.4	235.1	9.17
32	2976	421.9	235.9	8.86
34	2898	425.3	236.7	8.55
36	2821	428.5	237.5	8.24
38	2743	431.5	238.3	7.92
40	2665	434.4	239.2	7.61

The same type of analysis is done again, taking into consideration the use of a regenerative heater, which increases the cycle efficiency due to the provided regenerative heating and lower power consumption of the condenser's air cooling. The results are presented in Table 2.

Table 2

R227ea cycle efficiency for different condensation temperatures with use of a regenerator

T_c ◦C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC-R} %
20	3436	399.6	231.1	13.29
22	3359	403.5	231.9	12.9
24	3283	407.3	232.7	12.51
26	3206	411.1	233.5	12.12
28	3130	414.8	234.4	11.73
30	3053	418.4	235.1	11.34
32	2976	421.9	235.9	10.95
34	2898	425.3	236.7	10.55
36	2821	428.5	237.5	10.16
38	2743	431.5	238.3	9.76
40	2665	434.4	239.2	9.37

It is evident from these results that for the given working conditions (pressure at the beginning of the cycle, temperature differences in the heat exchangers) the fluid R152a has the highest performance. In the case where the cycle includes regenerative heating, R227ea's cycle efficiency is significantly higher. Adding a regenerator improves the cycle efficiency in all three cases. However, the condensation temperature still impacts the efficiency, generally decreasing it for as much as 4%.

The same type of analysis is done for the remaining two working fluids – R134a and R152a. The results of this analysis are shown in Tables 3, 4, 5 and 6.

Table 3

R134a cycle efficiency for different condensation temperatures

T_c ◦C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC} %
20	3235	284.1	232	10.4
22	3137	284.5	232.9	10.02
24	3040	284.7	233.9	9.64
26	2942	284.6	234.9	9.26
28	2843	284.3	235.9	8.88
30	2744	283.7	236.9	8.5
32	2644	282.9	237.8	8.12
34	2544	281.7	238.8	7.73
36	2443	280.1	239.8	7.35
38	2341	278.2	240.8	6.96
40	2238	275.9	241.8	6.57

Table 4

R134a cycle efficiency for different condensation temperatures with use of a regenerator

T_c ◦C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC-R} %
20	3696	324.6	227.7	12.02
22	3594	325.8	228.8	11.62
24	3491	326.9	229.8	11.22
26	3388	327.7	230.9	10.82
28	3283	328.3	231.9	10.42
30	3178	328.6	233	10.01
32	3072	328.6	234	9.59
34	2964	328.2	235.1	9.18
36	2856	327.5	236.2	8.76
38	2746	326.4	237.3	8.34
40	2635	324.8	238.4	7.92

Table 5

R152a cycle efficiency for different condensation temperatures

T_c ◦C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC} %
20	3531	269.5	228.8	11.6
22	3434	269.9	229.8	11.22
24	3337	270.1	230.8	10.85
26	3239	270.2	231.8	10.47
28	3141	270	232.8	10.09
30	3042	269.6	233.7	9.7
32	2942	269	234.7	9.32
34	2842	268.2	235.7	8.94
36	2741	267	236.7	8.55
38	2640	265.6	237.7	8.17
40	2538	263.8	238.7	7.78

Table 6

R152a cycle efficiency for different condensation temperatures with use of a regenerator

T_c ◦C	W_{ex} kW	W_p kW	W_{ACC} kW	η_{ORC-R} %
20	3743	285.6	226.9	12.35
22	3648	286.7	227.8	11.99
24	3553	287.6	228.8	11.61
26	3457	288.4	229.8	11.24
28	3360	288.9	230.7	10.86
30	3263	289.2	231.7	10.49
32	3164	289.3	232.7	10.11
34	3065	289.2	233.7	9.72
36	2964	288.7	234.7	9.33
38	2863	288	235.7	8.94
40	2760	286.9	236.7	8.55

The results of this analysis are presented graphically in Figure 5 for all three fluids in a cycle with and without a regenerator.

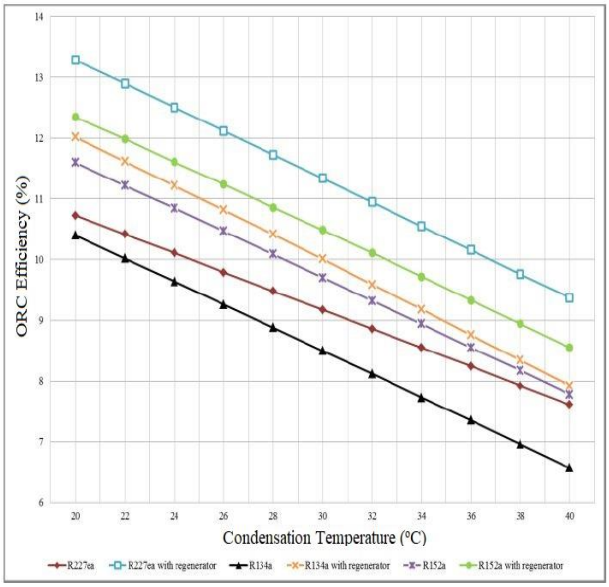

Fig. 5. Cycle efficiency for different condensation temperatures with and without regenerative heating

8. CONCLUSION

The organic Rankine cycle employs organic working fluids, whose properties allow for the cycle to exploit low to medium heat sources with much higher performances than the traditional air or water cycles. Geothermal power plants represent the largest portion of ORC applications.

However, due to the organic fluid's physical properties, the pump and air cooled condenser's fans consume a large amount of the generated electricity, thus significantly lowering the cycle's efficiency. To maximize the cycle's efficiency, a fluid selection process must be conducted for each geothermal source separately. For the heat source at hand, under the given work conditions the highest efficiency is achieved with the fluid R227ea.

Aside from the working fluid, this analysis concludes that the cycle performance also depends on the condensation temperature. Higher temperatures reduce the enthalpy drop in the expansion process and, therefore, the cycle efficiency is lowered. Additionally, the condensation temperature affects the efficiency through the pump and ACC fan consumption.

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Original scientific paper

OPTIONS FOR EFFICIENCY ENHANCEMENT AND NO_x EMISSION REDUCTION OF UTILITY COAL-FIRED STEAM GENERATOR

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A b s t r a c t: As fossil fuels dominate the world primary energy supply and will do it at least for the next few decades, further improvement of the fossil-fueled power plants is needed due to many reasons, including the environmental impact and economic operation. The thermal power plants operation is commonly evaluated on a basis of the energy analysis, combustion efficiency and the level of harmful emissions generated. Often, the real useful energy loss cannot be completely justified only by the first law of thermodynamics, since it does not differentiate between the quality and amount of energy. The aim of this work is to present a methodology for analyzing opportunities for improving the efficiency of fossil fuelled steam generators, based on integration of zone thermal calculation method and exergy method, while studying the impact of such measures on the emission of nitrogen oxides. The work deals with an analysis of the energy and environmental performances of a coal-fired steam generator, which is a part of a 315 MWe power generation unit. The steam generator is designed for operation on low grade coal – lignite with net calorific value in a range 6280–9211 kJ/kg, in a steam cycle at 545 ^oC/177.4 bar, with feed water temperature 251 ^oC. The combustion air is preheated to 272 ^oC in two rotating air-heaters and the flue gases mean temperature at the outlet is 160 ^oC. Since the largest exergy dissipation and losses in the thermal power plant cycle occur in the steam generator, energy and exergy balances of the furnace and heat exchanging surfaces are established in order to identify the main sources of inefficiency. The zone calculation method is used for determination of temperature profiles and heat distribution along the boiler gas path. An engineering method that considers the most influential parameters is used for estimation of the NO_x emission. On a basis of the conducted analysis several opportunities for improvement are envisaged, including recirculation of flue gases, retrofitting option of lignite pre-drying with flue gases and air preheating with dryer exhaust gases.

Key words: thermal power plant; steam generator; exergy; energy efficiency; combustion; NO_x

ОПЦИИ ЗА РАЗВОЈ НА ЕФИКАСНОСТА И ЗА НАМАЛУВАЊЕ НА ЕМИСИЈАТА НА NO_x ОД ГЕНЕРАТОР НА ПАРЕА ШТО РАБОТИ НА ЈАГЛЕН

А п с т р а к т: Со оглед на тоа што фосилните горива доминираат во светот на снабдувањето со примарна енергија, а тоа ќе трае барем уште неколку децении, потребно е натамошно подобрување на електраните на фосилни горива поради многу причини, вклучувајќи ги влијанието врз животната средина и економското работење. Работата на термоцентралите е проценета врз основа на енергетската анализа, ефикасноста на согорување и нивото на генерирани штетни емисии. Вистинската загуба на корисната енергија често не може целосно да се оправда само со првиот закон за термодинамиката. Истражувањето се занимава со анализа на енергетските и еколошките перформанси на генераторот на пареа на јаглен, кој е дел од 315 MWe единица за производство на електрична енергија. Генераторот на пареа е дизајниран за работа на јаглен – лигнит со низок степен на квалитет со нето-калориска вредност во опсег 6280–9211 kJ/kg, во циклус на пареа на 545 ˚C / 177,4 бари, со излезна температура на вода од 251 ˚C. Воздухот за согорување се загрева на 272˚C во два ротирачки воздушни грејачи и просечната температура на излезните гасови е 160 ˚C. Најголемото трошење на ексергијата и загубите во циклусот во термоцентралата се случуваат во генераторот на пареа, при што енергетските и ексергетските рамнотежи на печките и површините на топлиноизменувачите се воспоставуваат со цел да се идентификуваат главните извори на неефикасност. Врз основа на спроведената анализа се предвидени неколку можности за подобрување, вклучително и рециркулација на отпадните гасови, дополнителна можност за пресушување на лигнитот со димни гасови и загревање на воздухот со издувни гасови на сушилницата.

Клучни зборови: термоцентарла; генератор на пареа; ексергија; енергетска ефикасност; согорување; NO_x

1. INTRODUCTION

The energy needs in the world rely heavily on fossil fuels, since the majority of the power generation is met by coal, natural gas and oil. Even though renewable energy sources are being rapidly developed, their cost and current technology state have not advanced to a stage where they can significantly reduce the global dependence on fossil fuels. Therefore, it is important that fossil fuel plants, and coal-fired ones in particular, improve the efficiency and reduce their environmental impact. The energy conversion in the thermal power plants is a thermodynamic process, which can be improved by energy analysis that enables identification of energy efficient measures required to be addressed, which further leads to plant energy efficiency enhancement, lower cost of electricity and lower emission to the environment. The conventional methods of energy analysis based on the first law of thermodynamics focus on conservation of energy. Taking into account the limitations with this approach, achieving higher efficiency warrants additional analysis based on the second law of thermodynamics, which includes analysis of the exergy efficiency. The term "exergy" was coined in 1956 by Zoran Rant by using the Greek words *ex* and *ergon* meaning "from work" [1, 2], although the concept has existed since Gibbs ('available energy of the body and medium', 1873) [3].

The exergy of a system defines its availability to produce work. The exergy analysis aims to determine the maximum work that can be obtained in a work producing process from a given system [4].

The study [4] presents a number of exergy-based concepts and methods, e.g. efficiency concepts, exergy flow diagrams, exergy utility diagrams, life cycle exergy analysis (LCEA) and exergy economy optimization that are useful tools in order to describe, analyze and optimize energy conversion systems. The work [5] deals with comparison of energy and exergy analyzes of thermal power plants on fossil fuels.

The ratio of energy to exergy in a substance can be considered as an indicator for the improvement of the energy efficiency of large scale energy systems. In this study, an exergy analysis of a 300 MW lignite thermoelectric power plant, located in Ptolemais Greece, is carried out. In order to promote a more efficient solution, the existing lignite thermoelectric power plant is compared with three different cogeneration (CHP (combined heat and power)) systems, employing the Rankine cycle, designed to use the same amount of fuel as the existing one. The performed exergy analysis reveals that the utilization of the proposed CHP systems may result to a significant increase of the energy efficiency, compared to the performance of the existing power plant [6]. The work [7] deals with an exergy analysis of flue-gas pre-dried lignite-fired power system, based on steam generator with open pulverising system, aiming to explore the energy saving potential. In the work [8], Dincer has performed a thermodynamic analysis of reheat cycle power plants. An exergy analysis of a 210 MW thermal power plant is accomplished by Sengupta et al. [9].

Thermodynamic models that combine the concepts of economics cost and exergy analysis provide a possibility of optimising complex energy-generating systems to achieve the best balance between the thermodynamic efficiency and economic cost. Rosen and Dincer in their work [10] have performed an exergo-economic analysis of power plants that operate on various fuels. They investigated the relationship between the capital costs and the thermodynamic losses. Datta et al. [11] have presented an exergy analysis of a coal-based thermal power plant conducted by splitting up the entire plant cycle into three zones. Reddy and Butcher in their work [12] analyzed a waste heat recovery power generation system, based on second law of thermodynamics. A case study of detailed exergy analysis conducted in one unit of a coal-fired power plant is presented in [13]. The analysis identifies the locations and magnitude of exergy destruction in the system and its components and assesses different options to improve the efficiency of the system. In the work [14] the author explains his views that, to better understand and address environmental concerns, we need to focus on the linkages between exergy and the environment, and that much more research is needed in this area if the benefits, which are potentially immense, are to be fully tapped.

The principal nitrogen pollutants generated by combustion plants are nitric oxide (NO) and nitrogen dioxide (NO_2), collectively referred to as NO_x. While the major share of NO_x produced during combustion is NO, once emitted into the atmosphere, it reacts to form NO_2. In coal-fired steam generators, the NO_x is primarily formed as thermal and fuel NO_x and smaller share as prompt NO_x. Thermal NO_x is formed when nitrogen and oxygen from the combustion air combine with one another at high flame temperatures. Fuel NO_x is formed by reaction of nitrogen in the fuel with oxygen in the combustion air, it may occur at lower temperatures and it is dominant in coal-fired boilers. The formation of thermal

NO_x is directly dependent on the local flame temperature, while the amounts of nitrogen in the fuel and oxygen available in the main combustion zone determine the level of fuel NO_x [15].

NO_x control technologies can be classified into two main categories: 1) combustion control techniques (known as primary NO_x control measures) and 2) post-combustion methods. The primary measures tend to prevent the formation of NO_x during the combustion process by reducing peak temperature and reducing residence time of combustion products at peak temperature. They are significantly cheaper and although less effective, they are often applied during pulverized coal combustion. The common combustion control techniques include: low excess air combustion, multi-stage introduction of air and fuel, flue gas recirculation, burner modifications, water/steam injection and combination of these measures.

The existing measures of NO_x reduction can be further improved and their performance can be increased to the maximum level by using mathematical modelling and numerical simulations. Such approach plays an important role in the design of new systems for NO_x emissions reduction, as well as the proper selection of measures for emissions reduction which shall be applied in the plants under development, as well as in the existing ones [16]. This type of research has been successfully applied to describe the phenomena during the combustion of pulverized coal in the power steam boilers. Le Bris [17] and Diez [18] confirm the positive impact of over fire air (OFA) system on the reduction of nitrogen oxides in flue gases by comparing the results of numerical calculations and measurements on the thermal power plants.

As fossil fuels dominate the world primary energy supply and will do it at least for the next few decades, further improvement of the fossil-fueled power plants is needed due to many reasons, including the environmental impact and plant economic operation. The aim of this work is to present a methodology for analyzing the opportunities for improving the efficiency of fossil fuelled steam generators, based on integration of zone thermal calculation method and exergy method, while studying the impact of such measures on the emission of nitrogen oxides. In this study, a zone thermal calculation method of CKTI [19] is applied to the steam generator of a 315 MW lignite-fired thermal power plant located near the city of Prishtina, in combination with an exergy analysis in order to identify the locations, sources and magnitude of thermodynamic inefficiencies. An engineering method that takes into consideration the most influential factors is used for calculation of NO_x emission. Since lignite is the only significant fossil fuel resource in SEE Europe, it is of a great importance to define possible strategies to maximize the efficiency of the existing power plants, while reducing harmful emissions.

2. OVERVIEW OF THE ANALYZED STEAM GENERATOR

The present analysis considers a steam generator which is a part of a thermal power plant with nominal power output of 315 MW (Figure 1) that have been put into operation in the first half of 80-es [20]. The steam generator is designed to be fuelled on lignite with net calorific value (NCV) in range 6280–9211 kJ/kg as received, with a guarantee NCV of 7327 kJ/kg. The unit is aimed for operation in a cycle with feed water temperature 251°C, steam temperature 545°C and pressure 177.4 bar. The combustion air is preheated at 272°C and the flue gases average temperature at the rotating air-heaters outlet is 160°C.

The steam generator is a single gas path tower-type, with forced circulation, a direct tangential combustion system and with a system for slag removal in a solid state. Some of the basic features of the boiler are a large rectangular cross-sectional area (15.75×15.38 m×m), hot flue gas recirculation from the section between the second and fourth stages of the primary superheater and a large number of steam soot blowers (102) [20].

In all operating modes, forced circulation in the boiler evaporator is generated by means of circulation pumps, with the corresponding water level in the vertical steam separator. The evaporation heat exchanging surfaces (water-walls) are made of membrane panels with vertical tubes stretching from the collectors at the bottom of the furnace, via the super-heaters and re-heaters zones, up to the upper collectors, above which only the water economizer is located, in an unassembled box.

The steam superheaters, reheaters and the economiser are installed in one gas channel along the flue gas flow. The superheater second stage (SH2) is built in 'wind-walls' design, covering partially the screen evaporator water-walls in the zone below the suction openings of the hot gas recirculation. The working fluid parameters of the steam generator heat exchanging surfaces are given in Table 1 [21]. Drying and grinding of coal to pulverized state is carried out in fan mills (7 in function and 1

as reserve). The introduction of the coal dust-air-gas mixture into the furnace is done through a tangential firing system. The air and gas flows are divided into two parallel lines, with cracks in front of the rotary air heaters. The initial preheating of air is carried out in steam pre-heaters.

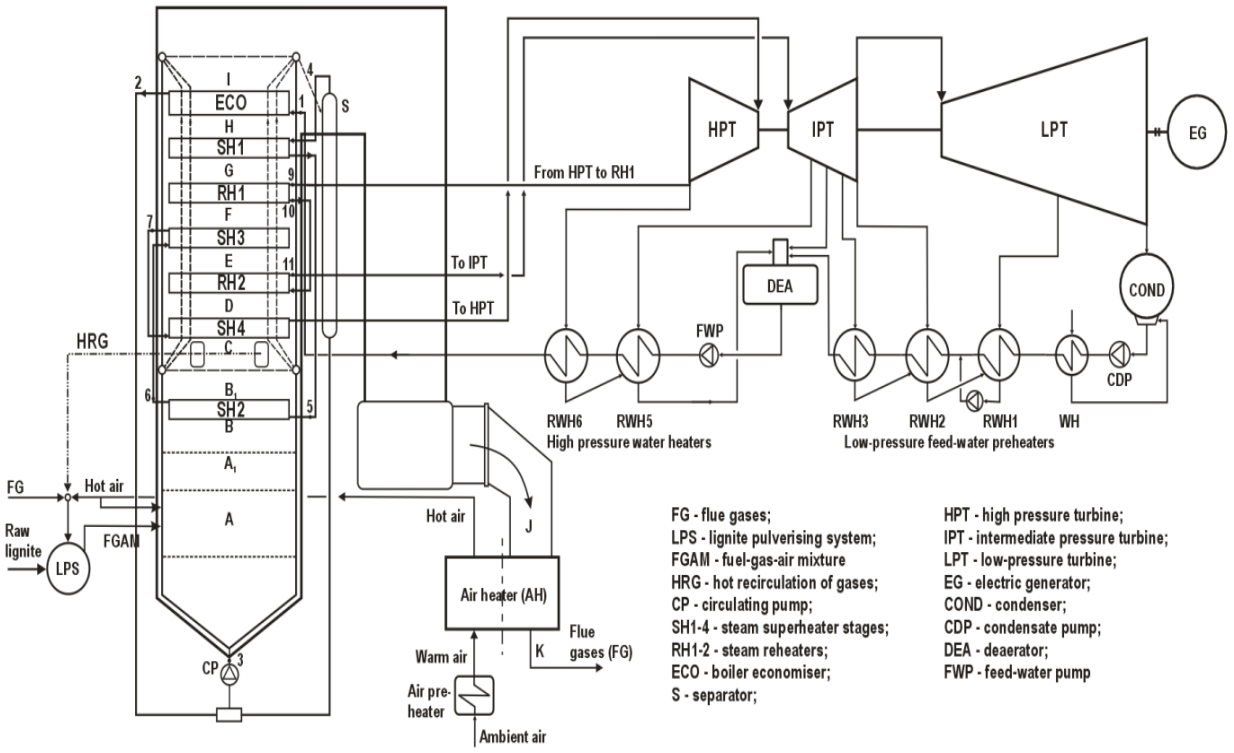

Fig. 1. Flow diagram of the power plant

3. METHODOLOGY

3.1. *The overall approach*

The limitation of the conventional energy analysis, based on the first law of thermodynamics, is that it does not take into account properties of the system environment, or degradation of the energy quality through dissipative processes, which means that it does not characterize the irreversibility of the system [22]. Achieving higher efficiency, therefore, warrants a higher order analysis, based on the second law of thermodynamics, as this enables us to identify the major sources of loss, and shows avenues for performance improvement [22]. Exergy analysis characterizes the work potential of a system with reference to the environment conditions, which is the maximum theoretical work that can be obtained from a system when its state is brought to the reference or standard atmospheric conditions. Specifically, the exergy analysis of a steam generator gives a qualitative picture of the exergy destruction and losses in the energy conversion process and the ability to limit these losses. This information can be useful in designing a new energy efficient system, but also for improving the performance of existing systems.

The first law of thermodynamics efficiency of a system or/and system component is defined as the ratio of energy output to the energy input to the system/component.

The second law efficiency is defined as:

$$\eta_{ex} = \frac{\text{Actual thermal efficiency}}{\text{Maximum possible (reversible) thermal efficiency}} = \\ = \frac{\text{Exergy output}}{\text{Exergy input}} = 1 - \frac{\text{Exergy loss}}{\text{Exergy input}} \quad (1)$$

The overal energy balancing of the steam generator in this work is based on the Normative Method [19], which is also used for determination of temperature distribution along the steam generator gas path. The general approach of the applied model concept is depicted in Figure 2 [21]. Finally, the energy and exergy balance results, as well as the obtained gas temperature distribution, are used as a basis for the estimation of the NO_x concentration.

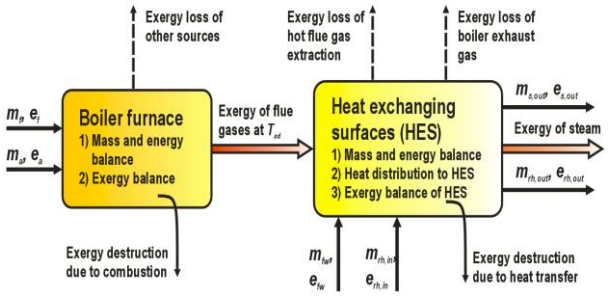

Fig. 2. General model concept of the steam generator exergy balance [30]

3.2. *Energy balance calculations*

The boiler is fueled on lignite with net calorific value (NCV) in a range 6280–9211 kJ/kg as received [20]. The average ultimate analysis of the fuel is presented in Table 2, giving NCV of 7580 kJ/kg. The calculation of the combustion statics, i.e. stoichiometric quantities of oxygen and air, as well as flue gas quantities is based on the Normative Method [19]. The baseline case is set as combustion at 20% excess air, i.e. $\lambda_f = 1.2$.

Table 2

Lignite ultimate analysis

C	H	O	S	N	A	W
23.0	2.3	13.0	0.6	0.6	16.0	44.5

Adiabatic flame temperature is used as reference temperature for calculation of heat transferred in the furnace. It is calculated from the energy balance of the boiler furnace, under the assumption that no heat transfer occurs to the surrounding surfaces and there are no energy losses due to combustion inefficiency and to the surroundings:

$$\text{Fuel chemical energy} + \text{Air physical energy} + \text{Physical energy of recirculating gases} = \text{Thermal energy in flue gases}$$

$$(\text{NCV}) + M_a c_{p,a}(T_a - T_0) + x_{gr} H_{gr} = M_g c_{p,g}(T_{ad} - T_0), \quad (2)$$

where M_a is combustion air mass flow (in kg/s), $c_{p,a}$ is specific heat capacity of air (kJ/kgK) at temperature T_a (K); T_0 is reference temperature, in this case $T_0 = 293$ K, x_{rg} is coefficient of recirculation, i.e. ratio of the recirculated gases flow rate to the total flow rate of flue gases; H_{gr} is enthalpy of recirculating gases (in kJ/kg fuel); M_g is flue gases mass flow (kg/kg fuel), $c_{p,g}$ is the mean specific heat capacity of flue gases mixture (kJ/kgK) and T_{ad} is adiabatic flame temperature (K). As a baseline case, the assumed adiabatic flame temperature at 10 % flue gas recirculation ($x_{gr} = 0.1$), is $t_{ad} = 1550$ °C.

The mean specific heat capacity of the combustion products mixture is calculated by the expression:

$$c_{p,g} = \frac{1}{t_{ad} - t_0}\left(c_{p,ad} t_{ad} - c_{p,g0} t_0\right). \quad (3)$$

With known quantity and composition of combustion products and assumed or known temperature, the enthalpy of flue gases in certain point is determined with the following expression:

$$H_g = H_{gt} + (\lambda - 1) H_{Lt} = H_{gt} + (\lambda - 1) M_{a,\min} c_{pa} t_g \text{ (kJ/kg)}, \quad (4)$$

where H_{gt} (kJ/kg) is stoichiometry enthalpy of flue gases ($\lambda = 1$):

$$H_{gt} = M_{CO_2} h_{CO_2} + M_{N_2}{}^t h_{CO_2} + M_{SO_2} h_{SO_2} + M_{H_2O}{}^t h_{H_2O}. \quad (5)$$

The obtained flame adiabatic temperature value at the baseline conditions is T_{ad}=1826 K. This is a basis for calculation of the exergy destruction due to the combustion process.

The temperature profile along the boiler furnace was determined using the zone method [19]. According to that approach, the mean temperature of flue gases exiting the main combustion zone was calculated by iterative procedure with the expression

$$t_g'' = \frac{\frac{\beta_C (NCV)}{\eta_c} + q_a + q_{f,ph} + q_r - q_6}{(M_g c_{p,g})} - \frac{\sigma_0 \varepsilon_w (T_g'')^4}{B_f (M_g c_{p,g})''} \psi A \quad (6)$$

where β_c is fraction of fuel undergone combustion until the exit of the considered zone, η_c is overall combustion efficiency, q_a is heat content of the combustion air, $q_{f,ph}$ is physical energy of fuel, q_r is heat content in the recirculating gases, σ_0 is Stefan-Boltzman constant ($56.7 \cdot 10^{-12}$ kW/m^{2}K^4), ε_w is emissivity of the furnace walls (average), B_f is fuel consumption (in kg/s), q_6 is heat loss due to the heat contained in the ash and slag falling through the furnace funnel (in kJ/kg), A is total zone surface (in m^2) and ψ is mean thermal efficiency of zone walls [19]:

$$\psi = \frac{\sum \psi_{zi} A_{zi}}{\text{A}}.$$

The mean specific heat capacity of the gas mixture is calculated on the interval between the inlet and outlet gas temperatures (i.e. t' and t''):

$$c_{p,g} = \frac{1}{t' - t''}\left(c'_{p,g}t' - c''_{p,g}t''\right). \quad (7)$$

Temperature of the flue gases at the exit of other zones was also calculated iteratively [19]:

$$t_g'' = \frac{\Delta\beta_c(NCV) + \left(M_g c_{p,g}\right)' t'}{\left(M_g c_{p,g}\right)''} - \left[1 + \left(\frac{T''}{T'}\right)^4\right] \cdot$$

$$\cdot \frac{\sigma_o \varepsilon_w (T')^4 \left[A_m(\psi'' - \psi') + \psi A_z\right]}{2B_f\left(M_g c_{p,g}\right)''}, \quad (8)$$

where $\Delta\beta_c$ is fraction of fuel undergone combustion in the considered zone, T' is flue gas temperature at the zone entry, T'' is temperature at the zone exit, ψ' and ψ'' are thermal efficiencies of the zone inlet and outlet surfaces [19], ψ is mean thermal efficiency of the side zone walls and A_z is the area of the zone side walls.

Temperature at the exit of zone with radiate-convective superheater was calculated as [19]:

$$t_g'' = \frac{2\Delta\beta_c B_f (NCV)}{2B_f (Vc)'' + \alpha_c A_c} +$$

$$+ t' \left[\frac{2B_f\left(M_g c_{p,g}\right)' - \alpha_c A_c}{2B_f\left(M_g c_{p,g}\right)'' + \alpha_c A_c}\right] +$$

$$+ t_z \frac{2\alpha_c A_c}{2B_f\left(M_g c_{p,g}\right)'' + \alpha_c - A_c} - \quad (9)$$

$$- \left[1 + \left(\frac{T''}{T'}\right)^4\right] \frac{\sigma_0 \varepsilon_l (T)^4}{2B_f\left(M_g c_{p,g}\right)'' + \alpha_c A_c} \psi A,$$

where α_c is convective heat transfer coefficient, Ac is heat transfer surface, ‹'› denotes value of variable at the zone entrance and ‹"› denotes value of variable at the zone exit.

Heat received by working fluid water/ steam in each heat exchanging surface is defined with the following equation:

$$Q_i = m_i(h_{out} - h_{in}), \quad (10)$$

where m_i is fluid flow rate [kg/s] and $h_{out/in}$ (kJ/kg) is specific enthalpy of the working fluid at the exit/entrance of the heat exchanging surface.

Heat transferred from the combustion products to each heat exchanging surface is determined with the following expression

$$Q_i = (H_{g,in} - H_{g,out}) B_f \eta_c \eta_{ins}, \quad (11)$$

where $H_{g,in}$ and $H_{g,out}$ (kJ/kg) are enthalpies of flue gas at the inlet/exit of the heat exchanging surface, B_f is fuel consumption (kg/s), η_c is fuel combustion efficiency and η_{ins} is insulation efficiency.

The previous equations were applied for energy balancing of all the heat exchanging surfaces in the steam generator, determining that way the energy distribution to the heat exchanging surfaces and the flue gas temperature change along the boiler height, as well. Further step towards an improvement of the overall procedure will be application of CFD analysis of the steam generator, with approach similar to the one implemented in [24, 25].

3.3. *Exergy balance calculations*

For solid fuels the chemical exergy is calculated with the following semi-empirical relation [26]:

$$e_{fuel,ch} = (NCV)(1.0438 + 0.0013\frac{h}{c} +$$

$$+ 0.1083\frac{o}{c} + 0.0549\frac{n}{c}) + 6740s \quad (12)$$

The total fuel chemical exergy (in kW) is

$$E_{fuel,ch} = B_f e_{fuel,ch}.$$

The specific physical exergy of the working fluid water/steam is generally defined as:

$$e_{w/s} = (h - h_0) - T_0(s - s_0), \quad (13)$$

where h is specific enthalpy [kJ/kg], s is specific entropy (kJ/kgK), T is absolute temperature and the subscript '0' denotes the reference state. In this case, the atmospheric pressure and reference state temperature are taken respectively as: p_0 = 101325 Pa and T_0 = 293 K. The water/steam side exergy flow rate (in kW) can be calculated with the equation

$$E_{w/s} = m_{w/s}\, e_{w/s}.$$

The specific physical exergy of flue gases is calculated as exergy of ideal gases mixture:

$$e_g = (h_g - h_0)\left(1 - \frac{T_0}{T_g - T_0}\ln\frac{T_g}{T_0}\right) + R_g T_0 \ln\frac{p_g}{p_0} \quad (14)$$

$$e_g = c_{p,g}\left[\left(T_g - T_0\right) - T_0 \ln\frac{T_g}{T_0}\right] + R_g T_0 \ln\frac{p_g}{p_0} \quad (14')$$

where h_g (kJ/kg) is specific enthalpy of flue gas at actual temperature, h_0 is specific enthalpy at reference temperature, T_g is absolute flue gas temperature (K), T_0 is reference temperature, R_g is gas constant (kJ/kgK), p_g is flue gas actual pressure (Pa), p_0 is reference pressure and $c_{p,g}$ is gas mean specific heat capacity (kJ/kgK). With $p_g \approx p_o$ and $p \approx$ const, the last term in the previous equations becomes ≈ 0, simplifying the equations. In these equations h_g and $c_{p,g}$ are calculated as for a gas mixture,

$$h_g = \sum x_k\, h_k \quad (15)$$

$$c_{p,g} = \sum x_k\, c_{p,k}, \quad (16)$$

where x_k is the share of each gas component in the mixture (in kg/kg).

The flue gas side exergy flow rate (in kW) is calculated with the equation

$$E_g = M_g B_f\, e_g.$$

Once the exergy flows of all input and output streams were calculated for certain component (i.e. heat exchanging surface), the exergy destruction was calculated as difference between the exergy changes on gas and on water/steam side.

The exergy losses with gas stream are calculated in similar manner. Thus, the specific exergy loss due to hot gas recirculation at level C (Figure 1), at $t_{gr} \approx 1050$ °C and extraction ratio about 10%, is calculated as

$$e_{l,gr} = (c_{pg}t_{gr} - c_{p0}t_0)\left(1 - \frac{T_0}{T_{gr}-T_0}\ln\frac{T_{gr}}{T_0}\right). \quad (17)$$

The exergy loss with the flue gases at the boiler exit is

$$e_{l,ge} = (c_{pg}t_{ge} - c_{p0}t_0)\left(1 - \frac{T_0}{T_{ge}-T_0}\ln\frac{T_{ge}}{T_0}\right). \quad (18)$$

Exergy dissipation due to combustion is calculated from the balance of the boiler furnace:

$$e_{\text{fuel,ch}} + e_{\text{air}} = e_{\text{ad}} + e_{\text{l}} + d_{\text{comb}}, \quad (19)$$

$$d_{\text{comb}} = e_{\text{fuel,ch}} + e_{\text{air}} - e_{\text{ad}} - e_{\text{l}}. \quad (20)$$

The total chemical exergy of fuel is

$$E_{fuel,ch} = B_f e_{fuel,ch}$$

and the total exergy dissipation due to combustion is $D_{comb} = B_f d_{comb}$.

The exergy of the preheated air is:

$$e_{air} = M_a[(c_{p,a}t_a - c_{p,0}t_0)\left(1 - \frac{T_0}{T_a-\mathrm{T_0}}\ln\frac{T_a}{T_0}\right)] \text{ (in kJ/kg)} \quad (21)$$

$$E_{air} = B_f e_{air} \text{ (in kW)}.$$

The exergy of the flue gas mixture at temperature T_{ad} is given as

$$e_{\text{ad}} = M_{\text{g}}[(c_{\text{p,g,ad}}t_{\text{ad}} - c_{\text{p,0}}t_0)\left(1 - \frac{T_0}{T_{ad}-\mathrm{T_0}}\ln\frac{T_{ad}}{T_0}\right)] \quad (22)$$

$$E_{ad} = B_f\, e_{ad} \text{ (in kW)}.$$

Apart of d_{comb}, the exergy losses related to the combustion chamber include losses due to incomplete combustion by chemical (q_3) and mechanical reasons (q_4), heat loss due to radiation and convection (q_5) and loss due to heat contained in the ash and slag falling through the furnace funnel (q_6):

$$e_{\text{l}} = q_3 + q_4 + q_5\left(1 - \frac{T_0}{T_{b,env}}\right) + q_6\left(1 - \frac{T_0}{T_{ash}}\right), \quad (23)$$

where $T_{b,env}$ is average temperature of boiler envelope and T_{ash} is temperature of ash and slag. The values of q_3, q_4, q_5 and q_6 (in kJ/kg fuel) are determined on a basis of the recommendations given in [19]. In this case, it was assumed that q_3 is 1% of the energy entering the furnace with the fuel q = (NCV), q_4 is 2% of q, q_5 and q_6 are 0.5% of q each, and T_{ash} = 873 K (600 °C). Thus, it is obtained e_l = 256 kJ/kg.

3.4. *Estimation of NO_x concentration*

The formation of thermal NO_x is directly dependent on the local flame temperature and residence time of combustion products in the combustion zone, while the temperature peak and the amounts of nitrogen in the fuel and oxygen available in the main combustion zone determine the level of fuel NO_x. The calculation procedure applied here is a modification of the proposed method in [27].

The highest temperature in the main combustion zone is calculated as a mean value between the adiabatic temperature and the gas temperature at the zone exit:

$$T_M = 0.5(T_{ad} + T_{A''}). \quad (24)$$

Temperature range of the NO_x formation reaction is defined as:

$$\Delta T_r = \frac{(T_M)^2\cdot 10^{-5}}{0.614+T_M\cdot 10^{-5}} = \frac{(1679.5)^2\cdot 10^{-5}}{0.614+1679.5\cdot 10^{-5}}. \quad (25)$$

Average temperature of combustion products in the main combustion zone is

$$T_{g,m} = 0.84[(T_M)^4+(T_A'')^4]^{0.25}. \quad (26)$$

Residence time of gases (combustion products) in the main combustion zone is defined as:

$$\tau_r t = \frac{273\xi}{q_V T_{g,m}\nu_g\lambda_b(1+x_r)} \quad (27)$$

where ξ is a degree of fulfillment of the zonw with combustion products; q_V is volumetric thermal load of the main combustion zone,

$$q_V = \beta_c B_f\left(\frac{NCV}{Vz}\right),$$

β_c is combustion efficiency, i.e. fraction of fuel undergone combustion until the exit of the considered zone, λ_b is excess air coefficient at the burners outlet (in the combustion zone) $\lambda_b = \lambda_f - 0.5\Delta\lambda_f$, λ_f is excess air coefficient at the furnace outlet and $\Delta\lambda_f$ is a rise in the excess air coefficient; and ν_g = 0.278 + 0.001 W (in m^3/MJ) is relative specific volume of gases.

The estimation time of reaction of NO_x formation is

$$\tau_r = \frac{\Delta T_r}{T_{ad} - T_{A''}} \left(\frac{q_A L}{300}\right)^{0.5}. \quad (28)$$

Theoretical time to reach equilibrium concentration of NO at temperature T_M,

$$\tau_o = 0.024 \exp\left(\frac{54290}{T_M} - 23\right). \quad (29)$$

Average concentration of O_2 (in kg/m^3) in the main combustion zone is

$$C_{O_2} = \frac{0.21 V_{a,min}[(\lambda_b - 1) + x_r(\lambda_{g,r} - \lambda_b)]\rho_{O_2}}{[V_{g,t} + 1.0161(\lambda_b - 1)V_{a,min}](1 + x_r)}. \quad (30)$$

The concentration of thermal NO_x (in g/m^3, calculated as NO_2) in combustion products at the exit of the main combustion zone is

$$C_{NO_2,t} = 7.03 \cdot 10^3 \cdot C_{O_2}{}^{0.5} \exp\left(-\frac{10860}{T_{M'}}\right) \frac{\tau_r}{\tau_o}. \quad (31)$$

The combined concentration of fuel and prompt NO_x (in g/m^3, calculated as NO_2), taking that average nitrogen content in fuel (as received) is 0.6%, is:

$$C_{NO_2,f} + C_{NO_2,p} = 1.25 \cdot (0.40 - 0.1 N^{ar}) \cdot \cdot N^{ar} \left(\frac{\lambda_b + x_r}{1 + x_r}\right)^2 \left(\frac{T_M - 800}{1000}\right)^{0.33}. \quad (32)$$

Total concentration of NO_x in the combustion products is

$$C_{NO_2} = C_{NO_2,t} + C_{NO_2,f} + C_{NO_2,p} \quad (33)$$

For the reduced steam generator capacity, $D < D_M$, the total concentration of NO_x is:

$$(C_{NO_2})_D = C_{NO_2,t}(D / D_M) + + (C_{NO_2 f} + C_{NO_2 p})\,(D / D_M)^{0.5} \text{ (in g/m}_n^3\text{)}. \quad (34)$$

4. RESULTS AND DISCUSSION

The main purpose of the exergy balance analysis is to identify the components of the system where large exergy losses occur. With that aim, based on an approach described here and in [5, 7, 13], exergy flow in different streams of the Kosovo B power plant steam generator was calculated at different points before and after the process components. Several operating modes of the power plant were subject of analysis, with regard to the real plant design parameters and measured values from the power plant monitoring system [21]. It is well known that, according to the first law analysis, the plant condenser has the highest heat loss in the cycle. However, according to the exergy analysis, it is not very significant due to its low quality and small potential for optimization. On the other hand, about 80–85% of the total exergy destruction occurs in the boiler, which is a reason for devoting more attention to the processes taking place in the boiler plant in order to improve its efficiency.

The flue gases temperature change along the steam generator, determined with the zone method [19, 28], is presented in Figure 3.

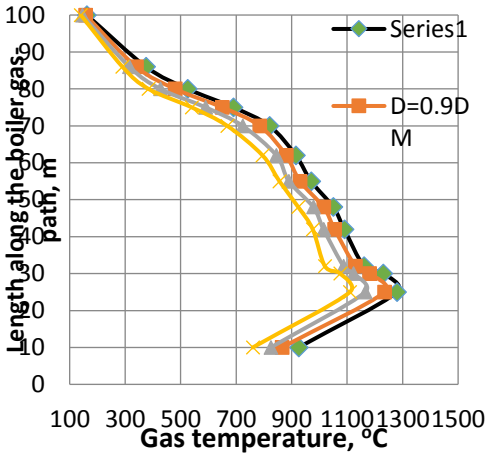

Fig. 3. Temperature profile along the boiler gas-path obtained in the case of nominal regime conditions

The largest exergy destruction in the steam generator occurs due to irreversibility of the combustion process and the internal heat transfer mechanism from the combustion products to the working medium (water, steam and air). Also, there are several other components that contribute to the huge steam generator's exergy dissipation, such as exergy destruction due to the hot flue gas extraction, exergy loss of boiler exhaust gas and loss in the blowdown stream of the boiler. Calculated exergy changes of the streams on the sides of the combustion products and water/steam, as well as the exergy dissipation due to combustion and heat transfer in the steam generator are presented with the Grossman diagram in Figure 4.

A comprehensive research yields more complete insight into the performance of the thermal power plant, as it includes both energy and exergy efficiency analyses [28]. With regard to the steam generator, on the basis of the previous analyzis, optimization of the combustion and heat transfer processes can be achieved through a set of measures. Thus, a potential to reduce the inefficiencies exists in the following: sufficient preheating of combustion air, controlling the amount of excess air at optimal level, lignite pre-drying by use of

recirculating flue gases heat, creating conditions for suitable fuel and air mixing, reducing temperature difference between combustion products and water-steam in every stage of heat transfer process, utilization of the energy contained in the exit gases and other measures.

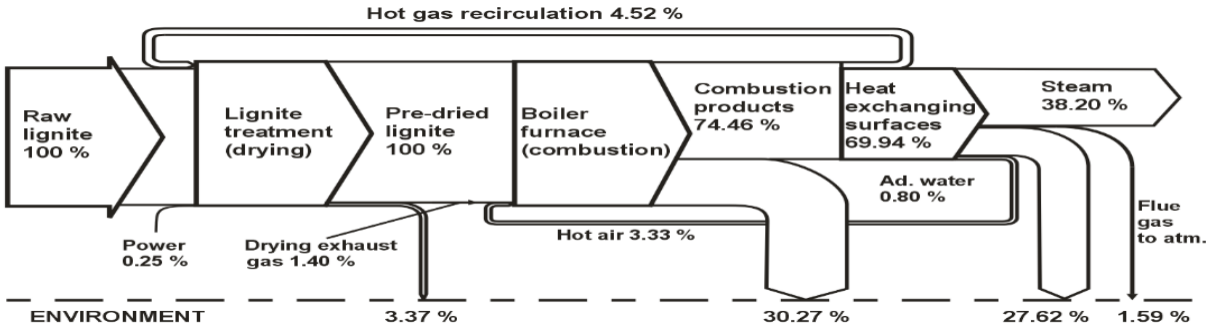

Fig. 4. Grassman diagram of the exergy flow in the steam generator

Taking into consideration the impact of the hot flue gas recirculation, air and fuel staging and excess air control, the results of the calculations of the NO_x concentration from the analyzed steam generator (TPP Kosovo B) are presented in Figures 5 and 6.

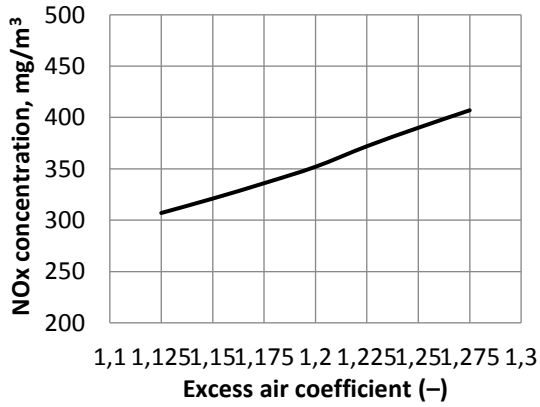

Fig. 5. NO_x concentration vs. excess air coefficient in the main combustion zone concentration

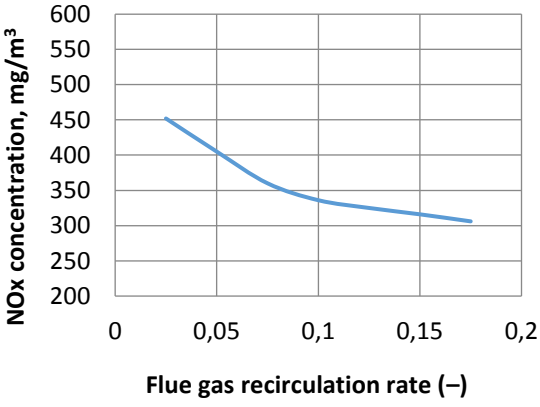

Fig. 6. Influence of the flue gas recirculation rate to the NO_x in the main combustion zone

Changes in the internal of the steam generator with the aim of heat transfer optimization are hard to be undertaken at this point, however, the retrofit measures related with fuel treatment enhancement and combustion process optimization seem to be achievable. In that sense, fuel pre-drying by use of combination of hot and cold recirculation of flue gases and fresh air preheating with dryer exhaust gases with saving potential of over 3%, as well as control of the excess air at optimal level, seem to be the most attractive options for the boiler efficiency improvement. Therefore, these issues will be the focus of further in-depth analysis.

5. CONCLUSIONS

The efficiency of the processes occurring in a utility steam generator of lignite-fired power plant Kosovo B is analyzed from the energy and exergy viewpoint. The optimization model is established, based on an energy balance and exergy method, in order to determine the energy distribution, exergy losses and temperature profiles along the steam generator gas path. The largest exergy destruction occurs due to the irreversibility of the combustion process and the heat transfer between the combustion products and water-steam stream. According to the exergy analysis, the steam generator is responsible for about over 80% of the total loss of exergy in the power plant. Despite the fact that the considered steam generator is already in use more than the technical design time, its energy efficiency is relatively high, since the internal irreversible phenomena do not affect the energy balance. However, the steam generator exergy efficiency is considerably lower, with values below 40% in different operating modes.

Several options are considered to be analyzed in more detailed manner for enhancement of the power plant and boiler efficiencies. In that direction, optimization of combustion and heat transfer through sufficient combustion air preheating, controlling the amount of excess air at optimal level, delivery of pre-dried fuel, creating conditions for suitable fuel and air mixing, reducing temperature difference between combustion products and water-steam in every stage of heat transfer process, utilization of the energy contained in the exit gases and other measures can be effective in controlling the exergy losses. Since pre-drying of lignite by use of combination of hot and cold flue gas recirculation, air preheating by use of dryer exhaust gases and excess air control at optimal level seem to be the most attractive options for the boiler efficiency improvement, these issues will be the focus of further research efforts. Most of these measures have consequent impact to the NO_x concentration in flue gases.

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Original scientific paper

MEASUREMENTS AND CALCULATIONS FROM AN INSTALLED PV/T SOLAR SYSTEM IN THE KINDERGARTEN "PAVLINA VELJANOVA" – KOČANI

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A b s t r a c t: Kindergartens are one of the biggest consumers of electrical and heat energy. Since they have limited installation area, hybrid (PV/T) collectors are the perfect fit for these kinds of objects. One hybrid collector is composed of an upper part of photovoltaic cell and below is the thermal part for hot water. The main objective of this paper is to present measured data about the performance of an installed solar system at a kindergarten in Kočani, Republic of Macedonia. The kindergarten is based in the center and that has about 350 kids enrolled. Measurement equipment is installed separately for the thermal and electrical part. Calculations about how the installed capacity corresponds to the needs of the kindergarten are also included. All of the produced electricity is mainly used for lightning the hall, offices and backyard. Thermal energy is also utilized for preparing food and children's nurseries.

Key words: photovoltaic; thermal energy; measurements; kindergarten

МЕРЕЊА И ПРЕСМЕТКИ ОД ИНСТАЛИРАН PV/T СОЛАРЕН СИСТЕМ ВО ДЕТСКАТА ГРАДИНКА „ПАВЛИНА ВЕЛЈАНОВА" – КОЧАНИ

А п с т р а к т: Детските градинки се едни од најголемите потрошувачи на електрична и топлинска енергија. Бидејќи имаат ограничен простор за инсталација, хибридни (PV/T) колектори се идеално решение за овој вид објекти. Еден хибриден колектор е составен од горен дел со фотоволтаични ќелии, а под нив се наоѓа термички дел за врела вода. Главна цел на овој труд е да се изнесат измерените резултати од работата на инсталираниот соларен систем во детска градинка во Кочани, Република Македонија. Детската градинка се наоѓа во центарот, а во неа се запишани 350 деца. Мерната опрема е инсталирана одделно за термичкиот и електричниот дел. Пресметките за тоа како инсталираните капацитети кореспондираат со потребите на детската градинка се исто така вклучени. Сета произведела електрична енергија е користена главно за осветлување на ходниците, канцелариите и дворот на градинката. Термичката енергија е исто така искористена за подготовка на храна.

Клучни зборови: фотоволтаик; термичка енергија; мерења; детска градинка

AIMS AND BACKGROUND

Big improvements in solar technology resulted in more efficient and extensive use of renewable sources. These systems require no fuel to operate and do not release harmful emissions. Implementing eco-friendly systems is affecting the environment in a positive way. Moreover, modern living dictates increases in energy demand. Since fossil fuels are about to disappear in the nearest future, there's got to be an alternative energy source to rely on. This has a big influence on the environment, since a large amount of the produced energy comes from fossil fuels.

Using green energy solves a part of the problems regarding air pollution and energy needs. People are still skeptical about their inconsistency and price. But the numerus subsidies, national support programmes and incentives towards green energy sources will provide good base for future development. For example, the kindergarten "Pavlina Veljanova" in Kočani has already taken a big step

towards using renewable sources with the help of global ecology funds.

Kindergartens have great demand of thermal and electrical energy, but limited area for installation of solar systems. Total area requirement of PV/T collector is around 40% less [1] compared to photovoltaic and thermal collectors with the same total capacity. So, these kinds of system are especially interesting for hotels, schools or hospitals. Buildings are also major energy consumers throughout their lifecycle [2]. Pavlina Veljanova is the central kindergarten in the city and has three (3) smaller kindergartens under her belt. The main kindergarten is preparing food for them all. The produced thermal energy from the hybrid system is mainly utilized to satisfy the kitchen, or nursery needs. On the other hand, electrical energy is used for lighting the halls, offices and backyard. Picture of the installed system is shown in Figure 1.

Fig. 1. Installed hybrid (PV/T) system in the kindergarten „Pavlina Veljanova" – Kočani

The aim of this paper is to present the techno-economic aspect of installing this kind of solar system. Measurement equipment is installed separately for the thermal and electric part. To accomplish this objective, first, a background analysis about the energy needs of the kindergarten is done. Measured data is gathered for each month of the following two periods: January 2015 to June 2015 and January 2016 to January 2016. The data show valuable information about produced thermal energy, produced electrical energy and energy bills that match the period of research

EXPERIMENTAL

Corresponding to the energy demand of the kindergarten an optimal solar system is installed. A questionnaire was being answered by the working personal to gather data of how much hot water and electricity is needed. Indisputable is the fact that this system will not cover all of the needs, but around 20% will be covered by the solar system.

From the information that were gained it is evident that thermal energy is needed more compared to the electricity (Tables 1 and 2). Liquid type PV/T collectors, air type PV/T collectors, concentrating PV/T collectors and building integrated PV/T collectors are the four different types of PV/T collectors [3]. For this kindergarten, a liquid type PV/T POWER TERM HYBRID collector with 750 W thermal and 150W electrical power was chosen. Five (5) collectors were installed at an azimuth angle of 55 degrees (Figure 2) for better absorption of solar radiation in late autumn and early spring. It is argued that photovoltaic cells are operating more efficient at lower temperature. The circulation of the working fluid in the hybrid system will affect positively on the working performance on the photovoltaic part. Typically, power increases with 0.2 to 0.5% per °C decrease of temperature, but when a PV module is integrated in a façade or roof, it will normally get warmer, than a module mounted in free air [4].

Table 1

Thermal needs of the kindergarten

Kitchen	Desert (l)	Snack (l)	Lunch (l)	Hot water per day (l)	Number of kids	Overall hot water per day (l)
Required amount of water for preparing food (45°)	0.2	*0.1*	0.3	*0.6*	*120*	*72*
Required amount of water for cleaning the dishes per child (45°)	0.5	0.1	1.2	1.8	120	216
Nurseries				*200*		*200*
Overall						*488*

Table 2

Electrical needs of the kindergarten (lighting)

Place	Type of light	Overall lighting places	Power (W)	Working hours (h)	Consumed electrical energy (W/h)
Backyard	LED	2	16	24	768
Offices, halls and kitchen	LED	35	16	2	1120
Overall consumed electrical energy					1888

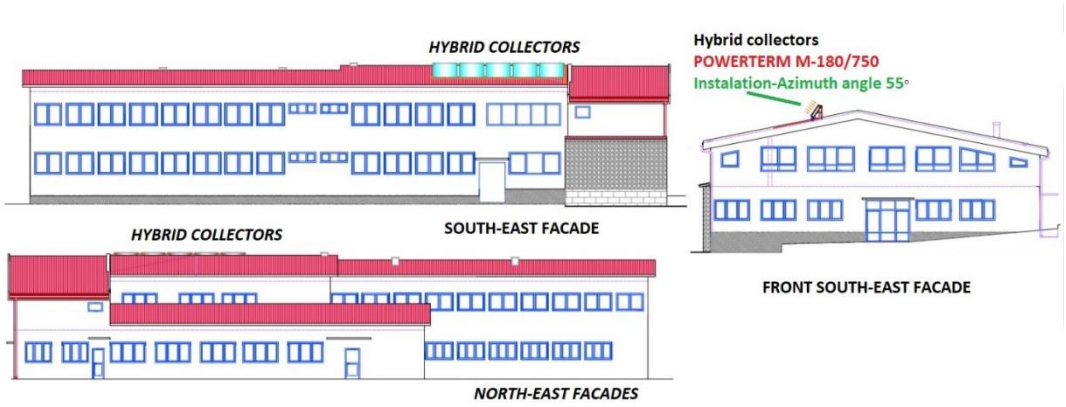

Fig. 2. Place of installing the hybrid system

Characteristics of the installed system: Thermal part: pumping group GIAKOMINI, expansion tank of 15 liters, polypropylene pipeline of 22 mm diameter for connection between the circuit elements, air release valves. In addition, external tank with a capacity of 300 liters is installed so hot water can be stored for a longer period of time. Detailed circuit drawing is shown in Figure 3. The system is independent of the city network and it is installed on the roof. Mixture of water (i.e. water-ethylene-glycol) is circulating throughout the collectors to extract heat from it. It is important so specify that three water heaters with a capacity of 80 liters and machine for washing dishes (4 kW installed el. heater inside) are the main consumers of thermal energy.

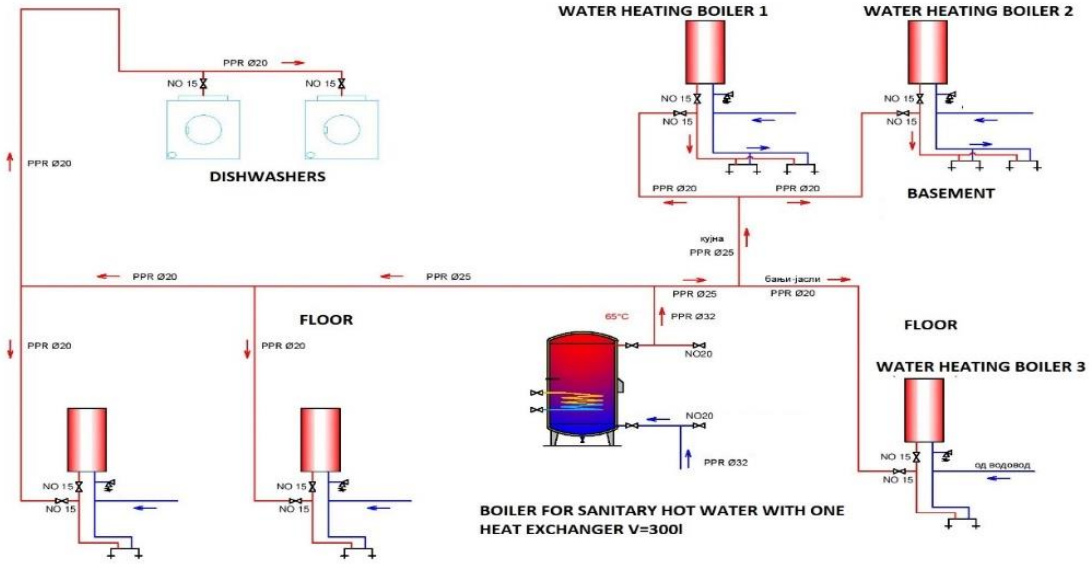

Fig. 3. Thermal consumers and water installation

Photovoltaic part: Consist 5 hybrid panels of 1.5 m^2. Each panel has 750 W thermal and 180 W photovoltaic power. The electricity generated by this system comes in two charging regulators STECA type 15 and 20 A. This energy is stored in 4 accumulators with tubular cells with a total capacity of 640 Ah. From here, through a 2 kW power inverter (shown in Figure 4), the produced electrical energy passes through the DATA LOGGER 4000 controller. This device has the ability to store data for 6 months and transmit it to the micro SD card for further analysis. From the measuring device, electricity comes to 38 lighting places in 7 corridors. In order to make additional savings, everywhere the old traditional lights are replaced with 15 W LED lights, which are activated by motion sensors. Only 2 lighting places work 24 hours (at the entrance to the kindergarten and on the internal stairs). There are periods when not enough electricity is produced from the system, like in the winter months or evenings. In this situation the system automatically switches to the local grid. Electricity from local grid does not go through the DATA LOGGER 4000 control device.

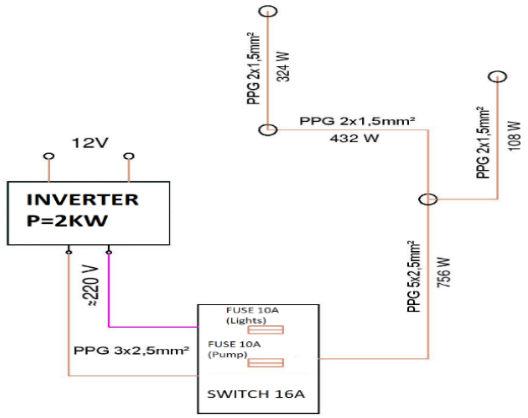

Fig. 4. Electrical scheme

RESULTS AND DISCUSSION

Delivered thermal and electrical energy from the hybrid system for the period January 2015 – June 2015 explained in Tables 3 and 4 and in Diagram 1.

Comparison between the electricity bills before and after installing the hybrid solar system (the first year of work) explained in Table 5.

Smaller consumption of electrical energy for January: 509.90 kWh; smaller consumption of electrical energy for February: 637.90 kWh; bigger consumption of electrical energy for March: 322.90 kWh; smaller consumption of electrical energy for April:1037.20 kWh; smaller consumption of electrical energy for May: 210.10 kWh; smaller consumption of electrical energy for June: 594.40 kWh.

Comment for the first year of work: The photovoltaic part of the hybrid collector showed relatively good performance in the first year of its work. On the other hand, the thermal part had relatively poor results compared to the installed power. Moreover, the thermal part of the hybrid collector produced a much higher value than the measured, but due to the fact that the biggest consumer of thermal energy was out of operation and that resulted in stopping the recalculation of the working fluid. This also affected in reducing the electrical efficiency as a result of the low flow rate, because PV cells become relatively warm and that results in lower electrical output. A low heat transfer results in a large temperature gradient and therefore in a high PV temperature. This decreases thermal and electrical efficiency [5]. In the summertime, when there was a very large number of sunny days, they remained unused. With an installed thermal power of 3750 W, it is illogical to get produced thermal energy of around 160 kWh for March. This number should be several times higher.

Table 3

Delivered electrical energy from the hybrid system

Data 2015	Delivered electrical energy (overall in kWh)
January	57.94
February	219.6
March	129.3
April	201.3
May	241.4
June	243.4
Overall	1092.94

Table 4

Delivered thermal energy from the hybrid system (kWh)

Data 2015	Delivered thermal energy		Overall
	L5/heat	L6/cool	
January	32.4	48.1	80.5
February	64.4	61.6	126.0
March	93.1	66.9	160.0
April	122.8	71.2	194.0
May	171.2	86.0	257.2
June	185.1	90.9	276.0
Overall	669.0	424.7	1093.7

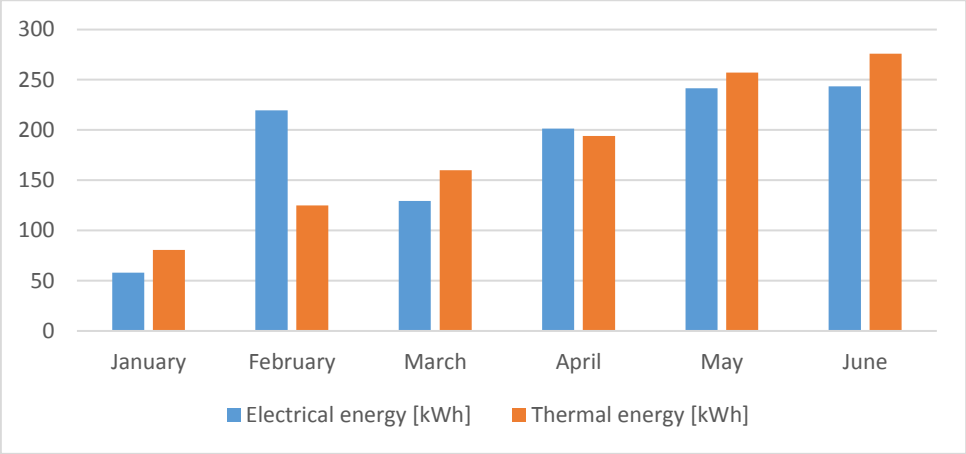

Diagram 1. Produced thermal and electrical energy from the hybrid system for 2015

Table 5

Comparison between the electricity bills in 2014 and 2015

Period	Consumption (kWh)	Value (Denars)	Period	Consumers (kWh)	Value (Denars)
26.12.2013 – 1.01.2014	3.205.00	13.887.99	30.12.2014 – 31.01.2015	2.695.10	12.074.04
23.01.2014 – 8.02.2014	4.599.00	19.928.51	27.01.2015 – 28.02.2015	3.961.10	17.745.73
1.03.2014 – 31.03.2014	3.010.00	13.043.02	28.02.2015 – 31.03.2015	3.332.90	14.931.39
27.03.2014 – 30.04.2014	3.757.00	16.279.93	28.03.2015 – 24.04.2015	2.719.80	12.184.71
1.05.2014 – 7.05.2014	2.564.00	11.110.39	25.04.2015 – 31.05.2015	2.353.90	10.545.47
1.05.2014 – 7.05.2014	2.823.80	12.236.17	23.05.2015 – 25.06.2015	2.229.40	9.987.71

However, despite the insufficient utilization of the thermal part of the hybrid collector, electricity bills are reduced (Diagram 2.). This is due in particular to the operation of the hybrid system, then replacing the classical 80 W Neon light bulb with a LED lights of 18 W. All these new lights are turned on using a motion sensor. Furthermore, staff is advised when and how to use the main consumers of electrical and thermal energy.

Measurements from the installed system in the kindergarten "Pavlina Veljanova" for 2016 explained in Tables 6 and 7.

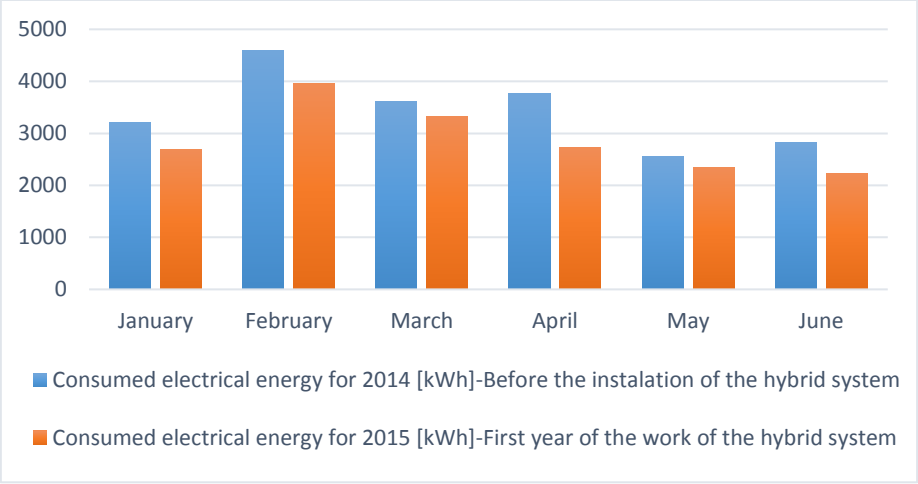

Diagram 2. Consumed electrical energy before and after the installation of the hybrid system

Table 6

Electrical performance of the PV/T collector

Period 2016	Delivered electrical energy (Overall in kWh)
January	86.4
February	232.5
March	150.6
April	220.4
May	250.5
June	285.4
Overall	1225.8

Table 7

Thermal performance of the PV/T collector

Month 2016	Delivered thermal energy (kWh)		Overall (kWh)
	L5/heat	L6/cool	
January	324.0	204.5	528.5
February	341.7	224.4	566.1
March	374.3	245.6	619.9
April	425.7	252.7	678.4
May	468.7	261.6	730.3
June	493.6	266.5	760.1
Overall	2.428.0	1.455.3	3.883.3

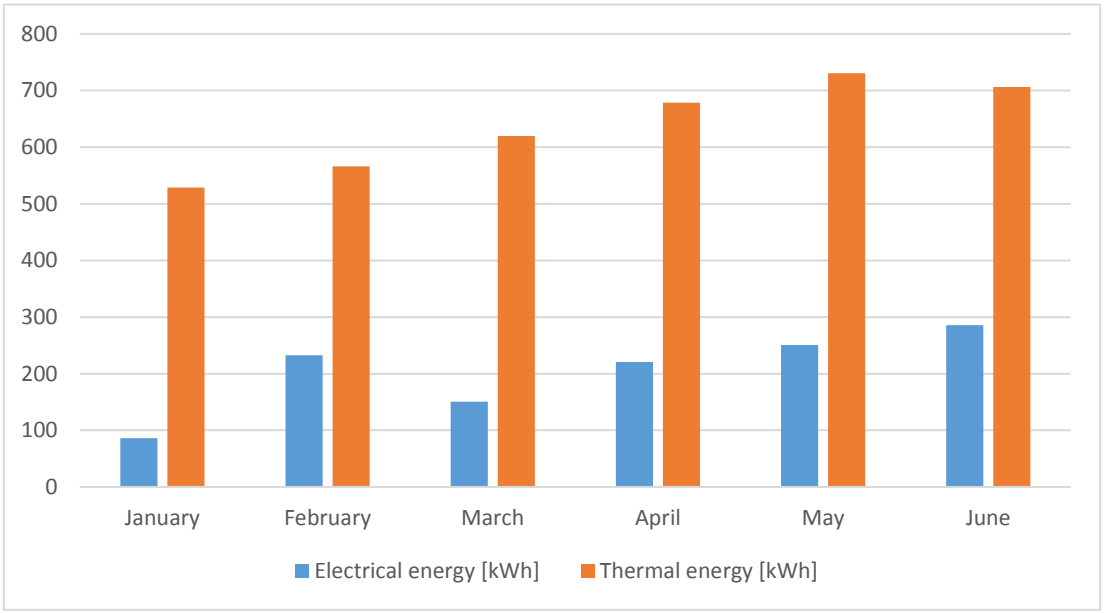

Diagram 3. Production of thermal and electrical energy for the period of 2016

Comparison of electricity bills for the period from January 2015 to June 2015 with the period January 2016 – June 2016 explained in Table 8 and Diagram 4.

Bigger consumption of electrical energy for January: 1081.60 kWh; smaller consumption of electrical energy for February: 225 kWh; bigger consumption of electrical energy for March: 230 kWh; bigger consumption of electrical energy for April: 571 kWh; bigger consumption of electrical energy for May: 387.3 kWh; bigger consumption of electrical energy for June: 227 kWh.

Comment for the second year of work: Characteristic for the second year of using the hybrid system is that it has a drastically higher production of thermal energy, but the consumption of electricity has increased. This is primarily due to working of the reestablished dishwashers (4 kW el. heater), new thermal consumers were additionally installed (80 liters water heater boiler), air conditioners in the offices and the unethical use of the main consumers of the working personnel. The largest difference compared to the 2015/2016 bills is in January for 1081 kWh. On the other hand, February is the only month where there is less electricity consumption compared to the previous year – 45 kWh.

Table 8

Comparison of consumed electricity for January–June 2015 and 2016

Period	Consumption (kWh)	Value (Denars)	Period	Consumption (kWh)	Value (Denars)
30.12.2014 – 31.01.2015	2.695.10	12.074.04	24.12.2015 – 31.01.2016	3.776.70	16.881.81
27.01.2015 – 28.02.2015	3.961.10	17.745.73	26.01.2016 – 29.02.2016	3.736.10	16.699.3
28.02.2015 – 31.03.2015	3.332.90	14.931.39	28.02.2016 – 31.03.2016	3.562.90	15.924.30
27.03.2015 – 30.04.2015	2.719.80	12.184.71	28.03.2016 – 24.04.2016	3.290.80	14.708.90
25.04.2015 – 31.05.2015	2.353.90	10.545.47	25.04.2016 – 31.05.2016	2.741.20	12.252.27
23.05.2015 – 25.06.2015	2.229.40	9.987.71	23.05.2016 – 25.06.2016	2.456.40	10.982.71

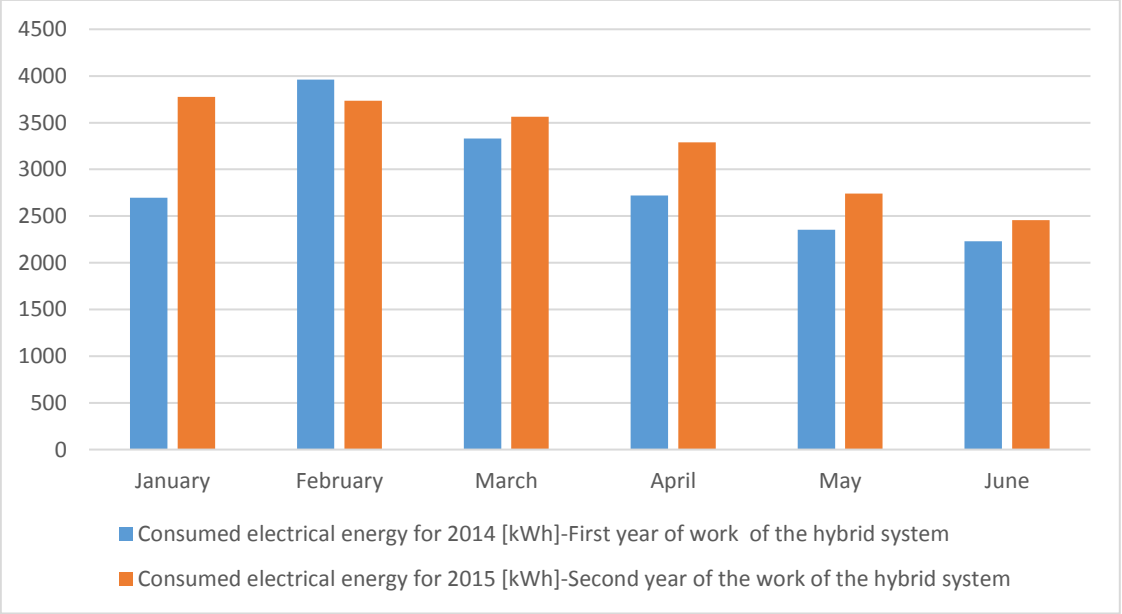

Diagram 4. Consumed electricity for kindergarten „Pavlina Veljanova" – Second year of operation of the hybrid system.

CONCLUSIONS

The most important conclusion of the whole paper is that there is a serious lack in system performance, field tests and long term monitoring of PVT systems. Hybrid systems represent an innovative solution that ensures production of heat and electricity and with its concept enables more efficient operation of the photovoltaic part. However, they are still a topic of research, monitoring and verification. The purpose of this research was to give an overview of the results, experiences and problems in the past two years of the hybrid system in a kindergarten. Sonja Popovska Vasilevska [6] gives a similar review in a pilot project regarding installing hybrid system in kindergarten. Energy efficiency from an economic point of view is defined as the scope of all changes that resulted in reduced amounts of used energy. Improving energy efficiency without changing the quality or quantity of energy demand for the consumers is a good sign for economic development. The best view of how for the hybrid system is performing at "Pavlina Veljanova" in Kočani would be given in the third year of its work. During this period, all the problems that have appeared in his previous period will be overcomed.

The prediction for hybrid collectors is that they will be used mostly in places where there is limited space for installation, and the requirements for heat and electricity are high. Classic examples for that

are: buildings, business facilities, kindergartens and schools. Many questions regarding optimal combination of installed electrical and thermal power need to be answered. After passing those obstacles, the large potential for PV/T can be accomplished. Various types of hybrid collectors will be produced, and the current ones will be further improved. This would result in an increase in the efficiency of the collectors themselves and a reduction in their price. The price of hybrid collectors in 2015 was quite high to be installed (480 euros for 1 panel with 180 W electric and 750 W thermal installed power). But in 2018 for the same price you can get a collector with higher installed power: 1000 thermal and 300 photovoltaic and now the price is quite low and available for every home. It's forecasted that they'll probably face the similar future as photovoltaics. Not long ago, installing photovoltaic system was quite expensive, and now their price is significantly dropped, making them affordable for every home.

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Original scientific paper

TREATMENT OF OILY EMULSION

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A b s t r a c t: The separation and treatment of oily emulsion, after mechanical treatment of refinery sludge, shall be explained in this paper. The oily emulsions generated in the process of treatment of refinery sludges have complex composition and therefore complex techniques are applied. The chemical composition analysis is approximate due to difficulties in representative sample taking because of the presence of different hydrophobic and hydrophilic components. Methodology applied follows several steps: extraction of the emulsion from the sludge and storing it in a closed tank, physicochemical stabilization by gravity in a period of one year, treatment of liquid phase into the waste water treatment plant (WWTP) in OKTA by adapting the mechanical and chemical part, upgrading the biological phase with NPK nutrition and introducing additional microbial species, transport of semisolid hydrocarbons from the tank to the open lagoons and possible operations for further recovery/disposal using soil bioremediation with both endogen microorganisms and plant cultures.

Key words: oily emulsion; refinery sludge; treatment; separation; bioremediation

ТРЕТМАН НА МАСНА ЕМУЛЗИЈА

А п с т р а к т: Во овој труд се објаснуваат сепарацијата и третманот на масната емулзија добиена по механички третман на талогот од рафинирање. Масните емулзии генерирани во процесот на третирање на талогот од рафинирњето имаат комплексен состав и затоа се применуваат сложени техники. Анализата на хемискиот состав е приближна поради тешкотиите при земањето на репрезентативен примерок поради присуството на различни хидрофобни и хидрофилни компоненти. Методологијата се применува во неколку чекори: екстракција на емулзија од милот и нејзино складирање во затворен резервоар, физичко-хемиска стабилизација во период од една година, третман на течната фаза во пречистителната станица за отпадни води на ОКТА со адаптирање на механичкиот и хемискиот дел, надградба на биолошката фаза со додавање НПК и внесување дополнителни видови микроби, транспорт на полуцврсти јаглеводороди од резервоарот до отворените лагуни и можни операции за понатамошна регенерација / користење на биолошко заздравување на почвата со ендогени микроорганизми и растителни култури.

Клучни зборови: масна емулзија; мил од рафинерија; третман; сепарација; биоремедијација

INTRODUCTION

In OKTA refinery within 30 years of operations, oily sludges are produced as a waste product. Such sludges are generally characterized as three phase, multi-component, organic sludges containing water, oil and solids.

Because of the presence of hazardous materials in such sludges, their disposal presents a huge problem for the petroleum refineries, taking into consideration all aspects, especially environmental, social and economic ones.

Various methods have been proposed for disposing of oil sludges, including solvent extraction, mechanical dewatering, thermal treatment, chemical fixation and stabilization (mixing the oily sludge with a solidifying agent such as cement), but to date none have proven to be entirely satisfactory. The process operation itself is time and money consuming to obtain the necessary permits for.

There is, however, a continuing search for a technique of disposing refinery sludges which both meets environmental regulations and is economically feasible.

AIM

The aim in finding solution to treat the emulsion derives from:

- The need to empty the tank, clean it and repair to use it to store final oil products, gasoline or diesel.
- Expenses for heating the emulsion during the winter period.
- Avoiding the risk for environmental incident-leakage into soil. Due to the high water content, the possibility for freezing and damage was high.

SCOPE OF THE WORK

- Emulsion separation by gravity and pumping the mid layer of the tank (up 4000 m^3) and directed to waste water treatment plant (WWTP).
- Upgrade of the biological part of the plant with nutrients and specialized cultures.
- Regular monitoring.
- Transferring the semisolid emulsion from the tank into the sludge pools and mixing it with soil.
- Bioremediation (micro and phytoremediation) on site of the heavy part of the emulsion mixed with soil.

SEPARATION OF 8000 m^3 EMULSION STORED IN A TANK

The emulsion of water and hydrocarbons got by decanting was stable and stored in one of OKTAs tanks (Figure 1). It was partially separated in three phases. The water phase was to be treated (Figure 2) into the existing WWTP (mechanical, physicochemical, biological part), using the already present microorganisms or additionally improved culture where needed.

Taking into consideration the strong bonds between the compounds, organic and inorganic solids and the water, the challenge was the separation of the emulsion with quantity 8000 m^3 and quality given in the Table 1.

Fig. 1: OKTA tank

Fig. 2. Extracting of emulsion

Table 1

Emulsion quality

Emulsion analysis	Unit	Tank
pH		7.5
Oily materials	mg/l	7000
COD	mg/l	340000
Humidity	% m/m	78.9
Organic sediments	% m/m	17
Inorganic sediments	% m/m	4.2

The samples of emulsion from different heights of the tank showed tendency to separation after 24 hours. Roughly, there were three layers into the tanks (Figure 3), surface light hydrocarbons and other colloids, mid layer of water and insignificant percentage of solids and bottom layer with heavy hydrocarbons and organic and inorganic sediments.

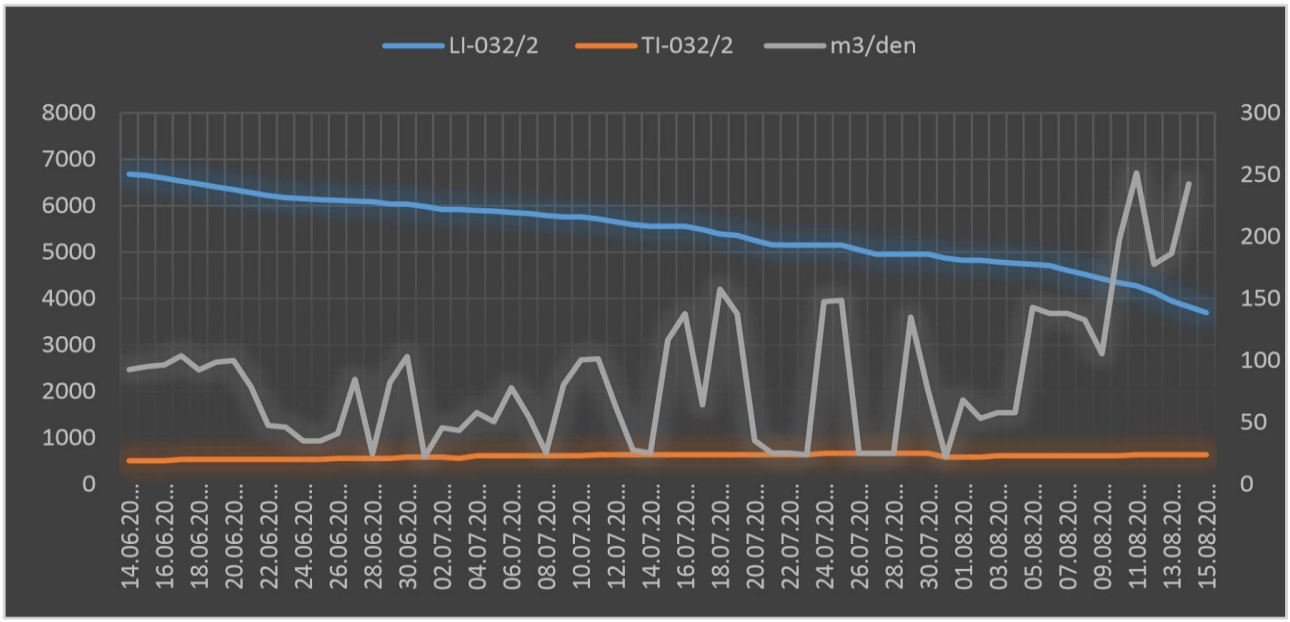
Fig. 3. Tank profile

The submersible pump has been placed on 2 m of the top of the tank and the oily water (4500 m^3) was directed through the existing pipeline to the mechanical part of the WWTP. The dynamic of pumping was adapted to the technical capabilities of the pump and often disturbances because of the pump blockage from the mechanical particles (Graph 1).

The technological treatment of the emulsion with the waste water is given in Figure 4. As it is shown it is performed in three phases: physico-chemical, mechanical, and biological. The mechanical waste water treatment (point T-182 in Figure 4) is performed through a precipitator for mechanical impurities, oil separator and precipitator-regulator. The precipitator (T-182 in Figure 4) is designed to keep the robust particles by means of a circular water movement.

The oil separator represents horizontal precipitator and from where the oil products that are floating on the surface are fed by means of return pipes located at the entrance and exit of the chambers, and the sediment from the bottom is fed by hydroelevators to the sludge separator. The precipitator-regulator (T 183/184 in Figure 4) performs an additional separation of the oil products and ensures the oil product concentration in the waste water to be less than 70 mg/l (Figure 5). After the mechanical treatment, the waste water mixed with chemical enters the flotation tank (T-186 in Figure 4) in order to be chemically treated (Figure 6). The partly separated waste water goes further in facilities for a joint biological treatment of the industrial and sanitary waste water. Prior to that, the mechanical impurities are separated in the basin for sanitary waste water. The mixing of the industrial and sanitary waste water is performed in the mixing chamber by means of airflow supplied through the perforated pipes located on the bottom of the mixer.

The *biological treatment* is performed in the basins-precipitators for bioaeration. Here a biochemical oxidation of the waste water is performed by means of aerobe microorganisms which colonies create an active mud. Before it is released in the recipient, the waste water can be disinfected with chlorination (T-188 in Figure 4).



Graph 1. Dynamic of pumping the emulsion

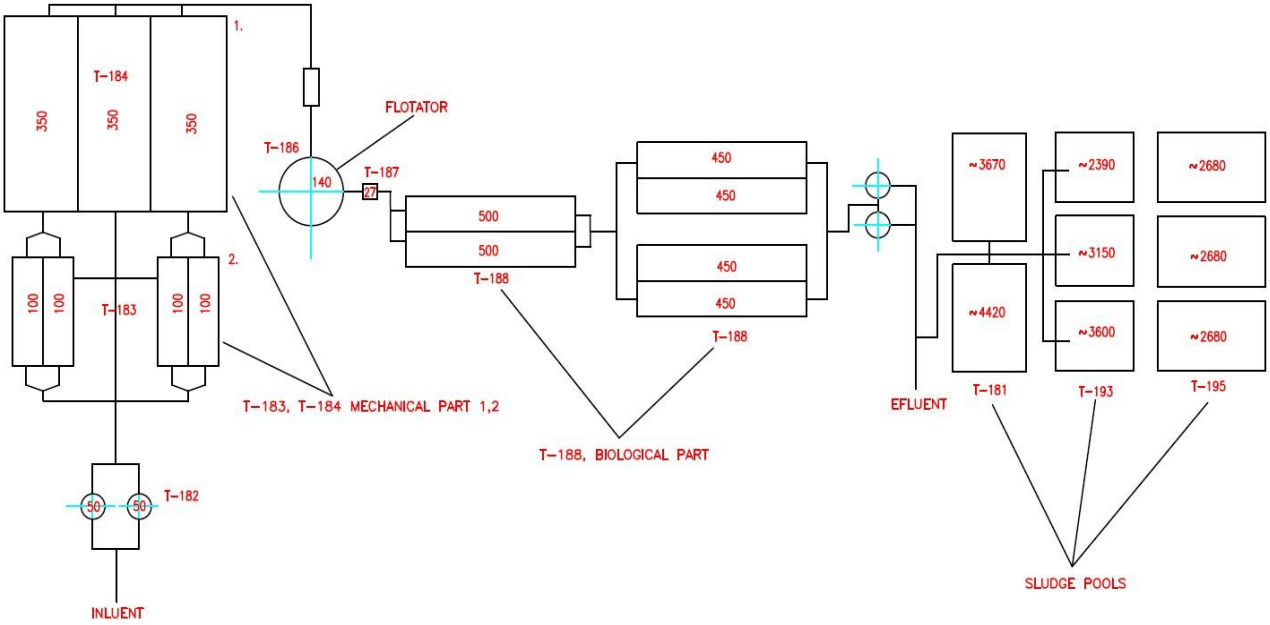


Fig. 4. WWTP scheme

Fig. 5. Separation of the oil products

Fig. 6. Flotation upgrade of the biological part of the plant with nutrients

NPK nutrients were added to the 1st biological pool in order to increase the aerobic biomass which is already existing in the plant for many years. In the same time in the 2nd biological degree poll were added new environmentally friendly bacteria to increase the efficiency of the biodegradation in the system where the input COD is 400 mg/l (the limit COD is 125 mg/l), the waste water inflow is 20 m^3/h into the poll with volume of 150 m^3 (Figure 7). The number of colonies was visually followed on MPN (most probable number) agar plates. The rough method gave satisfactory results (Figure 8).

The transfer of semisolid sludge was done in two ways: by installing new pipe and engaging the services of company specialized for industrial cleanings.

Fig. 7. 2nd biological degree poll

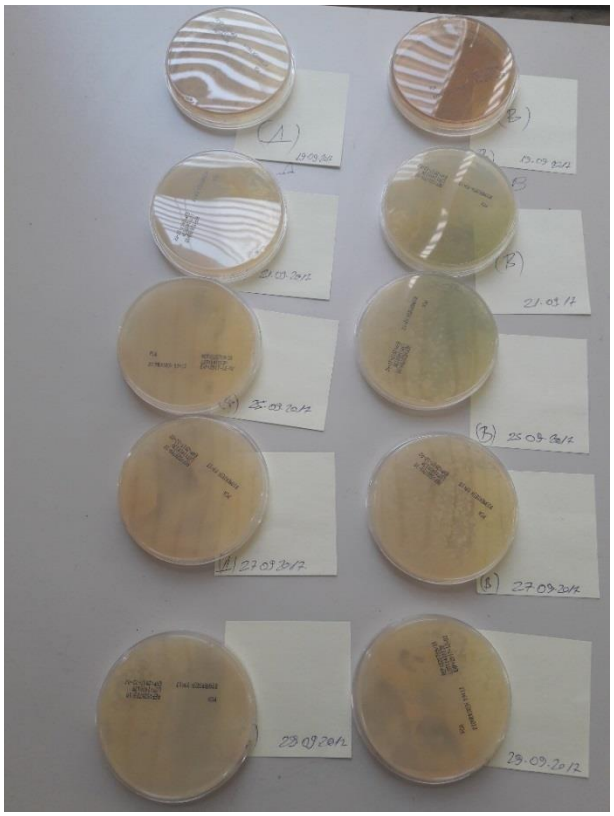


Fig. 8. MPN agar plates

Regular monitoring

Prior to their release in the recipient, all water flows that occur at the refinery site pass a complete treatment. Waste water quantities entering the WWTP are given in the Table 2:

Table 2

Quantity of waste water entering WWTP

Type of waste water	Quantity
Industrial waste water	around 134 m^3/h
Sanitary waste water	around 10 m^3/h
Storm water	depending on the meteorological conditions

The quality of the industrial waste water entering the waste water treatment facility is shown in Table 3:

Table 3:

Industrial waste water quality

Parameter	Quality
Oily material	up to 5 000 mg/l
Suspended material	up to 300 mg/l
BOD	up to 250 mg/l
COD	up to 250 mg/l
pH-value	7.5 – 8.5

The treated waste water must not disturb the quality of the recipient, i.e. the Bujkovačka River (third category water recipient). The treated waste water released in the recipient has to satisfy the following requirements (Table 4):

Table 4

Treated waste water quality

Parameter	Quality
Oily material	up to 15 mg/l
Suspended material	up to 35 mg/l
BOD	up to 25 mg/l
COD	up to 125 mg/l
PH-value	6.5-9.0

The monitoring was conducted according to the defined quality requirements for the parameters pH, hydrocarbon (oily materials), COD, suspended particles into the discharged water. The analyses were performed internally in OKTA's chemical laboratory. The concentrations of the pollution elements in the treated waste water deriving are far lower than the allowed values given by the design and the legislation.

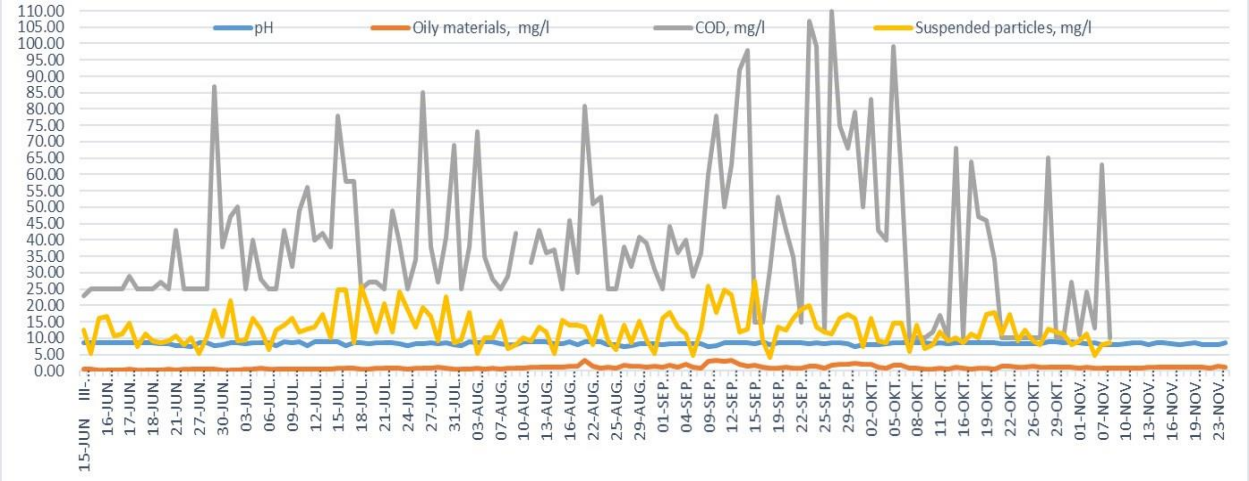


Fig. 9. Discharged water sample analyses N17 WWTP

TRANSFERRING THE SEMISOLID EMULSION FROM THE TANK INTO THE SLUDGE POOLS AND MIXING IT WITH SOIL

Extensive mixing with dragger took place in order to facilitate the aerobic bacteria that are present in the oily soil pool for two decades and put in the other pool as starter culture.

To the sludge on the bottom of the tank (Figure 10), with the already mixed sludge with soil into T195/3 would apply bioremediation technique on the basis on microbial degradation of oily fractions, by mixing it with soil (Figure 11). There the autochthonous cultures together with the specialized one would convert the soil into nonhazardous according to the criteria on control parameters which are defined into Rulebook.

Namely, the applied methodology shall be according to the best available techniques in EU (BREF), for which we have contact with reference companies in the region and worldwide.

Fig. 10. The sludge of the bottom

BIOREMEDIATION (MICRO AND PHYTOREMEDIATION) ON SITE OF THE HEAVY PART OF THE EMULSION MIXED WITH SOIL

The planting on site took place in November with assistance and know-how by the Faculty for Agriculture and Food – Skopje (Figure 12). There were planted three types of seeds on 200 m^2 soil mixed with hydrocarbons which are expected to give results in the spring. In parallel, laboratory samples were conditioned and visually gave good results due to the seeds germination in controlled conditions (Figure 13).

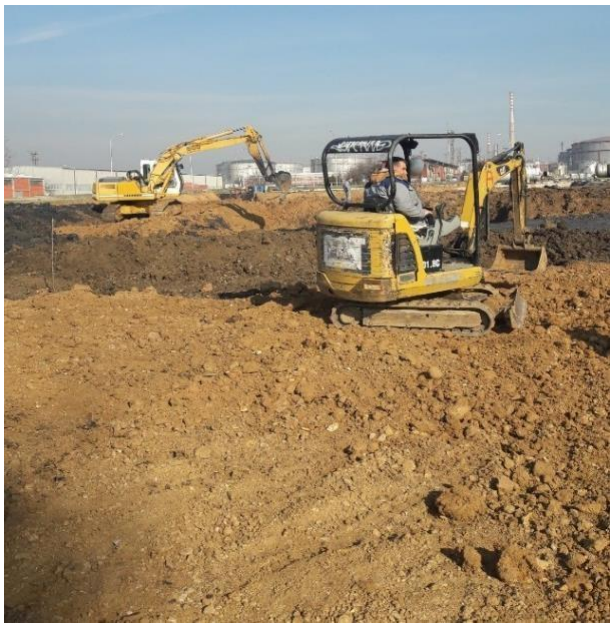


Fig. 11. Mixing with soil

Fig. 12: Soil mixed with hydrocarbons

Fig. 13. Laboratory samples

SUMMARY

The water-hydrocarbon emulsion in OKTA was collected in a tank in quantity of approximately 8000 m^3**.** It was generated while heating the sludge while mechanical treatment on the open sludge lagoons was done.

The nature of this emulsion shows no possibility for physicochemical separation due to the strong bonds within and the nature of hydrocarbons and solids. Three layers are visually distinguished: heavy hydrocarbon and inorganic sediments at the bottom, mainly water at the mid, and water and light hydrocarbon on the top of the tank.

The analyses showed huge variation and therefore it is very difficult to give precise and accurate data, due to difficulty to having a representative sample. Furthermore, the emulsion has not been mixed for 1.5 year and some physicochemical reactions contributed to slow separation.

The volume of 4000 m^3 emulsion was pumped and directed into WWTP using appropriate method and upgrade of biological treatment in the plant by nutrition and introducing new microbiological cultures.

The semisolid phase of the emulsion was transferred into the open lagoons and mixed with soil for bioremediation and phytoremediation. The preliminary finding give satisfactory results.

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Original scientific paper

KINETIC STUDY OF CATALYZED PYROLYSIS OF POLYOLEFINES

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A b s t r a c t: The aim of this work is to provide knowledge on catalytic degradation of waste mixture of high density polyethylene (HDPE) and propylene (PP) by thermogravimetric analysis (TGA). All experiments have been conducted in temperatures range 293–873 K, utilizing heating rates of 3, 5, 7, 10 and 20 $Kmin^{-1}$. TG experiments have shown the efficiency of different amounts of ZSM-5 catalyst in polyolefin degradation. The obtained TG curves indicate that catalytic process of pyrolysis occurs in one-step degradation. The apparent kinetic parameters such as activation (E_a) energy and pre-exponential (A) factor have been determined using an integral iso-conversion Flynn-Wall-Ozawa model free method.

Key words: non-isothermal kinetics; thermal degradation; kinetic parameters; model free methods

КИНЕТИЧКА СТУДИЈА ЗА КАТАЛИЗИРАНА ПИРОЛИЗА НА ПОЛИОЛЕФИНИ

А п с т р а к т: Целта на овај труд е со термогравиметриска анализа (TGA) да обезбеди знаење за каталитичка деградација на смесата на отпадот од полиетилен со висока густина (HDPE) и пропилен (PP). Сите експерименти се спроведени на температури од 293 до 873 К, користејќи стапки на греење од 3, 5, 7, 10 и 20 $Kmin^{-1}$. ТГ-експериментите покажаа ефикасност на различни количини катализатор ZSM-5 во деградација на полиолефин. Добиените ТГ криви укажуваат на тоа дека каталитичкиот процес на пиролиза се јавува во еден чекор деградација. Привидните кинетички параметри како што се активациона енергија (E_a) и пре-експоненцијален фактор (A) се определени со користење на интегрален изоконверзионен метод на Flynn-Wall-Ozawa со слободен модел.

Клучни зборови: неизотермална кинетика; термичка деградација; кинетички параметри; методи на слободен модел

1. INTRODUCTION

Petroleum is still the main source of liquid fuels, but its reserves are declining. Nowdays, the most promising resource for fuel production is the waste plastic, because of its high heat of combustion and increasing availability in local communities [1]. The conversion methods of waste plastics into fuel depend on the type of plastics, because this process requires feedstocks which are non-hazardous and combustible [1]. This waste is mainly produced by households and consists mainly of four polymers: polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinylchloride (PVC). So far, the waste is manly dumped or incinerated, but these options are forbidden in some countries [2]. A proper high-temperature pyrolysis process resolves the disposal problems and also recovers energy from the waste [3]. Pyrolysis is an endothermic process where polymers are decomposing to the small molecules in absence of oxygen. The most important parameters that control the process of pyrolysis are temperature, heating rate, time of reaction and pressure. Catalysts are used to increase the reaction rate

and decrease the operating temperature of the process [4]. For different type of plastics different catalysts are used, such as FCC [5], zeolites, ZSM-5 [7, 8], silica, alumina [9], basic catalysts [10] and many others. The type of reactor used is also very important for successful pyrolysis of plastics. Reliable data such as hydrodynamics, heat transfer, and kinetics are necessary for the optimal design and operation of pyrolysis reactors. Therefore, the knowledge on kinetics of pyrolysis is important in probing degradation mechanisms as well as in predicting the thermal stability of polymer waste [10]. For a better understanding of pyrolysis, thermogravimetric analysis is often applied (TGA) [11]. The polyolefins (polyethylene and propylene) decompose into a number of olefins and paraffins without a residue [12]. The obtained experimental TG data are suitable for subsequent kinetic calculations [13, 14]. There are various suggestions for calculation of the kinetic parameters of polymer degradation. Model-fitting and model free methods are the most used in determination of kinetic parameters from non-isothermal TG data. The first methods requires an assumption of a reaction model before activation energy and a frequency factor can be interpreted. Calculated activation energy is an average value for an entire conversion level, and single heating rate is used for non-isothermal conditions. On the other hand, the model free method has no need for the presumed reaction model. This method allows a variation of the activation energy with respect to both the temperature and the extent of conversion for an independent model. The advantage of the model-free analysis is founded on its simplicity and on the avoidance of errors connected with the choice of a kinetic model [15]. Polyethylene and polypropylene are in significant quantities in municipal plastic wastes. A lot of attempts have been made to identify the reaction model of the polyethylene and polypropylene pyrolysis [16, 17].

The purpose of this work is to investigate the kinetics of catalytic decomposition of waste mixture of high density polyethylene (HDPE) and polypropylene (PP). Our previous investigation has shown that the pyrolysis of this mixture into liquid and gaseous fuels proceeds with high efficiency under certain reaction conditions. The catalyst employed in this work was ZSM-5 zeolite, and non-isothermal TGA experiments were performed at several linear heating rates, in the temperature range of 30–700°C. The Flynn-Wall-Ozawa model-free non-isothermal method was used to calculate activation energy (E_a) and pre-exponential factor (A).

2. EXPERIMENTAL

2.1. *Materials*

Commercial mixture of high density polyethylene (HDPE) and polypropylene (PP) waste was investigated. The samples were re-granulated in form of 5–6 mm pellets. The melting temperature of HDPE+PP mixture, as determined by DSC, was 400 K and 436 K, respectively. The employed catalyst was ZSM-5 with ratio of $SiO_2 : Al_2O_3 = 23:1$ in powder form, with surface area 425 m^2g^{-1}. The catalyst was purchased from Alfa Aesar Gmbh & Co KG with high purity grade.

2.2. *TGA procedure*

The kinetic analysis of samples with catalyst was performed by thermogravimetric Perkin Elmer TGA Diamond analyzer. 11 mg of the sample was placed in a ceramic pan on the sample holder of the balance. All samples were pyrolyzed in the temperature range from 30 to 700°C in nitrogen atmosphere. The volume flow of N_2 was 3.5 l min^{-1}. The experiments were carried out in non-isothermal conditions at heating rates of 3, 5, 7, 10 and 20 $Kmin^{-1}$. The weight loss data were recorded as a function of time and temperature using the Pyrys software of the instrument.

2.3. *Theoretical background*

Generally it is assumed that the rates of conversion during polymer degradation are proportional to the concentration of reacted material. The rate of conversion follows Arrhenius equation:

$$\frac{D\alpha}{\mathrm{dt}} = Ae^{\frac{-E_a}{RT}} f(\alpha), \qquad (1)$$

where E_a (kJ mol^{-1}) is the activation energy, the pre-exponential factor is A (min^{-1}), and the gas constant is R (8.314 J $mol^{-1}{\cdot}K^{-1}$).

Conversion, α, is normalized form of weight loss data of decomposed sample and is defined as:

$$\alpha = \frac{m_0 - m_t}{m_0 - m_f}, \qquad (2)$$

where: m_0 is the initial mass of the sample, m_t is the actual mass of sample after "t" minutes (mg), and m_f is the final mass of sample after pyrolysis (mg).

The expressions of conversion function $f(\alpha)$ are used for describing solid-state reaction, hence many authors restrict the mathematical function

$$f(\alpha) = (1 - n)^n. \qquad (3)$$

where n is order for solid-state reactions.

2.4. *Mass loss kinetics as determined by the Flynn-Wall-Ozawa (FWO) method*

The reaction rate in logarithmic form in integral iso-conversional Flynn-Wall-Ozawa method [18, 19], using Doyle's approximation [20], can be expressed as:

$$\ln\beta_i = \ln\frac{E_\alpha A_\alpha}{R_g(\alpha)} - 5.331 - 1.052\frac{E_\alpha}{RT\alpha_i} \qquad (4)$$

The activation energy (E_a) is calculated from a plot of natural logarithm of heating rates, $\ln\beta_i$, versus $1000/T\alpha_i$, which represents the linear relation for any constant value of the conversion α, recorded at different heating rates β_i. The activation energy, E_a is calculated from the slope –1.052 E_a/R of Eq. (4).

3. RESULTS AND DISCUSSION

3.1. *Thermogravimetric analysis*

Catalytic decomposition of commercial mixture of HDPE and PP with different amounts of ZSM-5 catalyst, at the lowest heating rate (3 K min^{-1}), are shown in Figure 1. It is evident that the catalytic degradation of HDPE and PP mixture, under nitrogen atmosphere, takes place most rapidly. From Figure 1 it is evident that pyrolysis of a raw mixture and ZSM-5 catalyst exhibit single-step degradation.

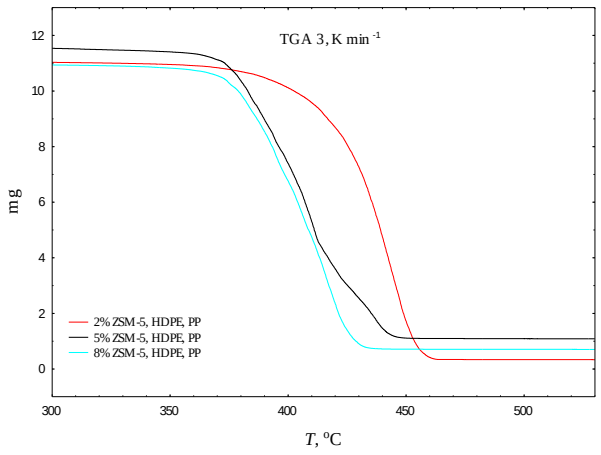

Fig. 1. Catalytic decomposition of HDPE and PP waste mixture with different amounts of ZSM-5 catalyst

The mass loss for samples with 8% ZSM-5 started at 641 K for a heating rate of 3 Kmin^{-1}, which corresponds with onset temperature of polyolefin mixture and ZSM-5 catalyst. The same temperatures for samples with 5 wt% and 2 wt% ZSM5 catalyst are 644.3 K and 658.3 K, respectively for, the same heating rate.

As can be seen from the plot, the small amount of ZSM-5 considerably decreased the initial temperature of reaction, which could be ascribed to the Brönsted acid sits that can remarkable promote the cracking reaction of polyolefines [21–23].

3.2. *Kinetic analysis*

The obtained data from thermogravimetric analysis recorded under non-isothermal degradation were evaluated according to the model-free integral Flynn-Wall-Ozawa (FWO) method. The kinetic parameters, activation energy E_a, pre-exponential factor A and linear correlation coefficient (R^2) were obtained. The kinetic parameters such as E_a obtained by FWO method was calculated according to eq.(4) for a given value of conversion, α in range of 0.05 to 0.9 (Table 1). According to the iso-conversional method, the kinetic parameters are dependent on the extent of conversion [25, 26].

From Table 1 it is observed that FWO method gives reasonable values of activation energy and correlation coefficient for all samples with different amount of catalyst. Until the value of α = 0.1, the obtained values are slightly differing from each other, but increasing the extent of conversation (α = 0.1 – 0.9) increases the difference between calculated E_a for all samples (Table 1).

Thus, the average E_a of 195.58 kJ mol^{-1} decreases to 159.5 kJ mol^{-1} by adding ZSM-5, which shows the significant influence of this catalyst on the activation energy.

Table 1

Calculated values for E_a and R^2 catalytic pyrolysis of waste mixture with ZSM-5 catalyst determined by FWO method

	2% ZSM-5 HDPE. PP		5% ZSM-5 HDPE. PP		8% ZSM-5 HDPE. PP	
α	Ea kJ mol^{-1}	R2	Ea kJ mol^{-1}	R2	Ea kJ mol^{-1}	R2
0.05	137.13	0.954	139.33	0.794	138.34	0.959
0.1	152.27	0.975	149.75	0.949	147.49	0.962
0.2	168.27	0.992	158.21	0.961	144.26	0.959
0.3	183.18	0.988	171.46	0.971	141.43	0.990
0.4	206.49	0.954	190.59	0.978	151.77	0.985
0.5	210.33	0.969	207.35	0.977	158.67	0.985
0.6	235.53	0.969	217.93	0.960	161.78	0.982
0.7	223.51	0.958	217.73	0.951	164.17	0.978
0.8	227.61	0.974	194.77	0.959	164.06	0.974
0.9	218.54	0.976	194.92	0.953	165.99	0.970
average	195.58		184.21		159.52	

The FWO plots depicted in Figure 2-a; 2-b and 2-c show the plot of $1/T$ against ln β to calculate the activation energy E_a and pre-exponential factor. The samples of the largest amount of catalyst (8 wt%) have the lowest value of E_a. Reducing the amount of catalyst from 8 wt% up to 2 wt% results in increasing the values of E_a.

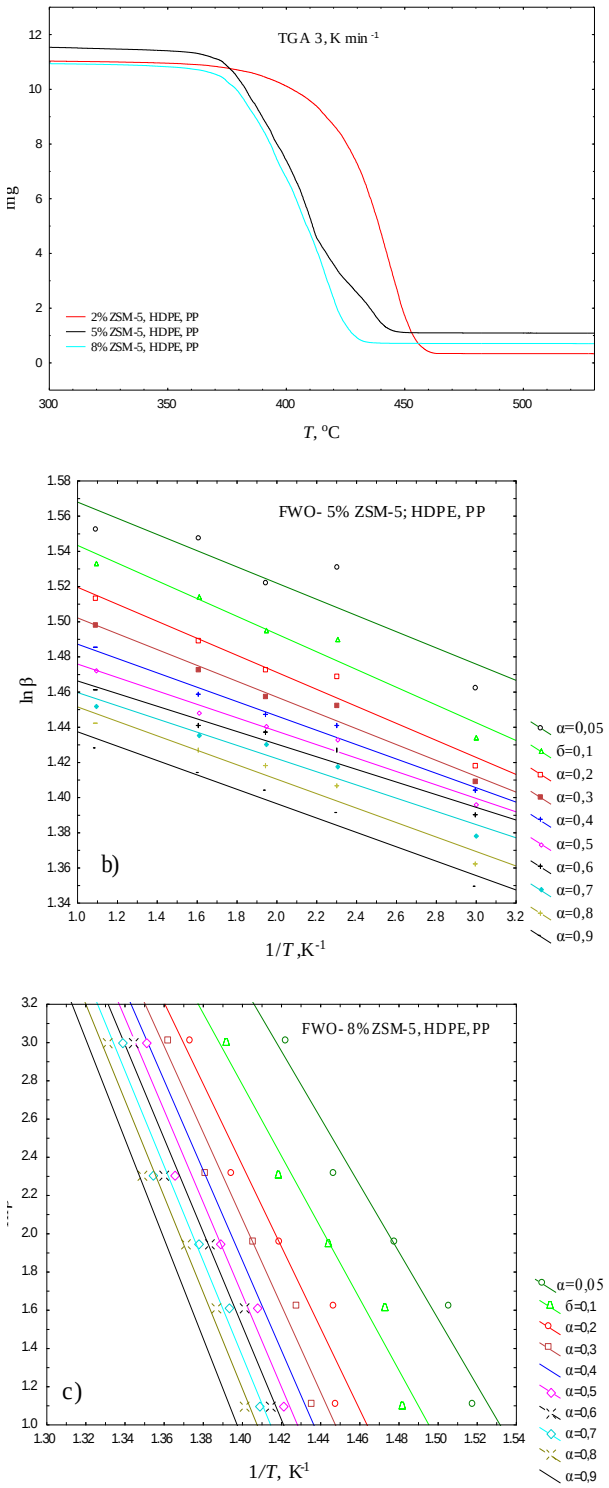

Fig. 2. Dependence ln$\beta = f(1/T)$ at different degrees of conversion α for a mixture of HDPE and PP and different amounts of ZSM-5 catalyst

The series of E_a values were determined from the slopes of each straight line obtained from different heating rates (3 – 20 Kmin^{-1}) for defined α (Table 1). The calculated values of pre-exponential factor A (for $n = 1$), obtained by substituting the obtained value of E_a back into the intercept of Y axis are summarized in Table 2.

Table 2

The obtained values of pre-exponential factor A [min^{-1}] of catalytic pyrolysis of waste mixture with ZSM-5 catalyst determined by FWO method

	2% ZSM-5 HDPE. PP	5% ZSM-5 HDPE. PP	8% ZSM-5 HDPE. PP
α	*A* min^{-1}	*A* min^{-1}	*A* min^{-1}
0.05	7.63E+11	2.17E+12	1.38E+12
0.1	4.39E+12	1.76E+13	3.03E+13
0.2	2.12E+14	1.13E+14	7.90E+14
0.3	1.73E+12	1.44E+15	1.39E+16
0.4	1.19E+13	4.93E+16	1.12E+18
0.5	4.48E+13	1.06E+18	4.92E+19
0.6	8.77E+13	7.44E+18	2.16E+20
0.7	1.52E+14	7.76E+18	2.54E+19
0.8	1.74E+14	1.42E+17	7.25E+19
0.9	2.89E+14	1.51E+17	1.73E+19
average	9.78E+13	1.66E+18	3.82E+19

It is evident that in FWO method there is a variation of the kinetic parameters with extent of conversion, for an independent model [16, 17] (Table 1, Figure 3).

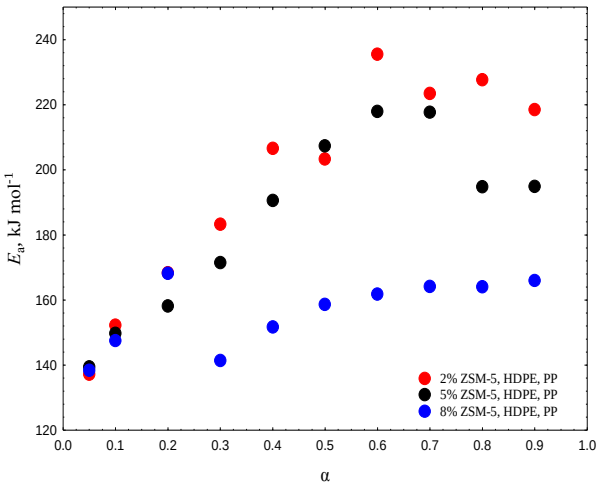

Fig. 3. The variation of E_a values with extent of conversion for FWO method

The variation in E_a for the sample pyrolized with 2% catalyst is 98.5 kJ mol^{-1}, for that one with 5% ZSM-5 in 78 kJ mol^{-1} and for the with 8% catalyst in 28 kJ mol^{-1}. These changes in the E_a of the reaction are due to the multi-step processes (melting or recrystallization during the reaction) and complex processes described by solid state reaction, or reversibility of the current mechanism of reaction.

4. CONCLUSION

The catalytic degradation of waste polymer mixture of HDPE and PP into valuable products (liquid and gaseous) was found to be a useful method of managing plastic waste. The results of TGA indicate that the ZSM-5 improved the polymer degradation. The apparent kinetic parameters were evaluated using Flynn-Wall-Ozawa iso-conversion method. The pyrolysis process performed by 8 wt% ZSM has the lowest value of E_a = 159.5 kJ mol^{-}. The kinetic parameters, activation energy and pre-exponential factor vary with the extent of conversion for FWO method.

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Original scientific paper

ENVIRONMENTAL IMPACT ASSESSMENT FOR USE IN SEEDBED PROCESSING A VIBRO-COMBINATORS SOIL TILLAGE

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A b s t r a c t: Nowadays, humanity is facing a major controversy over the choice of appropriate technology of soil tillage. It is the time that is required an intelligence choice between conventional technologies (classical) for seedbed preparation, assuming an intense mechanical processing of soil, which affects soil structure and soil organic matter, and the conservative tillage technologies for seedbed preparation, which removes these disadvantages in terms of an accepted decrease of the production [1]. Seedbed preparation for crop establishment (sowing) is one of the most important agricultural works, as is done with high energy consumption and high costs. The quality of this work influences in large measure the germination of crop and the productivity that can be obtained per hectare. Therefore, at present, there is different equipment from the ones found in classical cultivation technologies, which in single pass can achieve tillage with minimum energy consumption, thus creating optimal conditions for sowing and for obtaining higher yield without soil degradation [2]. These devices are called combinators. Of all the existing combinators, most performant are the vibro-combinators. The advantages of using vibro-combinators are: required preparation of seedbed in difficult working conditions and preservation of moisture and total porosity and reducing of soil compression degree. Such important factors can ensure fast, uniform and early germination of seeds, these requirements standing at the basis of abundant harvests. Advanced methods of statistical analysis (univariate three-way ANOVA and multivariate analysis, PCA, Manova and HCA) began to be successfully used in recent years for the study of soil behavior at the interaction with the working bodies. In order to carry out the research, we settled three parcels in the plains of the west of Romania so that we could have there different types of soils which are representative for that specific area. From each profile was collected soil samples in three steps of 6, 12 and 18 cm. For each sample were performed six repetitions ($N = 6$). We started by measuring the particle size distribution (granulometric composition) and the main physical properties of the soil (moisture, bulk density, total porosity and soil compression degree).

Key words: vibro-combinator; soil tillage; bulk density; total porosity; compression degree

ПРОЦЕНА НА ВЛИЈАНИЕТО ВРЗ ЖИВОТНАТА СРЕДИНА НА УПОТРЕБАТА НА ВИБРО-КУЛТИВАТОРИ ЗА ОБРАБОТКА НА ПОЧВАТА

А п с т р а к т: Денес човештвото се соочува со големи контроверзи околу изборот на соодветна технологија за обработка на почвата. Изборот треба да се изврши помеѓу конвенционалните технологии за подготовка на почвата за сеидба, земајќи предвид дека се врши интензивна механичка обработка на почвата која влијае врз структурата на почвата и органската материја во неа, и конзервативните технологии за обработување на почвата за сеидбата, за да се спречи намалување на производството [1]. Подготовката на почвата за сеидба е една од најважните земјоделски работи, која бара голема енергија и високи трошоци. Квалитетот на оваа работа влијане во голема мера врз ʾртењето на културите и со тоа и на приносот по хектар. Денес постои различна опрема од онаа што се користела при класичната обработка на почвата, со која за кратко време почвата може да се обработи со минимална потрошувачка на енергија и да се создадат оптимални услови

за сеење и за добивање поголем принос без притоа почвата да се деградира. Овие уреди се нарекуваат култиватори. Од сите постојни култиватори најпродуктивни се вибро-култиваторите. Предностите кои се постигнуваат со користење на овие култиватори се: подготовка на почвата за сеидба во тешки услови за работа и зачувување на влагата и вкупната порозност на почвата, како и намалување на степенот на компресија. Ваквите важни фактори можат да обезбедат брзо и рано никнување на посевот, што пак е услов за добра жетва. За проучување на однесувањето на почвата во интеракција со работната опрема во последно време успешно се користат напредните методи на статистичката анализа. За да спроведеме такво истражување, определивме три парцели во рамнините на западна Романија така да имаме три различни видови почва. Од секој профил беа земени примероци на почва на длабочина од 6, 12 и 18 cm. За секој примерок беа изведени шест повторувања. Го меревме гранулометрискиот состав и главните физички својства на почвата.

Клучни зборови: вибро-култиватори; обработка на почва; густина; целосна порозност; степен на компресија

AIMS AND BACKGROUND

The paper presents a study on the optimization of working regime of vibro-cultivators based on environmental impact assessment for use in seedbed processing. Study presents a method to determinate some physical and mechanical properties before and after soil tillage works of aggregates consisting of tractor and vibro-cultivators, in three parcels in the plains of the west of Romania.

Vibro-cultivators are machines for seedbed preparation. They are equipped with tools sustained by elastic suspension. The elasticity of supports facilitates the oscillations of working tool – elastic support assembly. This set has a natural mode shapes which corresponds to a natural frequency of vibrations [3].

Modern agricultural operations now demand the utilization of a wide variety of equipment and specialist machinery systems, with many having rotary elements such as axles, gears, pulleys etc. With these agricultural machinery systems which have rotary elements, uncontrolled vibrations may become an important problem to consider. When the initial 'switch-on' frequency meets with the natural frequency of a machine element in the system, undesired noise, high levels of vibrations and mechanical failures may occur during operation [4, 5].

Generally, combinators (Figure 1) consist of a vibro-cultivator (A) – cultivator for total processing of soil), composed of: frame (1), coupling device at the power source (2), wheels for limiting of working depth (3), soil loosening bodies (4), and a helix harrow (B), which consists of frame (5), two rodrotors (6), and horizontality adjustment system (7). Worldwide, more and more prestigious companies have incorporated into the range of products such vibro-combinators.

Deep tillage tools are one of the primary components of agricultural equipment which experience high level soil reaction forces during tillage operations. These forces may cause plastic deformation or failure which is undesirable for tillage machines/tools. The active tillage elements of agricultural machineries require extensive studies in order to obtain a proper soil fragmentation and displacement [5].

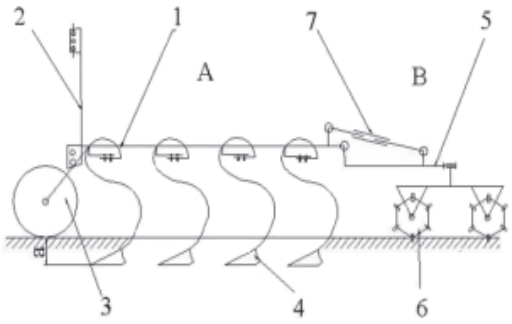

Fig. 1. General scheme of a vibro-combinator [6, 7]

EXPERIMENTAL

In order to obtain a global image on the impact of the new vibro-combinator (the prototype SANDOKAN 2) (Table 1) in terms of the physical-mechanical properties of the soil, it was necessary to determine its properties before the passage of the equipment (in the state of the soil), and after its passage on all the three parcels and trials. These parcels will be suggestively named: soil 1, soil 2 and soil 3; and the three types of active elements (Gamma, Delta 1 and Delta 2) (Figures 2 and 3).

The physical properties were determined by using the method of the cylinders with a constant volume of 100 cm^3, carrying out six repetitions at different depth, from 6, 12 and 18 cm (Figure 4). The methods of analysis and interpretation of the results as well as the work procedure for the determination of the physical-mechanical properties are those indicated in the specialized literature [8, 9].

Table 1

Main characteristics of the prototype vibro-combinator SANDOKAN 2

No. crt.	Characteristics	MU	Values
1	Mass	kg	5670
2	Length in transport	m	6.6
3	Height in transport	m	3.95
4	Width in transport	m	2.93
5	Width of the Gamma active parts, reversible chipper type	mm	35
6	Width of the Delta 1 active parts, arrow type	mm	150
7	Width of the Delta 2 active parts, arrow type	mm	250

Fig. 2. The prototype vibro-combinator SANDOKAN 2 equipped with the three types of active elements (GAMMA, DELTA 1, DELTA 2)

Fig. 3. Geometrical models for the three active elements [5]

Fig. 4. Placement of the sampling rings on different depth stages

Statistical analysis. All data were subjected to univariate three-way analysis of variance (ANOVA, P = 0.05) and done with KyPlot (Kyplot Version 5.0.2, http://www.kyplot.software.informer.com) [10]. The ANOVA factors were: soil (soil type), h (depth), device (active element) and their three order interaction. The means pairwise comparisons were investigated by Tukey's post-hoc test (P = 0.05). Multivariate analysis: principal component analysis (PCA) was performed with P.A.S.T. version 3.04 statistical software (Palaeontology Statistics, Copyright Oyvind Hammer and D.A.T. Harper (November 2014), http://folk.uio.no/ohammer/past/) [11].

RESULTS AND DISCUSSION

When analyzing the granulometric curves presented in Figure 5 and Table 2, one can notice the fact that there was a sandy-clay-dusty texture in soils 2 and 3 encompassed in the experiment at a participation quota that scarcely varies, with the exception of the 1st soil where the particles size distribution is different: clay-dusty-sandy texture

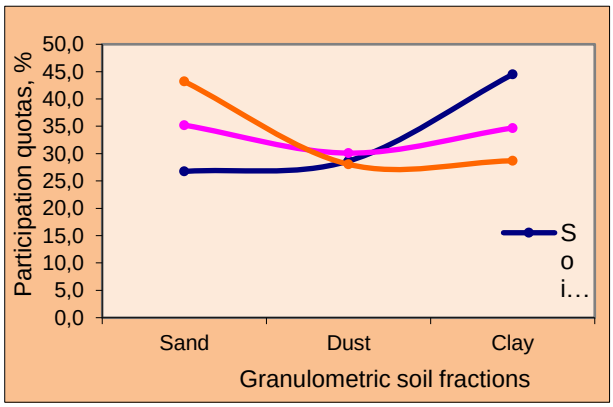

Fig. 5. Granulometric curves analysis of the soils

Table 2

Average values of the granulometric analysis at different depths of prelevation

Type of soil	Depth of prelevation (cm)	Values of the granulometric analysis (%)		
		Sand	Dust	Clay
SOIL 1 (S1)	6	26.2	28.6	44.8
	12	26.8	28.7	44.3
	18	27.4	28.7	44.4
SOIL 2 (S2)	6	35.7	30.2	34.5
	12	35.1	30.2	34.8
	18	35.1	30.1	34.7
SOIL 3 (S3)	6	43.4	27.8	28.5
	12	43.2	28.1	28.7
	18	43.2	28.5	25.9

From the analysis of the values gathered for the participation quotas of the granulometric fractions, we could infer some interesting differentiations among the three types of soil in which we tried the vibro-combinator, as follows:

- All the three types of soil that we tried on the vibro-combinator are a relatively close mix, but in different proportions among the three granulometric fractions;
- The sand fraction (gravel + fine) is predominant in the soil 3 (43.2 %);
- For the dust fraction (I + II), the differences among the three types range only for 2%, the highest value being registered on the soil 2 (30.1 %);
- The participation quotas of the clay granulometric fraction are among the biggest, varying between 28.7 % (soil 3) and 34.7 % (soil 2), and reaching 44.5 % for soil 1;
- The dust granulometric fraction is almost constant for all three types of soil.

To synthesize more efficiently the data taken and to be able to describe completely the intrinsic characteristics of the sample, it was chosen a statistic processing with the aid of the program KyPlot [10]. The results obtained are given in Tables 3 and 4, having as a purpose to underline the variance of bulk density, soil moisture, total porosity and soil compression degree, and comparative with each types of soils and three active elements (Gama, Delta 1, Delta 2). Thus, for each types of soils included in the experiment resulted in eight statistical indicators for each technical work use a new vibro-combinator, but also witness sample. The mechanical processing of the soil through tradetional and modern methods is currently put under question due to the high energy consumption and the continuous degradation of the arable horizon through erosion and excessive compaction.

It is known that the bulk density varies between 1–2 g/cm^3, according to the type soil and horizon, being generally lower in the case of the soils rich in humus and in the structured soils as compared to the unstructured soils. The values of the bulk density are in tight correlation with the degree of settlement of the soil. The high bulk density means a decrease of the capacity to retain water, of the permeability, of aeration and an increase of the mechanical resistance opposed by the soil during its sampling. On the contrary, low bulk densities can reduce the bearing of the soil, making difficult the mechanized execution of the works, even the driving of the operation machinery [13, 14, 15, 16].

By analyzing the values of total porosity, we can say that for the 1st type of soil we noticed an increase of the total porosity from 40.19 %, which represents the initial state of the soil, to 44.36 % (value obtained after the working of the soil with the vibro-combinator equipped with Gamma elements), 45.64% (with Delta 1 elements) and 45.71% (with Delta 2 elements).

The degree of settlement for the 1st type of soil presents values > 18%, which means that the soil is strongly settled for all levels of depth and after the passage with the three types of active elements of the cultivator.

The values gathered for the 2nd type of soil varies from weakly settled (1…10%) to moderately settled (11…18%). However, it is important to specify the fact that the lowest values of the degree of settlement appeared after preparing the germination bed with the aid of the active elements Delta 2.

In the case of the 3rd type of soil, we had negative values for this mechanical index of the soil at all depth, especially for the types of active elements, which means there is a soil moderately loose (–17…–10%) – fact that can be explained by the fact that this parcel has been annually worked.

Analyzing the influence of the active elements on the different types of soils, some conclusions can be made (Table 3 and Figures 6–10):

- In terms of bulk density values (Da), the lowest value is found on all soil types (S1, S2, S3) when working with the active elements Delta 2;
- The total soil porosity has maximum values when the vibro-combinator is equipped with the Delta 2 active elements, logical situation due to the existing relation to density and porosity;
- Soil moisture values reach peak values after processing with Delta 2 to S1 and S2, and in S3 the maximum value of soil moisture is reached after processing with Delta 1;
- The soil compaction degree has a similar humidity variation, namely: minimum values for S1 and S2 using Delta 2 and in S3 following the use of Delta 1.

Table 3

*Results for the soil physical and mechanical properties (values are expressed as mean ± standard deviation) for the interaction factor Soil*Device (CTRL, Gama, Delta 1, Delta 2)*

Soil*Device	Soil moisture (%)	Bulk density (g/cm^3)	Total porosity (%)	Soil compression (%)	Water retention (m^3/ha)
S1.CTRL	19.56h ±2.60	1.68a ±0.09	35.45f ±3.48	32.17a ±6.60	423.66e ±230.12
S1.Delta 1	17.48i ±5.34	1.48c ±0.05	43.08d ±1.98	17.56c ±3.74	351.98f ±218.78
S1.Delta 2	23.69g ±1.71	1.47cd ±0.06	43.48cd ±2.28	16.79c ±4.33	436.40de ±224.70
S1.Gama	17.48i ±1.02	1.59b ±0.18	38.85e ±6.83	25.66b ±13.04	350.94f ±183.72
S2.CTRL	28.72c ±4.93	1.47cd ±0.03	43.56cd ±1.14	14.00cd ±2.28	543.61b ±300.88
S2.Delta 1	27.25f ±4.14	1.42de ±0.06	45.48bc ±2.35	10.20de ±4.67	498.61c ±271.64
S2.Delta 2	29.19b ±4.42	1.40e ±0.08	46.35b ±3.24	8.50e ±6.42	528.84b ±298.40
S2.Gama	29.72a ±6.30	1.44cde ±0.04	44.62bcd ±1.61	11.91de ±3.22	563.18a ±328.87
S3.CTRL	28.06de ±5.93	1.22f ±0.02	53.21a ±0.93	-7.45f ±1.62	447.86d ±266.47
S3.Delta 1	28.26d ±6.01	1.19f ±0.02	54.46a ±0.94	-9.97f ±1.66	439.36de ±262.04
S3.Delta 2	27.86e ±5.85	1.17f ±0.02	55.03a ±0.91	-11.14f ±1.59	427.21e ±253.89
S3.Gama	28.06de ±5.93	1.20f ±0.02	53.83a ±0.89	-8.70f ±1.56	433.29de ±257.97

Table 4

*Results for the soil physical and mechanical properties (values are expressed as mean ±standard deviation) for the interaction factor h*Device (CTRL, Gama, Delta 1, Delta 2)*

*h*Device	Soil moisture (%)	Bulk density (g/cm^3)	Total porosity (%)	Soil compression (%)	Water retention (m^3/ha)
06.CTRL	19.82i ±2.73	1.40cd ±0.16	46.36de ±6.02	8.58cd ±13.78	164.47f±20.79
06.Delta 1	17.68k ±5.42	1.31fg ±0.11	49.74ab ±4.33	1.98fg ±10.55	136.34g±38.22
06.Delta 2	22.23h ±1.30	1.29g ±0.12	50.50a ±4.57	0.48g ±11.04	172.06f ±22.18
06.Gama	19.56j ±2.43	1.34efg ±0.12	48.53abc ±4.74	4.37efg ±11.23	155.02fg±18.05
12.CTRL	26.11f ±4.33	1.48ab ±0.22	43.17fg ±8.34	14.75ab ±18.16	454.72d ±54.87
12.Delta 1	25.74g ±4.15	1.38cde ±0.14	46.98cde ±5.51	7.40cde ±12.67	421.79e ±59.70
12.Delta 2	26.86e ±2.79	1.36def ±0.14	47.87bcd ±5.27	5.66def ±12.15	435.29e ±54.18
12.Gama	25.73g ±6.10	1.43bc ±0.21	45.03ef ±8.02	11.15bc ±17.30	430.53e ±92.09
18.CTRL	30.40b ±5.95	1.49a ±0.21	42.68g ±8.21	15.39a ±18.29	795.94a ±89.46
18.Delta 1	29.58d ±5.67	1.40cd ±0.14	46.29de ±5.50	8.41cde ±13.11	731.82c ±94.82
18.Delta 2	31.66a ±4.18	1.39cde ±0.15	46.49cde ±5.97	8.01cde ±14.04	785.11a ±83.48
18.Gama	29.96c ±8.25	1.46ab ±0.22	43.73fg ±8.44	13.35ab ±18.56	761.87b±168.46

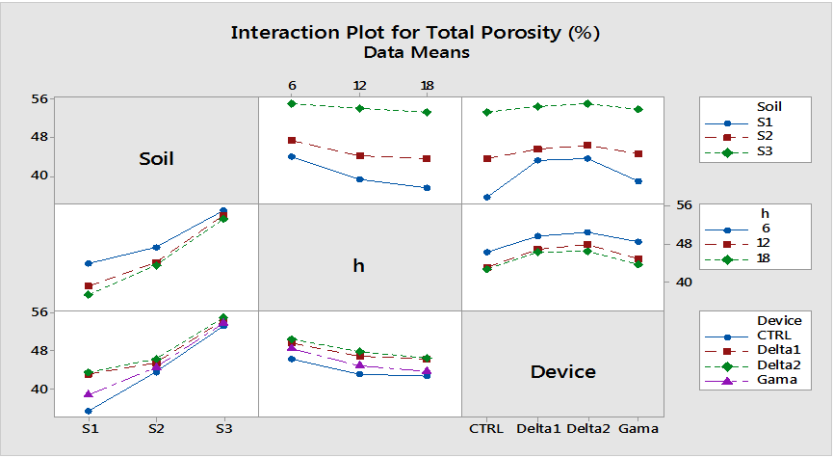

Fig. 6. Interaction plot for total porosity (from three-way ANOVA) for soil types (factor Soil), depth (factor *h*) and active elements (factor Device)

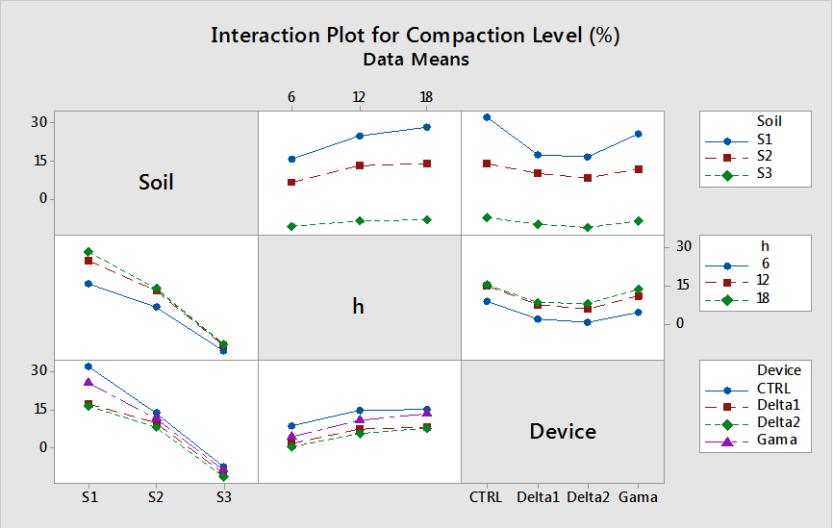

Fig. 7. Interaction plot for compaction level (from three-way ANOVA) for soil types (factor Soil), depth (factor *h*) and active elements (factor Device)

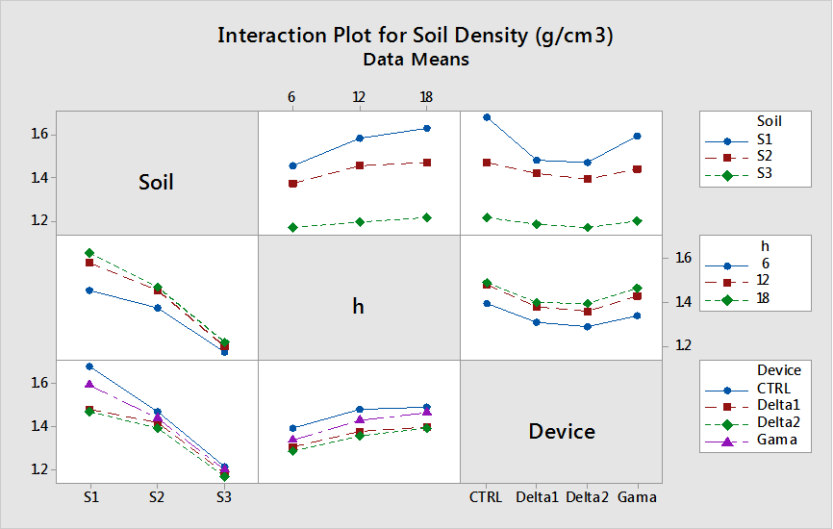

Fig. 8. Interaction plot for soil density (from three-way ANOVA) for soil types (factor Soil), depth (factor *h*) and active elements (factor Device)

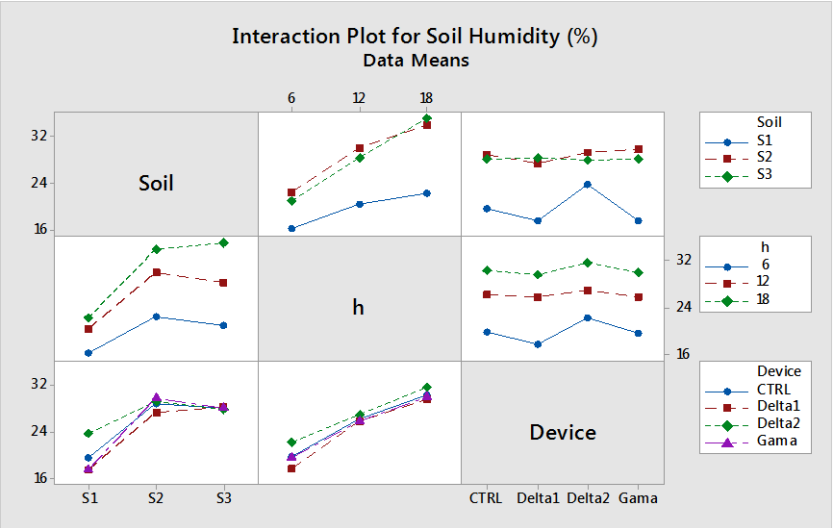

Fig. 9. Interaction plot for soil humidity (from three-way ANOVA) for soil types (factor Soil), depth (factor *h*) and active elements (factor Device)

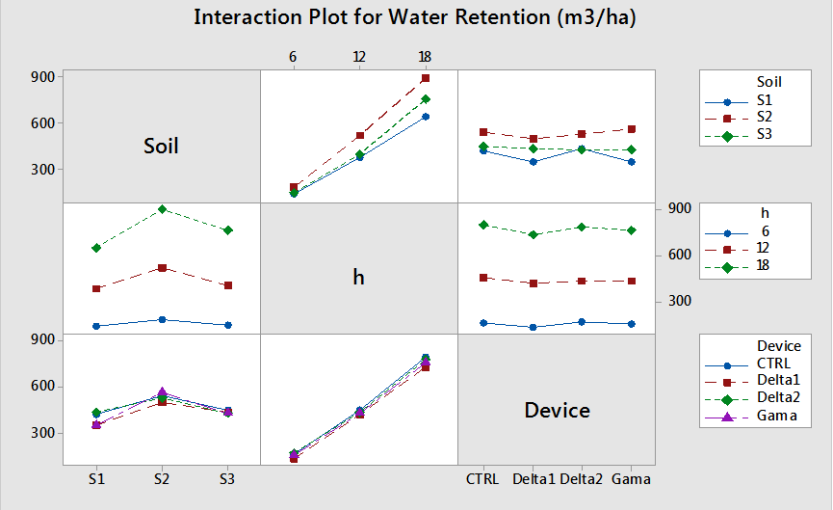

Fig. 10. Interaction plot for compaction level (from three-way ANOVA) for soil types (factor Soil), depth (factor *h*) and active elements (factor Device)

- Bulk density (Da) records minimum values when using Delta 2 for all three depths (6 cm, 12 cm, 18 cm);
- Total porosity has an inverse variation such as that of bulk density: the highest values are found for all three depths when working with Delta 2;
- Soil moisture values respect the same law that: for all three depths the maximum value occurs after processing with Delta 2;
- The soil compaction degree has a similar variation, that is, the smallest values are recorded at all depths when working with Delta 2,
- When working with Delta 2 active elements, all physico-mechanical soil indicators have optimal values regardless of working depth.
- The same legality is preserved (with few exceptions) and when analyzing the impacts of the active organ of the vibro-combinator on the soil types contained in the experimental field.

Multivariate analysis

To evaluate the vibro-combinators soil tillage performances were studied the variables: bulk density (g/cm^3), total porosity (%) and soil compression (%). To evaluate the soil environmental impact of the vibro-combinators were considered the variables: soil moisture (%) and water retention (m^3/ha). In order to assess simultaneously the vibro-combinators soil tillage performances and environmental impact, was involved the multivariate analysis: principal component analysis (PCA) and multivariate analysis of variance (MANOVA, $P = 0.05$). The PCA and MANOVA were done separately for each soil types S1, S2 and S3. The PCA method involved as input data the variables correlation matrix and between sample groups algorithm. The MANOVA algorithm used as input data the first two principal components (PCs) coordinates of the group samples. The group samples were described by the interaction factor Device × *h* (i.e. active elements × depth).

Statistical results for PCA for soil types are presented in Table 5. For all soil types the first two PCs present eigenvalues greater than unity and a cumulative percentage of explained variance greater than 95.0%. Due to this reason these PCs are sufficient to describe the experiment with statistically significance.

Table 5

Principal components analysis statistics for soil factor (PC represents the principal component)

S1	**PC**	**Eigenvalue**	**% variance**
	1	**3.578**	**71.567**
	2	**1.258**	**25.166**
	3	0.163	3.2669
	4	1.22E-05	0.0002
	5	5.49E-09	1.10E-07
S2	**PC**	**Eigenvalue**	**% variance**
	1	**4.380**	**87.614**
	2	**0.585**	**11.710**
	3	0.033	0.673
	4	0.0001	0.002
	5	6.86E-06	0.0001
S3	**PC**	**Eigenvalue**	**% variance**
	1	**4.239**	**84.793**
	2	**0.743**	**14.877**
	3	0.0158	0.3172
	4	0.0006	0.0120
	5	4.01E-05	0.00080181

The PCAs biplots gathers in the same graphical representation the samples scores and variable loadings (Figures 11–13). The sample groups are marked by points inside a convex hull and the variables are represented by vectors with the staring points in the coordinate system origin. The variable vectors end points show the direction that describes the highest abundance (or levels) of the corresponding variables. This means that the group samples placed in the one vector direction (marked by its end point), have high abundance/level of that variable. When the sample groups are placed in the opposite direction, they have the lowest abundance/levels for that variable.

Analyzing Figures 11–13, for the soil type S1, the PCA biplot prescribe (Tables 6–7).

Analysing Figure 13, for the soil type S3, the PCA biplot prescribes that the best performance for soil tillage and environmental protection have all the active elements Delta 1, Delta 2 and Gamma for 6 cm depth. However, at other depths the studied active elements are producing environmental damages of soils that have the same properties as S3.

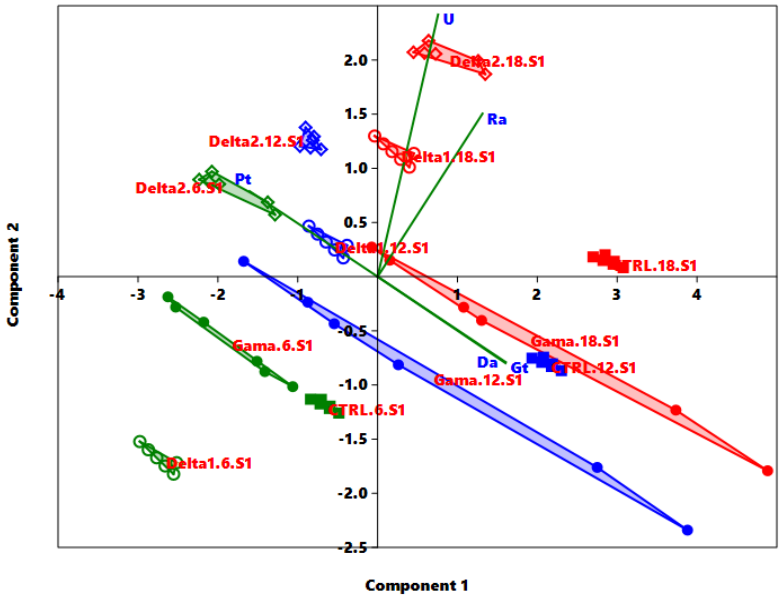

Fig. 11. Principal component analysis (PCA) biplot for different depths (factor *h*) and for the three active elements (factor Device) for soil type S1

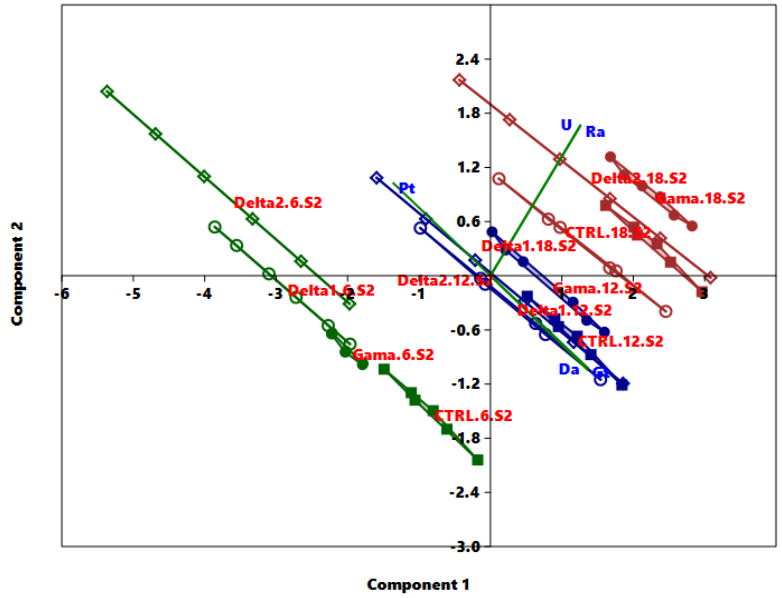

Fig. 12. Principal component analysis (PCA) biplot for different depths (factor *h*) and for the three active elements (factor Device) for soil type S2

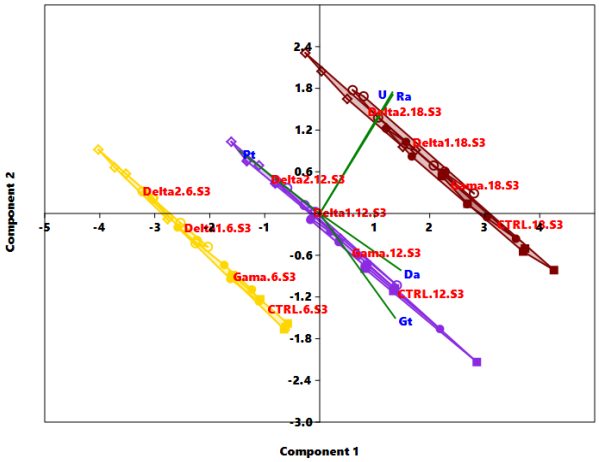

Fig. 13. Principal component analysis (PCA) biplot for different depths (factor *h*) and for the three active elements (factor Device) for soil type S3.

Table 6

Statistical significance values of multivariate analysis of variance (MANOVA, p = 0.05) for the soil type S1.

MANOVA *p*-values	CTRL.6	Delta 1.6	Delta 2.6	Gama.6	CTRL.12	Delta 1.12	Delta 2.12	Gama.12	CTRL.18	Delta 1.18	Delta 2.18	Gama.18
CTRL.6		<0.0001	<0.0001	**2.239**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Delta1.6	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Delta2.6	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Gama.6	**2.239**	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
CTRL.12	<0.0001	<0.0001	<0.0001	<0.0001		**3.940**	0.001	0.002	<0.0001	<0.0001	<0.0001	<0.0001
Delta 1.12	<0.0001	<0.0001	<0.0001	<0.0001	**3.940**		0.001	0.003	<0.0001	<0.0001	<0.0001	<0.0001
Delta 2.12	<0.0001	<0.0001	<0.0001	<0.0001	0.001	0.001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Gama.12	<0.0001	<0.0001	<0.0001	<0.0001	0.002	0.003	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001
CTRL.18	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		**0.241**	<0.0001	<0.0001
Delta 1.18	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.241**		<0.0001	<0.0001
Delta 2.18	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Gama.18	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Table 7

Statistical significance values of multivariate analysis of variance (MANOVA, p = 0.05) for the soil type S2.

MANOVA p-values	CTRL. 6	Delta 1.6	Delta 2.6	Gama .6	CTRL .12	Delta 1.12	Delta 2.12	Gama. .12	CTRL. 18	Delta 1.18	Delta 2.18	Gama. .18
CTRL.6		0.793	0.001	0.352	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Delta 1.6	0.793		0.001	2.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Delta 2.6	0.001	0.001		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gama.6	0.352	2.592	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CTRL.12	0.000	0.000	0.000	0.000		0.069	13.997	0.004	0.000	0.000	0.000	0.000
Delta 1.12	0.000	0.000	0.000	0.000	0.069		0.327	0.000	0.000	0.000	0.000	0.000
Delta 2.12	0.000	0.000	0.000	0.000	13.997	0.327		0.002	0.000	0.000	0.000	0.000
Gama.12	0.000	0.000	0.000	0.000	0.004	0.000	0.002		0.000	0.000	0.000	0.000
CTRL.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.938	0.000
Delta 1.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
Delta 2.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.938	0.000		0.002
Gama.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	

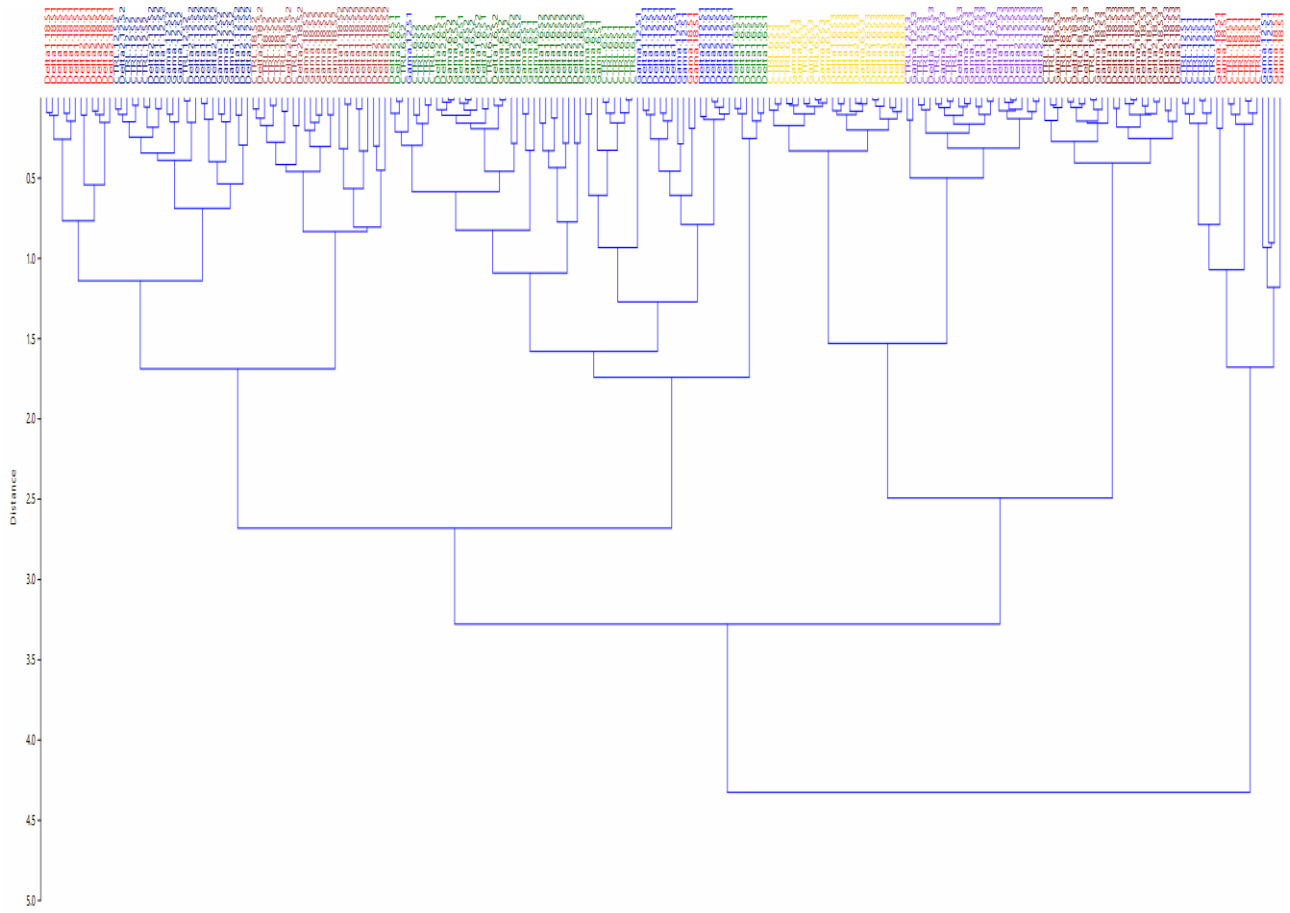

Fig. 14. Hierarchical cluster analysis (HCA) dendrogram with the clustering information for different types of soils, different depth 6, 12 and 18 cm and for the three active elements: Gama, Delta 1, Delta 2

CONCLUSIONS

The advantages of using vibro-combinators are: perfect preparation of seedbed in difficult working conditions and preservation of soil moisture. Such important factors can ensure fast, uniform and early germination of seeds, these requirements standing at the basis of abundant harvests. The research investigated the soil tillage performances and the environmental impact of several active elements of the vibro-combinators, at certain soil depths and soil types.

The multivariate analysis allowed to assess for each soil type which active elements performs both best soil tillage and environmental protection of the soils. From the technical point of view, the 6 cm depth is the most important to soil tillage for crop production. For this depth the active elements of the vibro-combinator: Delta 2 and Delta 1 are those that performs both best soil tillage and environmental protection of the studied soils.

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EXTENT OF UV-INDUCED DNA DAMAGE IN ANGIOSPERM PLANT SPECIES AT DIFFERENT ALTITUDES

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A b s t r a c t: Climate changes and anthropogenic factors are the main reasons for destruction of natural ecosystems. The aim of this study was to investigate the extent of plants adaptation to UV background and gross ß-activity, and the possible damages that can be recorded in plants grown at different altitudes in Rila Mountain using physicochemical, cytogenetic and molecular methods. Our investigations were done on nine plant species growing at three altitudes in Rila Mountain: 1350 m, 1782 m and 2925 m. The variation between species for ß-activity did not depend on the altitude and the plants' habitats. Adapted comet assay molecular analysis showed that DNA of *Epilobium angustifolium* grown at 1350 m was more susceptible to damage than that of *D. glomerata*. Both species did not show any increase in DNA damage at a slightly higher height, 1782 m. The level of migrated DNA of *P. orthantha* grown at 2925 m was comparable to that of species grown at a lower altitude. With regard to the formation of micronuclei, grass species were more sensitive than cereals to UV. The genotype played a more important role than the height difference of the habitats. This implies the existence of protective mechanisms developed by plants to overcome the stress of DNA damage.

Key words: UV-B radiation; height above mean sea level (AMSL); DNA damage; angiosperm species

СТЕПЕН НА ОШТЕТУВАЊЕТО НА ДНК ПРЕДИЗВИКАНО СО УВ-ЗРАЧЕЊЕ КАЈ АНГИОСПЕРМСКИ РАСТЕНИЈА НА РАЗЛИЧНИ НАДМОРСКИ ВИСОЧИНИ

А п с т р а к т: Климатските промени и антропогените фактори се главните причини за уништувањето на природните екосистеми. Целта на оваа студија беше да се истражи степенот на адаптација на растенијата на УВ-зрачењето и целокупната ß-активност и можните оштетувања кои можат да се евидентираат во растенијата кои растат на различни височини на планината Рила, користејќи физико-хемиски, цитогени и молекуларни методи. Нашите истражувања беа направени за 9 вида растенија кои растат на 3 различни височини на планината Рила: 1350 m, 1782 m, 2925 m. Варијациите на ß-активноста помеѓу видовите не зависат од височината и стаништето на растенијата. Молекуларната анализа покажа дека ДНК на *Epilobium angustifolium* кое расте на 1350 m е поподложна на оштетувања во споредба со *D. glomerata*. Двата вида не покажале никакво зголемено оштетување на ДНК на нешто повисока височина (1782 m). Во однос на формирањето на микронуклеуси, тревните видови се почувствителни на УВ од цереалиите. Генотипот одиграл многу поважна улога одошто разликите во височината на која расте растението. Ова подразбира постоење на заштитни механизми кои се развиени од самите растенија со цел да го надминат стресот од оштетувањето на ДНК.

Клучни зборови: УВ зрачење; височина над средното ниво на море (AMSL); оштетување на ДНК; видови ангиосперми

AIMS AND BACKGROUND

The global climate changes are the main reason for destruction of natural ecosystems and threaten many breeds of wild animals and plants with extinction [1]. Additionally, the anthropogenic factors can result in depletion of the ozone layer. This process can lead to changes in the UV spectral composition and to significant increases in UV-B (280–320 nm). As known, the UV spectrum consists of UV-A, UV-B and UV-C. UV-C with the shortest wavelength (100–280 nm) is completely blocked by the ozone layer and atmospheric oxygen, whereas UV-A (315–400 nm) is weakly absorbed and directly transmitted to the earth surface. Thus, UV-A has a milder effect [2, 3]. UV-B radiation is a minor component of sunlight (1.5% of total radiation) and is filtered through the stratospheric ozone layer; therefore, only a small portion reaches the earth surface. It is believed that UV-B has a wide range of effects on the biology and chemistry of terrestrial ecosystems. Thus, a 1% reduction in the ozone layer results in an average increase of 1.5% in the amount of biologically active UV-B radiation [4]. The increase in solar UV-B radiation may influence the genomic stability of plant populations [5]. The degree of UV-B increase depends mainly on the altitude.

The biological effects of UV radiation on plants include altered growth responses, reproductive dysfunction, epigenetic variations, plant susceptibility to biotic factors, premature senescence, damage to the photosynthetic apparatus, and altered conformation of membrane structures [6].

UV-B can alter the normal state of life by inducing a variety of cytotoxic, mutagenic and DNA lesions, interfering the integrity of the genome. Organisms have evolved various mechanisms to counteract and overcome these lesions [7]. In case of severe damage and/or failure of repair mechanisms, cells undergo apoptosis or induce a complex series of phenotypic changes.

DNA is one of the major targets of UV damage in both prokaryotic and eukaryotic cells. Proteins and lipids are other direct targets. Therefore, it is crucial to evaluate the response of plant performance to natural variations in UV-B levels.

Because plant growth depends on the presence of sunlight, plants shield meristematic tissues from light, annually dispose of photosynthetic tissues, produce UV-absorbing agents, and employ a variety of DNA repair mechanisms some specialized for the repair of UV-induced lesions. Such mechanisms by which plants may protect themselves from UV irradiation are of great interest. Flavonoids as UV filters are often interpreted as a protective/adaptive mechanism preventing UV-B radiation from reaching the mesophyll and in this way affecting photosynthesis. Additional defense mechanisms are the increase in leaf thickness (as a result of extensive cell length) on the one hand and, on the other hand, a decrease in the leaf area and stomatal frequencies [4]. Safaralikhonov and Aknazarov [8] observed an increase in the total auxin activity in plants at a low altitude compared to higher altitudes. The authors concluded that the activity of growth-inhibiting substances increases in plants that grow at a higher elevation.

Important physiological and biochemical responses to enhanced solar UV-B irradiation on terrestrial plants have been determined from laboratory and/or climate chamber under controlled conditions [9]. Field verification of laboratory investigations must be done under natural environmental conditions.

Gross ß-activity includes the activity caused by all ß-emitters. The primary sources of ß-activity are naturally occurring radioisotopes from the natural decay series of uranium, thorium and actinium, the primordial isotope, 40 K, and any residual fallout from anthropogenic weapons testing and the Chernobyl reactor accident in 1986. In 1995, the gross ß-activity of different samples from 18 Rila Mountain regions was measured for the first time [10]. Water, soil and plant samples were investigated. The authors determined normal content of river water and relatively high ß-activity for plant species. They found that probes from dead conifers taken at 2400 m in Beli Iskar spring regions show high levels of beta activity. These higher values could be explained with the Chernobyl impact in 1986.

So far, there have been few studies on the effects of UV-B and ß-activity in single plant species. Therefore, the studies on the biological and genetic effects of UV-radiation and ß-activity on wild plants are relevant in order to obtain a more complete picture of the adaptation of plants. The aim of our study was to investigate the extent of plants adaptation to natural UV background as well as ß-activity and the possible damages that can be scored in plant species grown at different altitudes in Rila Mountain using physicochemical, cytogenetic and molecular methods.

EXPERIMENTAL

Plant material: Four tree species of 4 families; one shrub species; six species from *Poaceae*; six species from *Fabaceae*; two species from

Juncaceae and 46 grass species from 23 families were registered around the locality named "Pioneer Camp", Beli Iskar at 1350 m.

Seven tree species from four families; three shrub species from three families; six species from *Poaceae*; five species from *Fabaceae*; two species from *Juncaceae* and 41 grass species from 25 families were registered in the region of the locality named "Third window" at 1782 m.

Six species from *Poaceae*, five species from *Juncaceae* and four grass species from four families were registered on the Moussala Peak at 2925 m and the area around it.

Out of this diversity, we selected wild plant species that are characteristic of the ecosystems in the Rila Mountain at these altitudes and appeared suitable for cytogenetic and molecular biology studies: namely, *Epilobium angustifolium, Fragaria vesca, Myosotis sylvatica* and *Dactylis glomerata.* These plant species were collected in June 2017 in habitats at two altitudes in the Rila Mountain at 1350 m and at 1782 m.

Poa alpine, Sesleria coerulans, Saxifraga cymosa, Myosotis sylvatica, Achillea clusiana and *Pedicularis orthantha* were collected in August/ September 2017 on the peak Moussala at 2925 m.

The plant material for cytogenetic and molecular investigations was stored at 4ºC immediately after sampling for further use.

Gross β-activity: We used a standard method previously described in detail [1, 2]. Total ß-activity in Bq/kg ash in tissues of whole plants was determined. The method includes preliminary preparation of samples. The plants were dried at 110 ºC to a constant weight and were then ashed at 450 ºC for 4 hours. One hundred milligrams of each sample (*E. angustifolium, P. alpine, S. coerulans* and *A. clusiana*) were transferred to a counting planchet 50 mm in diameter. The radioactivity on the steel planchet was read using a low-background beta counter (LAS 3A level activity system with 30 % efficiency on 40 K and background 1 cpm, INRNE) and was compared with measurements of a potassium-40 standard prepared and measured in the same manner. The background of the detector was determined by counting an empty planchet for 900 min.

Comet assay: *E. angustifolium, D. glomerata* and *P. orthantha* were adapted for comet assay. Nuclei were isolated from the leaves by careful slicing in 400 µl 1 × PBS on ice in dim light. For each sample, 30 µl of cell suspension was mixed with 60 µl of 1% low melting point agarose at 42ºC and dropped on slides precoated with 0.5% normal melting point agarose. Each drop was covered with a coverslip and slides were stored on ice. After removal of the coverslips, leaf nuclei were denatured for 10 min at room temperature. The slides were washed three times in ice cold 1 × TBE for 5 min and electrophorezed in ~1500 ml 1 × TBE at 15–17 mA and 1 V/cm (31 V) at room temperature for 6 min [13]. After electrophoresis, the agarose slides were placed in 70% and 96% ethanol for 5 min each, before air drying and staining with acridine orange (6 µg/ml in water).

Comets were examined from slides under 25 fold magnification using a fluorescence microscope (Jenalumar) equipped with a filter for acridine orange (at 480–490 nm) and a digital camera (Canon, Power Shot A95). The COMET image analysis system CASP (Comet Assay Software Project, www.casp.of.pl) was used for measurement of DNA content in the head and tail of each comet. Each experimental point is typically a mean value from 6 examined microgels.

Micronucleus test: *E. angustifolium, F. vesca, M. sylvatica, D. glomerata, P. alpine, S. coerulans, S. cymosa, M. sylvatica, A. clusiana,* and *P. orthantha* were adapted for micronucleus analysis.

For micronuclei (MN) scoring, the leaves were fixed in ethanol: glacial acetic acid (3:1) [14\. Because of the specificity of the plant species, the fixed leaves were hydrolyzed in 1N HCl at 60ºC for 9–20 min, macerated in 4% pectinase for 30 min at room temperature or at 60ºC, carefully sliced on slides and stained with Methylgreen, Giemsa and Acid Fuchsin, alone or in combination. The stains were not removed before squash preparation. The time for maceration of Poaceae species was extended to 1 h (60ºC).

Statistics: Statistical analysis of comet assay, micronucleus-test and gross ß-activity data was carried out using two-tailed Fisher's exact-test for group comparison of different plant species [13].

RESULTS AND DISCUSSION

The basic ß-emitters in the biosphere are the isotopes ^{137}Cs, ^{134}Cs and ^{90}Sr. Their values in the present study are given in Figure 1A. As early as 1995, the gross ß-activity of some monitor plants in the Rila Mountains was determined [15]. These data were used for comparative analysis of the results from the present study. In *E. angustifolium*, a peren-

nial grass, the total ß-activity was measured in plants grown at 1350 m and 1782 m. Plants grown at 1350 m showed a total ß-activity of 654 ± 12 Bq/kg and specimens that grew at the altitude of 1782 m had a ß-activity of 850 ± 16 Bq/kg. The plant material sampled on Moussala Peak at 2925 m included representatives of *P. alpine* and *S. coerulans*, as well as *A. clusiana*. Here we found a relatively low ß-activity in Poaceae (*P. alpine* – 413 ± 11 Bq/kg, and *S. coerulans* – 394 ± 12 Bq/kg). The data for grass *A. clusiana* (1253 ± 31 Bq/kg) demonstrated a higher sensibility concerning total ß-activity compared to the other phytomonitors.

Studies on the total ß-activity of plant material of various species have shown that different plant parts exert different levels of beta activity. For example, branches have a significantly higher content than needles or leaves [16]. Overall, all measured plant species, sampled in 1995, showed a significantly higher ß-activity (~ 5000 – 13 000 Bq/kg for grasses) than those in the present work (~ 400 – 1 300 Bq/kg). Detailed studies of a wider range of phytomonitors showed a broad variation between different plant species, which does not necessarily depend on the altitude of the habitats [15]. This statement corresponds with our data.

There are large differences in the tolerance to UV-B radiation among plant species and taxonomic groups. Our results on the UV-induced DNA damage evaluated using comet assay are presented in Fig. 1B. Due to the specificity of the plant objects, e.g. thick cell wall, etc., which is part of the adaptation to the habitat, we succeeded in adapting and applying comet analysis for three different species: *E. angustifolium*, *D. glomerata* and *P. orthantha*. DNA of *E. angustifolium* grown at 1350 m was more susceptible to damage. The amount of migrated DNA in the comet tail was 38.74 ± 2.22% compared to that of *D. glomerata* 22.75 ± 1.08%. Both species did not show any increase in the value of DNA damage at a slightly higher height, 1782 m. For *E. angustifolium*, it was 39.65 ± 1.23% and for *D. glomerata* 23.45 ± 0.49%. Molecular analysis of plants grown at 2925 m was carried out on *P. orthantha*. Here, the level of migrated DNA was 28.33 ± 1.12%, which is comparable to that of species grown at lower altitudes.

The frequency of MN formation were investigated on nine plant species grown at three different altitudes (see Figure 1C). Among the samples grown at 1350 m, *F. vesca* (0.33 ± 0.03%) was most sensitive, followed by *M. sylvatica* (0.27 ± 0.09%), *E. angustifolium* (0.20 ± 0.06%) and *D. glomerata* (0.07 ± 0.03%). The results were similar for plants grown at 1782 m; they ranked in susceptibility as follows: *F. vesca* (0.37 ± 0.07%) > *M. sylvatica* (0.30 ± 0.06%) > *E. angustifolium* (0.27 ± 0.03%) > *D. glomerata* (0.10 ± 0.06%).

M. sylvatica grown on Moussala Peak at 2925 m did not show any significant differences assessed by frequency of MN, compared with the plants which grew at a lower altitude (0.27 ± 0.03%).

MN induced are described in Figure 1C. For samples grown at 1350 m, *F. vesca* (0.33 ± 0.03%) was found to be the most sensitive, followed by *M. sylvatica* (0.27 ± 0.09%), *E. angustifolium* (0.20 ± 0.06%) and *D. glomerata* (0.07 ± 0.03%). The UV susceptibility of plants grown at 1782 m showed a similar trend. Their sensitivity ranked as follows: *F. vesca* (0.37 ± 0.07%) > *M. sylvatica* (0.30 ± 0.06%) > *E. angustifolium* (0.27 ± 0.03%) > *D. glomerata* (0.10 ± 0.06%). *M. sylvatica* grown on peak Moussala at 2925 m did not show significant differences in the frequency of induced micronuclei, compared with plants that grew at a lower altitude (0.27 ± 0.03%).

Since there is larger UV intensity on the Moussala Peak, we expected a higher frequency of MN. On the contrary, however, the yield of induced MN was relatively low. The plant species from Poaceae family grown in the localities "Beli Iskar" and "Third window" were not very sensitive. Cereal species, sampled on Moussala Peak, showed an extremely low frequency of MN, namely 0.03 ± 0.03 % for *P. alpine* and 0.03 ± 0.03 % for *S. coerulans*. All grass specimens showed no significant difference with plants which grew at a lower altitude. Here we obtained frequencies of MN for *S. cymosa* amounting to 0.17 ± 0.07 %, for *A. clusiana* 0.23 ± 0.03 % and for *P. orthantha* 0.17 ± 0.12 %.

Little is known about the effect of UV radiation regarding cell cycle arrest and apoptosis in plants [17]. Recently, G1-to-S arrest induced by UV-B has been suggested as a protective mechanism against UV-B-induced DNA damage, as it allows time for DNA damage repair before replication [18].

UV-B also results in numerous changes in plant morphology. The plant response to UV-B depends on different factors, such as the nature of the UV-B treatment, the extent of adaptation and acclimation to UV-B, and interaction with other environmental factors. UV-B responses are mediated by nonspecific signaling (reactive oxygen species and defense signaling) and specific pathways (mediating photomorphogenic responses) [19].

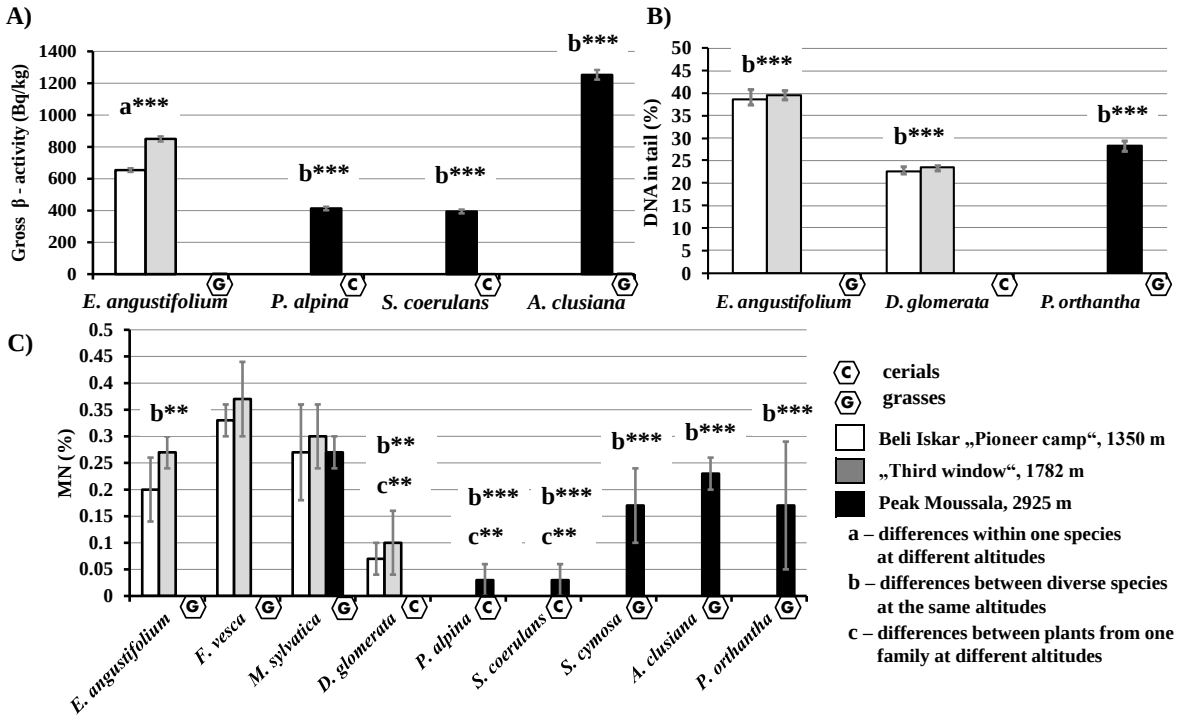

Fig.1. Total ß-activity, A); UV-induced DNA damage, B); and UV-induced MN, C) in plants grown at different elevations: locality Beli Iskar "Pioneer camp" 1350 m; locality "Third window" 1782 m; Moussala Peak 2935 m (p**≤ 0.01; p***≤ 0.001)

Different studies have shown that UV-B irradiation induces diverse phenotypic responses, including hypocotyl growth inhibition, cotyledon expansion and others in plants. The inhibition of growth of wheat primary leaves has been attributed to the effect of UV-B on the rate and duration of both cell division and elongation [20]. In plants grown under such defined laboratory conditions, the proportion of mitotically active cells was reduced and the duration of cell division was increased. Chen et al. [21] found that UV-B radiation does not influence the microtubule structures in germinated wheat seeds to affect chromosome behavior. Another study showed that the increasing of duration of exposure to higher UV-B doses induced various cytological anomalies in coriander in laboratory conditions. The authors obtained decreased mitotic index and a rise in chromosomal aberrations [22]. The higher doses were more genotoxic than the lower ones.

Overexpression of cyclobutane pyrimidine dimer (CPD) photolyase in UV-B resistant *Oryza sativa* cultivars results in higher CPD photolyase activity and thus the plants become significantly more resistant to UV-B than wild-type plants [23]. On the other hand, Wang et al. [24] observed an increase in the CPD level in perennial herbs grown at 300 to 1700 m. With the help of a stepwise multiple regression analysis, the authors found that the variation in the CPD level was solely affected by the UV-B level, whereas other environmental factors (temperature and photosynthetically active radiation) had no significant effects on the CPD induction.

Our present investigations showed that UV-irradiation and β-activity do not induce higher damaging effects on plant DNA at the level of the chosen physico-chemical, cytogenetic and molecular indicators. There are some differences in the tolerance to β-activity as well to UV-radiation among the plant species. Kovacs and Keresztes [25] and Kumar and Pandey [22] observed that lower doses and lower duration of exposure to UV-B in root meristems of *Coriandrum sativum* are less significant in their action and promote some important metabolic processes in plants, whereas higher doses are significant and have cytotoxic and genotoxic effects, such as decreased mitotic activity and enhanced induction of different types of chromosomal aberrations.

CONCLUSIONS

The present results imply the development of protective mechanisms by the plant from different habitats and altitudes of Rila Mountain to overcome the UV-induced stress at the cellular and DNA level. The results implied that the genotype plays a

more important role than the altitude difference of the habitats. The obtained data are first steps of a monitoring of UV effects and would be helpful for understanding the environmental impact on wild plant species in alpine zones and also in using of suitable plant species as bioindicators for UV load.

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Original scientific paper

DIRECT TREATMENT WITH ROUNDUP VS. TREATMENT WITH PLANT EXTRACT PREVIOUSLY INFLUENCED BY ROUNDUP: DOES THE GENOTOXIC EFFECT DIFFER?

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A b s t r a c t: Roundup, a commercial formulation of Glyphosate, is one of the most used non-selective systemic herbicides for weed control in agriculture. Some people are in occupational contact with this herbicide. On the other hand, human diet includes plants that could contain residual herbicides. There are many contradictory results about the cytotoxicity/genotoxicity of Roundup (RP). This gave us a reason to formulate the aim of our study: i) to evaluate the cytotoxic/genotoxic effects of RP after direct treatment; ii) to assess its effect in human lymphocyte test-system after treatment with extract from *Hordeum vulgare* previously influenced by RP. We used chromosome aberrations and micronuclei as endpoints for genotoxicity. Clear cytotoxic effect was obtained after both direct treatment with the herbicide and after treatment with plant extract affected by RP. The herbicide showed higher genotoxic activity compared to that observed in the untreated control. The genotoxic effect after treatment with PE from plants grown from seedlings of *H. vulgare* previously treated with RP was close to that observed after direct treatment with RP with the lower concentration (0.9 μg/ml). The study gives valuable information about the potential risk for humans whose daily diet includes plants treated with RP.

Key words: Roundup; genotoxicity; test-system; plant extract

ДИРЕКТЕН ТРЕТМАН СО „РАУНДАП“ НАСПРОТИ ТРЕТМАНОТ СО ЕКСТРАКТ ОД БИЛКИ НА КОИ ПРЕТХОДНО ВЛИЈАЕЛ „РАУНДАП“: ДАЛИ ГЕНОТОКСИЧНИОТ ЕФЕКТ СЕ РАЗЛИКУВА?

А п с т р а к т: „Раундап“ , комерцијална формулација на глифосат, е еден од најупотребуваните системски неселективни хебрициди за третирање на плевелот во агрикултурата. Некои луѓе се во професионален контакт со овој хебрицид. Од друга страна пак, човековата исхрана содржи растенија кои можат да содржат остатоци од хебрициди. Постојат многу контрадикторни резултати за цитотоксичноста / генотоксичноста на „Раундапот“ (РП). Ова ни даде причина да ја формулираме целта на нашата студија: 1) да ги процениме цитотоксичните / генотоксичните ефекти на РП при директен третман; 2) да го процениме неговиот ефект на човековите лимфоцити по третманот со екстракт од *Hordeum vulgare* кој претходно бил под влијание на РП. Користевме хромозомски аберации и микронуклеуси како крајни точки за генотоксичност. Јасен цитотоксичен ефект е добиен по директен третман со хербицидот и по третман со растителен екстракт кој претходно бил под влијание на РП. Хербицидот покажал повисока генотоксична активност во споредба со онаа забележана при нетретирана контрола. Генотоксичниот ефект по третманот со растенија добиени од садници на *H. vulgare* претходно третирани со РП, бил близок до оној забележан по директен третман со РП со пониска концентрација (0.9 μg/ml). Студијата дава вредни информации за потенцијалниот ризик за луѓето чија секојдневна исхрана вклучува растенија третирани со РП.

Клучни зборови: „раундап“; генотоксичност; тест-систем; екстракт од растенија

AIMS AND BACKGROUND

Roundup (RP) is a commercial formulation of Glyphosate, one of the herbicides most used in agriculture which has attracted public attention in the last decade. This herbicide is in use in more than 160 countries in the world for weed control of 76 weed types (Alam, 2010; Ismaili et al., 2015). To

facilitate the cell penetration of the active ingredient, Glyphosate, the RP formulation contains some adjuvants that could enhance the harmful effect. In addition to the occupational exposure of humans to the herbicide, human diet could also include plants containing residual herbicide. Thus the herbicide has a potential risk for humans. Lamb et al. (1998) and Schonbrunn et al. (2001) showed a specific biological mechanism of RP to affect plants, so it was proposed that the herbicide could not be hazardous for mammalian and human beings. However, many contradictory results about its toxic/genotoxic activities have been obtained using various test-systems and endpoints (Williams, 2000; Richard et al., 2005; Dimitrov et al., 2006; Prasad et al., 2009; Benachour and Seralini 2009; Mladinic et al., 2009; Koller et al. 2012, Guilherme et al., 2012; Kier and Kirkland, 2013; Alvares-Moya et al., 2014). According to the reports of some regulatory agencies, the herbicide does not show any harmful effect on human health (E.U., 2002). Manas et al. (2009) reported genotoxic effect of the Glyphosate formulation AMPA assessed by induction of micronuclei (MN) and chromosome aberrations (CA) in human lymphocytes, and DNA damage evaluated by comet assay. Another study also demonstrated cytotoxic/genotoxic effects of Glyphosate assessed by CA and MN induction in Swiss albino mice (Prasad et al., 2009). Some evidence showed the effect of metabolic activation when the level of DNA damage increased after application of the herbicide in the presence of S9 (Mladinic et al., 2009). There are limited data about herbicide residues in plant foods and a lack of studies about the cytotoxicity/genotoxicity of extracts obtained from plants/seeds treated with the herbicide. This fact and the controversial data published about the effect of RP motivated the aim of our study: i) to evaluate the cytotoxic/genotoxic effects of the RP after direct treatment, and, ii) to assess the effect of plant extract from *H. vulgare* previously influenced by RP, using human lymphocyte test-system. The endpoints for assessment of genotoxicity were chromosome aberrations and micronuclei, mitotic index (MI) was used as an endpoint for cytotoxicity

EXPERIMENTAL

Chemicals. Roundup (Monsanto, containing glyphosate, CAS № 1071-83-6) water work solution was prepared according to the instructions for weed control in agriculture. The alkylating agent MNNG (50 μg/ml) was used as a positive control.

Test-system. Human lymphocytes *in vitro* (1×10^6cells/ml) were prepared from venous blood of healthy non-smoking donors, aged 33–36 years, according to the method of Evans (1984).

Plant extract preparation. Two types of seeds of *H. vulgare* grown in the experimental field of Sofia University and picked up in August 2017 were used: seeds of non-treated plants and seeds of plants treated with 3.6 μg/ml of RP, a concentration used in agriculture. Both types of seeds were presoaked (1 h) in tap water and germinated (18 h) at 24 °C. Then the plants were grown as hydroponics. The upper leaves'parts of 4–5 day plants were cut out and ground at 0 – 4 ° C in 0.9% cooled sodium chloride solution (1:10). The obtained homogenate was centrifuged at 0 – 4°C and 10,000 × g for 15 min. The supernatant (S10 fraction) was passed through a sterile filter (0.45 μm) for further use. This plant fraction S10, herein referred to as plant extract (PE), was prepared by the method of Darroudi and Natarajan (1987).

EXPERIMENTAL SCHEME

To test the cytotoxic and genotoxic activities of the herbicide, the human lymphocytes were treated with Roundup (RP) in concentrations of 3.6, 1.8, 0.9, 0.36 and 0.036 μg/ml (60 min) at the 18th hour (G1) after PHA stimulation in a serum-free RPMI 1640 medium.

To assess the effect of plant extract (PE) from *H. vulgare* previously influenced by RP at the 18th hour (G1) after PHA stimulation, we added 1 ml (60 min) of non-treated PE to part of the lymphocyte cultures, and to another part, 1 ml (60 min) PE from seedlings of plants previously affected by the herbicide (3.6 μg/ml).

After each treatment, the lymphocytes were washed with fresh RPMI medium. The lymphocyte cultures were cultured and at the 72nd hour of cultivation, 0.02% colchicine was added to each culture, followed by 0.56 % KCl, fixation in methanol : glacial acetic acid (3:1, v/v), and staining in 2% Giemsa. Untreated cells were used as a negative control.

Endpoints. Mitotic index (MI) was used as an endpoint for cytotoxicity; chromosome aberrations (CA) and micronuclei (MN), as endpoints for genotoxicity. MI of the treated variants was calculated as percentage of the negative control. The percentage of metaphases with chromosome aberrations (MwA% ± SD) was calculated. Chromatid breaks

(B'), isochromatid breaks (B") and translocations (T) were determined. Percent of micronuclei (MN% ± SD) was also calculated.

Statistical analysis. Student's *t*-test and *chi*-square method were used for statistical analysis. The experiments were performed in triplicate.

RESULTS AND DISCUSSION

Our results showed well expressed cytotoxic effect ($p < 0.001$) of RP assessed by value of MI (Figure 1A). The cells' viability decreased in a concentration-dependent manner (from 76.4% for 0.036 μg/ml to 29.6% for 1.8 μg/ml). The effect was most pronounced in cells treated with 3.6 μg/ml where there was a lack of any dividing cells. This concentration corresponds with that used in agriculture. Our results are in agreement with the study of Marc et al. (2002), who showed that this herbicide can disrupt the animal cell cycle in urchin eggs. Our data also correspond with the data of Richard et al. (2005), who reported that RP reduces the cell viability of human choriocarcinoma (line JEG3) with concentrations 10 times lower than those used in agriculture. In the present here study, the genotoxic activity of RP assessed by chromosome aberrations increased in a dose-dependent manner (Figure 1B). The MwA values increased from 3.6-fold for 0.036 μg/ml RP to 7.0-fold for 1.8 μg/ml RP compared to those in the non-treated lymphocytes. The spectrum of induced chromosome aberrations consisted of isochromatid breaks followed by chromatid breaks (data not shown).The RP genotoxic effect assessed by MN as endpoint was not so well pronounced. The percent of micronuclei were significantly increased ($p < 005$, $p < 0.01$) by RP concentrations of 0.9 μg/ml or higher (Figure 1C). Our results are in agreement with the data of Polleta et al. (2009) in Caiman embryos and Koller et al. (2012) in cultured human buccal epithelial cells. The genotoxic effect of RP was lower than that of MNNG (50 μg/ml).

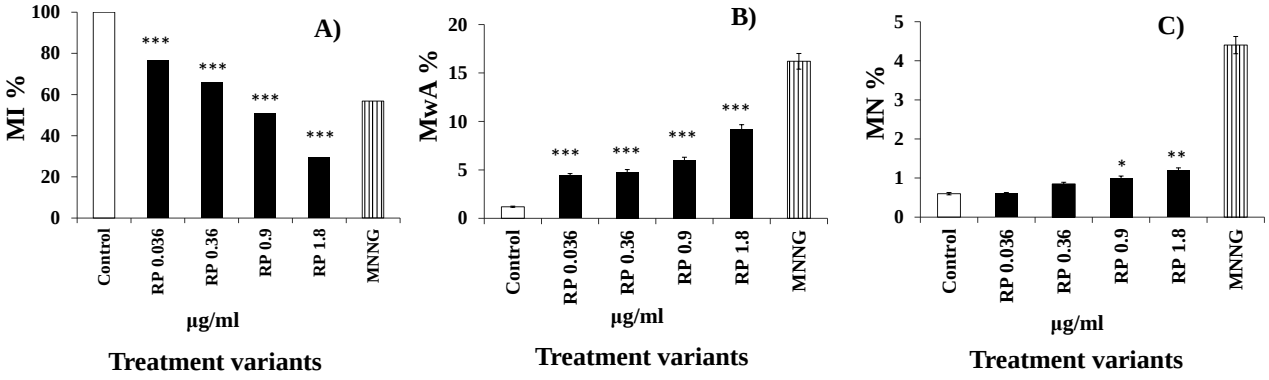

Fig. 1. Cytotoxic/genotoxic effects of different concentrations of Roundup (RP) assessed by: A) MI; B) CA; and C) MN in human lymphocyte test-system, ***$p < 0.001$, **$p < 005$, *$p < 0.01$

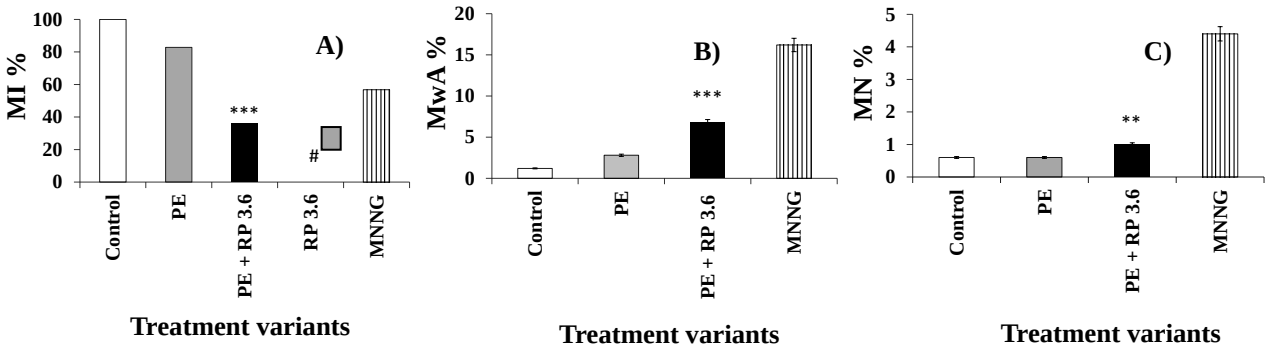

Fig. 2. Cytotoxic/genotoxic effects observed after treatment with plant extract (PE) of non-treated *H. vulgare* (▒) and plant extract from plants previously affected (■) by Roundup (3.6 μg/ml) assessed by: A) MI; B) CA; and C) MN in human lymphocyte test-system, **$p < 0.001$, **$p < 005$

Interestingly, in human lymphocytes treated with PE from H. vulgare previously affected by the herbicide (3.6 µg/ml), the mitotic activity (MI) was significantly reduced ($p < 0.001$) compared with both the negative control and the cultures treated with PE from plants non-affected by the herbicide (Figure 2A). Moreover, there was higher frequency both of chromosome aberrations and micronuclei ($p < 0.001$, $p < 005$). Their values were close to those obtained after direct treatment with RP, but with the lower concentration 0.9 µg/ml (Figure 1B,C and Figure 2 B, C). After RP direct treatment MwA was 6.0 ± 0.9, MN 1.1% ± 0.3, respectively, and treatment with PE from H. vulgare previously affected by the herbicide induced 6.8% ± 0.8 MwA and 1.2% ± 0.2 MN, respectively. The spectrum of chromosome aberrations was similar to that observed after direct treatment with RP. The data obtained by us suggest that *H. vulgare* (PE) could contain some quantity of residual herbicide that induces cell injuries including DNA damage. This speculation is further supported by our data showing down gradation in the values of the morphometric endpoints of the plants from which the extract was obtained as a result of RP (unpublished data). Glyphosate, the active compound of RP, inhibits the shikimic acid pathway, which participates in the biosynthesis of phenylalanine and tyrosine and is also the major pathway in the biosynthesis of most plant phenolics (Alam, 2010).

The present study gives valuable additional information about the potential risk for humans whose daily diet includes plants that could contain residual herbicide as a result of treatment with RP.

CONCLUSIONS

Clear cytotoxic/genotoxic effects were obtained after direct treatment with RP. The genotoxic activity obtained after treatment with PE from plants grown from seedlings of *H. vulgare* previously treated with RP was close to that of observed after direct treatment with RP with the lower concentration 0.9 µg/ml.

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EVIDENCE OF *IN VIVO* GENOTOXICITY INDUCED BY EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS COMPARED WITH IONIZING RADIATION AND A CHEMICAL MUTAGEN

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A b s t r a c t: Electromagnetic fields (EMFs) and waves, encompass a ubiquitous and very broad range of frequencies in the modern environment. The aim of the present study was to evaluate the genotoxic potential of 60-Hz EMFs compared with ionizing (gamma rays) radiation and Mitomycin-C (MMC), a well-known genotoxic agent. The frequency of micronucleated polychromatic erythrocytes (MN) in bone marrow was evaluated in three-month-old male BALB/c mice exposed to 0.1Gy, 0.2 Gy, and 1.0 Gy gamma rays, 1.0 mT, 1.5 mT, and 2 mT EMF, 5 mg/kg MMC alone or the combinations 0.1, 0.2, or 1 Gy + MMC, and 2.0 mT EMF + MMC. Statistically significant differences on MN frequency due to genotoxic effect were observed after exposure to 1.0 Gy gamma rays, 1.5 and 2.0 EMFs, and MMC, as compared with controls. In addition, co-exposure to gamma rays and MMC significantly increased MN frequency, as compared with treatments alone. In contrast, an antagonistic effect between EMF treatment and MMC was observed. In conclusion, the present study indicates in *vivo* susceptibility of mice to the genotoxicity potential of EMFs compared with ionizing radiation and a chemical mutagen.

Key words: extremely low frequency magnetic fields; ionizing radiation; chemical mutagens; micronucleus test, genotoxicity

ДОКАЗИ ЗА *IN-VIVO* ГЕНОТОКСИЧНОСТ ПРЕДИЗВИКАНА ОД ЕЛЕКТРОМАГНЕТНИ ПОЛИЊА СО НИСКА ФРЕКВЕНЦИЈА СПОРЕДЕНО СО ЈОНИЗИРАНА РАДИЈАЦИЈА И ХЕМИСКИ МУТАГЕНИ

А п с т р а к т: Електромагнетните полиња (EMFs) и бранови опфаќаат многу широк спектар на фреквенции во современото опкружување. Целта на оваа студија беше да се оцени генотоксичниот потенцијал на 60 Hz EMF во споредба со јонизирачкото зрачење (гама зраци) и митомицин-Ц (MMC), добро познат генотоксичен агенс. Фреквенцијата на микронуклеарни полихроматски еритроцити (MN) во коскената срцевина беше оценета кај тримесечни машки BALB/c глувци изложени на 0,1 Gy, 0,2 Gy и 1,0 Gy гама зраци, 1,0 mT, 1,5 mT и 2 mT EMF, 5 mg/kg MMC одделно или во комбинации 0,1, 0,2 или 1 Gy + MMC и 2,0 mT EMF + MMC. Статистички значајни разлики на фреквенцијата на MN поради генотоксичен ефект беа забележани по изложеност на 1,0 Gy гама зраци, 1,5 и 2,0 EMF и MMC. Покрај тоа, ко-изложеноста на гама зраци и MMC значително ја зголеми фреквенцијата на MN. Наспроти тоа беше забележан антагонистички ефект помеѓу третманот со EMF и MMC. Како заклучок, оваа студија покажа in-vivo чувствителност спрема генотоксичниот потенцијал на EMFs кај глувците наспроти јонизирачкото зрачење и хемискиот мутаген.

Клучни зборови: екстремно ниски фреквециски магнетни полиња; јонизирачко зрачење; хемиски мутагени; микронуклеусен тест; генотоксичност

AIMS AND BACKGROUND

Exposure to electromagnetic fields (EMFs) and waves is a common feature of modern life. The modern technology has largely developed using energy forms, of which the most relevant is electricity. In fact, it has been determined that living in a major metropolitan region will increase at least three-fold

exposure to environmental EMFs than that of organisms living in suburban or rural areas [1], although the level of exposure depends on the proximity and time of exposure to a radiation source.

EMFs and waves are reported to produce direct and indirect effects on genes and chromosomes of living beings, which depend on many physical, chemical, and biological factors [2]. They may be visible or not, immediately after exposure. However, there may be subtle changes only detectable upon careful laboratory study, or be apparent after a long period of time.

The understanding of the interaction of EMFs with living systems is progressing in a wide range of areas [3]. Nowadays, the increasing amount of research related to the evaluation of EMFs genotoxic effects, lead to consider the potential risk associated with EMFs exposure. EMFs have been classified as "possibly carcinogenic" by the International Agency for Research on Cancer [4]. Some publications have reported associations between EMF exposure and DNA damage [5 – 9], but other studies contradict such findings [10 – 14].

Cytomorphological changes, such as micronuclei (MN), indicative of genomic damage, are biomarkers of genotoxicity. We recently presented evidence of genotoxicity induced by 60 Hz magnetic fields on mice bone marrow as assessed by micronucleus test [15] statistically significant differences suggestive of EMFs genotoxic effects were observed for MN frequency, when comparing EMF-exposed and control animals at 1.5 and 2.0 mT of magnetic flux density. However, the issue of genotoxic potential of EMFs is controversial. Absence of independent replication has been a common characteristic of experimental studies searching for weak EMFs biological effects [16]. The current study was aimed to further evaluate the possible genotoxic effect of 60 Hz sinusoidal magnetic fields compared with ionizing, gamma radiation, and a well-known genotoxic drug, mitomycin C (MMC) on bone marrow cells of whole exposed mice by means of the micronucleus test.

Animals. Sexually mature, 3-month-old male BALB/c mice (25–30 g) were used. Animals were born and raised in our breeding colony. After a 10-day quarantine period, they were then randomly distributed into experimental and control groups. This research project fulfilled all requirements of the University's Animal Care and Use for Research Protocol, which is based on the National Guidelines for Ethics and Biosafety under the General Law of Health for issues regarding Health Research, Ministry of Health, Mexico City.

Treatment protocol. Twelve treatment regimens were considered: (1) animals exposed to 0.1 Gy of gamma rays, (2) 0.2 Gy of gamma rays, (3) 1.0 Gy of gamma rays, (4) 5 mg/kg MMC, (5) 0.1 Gy of gamma rays + MMC, (6) 0.2 Gy of gamma rays + MMC, (7) 1.0 Gy of gamma rays + MMC, (8) 1.0 mT EMF, (9) 1.5 mT EMF, (10) 2.0 mT EMF, (11) 2.0 mT EMF + MMC, and (12) controls, animals not exposed to any physical or chemical agents. For ionizing, gamma ray irradiation, an acute exposure was considered and 72 h after the radiation treatment, animals were sacrificed and then MN test was performed. For EMF exposition, a 72 h exposure was carried out and the MN frequency was analyzed at the end of the electromagnetic treatment. The exposure time of 72 h was chosen because it is known that the period of differentiation from stem cells to mature polychromatic erythrocytes in mice is about 72 h [17]. Six animals were used for each treatment regimen and controls.

Gamma-ray exposure. Animals contained in plastic cages were exposed to ionizing gamma ray radiation using a Cobalt-60 irradiator, model Gammacell 220 (MDS Nordion, Ontario Canada), at a dose rate of 0.740 kGy h^{-1}.

MMC-treatment. Animals were injected i.p. with 5 mg/kg of MMC, dissolved in sterile bi-distilled water. After 72 h of injection, mice were sacrificed. In the case of negative controls, only the vehicle (distilled water) was i.p. injected.

EMFs exposure facilities. A standardized magnetic field exposure device of similar characteristics was used [13, 15, 18]. A coil was built by winding 552 turns of 1.3 mm diameter enamel insulated copper wire to form a cylindrical solenoid with a radius of 13.5 cm and a length of 71 cm, which was connected to a step-down transformer and to a variable transformer, plugged to a 110 V AC source. Animals were allocated in the middle of this solenoid where the EMF was homogeneous, and kept at a temperature of 25 ± 0.2°C and 45% humidity. An equal number of sham-treated animals were used as controls and were placed in the same room into an EMF device of identical design as the one mentioned above, but it was turned off.

Magnetic flux density (rms) was measured using an axial Hall-effect probe (Bell FW 6010 Gaussmeter, Orlando, FL, USA). An oscilloscope (BK-Precision model 2120) was coupled to the system to monitor the resulting field. A 60 Hz alternating sinusoidal EMF was then generated. The EMF frequency content was nearly pure 60 Hz (<2% total harmonic distortion). The local temperature, inside

the solenoids with baffles present but without animals, was measured setting the Bell FW 610 Gaussmeter in Temp mode. The temperature value average was 25.0 ± 0.114 when the field was on and 24.6 ± 0.121°C without current in the coils; no statistically significant differences were observed between two solenoids (Kolmogorov-Smirnov test for normality, followed by paired t-test).

In order to keep the geometry of exposure, a plastic separator was placed inside the solenoid to allow the placement of uncaged mice in predetermined zones where the rms value of the EMF was 1.0, 1.5 and 2.0 mT. A food container and a water bottle were also placed inside these compartments. Animals were given water and food *ad libitum*.

The magnetic field ambient background level was <0.4 μT. Moreover, the local geomagnetic field was also measured, setting the Gaussmeter in DC mode and by using an axial high sensitivity Hall probe (Integrity Design IDR-321 geomagnetometer, Essex Jct., VT). The average value was 20 μT within the exposure room.

Micronucleus test. Following animal's death by cervical dislocation, the frequency of micronucleated erythrocytes in bone marrow was evaluated according to the procedure of [19]. Decoding of the slides was done after finishing the microscopic analysis. All chemicals were supplied by SIGMA-ALDRICH (USA).

Statistical analysis. The statistical significances were calculated among groups by using the nonparametric methods and of Kruskal-Wallis and the Mann-Whitney U test from non-normal data distribution. The normality of the data was estimated by the Kolmogorov-Smirnov test ($p < 0.05$). All analyses were performed by using SPSS package version 22.0. Differences were considered to be significant when p values were lower than 0.05.

RESULTS AND DISCUSSION

The design of the present study evaluated the clastogenic potential of 60 Hz EMFs compared with ionizing (gamma rays) radiation and MMC, on the frequency of MN in bone marrow polychromatic erythrocytes. Additionally, three dosages of ionizing gamma-rays of 0.1, 0.2 and 1.0 Gy, and combined treatments with MMC for each dose were tested. Figure 1 shows the MN frequencies for eleven treatment regimens and controls. An increased MN frequency in 1.5 and 2.0 mT, 72 h-exposed animals was observed ($p < 0.05$), whereas no variation in MN frequency was observed for mice exposed to EMFs, 72 h at 1.0 mT when compared with unexposed negative controls. Animals treated with 5 mg/kg of MMC showed higher MN frequencies when compared with negative controls. With regard to ionizing gamma rays, an elevated MN frequency was observed for 1.0 Gy exposure condition, but no variations were found for 0.1 and 0.2 Gy treatments compared to controls.

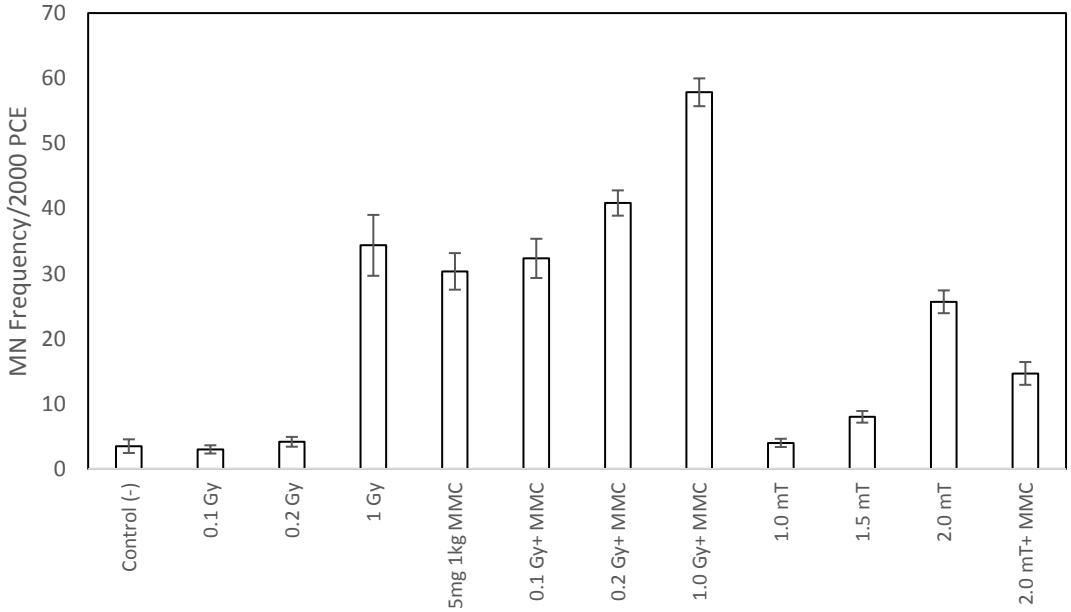

Fig. 1. Effect of non-ionizing 60 Hz EMFs, ionizing gamma rays, and 5 mg/kg of MMC as a chemical mutagen, and combined treatments on frequency of MN/2000 PCEs. Bars represent arithmetical means ± SD of 6 replicates per group.

In addition, Figure 1 also shows a synergistic effect when gamma rays and MMC were applied simultaneously to the animals at all dosages. On the contrary, when animals were co-exposed to EMFs and MMC, an antagonistic effect in terms of MN frequency was observed. The treated animals showed, in spite of the genotoxicity of the MMC, lower MN frequencies when compared with animals treated with MMC alone.

Regarding the comparison among non-ionizing EMF radiation, gamma rays ionizing radiation, and the chemical mutagen MMC, it was noted that 1.0 Gy treatment and 5.0 mg/kg MMC showed similar values, higher than those observed for 2.0 mT EMF treatment. However as explained above, magnetic treatment increased the MN frequency as compared with negative un-exposed mice.

The amount of genotoxic effects related to radiations and chemical mutagens is large, nevertheless, we confined our *in vivo* experimental investigation to a single parameter; the frequency of MN as a biomarker for a genotoxic effect. In the present study, was found an elevated frequency of MN in PCE of mice bone marrow cells indicating of genotoxicity attributed to EMF exposure when compared with the well-known clastogenic agents ionizing gamma-ray radiation and MMC [20]. For gamma rays 1.0 Gy treatment, and 5 mg/kg MMC, an elevated MN frequency was found with very similar values as compared with 2.0 mT EMF exposure. The knowledge of the genotoxicity of ionizing radiation, and now by EMFs, leads to a wider concern about possibly similar effects of nonionizing electromagnetic radiation other than EMFs as for instance; radiofrequency and mobile phone signals. For instance, it is known that the interaction of EMFs and waves with biological systems is frequency-dependent. High frequencies, i.e. ionizing radiation possess more energy and different interaction mechanisms than the low ones.

In regard to the potential genotoxicity of extremely-low-frequency-EMFs, the recent work showed evidence of genotoxicity induced by acute and expanded exposures to a 60 Hz magnetic field on mice bone marrow as assessed by the same *in vivo* micronucleus test [15]. In spite of increasing evidence of potential genotoxicity of EMFs, this concern is yet controversial. Many researchers agree that living beings could be adversely affected by exposure to this non-ionizing electromagnetic radiation [19, 20]. In the present study, an evidence of a genotoxic effect induced by *in vivo* exposure to 60 Hz at 1.5 and 2.0 mT magnetic fields on mice bone marrow cells was found. These results agreed with others using the MN assay, suggesting a genotoxic effect associated to magnetic field exposure [14, 15]. Furthermore [16], suggested a clastogenic potential of intermittent low-frequency EMFs, which may be associated to significant chromosomal damage in human diploid fibroblasts. In addition [17] found an augmented MN frequency in Wistar rat tibial bone marrow cells exposed to long-term extremely-low-frequency EMFs, compared with non-exposed and acutely exposed animals [18]. observed a significant increase in new born rat bone marrow cells MN frequency, suggesting a clastogenic effect by magnetic field exposure. More recently [19], found a slight genotoxic damage when mice were exposed to 50 Hz, 65 μT magnetic field, 24 h/day, for a total of 30 days, starting from 12 days post-conception as assessed by the MN test. In contrast, there are several studies showing lack of magnetic field exposure-mediated genotoxic or cytotoxic effects [10, 11, 12]. Recently [13] reported an absence of genotoxicity in a very sensitive model of human lens epithelial cells *in vitro*, examined by alkaline comet assay after an exposition to 0.4 mT EMF.

The controversy about EMF cytotoxic effects, derives from the fact that many scientists believe EMF devices emit little energy and are therefore too weak to have any effect on cells. Furthermore, the inconclusive nature of laboratory experiments turns this concern very difficult.

The results of the present study did not find alterations in MN frequency when animals were exposed to 1.0 mT magnetic flux density compared with controls. However [14] reported a statistically significant incidence of chromosomal aberrations when cultured human lymphocytes were exposed to a very similar intensity of 1.05 mT of pulsing 50 Hz magnetic fields. This magnetic field strength of 1.0 mT agreed with the threshold limit value (TLV) established for extremely-low-frequency EMF since 1994 by the American Conference of Governmental Industrial Hygienists [15]. In a study conducted by [13] there was a large discussion on this topic, and taking in account the opinion of scientists and other risk experts, they concluded that TLV for 60 Hz magnetic fields should be revised to be made stricter. Nevertheless, it has been recently established that EMF exposure levels reaching 1.0 mT do not induce breakage of DNA strands. Moreover, the DNA repair system is not perturbed by this exposure strength [17]. Furthermore, it was observed that EMF exposure at 1.0 mT and 60 Hz did not enhance

the MN frequency in mouse embryonic fibroblast NIH3T3 cells and human lung fibroblast WI-38 cells [18].

Regarding the issue that weak fields may have too little energy to cause genotoxic effect or DNA damage, it has been proposed that because low frequency electromagnetic radiation does not transmit enough energy to affect chemical bonds, it is generally accepted that EMFs are not capable of damaging the DNA directly [19]. Nevertheless, several hypotheses have been put forward of how EMFs might indirectly affect DNA structure. Secondary currents and, hence, a movement of electrons in DNA might be induced [10]; this may generate guanine radicals, which upon reaction with water may be converted to oxidative DNA damage [20]. In a recent study, [12] reported that human primary fibroblasts exposed to 50 Hz EMFs induced a significant increase in DNA fragmentation, as tested by the Comet assay. Moreover, they showed that EMF-induced responses in the Comet assay were dependent on cell proliferation, suggesting that processes of DNA replication rather than the DNA itself may be affected.

On the other hand, the obtained results showed an antagonistic effect between EMF exposure at 2.0 mT and MMC in terms of MN frequency. There are many reports attempting to investigate the possibility of antagonistic or synergistic effect by co-exposure conditions for a variety of radiations, chemicals, and cytological endpoints. Such antagonistic effect between magnetic fields and MMC, after measuring cell kinetics and mitotic rate in human lymphocytes treated with magnetic fields with identical characteristics of those used in the present study have been previously reported by [13] and for chromosomal aberrations and sperm morphology in germ cells of mice [14], at the same co-exposure conditions used in this report. In contrast, in vitro research developed by [14, 15] on different cell systems, provided evidence for a lack of an antagonistic or synergistic effect between continuous and pulsed microwaves at different power densities and MMC, Adriamycin and Proflavin. In addition [16] did not find any antagonistic or synergistic effect on cell cycle progression of radio frequency electromagnetic radiation and Adriamycin.

Several studies have reported synergistic effects. [17] reported an enhancement of genotoxicity of cisplatin nanocomposite combined with an exposure to magnetic fields in MCF-7 human breast cancer cells determined by MN test and Comet assay. In addition, a synergistic effect between gamma ray exposure and MMC treatment in terms of MN frequency was observed for this co-exposure condition in the present study, and these findings agreed with previous reports [18, 19].

CONCLUSION

In conclusion, the present *in vivo* study suggests that 60 Hz magnetic fields can induce a clastogenic effect in mice after a magnetic field exposure at 1.5 and 2.0 mT, in a similar way as that genotoxicity induced by ionizing radiation and a well-known mutagenic agent. In addition, an antagonistic effect between EMF and MMC, in terms of MN frequency was observed. On the contrary, a synergistic effect was found in mice co-exposed to gamma rays and MMC. Nevertheless, we believe that further experiments are required, recruiting more DNA damage endpoints, i.e. comet assay and chromosomal aberrations to corroborate and definitely resolve the controversy concerning the possible genotoxic risk associated with magnetic fields. In the past century, ionizing radiation effects were widely studied; nowadays, the non-ionizing band of the electromagnetic spectrum will probably turn out to be far more significant than anyone heretofore imagined. There is the distinct possibility, for instance, that entrainment phenomenon, resonance relationships, and other reactions to non-ionizing electromagnetic fields will prove to be a critical, but hidden, variable in all scientific research, be it experiments with animals, environmental observations in the field, laboratory experiments using culture specimens, or epidemiology studies tracking disease states in the population.

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Original scientific paper

RURAL AREAS IN SERBIA AND CLIMATE CHANGE – IMPACTS AND POSSIBLE DIRECTIONS FOR ADAPTATION –

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A b s t r a c t: In Serbia, 75.1% of the territory are rural areas where approximately 49.9% of the total population lives, and average population density is about 62 inh/km^2. There are 6,158 settlements in Serbia, of which 193 are urban (3.1%) and 5,965 are "other settlements", which are considered as rural villages and which have rich natural resources. Like in other countries, rural areas in Serbia are underdeveloped and they are one of threats for sustainable regional development. In order to promote their further development and overcome all negative impacts, it is necessary to have multidisciplinary approach and to take into account all possible impacts, among others also climate change. This paper discusses impacts of climate change on rural areas in Serbia and possible measures for adaptation. Both urban and rural areas are facing effects of climate change and one of the main tasks of modern spatial planning is to define a model for revitalization as an instrument for the adaptation of settlements to climate change, and in order to overcome, among other things, existing environmental problems and reduce pollution of the environment. Successful model for adaptation, should be based on vulnerability assessment and should consider both short and long–term impacts in order to make resilient settlements.

Key words: rural areas; climate change; adaptation of settlements; vulnerability assessment

РУРАЛНИ РЕГИОНИ ВО СРБИЈА И КЛИМАТСКИТЕ ПРОМЕНИ – ВЛИЈАНИЈА И МОЖНИ ПРАВЦИ ЗА АДАПТАЦИЈА –

А п с т р а к т: Во Србија 75,1% од територијата зафаќаат руралните подрачја во коишто живеат 49,9% од вкупното население, а средната густина на населението е околу 62 жители/km^2. Во Србија има 6.158 населени места, од кои 193 се урбани (3,1%) и 5.965 се „други населби", кои се сметаат за рурални села и кои имаат богати природни ресурси. Како и во други земји, руралните области во Србија се недоволно развиени и претставуваат закана за одржливиот регионален развој. За да се промовира нивниот понатамошен развој, неопходно е да се има мултидисциплинарен пристап и да се земат предвид сите можни влијанија, меѓу другото и климатските промени. Во овој труд се разгледуваат влијанијата на климатските промени врз руралните области во Србија и можните мерки за адаптација. И урбаните и руралните области се соочуваат со ефекти од климатските промени, а една од главните задачи на современото просторно планирање е да дефинира модел за ревитализација како инструмент за адаптација на населбите кон климатските промени и со цел да се надминат, меѓу другото, постојните еколошки проблеми и да се пристапи кон намалување на загадувањето на животната средина. Успешен модел за приспособување треба да се базира на процена на ранливоста и треба да ги разгледа и краткорочните и долгорочните влијанија, со цел да се направат флексибилни населби.

Клучни зборови: рурални подрачја; климатски промени; адаптација на населби; процена на ранливоста

AIMS AND BACKGROUND

Rural areas are defined as areas with very low population density (less than 150 inh/km^2) [1] and with agriculture and husbandry as main activities. Because of natural resources and agriculture productions, these areas are main "food producing hubs" and they play very important role in development and supply of urban areas. According to European Comission statistics from 2015. in the

states members of European Union (EU) lived about 28 % of total population, around the world almost half the world's population and about 70% of the developing world's poor people, and at the same time in Serbia 37.4% of total population lived in rural areas [2]. If we apply definition according which in rural areas main physical and geographical characteristics of land use are for the needs of forestry, livestock and agriculture, in Serbia approximately 70% of the territory is rural [3]. Because of uneven economic development there are huge differences between urban and rural areas. It is very difficult to define strict and clear line between urban and rural because of numerous classifications, and also because of territory overlapping. Because of the spreading of urban territory, some rural settlements became part of urban sprawl but they remain rural in character. In general, urban residents have better possibilities for education, health care and transportation than population in rural areas.

Serbia is candidate for membership in EU and because of that many of the regulations regarding rural areas and rural development from European legislation have impact on the situation in Serbia. EU has development policy for rural areas with main goal to meet all the challenges that rural settlements are facing and to improve sustainable development of settlements and different regions. In 2014, EU Commission issued *Rural Development policy priorities in the 2014–2020 programming* [4] within which six main priorities were defined: p1_Knowledge Transfer and Innovation; p2_Farm Viability and Competitiveness; p3_Food Chain Organisation and Risk Management; p4_Restoring, Preserving and Enhancing Ecosystems; p5_Resource-efficient, Climate-resilient Economy; p6_Social Inclusion and Economic Development. Within priority 5, 5 focus areas were defined: Increasing efficiency in water use by agriculture, Increasing efficiency in energy use in agriculture and food processing, Facilitating the supply and use of renewable sources of energy, Reducing greenhouse gas and ammonia emissions from agriculture and Fostering carbon conservation and sequestration in agriculture and forestry. Priority 5 and focus areas within, foreseen measures for adaptation on climate change and they are mainly focused on agriculture and husbandry – as main activities in these areas, food processing and gas emissions regarding agriculture and forestry. Financing of rural development is through the European Agricultural Fund for Rural Development and it is 30% of the total contribution from this fund should be used for climate change mitigation and adaptation as well as environmental issues for each development program [5]. One of the questions that was raised within these development programs is also life quality which is important fact because it can prevent negative depopulation trend and transform rural settlements in more attractive place for living [6, 7].

Within the *Spatial Plan of the Republic Serbia for the period 2010–2014–2021* [8] three structural types of rural settlements and their disposition were defined. As the first type – successfully integrated areas – which feature favorable socio-economic and spatial indicators of development as well as more developed economy. The second type are the central rural areas where rural settlements are in direct connection with urban settlements and beside agriculture, there is also an "industry in development" as well as service activities. The third type of settlement consists of settlements in southern, eastern and partially western Serbia. Settlements of this type are quite heterogeneous, but they are located on peripheral – edge regions of the Republic of Serbia and because of that they are called remote rural areas. In the rural areas of western Serbia, tourism and catering are the main activities, while agriculture is underdeveloped. In eastern and southern Serbia, the situation is different, and production is directed towards the utilization of natural resources and agriculture in areas where this is possible due to geomorphological characteristics. The greatest threats for rural areas in Serbia is depopulation trend and there are many settlements with less than 100 residents and according census from 2011 there were total 84 of these settlements [9]. These settlements are mainly on the "periphery" – border region and on mountains where, on the other hand, are the greatest areas of agriculture and forestry land but with mainly elderly population, undeveloped infrastructure service and extreme depopulation trend [10]. Depending on demographic structure, rural areas can be divided in 4 types: Progressive type (around urban areas and regional centres), Stagnant type (mainly in Vojvodina), Regressive type (central Serbia) and Dominant regressive type (southeast, southwest and part of east Serbia) [11].

Awareness of climate change impacts is not developed in Serbia and the first documents and actions were adopted in 2004 because of membership in EU. Agency for energy efficiency was established with main goal to improve energy saving and energy exploitation – consumption in general. This Agency adopted 3 action plans so far and they are all for different periods starting from 2010, but in last action plan saving in energy consumption in 2018 of 0.7524 Mtoe was predicted [12]. Serbia

ratified the Kyoto Protocol in January 2008 and in 2011 document *Efficient ways for GHG emissions reductions within the post-Kyoto framework in Serbia* was adopted [13]. Because Serbia is in group of developing countries, there are no quantitative obligations regarding GHG emissions in the first stage, but still all the obligations regarding establishment and implementation of measures and activities for achieving goals of Convention must be applied. Currently, *Strategy for climate change together with Action plan* [14] is being in the preparation process. The Strategy will identify priority measures for GHG (mitigation) emissions, as well as the time framework for implementation and the total financial resources needed.

Within strategy 6 group results are defined: Assessment of the existing policy framework in the field of climate change in Serbia; Development of basic scenarios of greenhouse gas emissions for 2020, 2030 and 2050; Development of scenarios of greenhouse gas emission reduction (mitigation) for 2020, 2030 and 2050; Assessment of the impact of greenhouse gas emission reduction scenarios on economy, society and the environment for 2020, 2030 and 2050; Assessment of the adaptation options for climate change for 2030 and 2050; Preparation of the Final Draft of the Strategy for facing Climate Change with the Action

This paper discusses impacts of climate change in rural areas in Serbia. As these areas represent majority of total territory surface and they are exposed to many natural hazards it is obligatory to have strategies and programs for their adaptation and protection in order to promote their sustainable development.

RESULTS AND DISCUSSION

Climate changes are mainly consequences of direct human impact because of intensive harmful emissions caused by rapid urbanization and uncontrolled land use. Because of that, urban environment has different bioclimatic factors than rural areas and process of urbanization changes natural environment and atmospheric conditions [15]. In Serbia awareness of climate change is not developed adequately and even there are many documents regarding plans and programs for reduction of negative impacts, still concrete actions and measures are not implemented. During last few years many extreme weather – hazard events occurred such are floods in 2014 which activated numerous of landslides along the country. Beginning of 2018 is also marked with rain and snowfalls which caused many floods and landslides especially in Nišava district. Because of lack of actions and documents on local level, many times local authorities are prevented and not technically prepared to react immediately and also lack of finances is huge problem. Depopulation of rural areas and very low income are great threats to their "survival" and also to climate change adaptation [16].

As it was mentioned earlier, there are different typologies of rural areas and in this research classification according Spatial plan will be used [8]. Because of very dynamic and diverse topography, there are huge differences amongst rural areas in Serbia and also there are different natural hazards. Common for all the rural areas is that they have great potential in use of RES but inadequate infrastructure for exploitation.

In Serbia the regulations that are adopted are very general and they are mutual for entire country without differences between rural and urban. As main weakness is also that local communities in rural settlements, but also some local authorities of nearby cities have no instructions and programs for reacting in emergency situations. Everything goes on state level and just few "bigger" cities have some technical equipment. Municipalities that are in the mountains and border regions are underdeveloped and very poor connected with other settlements and it occurs that after heavy snowfalls or huge landslides some settlements are "cut off".

Distribution of different types of rural areas is shown on the Figure 1 where it is obvious that within one type there are different population density values. The greatest number of risk events is possible in the southern part of the country where dominantly rural areas are.

As main natural risks in Serbia are:

Seismic activity: Many earthquakes with different magnitude occured on the territory of Serbia. It is considered that approximately 63.2% is the probability of earthquake occurrence with a 100-years period of the observed seismicity [17]. The most vulnerable is territory of central Serbia (Figure 2) where in last decade was very destructive earthquake in city of Kraljevo. This teritory has large number of "central rural settlements" – type 2 in Spatial plan with density in range od 50–150 inh/km^2. Seismic activity is great threat because beside immediate disaster it can provoke many cascade events. Earthquakes are direct threat to residents lives, agriculture land and forest land.

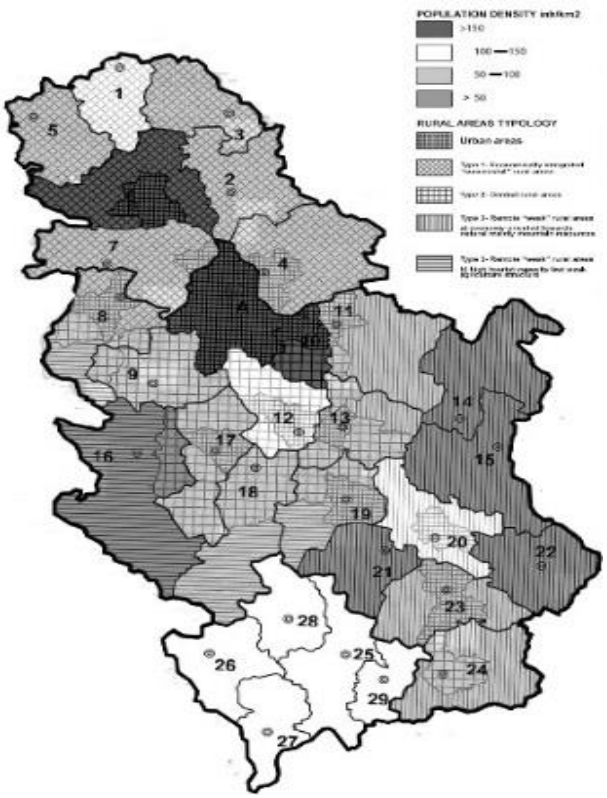

Fig. 1. Rural areas typology
Source: Strategy for Spatial Development of Republic Serbia for period 2009–2013–2020

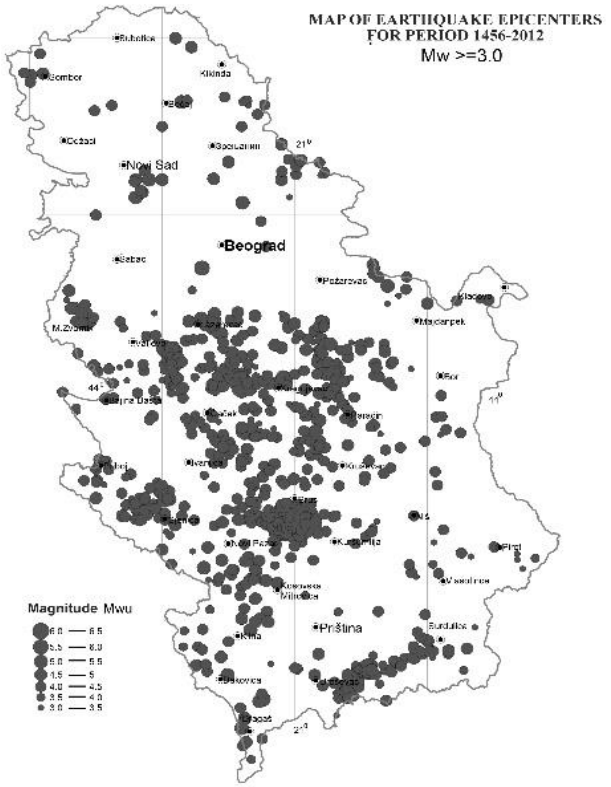

Fig. 2. Map of earthquake epicenters in Serbia
Source: Seizmological Survey of Serbia:
http://www.seismo.gov.rs/Seizmicnost/Karte_hazarda_l.htm

Landslides and land erosion: Map of territory endangered by landslides and land erosion is shown on the Figure 3. It can be seen that mainly territory south from Danube river flow is affected by this hazards. The greatest landslide was in 70-ies in the village of Zavoj when because of heavy snow and rainfall landslides on Mt. Stara Planina started, 3 villages were submerged and artificial Zavoj lake was formed. Large number of landslides was activated after 2014 floods in Obrenovac. In March 2018 many of the landslides were activated because of heavy rain and snowfall and the most endangered is Nišava district where many rural settlements are flooded and road network to some of them is destroyed by landslides. Soil erosion is also highly expressed on mountainous areas and along river banks and it represents great threat to agriculture production. These two hazards are often caused by some extreme weather event and they have destructive impact on built area and also on agriculture and forestry land.

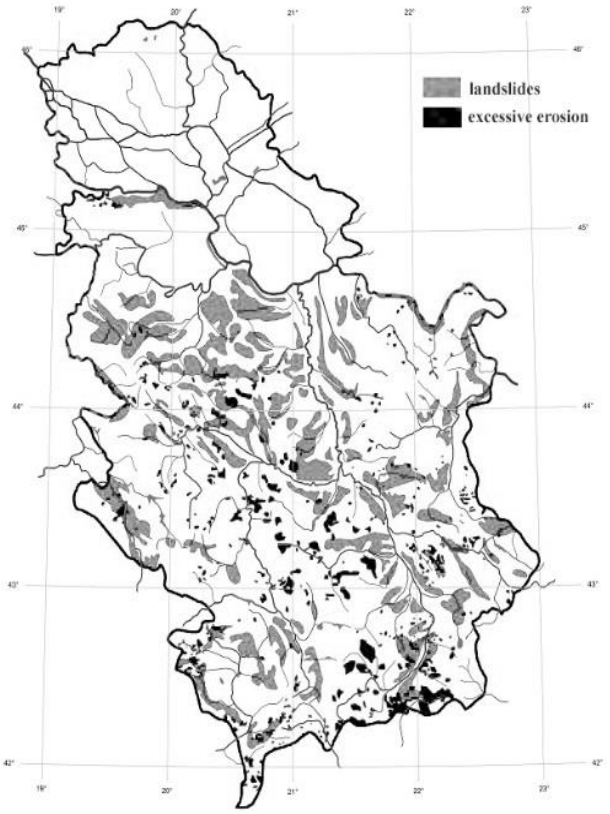

Fig. 3. Landslides and erosion map
Source: http://indicator.sepa.gov.rs/pretraga/indikatori/svefind/5de1925a414949f08424844496985a00

Floods and torrential floods: Serbia has huge hydropotential because of very rich water flows. Because of specific climate conditions and also because of heavy rains that are not frequent but

during spring and summer months can cause floods. In mountainous regions, there is higher risk of torrential floods which are often caused by snow melting. The greatest floods are along the flow of Danube – the biggest river in the country, but significant are also floods along other big rivers – Nišava, Morava, Toplica… On Figure 4 there is a map of most significant floods in the past and on Figure 5 areas that are most threatened by floods. The most endangered are areas in Vojvodina which is part of the greatest flat land Panonija. This area is mainly with agriculture land and with large number of rivers and canals that are affluent to Danube. These floods have negative impact on agriculture and food production and they are characterized as long-lasting floods. On the other side, torrential floods are mutual impact with soil erosion and they are "responsible" for topography in hilly and mountainous regions. Torrential floods emerge by expressed action of climatological and meteorological factors, such are large showers and thunderstorms, and they are manifested by diversity, high speed of formation and short duration [18]. This natural disaster is very dangerous because it is completely unpredictable and often followed by human victims.

Fig. 4. Map of significant past floods,
Source: http://www.ingkomora.org.rs/materijalpo/download/2015/ 20151216_6708_ODBRANA_OD_POPLAVA.pdf

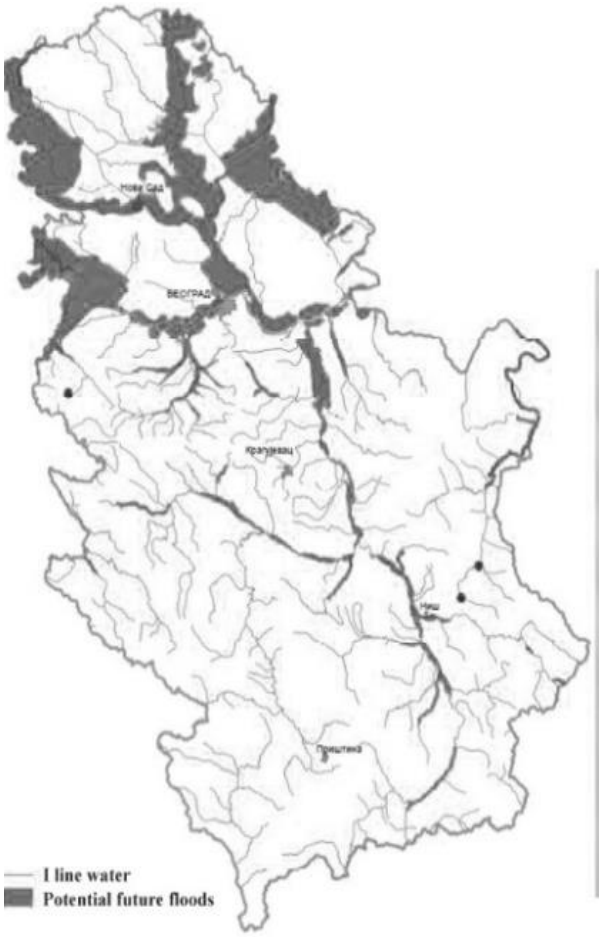

Fig. 5. Areas endangered by floods
Source: http://www.ingkomora.org.rs/materijalpo/download/2015/20151216_6708_ODBRANA_OD_POPLAVA.pdf

In Serbia torrential floods are most expressed in west Serbia, mountain region in central Serbia, southeast and east part (Figure 6). Most fertile land, where main producers of vegetables are, is along the South Morava river banks and often because of the floods all of the crops are destroyed.

Drought: Because of extremely high temperatures and not very often rains during summer period, drought is one of the biggest problems for agriculture. Drought periods can be very long during summer months and also in spring and autumn, and they can cause drying of crops and reduction of yield. Division of territory regarding droughts and droughts in period 2000–2012 are shown on Figures 7 and 8. Serbia is divided in 3 regions according different probability of droughts and percentage of years that are characterized by droughts. Regions 1 and 3 have almost same percentage of years characterized by droughts about 45%, and according conducted study approximately 70% of the frequency of drought belongs to the near normal drought category [19].

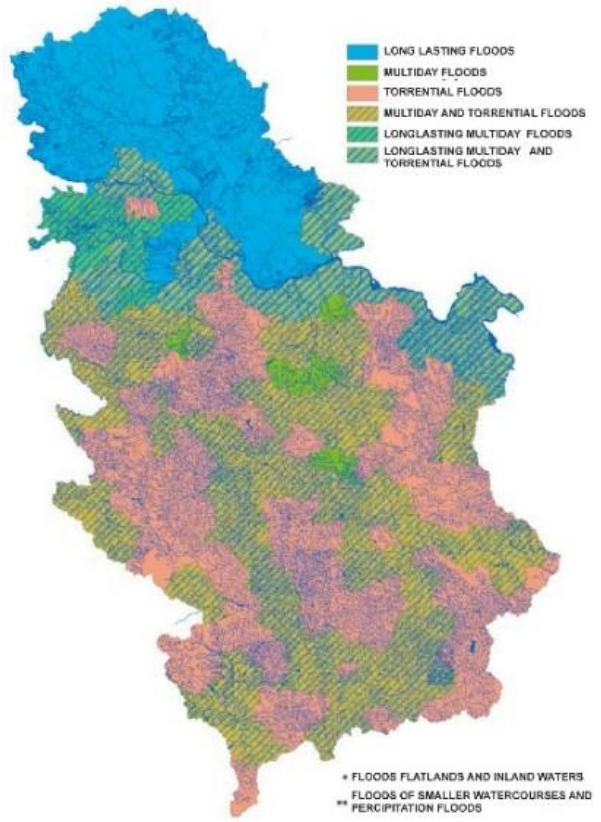

Fig 6. Map of river / torrential floods
Source: https://www.osce.org/sr/serbia/148311?download=tr ue

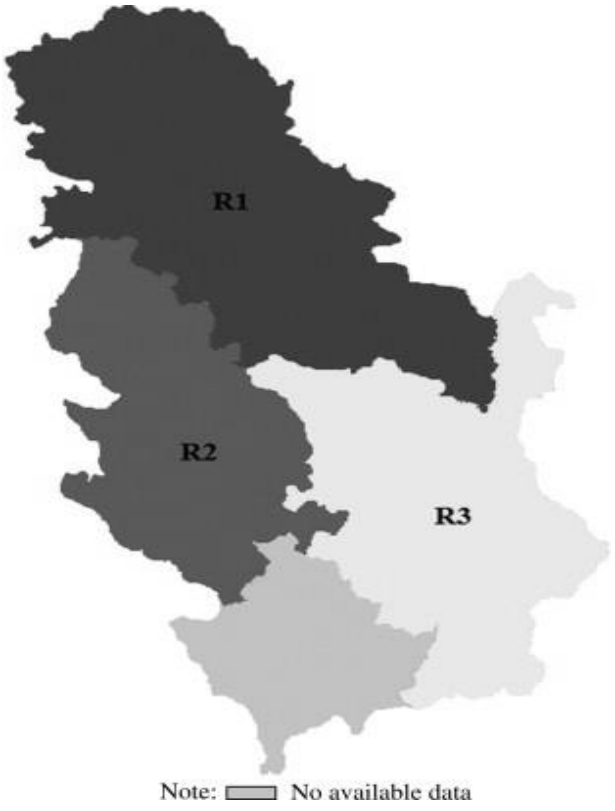

Fig. 7. Drought regions in Serbia
Source: M. Gocić, S. Trajković: NatRisk project, available: http://slideplayer.com/slide/12333229/

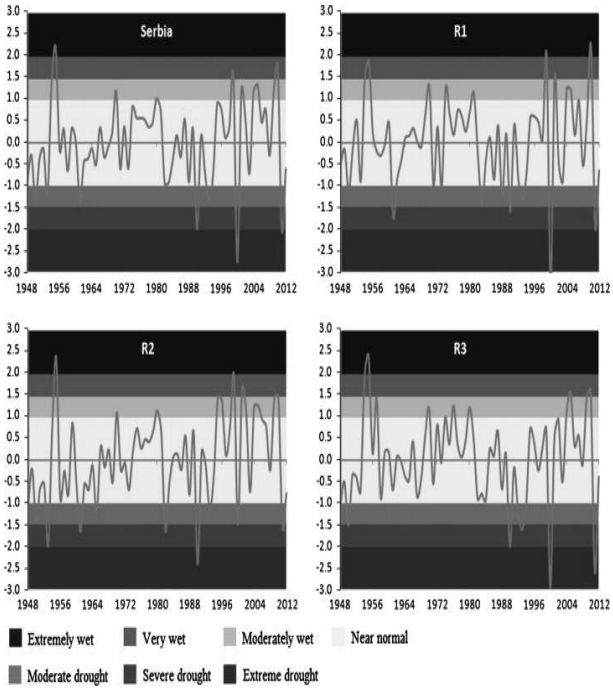

Fig. 8. Droughts in period 2000–2012
Source: M. Gocić, S. Trajković: NatRisk project, available: http://slideplayer.com/slide/12333229/

Forest fires: Fires in general represent great threat to built area, soil fertility and human's lives (Figure 9). Fires are spreading rapidly in forests and they are also known as wild fires. In Serbia, forest and agriculture fires are often during summer because of heat waves but also because of disregard of people who use flame in forest and also burn straw. On the field after plow there is straw that residents burn and this straw can be used for heating and estimated energy value for heating is approximately 16 MWh/ha. By using the straw residue, only in the Nišava district approximately 1.500 GWh of annual energy used for heating can be saved.

Beside above mentioned natural hazards, overheating and extreme low temperatures are also threat for Serbian rural areas (Figure 10). Temperature varies during years and extremely hot weather is not only in summer which causes droughts and a lot of damages to agriculture (high temperatures initiate fruit ripening and then frost destroys yield) but also it provokes faster snow melting and cause floods, torrential floods, landslides and erosion. Last decade was marked with many extreme weather events and according to data from Hydrometeorological Institute, average temperatures have changed for few degrees in last decades.

In order to develop rural areas, improve life quality in them and to prevent negative depopulation trend it is necessary to revitalize rural areas.

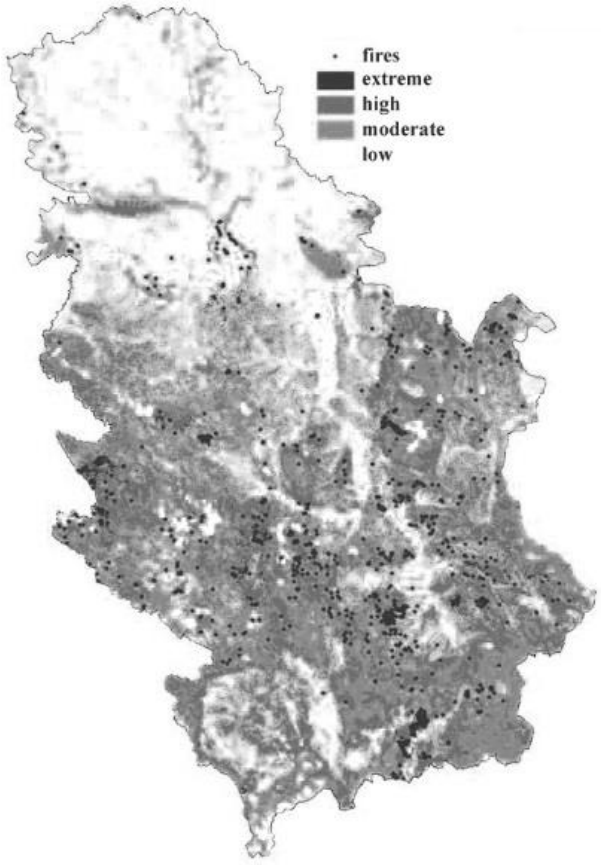

Fig 9. Map of fires in Serbia
Source: http://www.forest.org.rs/files/10%20Koriscenje%20GISa.pdf

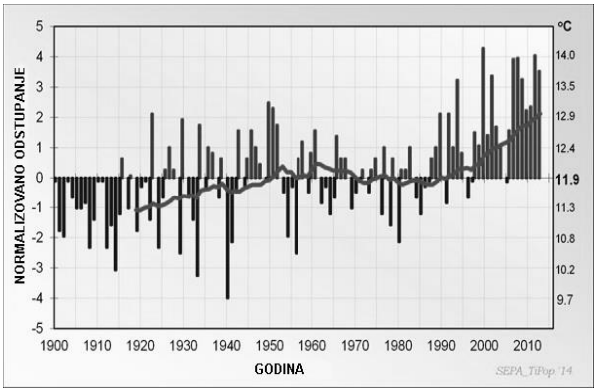

Fig. 10: Temperature diagram for period 1900–2010
Source: http://indicator.sepa.gov.rs/pretrazivanje-indikatora/indikatorilat/allfindu/2541db7873af4a7c89a8af252092ce4f

How to get best results and really develop and improve marginalized areas it is very important to have multidisciplinary approach and to take all the possibilities and threats into account, and amongst them climate change as one of the major setbacks. Climate change can have direct influence on rural areas and settlements with extreme weather and natural hazards or because of effects of climate change territory becomes very vulnerable to natural hazards and extreme weather conditions. As it was mentioned, government in Serbia has adopted various strategies and programs for climate change but they are all in general, regarding urban areas and mainly considering only GHG emission reduction. Strategies that exist for rural areas are not considering adaptation to climate change as one of the factors that could significantly improve economic and sustainable development. Rural areas and rural settlements are in direct economic and spatial dependence of surrounding urban areas, but urban areas depend on rural in terms of agriculture and food production and also in use of RES. Climate change impact on both urban and rural areas is increasing and it is obligatory to have measures for mitigation and adaptation in order to prevent future natural disasters.

First of the obstacles for adequate implementtation of the suggested measures is that in Serbia, in endangered rural areas, age structure is unfavourable and main population is elderly. Another problem is underdeveloped or completely absent infrastructure network and systems for protection from natural disasters in general. Most of the villages have no local community office or some legal body to suggest programs and solve exact problems locally. In order to react fast and effective, study of vulnerability risk assessment must be done for each municipality and rural area or settlement within. Different rural areas have different natural threats and programs for adaptation are not always the same and they differentiate locally. Unfortunately, some of the extreme weather events cause natural disasters uncontrolled and on the land which never had that vulnerability. This was the case in 2014 when floods in Obrenovac caused serious of landslides on the territory which was not threatened by floods earlier. Because of that it is important to raise awareness of the residents and to organize seminars and workshops so they can realize importance of this issue. In case of extreme events, local community can react fast and in some cause can minimize damage or maybe mitigate disaster effects. Strategies for adaptation must be constantly updated because using past adaptation strategies is not always successful. Coping strategy from international to national and then to local level can result with an increase in vulnerability degree for future events because only short term activities were considered [20].

At the moment the greatest threats to rural areas in the county are floods and landslides emerged due to heavy precipitation and snowfall. Almost all villages have streams on their territory which are often place for many wild landfills – illegal waste

disposal, and when a large amount of water comes there is an outflow which results with floods. On the other side, mountain streams are known by torrential floods which make damage to settlement – both built area and agriculture fertile land, and they are direct threat to residents lives. It is important that on the local level, protection from floods is defined and that in case of heavy precipitation residents can be prepared and can prevent serious disasters. Another problem is that because of uncontrolled and illegal construction many buildings are illegally built near rivers and they are directly threatened by floods. Torrential floods cause erosion of land which can be followed by uncontrolled landslides that can be activated on the territory which is not characterized with that vulnerability. There are many measures for preventing floods and one of them is also developing systems for collecting atmospheric water and their reuse (for example for irrigation during drought months) or constructing hydropower plants on some of potential rivers (for transforming hydropower). Using study of land characteristics, people would knew soil condition for construction and number of houses built on landslides would be reduced.

Opposite to precipitation and floods, heat waves or overheating can also cause serious of problems especially to crops and humans health. As consequence of long term droughts are extremely precipitations with devastating effects which cannot recover crops. Overheating can also cause fires and it is great threat to forest and agriculture land. Because of great solar potential – solar radiation, three times greater than in Central Europe, solar systems can be used for collecting and transforming solar into electrical energy which could supply small settlements and help them become "off grid" in case of extreme events. Another extreme can be heavy snowfalls and low temperatures that can unable transportation which was the case few years ago in Majdanpek in eastern Serbia. Most of the rural settlements have only one road which connects them with other settlements and closing of the road because of snowfall or landslide isolated settlement completely.

An independent organization can be formed in order to help residents in rural areas to prepare and to learn how to react in short time. Use of IT sector is also very important because many systems for monitoring can be installed on the field and constantly monitoring of the situation can help predicting some of the events. Also use of technologies can create network of smart villages that can function completely independent thanks to RES exploitation. Still, because of educational and age structure, residents are often not able to use all the application by themselves.

CONCLUSION

Rural areas represent very significant territory of every country, they are mutually dependent with urban areas in terms of economic development, administration and food production. Still, rural areas and settlements are not independent in terms of legislation and authority which in many cases is setback in development and protection of rural areas. Local communities have no authonomy in decision making neither in urgent reaction or prevention process. Another dependence is financial because local communities are directly dependent on funds from cities or foreign funds which are in jurisdiction of municipalities. In order to have responsible actions towards climate change adaptation, it is necessary to involve local community – all the residents as end users and local authorities as decision makers and a financial supporters. All the programs and strategies adopted by the state government can be base for further detailed plans for mitigation and adaptation to climate change impacts.

Because of diverse topography there are different natural conditions within Serbain territory and also different natural hazard threats. Even climate is moderate, there are numerous temperature deviations during year – both in summer and winter months. Climate change has impact on weather events which affect land and as cascade events many natural hazards occure. Unified measures cannot be asopted for urban and rural araes because they are not threatened by the same negative impacts. In urban areas – in cities there is air pollution and effects of GHG are more expressed and all the studies are oriented towards GHG emissions reduction. Protection from floods and droughts are main problem in rural – agriculture areas, but still are not developed. In urban areas there are often workshops, seminars about climate change and its negative impacts, while rural residents are not familiar with it but still everyday they are facing consequences.

With responsible and serious measures and controlled and efficient implementation, adaptation and mitigation to climate change can be achieved also in rural araes. At the moment, in Serbia main focus is on urban area but it is certain that rural areas must be in focus too because they are main producers of food and agriculture products and also main RES are in rural areas.

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Original scientific paper

ECOLOGICAL STATUS ASSESSMENT VS. SPECIFIC POLLUTANT LOAD: IS ICT THE MISSING LINK?

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A b s t r a c t: With the development of society, the problem of treatment of generated waste water is getting increasingly bigger. Polluting substances from waste waters directly affect the quality of surface and indirectly the quality of ground water. Disturbances of aquatic ecosystems caused by the discharge of untreated waste water have gradually increased to such a degree that the purification was imposed as a necessity. In this sense, the paper is organized as follows. The first part of the paper is dedicated to the issues of ecological status parameters monitoring, evaluation and assessment. The advantages and constrains of this methodology are showed at the example of relatively large surface water body – the Danube river, class I surface water body, and relatively small water body – the Nišava river, class III surface water body. While the ecological status assessment represents some kind of "diagnosis measure", the specific pollutant load represents initial water protection measure, particularly in the sense of "water pollution hot-spot" identification, which is further elaborated within the second part of the paper. Additionally, the third part of the paper presents an in-depth analysis of ICT application potential within various water protection segments and different stakeholders, with particular regard to the field of specific pollutant load management, as most prominent one in almost every modern society.

Key words: ICT; water quality management; ecological status; specific pollutant load; sustainability

ПРОЦЕНА НА ЕКОЛОШКИОТ СТАТУС НАСПРОТИ СПЕЦИФИЧНОТО ЗАГАДУВАЊЕ

А п с т р а к т: Со развојот на општеството проблемот со третманот на создадените отпадни води станува сè поголем. Загадувачките супстанции од отпадните води директно влијаат на квалитетот на површинските и индиректно на квалитетот на подземните води. Нарушувањата на водните екосистеми предизвикани од истечувањето на нетретирани отпадни води постепено се зголемувале до степен по кој прочистувањето било наметнато како неопходност. Во таа смисла, во трудот како прво вниманието е посветено на разгледување податоци од мониторингот на еколошкиот статус. Предностите и ограничувањата на оваа методологија се прикажани на примерот на релативно големо површинско водно тело – реката Дунав, површинска вода од класа I, и релативно мало водно тело – реката Нишава, површинско водно тело од класа III. Иако проценатa на еколошкиот статус претставува некаков „вид дијагностицирање", карактеристиките на загадувачот претставуваат иницијална мерка за заштита на водата, особено во смисла на идентификација на „критично загадување на водата", што е разработено во вториот дел од трудот. Дополнително, во третиот дел од трудот е дадена длабинска анализа на потенцијалот на користењето на информациски и комуникациони технологии (ICT) во различни сегменти на заштита на вода и засегнати субјекти, со посебен осврт на специфичноста на управувањето со загадување како најважното нешто во речиси секое современо општество.

Клучни зборови: ИКТ; управување со квалитетот на водата; еколошки статус; специфично оптоварување на загадувачот; одржливост

AIMS AND BACKGROUND

Nowadays, the Republic of Serbia is at the bottom of the scale of European countries in terms of the utility equipment of the respective communal infrastructure in the area of waste water collection, treatment and discharge. The current situation in the area of water resources management in the Republic

of Serbia indicates that the basic problems are insufficient construction of sewerage infrastructure within cities, i.e. insufficient coverage of the sewerage network of users connected to the public or private water supply network followed by insufficient number of constructed (and operated) waste water treatment plant. In this context, a particular problem is the requirement for relatively large initial investments in the sector of waste water collection and treatment [1, 2]. A special difficulty represents the low price of delivered and channeled water within the public utility system, which is insufficient to provide at least maintenance of the existing water supply and sewage systems and generates the development and improvement of the existing system. In Serbia, only 5–10% of total amount of generated waste water is currently treated, with different procedures and with uneven and, most often, insufficient purification effect. Dominant ratio of biodegradable matter leads to a different processes that affect the quality of the receiving water body, which is showed in Figure 1.

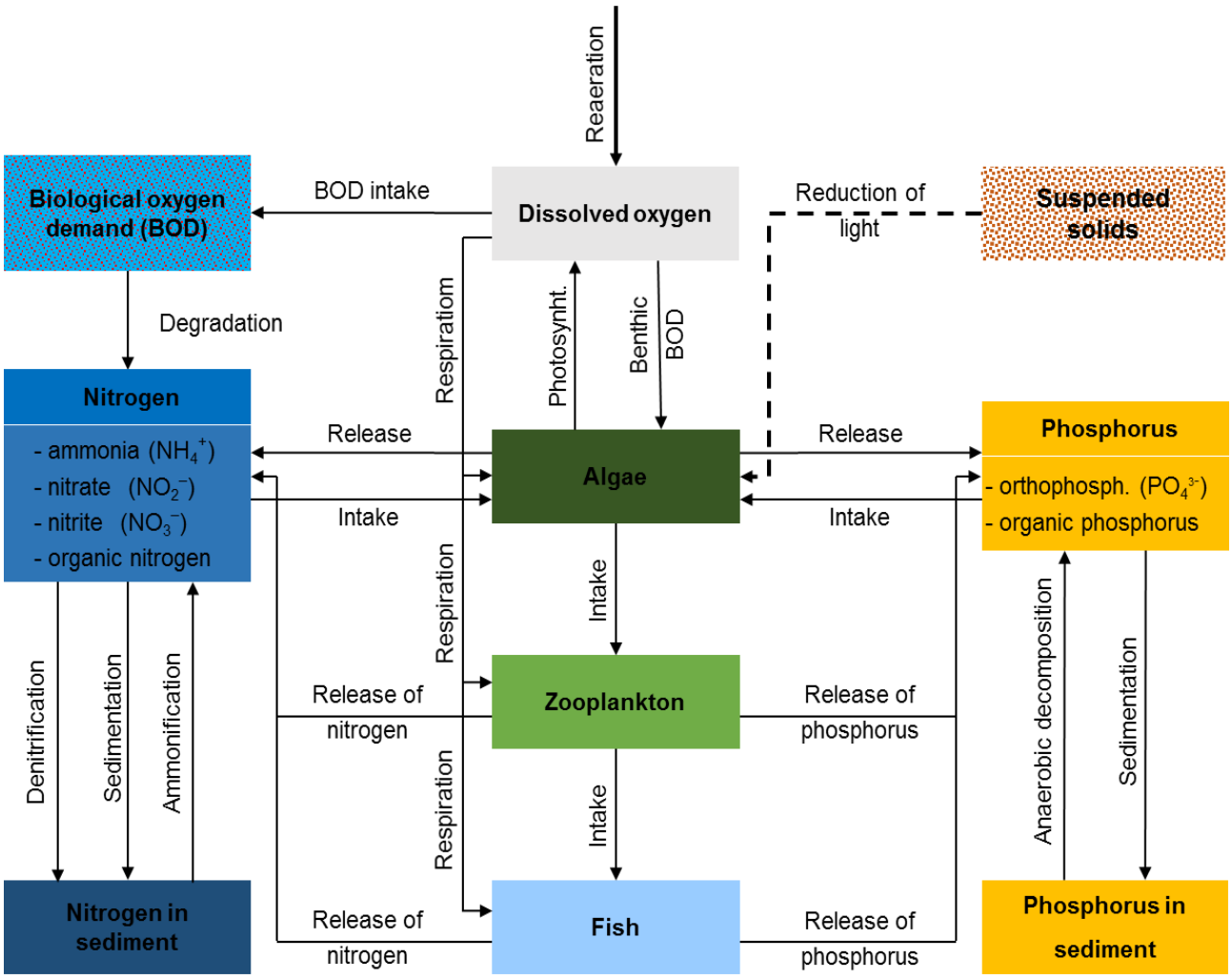

Fig. 1. Aquatic ecosystem processes induced by biodegradable matter

In addition to waste water generated by households, a special problem is also inadequate or no-treatment of industrial waste water [3]. Certain advances in the examination of key industrial polluters can be noticed in the intensification of procedures related to the issuance of integrated permits according to the requirements of the industrial emissions directive (IED) and other relevant directives [4, 5]. As far as the population is concerned, a special step has been made by implementing a specific pollution load to the receiving water stream that sees both the total emission of waste waters of a particular settlement, as well as the capacity for dilution and self-purification of the immediate natural recipient [6]. In this sense, the aim of this paper work is to demonstrate that limited financial funds dedicated to the

issues of water protection, i.e. waste water treatment should be allocated in the most functional way, using different priority inputs, like both ecological status and specific pollutant load [7].

MATERIALS AND METHODS

In this part of the paper a comparative analysis of two representative watercourses in the Republic of Serbia – Danube and Nišava, is presented, in relation to the quantitative characteristics of the recipient [8]. The main purpose of water protection from man-driven pollution is to both to preserve human health and environment-ecosystem functions by reaching and preserving the good status of surface and ground water (ecological status / potential and chemical status), reducing hydro-morphological pressures on natural water bodies, preventing and controlling water pollution and rational using of available resources [9]. Protection against concentrated sources of pollution is enhanced by the construction and adequate functioning of communal infrastructure, like sewage and waste water treatment plants.

The Danube river, after the Volga river, is the second longest and second water richest river in Europe. The main tributaries of the Danube river in Serbia are the Tisa, Sava and Velika Morava rivers. The water regime of the Danube river throughout Republic of Serbia is monitored by ten measuring stations (Bezdan – entry point – 1,425.59 km from the river mouth, Bogojevo – 1,367.4 km, Novi Sad – 1,254.98 km, Slankamen – 1,215.5 km, Zemun – 1,174 km, Smederevo – 1,116.9 km, Banatska Palanka – 1,076.6 km, Tekija – 956.2 km, Brza Palanka – 883.8 km, Radujevac – exit point – 852 km) starting from measuring station Bezdan close to Hungarian border and ending by Radujevac close to the Bulgarian border. The largest polluter of the Danube river in Serbia is the city of Belgrade, with approximately 3 000 000 PE [10].

The Nišava river is the largest tributary of the South Morava river and, consequently, the Danube river. There are two measuring stations located on the Nišava river (Dimitrovgrad and Niš), which are used to monitor water regime parameters. Dimitrovgrad measuring station includes the course of the Nišava upstream of the bridge near the village of Dolac all the way to the country's border. Niš measuring station includes the course of the Nišava from its confluence into the South Morava river to the confluence of the Studena river. The largest polluter of the Nišava river in Serbia is the city of Niš, with approximately 300 000 PE [11.

Tables 1 and 2 are dedicated to the representative quantitative parameters of both abovementioned water bodies, like average, minimum and maximum volumetric flow [12].

Although both watercourses are burdened by relatively large organic pollution, where the largest point-source pollutant of the Danube river is about ten times larger than the largest point-source pollutant of the Nišava river, the results obtained through the national monitoring network do not show drastic differences in terms of water quality [12]. It is obvious that there is a great influence of representative volumetric flows on such state of water quality – by pollution load expressed in PE Belgrade is approximately ten times larger polluter than city of Niš, while the Danube river is 496 times larger by $Q_{95\%}$ volumetric flow. This fact greatly affects the future activities dedicated to the issues of waste water collection, treatment and disposal.

Table 1

Average month and annual volumetric flow (time period 1946–2006), in m^3/s

River	Station	January	February	March	April	May	June
Danube	Bezdan	1948	2115	2432	2893	2839	2870
Danube	V. Gradište	5253	5481	6499	7939	7237	6244
Nišava	Niš	28.94	40.26	51.32	55.81	43.89	32.17
		July	August	September	October	November	December
Danube	Bezdan	2774	2357	1858	1615	1674	1837
Danube	V. Gradište	5361	4306	3652	3611	4279	5095
Nišava	Niš	17.31	11.09	10.42	13.07	17.20	25.16

Table 2

Basin, minimum flow, average annual flow and maximum flow, in m^3/s

	River	Station	F (km^2)	$Q_{95\%}$ (m^3/s)	$Q_{av\ year}$ (m^3/s)	$Q_{1\%}$ (m^3/s)
1.	Danube	Bezdan	210.250	952.00	2.268.0	8.356
2.	Danube	Bogojevo	251.593	1.257.00	2.777.0	9.275
3.	Danube	Smederevo	525.820	1.976.00	5.264.0	15.323
4.	Nišava	Niš	3.870	3.98	28.89	946

In this sense, the construction of sewerage and waste water treatment facilities, in accordance with the EU Urban Waste water Treatment Directive, should cover all settlements greater than 2,000 PE [13]. Since the Republic of Serbia has no economic opportunity to realize such a condition at once, it is necessary to make certain priorities [14]. In this sense, the basic criteria for selecting priorities for the construction of sewage systems and WWTPs in settlements larger than 2,000 inhabitants are:

1. specific pollutant load (kg of specific pollution per m^3 of small, medium or minimum volumetric water flow),
2. recipient self-purification capacity (directly connected to the volumetric flow), and
3. the degree of sewage construction and percentage of the population connected to the sewerage network.

Based on the first two criteria – characteristics of the recipient, the WWTPs should first be built in settlements located in protected areas, followed by relatively large settlements located near relatively small watercourses (watercourses with unfavorable hydrological regime in terms of small and medium waters), and at the end in settlements near large watercourses (like Danube). Regarding the construction of the sewage network, the priority should be given to the construction and completion of the network in settlements with low degree of the population connected to the sewerage network, while in the case of a higher degree of the population connected to the sewerage network construction priority should be given to waste water treatment plants.

THE ROLE OF THE ICT APPLICATION

The key factor in the process of system management and control is the information exchange between different stakeholders or actors. Figure 2 shows the key stakeholders in the process of water management (Republic Hydrometeorological Service of Serbia, Environmental Protection Agency of Serbia, Water issues related institutes, Industrial facilities connected to the sewage system, Public utility companies and Municipal Committee for Communal Activities) and information exchange among them.

Management system is hierarchically organized, starting from national to local level. At the national level, a regulatory framework for governance is defined. It is determined by the government and adopted by the assembly. The Republic Hydrometeorological Institute defines quantitative aspects of water management, while SEPA (Serbian Environmental Protection Agency) defines the qualitative aspects. Mutual coordination of activities is necessary for these two approaches to management can lead to the desired results [15]. At the lower level of governance, there are institutes, industry, public utility companies, and municipal administrations for communal services. The management aspects that they present are mapped to specific field activities, determined by time and space scales for monitoring water resources. The main goal is to enable the desired level of water quality at the local level to be achieved [16]. The perception of water quality differs in relation to the level of observation. At global level, a water resource is classified into a particular category, but field measurements can show that certain micro locations are in a much worse condition than expected according to defined class of a water resource. Therefore, it is important to establish coordination and collaboration between stakeholders in the governance system, exchange information between different hierarchical levels, and make effective decisions based on available information.

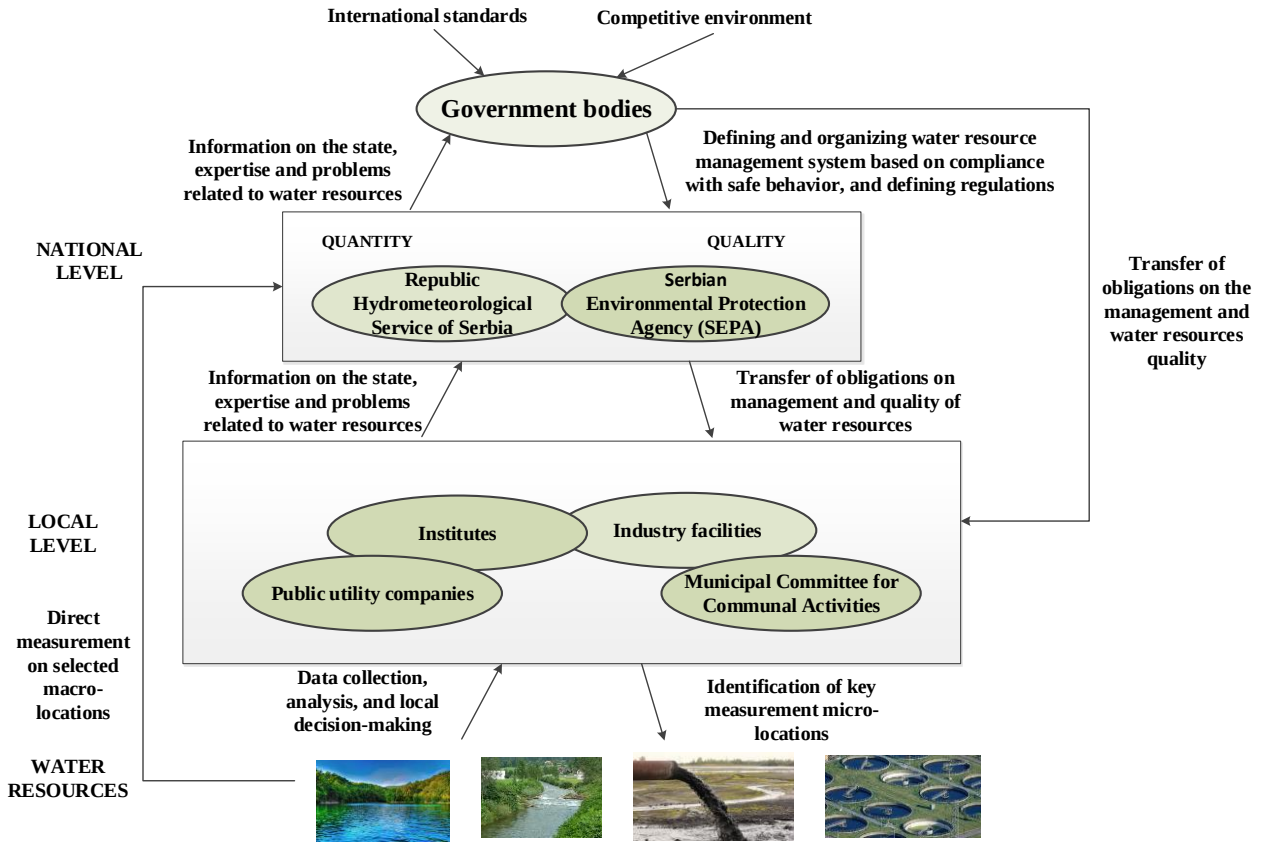

Fig. 2. Information exchange among the stakeholders – Serbian water management system

CONCLUSION

The water resources are integral part of the living environment, so the protection of the natural environment is unthinkable without preserving and improving the quality of water. Current problems of water pollution in the Republic of Serbia require the characterization and assessment of the ecological status of water quality in order to achieve the principles of sustainable water management in accordance with Directive 2000/60/EC, as well as to preserve the quality of the environment. Within this paper, selected water quality parameters were analyzed which reflect the natural and anthropogenic impact on the characteristics of selected aquatic ecosystems, i.e. condition in the recipient. On the other hand, the specific pollutant load is analyzed as another input parameter on the basis of which the list of water protection priorities can be defined. Successful integral management of water resources in the river basin, based on the principles of sustainable development, cannot be provided without reliable data and other information on water quality and quantity and all processes that take place in them. In this respect, the paper also examines the possibility of using ICT as a collaborative platform to exchange experiences of local governments and other prominent stakeholders and define future joint activities.

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Original scientific paper

CHANGE OF NATURAL MAGNETIC FIELD IN BED AS A CAUSE FOR HEALTH IMPAIRMENT

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A b s t r a c t: Deformation of the natural magnetic Earth field by introducing ferromagnetic objects and electrical devices leads to the creation of an anomalous magnetic field (AMP) in which a person resides. Defining these anomalies in relation to the natural magnetic field may be done by measuring the magnetic field using proton magnetometer. Another way of determining the new field distribution is numerical calculation of the magnetic field by numerical methods. The longest period of time a person resides in bed is in a static position, and according to scientific facts the magnetic field change has significant impact on health. Therefore, it is important to carry out calculation of the magnetic field for different construction types of beds with mattresses with ferrite core (springs). The paper consists of the following sections: The first section provides an overview of the latest scientific information of the influence of the magnetic field on the functioning of the cell, tissues, organs and biological system. In the second section, calculation of the field in the bed area for particular bed constructions, such as single bed, bed with a back, with a ferrite core and a double bed on two levels was carried out. Validation of the obtained results was performed. In the third section, measurement of individual subjects using magnetic field proton magnetometer was performed and the obtained results of the measurement of anomalous magnetic field were connected with the impaired health status of these patients. The conclusion was drawn and the directions for further research were suggested.

Key words: magnetic field and anomalous magnetic field; numerical simulation of magnetic field; effects of magnetic field on health; a person in magnetic field

ПРОМЕНА НА ПРИРОДНОТО МАГНЕТНО ПОЛЕ НА КРЕВЕТ КАКО ПРИЧИНА ЗА ОШТЕТУВАЊЕ НА ЗДРАВЈЕТО

А п с т р а к т: Деформацијата на природното магнетно Земјино поле со примена на феромагнетни предмети и електрични уреди доведува до создавање аномално магнетно поле во кое лицето престојува. Дефинирањето на овие аномалии во однос на природното магнетно поле може да биде измерено со протонски магнетометар. Друг начин за одредување на нова распространетост на полето е нумеричка пресметка на магнетното поле со нумерички методи. Кога лицето долг временски период престојува во кревет, тоа е во статична положба, а според научните факти промената на магнетното поле има значително влијание врз здравјето. Затоа е важно да се изврши пресметка на магнетното поле на различни конструктивни типови кревети со душеци со феритно јадро. Трудот се состои од следните делови: Првиот дел дава преглед на најновите научни сознанија за влијанието на магнетното поле врз функционирањето на клетките, ткивата, органите и биолошкиот систем. Во вториот дел е извршена пресметка на полето за одредени типови кревети – единични кревети, кревети со наслон, кревети со феритно јадро, двојни кревети и кревети на две нивоа. Извршена е валидација на добиените резултати. Во третиот дел е извршено мерење на одделни субјекти користејќи протонски магнетометар со магнетно поле, а добиените резултати од мерењето на аномалното магнетно поле се споредени со оштетениот здравствен статус на овие пациенти. Заклучокот е извлечен и се предложени упатства за натамошни истражувања.

Клучни зборови: магнетно поле и аномално магнетно поле; нумеричка симулација на магнетно поле; ефекти на магнетното поле врз здравјето; лице во магнетно поле

AIMS AND BACKGROUND

The aim of this paper is to present the latest research about the impact of magnetic and anomalous magnetic field on physiological and pathophysiological processes in the organism in order to connect conditions of people living in such fields with health effects. The latest scientific knowledge dealing with this issue as well as authors' research is briefly presented. Taking these findings into account, the effect of changing the magnetic field caused by the construction of the most commonly used beds was analyzed. In accordance with the results obtained, conclusion was drawn about the effects on the health of people who sleep in these beds during night.

RESULTS AND DISCUSSION

Introduction

Human aspiration to be surrounded with objects that increase comfort and improve quality of life has led to introduction of new objects and electrical devices that were not present in previous decades. The use of steel and other ferromagnetic materials in civil engineering industry has been dominant in the last decades. Introduction of devices that emit electromagnetic waves has been recognized to be potentially harmful because one part of energy waves remained in biological subject and was transformed in heat. The first regulations in the field of protection against electromagnetic non-ionizing radiation focused on protection from thermal effects in the human body by limiting the density of the force of the incident wave.

The regulation based on such an approach has been implemented in most of the countries in recent decades. Newer studies have indicated the need to connect physiological effects in tissues with electromagnetic dosage quantities, such as Specific Absorption Rate (SAR) and induced current in the body. However, non-cellular effects at cellular, subcellular and molecular level have not been widely considered and are even less included in the regulations concerning the protection of the population. There is not enough medical knowledge that explains and analyzes the interaction between cellular organelles and molecules with electromagnetic quantities of the medium (the magnitude of electric and magnetic fields). However, most molecular biologists and physicists agree that the basis of action at the molecular level is electrical and electromagnetic interaction between electrons, which is at the same time the basis of all chemical bonds.

Taking into account this fact it is logical to conclude that the electromagnetic fields in which we live and which we have generated in the last decades represent the dominant factor of life for all our cells, tissues and functioning of our organism.

Earth magnetic field as element of life on the Earth

Bioelectromagnetism is a branch of science that studies connection between electric, magnetic and electromagnetic fields and biological processes in living organisms.

It is not difficult to prove that animals and humans are electromagnetic beings, but the influence of electromagnetic fields at the level of the cell and cell organelles up to the molecular level has not been fully explained, which certainly slows down the development of medicine. The cell metabolism is conditioned by an electric field on both sides of the cell membrane and magnetic properties of cell organelles and magnetic fields of surroundings. Nerve impulses are control-management signals in the physiological processes of the organism.

Magnetic phenomena in the body have not been fully explored [1]. Therefore, this paper shows the importance of understanding these phenomena in the functioning of the cell and the whole organism. Magnetic properties of the cell are conditioned by the structure of cellular organelles and their molecular composition. In magnetic sense, according to the values of magnetic permeability and associated constant, magnetic susceptibility χ_m,

$$\chi = \mu_r - 1,$$

materials are divided into the following groups:

diamagnetics ($\mu_r < 1$, $\chi_m < 0_-$),
paramagnetics ($\mu_r > 1$, $\chi_m > 0_+$) and
ferromagnetics ($\mu_r >> 1$, $\chi_m >> 0_-$).

For proper explanation of the performance of biological functions, it is necessary to know the structure of the cell and the type of substance, i.e. molecules and sort them into these groups.

Table 1 shows the most commonly used cellular substances and their magnetic properties.

Magnetic susceptibilities of most biological materials are less known. Their values may be obtained by measuring or calculating using various mathematical models [3, 5]. Most biological materials are diamagnetics, some are paramagnents, and few of them are ferromagnetics. In general, elements and compounds that do not have unpaired electronic pairs are diamagnetic and their susceptibility is not temperature dependent.

Table 1

Volume magnetic susceptibility of elements and biological materials

Material	Volume susceptibility $\cdot 10^{-6}$	Type of magnetic susceptibility
Hydrogen	$\cdot 2.23\times10^{-9}$	diamagnetic
Carbon	–0.000014	diamagnetic
Nitrogen	-6.8×10^{-9}	diamagnetic
Water	-0.9×10^{-6}	diamagnetic
Human tissues	–110 to –7.0	diamagnetic
Whole blood (deoxygenated)	–7.90	diamagnetic
Red blood cell (deoxygenated)	–6.52	diamagnetic
Magnesium	0.000012	paramagnetic
Potassium	5.74×10^{-6}	paramagnetic
Calcium	0.00002139	paramagnetic
Oxygen	1.9077×10^{-6}	paramagnetic
Sodium	8.6×10^{-6}	paramagnetic
Hemoglobin molecule	+0.15	paramagnetic

Table 2

Magnetic susceptibility of hemoglobins [2]

Hemoglobin derivate	Unpaired electrons	Magnetic susceptibility
Oxyhemoglobin (Oxy-Hb)	0	diamagnetic
Deoxyhemoglobin (Deoxy-Hb)	4	paramagnetic
Methemoglobin	5	paramagnetic

Compounds that do not have unpaired electronic pairs are diamagnets and their susceptibility is not temperature dependent.

Free radicals and some covalent compounds having ions of transition metals with unpaired electrons are paramagnetics with positive temperature dependence. Researchers of biological tissue found that fresh (living) biological tissue parts are usually diamagnetic, and that when without water become less diamagnetic [6, 4]. In living organisms there are few pure substances, most of the compounds are dissolved in water, so there is dissociation and ions are present in the highest amount. A special example is the one of change in the susceptibility of hemoglobin, where oxidation or change of pH values significantly changes susceptibility. It is significant that tumor tissues have higher magnetic susceptibility than healthy tissue [4, 11] indicating that their magnetization occurs, and it will exist in an enhanced magnetic field. This leads to a significant assumption that an enhanced magnetic field, i.e. life in an area in which we have anomalous zones may lead to the induction of cancerous changes. Magnetic properties of molecules of chemical compounds can be considered as basic magnetic dipoles that generate micromagnetic fields.

By vector addition of these magnetic fields, the intensities of the microfields of particular cellular organelles are obtained. Analyzing the structure and chemical composition of organelles, it can be said that the nucleus is a site with pronounced magnetic properties, i.e. that the nucleus is a space in which the magnetization vector is larger compared to other parts of the cell, so it means that the nucleus is magnetized. The greater the nucleus the greater the magnetization and vice versa [10]. This implies that the cell will eject diamagnetic molecules through the cell membrane and attract paramagnetic molecule and substance from the extracellular space to the inside of the cells.

In scientific literature it is known that the site of the strongest magnetization in a human body is located in the pineal gland [13]. The advance in bioelectromagnetic research led to the insight into: action potentials, application of electrophysiology, thermal effects of electromagnetic fields, the effects on the nervous system and the behavior of people (behavioral effects), the development of the use of pulse-magnetic fields in spectroscopy, MRI, NMRI, etc.

Earth electric and magnetic fields are indispensable part of human life [7, 8], so it is logical that all processes in tissues and cells largely depend on the value of electromagnetic quantities that follow the parameters of these fields. This fact has not been significantly and sufficiently analyzed in the literature [10].

Important are new findings about the influence of the earth magnetic field on normal functioning of the human organism and its systems, as well as those about the effect of anomalous magnetic field on disbalance of functioning of organs and its role in the development of cancer, diabetes and autoimmune diseases [11, 12]. In twenty year long surveys [10], geophysical measurements of the Earth magnetic field were performed in the living spaces of patients with cancer. These measurements were performed by a 100 nT proton accuracy magnetometer and correlation between increased magnetic field

values in the bed area and the onset of cancer was established. The areas with increased values in relation to the natural field values are called anomalous zones or the so called pathological magnetic and electromagnetic fields and represent the areas in which people live and may be often affected by various health problems.

They are most often the spaces in which a person is surrounded by ferromagnetic objects that have increased intensities of magnetic flux density (magnetic induction, *B*) or spaces with strong electromagnetic sources such as domestic appliances in the immediate surroundings. Diagnostics and treatment of patients were performed by competent medical institutions using medical procedures established by officially recognized protocols of traditional medicine. It was found that good therapeutic results were noticed in people who, along with appropriate medical procedures, changed their living space by sleeping in areas that were within the natural magnetic field, i.e. they removed their beds from anomalous magnetic fields [11, 12].

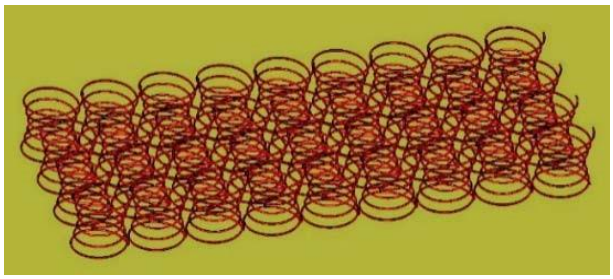
RESEARCH METHOD

Considering that ferromagnetic objects in the magnetic field can be magnetized and thus become sources of the external magnetic field, we set off to explore this effect.

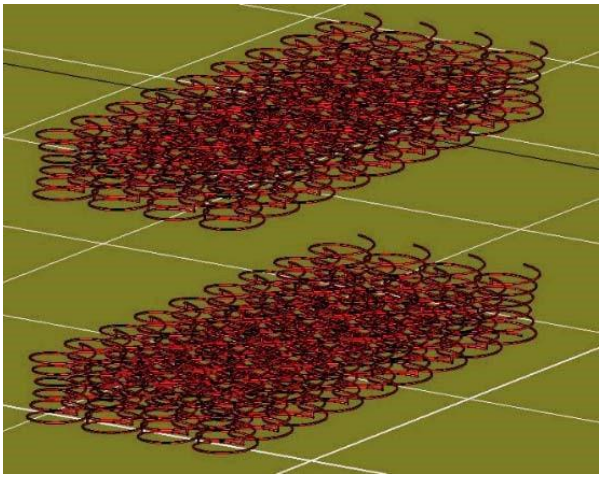
A man spent most of his time in bed, and accordingly, the focus of the research was on the metal structures of beds. Analysing the construction of beds and mattresses, we focused on the mattress with a steel core composed of springs. The research included 3 most commonly used bed constructions: a single bed (Figure 1a), a double-decker (Figure 1b) and a sofa with a steel core.

Simulation setup

Springs are helicoidal structures made up of 6 coils having approximately the same radius, with the central coils having about 10% smaller radius. The conductive material interconnects the springs and the ends of the springs do not end at the same angle. This provides the reality of the wire core structure that is achieved in the production of this mattress. Modeling of the structure of 90 × 200 cm mattresses was performed with simulation of a network of 9 × 4 springs of 10 cm radius, which were equidistantly placed, and in galvanic bond (Figure 1).



a)



b)

Fig. 1. a) Mattress model with steel core and b) double-decker model with mattress

The mattress was set at the height of 25 cm from the ground. In order to provide the reality of the initial data in the simulation model, the intensity of the magnetic induction of the natural Earth magnetic field by the proton magnetometer was measured. Mean value of natural magnetic field B = 47.8 μT was measured. This value was used to determine the initiative magnetic field in the airspace during the simulation. The spring (helix) is made from ferromagnetic material and is characterized as $\mu = {}_r 1000$, $\sigma = 1.04\ 10^{-7}$ S/m. The magnetization curve for the materials made of helix in work point is defined by values $H = 38$ A μ B/, = 0.6 T .

RESULTS OF SIMULATION

For the simulated parameters defined here, the calculation of the magnetic field in the immediate surroundings of the construction was carried out.

The following figures show distribution of intensity of magnetic induction vectors in the bed area where human body is at rest. Figure 2 shows distribution of magnetic field at the height of 5, 10, 15 cm from wire core, while Figure 3 shows relative position of a person lying on the same bed, whereby

electromagnetic characteristics of a person were not taken for calculation. The control of the values obtained from calculation and the values obtained by measuring on a similar physical model showed a satisfactory agreement.

It may be noticed that the intensity of magnetic induction decreases with distance, which will produce unequal exposure to the magnetic field of individual organs depending on the physiological position in sleep.

Simulation and calculation of the magnetic field was performed for a double-decker bed, where the mattresses are located at a distance of 60 cm (Figure 1b). In this simulation, the construction of the bed was not taken into account, considering that it is made of wood and in magnetic sense did not have any influence on this calculation. The calculation results are given in Figures 4 to 6.

Sofa is also frequently used and may be folded (sitting position) and unfolded (lying position). Simulation and calculation of the magnetic field was performed for sofa where the core is located in the sitting and the back part (Figure 3). The obtained results are shown in Figure 7 showing a person in a sitting position on sofa.

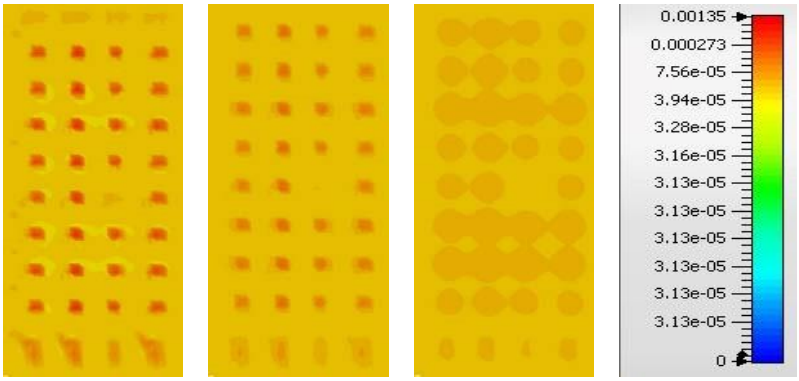


Fig. 2. Distribution of magnetic field B (μT) at the height of 5, 10, 15 cm from wire core

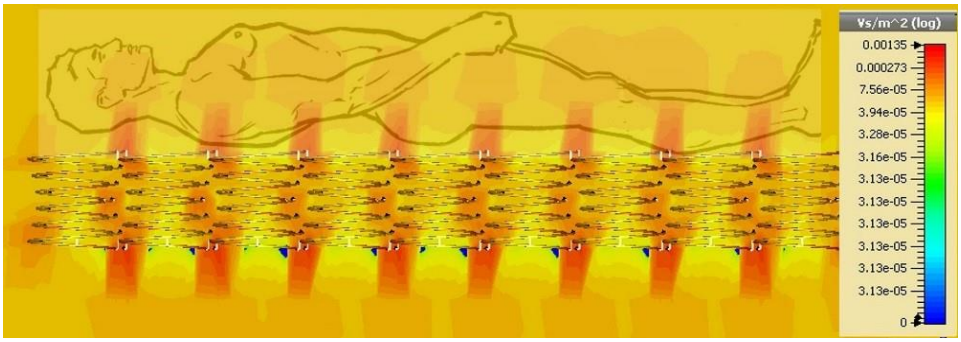


Fig. 3. Distribution of magnetic field B (μT) in mattress cross ection

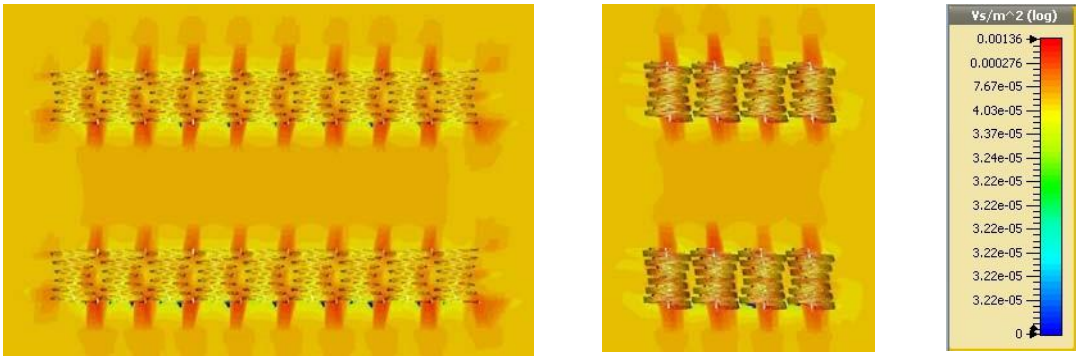


Fig. 4. Distribution of magnetic field B (μT) in cros section of a double-decker – two cross sections

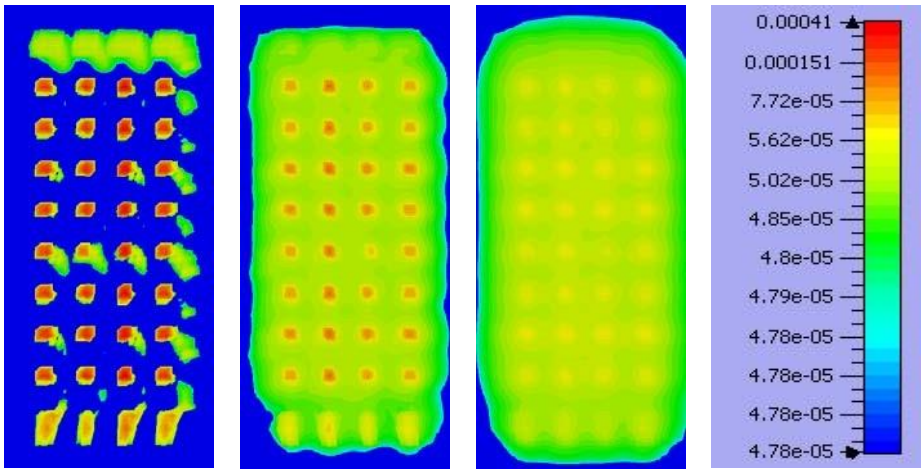


Fig.5. Distribution of magnetic field B (μT), at the height of 5, 10 and 15 cm from wire core of lower bed

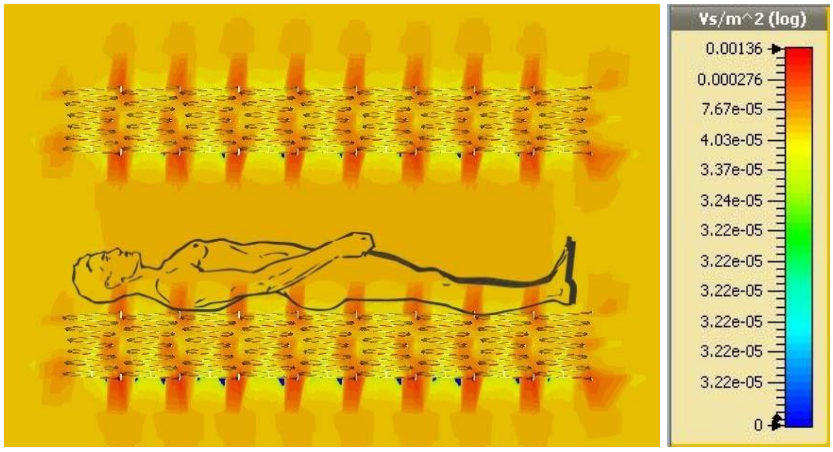


Fig.6. Distribution of magnetic field B (μT) in mattres cross section showing a person lying on a double-decker bed

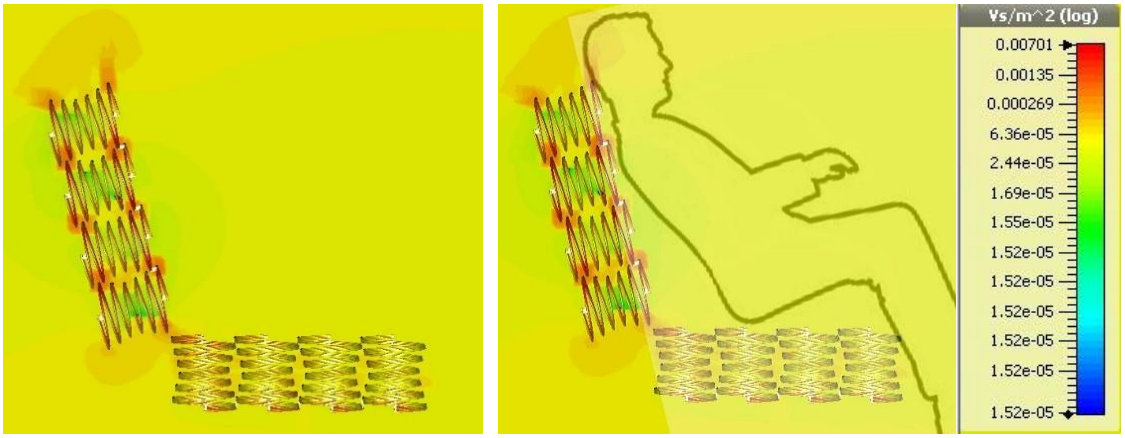


Fig. 7. Distribution of magnetic field B (μT) in sofa cross section

ANALYSIS OF RESULTS

Analysis of the results suggests that the homogeneity of the natural magnetic field is affected by change of the intensity of magnetic induction in the following way:

1) In a single bed local maximum values of magnetic field intensity that are 5.6 times greater than natural intensity of magnetic field are observed (Figures 2–3) .

2) In a double-decker apart from local maximum values there are greater homogenous field

values of magnetic induction greater than natural that is present between 2 mattresses (Figures 4–6). Distribution of intensity vectors of magnetic induction at the distance of 5 cm, 10 cm, and 15 cm from the upper surface of the core is in range B_{max} = (76–265) μT.

3) In sofa there is increase of values of intensity of magnetic field at the junction part of sitting and back part, as well as at the end of back in the head area is observed. Distribution of intensity or deviation of vectors of magnetic induction at 10 cm from upper edge of sofa back B_{max} = 135 μT, that is at the height of a person's head is shown on diagram on Figure 7.

In all the observed cases, for more precise localization of the intensity of magnetic induction in humans, that is, for making connection between physiological effects in tissues and electromagnetic dosage sizes, human contour was used without using electromagnetic properties in calculation.

In this way it may be more precisely determined which parts of the body or tissues are exposed to increased magnetic field intensity. In addition, the risk of the severity of disease may be established.

CONCLUSIONS

Depending on the position of a person at sleep and his sleeping habits it may be expected that some body parts during sleep are always in anomalous magnetic field, which may cause body viscous magnetization. Moreover, longer stay in such fields may increase possibility for development of cancer and autoimmune diseases, diabetes, in particular [11, 12]. In sofa type of bed the greatest increase of magnetic field is in the head and neck region. According to litearture data, persons who spend a lot of time in such position may develop arthrosclerosis [14] and neurological problems [8].

the possibility of health deterioration increases in case of additional metal structures of the bed, as well as when a person is surrounded by electrical devices that emit additional electrical, magnetic and electromagnetic fields. this finding is also confirmed by international agency for research on cancer (iarc) within who which classified electromagnetic radiation of mobile phones into 2b group of potentially carcinogenic substances for development of one type of brain cancer [15]. in order to avoid this, it is necessary to replace ferromagnetic materials as constitutive bed parts with non-ferromagnetic materials. in this way, anomalies of the magnetic field in the bed space relative to the naturally homogeneous magnetic field could be avoided. therefore, this could be safe environment for normal functioning of human immune system. such research indicates that it is necessary to constantly reconsider how people out of ignorance could make an environment harmful for proper functioning of the organism. electromagnetic environmental pollution emphasizes the need for development of electromagnetic ecology of living and working space, which has already been suggested by scientific community.

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THE EFFECTS OF AGRICULTURAL IRRIGATIONS: THE CASE OF TURKEY

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A b s t r a c t: In this study, we examined the Asartepe dam in Ankara province. We evaluated the economic and social effects of agricultural irrigation. Selected different variables are observed as follows: agricultural usage of water, agricultural production, agricultural productivity, income and environment effects, social-cultural design, migration, economical conditions and etc. Production data of agricultural enterprises for 2015 and 2016 was collected by questionnaire. Agricultural establishments are selected by Simple Random Sampling (SRS) method. Agricultural establishments dealing with irrigation are divided into 2 groups and these are the same. One of them is belong to pre-irrigation group and the other group is belong to after-irrigation group. Pre-irrigation group is stratified into 2 strata and after-irrigation group is stratified into 2 strata according to the planting fields of products. According to the SRS method, sample size is 42. After determining the sample size, this sample is distributed by the method of proportionate distribution. Numbers of the first layer is 31, second layer is 11. The information of the questionnaire data is entried by MS Office environment. During the data analysis is used with SPSS package program. Discriminant statistical analysis will be used for comparing between pre-irrigation group and after-irrigation group.

Key words: irrigation; economic and social effects; discriminant analysis

ЕФЕКТИ ОД НАВОДНУВЊЕТО ВО ЗЕМЈОДЕЛИЕТО: ПРИМЕР ОД ТУРЦИЈА

А п с т р а к т: Во оваа студија ја разгледавме браната Асартепе во провинцијата Анкара. Ги оценивме економските и социјалните ефекти од наводнувањето во земјоделството. Избрани различни променливи се забележани на следниов начин: земјоделско користење на водата, земјоделско производство, земјоделска продуктивност, приходи и ефекти врз животната средина, социјално-културен дизајн, миграција, економски услови и др. Податоците за производството на земјоделските претпријатија за 2015 и 2016 година беа собрани со прашалник. Земјоделските претпријатија се избрани со едноставен метод на случајно земање примероци (SRS). Земјоделските претпријатија кои користат наводнување се поделени во две исти групи. Едната од нив е припадник на групата пред наводнување, а другата припаѓа во групата по наводнување. Групата пред наводнување е поделена во две подгрупи, а групата по наводнување исто така во две подгрупи според видот на одгледувани растенија. Според методот SRS, големината на примерокот е 42. По одредувањето на големината на примерок, примерокот се дели според методот на пропорционална застапеност. Бројот на првата подгрупа е 31, втората подгрупа е 11. Информациите од податоците во прашалникот се внесени со MS Office. За време на анализата на податоците е користен програмскиот пакет SPSS. Споредбената дискриминантната статистичка анализа е користена за споредување помеѓу групата пред наводнување и групата по наводнување.

Клучни зборови: наводнување; економски и социјални ефекти; споредбена анализа

AIMS AND BACKGROUND

Many technical, economic, sociological and financial data are needed for the various calculations of the return on an irrigation project that some of this information is to be found in studies done by specialists whose viewpoint is generally more technical than economic [1]. In this study we emphasized on the economic analysis of irrigation project in Turkey.

An important part of the material used in the study includes the area of agricultural holdings engaged in different products from where the survey is done. Sample establishments were selected and questionnaires were filled by making personal interview. Information was collected from the agricultural establishments in this survey from 2015 to 2016 production period. Under the preliminary study, the characteristics that could represent the Ankara province Ayaş county as purposeful districts respectively were chosen. The sample population was drawn by Simple Random Sampling (SRS) method. Proportional method was the formula used for finding the value of n [2]. N value is founded by formula in the proportional method,

$$n = \frac{N\sum N_h S_h^2}{N^2 D^2 + \sum N_h S_h^2}.$$

Agricultural establishments dealing with irrigation are divided into 2 groups and the same: One of them belong to pre-irrigation group and the other group is belong to after-irrigation. Pre-irrigation group is stratified into 2 strata and after-irrigation group is stratified into 2 strata according to the planting fields of products. According to the SRS method, population, as a result of the withdrawal of the sample size, is 42. As a result of the sample based on the method of proportionate distribution of the first layer $n_1 = 31$, second layer $n_2 = 11$. In addition, reserve up to 25% of the sample volume of the agricultural establishments has been identified. Villages to do the survey sample, survey were chosen by the operators in the absence of reserves.

EXPERIMENTAL

Materials. Data are compiled from agricultural establishments by questionnare through face to face meeting. In this study, we used the various data are as follows: domatoes planting field and the other independent variables are as follows: medicine, chemical fertilizer, total payment of water, water technics and diesel invoice.

Method. In this study, we use the discriminant analysis. Discriminant analysis finds a set of prediction equations based on independent variables that are used to classify individuals into groups. There are two possible objectives in a discriminant analysis: finding a predictive equation for classifying new individuals or interpreting the predictive equation to better understand the relationships that may exist among the variables [2].

In many ways, discriminant analysis parallels multiple regression analysis. The main difference between these two techniques is that regression analysis deals with a continuous dependent variable, while discriminant analysis must have a discrete dependent variable. The methodology used to complete a discriminant analysis is similar to regression analysis. You plot each independent variable versus the group variable. You often go through a variable selection phase to determine which independent variables are beneficial. You conduct a residual analysis to determine the accuracy of the discriminant equations [3].

The mathematics of discriminant analysis are related very closely to the one-way MANOVA. In fact, the roles of the variables are simply reversed. The classification (factor) variable in the MANOVA becomes the dependent variable in discriminant analysis. The dependent variables in the MANOVA become the independent variables in the discriminant analysis [3].

The information of the questionnaire data was entried by MS Office Excel environment. Estimations of the discriminant analysis were made by using SPSS Statistics package program.

RESULTS AND DISCUSSION

Assumptions 1

H_0: Covariances matrix for groups are equal.

H_1: Covariances matrix for groups are not equal.

Due to the significance value 0.000 < 0.05, H_0 is reject. That is, covariances matrices for groups are equal. When sampling size is high, significance value will be expecting to take a high value. Shortly, tests null hypothesis of equal population covariance matrices (Table 1).

Table 1

Test results

Box's M		74,786
F	Approx.	74,153
	df1	1
	df2	20172,000
	Sig.	,000

Assumptions 2

There is no problem with multiple connections between variables. For this, correlations between independent variables are examined (Table 2). Very high correlation values are not available between variables. Therefore, Assumption 2 is provided (Table 2).

Table 2

Pooled within-groups matrices

		Property	Rent	Watery	Dry	Domatoes	Fertilizer	Medicine	Water	Fuel	Forage	No. of animal
Correlation	Property	1.000	–.230	.195	.740	–.039	–.001	–.034	.035	.068	.275	.366
	Rent	–.230	1.000	.670	.137	.590	–.007	–.055	.378	.248	.235	–.053
	Watery	.195	.670	1.000	–.006	.793	.000	.052	.534	.145	.133	.119
	Dry	.740	.137	–.006	1.000	–.172	–.004	–.131	–.052	.201	.439	.262
	Domatoes	–.039	.590	.793	–.172	1.000	.006	.044	.666	.120	–.140	–.094
	Fertilizer	–.001	–.007	.000	–.004	.006	1.000	–.209	.021	–.118	–.178	–.097
	Medicine	–.034	–.055	.052	–.131	.044	–.209	1.000	–.001	.052	–.144	–.087
	Water	.035	.378	.534	–.052	.666	.021	–.001	1.000	–.129	–.004	–.092
	Fuel	.068	.248	.145	.201	.120	–.118	.052	–.129	1.000	.043	.125
	Forage	.275	.235	.133	.439	–.140	–.178	–.144	–.004	.043	1.000	.218
	Numb. of animal	.366	–.053	.119	.262	–.094	–.097	–.087	–.092	.125	.218	1.000

Evaluation of importance for discrimination functions

Canonical correlation, Eigenvalue and Wilk's Lambda statistics are used to determine how important the discrimination function is.

Canonical correlation and discrimination scores measured relationship between groups and at the same time showed the total variance explained. Canonical Correlation value is 0.243. If we make an evaluation this value, we must take a square this $(0.243)^2 = 0.059$. Namely, our model explains 5.9% of the variance at the dependent variable (before and after irrigation) (Table 3).

The fact that the eigenvalue statistic is large indicates that a larger part of the variant for dependent variable will be explained by that function. The Eigenvalue values greater than 0.40 with good precision are good but this proportion value is not exact value (Table 3).

Table 3

Eigenvalues

Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	.062[a]	100.0	100.0	.243

[a] First 1 canonical discriminant functions were used in the analysis.

Wilk's Lambda statistic shows the fraction of the total variance in the discrimination scores that is not explained by the differences between the groups. In this study, 0.941 (94.1%) of the total variance in the discrimination scores can not be explained by the differences between the groups (Table 4). Here, Wilk's Lambda significance statistic is $0.026 < 0.05$, then there is significance of eigenvalue statistic and only 1 discriminant function (Table 4).

Table 4

Wilks' Lambda

Test of function(s)	Wilks's Lambda	Chi-square	df	Sig.
1	.941	4.941	1	.026

Evaluation of importance for independent variables in discriminant analysis

To evaluate the significance of the independent variables, we need to look at the discriminant function coefficients and the load of each independent variable in the structure matrix. The standardized separation function coefficients are given below (Table 5). The number of animals is an important independent variable that distinguishes in pre- and post-irrigation establishments. The number of animals coefficient is 1.000. Therewithal, this coefficient is correspond to beta coefficients in the regression analysis. That is, it shows proportional importance of independent variables for estimation of dependent variable. Property, Rent, Watery, Dry, Domatoes, Fertilizer, Medicine, Water, Fuel, Forage variables are not effective variables to distinguish in pre- and post-irrigation establishments. (For that reason, you can't see these variables in Table 5.)

Table 5

Standardized canonical discriminant function coefficients

	Function
Number of animal	1.000

Structure matrix is used for evaluating the importance of independent variable. This matrix shows the correlation of each variable with the discriminant function. In this study, there is only one function due to the one function. When the number of categories at the dependent variable is large, the number of discrimination functions will also be large. Every column shows one function. Correlations in here may be liken factor loadings in factor analysis (Table 6).

Table 6

Structure matrix

	Function
Number of animal	1.000
Property[a]	.366
Dry[a]	.262
Forage[a]	.218
Fuel[a]	.125
Watery[a]	.119
Fertilizer[a]	–.097
Domatoes[a]	–.094
Water[a]	–.092
Medicine[a]	–.087
Rent[a]	–.053

[a]This variable not used in the analysis.

According to Structure matrix, Number of animal variable has the most highest correlation with discrimination function. Property, Rent, Watery, Dry, Domatoes, Fertilizer, Medicine, Water, Fuel, Forage independent variables are not an important estimator (Table 6).

Discriminant function and remarks

The discriminant function called the Canonical root is a linear combination of independent variables (Table 7). That is,

$$Z = \alpha + b_1X_1 + b_2X_2 + \cdots + b_nX_n.$$

Here,

Z: discriminant score;
α: constant;
b: discriminant coefficients;
X: independent variables.

The *b* coefficients maximize the distance between the averages of the independent variables.

Table 7

Canonical discriminant function coefficients

	Function
Number of animal	.014
(Constant)	–.368

Unstandardized coefficients

Above table shows us unstandardized discriminant coefficients. These coefficients are correspond to unstandardized beta coefficients. Discriminant function is as follows:

$$Z = -0{,}368 + 0{,}014\ (Hayvan\ sayısı)$$

Table 8

Classification results[a]

	Tabaka	Predicted group membership 1	2	Total
Count	1	**37**	5	42
	2	29	**13**	42
%	1	88.1	11.9	100.0
	2	69.0	31.0	100.0

CONCLUSIONS

Z scores belong to establishments can be calculated by replacing animal numbers for all. It does not matter if the coefficients are plus or minus sign. Expresses whether the relation of the independent variables to the dependent variable is positive or negative.

The success of the analysis in the discrimination analysis is the correct classification percentage. The higher the percentage of correct classification, the more successful the analysis is. As given in the following table, 59.5% of the sample we included in this study were correctly classified. Namely, 50/84 = %59.5.

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AGRI-ENVIRONMENTAL REFORMS OF EUROPEAN UNION IN THE PERIOD OF 2014–2020 AND EFFECTS ON TURKEY

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A b s t r a c t: The necessity of fair distribution of agricultural supports among Member States, the re-evaluation of support policies to consider the rising of price volatilities and environmental concerns, and the recent food crisis with the danger of global warming, are the main reasons for the reforms of Common Agricultural Policy (CAP), which covers the period 2014–2020, in European Union (EU). EU agriculture needs to attain higher levels of production of safe and quality food while preserving the natural resources that agricultural productivity depends upon. Therefore, new CAP away from product-based support towards farmers support and considerations for the environment. The most important of this new support is “greening”. Greening can be defined as making environmentally friendly production and emphasize the importance of the protection of the environment. This new policy instrument is one of the payments that in the Pillar 1 of the CAP. Given the pressure on natural resources, agriculture has to improve its environmental performance through more sustainable production methods. From 2015 onwards, the CAP introduces a new policy instrument in the Pillar 1, the Green Direct Payment. Accordingly, farmers have to implement 3 agricultural practices compulsorily. These are crop diversification, the maintenance of permanent grassland and Ecological Focus Areas. Measures determined by the new reforms are agri-environmental-climate measures, organic farming, Areas of Natural Constraints (ANC), Natura 2000 areas, forestry measures and investments which are beneficial for the environment or climate. This study aims to evaluate reforms that will be implemented in the period of 2014–2020 in CAP specific to agri-environment and these reforms are aimed to be examined in terms of Turkey that continued negotiations with the EU. The study is based on literature. In this frame, examination, synthetizing and establishing relationships with sources was followed. According to the findings, the aim of the new reforms in EU related to agri-environment is environmental and climate benefits. But in Turkey, there are not any policy implementations yet.

Key words: European Union; agri-environmental measures; CAP 2014–2020 reforms; greening; Turkey

АГРО-ЕКОЛОШКИТЕ РЕФОРМИ НА ЕВРОПСКАТА УНИЈА ВО ПЕРИОДОТ 2014–2020 И ЕФЕКТИ ВРЗ ТУРЦИЈА

А п с т р а к т: Потребата од правична распределба на поддршките на земјоделството меѓу земјите-членки, повторната евалуација на политиките за поддршка со разгледување на зголемувањето на порастот на цените и загриженоста за животната средина, како и неодамнешната криза со храна со опасноста од глобалното затоплување, се главните причини за реформите на заедничката земјоделска политика (ЗЗП) во Европската Унија (ЕУ) која го опфаќа периодот 2014–2020 година. Земјоделството на ЕУ треба да постигне повисоко ниво на производство на безбедна и квалитетна храна, истовремено зачувувајќи ги природните ресурси од кои зависи земјоделското производство. Затоа, новата ЗЗП од поддршката на фармерите заснована на производи дава поддршка и со оглед на животната средина. Најважното од оваа нова поддршка е „позеленувањето“. Позеленувањето може да се дефинира како еколошко производство и нагласување на важноста на заштитата на животната средина. Овој нов политички инструмент е едно од плаќањата што се во Столб 1 на ЗЗП. Со оглед на притисокот врз природните ресурси, земјоделството треба да ги подобри своите еколошки перформанси преку поодржливи производствени методи. Од 2015 година наваму, ЗЗП воведува нов инструмент за политика во Столб 1, директно зелено плаќање. Според тоа, земјоделците треба задолжително да спроведат 3 земјоделски практики. Тоа се: диверзификација на културите, перманентно одржување на пасиштата и области од еколошки интерес.

Мерките утврдени со новите реформи се агро-еколошко-климатските мерки, органското земјоделство, областите на природни ограничувања, областите Природа 2000, шумарските мерки и инвестициите кои се корисни за животната средина или климата. Оваа студија има за цел да ги оцени реформите кои ќе се спроведат во периодот 2014–2020 година со ЗЗП специфични за агро-екологијата и да бидат испитани во однос на Турција која ги продолжи преговорите со ЕУ. Студијата е базирана на литература. Во оваа рамка следеше испитување, синтетизирање и воспоставување врски со извори. Според наодите, целта на новите реформи во ЕУ поврзани со агро-екологијата се придобивките за животната средина и климата. Но во Турција сè уште нема никаква имплементациона политика,

Клучни зборови: Европска Унија; агро-еколошки мерки; реформи на Заедничка земјоделска политика; Турција

AIMS AND BACKGROUND

Over the last two decades, the Common Agricultural Policy (CAP) has undergone a gradual change from market intervention instruments (e.g. price support) to farm-specific measures attempting to enhance the environmental performance of the EU agricultural sector [1]. The reasons for the reform's need are CAP's internal problems, spending that are not properly reached to the target groups, being focusing problems which quickly decrease society support for CAP and complicate decision maker's jobs for CAP, and makes difficult in CAP's related decision making process for unit's personals and defending it in EU budget debate [2].

When compared to the reforms of the past years, it is seen for the first time that the entire CAP has been fully reviewed and the European Parliament acts as a co-legislator with the Council. The new CAP has focused those new instruments which are especially given direct payments, better targeted, fairer and greener and more strengthened rural development subjects. Moreover, new reforms have been organized more efficiently, targeted and consistently. In short, the new CAP can be said to have built on the reforms of the past years to meet new challenges and objectives.

The long path that led to this decision moves from two different origins: on the one hand, the acknowledgement of the rapid post-war transformation of agriculture in Europe that entailed many environmental consequences, especially in terms of biodiversity reduction and pollution increase; on the other hand, the need to justify the large amount of direct payments granted to farmers with no specific commitment on their behalf. With the greening of direct payments, the EU keeps following the same path: a mandatory set of requirements to meet in order to "gain" the full amount of direct payments. The logic underlying the greening of direct payments in the most recent CAP reform is enhancing the provision of public goods through the agricultural activity [3].

While EU farming seeks to achieve a level of quality and safe food production, on the one hand, it also needs to protect the natural resources which agricultural production depends. For this reason, the CAP in the new period is switched from product based support to farmers oriented and environmental-friendly support. One of the main new features of the 2014–2020 regulations is payment for agricultural practices that are beneficial for the climate and the greening payment[4]. This new policy instrument is one of the payments in the Pillar 1 of the CAP. CAP greening includes measures that are obligatory for farmers who wish to receive full direct payments and farmers who follow a specified set of mandatory farm practices [1, 4].

Turkey's EU candidacy was officially approved at the Helsinki Summit held in 1999 and it was decided to start negotiations on October 3, 2005. Developments in the EU are closely concerned to Turkey in this respect and Turkey has worked in the framework of alignment with the EU. One of the relevant fields of study is the agri-environmental policies.

The objective of this paper is to evaluate CAP reforms in the period between the years 2014–2020 specific to agri-environment, to examine these reforms for Turkey, to contribute to the literature in this way and to give a different perspective to the subject.

EXPERIMENTAL

As this study is based on a literature review, it includes the studies on the general sources of agri-environmental reforms of EU in the period of 2014–2020 and effects in Turkey and carried out by several private and state institutions. Internet sources, books and articles on this subject have also been used. The research methodology consists of interpreting previous studies, evaluating and synthesizing sources, identifying agri-environmental reforms of EU in the period of 2014–2020 and, as a result, to identify the effects of Turkey in the field of agri-

environmental policies. The main method adopted has to evaluate, synthesize and establish relationships among the works form the relevant literature.

RESULTS AND DISCUSSION

Developments in global agricultural markets and new EU commitments on climate change and sustainable development mean the common agricultural policy needs to evolve yet again, to meet these continuing challenges [5].

Because of the increased pressure on natural resources, agriculture has to improve its environmental performance through more sustainable production methods. Farmers also have to protect themselves from undesirable situations such as climate change, global warming, fire, flood or drought and to adapt to these situations. A new application under the name of "Green Direct Payments" is continuing in the Pillar 1 of the CAP starting in 2015. Accordingly, farmers have to implement 3 agricultural practices compulsorily. These are crop diversification, permanent protection of grasslands and Ecological Focus Areas. It has made arrangements in the matter of allocating at least 30% of direct payments to environmentally friendly investments and allocating 30% of rural development program budget to agri-environmental measures for the implementation of these practices for farmers [6]. In addition, farmers are rewarded with respect for environmental services (e.g. landscape, agricultural land, biodiversity, climate change mitigation, etc.), although they do not have market values [7].

All payments will still be subject to respecting certain environmental and other rules. In addition to the Basic Payment Scheme/Single Area Payments Scheme, each holding will receive a payment per hectare for respecting certain agricultural practices beneficial for the climate and the environment. This is compulsory and failure to respect the greening requirements will result in penalties which go beyond the greening payment, i.e. after transition offenders will also lose up to 125% of their greening payment [8].

Greening. The reform introduced a new greening component as part of direct payments [9]. "Greening" is a major innovation brought in under the 2013 CAP reform, makes the direct payments system more environment-friendly. Farmers who use farmland more sustainably and care for natural resources as part of their everyday work benefit financially [7]. The reformed CAP imposes stronger linkages of decoupled payments to agricultural practices beneficial to the climate and environment. The conditions are similar to cross compliance but more demanding than the cross-compliance requirements [10]. The requirements of this measure are in addition to cross-compliance constraints, which are requirements intended to protect the basic environmental conditions necessary to agriculture [4]. As a general rule, the greening payment is to be granted as a flatrate payment per eligible hectare declared under the Single Area Payment Scheme or per entitlement activated under the Basic Payment Scheme.

For the first time in the CAP 2014–2020, an explicit attempt to remunerate public goods produced by farmers through a specific component of the direct payments has been introduced. Green payment is a share of the total potential payment that farmers may receive from the CAP in exchange for the provision of public goods [3]. The purpose of introducing a green direct payment scheme into the Pillar 1 of the CAP is to ensure that all EU farmers in receipt of support go beyond the requirements under crosscompliance and deliver environmental and climate benefits as part of their agricultural activity [11]. To achieve these environmental and climate change goals, the EU uses key instruments of Pillars 1 and 2 to provide more public goods from EU agriculture encapsulated in the slogan "public money for public goods" [9]. In this context, it should be stressed that the introduction of greening practices does not necessarily entail changing all practices in all farms [11]. Member States have to use 30% of their Pillar 1 ceilings for these new payments, corresponding to a maximum of €89.3 billion or 21.7% of the total EU budget for agriculture [9]. Farmers receiving an area-based payment have to make use of various straight-forward, noncontractual practices that benefit the environment and the climate. These require action each year. They include [12]:

- ***Diversifying crops:*** This requirement applies to farmers with over 10 ha of arable land.
  - *Up to 30 ha*: Farmers have to grow at least 2 crops and the main crop cannot cover more than 75% of the land.
  - *Over 30 ha*: Farmers have to grow at least 3 crops, the main crop covering at most 75% of the land and the 2 main crops at most 95%.

Farmers who already meet the objectives of crop diversification - because a significant amount of their overall land is grassland or fallow are exempt.

- ***Maintaining permanent grassland:*** National governments must designate environmentally

sensitive permanent grasslands in Natura 2000 areas. They may also designate environmentally sensitive permanent grasslands outside such areas. Environmentally valuable grasslands cannot be ploughed or converted.

Land area to be maintained was set at an average between the base year (average for 2007–2009) and the 2020 baseline. National or regional governments must also maintain the ratio of permanent grassland to the total agricultural area. This must not fall by more than 5% compared to the reference year. If the ratio is falling or has already passed the 5% threshold, EU countries are obliged to take action. For instance, farmers who have previously converted permanent grassland to other uses must reverse the conversion, and bans on further conversions are issued.

- ***Dedicating 5% of arable land to "ecologically beneficial elements" ("Ecological Focus Areas – EFA"):*** Farmers with arable areas exceeding 15 ha (excluding permanent grassland), i.e. field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips, afforested area must ensure that at least 5% of such areas is an "Ecological Focus Area (set-aside)" dedicated to ecologically beneficial elements. This figure will rise to 7% after a Commission report in 2017 and a legislative proposal [8]. AFAs cover a broad range of features, including ones that affect biodiversity:
  - *Directly*, such as fallow land, field margins, hedges & trees, buffer strips.
  - *Indirectly*, by cutting use of inputs or better soil protection (e.g. in areas covered by catch crops (fast-growing crops grown between plantings of main crops) or nitrogen-fixing crops).

Member States may decide to implement up to 50% of the EFA at the regional level in order to obtain adjacent AFAs and may also decide to allow farmers whose holdings are in close proximity to fulfill this obligation on the basis of a collective implementation [3].

It is up to national governments to draw up, based on the common list, a list of AFAs, based on national priorities and farming systems, from which their farmers can choose. There are some exemptions, notably for farmers with a large proportion of grassland (environmentally beneficial).

Member States may allow farmers to meet one or more greening requirement through equivalent (alternative) practices. These equivalent practices must be carried out either under agri-environment climate schemes within Member State Rural Development Programmes (RDPs), or in accordance with national or regional certification schemes, and must yield an equivalent or higher level of benefit for the climate and the environment [13].

During 2014–2020 in EU there is a new greening structure in CAP (Figure 1). As seen in Figure 1, there are voluntary, mandatory and regulatory implementation mechanisms in the new greening structure for the period of 2014–2020. For example, green direct payments are mandatory [6].

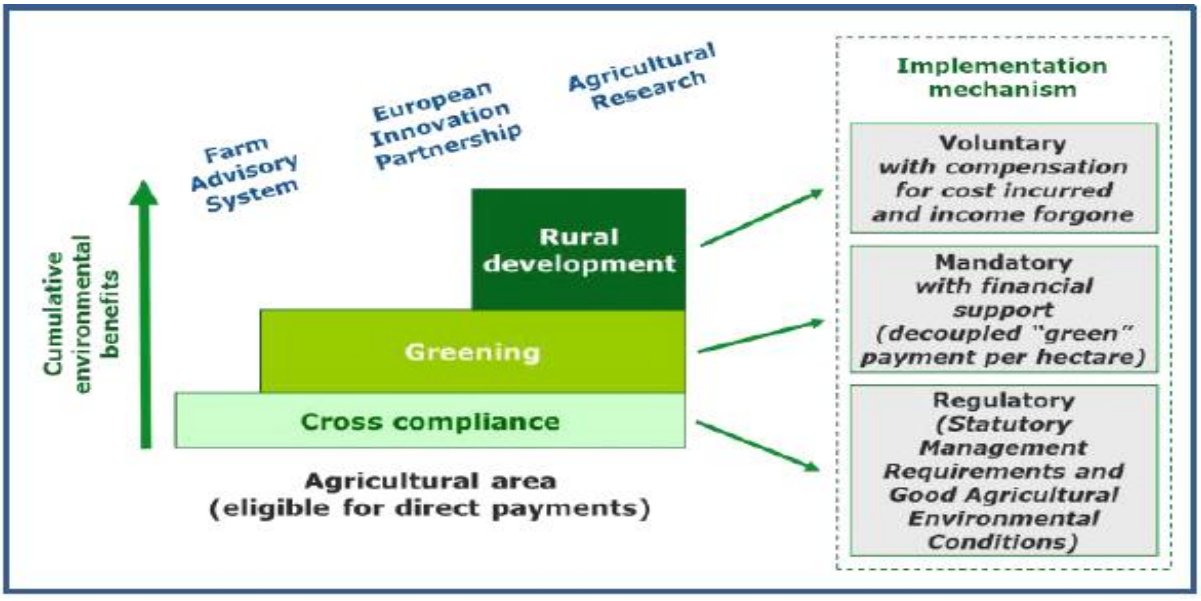

Fig. 1. Environmental instruments of the CAP

In order to avoid penalizing those that already address environmental and sustainability issues, the accord foresees a "greening equivalency" system whereby the application of environmentally beneficial practices already in place are considered to replace these basic requirements. For example, organic farmers will have no additional requirements as their practices are shown to provide a clear ecological benefit [8]. Because organic farms are considered "green by definition" as they already apply strict rules on admissible practices which are highly beneficial for the environment [11]. Small farmers (5% of EU agricultural area) are exempt from greening rules, for administrative and proportionality reasons. For others, agri-environment schemes may incorporate measures that are considered equivalent. The new regulation contains a list of such equivalent measures [8].

Farmers who fail to comply with the greening rules do not receive the full payments. Farmers who break greening rules will be paid less. Such reductions reflect the number of hectares identified as noncompliant, taking into account the specific nature of the requirement concerned [13]. As of 2017, reductions can be accompanied by administrative penalties. In line with the proportionality principle, the size of such penalties depends on the severity&scope of non-compliance, whether it has a lasting impact, whether it recurs [12].

Green rural development targets 2014–2020 [14]:

- %19 EU farmland under biodiversity management contract.
- %15 EU farmland under soil management contract.
- %15 EU farmland under better water management contract.
- %7 EU farmland under contract to reduce Greenhouse Gas or Ammonia.
- %2 livestock units (the equivalent of 3 million pigs) concerned by climate investments.

CAP 2014–2020 budget and agri-environmental reforms. For over 50 years, CAP has been EU's most important common policy. It has taken a large part of the EU's budget, with a declining percentage over recent years. Approximately 38% of the EU budget (equivalent to 0.4% of the EU's Gross Domestic Product) is spent on agriculture and rural development[15]. Annually, EU spends around 58 billion Euro on CAP with the aim of supporting farmers' income and the production of public goods, such as landscape and clean environment [10].

There are five General Expenditure Categories in the Financial Framework for 2014–2020 that was presented to Council's evaluation on 29 June 2011 by the Commission under the Commission's comprehensive reform proposal. The second title, "Sustainable Growth: Natural Resources" which contains natural resources, direct expenditures for the markets and direct payments within the scope of the CAP, rural development and environment and climate change tackling programs was allocated 373.179 million Euro (2011 prices). When the distribution of expenditures in the 2014–2020 Financial Framework proposed by the Commission is examined, it is seen that "Sustainable Growth: Natural Resources" has a share of 38.9% [16]. In the new Financial Framework, the amount of funding allocated for this title has decreased by 11.3% compared to the 2007–2013 Financial Framework. By the way, it is observed that the share of agricultural expenditures in the budget has decreased to about 27% in the new Financial Framework from 40% in the previous period (2007–2013) [17].

From 2015 onwards roughly 12 billion Euro a year are reserved within the direct payments system for certain practices aimed at addressing biodiversity loss, avoiding crop monoculture and securing carbon sequestration ("greening"). In addition, through RDPs, spending on agri-environmental measures from 2014–2020 is forecast to rise to 25 billion Euro. It will cover a somewhat smaller area, but thereby increase the environmental performance for every euro invested [15].

One of the main policies of the European Commission regarding agriculture is the CAP which is divided into two pillars. The first uses annual direct payments and market measures and the second is rural development as their main policy instruments[18]. One of the implications of the new reforms is the flexibility between pillars to the Member States in terms of budget and the implementation of policy instruments in Pillar 1.

Measures in the RDPs and agri-environmental policies. The CAP has contributed significantly to the financing of numerous programs for rural development and to a differentiation of its production basis [19]. Each RDP should use 30% of the total European Agricultural Fund for Rural Development (EAFRD) contribution for climate change mitigation and adaptation as well as environmental issues. This corresponds to only 8% of the total EU public expenditure for agriculture [9]. Building on these compulsory elements, rural development will continue to play a pivotal role in achieving the CAPs

environmental objectives and in combating climate change. These include agri-environmental climate measures, organic farming, Areas of Natural Constraints (ANC), Natura 2000 areas, forestry measures and investments which are beneficial for the environment or climate [6].

The 2020 strategy of the EU is to act in the direction of sustainable growth, rational growth, and intrinsic growth. When it is looked at the distribution of CAP's rural development measures in the direction of 2020, many measures have been determined for rural development both in the expectations of the Member States and in the direction of the 2020 strategy. The protection of the environment related to agricultural production (23.1%) has been determined as the most funding measure within the rural development measures [20]. The measures include investment in the environment and climate, the development of woodland and improving the viability of forests, "agri-environmental climate" measures, organic farming and payments under Natura 2000.

To avoid double funding under agro-environmental conditions, payments made through RDPs must take into account the basic greening requirements [4].

2014–2020 reforms and Turkey's situation

When one closely looks at the reforms of EU for the period of 2014–2020, it could be seen that the environmentally friendly practices in the agri-environmental context are the ones being at the forefront. Especially, it could be said that greening in the direct payments is the most important reform and that reform is attached to the main 3 criteria. When Turkey is evaluated in that context, it could be said that current supports are not attached any of the environmental criteria. However, there are several support tools given a long time for the agri-environmental issues such as Environmentally Based Agricultural Land Protection Program (ÇATAK), organic farming, Good Agricultural Practices, biological and biotechnical managements, climate change. In the support tools, for instance, organic farming is out of the scope of current reforms in EU. Even though ÇATAK is seen as a practice of cross-compliance, it does not cover the issues in EU because of its voluntary application.

Biodiversity conservation, soil and water management within the framework of rural development objectives in the new era in the EU are among the topics discussed in agri-environment policies in Turkey. However, these subjects are not a prerequisite for the support provided within the scope of the agricultural environment.

In brief summary, it can be said that the situation of connecting agri-environment measures to the subsidies in EU has not a policy implemented in Turkey yet. What need to be considered at this point is Turkey's preference is whether a policy in this direction. It is also believed that reevaluation of this issue will be beneficial in the EU alignment phase.

In addition, supports in EU is generally determined for long periods of time and farmers' given the opportunities to make long-term plans based on these payments can be said that disadvantaged farmers in Turkey on this issue.

CONCLUSIONS

The purpose of the present paper is to assess the 2014–2020 CAP reform specific to agri-environment and evaluate these reforms from the point of Turkey. Compared to previous studies, there are many studies about 2014–2020 CAP reform, but there aren't any studies related to Turkey's situation. So, it is thought that such a study can contribute to the literature and give a different perspective to this subject.

The most important reform in the period of 2014–2020 in EU is "greening". This reform has a substantial change to the implementation of direct payments. The protection of the environment and the tackling climate change is the basis of EU's reforms and the CAP can play an important role for these purposes. Therefore, there is a need in order to better understand where the current CAP reforms can be simplified and modernized. The CAP greening measures include crop diversification, maintenance of permanent grassland and EFA.

There are main instruments for CAP reforms and Member States have the flexibility to choose which of these tools to use in order to achieve the desired results, taking into account their national context. Member States can develop its own strategic plan and how they can meet these agri-environmental objectives.

When the subject is evaluated in terms of Turkey, Turkey needs to draw lessons from these practices. Agricultural supports in EU are announced on a five years calendar. It will be useful their year's support (now, one-year support) for Turkey at least. Because the farmers need to be able to see the coming years. This issue is much more important in terms of small farmers.

As a result, the CAP will continue to have strategic importance in the direction of Europe 2020 objectives. To sum up, CAP continues to be important, reshaping its day-to-day requirements. It should not be forgotten that the only thing that does not change is change.

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Original scientific paper

A RESEARCH ON DETERMINING THE EFFECTS OF DIFFERENT SOIL PROPERTIES ON SPECTRAL REFLECTANCE VALUES OF CROPLANDS

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A b s t r a c t: Usage of remote sensing techniques and Geographical Information Systems (GIS) in agricultural activities is becoming more and more popular. Benefiting from remote sensing, essential functions including cropland coverage estimation and monitoring can be achieved. Considering the fact that the reflectance values of same product type can differ with respect to soil characteristics. This research aims to investigate relationship between soil properties and the cropland reflectance values. The canopy rates of cropland also effect reflection values significantly. In this study 104 wheat-barley parcels and 26 potato parcels in Central Anatolia region of Turkey were chosen from the two different districts, Haymana and Bünyan. To disclose the relationship, images from Sentinel 2 and Landsat 8 satellites are downloaded for predefined parcels during one season of production (March to December 2017). Image Analyst, ArcGIS® and also Agrovisio®© software were used in preprocessing steps of satellite images and getting digital numbers of pixels. Soil properties are affected by cropland characteristics such as water holding capacity, organic matter content and mineral components. Soil cover ratio of canopy is related to its phenological stages. Digital numbers (DN) of satellite images have been changing according to species' phenological stages for each band. Therefore, soils cannot be shown any standardization on reflection values even for the same crop species. In this study, the reflection characteristics of two plant species grown on different colored soils were investigated. Dark color soils have high organic matter and clay percentage thus has much moisture content that are increasing their absorbance legibility for each band. However, light color soils have much more felsite minerals inside and lower water holding capacity that have higher reflection values for each band. As the outcome of this research, soil properties which includes soil color, water holding capacity and mineral composites should be consider for the determination of the reference for reflection values of cropland.

Key words: remote sensing; satellite images; soil color; crop phenological stages; vegetation canopy rates

ИСТРАЖУВАЊЕ ЗА ОДРЕДУВАЊЕ НА ЕФЕКТИТЕ НА ОДДЕЛНИ СВОЈСТВА НА ПОЧВАТА ВРЗ СПЕКТРАЛНАТА РЕФЛЕКСИЈА НА ОБРАБОТУВАНОТО ЗЕМЈИШТЕ

А п с т р а к т: Во земјоделските активности сè попопуларна станува употребата на техниките за сателитско снимање и на географските информациски системи (ГИС). Со помош на сателитското снимање се добива слика на основните функции на почвата вклучително процена на опфатот на замјоделските површинии и се врши мониторинг. Со оглед на фактот дека вредностите на рефлексијата кај истиот вид производ можат да се разликуваат според карактеристиките на почвата, ова истражување има за цел да ја истражи врската помеѓу својствата на почвата и вредностите на рефлексијата на земјоделските површини. Положбата на земјиштето исто така значително влијае врз вредностите на рефлекцијата. Во ова истражување беа опфатени 104 парцели со пченица и јачмен и 26 парцели со компири во две различни области, Хајмана и Бињан, во централна Анадолија во Турција. За да се утврди врската, од сателитите Sentinel 2 и Landsat 8 се симнати снимките за однапред утврдените парцели во текот на една производна сезона (март–декември 2017). За претходна обработка на сателитските снимки и за добивање дигитален број пиксели беа користени софтверите Image Analyst, ArcGIS®, како и Agrovisio® ©. Врз својствата на почвата влијаат карактеристиките на обработуваното земјиште, како што се влагата, содржината на органски материи и минералните компоненти. Почвената покривка зависи од нејзините фенолошки стадиуми. Дигиталните броеви (DN) на сателитските снимки се менуваат спо-

ред фенолошките фази за секој појас. Поради тоа почвите не можат да бидат прикажани со некаква стандардизација на вредностите на рефлексијата, дури и за истите видови култури. Во оваа студија беа испитувани карактеристики на рефлексијата на два растителни вида, израснати на различно обоени почви. Темните почви имаат висока содржина на органска материја и висок процент на глина, па затоа имаат висока содржина на влага што ја зголемува читливоста на нејзината апсорпциона способност за секој појас. Меѓутоа, светлите почви имаат многу повеќе минерали на фелсит и помал воден капацитет, па така имаат повисоки вредности на рефлексијата за секој појас. Како резултат на ова истражување, за одредување на референтните вредности за одгледуваните култури треба да се земат предвид својствата на почвата, кои вклучуваат боја на почвата, капацитет за заржување на вода и минерален состав.

Клучни зборови: далечинско снимање; сателитски снимки; боја на почвата; фенолошки фази

AIMS AND BACKGROUND

Reflection values of crops depend on several factors; soil covering rates of canopy, physiological properties of plants and phenological stages of crop types. Relation of soil and reflection values could be explained with the soil properties; soil color, water content, organic matter and clay percent in soil texture. Same crop type on different soil characteristics would have different reflection values. Identification of crops on different soil properties and different reflection characteristics are only possible by knowing the effects on reflections related to soil types. In this research, reflection values of wheat-barley and potato fields on different soil types were examined.

Monitoring of agricultural production in very large areas is vitally important for agricultural statistics, agricultural insurance, guessing crop yield harvest, farmer declaration checks and so on. However, for the identification and development of the agricultural product from the satellite images, a reference catalog is required which includes reflection characteristics along with the phenological stage of the vegetation types. Reflection values of some agricultural crops are already determined according to the type of product and the recording capabilities of the sensors. For example, digital reflection values of some field crops such as wheat, cotton, corn and alfalfa. are known in terms of phenological stages in images taken from commonly used Landsat, Rapid Eye and Sentinel 2 satellite sensors. However, acknowledge reflection values of pixels are deviating from the reference values on different soil properties although the crop pattern is the same. This obstacle raises the error rate of the reference data, and presents significant problems for the identification of crop pattern as well as monitoring of their development.

In this study, the characteristics of solar energy are reflected from topsoil are being investigated. The effects of soil properties on the average pixel reflection values during the phenological stages of potato and wheat / barley plant covering are investigated. The results of the research show that the identification of the agricultural crop pattern and the monitoring of its development levels can be done more accurately if the soil color is taken into consideration. At the beginning of phenological period of plants, the soil has a dominant portion in a pixel reflection value due to the low plant cover rate of the soil. However, plant cover rate of soil increases in next weeks, and this time plants reflection become more effective. In all this process, soil color and soil texture are very effective in the reflection values of the pixel. When the soil color is in the light tones, it has an effect that increases the reflection in all the bands, whereas the dark color is the absorbance effect. Soil color changes depending on its mineral composition and moisture content. In organic matter, mafic minerals and clay contents in the soil content are darkening the soil color. The sandy soil structure with low water holding capacity has less moisture than can be determined by higher reflection values. The high lime content in the soil and the presence of the felsite minerals are known to increase the reflection throughout the entire wavelength.

Measurement of dry and moist soil reflectance, the SWIR region offers significant potential for relating moisture [1]. Determining soil properties by using spectroscopy is a reliable, reproducible, rapid, and low-cost technique for the in situ diagnosis. And also to quantitative assessment of soil organic matter, VIS-NIR spectroscopy analysis is highly helpful [2].

EXPERIMENTAL

Study area. Two different regions were chosen as study areas in Central Anatolia (Figure 1). Names of the region are Haymana (in Ankara) and Bünyan (in Kayseri). Surface of the study area in Haymana is 8611 ha and 23675 ha in the Bünyan district.

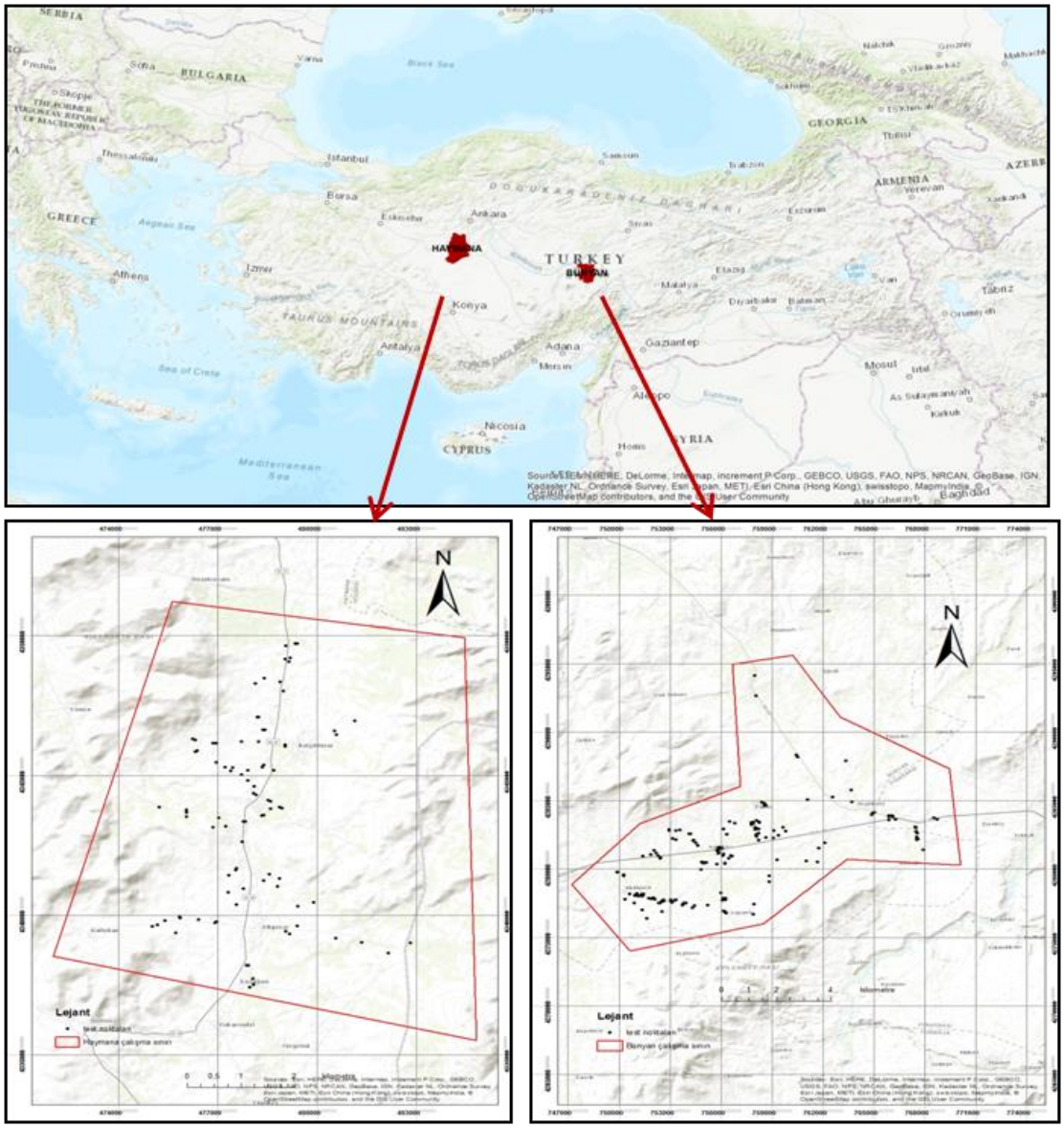

Fig. 1. Location of study areas

The study site consists of cultivated area that is commonly planted with wheat, barley, potato, forage crops, clover and sugar beet. Two of the dominant crops are wheat/barley and potato were investigated as materials in this research. Wheat and barley have been examined together as one crop type because of these two crops has same phonological period and similar reflection values.

The most widely used satellite images in recent years are from SENTINEL-2 that is a wide-swath, high-resolution, multi-spectral imaging mission, supporting Copernicus Land Monitoring studies, including the monitoring of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas. SENTINEL-2 can record separately 13 spectral bands including visible wavelength and also RedEDGE and infrareds (Table 1). The acquired data, mission coverage and high revisit frequency provides for the generation of geoinformation at local, regional, national and international scales [3].

In this study, the reflection values of the soil with different structure and color were determined in the Sentinel 2 images taken during the periods when almost there was no plant covered on the soil. Sentinel 2 images were acquired in 4rd and 1th of April 2017. For this purpose, 200 parcels were visited during the study area and the soil color (moist and dry) at these points was determined by Munsell color card.

Due to the fact that the topsoil was naturally dry on the date when the image was taken, dry soil color was taken into account when studying the

statistical relationships. The coordinates of the test points were determined by a hand GPS. Locations of the test parcels on the satellite images were determined by using these coordinates. In order to monitor the reflection properties of the targeted plants along their phenological periods, satellite images of the study area were continued to be taken at the end of the year. In the study, 16 SENTINEL-2 and 15 LANDSAT 8 satellite images were taken between 04.04.2017 and 11.12.2017.

Table 1

Spectral and spatial resolutions of Sentinel-2 sensor

Sentinel-2 bands	Central wavelength (μm)	Resolution (m)
Band 1 – Coastal aerosol	0.443	60
Band 2 – Blue	0.490	10
Band 3 – Green	0.560	10
Band 4 – Red	0.665	10
Band 5 – Vegetation red edge	0.705	20
Band 6 – Vegetation red edge	0.740	20
Band 7 – Vegetation red edge	0.783	20
Band 8 – NIR	0.842	10
Band 8A – Vegetation red edge	0.865	20
Band 9 – Water vapour	0.945	60
Band 10 – SWIR - Cirrus	1.375	60
Band 11 – SWIR	1.610	20
Band 12 – SWIR	2.190	20

Purposive sampling method was applied to collect targeted samples. Sampling parcels were chosen from different soil characteristics sites. Four soil texture types had been commonly observed in study area as clay loam (CL), sandy loam (SL), loam (L) and sandy clay loam (SCL) according to the United States Department of Agriculture (USDA) triangular diagram of soil texture classification. Organic matter content of the soils was determined between 0.29 and 4.4%.

In order to study about statistical relationships between the pixel reflection values and the soil color, the pixel reflection values of the area covered by the test parcels were extracted for 13 bands of SENTINEL 2 and 8 bands of LANDSAT 8. Totally 200 parcels were proceeded. Following, averages of all pixel values calculated for each parcel and each band. A software (AGROVISIO) was developed in the framework of the project was used for this purpose. Reflection values of parcels were calculated in every band as minimum, maximum and mean of digital numbers of pixels were collected for analysis. In this research, statistical relations between the reflection values obtained for each band and soil color and soil structure were investigated. The Pearson method was adopted in the statistical evaluation of data. The soil colors were graded from dark to light and each degree was symbolized by consecutive numbers begin from one. Then correlation analysis between soil color values and multiband pixel digital values was made. As a result of statistical analysis, significant statistical relations were determined between soil color and average pixel reflection values of each band. For monitoring corp pattern changes, high spatial resolution soil characteristics maps must be used. Spectral reflectance affected from plant cover rate of the cultivated soil, soil texture, nitrogen and organic matter content and soil salinity [4].

RESULTS AND DISCUSSION

Data analysis in the study was carried out in two stages. In the first step, statistical relationships between different soil colors and the spectral bands of the Sentinel 2 and Landsat 8 satellites sensors were determined. Then, multi-band reflectance values of wheat, barley and potato cultivated parcels on different soil colors were investigated during their phenological stages.

The *Munsell color* system is a color space that specifies colors based on three color dimensions: hue, value (lightness), and chroma (color purity) [5]. In this study value of colors were take consider into to grading of color from dark to light. The soil colors determined in the study area were graded into 5 groups from the dark to the light (Table 2). Synchronized fieldworks were done to date of image acquisition in order to determine relations between reflections values and soil color within high accuracy. The soil color measurements made on 200 parcels and colors were determined 10 YR 7/2 as the lightest and 10 YR 3/2 as the darkest. The average of multi-band pixel reflection values of the parcels in each color group was calculated. As a result of statistical analysis between parcels pixel values and darkness grades, significant statistical relations were determined (Figure 2).

Plants absorb the blue and red wavelengths of the energy from the sun to do photosynthesis and

produce protein. However, they reflect the different levels of green and infrared wavelength energy. Because of that, for determining and monitoring vegetation by satellite images different portions of infrared wavelengths energy are being used. Initial development period of the plants can cover the soil surface in low rate and in that time infrared reflection level is the lowest. However, infrared reflections from canopy in the following periods are . Electromagnetic energy from sun in between 0.63 and 0.69 μm wavelength is used by plants for production of organic matter from inorganic matter [6]. But NIR wavelength energy is reflected from all green parts of plants. Depending on whether the soil is covered by the plants, the blue and red wavelengths reflections from surface are decrease. Near and just after the harvest, significant decreases were determined in the infrared wavelength. Figures 3, 4, 5 and 6 show changes in the rate of plant covering the soil during to the growing periods of wheat and potato plants.

The coverage rates of the target plants in the study areas were measured by fieldwork. At the beginning of the development period of the plants it was determined that the soil color significantly affected the pixel reflection characteristic. It has been determined that dark soil, especially due to moisture and organic matter content, has an absorbance effect when the plant cover rate is below 40% while light soil has an increasing effect on all bands. Kumar et al. tried for estimating soil organic carbon (SOC) in forest using geospatial techniques. They used the visible and near-infrared reflectance data of Sentinel-2A satellite. They studied to find statistical relationship between soil organic carbon (ground and predicted) and leaf area index (LAI) measured from satellite data was examined through regression analysis. They found a significant coefficient of correlation (R2) is 0.95 (p-value < 0.05) for predicted soil organic carbon and satellite measured LAI [7].

Potato is seeded in May in study areas. It covers soil 3–15% in June and 40–60% in July. This rate reached 95% with the highest covering rate in August. Irrigation practices are starting in July. Transient absorbance is observed due to the wetness that occurs in the fields during the irrigation period. It can be observe Figures 7–8. Potato plant harvest is done in October. Just 15 days before harvesting, a plant growth regulator is used to stop growing and then the green leaves of potato dry very quickly. As a result, there are sharp drops reflection values of the infrared and RedEDGE wavelength. Wheat and barley are seeded in October-November and harvested in July or at the beginning of August at the study area. In April the plants are seen with a very low cover rate (5–10%) on the soil, reaching 40-50% levels in May and finally it reaches 80–90% in fertile soil in June.

In the beginning of the development of the wheat plant, the rate of covering the soil like every other plant is rather low. At this stage the soil color is very influential towards absorption according to its texture and color. Besides, wheat is generally cultivated by rainfall. water holding capacity of soils in agricultural production is very important due to precipitation. Clay texture soils have higher water holding capacities and the plant develops better in summer. The plants are developing weakly on sandy soils and their rate of covering the soil is lower comparing loamy texture soil. For this reason, the effects of reflection of sandy and light color soils continue for a long period of time. Figures 5 and 6 show that the wheat plants can reflect Electro Magnetic Energy (EME) from sunlight in the initial phase of development depending on the soil structure. In the later stages of the development of the wheat plant dependents on the presence of water holding capacity of the soil, if it is enough, NIR reflections are increase. After harvesting, all bands have reflection values close to each other.

Table 2

Statistical relationship between soil color tons and multispectral reflection (DN) values

Munsell colour values	Darkness grade	NIR	Red	Green	Blue	Red edge (5)	Red edge (6)	Red edge (7)	Red edge (8A)	SWIR (11)	SWIR (12)
10/7,5 YR 3 value..	1	2084	1486	1124	814	1696	1846	1936	2046	2433	2104
10/7,5 YR 4 value	2	2093	1435	1073	767	1628	1820	1928	2043	2426	2067
10/7,5 YR 5 value	3	2270	1658	1256	914	1864	2031	2133	2244	2676	2334
10/7,5 YR 6 value	4	2595	2009	1571	1185	2213	2351	2440	2534	2838	2510
10/7,5 YR 7 value	5	2839	2258	1814	1397	2481	2597	2680	2765	3054	2732
Correlation		0,96	0,95	0,94	0,94	0,94	0,95	0,96	0,96	0,97	0,96

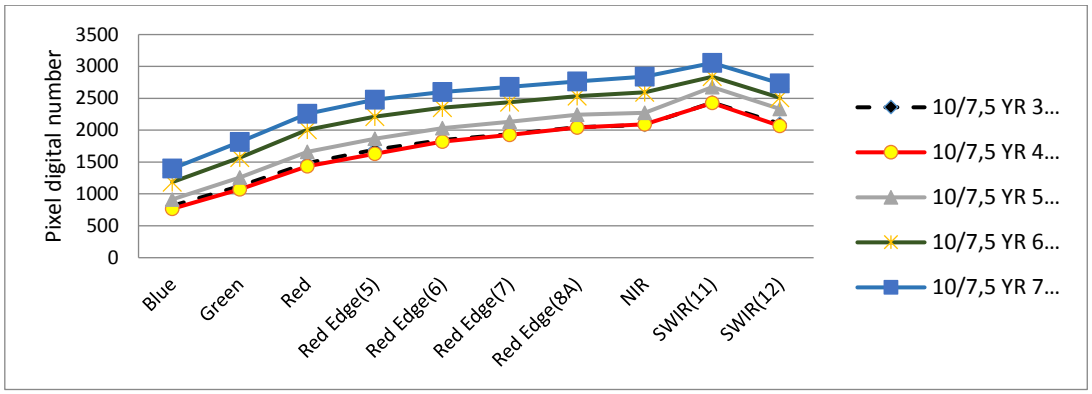

Fig. 2. Pixel digital numbers of multiband of Sentinel 2 according to different soil color

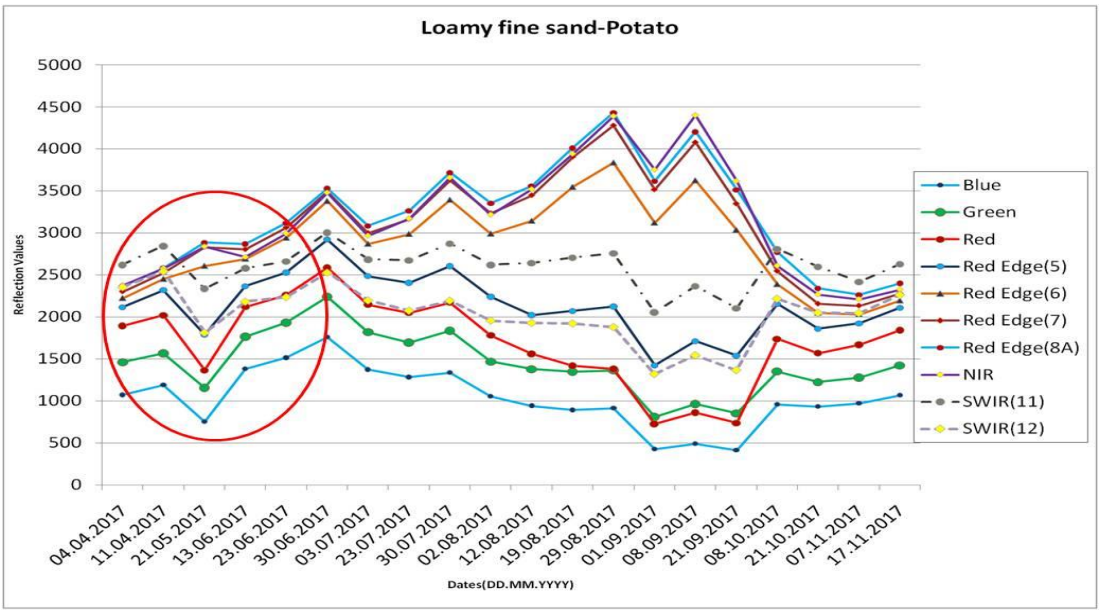

Fig. 3. Pixel digital numbers of Sentinel-2. Multibands images during to phenological period of potato cultivated fields on light color loamy fine sand texture soils

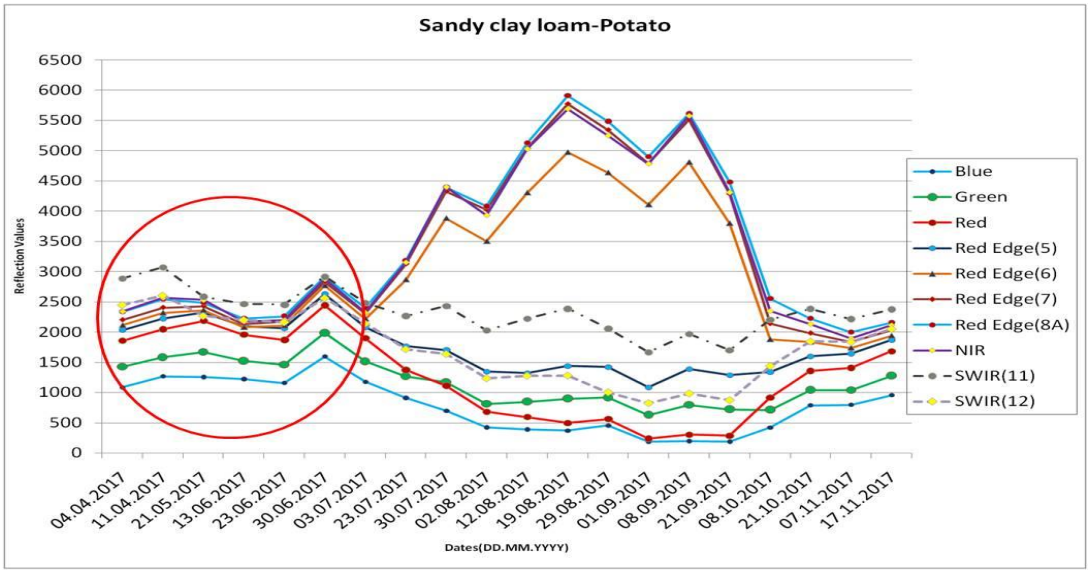

Fig. 4. Pixel digital numbers of Sentinel-2. Multibands images during to phenological period of potato cultivated fields on dark color sandy clay loam texture soils

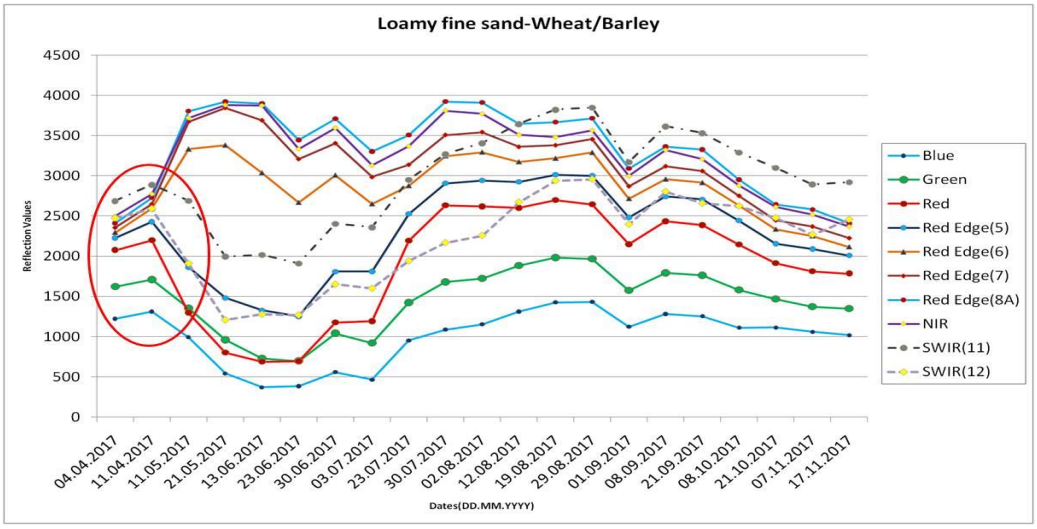

Fig. 5. Pixel digital numbers of Sentinel 2. Multibands images during to phenological period of wheat cultivated fields on light color loamy fine sand texture soils

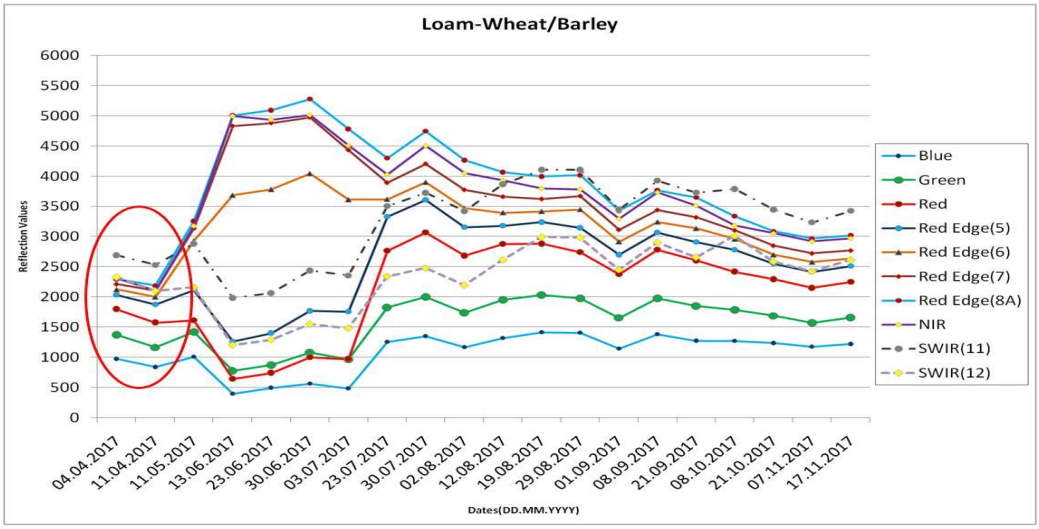

Fig. 6. Pixel digital numbers of Sentinel 2. Multibands images during to phenological period of wheat cultivated fields on dark color loam texture soils

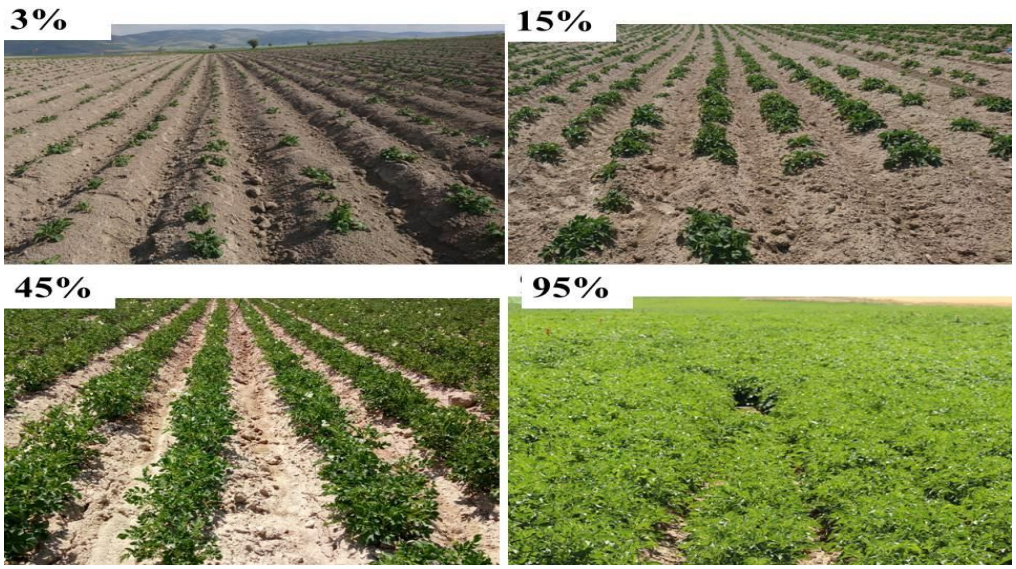

Fig.7. Development of soil cover range of potato during to its phenological stages

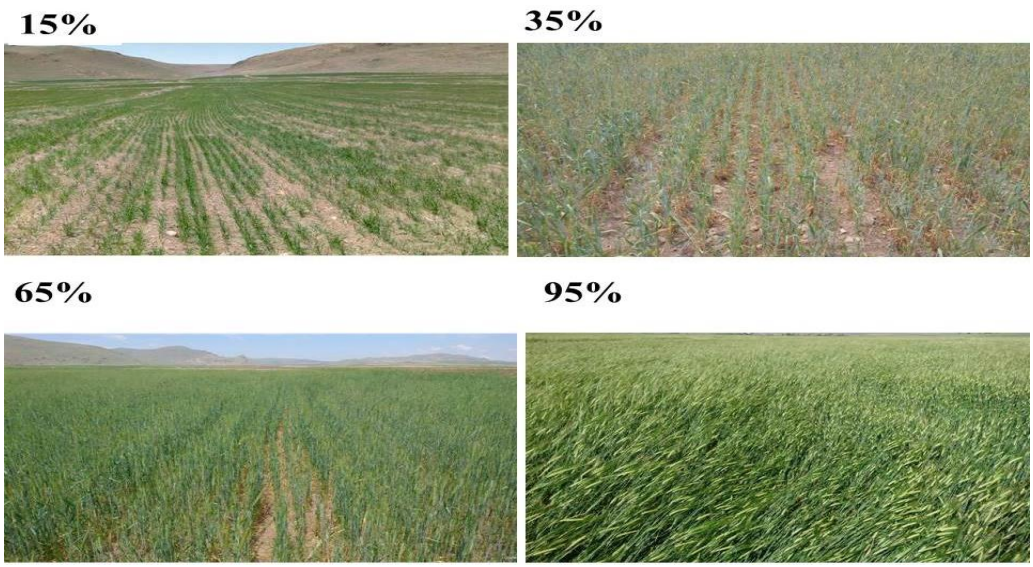

Fig. 8. Development of soil cover range of wheat/barley during to its phenological stages

CONCLUSIONS

To determine and to monitor plant cover with remote sensing technique, it is necessary to know the multi-band reflection values taking into consideration the climate, soil properties and plant phenological stage in which the vegetation cover is located. In this study, the effects of soil colors on the original reflection values of each crop were investigated in order to determine potato and wheat/barley plants. It was understood that the soil color differences caused deviation according to the known reflection values of the crop pattern. Secondly, the soil reflection characteristics should be taken into account when determining the reference reflection value. In this study, it was determined that the reflection of each band is higher than normal in light-colored sandy soils on the contrary of dark colored clayey soils. It was observed that clay-based and moist soil with high organic matter effected absorbance even during periods when the plant cover rate of soil was low. However, dark soils have more water-holding capacity and more fertile, which means the plant growth capacity is higher and also has high NIR reflection. Remote sensing techniques can be used to determine salinity of soil due to color changes. For his purpose the Normalized Difference Vegetation Index (NDVI) or the Canopy Response Salinity Index (CRSI) can be calculated from, satellite multispectral reflectance data [8]. It has been determined that there is a difference in planting time during the year as another important issue to be considered for the identification of agricultural products by remote sensing technique. This situation has been determined as another feature that affects reflection alone.

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Original scientific paper

EVALUATION OF DAIRY ESTABLISHMENTS IN TURKEY WITH REGARD TO FOOD QUALITY AND SAFETY IN EUROPEAN UNION PROCESS: RESEARCH OF ANKARA PROVINCE

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A b s t r a c t: In Turkey, the quality and safety of food products have become increasingly important as a requirement of the international relations and trade with the European Union (EU). EU harmonization studies have brought in legislation related to food safety. In the framework of negotiations with the EU, it is stated that food establishments meet EU hygiene standards and legal arrangements should be made to ensure their renewal by taking into account their operating capacities within the chapter "Food Safety, Veterinary and Plant Health". One of the important sub-sectors that need to comply with the legal regulations is the dairy sector. This study aims to examine the attitudes, opinions, and ideas of the authorities of food establishments producing milk and milk products on issues EU hygiene standards, quality, and safety of milk and milk products, living problems etc. The basic material of the thesis is the results of the questionnaire applied to the officials of food business operators producing milk and milk products in Ankara during the process of harmonization with EU food legislation. As a method, the "Full Count Method" was used and was interviewed with the authority of 15 dairy establishments. According to the information obtained from the research results; it is understood that 66.7% of the authorities do not have sufficient knowledge about EU legislation. In addition, 53.3% of food establishments' authorities see the supply of quality raw milk for the dairy sector as a significant advantage in the consequence of full membership to the EU. Furthermore, the lack of a good organizational structure negatively affects the sustainability of the existing dairy sector in terms of the supply of quality raw milk in Turkey. In order to compete in international markets, raw milk quality must first be brought to the competitive level.

Key words: food quality and security; dairy establishments; European Union food legislation; European Union harmonization process

ОЦЕНА НА МЛЕКОПРОИЗВОДСТВОТО ВО ТУРЦИЈА СО ОГЛЕД НА КВАЛИТЕТОТ И БЕЗБЕДНОСТА НА ХРАНАТА ВО ПРОЦЕСОТ НА ПРЕГОВОРИТЕ СО ЕВРОПСКАТА УНИЈА: ИСТРАЖУВАЊЕ ВО ОБЛАСТА НА АНКАРА

А п с т р а к т: Во Турција квалитетот и безбедноста на прехранбените производи стануваат сè поважни како услов за меѓународните односи и трговијата со Европската Унија (ЕУ). Студиите за хармонизација со ЕУ придонесоа за законодавство поврзано со безбедноста на храната. Во рамките на преговорите со ЕУ се наведува дека производството на храна ги задоволува стандардите за хигиена на ЕУ и дека треба да се донесат правни акти за нивно заживување, земајќи ги предвид оперативните капацитети предвидени во поглавјето „Безбедност на храната, ветеринарство и здравје на растенијата". Еден од важните потсектори кои треба да ги почитуваат законските прописи е секторот на млекопроизводството. Оваа студија имаше за цел да ги испита ставовите, мислењата и идеите на управните органи на прехранбените претпријатија кои произведуваат млеко и млечни производи за стандардите на ЕУ за хигиената, квалитетот и безбедноста на млекото и млечните производи, животните проблеми итн. Основниот материјал за оваа задача се одговрите од прашалникот доставен до

претставниците на организациите кои произведуваат млеко и млечни производи во Анкара во време на процесот на усогласувањето со законодавството на ЕУ. Како метод беше употребен "Full Content Method" и интервјуирани беа раководствата на 15 млекопроизводители. Според резултатите од истражувањето 66,7% од раководителите немаат доволно знаење за законодавството на ЕУ. Покрај тоа, 53,3% од органите на прехранбените претпријатија го гледаат снабдувањето на млечниот сектор со квалитетно сурово млеко како значајна придобивка од полноправното членство во ЕУ. Но недостигот на добра организациска структура негативно влијае на постојниот млечен сектор во однос на снабдувањето со квалитетно сурово млеко во Турција. За да се натпреварува на меѓународните пазари, квалитетот на суровото млеко мора прво да се доведе на конкурентно ниво.

Клучни зборови: квалитет и безбедност на храна; млекопроизводство; законодавство за храна на Европската Унија; процес на усогласување со Европската Унија

AIMS AND BACKGROUND

The concept of food security can be defined as the ability to reach the food that all people need to live their lives in a healthy way. However, in the developing world, while reaching food for nutritional purposes priory, countries that have provided food security are not only sufficient for food consumers, but demand for safety and healthy food is increasing. In addition, changes in consumer habits with the passage of time have led to the guarantee of the safety of consumed foods. Only half a century ago, when there is no fridge in people's homes and a larger part of the population lives in the countryside and produces its own food, today with the globalizing world, the growing food industry and changing living conditions consumers are choosing to use their choice of packaged food products from large grocery stores even ready meals. This situation places food safety at a crucial place [1]. The food safety refers to the assuring (of the producers and consumers) that a food does not harm the consumer when it is prepared and consumed as pointed out [2].

The quality and hygiene of the raw materials directly affect the hygiene of the products in the foodstuffs, the quality of the produced products and hygiene are effective in shelf life and consumer satisfaction. In this context, it is clear that one step of the food chain cannot be separated from the other, and that both the primary and the final product hygiene are necessary for the operators and the authorities to implement the necessary controls to protect the consumer [3]. Within this framework, the "farm to fork" food safety policy adopted by EU at the beginning of the 2000s which gives primary responsibility for food business operators at every stage of the food chain. In addition, with the audit and control authority given to the competent authorities is putting maximum effort to minimize the risks and protect the consumer. For this reason, the European Parliament and Council Regulation (EC) No. 178/2002 laying down the general principles and requirements of the Food Law, establishing the European Food Safety Authority and establishing procedures for food safety issues have been published [4].

Negotiations between the EU and Turkey are being carried out under 35 titles, 12 of them with "food safety, veterinary and phytosanitary policy" chapter in negotiations Ministry of Food, Agriculture and Livestock in coordination. The "Veterinary Services, Plant Health, Food and Feed Law" No. 5996, which enable the full transposition of the acquis in line with the EU in food, feed, and veterinary matters in the short term under the chapter "Food Safety, Veterinary and Plant Health" was published on June 11, 2010. Within the scope of Law No. 5996, Regulations issued in compliance with the regulations in the EU food legislation have been published in Turkey [5].

Within the chapter "Food Safety, Veterinary and Plant Health", it is stated that food business operators must meet the EU hygiene standards and that legal arrangements should be made to ensure their renewal by taking into consideration their operating capacities. One of the important sub-sectors that need to comply with the legal regulations is the dairy sector.

Milk is considered to be the most balanced food ever found in nature, which contains most nutrients. It is drunk by people of all ages and nationalities, and the quantity varies according to the eating habits and to its availability. Milk and milk products are an important part of the daily diet of babies, children, elderly and sick people [6]. Milk is a very important issue in terms of industrial sector as well as agriculture sector. In Turkey, the share of the value of agricultural production in dairy sector is around 8.5–9%. Turkey is among the 15 most milk producing country in the world with production of 18.6 million tons [7].

In this context, establishing the present situation of the dairy products industry, which has a

significant place in the Turkish food manufacturing industry, problems related to meeting the EU hygiene standards of food establishments producing milk and milk products, implementations within the framework of national legislation prepared in accordance with EU food legislation and reflections of official controls on dairy establishments are needed to investigate.

In previous studies on the subject, how food safety studies in the EU have emerged, what legislation is in force for the provision of food safety by the EU, food legislation applicable in Turkey and overall harmonization of EU food legislation impact on Turkey's food industry are discussed [8]. However, in addition to these issues examined in this study, food establishments that produce milk and milk products, which are an important dimension of the subject, the level of awareness of Turkish food legislation in the EU harmonization process has been examined and thus tried to ensure the integrity of the subject. The study may be useful for food legislation prepared under EU harmonization and official audits made by the competent authority to see the problems that may arise in food establishments producing milk and milk products and decision-makers to make necessary legal arrangements to resolve these problems. Thus, necessary measures can be taken to prevent adverse effects of compliance with EU food legislation in food business operators in the dairy sector.

The main objective of this study is to examine the attitudes, opinions, and ideas of the authorities of the food establishments producing milk and milk products in the province of Ankara, Turkey and to give a different perspective to the subject.

EXPERIMENTAL

Materials. The main material of this study is the primary data obtained through the interviews made with the officials of food business operators producing milk and milk products in Ankara.

The questionnaires were designed to make it possible to compile the survey data easily and were filled out in face to face interviews. The questionnaire contains the crucial questions needed to analyze attitudes, opinions, and ideas of the authorities of food establishments with regard to EU hygiene standards, food quality and safety of milk and milk products, living problems etc. In addition to the data obtained through the surveys, the articles and studies on this matter and the records and statistics of several institutions were looked at. The survey data of this study based on October of 2016.

Method. The study was carried out in the province of Ankara, Turkey. Ankara having around 7% of Turkey's population is one of Turkey's leading cities in terms of crop production. In terms of animal production, Ankara has maintained its importance for sheep and bovine breeding for years. 355.000 bovine animals, 2.5% of 14.2 million bovine animals in Turkey and 999.000 small cattle, 2.38% of 41.3 million small cattle in Turkey are located within the borders of Ankara. In addition, 277.000 tons of milk, 1.5% of the approximately 18.5 million tons of milk in Turkey are produced in Ankara and this milk is used as an input for milk enterprises operating within the provincial borders.

In Ankara, the number of dairy establishments with 30 horsepower (hp) engine power or more than 10 employees is 15 with the approval of the Ministry of Food, Agriculture and Livestock. When the surveyed 15 dairy establishments were examined, 8 establishments with a capacity of 60 hp and above (53.3%) could be considered as large establishments and the remaining 7 establishments (47.7%) with a capacity of under 60 hp could be considered as small establishments.

Likert scale questions include a statement of attitude or opinion about the topic being investigated and options to indicate the level of participation in that statement. In order to determine the level of participation in Likert scale questions, multiple options are offered between the two extremes. These options are ranked from "highest to lowest" or "best to worst". The 3-point Likert scale was used in this study [9].

In the determination of the surveyed establishments, the "Full Count Method" was used to collect data on the variables subject to the survey through all the establishments [10]. The dairy establishments with 30 hp engine power or more than 10 employees determined by the method of Unpredicted Sampling and applied the Full Count Method. The size of the population was determined as the number of dairy establishments operating in Ankara with 30 hp of engine power or more than 10 employees and the sampling volume was calculated as 15.

RESULTS AND DISCUSSION

The attitudes, opinions, and ideas of the authorities of food establishments producing milk and milk products are the source of research. The

authorities have a vital role in implementing EU hygiene standards, ensuring food quality and safety of milk and milk products and resolving living problems. The individual characteristics of food establishments authorities analyzed in this study (Table 1). 60% of the authorities interviewed within the scope of the survey are between 31–40 years of age. Given that the distribution of the authorities of food establishments according to their genders, 66.7% of authorities are male. The working title of the authorities is distributed as 53.3% Food Engineer, 40% Agricultural Engineer and 6.7% Veterinarian 33.3% of the surveyed authorities have 6–10 years, 26.7% 1–5 years, 26.7% 11–15 years and 13.3% more than 16 years experiences (Table 1).

Table 1

The individual characteristics of food establishment's authorities analyses

Characteristics						
Age of authorities	Age 31–40 9	Age 21–30 2	Age 41–50 2	More than 51 2	Total 15	
Gender of authorities (%)	Ma le 66.7		Female 33.3		Total 100	
The working title of authorities (%)	Food engineer 53.3	Agricult ural engineer 40		Veterinarian 6.7	Total 100	
Working experience of authorities	6–10 years 5	1–5 years 4	11–15 years 4	More than >15 years 2	Total 15	
The business mission of authorities (%)	Production engineers 60		Responsible personnel 40		Total 100	
Production capacities (%)	Over 60 hp 53.3	Less 30 hp 33.3	31–40 hp 6.7	41–50 hp 6.7	Total 100	
Number of personnel (%)	11 personn el and over 6.7		Less than 11 personnel 33.3		Total 100	
Legal structures of milk companies (%)	Limited liability company 53.3	Capital company 20	Joint stock company 13.3	Public company 6.6	Private company 6.6	Total 100
Packaged milk-producing establishments	Packaged milk producers 13		Non-packaging milk producers 2		Total 15	

The production engineers working in the food establishments investigate the processing, storage, and development of new products, solve the problems that may arise during the production, ensure the continuation of the operations, work to produce the best product at reasonable cost and inspect and control quality at all stages from raw material to consumer [11]. The authorities within the scope of the research, 60% of their duties are designated as production engineers and 40% as responsible personnel (Table 1). Hence, the result is that the majority of the food establishments' authorities producing milk and milk products work as production engineers in Ankara. Therefore, the fact that the authorities are generally the production engineers who dominate the production and manufacturing processes can be evaluated positively in terms of close monitoring of the EU legislation, implementtation of the current food legislation and manufacturing of products in accordance with food safety.

In the questionnaire study, the annual production capacities (hp) of machines used in production,

which is a criterion for measuring the size of establishments, are taken into account [12]. In this context, when the capacities of the food establishments are examined, it is seen that 53.3% of them are over 60 hp, 33.3% of them are over 30 hp, 6.7% of them are 31–40 hp and 6.7% of them are 41–50 hp seen (Table 1).

When the number of personnel of food establishments is examined, it is seen that 66.7% of the food establishments employ 11 people and over (Table 1). This requires good staff hygiene in order to prevent contamination of the food directly with foodstuffs, from the acceptance of raw materials to the stages of production, processing, packaging and transport, which are the production steps.

According to the legal structures of dairy establishments, 53.3% is a limited liability company, 20% is a capital company, 13.3% is a joint stock company, 6.6% is a public company and 6.6% is a private company (Table 1).

While 13.3% of the food establishments produce packaged milk, the remaining 86.7% are not produced (Table 1). This result shows that the dairy establishments in Ankara used to make more milk products (ayran, kefir, cheese, kashar cheese etc.) rather than to pack and sell raw milk and the majority of packaged milk sold in Ankara comes from food establishments outside of Ankara.

Official audits made by the competent authority are carried out the appropriate frequency and directly proportional to the risk carried by the foodstuff. In the risk-based audit system; the minimum technical and hygienic conditions of the operator, the knowledge and experience gained from previous controls, and the results of the autocontrol performed by food operators are taken into account.

The opinions of the food enterprises in the research area concerning the official controls made by the competent authority have also been investigated. 73.3% of the authorities of the food establishments stated that the frequency of official control was high. That is, it is stated that the number of official food controls conducted by the competent authority is too much and the establishments should be audited less frequently.

73.3% of the food business operators stated that the amount of punishment imposed by the competent authority is excessive (Table 2). It is thought that the gradual determination of penalties according to the capacities of establishments and annual turnover will be appropriate in terms of ensuring competitiveness and justice between small and large businesses.

As a result of official controls made in accordance with Law No. 5996, there is a legal period of 15 days for the food operator to overcome the shortcomings found in food operation, except in cases where human health would be jeopardized. It is seen that 66.7% of the food business operators participated in this related question (Table 2).

The official controls carried out in Turkey are fulfilled in accordance with the principles of fairness, impartiality, transparency and professional confidentiality, on a risk basis, without prior notice, except where preliminary notification is required [13]. When the answers to the questions asked by the food business operators regarding the official controls are made in accordance with the objective, transparent and professional confidentiality principles, 60% of them seem to have participated in this situation (Table 2).

73.3% of the food business operators said that they participated in the question about the control officers involved in official controls (Table 2). The data in the table show that a large part of the food business operators see the control officers as an expert and qualified.

The food sample is described as foodstuffs the date of manufacture, the serial number of which is the same, and the mass that it is receiving, the amount and quality that the party can represent in every direction. The fact that the sampling frequency is high by the food business operators, when evaluating the scope of the studies on Turkey's adaptation to EU legislation, it is emerging as a condition to be taken into account by the official authorities [14].

Looking at the findings of the determination of the effectiveness of official controls, 53.3% of food business operators seem to have participated in this situation (Table 2).

Information on products determined to be harmful to human health or detected to be imitated or adulterated within the scope of Law No. 5996 is presented to the public information on the official website of the competent authority. Referring to the answer given by food business operators for the opinion to be shared with the public's negative results emerged in official control, 60% of food business operators are unstable (Table 2).

All of the food business operators are of the opinion that harmonization with EU legislation will affect the sector positively.

Table 2

Opinions of food business operators on official controls

Opinions about official controls	I agree		No opinion		I do not agree		Total	
	Number	%	Number	%	Number	%	Number	%
I find the number of fines imposed on my business too high.	11	73.3	2	13.3	2	13.4	**15**	**100**
At official controls, the statutory period is sufficient to overcome the deficiencies identified in the operation.	10	66.7	3	20.0	2	13.3	**15**	**100**
Official controls are conducted on a risk basis in accordance with impartial, transparent and professional confidentiality principles.	9	60.0	5	33.3	1	6.7	**15**	**100**
The control officers involved in official controls are experts in their field, qualified persons with the necessary knowledge and skills.	11	73.3	3	20.0	1	6.7	**15**	**100**
If the business needs to be renovated, I think the legal period is sufficient.	10	66.7	3	20.0	2	13.3	**15**	**100**
Very frequent samples are taken at official controls.	12	80.0	1	6.7	2	13.3	**15**	**100**
In terms of food safety, I find that the official controls are effective in order to protect the consumer.	8	53.3	5	33.3	2	13.3	**15**	**100**
I believe that if the negativity is detected in the establishment, the negativity should be shared with the public.	3	20.0	9	60.0	3	20.0	**15**	**100**

CONCLUSIONS

The issue of food safety has become an increasingly important issue for recent years, which has gained importance in terms of public health and economic dimension in terms of all countries. Within this framework, it adopted by the EU "from farm to fork" food safety policy has been implemented in Turkey. The implementation of this policy, regulatory framework for EU legislation considered and legal arrangements were made for food business operators in Turkey to meet hygiene standards applicable in the EU. One of the important sub-sectors that need to comply with the legal regulations is the dairy sector.

Surveys were conducted assuming that the food business operators in the research area were aware of the legal obligations set out in the Turkish food legislation in the EU harmonization process. Because according to the Law No. 5996, food business operators are obliged to provide and verify the conditions stated in this Law at every stage of their field of activity. However, this legally determined situation does not seem to be reflected in practice.

It is understood that the food establishments authorities interviewed within the scope of the study do not have accurate information about food legislation in the EU in general terms. As a matter of fact, it has been seen that many of them gave wrong answers to the questions regarding the EU Regulations. These results show that food business operators lack information on EU legislation.

In this study; the attitudes, opinions, and ideas of the authorities of food establishments regarding

the case of harmonization Turkey's legislation to EU have been researched in terms of sector reflections. In this context, surveyed all food business operators have a positive view if food legislation in Turkey is made compatible with the EU. In addition, many food establishments authorities have expressed their opinion that harmonization with EU legislation will result in a positive impact on the dairy sector.

Within this study, more than half of the food business operators stated that the amount of raw milk is inadequate and policy not followed to support the milk producer in Turkey. In this context, it is considered that measures should be taken to increase the production of raw milk in compliance with the legislative requirements of the official authorities, and a policy should be followed to support food business operators in terms of supplying raw milk adequately. In EU countries, the base criterion for 1 liter of raw cow milk is 4.2% for fat and 3.4% for protein. In order to compete in international markets, raw milk quality must first be brought to the competitive level. Therefore, in order to be able to compete with the EU countries, it is necessary to determine the reference price of the raw cow's milk and to observe a policy that respects the quality of raw milk in the payments in Turkey.

In addition, there are some important points to note. The production cost of 1 liter quality raw cow milk in Europe is about 0.30 Euro. In Turkey, the cost (0.33 Euro) is slightly higher than the cost in Europe. For this reason, if the costs are not reduced, it will not be possible with expensive production to produce milk at low prices either in export markets or in domestic markets. In Turkey, the policies for rural development should be monitored in order to ensure the competitiveness of EU raw milk production costs. In this context, it is crucial to ensure that small and medium-sized enterprises in the dairy sector exceed long-term economic sustainability thresholds, improve the quality and hygiene conditions of the plants, and produce in EU standards at the production and processing stages.

Finally, before it is too late, food establishments should be told that it is extremely vital to make production in compliance with EU legislation and to compete with counterparts in EU in order to achieve sustainable their assets in the market. It should not be forgotten that there is no healthy life without food safety.

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NONWOOD FOREST PRODUCTS AS AN INSTRUMENT FOR RURAL DEVELOPMENT: PERSPECTIVE OF FOREST VILLAGERS FROM ISTANBUL

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A b s t r a c t: Nonwood forest products (NWFP) related issues have taken place among the emerging strategies of rural development in recent decades. Production and marketing of NWFPs has economic, social and environmental impacts on rural development. At this point the attitudes and problems of rural dwellers working as producers, gain importance in terms of strengthening the contribution of NWFPs to rural development. In this context, the aims of the paper are to determine the contribution of local people in NWFPs' producing process, to analyze the effects of this kind of products on rural development and to examine the related problems of local people. In order to achieve the mentioned goals, questionnaires were applied in case of Istanbul and 129 villagers participated in the questionnaire survey. The data were analyzed by descriptive statistics and comparative analysis. The results obtained are; there are some problems on relations between forest and villagers and also NWFPs don't have direct effect on rural economic livelihood, however the products contribute rural food supply. Thus, i) legal instruments, ii) regulatory instruments, iii) economical instruments (taxes and incentives), iv) information-based instruments (education–research), v) public relations and participation should be strengthened to increase the contribution of NWFPs to rural development.

Key words: forestry organization; rural development, nonwood forest products

НЕДРВЕНИ ШУМСКИ ПРОДУКТИ КАКО СРЕДСТВО ЗА РУРАЛЕН РАЗВОЈ: ПЕРСПЕКТИВИ НА ШУМСКИТЕ СЕЛА КАЈ ИСТАНБУЛ

А п с т р а к т: Недрвените шумски продукти во последните децении се најдоа во новите стратегии за рурален развој. Собирањето и маркетингот на недрвени шумски продукти имаат економско, социјално и еколошко значење за руралниот развој. Од оваа гледна точка ставовите и односот на руралните жители кои работат како производители добиваат значење за зајакнување на придонесот на недрвените шумски продукти за руралниот развој. Во тој контекст, целите на трудот се да се утврди придонесот на локалното население во процесот на собирањето на недрвените шумски продукти, да се анализираат ефектите од овој вид дејност врз руралниот развој и да се испитаат проблемите поврзани со локалното население. За да се постигнат споменатите цели, во Истанбул беше спроведена анкета во која учествувале 129 селани. Податоците беа анализирани преку описна статистика и компаративна анализа. Добиените резултати се: постојат некои проблеми на релацијата шумите и селаните, а исто така недрвените шумски продукти немаат директен ефект врз руралното економско опстојување, но продуктите придонесуваат за рурално снабдување со храна. Затоа треба да се зајакнат: 1) легалните инструменти, 2) регулаторните инструменти, 3) економските инструменти (даноци и стимулации), 4). инструментите базирани на информации (образовно-истражувачки), 5) односите со јавноста и субвенциите, за придонесот на недрвените шумски продукти во руралниот развој да се зголеми.

Клучни зборови: шумска политика; рурален развој; недрвени шумски продукти

AIMS AND BACKGROUND

The demands on wood material increased by the increment of permanent settlements and agricultural activities and also the initial forestry implementations focused on regulation and enhancing wood production [1, 2]. Thus, wood production had been the essential forest utilization type until the

20th century. After then, forestry has also begun to focus on the other economic, social and environmental functions of forests [3]. In this context, NWFPs has become as one of the prominent functions of forests. Besides, Erdönmez and Yurdakul Erol mentioned that nonwood forest products utilization is one of the main utilization types during the pure agricultural society period [4]. Although NWFPs were seen as a source of foodstuff in this period, modern forestry has focused on economic, social, cultural and environmental dimensions of these products. The increased interest on NWFPs is deal with international shift to multifunctional sustainable management [5]. Parallel to this approach, NWFPs gained importance in the context of their potential of contribution to rural development, being source of some natural food, cosmetics and medical products, maintaining source of income to forestry organization [6, 7]. Also NWFPs have effect on rural development in terms of health, food security, environmental protection and collaboration-cooperation between rural people [8]. Also Fu et al. expressed that utilization of NWFPs as a source of livelihood also has positive effects on protection of forest resources [9].

Management authority related NWFPs belongs to General Directorate of Forestry and this governmental organization employs forest cooperatives and villagers in harvesting of these products in Turkey. Also forest villagers have some legal rights in terms of harvesting and marketing some NWFPs by paying reduced prices.

The harvested and traded NWFPs are plant-based and according to the official records, there are 346 types of these products and 98 of them has been traded in Turkey. 24 of these species have endemic characteristics and 7 of them have been exported [10]. Export of these products has made by private companies. However, the total income also the share of forest villagers is lower than the potential economic value. Turkey exports these products as raw material that provides lower economic income when compared with the value of manufactured products. Furthermore, there has been an increment in the Turkey's export income level that is provided by NWFPs in recent years. While this income was 38.7 million $ in 2002, it was raised to 122.5 million $ in 2010 [11]. This increment is important for both national economy and rural economy. Sakarya and Canlı also highlighted that NWFPs sector takes place in the second place in terms of financial and real income resources of forest villagers [12].

Furthermore, considering local interest, demands and properties and also maintaining participation of local people to decision making process has critical importance in terms of providing sustainability of NWFPs [13, 14]. Because, the utilization dynamics and social effects of forest resources utilization show different characteristics at different regions.

At this point, the determination of problems and attitudes of forest villagers at local level gain importance in terms of strengthening the contribution of NWFPs to rural development. In this context, the aims of the paper were to determine the contribution of local people in NWFPs' producing process and to examine the related problems of local people in the context of sample cases.

EXPERIMENTAL

In the first stage of the research the sample cases were selected by considering the properties of forest enterprises operate under Istanbul Regional Directorate of Forestry. In this context, Çatalca and Şile Forest Enterprises were chose as the two samples. Purposive (deliberate) sampling method was used while determining sample cases. In this context the two sample forest enterprises were chose by considering their NWFPs' activities and related potential, their location and existence of related scientific research. In this context, the two samples have important and big potential in terms of production of NWFPs in Istanbul. Besides, Şile is in Asian side, whereas Çatalca locates in European side of the city. On the other hand, there are some previous scientific projects made in Şile however there is not any projects in Çatalca related NWFPs. It is important in terms of the attitudes and awareness of the villagers. In the second stage a questionnaire survey was conducted to collect data. In this context 129 villagers completed the questionnaires. The features of the villagers in terms of the status of the villages that they live, the period of living time in the village, age, education level, income level and source of income can be seen in Table 1.

The 80 % of the participants live in forest and the rest lives nearby forests (Table 1). Approximately all of the participant (98 %) has lived in their villages for more than 20 years and 65.9 % of the participant villagers is more than 41 years old. Half of them (54.3 %) are graduated from primary school. The monthly average income is less than 1200 TL (440 $) for 90 % of the participant villagers. Forestry and livestock is the main source of income for 40.3 % and 26.4 % of the participants respectively (Table 1).

Table 1

Frequency and percentage of forest villagers participated to the questionnaire in terms of socio-economic features

Features of villagers		N (Frequency)	% (Percentage)
State forest enterprise	Çatalca	44	34.1
	Şile	85	65.9
Status of village	Inforest	103	79.8
	Nearby forest	26	20.2
Period of living time in the village	Less than 20 years	3	2.3
	20–40 years	33	25.6
	More than 40 years	93	72.1
Level of education	Primary school	71	55
	Secondary School	37	28.7
	High school	18	14
	University	3	2.3
Age	20–40	44	34.1
	41–60	71	55
	Older than 60	14	10.9
Income level (average monthly)	Less than 1.200	38	29.5
	1200 – 2000	78	60.5
	More than 2000 TL	13	10.1
Main source of income	Forestry	62	48.1
	Agriculture	15	11.6
	Livestock	34	26.4
	Trade	5	3.9
	Civil servant	13	10.1

The questionnaire consisted of two main parts of questions. The first part was related with harvesting process and the second part focused on the effects of NWFPs-related process and developments on forest villagers. The first part of the questionnaire also consisted of statements using five point Likert type scale. Answers to each question were given as a reflection of choices from the strongest agreement to the strongest disagreement (I strongly agree, I agree, I am neutral, I don't agree, I strongly disagree). A three-point scale was also used in the second part, where the value of 1 corresponded to "improve", and the value of 3 corresponded to "regress". The results of the questionnaire were evaluated by SPSS (Statistical Package for Social Sciences). First of all, reliability analysis was conducted in testing scale reliability and the item-total correlation. The estimate of Cronbach's alpha (α) for the first group of questions was $\alpha = 0.55$, and for the second group was $\alpha = 0.51$. Thus the reliability is at moderate level and appropriate for statistical analysis.

Some descriptive analysis was made and also analysis of variance (ANOVA) and *t*-test were used in order to determine the statistically significant differences among the answers given by forest villagers depending on the various characteristics. The settlement location, the status of the village, average income, education level, source of income, living period in the village were taken as independent variables in the comparisons. In the comparisons by using ANOVA and *t*-test, evaluations were made according to the significance levels (p) of 0.05 and 0.01. When a difference was found between groups, Tukey post hoc test was used to determine which group is different from each other.

RESULTS AND DISCUSSION

Evaluation of NWFPs' harvesting system

The participants agreed with the expression related having adequate knowledge and experience

about harvesting NWFPs (M = 3.96). Based on *t*-test and ANOVA results there were statistically significant differences between the forest villagers on the basis of the state forest enterprise (p = 0.00, MD = 0,70), status of the village (p = 0.00, MD = 0,81), period of living time in the village and average income (p = 0.00, F = 11,91) concerning the adequacy of knowledge and experience on harvesting-related issues. The villagers who live in Şile (M = 4.20) had higher acceptance level than who live in Çatalca. Also the people who live in villagers nearby forests had higher level of acceptance (M = 4.62) than the people live inforest villages (M = 3.80). Tukey test was also showed that the main difference in this group is among those who live in the village less than 20 years and those live between 21 and 40 years (MD = 1.81, p = 0.01) and more than 40 years (MD = 1.61, p = 0.02). Besides, Tukey test was also revealed that the main difference about the knowledge and experience level is among those who have the highest level of income (more than 2000 TL) and those whose income level is middle (1200–2000 TL) (MD = 1.67, p = 0.00) and the lowest (less than 1200 TL) (MD = 1.66, p = 0.00).

The findings regarding evaluation of the participants' approaches in terms of harvesting NWFPs by private enterprises showed that the villagers agreed moderately on this statement (M = 3.12). The results of *t*-test revealed that there were also statistically difference among the acceptance levels of villagers in terms of state of enterprise that the villages locate (MD = 1.91, p = 0.00) and status of the village (MD = 1.14, p = 0.00). The agreement of this expression was higher in people who live in Şile (M = 3.78) and nearby forest villages (M = 4.04) (Table 2). Regarding the main source of income, based on post hoc test, the difference is between those having income from agriculture and forestry (MD = 1.65, p = 0.00), livestock (MD = 1.28, p = 0.00). It is also interesting to find out that the villagers whose main income is forestry had the highest acceptance level regarding the expression about harvest of NWFPs by private enterprises (M = 3.45).

The participants' approach about the expression regarding sale of NWFPs as stumpage was at moderate level (M = 3.12). The results of *t*-test showed that there were statistically important differences regarding state of enterprise (MD = 0.86, p = 0.00) and status of the village (MD = 0.62, p = 0.03). The agreement of this expression was higher in villagers who live in Şile (M = 3.41) than those live in Çatalca (M = 2.55). Also the agreement level of the villagers who live nearby forest (M = 3.62) was higher than those live in inforest villages (M = 2.99). Moreover, the results of the Tukey test showed that there is a difference among the villagers whose main source of income is agriculture and forestry (MD = 1.25, p = 0.00). In this context the villagers whose main source of income is forestry agreed highly (M = 3.45) to the statement whereas the agreement level of the participants whose income depends on agriculture is low (M = 2.20).

Besides, the findings regarding evaluation of the participants' approaches in terms of taking permission from forestry organization showed that the villagers agreed highly on this statement (M = 3.81). The results of *t*-test revealed that there were statistically difference among the acceptance levels of villagers in terms of state of enterprise (MD = 1.12, p = 0.00). Tukey test also revealed that the main difference about permission taking from forestry organization is among those who have secondary school graduation and high school graduation (MD = 0.91, p = 0.04).

There were no differences among participants in terms of the statement of "NWFPs' economic value will be greater than wood products in the future". Besides, any significant difference did not exist between the opinions according to age.

The effects of NWFPs-related process and developments on forest villagers and problems on marketing

Based on the results, the level of agreement on 5 statements were very high, while one of them was moderate. The participants recognized that strengthening forestry organization and villager's relations (M = 2.77), improvement new harvesting techniques (M = 2.70), improvement socio-economic conditions of forest villagers (M = 2.66), producing NWFPs cultivation (M = 2.64) and enlargement of the areas allocated for harvesting (M = 2.66) have improving effect on NWFPs harvesting (Table 3). Besides, the participants thought that rearrangement of legal issues regarding utilization rights doesn't affect the NWFPs harvesting process.

According to *t*-test results there was statistically significant difference between the forest villagers on the basis of the status of the village (p = 0.03, MD = 0.23) concerning the effect of improvement of socio-economic conditions of villagers. The agreement of this expression was higher in the villagers who live nearby forest than those who live in inforest villages.

Table 2

Assessment and comparison of attitudes of forest villagers on NWFPs harvesting-related issues

Features	"I have adequate knowledge and experience about harvesting NWFPs"	"It is better to have NWFPs harvested by private enterprises"	"It is better to have NWFPs sold as stumpage"	"NWFPs' economic value will be greater than wood products"	"It is necessary to take permission from forestry organization regarding NWFPs' harvesting
State forest enterprise					
Çatalca	3.50	1.86	2.55	4.14	3.07
Şile	4.20	3.78	3.41	4.09	4.19
	Sig.0.00 – MD: 0.70	Sig.0.00 – MD: 1.91	Sig.0.00 – MD: 0.86		Sig.0.00 – MD: 1.12
Status of the Village					
Inforest	3.80	2.89	2.99	4.11	3.74
Nearby forest	4.62	4.04	3.62	4.12	4.08
	Sig.0.00 – MD: 0.81	Sig.0.00 – MD: 1.14	Sig.0.03 – MD: 0.62		
Period of living time in the village					
Less than 20 years	2.33	4.33	3.33	3.00	3.33
20-40 years	4.15	3.00	3.24	4.06	3.73
More than 40 years	3.95	3.13	3.06	4.16	3.85
	Sig.0.01 – F: 4.58				
Level of education					
Primary school	3.92	3.15	3.01	4.00	3.69
Secondary school	4.03	3.11	3.46	4.27	4.24
High school	4.06	3.06	2.89	4.33	3.33
University	3.67	3.00	2.67	3.33	4.00
					Sig. 0.04 – F: 2.75
Age					
20-40	4.11	3.23	3.32	4.16	3.84
41–60	3.93	3.04	2.93	4.10	3.85
Over 60	3.64	3.21	3.43	4.00	3.50
Income level (average monthly) (TL)					
Less than 1.200	4.13	3.58	3.34	3.97	4.21
1200 – 2000	4.13	3.00	2.96	4.40	3.64
More than 2000 TL	2.46	2.54	3.38	3.62	3.62
	Sig. 0.00 – F: 17.61				
Main source of income					
Forestry	4.16	3.45	3.45	4.15	3.81
Agriculture	3.80	1.80	2.20	4.07	3.13
Livestock	4.00	3.09	3.00	4.32	4.09
Trade	3.60	3.20	3.20	3.40	4.20
Civil servant	3.23	3.15	2.85	3.69	3.69
		Sig. 0.005 – F: 3.954	Sig. 0.016 – F: 3.189		
AVERAGE	3.96	3.12	3.12	4.11	3.81

Table 3

Assessment and comparison of attitudes of forest villagers on NWFPS – related process and developments

Features	Strengthen forestry organization villager relations	Improvement new harvesting techniques	Improvement socio-ecomic conditions of villagers	Rearrangement of legal isues regarding utilization rights	Producing NWFPs cultivation	Enlargement of the areas allocated for harvesting
			State forest enterprise			
Çatalca	2.61	2.59	2.50	2.59	2.82	2.82
Şile	2.85	2.75	2.74	2.36	2.54	2.55
			Status of the village			
Inforest	2.76	2.69	2.61	2.48	2.65	2.69
Nearby forest	2.81	2.73	2.85	2.31	2.58	2.46
			Sig.0.03			***Sig.0.04***
			MD: 0.23			***MD: 0.22***
			Period of living time in the village			
Less than 20 years	2.67	2.33	2.67	2.67	2.33	2.67
20–40 years	2.85	2.82	2.61	2.52	2.79	2.70
More than 40 years	2.74	2.67	2.68	2.41	2.59	2.62
			Level of education			
Primary school	2.75	2.66	2.72	2.35	2.63	2.63
Secondary school	2.81	2.84	2.70	2.51	2.59	2.68
High school	2.78	2.61	2.39	2.67	2.67	2.61
University	2.67	2.33	2.33	2.33	3.00	2.67
			Age			
20–40	2.89	2.80	2.70	2.30	2.75	2.57
41–60	2.70	2.63	2.63	2.51	2.55	2.63
Over 60	2.71	2.71	2.64	2.57	2.71	2.93
			Income level (average monthly)			
Less than 1.200	2.76	2.66	2.63	2.39	2.50	2.55
1200 – 2000	2.76	2.72	2.71	2.44	2.68	2.64
More than 2000 TL	2.85	2.69	2.46	2.62	2.77	2.92
			Main source of income			
Forestry	2.74	2.69	2.61	2.29	2.65	2.58
Agriculture	2.80	2.67	2.67	2.53	2.80	2.73
Livestock	2.88	2.76	2.76	2.56	2.62	2.71
Trade	2.60	2.40	2.60	3.00	2.00	2.60
Civil servant	2.62	2.69	2.62	2.54	2.69	2.69
				Sig.0.03		
				MD: 0.26		
AVERAGE	2.77	2.70	2.66	2.44	2.64	2.64

Furthermore, the results of *t*-test revealed that there were also statistically difference among the agreement levels of villagers about enlargement of the areas allocated for harvesting in terms of status of the village that they live (MD = 0.22, p = 0.04). The agreement of this expression was higher in people who live in inforest villagers (M = 2.66) than who live in nearby forest villages (M = 2.46) (Table 3).

In addition, the villagers mentioned that the biggest problem regarding marketing of NWFPs is about inadequacy on finding products (44%) and underbid prices of harvested products (36.4%) respectively (Table 4). The findings also showed that there are not any important problems regarding legal arrangement (10.85%) and taking permission from forestry organization (2.33).

Table 4

Evaluation of problems on NWFPs

PROBLEMS	ÇATALCA		ŞİLE		Total	
	f	%	f	%	f	%
Unable to find adequate products	22	50	36	42.35	58	44.96
Quote low prices to the harvested products	10	22.73	37	43.53	47	36.43
Having problems with forestry organization regarding permission	1	2.27	2	2.35	3	2.33
Lack of legal arrangements	6	13.64	8	9.42	14	10.85
Other	5	11.36	2	2.35	7	5.43
Total	44	100.0	85	100.0	129	100.0

CONCLUSION

NWFPs are important and essential components of rural development in terms of rural economy in the context of legal utilization rights and food security [15]. However, national political background is insufficient about sustainable management of NWFPs [16]. National policies gain importance in terms of maintaining the essential aims and tools in the country. Besides, making local scale policies gains importance to focus on interactions between social, economic and environmental aspects at local level. Also environmental and economic potentials and obstacles of rural areas are defined as the starting point of defining sustainable strategies and development axis [17].

Parallel to this approach, the study was conducted in the Çatalca and Şile forest enterprises. The participants thought that they have adequate knowledge and experience, taking permission from forestry organization is necessary and NWFPs will gain economic value (more than wood products). However, they were not sure about the need of employment of private enterprises in NWFPs' harvesting process and about sale of NWFPs as stumpage. Also the participants recognized that strengthening forestry organization and villager's relations, improvement new harvesting techniques, improvement socio-economic conditions of forest villagers, producing NWFPs cultivation and enlargement of the areas allocated for harvesting have improving effect on NWFPs harvesting. Moreover, the participants thought that rearrangement of legal issues regarding utilization rights doesn't affect the NWFPs harvesting process. In addition, the villagers' biggest problems regarding marketing of NWFPs were about inadequacy on finding products and underbid prices of harvested products.

In the light of these findings the prominent aspects are related with strengthening training activities on harvesting techniques and marketing of NWFPs. Although the participant thought rearranging legal arrangement doesn't have direct effect on harvesting process, it directly affects utilization, employment, marketing and pricing related issues. In this context, the participants also mentioned that they have problems regarding marketing of NWFPs on finding products and underbid prices of harvested products. Thus, one of the critical issues is related with the increasing the share of local people from the total income of NWFPs' sale. Also forest villagers should be supported regarding creating market, price determination and direct selling opportunities.

In addition, active usage of public relations instruments in terms of increasing public awareness about economic value of NWFPs, requirements about sustainable management and ecosystem management is essential. At this point, improvement mechanisms regarding participatory management and cooperation between local people and forestry organization have critical role to improve the effectiveness of NWFPs to rural development.

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Original scientific paper

THE EFFECT OF CLIMATE CHANGE ON FOOD SUPPLY OF TURKEY

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A b s t r a c t: The aim of this study is to determine the effect of climate change on food supply in Turkey. To achieve this aim, the main agricultural products of Turkey were selected as wheat, barley, rye, oats, sugar beet, rice, dried beans, red lentils, green lentils, chickpeas, milk as to area sown, production quantity, economic importance and available data. The data of this study (production, consumption, import, export and price) were collected between 2000 and 2016 periods from Turkish Statistics Institute. In calculating the effect of climate change on yields it was taken as the base year of 2014. The temperature and precipitation projections was taken from General Directorate of Meteorology (MGM) for 2020–2050–2080 years. Analysis and evaluations were made at the regional and national levels and the 'Level 1' regional system of the Turkish Statistics Institute (12 sub-regions) was used as the regional level. The effect of climate change on yields was calculated using the Penman-Monteith and Blaney-Criddle formulas. According to research finding, it was estimated that product yields would be decrease in the average 2–7% in 2020, 4–12% in 2050, 5–20% in 2080. The yield and production decreases would make a serious threat with increase of population and per capita income with the climate change on food security of Turkey.

Key words: climate change; yield; food supply; agriculture

ВЛИЈАНИЕ НА КЛИМАТСКИТЕ ПРОМЕНИ ВРЗ СНАБДУВАЊЕТО СО ХРАНА ВО ТУРЦИЈА

А п с т р а к т: Целта на оваа студија е да се одреди влијанието на климатските промени врз снабдувањето со храна во Турција. За да се постигне оваа цел, беа избрани главни земјоделски производи од Турција: пченица, јачмен, `рж, овес, шеќерна репка, ориз, сушен грав, црвена леќа, зелена леќа, наут, млеко, според потеклото, произведени количини, економско значење и достапни податоци. Податоците од оваа студија (производство, потрошувачка, увоз, извоз и цена) беа собрани во периодот 2000–2016 од Турскиот институт за статистика. При пресметувањето на ефектот од климатските промени врз приносите, како базна беше земена 2014 година. Проекциите за температурата и врнежите беа преземени од Генералниот директорат за метеорологија (МГМ) за 2020–2050–2080 години. Анализата и оцените беа направени на регионално и национално ниво, а регионалниот систем "Ниво 1" на Турскиот институт за статистика (12 подрегиони) беше земен како регионално ниво. Ефектот на климатските промени врз приносите беше пресметан со помош на формулите на Пенман-Монтејт и Блани-Крајдл. Според наодите од истражувањата, се проценува дека приносите ќе се намалат во просек за 2 до 7% во 2020 година, 4 до 12% во 2050 година, 5 до 20% во 2080 година. Намалувањето на приносите и производството поради климатските промени заедно со порастот на населението може да биде сериозна закана за приходот по глава на жител и за обезбедувањето храна во Турција.

Клучни зборови: климатски промени; принос; снабдување со храна; земјоделство

AIMS AND BACKGROUND

Climate change is one of the biggest environmental problems of our time. According to the reports of the Intergovernmental Panel of Climate Change (IPCC), temperature is expected to rise from 2.4^0C to 4^0C in the next century [1]. The same reports stated that the Mediterranean Basin including Turkey will be one of the most effected region of the world in the next century and there will be

more severe heat waves, increased temperature, reduced precipitation, decreased soil moisture, rise of sea levels. It is reported that temperature increases and changes in precipitation regime in semi-arid and arid regions in the Mediterranean region will be more frequent, extreme weather events such as floods and droughts will be more intense and frequent [1, 2].

There are 24 million hectares of agricultural land in Turkey and approximately 20% of them is irrigated. In other words, 80% of agricultural land is depending to rainfall. On the other hand, although only 20% of agricultural land irrigated, more than 70% of total water resources used for agricultural irrigation in Turkey.

One of the disasters caused by climate change is drought. Turkey in which located in semi-arid region is under drought risk, and experiencing more severe dry years. In the drought years, food supply can be threatened by decreasing agricultural production as quantity and quality, and those trigger increasing food prices, especially low income groups becoming harder to access food, malnutrition, hunger and deaths. The effect of the drought continues in the following years. Because of lack of capital, farmers tend to withdraw from the production and/or use lower input including fertilizer. Thus, in the post-drought period agricultural production level is also effected.

There are many studies on regional, national and global scale on the impact of climate change on agriculture. In these studies it is estimated that climate change will affect agriculture negatively [3–10]. It is estimated that climate change will reduce the yield, production and increase prices in agriculture.

In the study by Rosenzweig and Iglesias (2006), it was estimated yield changes of some agricultural products in some countries. In this study, the estimates for Turkey, the impacts of climate change in the yields of grain and oilseed crops for the year 2080 would result in a 12% reduction on yield [11]. Another study conducted Turkey related to impacts of climate change on agriculture found that yields of selected crops which were wheat, barley, corn, sunflower and cotton, were estimated decrease for 2050. Due to the decrease in production, the amount of production will decrease, the production pattern will change according to the regions, the exports in wheat and sunflower will decrease, the imports in corn and cotton will increase [12]. In this paper, the study which was done by Dellal et al. (2011) [12, 13] has been expanded and updated.

EXPERIMENTAL

In this paper, the study done by Dellal et al. (2011) [12, 13] was updated and expanded. According to the amount of production and economic importance rye, oats, sugar beet, rice, beans, red lentils, green lentils, chickpeas were added to the prior study covered crops including wheat, barley, sunflower, corn, cotton. The base year of the updated model was considered as 2014 year, and the time series data of 2000–2016 period was used. The analysis was done by regional and national level. As regional level it was used as Turkish Statistics Institute (TURKSTAT) Level 1 regional system [14].

The biophysical effect of climate change is measured using the Penman-Monteith and Blaney-Criddle formulas. In these formulas, evapotranspiration (ET) is calculated. Evapotranspiration is the total amount of water given to the atmosphere through evaporation from the soil surface and transpiration from the plant leaves. These formulas are generally used in irrigation water calculation studies [15–18] and in crop yield calculations according to climatic conditions [19–23].

To determine the climate change effect on yields of selected crops is made by Penman-Monteith formula. For this, the results of the project on Plant Water Consumption conducted by the General Directorate of State Hydraulic Works (DSI) and General Directorate of Agricultural Research and Policies (TAGEM) were used. The evapotranspiration values found thereafter were calculated using the Blaney Criddle formula [19] as

$$1 - Y_a / Y_m = k_y (1 - Et_a / Et_m).$$

In the formula, Y_a: yield (kg/ha), Y_m maximum yield (kg/ha), k_y yield efficiency factor, Et_a evapotranspiration (mm) and Et_m maximum evapotranspiration (mm). Potential evaportranspiration (ET_o) is $Et_o = K_c.ET_o$. K_c is plant coefficient and Et_o is Penman-Monteith method. K_y was selected from a table for climate characteristics of the region prepared by FAO [20].

After calculating yields and evapotranspiration for the base year, yields changes as to climate change was calculated for the years 2020–2050–2080. Thus, the climate change effects on crop yields has been found.

The projections for temperature and precipitation for in Turkey were obtained from the General Directorate of Meteorology. The temperature and precipitation projections in regional level and time periods are shown in the Figures 1 and 2.

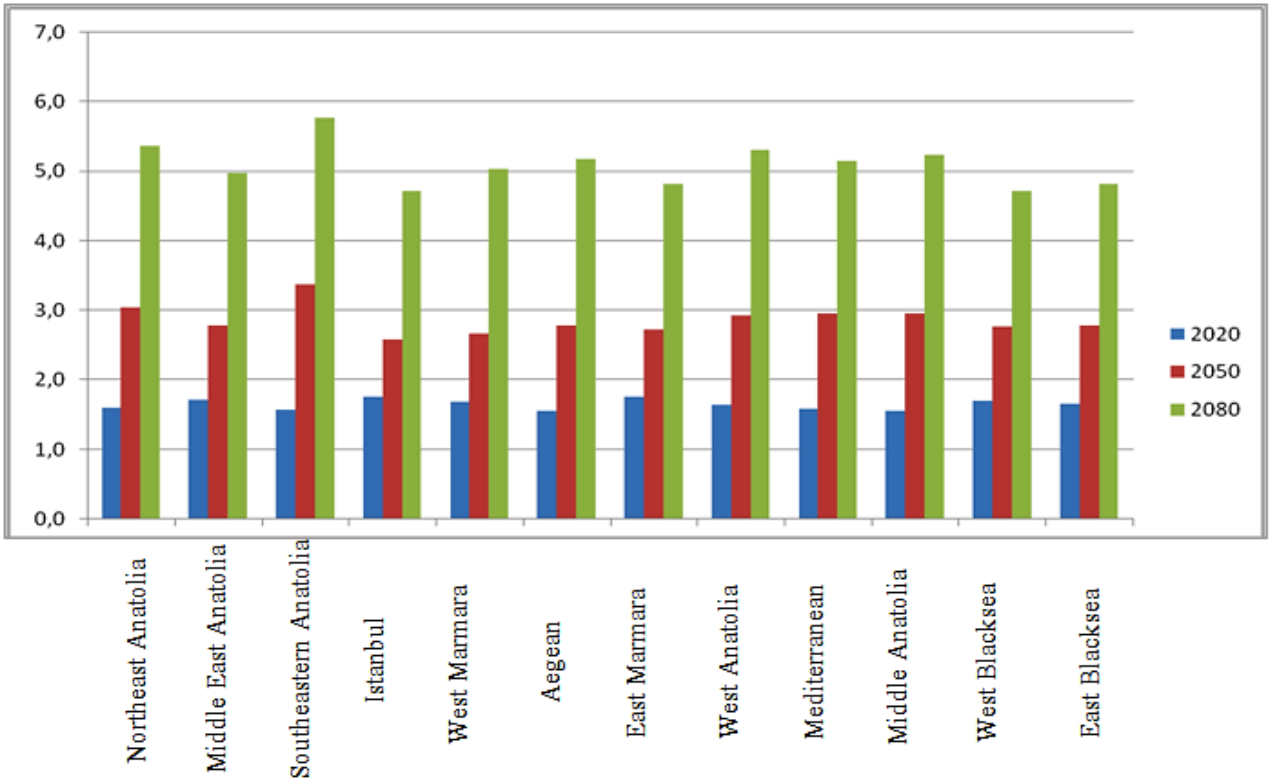

Fig 1. The temperature prediction in Turkey by regions (°C) (MGM 2018)

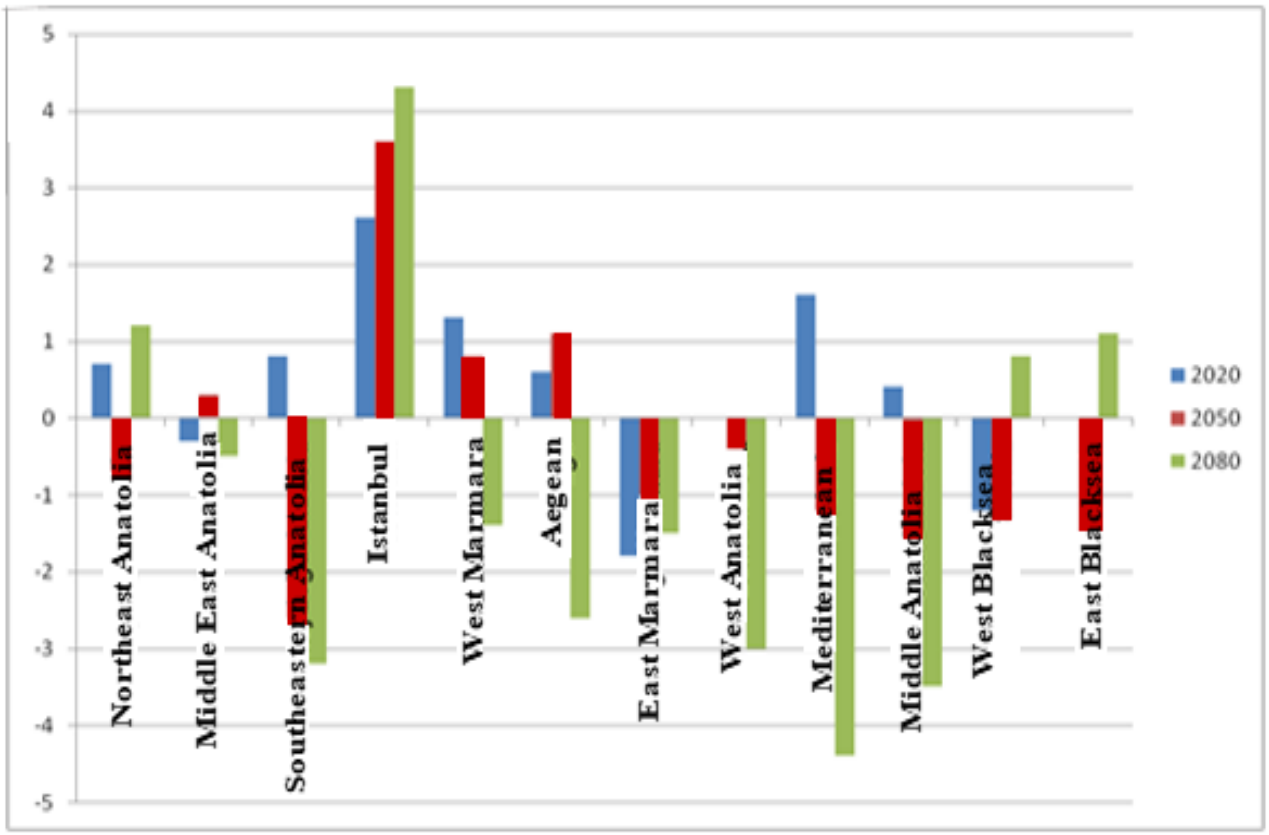

Fig 2. The precipitation prediction in Turkey by regions (mm) (MGM 2018)

Table 1

The yield changes of climate change for selected products in 2020 (%)

REGIONS	Wheat–Barley – Rye–Oat	Corn	Dried beans – Chickpeas – Lentils	Sunflower	Sugar beet	Rice	Cotton	Milk production
Northeast Anatolia	–4	–7	–4	–3	–5	–7	–2	–4
Middle East Anatolia	–3	–7	–4	–4	–5	–7	–2	–5
Southeastern Anatolia	–5	–6	–3	–3	–5	–7	–2	–5
Istanbul	–3	–6	–2	–2	–4	–7	–	–4
West Marmara	–6	–6	–2	–2	–5	–8	–	–3
Aegean	–4	–5	–2	–2	–4	–8	–	–4
East Marmara	–7	–7	–3	–3	–3	–	–	–4
West Anatolia	–8	–8	–4	–4	–5	–	–	–4
Mediterranean	–3	–9	–2	–3	–5	–	–	–4
Middle Anatolia	–6	–9	–5	–5	–4	–	–	–4
West Black Sea	–4	–8	–2	–2	–5	–	–	–4
East Black Sea	–6	–8	–2	–3	–5	–	–	–4
Turkey	–5	–7	–3	–3	–5	–7	–2	–4

It was estimated that crop yields will decrease in all regions of Turkey in 2020 due to the decrease in temperature and precipitation. The decreases were following: for wheat, barley, rye, oat as 5%, for corn as 7%, for sunflower as 3%, for pulses (dry beans, chickpeas, green and red lentils) as 3%, for rice as 7 %, for sugar beet as 5%, for cotton as 2% and for milk production as 4 %.

Table 2

The yield changes of climate change for selected products in 2050 (%)

REGIONS	Wheat–Barley – Rye– Oat	Corn	Dried beans – Chickpeas – Lentils	Sunflower	Sugar beet	Rice	Cotton	Milk production
Northeast Anatolia	–9	–15	–7	–7	–10	–13	–3	–13
Middle East Anatolia	–8	–15	–7	–7	–10	–12	–3	–15
Southeastern Anatolia	–7	–12	–8	–8	–10	–11	–3	–14
Istanbul	–6	–12	–6	–6	–9	–13	–	–13
West Marmara	–8	–11	–6	–6	–10	–13	–	–10
Aegean	–9	–8	–7	–7	–9	–13	–	–10
East Marmara	–9	–10	–6	–6	–8	–	–	–11
West Anatolia	–12	–12	–7	–7	–10	–	–	–11
Mediterranean	–9	–13	–7	–7	–10	–	–	–11
Middle Anatolia	–10	–15	–9	–9	–8	–	–	–12
West Black Sea	–6	–10	–7	–7	–10	–	–	–13
East Black Sea	–7	–13	–7	–7	–10	–	–	–13
Turkey	–8	–12	–7	–7	–10	–13	–3	–12

It was estimated that crop yields will decrease in 2050 as following: for wheat, barley, rye, oat as 8 %, for corn as 12 %, for sunflower as 7 %, for pulses (dry beans, chickpeas, green and red lentils) as 7 %, for rice as 13 %, for sugar beet as 10%, for cotton as 3% and for milk production as 12%.

Table 3

The yield changes of climate change for selected products in 2080 (%)

REGIONS	Wheat–Barley–Rye–Oat	Corn	Dried beans - Chickpeas–Lentils	Sunflower	Sugar beet	Rice	Cotton	Milk production
Northeast Anatolia	–15	–20	–12	–11	–16	–20	–5	–22
Middle East Anatolia	–17	–18	–12	–12	–16	–18	–5	–25
Southeastern Anatolia	–18	–18	–13	–13	–16	–20	–5	–23
Istanbul	–12	–15	–11	–11	–15	–20	–	–21
West Marmara	–14	–14	–11	–11	–16	–20	–	–16
Aegean	–12	–10	–11	–11	–15	–20	–	–17
East Marmara	–13	–13	–12	–12	–15	–	–	–19
West Anatolia	–16	–16	–13	–13	–16	–	–	–18
Mediterranean	–13	–16	–11	–11	–16	–	–	–19
Middle Anatolia	–16	–20	–14	–14	–16	–	–	–19
West Black Sea	–10	–13	–11	–11	–16	–	–	–22
East Black Sea	–10	–15	–11	–11	–16	–	–	–22
Turkey	–14	–16	–12	–12	–16	–20	–5	–20

It was estimated that crop yields will decrease in 2080 as following: for wheat, barley, rye, oat as 14 %, for corn as 15%, for sunflower as 12 %, for pulses (dry beans, chickpeas, green and red lentils) as 12%, for rice as 20%, for sugar beet as 16%, for cotton as 5% and for milk production as 20%.

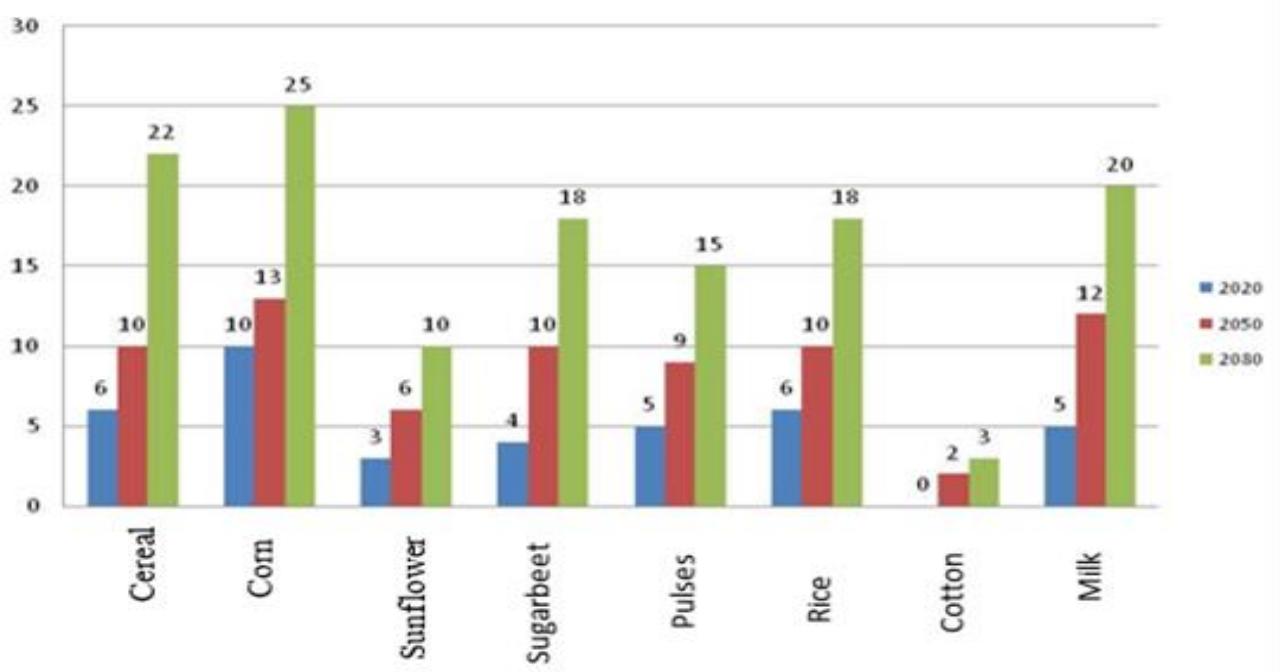

Fig. 3. The impact of climate change on prices in Turkey (%)

RESULTS AND DISCUSSION

The yield changes of crops were calculated for each region by the biophysiological model as to the basic parameters for plant growth periods. According to research results it was estimated to be a decrease in the selected products in all regions in Turkey.

These decreasess were predicted to be mostly in the production of milk, rice, sugar beet and corn. These findings are consistent with previous studies. The study made estimates as 12% reduction in the yield in 2080 for cereals and oil seeds [11].

As the decreases crop yields, the prices are estimated to increase. It is estimated that price increases will be 5%: in wheat, barley, rye, oat 6%, corn 10%, sunflower 3%, legumes (dry beans, chickpeas, green and red lentils) 5%, rice 6%, sugar and sugar beet 4% of 2020.

In 2050, the price increases were 10% in wheat, barley, rye, oat, 13% in corn, 6% in sunflower, 9% in legumes (dried beans, chickpeas, green and red lentils).

As of 2080, price increases were 15%: in wheat, barley, rye, oat 22%, corn 25%, sunflower 10%, legumes (dry beans, chickpeas, green and red lentils) 15%, rice 18%, sugar beet 18%.

It is estimated that the decrease in production and the increase in food prices will be a serious threat in accessing food for especially low and middle income groups.

On the other hand, the economic losses of climate change were estimated as $1.1 billion in 2020, $2.3 billion in 2050 and $3.8 billion in 2080. Related estimates were done in a study in Peru as 2,300 $ loss per hectare [10].

CONCLUSIONS

As a result of climate change by causing a decrease in the crop yields in Turkey, it is estimated to decrease production and increase prices. The decrease in production is estimated in the average in national level as 2–7% for 2020, 4–12% for 2050 and 5–20% for 2080. Crop prices are expected to increase by 0–6% for the year 2020, by 2–13% for the year 2050 and by 10–25% for the year 2080. The economic losses of climate change were calculated as $1.1 billion in 2020, $2.3 billion in 2050 and $3.8 billion in 2080.

When the results of this study are assessed, to decrease the negative effects and to adapt climate change:

- An inventory of local and regional cultivated crops and their varieties and their ability to adaption capability to climate change should be undertaken.
- An inventory should be drawn on how the farmers' practices in agricultural adaptation to climate change.

- Regional and more detailed studies should be supported.
- Work on other ways to compensate the negative effects in overhead (such as loss and waste reduction) should be increased.

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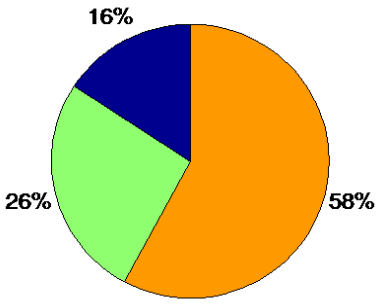

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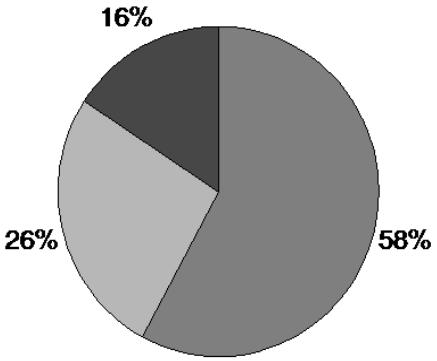

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