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ACOMPLISHING GOALS OF TERTIARY ENVIRONMENTAL EDUCATION BY USING DEBATE AS AN EDUCATIONAL METHOD

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Abstract: *Vast majority of educational systems are unsuitable to respond to modern needs, and their evolutions is very slow and lengthy process. We propose debate as a method of education, with focus on courses that study environmental issues, and in this paper specifically on its implementation within tertiary education. We argue that it would provide deeper understanding of the problems planet is facing, bring up the quality of the discussion about relevant issues; improve both awareness raising and solution finding. This paper will try to prove the relevance, urgency and necessity of adaptation of educational systems, unsuitable for Information age, age of man-made climate change and environmental catastrophes which became so often and expected that we can easily say "common" – we don't even report any more on so many of them. Efficient improvements are needed, and that is especially true for environmental literacy, which raises awareness – without it, we cannot hope to achieve the bare sustainability of our environment, while the ideal of "sustainable development" dispatches to some imaginary realm. Debate as a method is perfectly suitable to answer to these challenges.*

Keywords*: environment, ecology, education, debate, awareness, critical thinking, sustainable development*

1. INTRODUCTION

Back in 1962 Thomas Kuhn (Kuhn, 2012) said that our textbooks are more and more alike touristic brochures – fact not the way, neither the counter attitudes of scientists which were also experts by current paradigms. Simplification of knowledge and omission of context which established dominant approach, followed by next 50 years in which ex-cathedra approach dominated, along with the cult of the professor – established not necessarily by the authority of knowledge but position (Weber, 2009).

It is also important to note that current educational system main form is to create a class of educated people, ready to, through their participation in the market, contribute to general prosperity. Throughout the process, most of the historical evolution is based on specialization combined with market's pace and inherited urge to spread. This resulted in a simplification of science, solidified with our desire for better and faster understanding.

"Exactly that is the product of educational system we currently have. It simplifies the science by simplifying the participants in educational process: firstly, domain is defined, isolated from the context and from its historical background, then to its narrow area of interest, special logic is given. The result is vast majority of educational systems designed to tell what we have come to, as a conclusion, standard, unit of measure or a fact – not how we've done it" (Feyerabend, 1993). Educational systems around the world have, trying to make knowledge more accessible and comprehensible to students, have detached the discussion about facts and postulates on which most sciences are founded – that moved away the debate about postulates of sciences from majority of students. Furthermore, while that led to few but still, harmful impacts in some areas. In areas such as environmental studies, which are comparatively still young areas of science, and which postulates did not pass through decades and centuries of academic scrutiny it led to much greater number of harmful effects. Evidences suggest that ecology as a concept existed even in 4th century A.D. but it's recognition and following development happened only recently, in the eve of 20th century (Odum, Howard, & Andrews, 1971): in 1992 during the summit in Rio de Janeiro, United Nations came to "Rio Declaration on Environment and Development", term "sustainable development" was crafted for the first time, in Norway in 1989, adopted by European Union year later (Rodale, 2015).

Not until the last decade of 20th century, humanity has recognized importance and necessity of development of ecology as a science, and additionally that this area is a prerogative for even hoping to solve some of the imminent problems we have created. World had to deal with environmental catastrophes of 1960's to recognize necessity and finally recognize ecology as a science, and as field of expertise that is highly needed. Even these catastrophes were not enough for our collective realization of how big of the problem life

on planet faces, let alone that each and every of them proved that we haven't had developed any mechanism of how to respond to consequences.

Inclusion of youth in the problem solving process is predicament for achieving sustainable development (Cirovic, et al., 2014) as ecological problems require long term policies. Awareness raising and education of youth and general public is infallible. It is important in order for policies to work and be supported to maintain general public as equal member in a debate, both as a rational marker and as an expanding pool of inventors. But we need to make sure that policy makers, scientists and whole academic community are able to verbalize justifications, explain discoveries and theories and shape the discussion objectively, respectively.

Here where we come to another specificity of ecology as a science, unlike other that had "luxury" of taking several hundred years of building on their importance and paving their way to what we understand as common knowledge.

Regarding that society needs environmental knowledge now, this is why it is the focus of this paper to argue the change in the way ecology is taught, and to consequently change the way by and narrative in which ecological issues are discussed. It will be argued that debate is student-oriented method, and that is therefore more efficient, as it is proved to provide better acceptance of knowledge and its adoption (UNESCO, 2011).

2. DEBATE AS A METHOD

More than two millennia's ago, debate was already recognized as powerful method of teaching (Freeley & Steinberg, 2005). Ecology in this relationship – demands approach that can include and adopt different ecological philosophies in order to create possibility of understanding the problems and their complexity (Tumposky, 2004).

2.1. Academic debate

Most of the people understand debate as some form of a public discussion, exemplified in political duels or debates produced for broadcasting – which are still largely dominated by demagogy, logical fallacies and unsupported assertions. Debate as a method was crafted by a need for competitive debate, defined as: "balanced and fair communicational event on certain subject, with advocates on opposed sides whose speeches are going one after another, before verdict is reached" (Snider, 2011).

Debate requires academic discipline, accuracy, impeccable logic, and analytical explanation of assertions and argumentation. Reason founded on arguments rather than assertions and without leaps of logic is more persuasive – because it is simply more understandable. Communication founded in the idea of expressible argument that requires structured knowledge brings deeper and more profound understanding of the matter in question (Maloy, 1993; Toulmin, 1973).

2.2. Student oriented method

Debate is completely student-oriented method of teaching, and very efficient – as studies have shown that active role during the learning process in comparison to passive one (listening only), makes learning faster (Bonwell & Eison, 1991). Active learning has many definitions, but in general it should depict: the opportunity for students to talk and listen, discuss and reflect their thoughts about certain problem, idea or curriculum (Mayers & Jones, 1993). No teaching method is perfect as students learn differently and respond to different methods and incentives they provide (Snider & Schnurer, 2002) but study has shown positive correlation between student's engagement, critical thinking and student's grades, especially among students with lower average grades (Carini & Klein, 2006). Study supports debate and its usage in education because it requires engagement from students, research, articulation and argumentation of certain position or view (Dundes, 2001).

Research also shows that debate provokes engagement among passive students during lectures. For professors struggling with unprepared students, debate is offering reward of public presentation and fear of presenting unprepared to fellow peers, serves as a mechanism that brings responsibility back to students (Goodwin, 2003). Despite critics that say that preparation for debate is an additional burden, students that have debated on certain topics, show deeper level of understanding of that part of curriculum, which proves

that debate is useful to students, more than the other methods (Combs & Bourne, 1994; Vygotsky, 1978; Osborne, 2005).

Most importantly, debate offers the possibility for students to go further from basics of the subject they study, and advance their argumentation to levels of "higher critical thinking", which is necessary for a good debate. Debaters need to analyse, evaluate and synthesize knowledge to be able to argument certain attitude, to oppose it, or to be able to make certain strategic choices (Elliot, 1993). They have to apply acquired knowledge to create solid arguments, that need to be understandable and persuasive not only to professor – but to their colleagues as well (Cronin, & Glenn, 1991). This process develops and advances oral communication skills and active listening skills that are necessary to be able to respond to the arguments and case of the other side (Gorman, Law, & Lindegren, 1981; Allison, 2002).

3. IMPLEMENTATION AND SIGNIFICANCE

Importance of debate training was documented by monumental study (Malton & Keele, 1984) of ex-debaters, which proves affirmative link between competitive debate engagement and goals of higher education. Debate is one of the most successful methods of teaching because it is inherently interactive, and studies show that interactive formats are more efficient and give better results in development of critical thinking, cognitive learning, problem solving, attitude re-evaluation and improvement of communicational skills. Out of six recommended methods of active learning, debate uses five (Nyquist & Wulff, 1990).

3.1. Arguing both sides

As students are not choosing the side they will argue on the given motion. Teams positions are given to them, which means that, on average, students will have to argue position counter to their own. In everyday life arguing different positions of what you believed till that very moment would be considered and labelled as hypocrisy, and yet, we are to argue that that is essential, as it is fundamental difference between debate and other educational methods.

Debate is always a clash of values, principles and mechanisms to solve specific problem that already exists in our society (either in practical or intellectual or moral domain) and that involves the analysis of a status-quo, stakeholders, possible consequences and implications of establishing certain paradigms. Here we come to the first rule – debate motion (resolution) needs to be balanced, as there is no point in debating one sided motions, as presumption behind one sidedness is that we have already solved the problem in question.

Building arguments and constructing case for the opposite side of the one student would intuitively choose, makes them:

- Create arguments, re-evaluate facts and attitudes to support them;
- Makes them understand the position opposite to theirs, which necessarily makes them more tolerant because it makes them more likely to understand and be aware of merits, shortcomings and flaws of any of the sides;
- Leads to re-evaluation of postulates that are the core values proposed in a debate – which is by definition critical thinking;
- Demands from debaters to recognize and precisely define issues of relevance to the topic.

Accepting the flaws of one's own attitude is the first and necessary step towards gaining the credibility that is needed to influence, and eventually change someone else's attitude (Popper, 1972). If we know anything about ecological problems that humanity is facing, we know that they are controversial by nature – and while it is not the focus of this paper to examine that, it is worth to notice that students without debate training are much more likely to stay unaware of causes of this differences presented to us by nearly all of public discourse participants.

3.2. Problem definition and value of clash

Process of debating is focused towards defining the particular problem within the scope of the motion given, and explaining the potential value of one of the proposed solutions. From one perspective, debate presents the analysis of the practical implications of certain decision, but at the same time it brings clash of abstract principles and underpinning values that are foundation and starting points for proposing any policy or decision that changes status-quo.

Opposite to any discussion or other form of arguing, debate by its rules requires usage of structured knowledge, active listening, so that valid reply or counter argument can be formed. This tells us that after this approach to the studying process, personal attitude and view person holds in regard to different philosophies or views are free, informed and chosen. These views now emerge through evaluation of other views and philosophies, values or systems in comparative analysis.

For us, this represents the peak of our interest: that the informed choice, a point of view built on constantly re-evaluated arguments, and not learned doctrine – is how we need to educate youth about imminent ecological threats, different eco-philosophies, and everything which is within the scope of ecology.

3.3. Case building

Teams in the debate present their case, which in comparative with cases (case statements) of other teams in a debate are more or less persuasive, or simply said, believable. The debate is always judged on comparative, which is important because it instils the metric for evaluation in real problems we're facing in today's world. Idea, policy or measure cannot be accepted and implemented without contrasting pros and cons, as one would say in debate jargon. Pros and cons here define consequences that change in status-quo that measure inflicts in all adjacent spheres, whether it is legislative, or change in behaviour which changes social interactions or laws that inflict immediate change – none of it exists in a vacuum. This means that all of this needs to be taken into account when evaluating the quality and depth of analysis presented in a team's case.

That is why case building is important for us in the context of this paper and its aims; case building need to answer basic questions: who, what, how, and what are the conditions that create context in which this proposal occurs.

To define these, at the first glance, students need to be aware of very basic questions:

- What the real problem is and what stops us to solve it (contextualization)?
- Who and how is effected by the proposed solution (stakeholder analysis)?
- Is there a better alternative (justification of the proposition)?

While answering these questions and trying to synthesize them in their case, students are well aware that every stance has a set of principles that are upholding it. Here we have to emphasize that this is when evaluation of known ecological philosophies, their values and perspectives come in play. They are not detached from students, nor obscure dogmatic definitions or contemplations, they become real through synthesizing knowledge as a platform from which arguments, attitudes and proposals are risen – and the gap between students and process of establishing scientific "truth" is narrowed if not closed – as they gain agency to play the main role in it. They become equipped with skills previously unavailable to them, which secure more profound understanding of matters in question.

4. CONCLUSION

Back in 1975, one study (Huseman & Goodman,1976) discovered that 55% percent of the U.K. Parliament attended some training in competitive debate, out of which outstanding 87% claimed that debating helped them in their professional carriers. No evaluation of debating as an educational activity was negative. This result, that may be surprising as we are back in the day looking at the world in which very few countries had a debate program, apart from the Commonwealth, and that even if they have had it, it was considered to be an extracurricular activity. Nevertheless, studies of Schroeder and Schroeder in 1995 have confirmed this – debating has a positive effect on person's professional development; skills they use they credit to debate, not university education. There are strong empirical evidences that debating teaches crucial skills – it inevitably advances communicational skills; offers unique techniques for complex analysis of current affairs in almost any sphere of human endeavour; focused critical thinking; improves probability of success in pursue of professional success. (Colbert & Biggers, 1985). Out of 100 people more than 90 believes that debate helped them in their professional career – and that is an outstanding score of recognition (Klopf & Lanham, 1967).

If we return all of these studies back to context, and if we remember that when most of them were done, we didn't even have ecology as a recognized science. This fact should alter the conversation: studies, research, and evaluation – all was done in context in which everything was different - world had no knowledge about how serious and fast we destroy our environment. We didn't have Internet – which means that we have had limited access to information, less accessible knowledge, and last but certainly not least, different and slower

communication. Skills that debating as activity develops, and mechanisms and requirements it imposes as educational method – were desirable, but now they are necessary.

It is also very important to note that today students are overloaded with information and data, and they need to be trained, and equipped with skills that would allow them to assess information they receive instantly, and to be able to do proper evaluation through research.

This, in context of this paper, means that when so called experts give side opinions and publish researches that diverge from what was established as problematic or worrying, they need to be able to see whether it was done because of pursuing scientific truth, or because there were other interests in place. We need to remember that even in 21st century we still have spokesmen of various industries (oil industry first and foremost) who not only actively underestimate damages done to the environment, but even go as far to disprove that human activity has any influence on it. That being noted – importance and relevance of critical thinking being trained and practiced during studies is clearly immense.

Intrinsic motivation for learning, that comes with honest satisfaction for the acquirement of new knowledge and widening of awareness spectrum is very rare to be seen in current educational systems. Motivation, that is driven from personal, inner goals, not by outer demand or even recognition – is the strongest and best motivation for process of learning. If you have students motivated in this way, implementation of high standards in educational system and their achievement becomes an easy process (Ames, 1992). As mentioned earlier, debating offers exactly that urge – in order to win, and represent yourself in the desired manner , you need to be better; in other words, you really need to know and understand what you are about to argue. That is where the inner motivation comes from, for a person to appear, especially in front of your peers, credible. Debate being specific as it was argued before in this context, unlike any other form of discussion, it is based on argumentation, not demagogy or rhetoric. So for student to be able to accomplish this goal really needs to know, understand, and learn how to show this in the best possible manner; it doesn't enable credibility to appear where there is no proper argumentation.

This is very important to notice, for acceptance and adoption of ecological values, principles and behaviour today, more than ever before: societies have need for high quality ecology education programs, which with success are raising the system of values, and change behaviour in direction of sustainability, by promoting conservation and appraisal of protection of environment and nature (Petrovic, 2012).

Accomplishing goals of United Nations infamous "Agenda 21" is completely compatible with proposed method of education. If a team proves that their proposal leads to better world, even if it is just an incremental improvement, then they win. Same is true in a debate, and as a reiteration, that is the biggest difference in narrative that this method would provoke, because it changes the goal of educational system. It is not teaching "facts that need to be preserved" no more, because it establishes a consensus that we are willing to change or challenge facts if we are to believe that that would mean an improvement. This is what is a necessity for achieving "ecological literacy" , that needs to be brought back to the processes of coming to scientific facts and achieving both academic and social consensus back to our education, if we want people to understand and adopt the changes in their lives necessary for our environment's sustainability (UNEP, 1992).

Lastly on this: level, depth and quality of acquired knowledge, as we have seen rise rapidly among students who had debate on the motion that covers certain area of studies. This is very easy to explain: people think in greater depth when they need to explain something to someone else. Debate requires that process to be impeccable, without any logical fallacies or shortcomings of elaboration, and persuasiveness – which demands that assertions and arguments be related to the audience. This produces both understanding and analysis that is incomparable to any other educational method used today. If we apply the rules of competitive debate, in which no usage of electronic devices is allowed during the preparation time, this method makes students perfect agents to enact change.

Change in narrative surrounding ecological issues, questions and problems is of utmost importance if we want all relevant actors to be included, ecology as a science simply doesn't have the luxury of becoming detached from general public, of becoming prestigious in any manner. This is prerogative for ecology education, since we had too many doubts loudly presented to us by scientists, politicians, experts: we came to consensus that human activity does cause global warming, only at the beginning of 21st century, and there is still incomprehensibly huge amount of people that reject that notion. Hence, as Schopenhauer argued, dialectic way is the most efficient tool of coming to realization; which can be especially true when having, as today, an overload of information (Schopenhauer, 2008).

Conclusion is that this method, integrated in education, promotes ecological literacy and development of skills that are necessary for life learning. This fosters efforts not only to engage general public in discussion about our environment, while it raises general conciseness and knowledge about ecological problems and environmental threats that we are causing (Petrovic, Jeremic, Petrovic, & Cirovic, 2013). Processes that are integrated in academic debate as a form of problem-solving mechanism, inherently require critical thinking, and decision making skills in general – this is what we need to strive for, in order to grow into population that will be aware of environmental problems (Petrović, Išljamović, Jeremić, & Drakulić, 2011), and that will consciously make decisions concerning ecology, or in other words – sustainability. This ought to be our imperative if we are to strive to ideal of sustainable development. (Petrovic, et al., 2013).

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AIR POLLUTANTS AND GREENHOUSE GASES

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Abstract: *The purpose of this paper is to discuss some facts about air pollutants and greenhouse gases. Nevertheless both groups of substances are related and often derive from the same sources these two terms should not be confused. However, it seems that this often happens in discussions. Therefore, the intention of this paper is to present the main air pollutants as well as the most important greenhouse gases and their environmental impact. At first the impacts of air pollutants on air quality and their possible adverse effects on health are briefly discussed. Special emphasis is given to the role of some of the most important pollutants as are ground level ozone, particulate matter, carbon monoxide, nitric oxide, nitrogen dioxide, sulphur dioxide, hydrocarbons and lead. The main features of greenhouse effect are also briefly shown as well as the role of some the most potent greenhouse gases as are carbon dioxide, methane, chlorofluorohydrocarbons, ground-level ozone and nitrous oxide. Additionally, the relation between both groups of substances and certain ambiguities regarding this problem are briefly discussed. It is important to take care of adequate understanding of terms of air pollution and greenhouse effect in environmental educational programs.*

Keywords*: air pollutants, greenhouse gases, atmospheric pollution, global warming, environmental education*

1. INTRODUCTION

Atmospheric pollution results from various human activities (energetic, industry, traffic etc.) and presents an outstanding problem for decades. For a long time this problem was connected mainly with the aggravated air quality in urban environments as well as in industrial areas. In last two decades increasingly more attention is devoted also to the greenhouse effect which is recognized as the reason of global warming and undesired climatic changes. However, it seems that there is often some ambiguity in publicity when discussing these two problems. Nevertheless both problems derive often from the same sources and certain substances behave both as pollutants as well as greenhouse gases these two terms should not be confused.

In the last decades increasingly more attention is concerned to incorporate awareness about air-pollution into educational programs from the elementary school level up to the universities. The intention of these programs is to improve the basic comprehension of air pollution topics and to rise environmental awareness. Students should recognize the possibilities how to reduce the level of pollution and environmental degradation (Petrović, 2009, p.205). In addition to this should be mentioned more goal oriented programs designed for people suffering from some chronic diseases which are particularly sensitive to air quality as are by example asthmatic patients (Dorevitch et al., 2008). On the other hand the greenhouse effect and its consequences as are global warming and undesired climatic changes seem to become in the period after 2000 one of the most highlighted problems not only from an environmental point of view, but generally. People have become aware of the problem and also of possibilities of reducing greenhouse gases emissions. However, there still certain lack of understanding of physical and chemical processes connected with both air pollution and greenhouse effect can be found even among university students. Therefore both phenomena are often confused.

2. AIR POLLUTANTS

As air pollutants are classified all substances present in the air which are harmful to the human health and/or have some negative impact on the environment. Some of these substances can be present in the atmosphere also according to some natural processes as are forest fires, volcanic eruptions, organic matter decay etc. As such events often happen accidentally these substances are not normal components of the air. They are sometimes also named accidental components of the air as they appear in the atmosphere occasionally and their concentration in air is quite variable (Lazarini and Brenčič, 1984, p. 270; Oxtoby et al. p.99, 1999). However, according to pollution caused by human activities these substances are often continuously present in the atmosphere particularly in urban areas and industrial regions. This is connected with aggravated air quality and adverse effect on the health of the people living in these areas. The adverse effects of these substances are not always limited to the neighbourhood of their formation as they can be

transported by air flows on considerable distances – sometimes even several thousand kilometres. Therefore the control of air pollution is not only the problem of individual countries but it should be the subject of international cooperation. Into this purpose in 1979 the Convention on Long-range Transboundary Pollution was introduced (ARSO, 2016; UNECE, 2016.)

The following substances are submitted under the control (ARSO, 2016):

- Basic pollutants: sulphur oxides (SO_x), nitrogen oxides (NO_x), non-metane volatile organic compounds (NMVOC), ammonia (NH_3) and carbon monoxide (CO).
- Particles: particulate matter with diameter under 10 μm (PM 10), particulate matter with diameter under 2,5 μm (PM 2,5), total suspended particles (TSP) and black carbon
- Heavy metals: lead (Pb), cadmium (Cd) and mercury (Hg)
- Stable organic pollutants: polyaromatic hydrocarbons (PAH), dioxins and furanes (PCDD/PCDF), polychlorinated byphenils (PCB) and hexachloro benzene (HCB).

Similarly, also Clean Air act in United States requires Environmental Protection Agency to set EPA standards for six common pollutants – which are often named also “criteria” pollutants are (EPA, 2016 a):

- Ground level (tropospheric) ozone
- Particulate matter
- Carbon monoxide
- Nitrogen dioxide
- Sulphur dioxide and
- Lead.

Six main pollutants according to EPA are schematically shown in Figure 1.

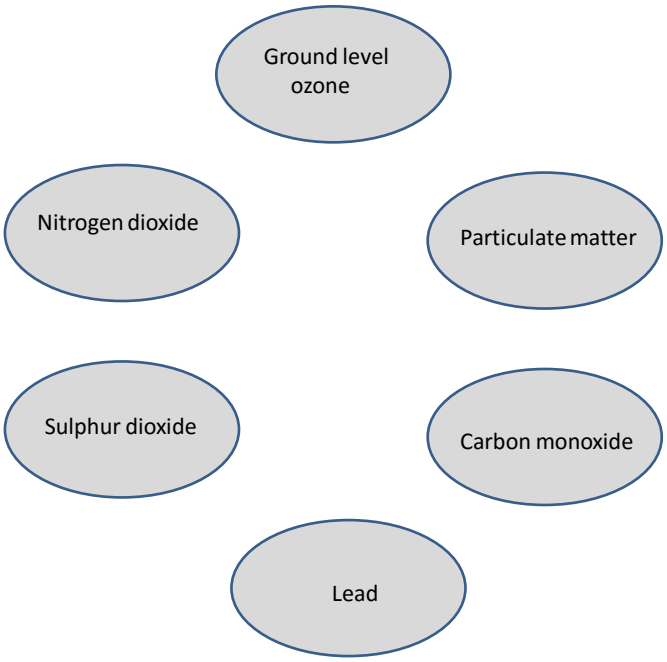

Figure 1: Six main pollutants according to EPA standards (EPA, 2016a).

Pollutants which concentrations in the air are regularly monitored in Slovenia are (ARSO, 2015):

- Particulate matter (PM 10 and PM 2,5)
- Ground level ozone
- Nitrogen oxides
- Sulphur dioxide
- Carbon monoxide and
- Hydrocarbons (Benzene).

Some main properties and adverse effects of particular pollutants are briefly discussed bellow.

Ozone

Ozone (O_3) is three atomic modification of oxygen. Unlike ordinary (two atomic) oxygen which is odourless and colourless gas ozone at normal conditions is blue gas with a pleasant odour. Ozone is strong oxidant and therefore chemically reactive substance ((Lazarini and Brenčič, 1984, p. 273). Ozone is harmful mostly for the respiratory system but also to cardiovascular system (Goudarzi et al., 2015). Its adverse effects affect particularly more sensitive parts of population like children and patients suffering from asthma. Ozone exhibits also negative impact on plant growth (Proietti et al., 2016).

When discussing ozone problems it is necessary to distinguish between stratospheric ozone (named also "good" ozone) and tropospheric or ground level ozone (named also "bad" ozone) (EPA, 2016a). It should be emphasized that in both cases this is the same substance – the difference exists only according to the position in the atmosphere.

Stratospheric ozone: Over 90% of ozone naturally is located in the stratosphere – actually between 15 to 20 km above sea level. Stratospheric ozone has no adverse effects as it cannot be breathed, but it has important role by absorbing harmful UV-B radiation. This ozone layer is called also ozone shield due to its protective effect. Ozone concentration in the stratosphere decreased in the last decades due to intensive use of chlorofluorohydrocarbons (CFC) in sprays, refrigerators etc. This effect is known as ozone holes and results in enhanced UV-B radiation intensity at the earth surface.

Ground level (tropospheric) ozone: In troposphere ozone naturally is not common. Ozone is formed by electrical discharging – for example by lightning. However, in polluted air ozone is formed as a by-product in photochemical reactions taking between nitrogen oxides and hydrocarbons. In the troposphere ozone cannot have any protecting role absorbing UV radiation but its negative impacts on human health and other living organisms are expressed. Ozone presents one of the most problematic pollutants in the last period. Its concentration raised particularly in summer as in hot sunny days there are very favourable conditions for photochemical reactions (ARSO, 2015). As ozone is not component of any exhaust gases but it is formed in the troposphere by reaction between other pollutants (nitrogen oxides and hydrocarbons) it is designated as secondary pollutant.

Particulate matter

Particulate matter or particulates include various solid particles which can have different chemical composition. They can derive booth from natural processes as well as from anthropogenic sources. Particularly problematic are soot particles resulting from incomplete fuel combustion often called also black carbon particles. They derive from various sectors as are traffic, energetics, industry and individual heating devices. Particulates are ordinarily divided into two classes:

- PM 10: particles with diameter less than 10 μm and
- PM 2,5: particles with diameter less than 2,5 μm.

Particulates present probably the most problematic kind of pollutants. They are the main reason for low air quality in urban areas and have been recognized as a reason for a great number of premature deaths. Contrary to the ground level ozone which is problematic particularly in the summer elevated concentrations of particulates are common in the cold part of the year (ARSO, 2015).

It is not surprising that PM 2,5 particulates are more dangerous as due to its smaller size they more easily penetrate into respiratory system. Particles generated by incomplete combustion (black carbon particles) are more problematic than particles deriving from other sources. Both short-term and long-term exposure to particulates results in health problems. Adverse effects can be observed on the respiratory tract (asthma, lung cancer) as well as on the cardio-vascular system (WHO, 2013; Simoni et al. 2015).

As one of the most problematic sources of particulate matter diesel (compression-ignition) engines have been emphasized which produce incomparably higher emissions of particulates than conventional petrol (spark-ignition) engines. Therefore, EURO emission standards determined permitted level of PM emissions for vehicles with diesel engines. The use of particulate filter is often necessary to fulfil the requirements of standards. However, the modern petrol engines with direct injection of fuel express even higher PM emissions than diesel engines and thus EURO 5 and 6 standard series also determine permitted PM emissions for direct injection petrol engines (Dieselnet, 2015).

Sulphur dioxide

Sulphur dioxide (SO_2) is generated by combustion of sulphur which is present in various fossil fuels (carbon, oil derivatives). Sulphur dioxide is at normal conditions colourless gas which is not poisonous but exhibits choking effect as well as irritating effect on mucosa and respiratory tract. Therefore elevated concentrations of sulphur dioxide in the air are harmful for living organisms. Sulphur dioxide is also important as acid rain precursor. (Lazarini and Brenčič. pp. 314-315).

Nitrogen oxides

Nitrogen oxides present a group of seven different compounds. All nitrogen oxides except nitrous oxide (N_2O) are toxic. Nitrous oxide is a green-house gas and will be briefly discussed in the following chapter. When discussing air pollution two other nitrogen oxides are important: nitric oxide (NO) and nitrogen dioxide (NO_2). They are often together designated as NO_x.

Nitric oxide (NO) is at normal conditions colourless gas. Nitric oxide is synthesised by high temperatures from nitrogen and oxygen which are constituents of air. Nitric oxide plays certain role in human metabolism where it serves as cellular signalling molecule and shows vasodilation effect (Abrams, 1996). However, its concentrations are recommended to be kept bellow 25 ppm (30 mg per m^3). At higher concentrations irritating effects on eyes, skin and respiratory system can be observed. Concentrations of NO above 100 ppm are immediately dangerous for life (CDC, 2011).

In air nitric oxide is oxidized to nitrogen dioxide. Nitrogen dioxide (NO_2) is at normal conditions brown gas. Nitrogen dioxide is poisonous gas which affects particularly respiratory tract. Exposure to nitrogen dioxide can lead to respiratory problems and lungs function decrease (WHO, 2003). Beside direct adverse effects nitrogen dioxide is problematic also as precursor of tropospheric ozone and acid rain.

Contrary to nitrous oxide both nitric oxide and nitrogen dioxide does not have an important direct greenhouse effect. However, as precursor of tropospheric ozone it contributes indirectly to global warming.

Carbon monoxide

Carbon monoxide (CO) is colourless and odourless gas. Carbon monoxide is result of incomplete combustion of fuels. It is extremely toxic due to its tendency for binding on hemoglobin where it prevents binding of oxygen. High concentrations of carbon monoxide can cause death what is especially dangerous in closed space. In external space the situation is not so critical however elevated carbon monoxide concentrations reduce oxygen delivery to the tissues. This can affect particularly people suffering from ischemic heart disease (EPA, 2016a).

Hydrocarbons

Hydrocarbons (HC) sometimes also designated as volatile organic compounds (VOC) or non-methane volatile organic compounds (NMVOC) are present in the air due to various reasons – they derive from traffic, energy sector, individual heating devices, industry etc. Automotive emissions present an important source of hydrocarbons, by example both petrol and diesel fuel contain mixtures of various hydrocarbons. These compounds to certain extent leave engine unburnt – in original form or only partly changed. More than hundred different hydrocarbons have been detected in the analysis of automotive exhaust. The majority of these compounds show some irritating effects but some of them (by example benzene) are carcinogenic (Mondt, 2000).

Lead

In addition to the kinds of pollutants listed above also some other pollutants are problematic as are heavy metals. As mentioned EPA standards include among six main pollutants also lead. Lead exhibit various negative affect on human organism affecting immune system, kidneys, cardiovascular system and nervous system. Lead is even in relatively low levels particularly harmful for developing nervous system in children and youth. Lead presence in the air derives mainly from metal processing, aircraft engines, waste incinerators and lead battery manufacturing. Lead was in the paste widely used for the rising of octane number of petrol. Therefore lead tetraethyl or lead tetramethyl were added to petrol. However after introduction of catalytic converters the use of lead compounds was abandoned and aromatic compounds are now used for improving the fuel octane number. According to the EPA data concentrations of lead in the air in USA decreased in the period 1980-2014 for 98 per cents (EPA, 2016 a). In European countries catalytic converters have been introduced in the beginning of 1990s. Therefore also leaded fuel use was abandoned slightly later – in Slovenia in 2001. In spite of this fact it does not happen so rarely that in some environmental discussions automotive emissions are still wrongly stated as source of lead emissions.

3. GREENHOUSE GASES

Greenhouse effect is caused by the fact that in the atmosphere exist certain substances which molecules are capable of absorbing infrared light. In such way these substances which are designated as greenhouse gases retain heath in the atmosphere. Greenhouse effect is to certain extent natural phenomena which is necessary condition that the life on the Earth is possible. Without any greenhouse effect the temperature on the Earth surface would be about 30 ^{o}C lower as it is and there would be very large fluctuations in the temperature. Therefore the greenhouse effect itself is by no means problematic. The problem exists in additional human contributions to the greenhouse effect – so called anthropogenic greenhouse effect. The main factor contributing to the natural greenhouse effect is water vapour. However in the case of water vapour there exists very efficient natural temperature regulation – when air becomes saturated with water vapour the excess vapour simply condenses. Therefore any human activity cannot increase the water vapour concentration in the air. However in the case of the other greenhouse gases there does not exist such regulating mechanism. This is the reason that concentration of these substances increased considerably in the past decades enhancing the ability of atmosphere to retain heath. This is believed by many scientists to be the reason for global warming and undesired climatic changes.

Substances contributing to the anthropogenic greenhouse effect derive mainly from the same sources as the air pollutants. Some substances also take both roles – as air pollutants and greenhouse gases. Nevertheless both roles should not be confused. In the case of classical pollutant the problem exists in the fact that substance is either poisonous or on some other way harmful to humans or other living organisms. In the case of greenhouse gases, however, the problem exists in the ability of substances to retain heath in the atmosphere. The contribution of the various gases to the anthropogenic greenhouse effect is shown in Figure 2.

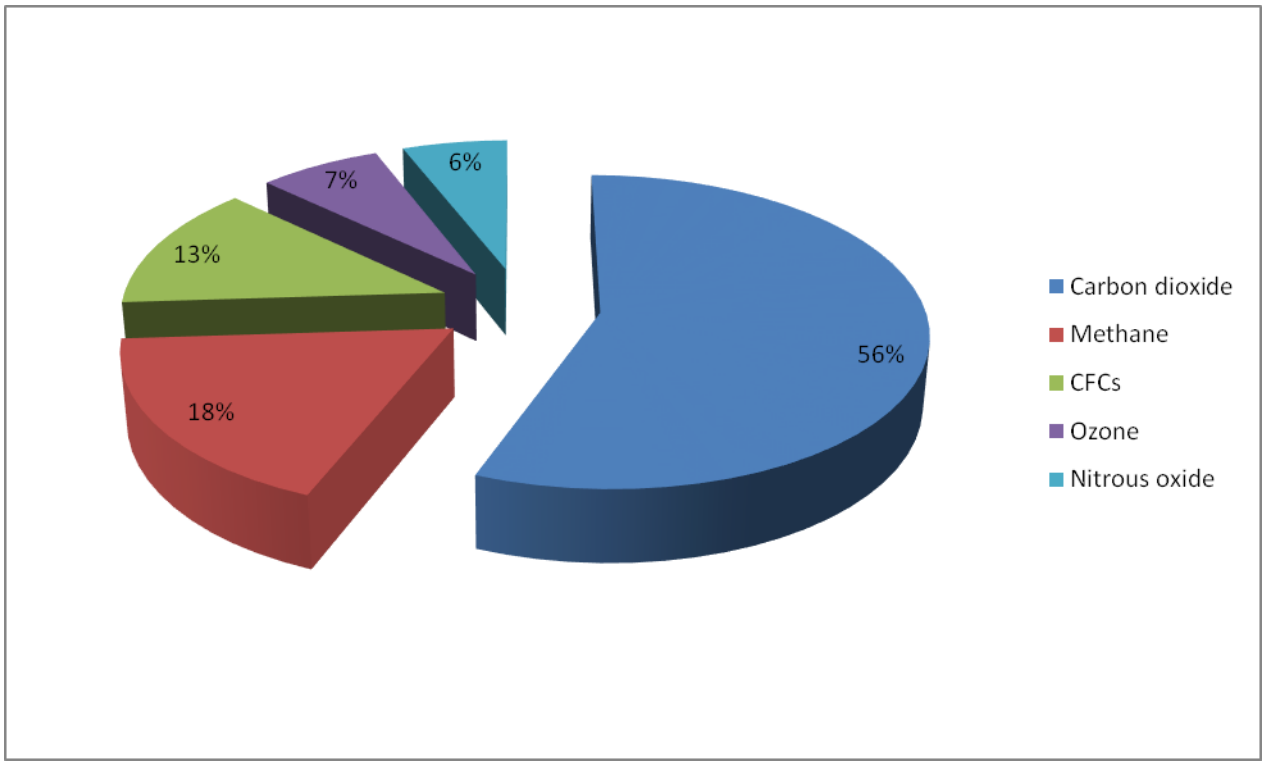

Figure 2: Contribution of various gases to the anthropogenic greenhouse effect (Botkin and Keller, 2003).

Carbon dioxide

As can be seen from Figure x carbon dioxide (CO_2) has by far the largest contribution to the anthropogenic greenhouse effect. On the other hand the presence carbon dioxide in the atmosphere has (unlike carbon monoxide) any direct harmful effect on human health or on other living organisms and is therefore not considered as air pollutant. Carbon dioxide is, of course, the product of cellular respiration. However, this does not present any problem as there has been established a perfect balance in nature – carbon dioxide produced by respiration is used in the photosynthesis. The problem exists in large additional quantities of carbon dioxide which are released in the atmosphere by combustion of fossil fuels. The final product of

combustion of any carbon containing fuel is carbon dioxide. In the case of fossil fuels – coal, oil or natural gas – great quantities of carbon which have been kept underground for millions of years are released into the atmosphere every year. Autotrophic organisms (plants, algae, cyanobacteria) are not able to process these additional quantities of carbon dioxide. The situation is still aggravated because of intensive deforestation in tropic areas.

Methane

Methane (CH_4) is product of anaerobic decay of organic matter. Nevertheless methane presence in the atmosphere derives also from natural sources human activities as are livestock breeding and waste deposition significantly contribute to the methane formation

Clorofluorohydrocarbons

Chlorofluorohydrocarbons (CFC) are problematic for the environment from two points of view. As mentioned in the previous chapter they are the main destroyers of stratospheric ozone forming in this way ozone holes. Besides this CFCs show considerable contribution to the greenhouse effect (Ramanathan, 1975; Ramanathan and Feng, 2009).

Groun-level (tropospheric) ozone

Tropospheric (ground level) ozone (O_3) has been also mentioned as one of the most problematic air pollutants. On the other hand tropospheric ozone is also important greenhouse gas.

Nitrous oxide

Nitrous oxide (or dinitrogen oxide, N_2O) is the only compound of nitrogen oxide group which is not toxic. It is known as laughing gas and is widely used as mild and very safe anaesthetic in dentistry and medicine (Sedation Dentistry 4U, 2016). Contrary to nitric oxide and nitrogen dioxide which are among the common air pollutants nitrous oxide is not designated as pollutant however it shows considerable greenhouse effect. The major source of nitrous oxide emissions is agriculture (EPA 2016 b).

4. RELATION BETWEEN AIR POLLUTANTS AND GREENHOUSE GASES

As mentioned in the introduction it seems that there is often some ambiguity when discussing about air pollutants and greenhouse gases. Nevertheless both groups of substances have negative impact on the environment and both often derive from the same sources – some substances like ground level ozone even belong also to both groups – some distinction exists between them which should be taken into account. It seems that in public discussions or by example by students when dealing with environmental content both terms are often confused.

Thus fossil fuels combustion presents both one of the main sources of pollutants as are particulate matter, hydrocarbons, carbon monoxide and nitrogen oxides as well as on the other hand also the source of carbon dioxide - the most important greenhouse gas. In the case of automotive exhaust emissions of pollutants can be efficiently lowered by catalytic converters or particle filters which have no effect on carbon dioxide emissions. Emissions of carbon dioxide can be lowered only by reduced consumption of fuel or use of alternative fuels or driving modes.

Biomass and biofuels are theoretically considered as carbon neutral. By the combustion of biomass or biofuels, of course, also carbon dioxide is formed. However, this is compensated by the photosynthesis during plant growth where the same amount of carbon dioxide is used. The net quantity of the entire cycle (plant growth – fuel production – fuel use) is zero. The carbon dioxide balance comparison for fossil fuels and biomass/biofuels is shown in Figure 3.

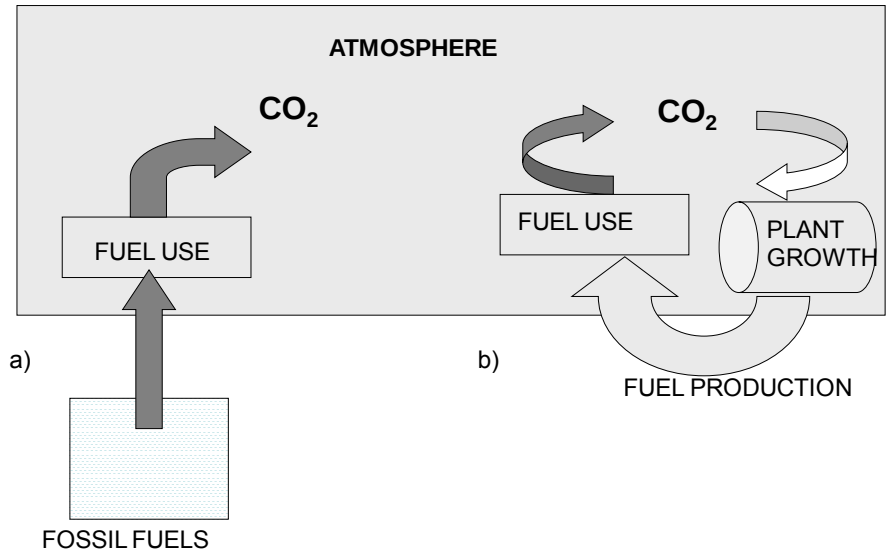

Figure 3: Balance of carbon dioxide emissions for a) fossil fuels and b) biofuels.

It should be emphasized that this is idealized picture and that in practice there are certain net emissions of carbon dioxide. Nevertheless, by the substitution of fossil fuels with fuel derived from biomass considerable lowering of greenhouse gases emission can be achieved. The actual lowering of carbon footprint depends on the source of biofuel and their mode of production. Therefore substitution of fossil fuels with fuels of biological origin is desired from the viewpoint of greenhouse effect. However, this does not necessarily mean that biofuels or biomass presents always the optimal solution when regarding pollutants emissions. In the last years, by example, in Slovenia many citizens due to increasing oil prices and insecurities in supply of natural gas have decided to change oil or gas heating for wooden pellets. Of course, their decision was motivated by economic reason. When considering environmental effects such change can be estimated as positive from the view point of greenhouse effect. However, when considering the pollutants emissions the effect is opposite as wooden biomass is problematic because of considerable emissions of particles. This can be connected with the expressed problem of elevated particle concentration in the air in urban areas in Slovenia (ARSO, 2015).

An example which also illustrates inadequate understanding of environmental topics is also by example that people still often think that lead emissions from automotive exhaust present considerable environmental problem. This really was the case in the past, however, the adding of lead to petrol in Slovenia was abandoned in 2001.

5. CONCLUSION

One of the important conditions for the comprehension of environmental problems is the ability to distinguish between different categories and terms. It seems that terms air pollutant and greenhouse gas are often confused. Nevertheless both categories are undesired from the environmental point of view and often derive from the same source and sometimes certain substance can even behave both as air pollutant and greenhouse gas these two terms should not be equated. The understanding of physical, chemical and biological processes connected with these phenomena are important for adequate understanding. Therefore it is important to devote adequate attention to this problem in environmental education programs. Rising of the level of environmental awareness is important part of environmental education and can be designated as necessary condition for improving the environment. However, adequate knowledge and comprehension of processes seems to be the sufficient condition that someone is capable of solving environmental problems.

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APPLICATION OF EU LEGISLATION AIMED AT PREVENTING MAJOR ACCIDENTS IN THE CONTEXT OF ENVIRONMENTAL PROTECTION

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Abstract:
Industrial plants are major pollutants of the environment. In order to prevent and control environmental pollution and reduce the consequences in the event of major accidents, mandatory environmental requirements have been prescribed for operators who handle hazardous substances. On accessing the EU, Croatia implemented obligations in the field of environmental protection in its legislation.
The authors examine the negative phenomena that accompany the technology of industrial plants and the measures that need to be implemented in a timely manner in order to minimize damage, but also preserve the health and lives of people and property. They analyse the content of the Safety Report and the Accident and Disaster Risk Assessment of the environment, documents which have to be prepared by each operator handling hazardous substances in their facility. The aim of the paper is to point to the importance of implementation of the legal obligation to prepare documents and apply them in industrial plants.

Keywords*: industrial plant, operator, major accidents, hazardous substances, environmental pollution*

1. INTRODUCTION

People, material and cultural goods can be exposed to different types of threats, classified by their sources into two groups:

- Natural (floods, earthquakes, other natural causes)
- Technical and technological hazards (accidents in industrial facilities, traffic, nuclear threats, epidemiological accident).

This paper investigates the technical and technological hazards caused by accidents in industrial facilities which in their work handle - produce, process or otherwise use, store or dispose of hazardous substances. The degree of risk of technical and technological accidents growing into a major disaster or catastrophe depends on the type, concentration and amount of hazardous substances used by an operator at the plant, its geophysical position, the distance from the nearest inhabited place, and the speed of reaction of rescue forces. According to the pace of the action it can be immediate (e.g. explosions), very fast (e.g. sudden release/discharge of large quantities of hazardous substances) of the ongoing gradual (e.g. the spread of dangerous substances in the air or water) or a long-term view of the ongoing and acting accident (Kulišić, 2010).
An accident in the technological plant can arise due to leakage and/or explosion of dangerous substances due to the use of faulty equipment, negligent operation or deliberate sabotage. Implementation of preventive measures to avoid accidents, restricted access to parts of the plant with hazardous substances only to authorized personnel, and responsible behaviour towards the environment demonstrated in informing the local population of the potential hazards, application of measures taken to prevent accidents and methods of self-defence until the arrival of protection and rescue forces in the event of an accident, are the obligation of all technological facilities.
The consequences and impact of such disasters on the environment can vary. Through their destructive effects on both the environment and the economy or safety of life, they affect the economic and social development of the regions exposed (Babut et al, 2015). Investments in safety are related not only to reduce financial losses, caused by industrial accidents, but they also represent an opportunity for sustainable business development and competitiveness leading to industrial growth (Kirin et al, 2012).

2. IMPLEMENTATION OF THE SEVESO DIRECTIVE INTO THE CROATIAN LEGAL SYSTEM

The incident that occurred in 1976 in Seveso, Italy from the ICMESA chemical plant for the production of herbicides and pesticides prompted the EU to regulate yet another segment of environmental protection, the one referring to the prevention and control of industrial pollution and risk management. Since then, numerous activities have been undertaken and many regulations and documents adopted in order to prevent and reduce the environmental impact of industrial plants. Protection of the environment consists in determining the thresholds for different forms of pollution, proposing legislation, and introducing preventive

and corrective measures in the event of non-compliance or any incident in the environment (Kondić & Piškor, 2010).
The Seveso Directive aims at the prevention of major accidents involving dangerous substances and their mixtures, but also at limiting the consequences of such accidents not only for human health but also for the environment and thus ensure a high level of protection across the EU in a consistent and effective way. The Directive defines certain special obligations of each legal entity/operator/company, namely, the operator, in taking measures to prevent major accidents, their obligations in the event of significant changes in the installation of the legal person/operator/company, obligations in the event of a major accident, procedures and obligations in the event of a major accident with cross-border effects, the obligation to reduce the consequences of a major accident, as well as other conditions and measures to prevent major accidents in accordance with internationally recognized standards and regulations; and the manner of submitting reports on the implementation of security measures and their mandatory content (Soflić, 2013).
At present, EU member states regulate accidents in industrial facilities handling hazardous substances according to the provisions of the Seveso III Directive. Substances and mixtures in the scope of the Seveso Directive are assigned to a generic entry based on hazard classification, or to a specific named entry when one is available (Petrus et al, 2013). Compared to the Seveso I and II (Directive 96/82 / EC), the Seveso III Directive (Directive 2012/18/EU) provides better access to information on the risks arising from the activities of industrial facilities that handle dangerous substances.
Upon its accession to the European Union, the Republic of Croatia fulfilled its obligations in the field of environmental protection and aligned its environmental policies with EU laws. Croatia aligned its legislation in the field of air, climate change, water, waste management, water and coastal areas, nature protection, industrial pollution and risk management, soil and land, chemicals and noise (Nekić & Krajnović, 2015).
The objectives of Council Directive 96/82/EC, Directive 2003/105/EC and Council Directive 2012/18/EU of the so-called Seveso II Directive, namely, the establishment of a safety management system and the shift from remedial to preventive action, were transposed into the Croatian legal system through the Regulation on the prevention of major accidents involving dangerous substances (Official Gazette 44/14). The Regulation stipulates the obligations of the operator for preventing major accidents by implementing a series of precautionary measures in accordance with the extent of the potential dangers recorded in the relevant facility.
The valid EU regulations were transposed into national legislation in 2008 with the Regulation on the prevention of major accidents involving dangerous substances, the Ordinance on the registry of installations in which dangerous substances are present and the Register of reported major accidents, the Law on Protection and Rescue, and the Regulation on the methodology for making risk assessment and protection and rescue plans. The Regulation on the prevention of major accidents involving dangerous substances prescribes the types of hazardous substances and groups of hazardous substances that are present in plants, their respective amounts and the criteria by which these substances are classified as dangerous. It also prescribes the special obligations of the operator and the plant in taking measures to prevent major accidents, the obligations in the event of a major accident, the procedure and obligations in the event of a major accident with cross-border effects, the obligation to reduce the consequences of a major accident, as well as other conditions and measures to prevent major accidents in accordance with internationally recognized standards and regulations.
The Seveso Directive obliges EU Member States to make sure that their operators who handle hazardous substances above the minimum amount implement the Policy of prevention of major accidents in their work. The policy of preventing major accidents established by the operator must be designed so as to guarantee a high level of protection of people and the environment by appropriate means, structures and management systems, all in accordance with the Regulation on the prevention of major accidents involving dangerous substances (Official Gazette 44/14).
The implementation of the Policy of prevention of major accidents is monitored through an internal control in the field of sustainable development, protection of health, safety and the environment, internal and external audits of the quality system, through a system of internal audits and through inspections. The consequences of non-compliance with the Policy are subject to penalty provisions. The Policy can be updated or revised when it needs to be harmonised with the new legislation, or when some irregularities have been detected during internal controls, audits or inspection. All employees are to be informed about the possible steps and trained for the proper procedures in their area of competence stipulated in internal documents. During regular activities of a facility, external contractors also have to receive proper training before they start working in it. The training should cover all the information about the risks, obligations and responsibilities of the contractor, and also an introduction to the Policy.
Safety reports and internal emergency plans are drafted and publicly presented for all facilities in which major accidents may occur. A safety report describes all the measures to be taken in order to prevent major accidents, as well as the structure of the safety management system.
Control is carried out thought a structural approach, which implies that the higher the presence of hazardous substances in a facility, the more stringent are the rules applying to it. Facilities with an elevated presence of hazardous substances area classified as upper tier, and those with a lower level as lower tier facilities.

The Environmental Protection Act (Official Gazette 80/13, 153/13, 78/15) defines hazardous substance as substances, mixtures or preparations present in a plant as raw materials, products, by-products, rest or semi-products, including the substances which may be expected to be created in the event of an accident and which may have harmful consequences for human health, property and the environment. The use of hazardous substances is indeed inevitable in industry, but their effect on human health and the environment can be disastrous. The direct impact of hazardous substances is reflected in the functional changes of the matter in which they act. Indirect effects of hazardous substances are most commonly manifested as fires, consequences of explosions and radiation of radioactive substances, due to the fact that some of them react with oxygen (fuel as flammable liquids, gases and solids, oxidizers, ignition devices, corrosive substances), quickly decompose chemically (explosives, explosive-filled objects), or react with substances with which they come into contact, e.g. with water or other substances (Pavelić, 2013).
The Regulation on the prevention of major accidents involving dangerous substances (Official Gazette 44/14) stipulates the method of determining the quantities, the permitted quantities and the criteria according to which these substances are classified as dangerous; the method of submitting and mandatory content of the notification of the presence of hazardous substances in a plant; the mandatory content of the Statement of conduct with regard to the prevention of major accidents; the mandatory content of the Safety report, the manner of application for approval of the Safety report; the mandatory content and manner of giving approval; the manner of application for extension of approval issued and the relevant deadlines; data confidentiality agreement; the manner and conditions of supervision of the implementation of activities and measures in accordance with the issued approval of the Safety report; special obligations of the operator in: taking measures to prevent major accidents, in the event of significant changes in the plant, in the event of a major accident, the procedure and obligations in the event of a major accident with cross-border effects, other conditions and measures to prevent major accidents in accordance with internationally recognized standards and regulations, the content and manner of keeping records of operators and their plants in which accidents with a domino effect may occur, and other relevant issues. The Annexes of the Regulation comprise:

- List of hazardous substances and the threshold quantities above which the substances are considered dangerous (Annex I.A)
- List of hazardous substances and the threshold quantities above which the substances are considered dangerous (Annex I.B.)
- Forms to be used to report on the presence of hazardous substances (Annex II).
- The form to be used to report on the presence of hazardous substances in the area of a plant with quantities below the threshold quantities under Annex I.A or Annex I.B of the Regulation (Annex II.A)

The Regulation applies to the areas of plants in which dangerous substances were identified in quantities equal to or greater than those listed in Annex I.A, parts 1 and 2, and in Annex I.B. of the Regulation.

3. SAFETY REPORT

The purpose of the Safety report is for the operator to demonstrate that they have taken all the technical, organizational and management measures to prevent major accidents and that all the possible risks of a major accident have been analysed. It is the operator's task to enable the competent authorities to evaluate the safety of a plant in terms of the possibility of major accidents occurring in it.
A safety report typically contains information on the management and organizational of the plant from the aspect of preventing major accidents, and refers to the policy of preventing major accidents and safety management system, which includes the organization and personnel, identification and assessment of significant risks, supervision of the plant operations, change management, planning for emergency, monitoring effectiveness, audit and inspection.
Description of the location of the plant area includes, in addition to its description, the identification, definition and analysis of adjacent facilities and areas, including public facilities such as hospitals or schools that could be the source of or increase the risk of accidents and their consequences through the domino effect. Preventive measures are implemented through permanent control of security systems, equipment maintenance and supervision of working procedures.
The operator must evaluate the possible consequences of a major accident for both human health and the environment, and calculate the size of the impact area according to the "worst case scenario". When formulating a scenario, the probability of natural disasters occurring within the area of the plant are taken into account and used as a starting point for predicting the measures, procedures and technologies that would be able to reduce the risks to a minimum considered (Plavšić, 2006). Description of all unwanted scenarios that could lead to a major accident in an industrial plant, the probability of their occurrence and the estimated effects require an accurate presentation of the results, including the "worst case scenario". Based on the results of such analyses, preventive, accidental and palliative procedures for reducing the effects on the area

affected by a major accident are defined (Toth et al, 2010). The operator must secure the safety feasibility report at all times (Buljan & Mikulić, 2010).
An integral part of the Safety report is the internal emergency plan, which must contain all the data and information contained in Annex V of the Regulation and the provisions governing protection and rescue. The internal emergency plan can be used for preparation of the external protection and rescue plans for operational and rescue forces in the event of accidents involving hazardous substances or those of natural and technical-technological causes that can result in disasters or major accidents, including the ravages of war and the consequences of terrorism. The preparation of external emergency plans is the obligation of the counties and the City of Zagreb pursuant to a decision of the Director of the State Administration for Protection and Rescue. After completion of a draft external emergency plan, its parts that are not confidential should be presented to the public, and interested and professional public invited to give their opinions, suggestions and comments. Public participation can also use the private sector so as to help it discover inefficiencies in the production process of raw materials, energy consumption, which can lead to an actual reduction in production costs (Ofak, 2009).

4. RISK ASSESSMENT OF THE POPULATION, MATERIAL AND CULTURAL GOODS AND THE ENVIRONMENT FROM DISASTERS AND MAJOR ACCIDENTS

Risk assessment of the population, material and cultural goods and the environment from disasters and major accidents is the baseline document for the development of plans, operational plans and civil protection plans. It is prepared and adopted for the territory of municipalities, cities, counties, the City of Zagreb and the Republic of Croatia. Such assessment also has to be made by all legal persons handling hazardous substances. The assessment includes the potential threat to the population, material and cultural goods and the environment from the occurrence and impact of disasters and major accidents, the necessary funds for protection and rescue, and the preparedness to act in the protection and rescue.
Due to the variety of accidents on the one hand, and their consequences on the other, analysis of the threat of natural and other disasters must consider several related aspects associated with the natural, civilisational and other phenomena that exist in the monitored area. It evaluates the likely intensity of these phenomena, the possible surprise effect, namely, the speed with which a given phenomenon may occur and develop, the degree of threat to people and property, the overall level of social organization, and the preparedness for prevention, protection and rescue, especially for those in charge of activities and tasks in the field of protection and rescue. Furthermore, account should be taken of the number of local population in a given time period that may be at risk, especially during the tourist season.
Hazard analysis includes methods of determining the sensitivity of a geographical area with regard to the discharge of hazardous substances, identification of potential sources of emissions of hazardous substances from stationary facilities that manufacture, process or otherwise use, store or otherwise dispose of substances that are generally considered dangerous. Using software and mathematical calculations and a series of elaborations by each individual case of threat, it is possible to calculate the degree of risk for the areas for which the assessment is being made.
The content of the assessment is determined by the Regulations on the methodology of development of threat assessment and protection and rescue plans (Official Gazette 38/08). The assessment includes:

1. the type, intensity and effects, and possible consequences of natural and technical-technological disasters and major accidents for the population, material and cultural goods and the environment
2. protection and rescue forces,
3. final assessment,
4. maps.

Local and regional governments define and prescribe preventive measures the implementation of which will reduce the consequences and effects of the natural and technological disasters and major accidents, and increase the level of safety of the population, material goods and the environment in the special excerpt from the Assessment, entitled Requirements for protection and rescue in physical planning documents.

5. ANALYSIS OF THE SITUATION IN THE REPUBLIC OF CROATIA

The Environmental Protection Act (Official Gazette 80/13, 153/13, 78/15) stipulates the introduction of implementing legislation governing the prevention of major accidents involving hazardous substances, and the adoption of the Ordinance which prescribes the manner of organization and content and method of keeping the Register of facilities in which dangerous substances are present and the Register of reported major accidents. The presence of hazardous substances in small quantities requires procedures in accordance with regulations governing protection and rescue, and the data submitted to the Environmental Protection Agency and the State Administration for Protection and Rescue.

The list of plant areas in Croatia in which dangerous substances of the lower and higher tier are present ("Seveso-bound") and those bound by Annex II.A is shown in Table 1.

Table 1: Facilities in which dangerous substances were present on 19/01/2016

Counties and the City of Zagreb	Facility area category - upper tier	Facility area category – lower tier	Facility rank – lesser amount	Facilities bound by Annex II.A	Facilities currently applying
Zagreb	3	3	0	27	21
Krapina-Zagorje	2	1	0	21	5
Sisak-Moslavina	5	5	0	3	26
Karlovac	1	4	0	9	18
Varaždin	0	2	0	21	2
Koprivnica-Križevci	1	0	0	14	1
Bjelovar-Bilogora	1	0	0	15	2
Primorje-Gorski Kotar	4	0	0	46	2
Lika-Senj	0	1	0	18	1
Virovitica-Podravina	0	1	0	8	2
Požega-Slavonia	0	0	0	12	3
Brod-Posavina	1	0	0	14	7
Zadar	0	0	1	25	5
Osijek-Baranja	1	4	0	35	1
Šibenik-Knin	0	0	3	13	4
Vukovar-Srijem	0	0	0	24	2
Split-Dalmatia	2	4	0	39	7
Istria	1	3	0	53	40
Dubrovnik-Neretva	1	0	0	19	2
Međimurje	0	1	0	17	1
City of Zagreb	3	4	0	58	9
Total	26	33	4	491	161

Source: authors according to the Register of installations in which dangerous substances are present

A total of 63 areas of the facilities bound by requirements of the Seveso Directive were found, of which 26 of the upper tier, 33 of the lower tier, and four areas with lesser amounts. There were 491 areas of facilities with quantities below the threshold values given in Annex IA that are bound by Annex IIA of the Regulation, and 161 business entities that are in the process of application in accordance with Annex IIA.

6. CONCLUSION

All business entities that use hazardous substances in their daily operation are exposed to the potential risk of accidents caused by fire, explosion or release of hazardous materials. In order to reduce such risks, a number of organizational and technical measures are applied.

It is the obligation of the operator to produce a safety report to demonstrate that appropriate measures will be taken for the identified risks of major accidents in the plant in order to prevent such accidents and limit their consequences. General and interested public must be informed about the possibility of a major accident occurring and its potential consequences. An appropriately drafted internal emergency plan can be used for preparing an external emergency plan.

Assessment of the level of risk of disasters and major accidents to which the population, material and cultural goods and the environment are exposed is used to define the threat and risks that could endanger local communities. The needs and possibilities of prevention, reduction and elimination of consequences of disasters and major accidents are also assessed.

Precautionary measures are taken, as far as possible, at the very source, i.e., in the facility, in order to minimize the possibility of a major accident. Timely preparation of an accident scenario and the acquired knowledge and skills can help prevent accidents and mitigate their consequences.

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COMBINING LEAN AND GREEN IN LOGISTICS: A SURVEY OF LOGISTICS COMPANIES IN SLOVENIA

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Abstract:*Lean and green management practices represent a major opportunity for Slovenian logistics companies to competently respond to the escalating expectation of a global logistics market and achieving environmental performance profitably. In this paper, a survey analysis on lean logistics and green logistics among Slovenian logistics companies will be presented. Although similar analysis on lean and green do exist, only a few of them focus on the field of logistics as such and also none of them have been performed in Slovenia. Key findings indicate that the surveyed Slovenian logistics companies obtain more certificates and/or recognition concerning lean than green, most of them prove their leanness and/or greennesswith ISO standards ISO 9001 and ISO 14001 and that the surveyed companies in most implement lean and green concepts within their companies.*

Keywords*:logistics, lean, green, sustainable, ISO standards*

1. INTRODUCTION

A key task of a well function logistics system is that it has to guarantee that goods are in the right place, at the right time and in the strictly necessary quantity. The latter allows us to fully comprehend its real mission, which is to better ensure the space and time availability of goods through flows management (La Londe, 1983). Its activities are often identified with a high degree of manual control and human resource management of, which in turn greatly affects the execution of operations. Especially costly time interruptions, which result out of failure in material or information flows, explain the importance of a well-functioning logistics system (Christopher, 1992).

Maintaining low costs in a bid to gain/obtain competitiveness is of substantial significance; consequently, companies are forced to examine every part of their organization for potential improvements. It is therefore not surprising that there are many initiatives for possible improvements in logistics. We also have to acknowledge that global logistics costs were estimated at USD 9,177 billion in 2015 (Armstrong & Associates, 2014), so every failure, inconsistency or any kind of waste can represents great costs.

Besides eliminating non-value added activities in logistics, also assuring sustainable processes is one of modern companies‟ challenges. The environmental aspect and ecological consciousness have increased drastically over the last two to three decades, especially in the developed economies. This has been shown by BearingPoint research (*Supply Chain Monitor "How Mature is the Green Supply Chain?"* 2008), where 35% of global companies said that they have incorporated a green supply chain policy in the company‟s vision.

The area of logistics has been rarely exposed to research on lean and green, most of them were in fact made in other fields, mainly in the area of lean manufacturing management. Therefore, this study represents a contribution for academia and industry. For academia mainly due to the fact that this research is one of the first of its kind and it takes into account both paradigms in the area of logistics. For industrials it will provide an insight on the current state of lean and green logistics implementation in Slovenia‟s logistics companies, new trends and possible contributions from each paradigm.

The most important aim of this survey, of which this paper presents some results, is to analyse the respondent‟s familiarity with the terms „lean logistics‟ and „green logistics‟, their opinion on the implementation of both concepts within their own companies. Furthermore, the attempt has been made to highlight which certificates or recognition from both areas Slovenia‟s logistics companies hold.

2. METHODOLOGY

First of all an extensive analysis of previous research has been conducted. The search has been restricted to articles which contained specific keywords connected to lean logistics and green logistics in Emerald Online, Science Direct, Springer Link and Taylor and Francis portals. For keywords we firstly employed a brainstorming technique and then decided to narrow our choices and only focus on international journal articles which contained specific keywords closely associated to lean logistics and green logistics. At the same time keywords containing „supply chain", „production" or „manufacturing" were mainly excluded. The main reason lies in the fact that the aim was to narrow the scope of the research to a specific field – logistics rather than supply chain management or production and manufacturing.

It was further noted that some of the international journals have very little published articles, limited access to some of them, as well as the lack of a narrow focus on any part of lean logistics, green logistics and/or green and lean logistics.

Later on we prepared a research questionnaire and obtained 104 completed questionnaires.Our relatively small sample size required special attention to formulate appropriate conclusions, which is why we combined the statistical analysis with the abductive approach (Kovács & Spens, 2005) (see Figure 1).

The analysis was conducted through 4 phases: (1) theoretical overview where conceptual and descriptive methods were used, (2) the empirical phase features an empirical methodology which employs quantitative approaches to collecting primary data for our database and a statistical analysis.

Our survey was divided into two parts, where the first set consisted of 7 questions related to demographic issues. Second part consisted of 7 questions which were divided by individual areas of intralogistics, for which it was necessary to evaluate two aspects: lean logistics and green logistics aspect.

This means that individual company evaluated the importance of every part of intralogistics area. For the purpose of this paper we only focused on the first part, which also contained two questions regarding the familiarity with both of terms, their implementation in companies and also certificate or recognition connected to lean or green which companies could hold. (3) Theory matching between theory findings and statistical analysis findings; and at last (4) theoretical conclusions and application.

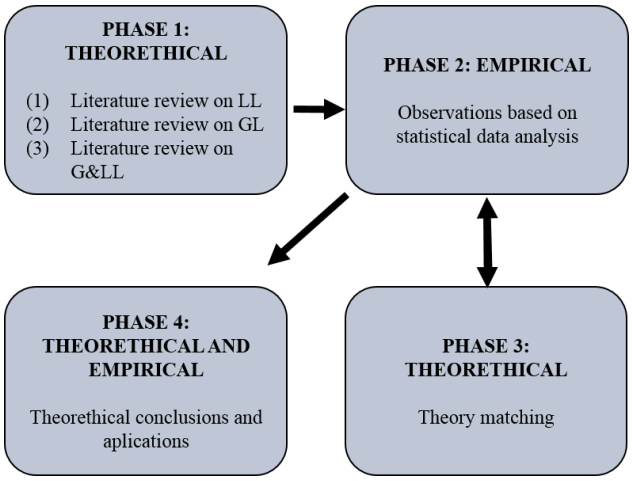

Figure 1: Abductive reasoning process

3. LEAN AND GREEN PARADIGMS IN LOGISTICS

Taiichi Ohno who was one of beginners of lean thinking and also worked in the Toyota Production System in the 80ʻs identified seven wastes, activities which add cost but no value: (1) production of goods not yet ordered, (2) waiting, (3) rectification of mistakes, (4) excess processing, (5) excess movement, (6) excess transport and (7) excess stock (Monden, 1993).

Since there are not only manufacturing or production created activities which add no value, industrials also started to put their focus on logistics non-value-added activities. From here on the new concept – lean logistics – appeared. By Baudin (2004), lean logistics is a logistical dimension of lean manufacturing. Its primary objective is to deliver the right materials to the right locations, in the right quantities, and in the right presentation; its second to do all this efficiently.

During 1990"s another practice of responding to environmental issues in a socially responsible manner – environmentalism has become increasingly important. It has been characterized as one of the most significant force shaping the economy (Limoubpratum, Shee, & Ahsan 2014; Murphy, Poist, & Braunschweig, 1995). Many articles based on concern for the environment have at that time also been written in the field of business and logistics (Van Hoek, 1999; Wu & Dunn, 1995).

The fundamentals of greening as a competitive initiative have also been discussed by Porter & van der Linde (1995). Their basic reasoning was that investments in greening can be resource saving, waste eliminating and productivity improving. They state that green initiatives could lower not only the environmental impact of a business but also raise efficiency, possibly creating major competitive advantages in innovation and operations. Skjoett-Larsen (2000) wrote a foresight work upon European companies facing new challenges in the next millennium one of which is also green logistics. The author stipulates that within the next five to ten years green supply chains will increasingly dominate the theory and practice in the logistics area. Moreover, with green logistics a completely new sub-sector of logistics appeared, using new models and tools as green logistics management. The trend is therefore to switch from traditional logistics to green logistics (Beškovnik & Twrdy, 2015).

There are separate streams of research on lean logistics and green logistics, however few researchers explore some intersections of these two paradigms (Banawi & Bilec, 2014; Garza-Reyes, 2015). This represents a critical point for companies which are most likely missing opportunities for synergies that are available with improved simultaneous introduction and also may fail in addressing important trade-offs that may occur when there is incompatibilities between strategic initiatives.

Lean, according to (2006) is based on the assumption that time contractions reveal hidden quality problems and their solutions lead to improved, cost-effective business processes. The authors further contend that if time contraction implies to lower emissions, then as by the emissions measurements, a lean system is always greener. If the reduction of time does not lead to reduced emissions, it is necessary to find a way or further changes of the lean system to become greener.

Researchers state that lean companies, which include green practices, achieve better lean results than companies which do not. Their findings indicate that only when both concepts are implemented simultaneously, they can disclose their full potential and make a greater contribution than if they were implemented separately. As such (Bergmiller & McCright, 2009), emphasize that while lean practices can lead to positive environmental contributions, conversely environmental practices often lead to improved lean practices.

Nevertheless, a waste of both paradigms is defined otherwise but both respectively target the removal of excess: the waste in the broadest sense. Lean logistics is focusing on removing 8 wastes related to efficient flow, while green logistics is focusing on green wastes in the form of inefficient use or waste production (Kleindorfer, Singhal, & Van Wassenhove, 2005).

4. ANALYSIS AND RESULTS

The following sub-sections present and discuss our results.

Analysis of demographic data referring to data on the respondents and companies in which respondents are employed. The data are presented in the following tables.

Table 1: Demographic data related to companies, in which respondents are employed

Variables	Replies	Percent (%)
D1 Company activity		
Service	81	38.21
Manufacturing	97	45.75
Trade	34	16.04
D2 Company size		
a) Up to 10 employees (micro enterprise)	76	35.85
b) Small (11-50 employees)	63	29.72
c) Medium (51-250 employees)	37	17.45
d) Large (more than 251 employees)	36	16.98
D3 Company as part of an international corporation		
a) Yes	41	19.43
b) No	170	80.57

A detailed examination shows that on the question »what is the main activity of the company according to the standard classification of activities« answered 212 respondents. The results show that most respondents come from manufacturing activities (45.75%), services (38.21%) and least from trade (16.04%).

Concerning question about company size reveals that most of the respondents come from micro enterprises (35.85%) and least from the category of large companies (16.98%). 80.57% of companies, participating in our survey state they are not part of an international corporation.

The following demographic data refers to data concerning our respondents (see Table 2).

Table 2: Demographic data related to the respondents

Variables	Replies	Percent (%)
D4 Working position		
a) Senior management	70	35.90
b) Head of Logistics	40	20.51
c) Head of Purchasing	8	4.10
d) Head of Production	5	2.56
e) Head of Warehouse	5	2.56
f) Technical Assistant in logistics	13	6.67
g) Head of processes/projects, which also deals with logistics	13	6.67
h) None of these	41	21.03
D6 Gender		
a) Male	113	58.85
b) Female	79	41.15
D7 Highest level of education completed		
a) High School or less	39	20.21
b) College	50	25.91
c) High Technical School	46	23.83
d) University degree or more	58	30.05

We have included senior managers (35.90%), heads of logistics (20, 51%), heads of purchasing (4.10%), heads of production (2.56%), heads of warehouse (2.56%), technical assistants in logistics (6.67%) and heads of processes/projects, which also deal with logistics (6,67%). 21.03% of respondents carry out other work.

Respondents‟ average age is 35 years. In survey participated 113 men (58.85%) and 79 (41.15%) women.

For the question concerning “completed education” largely participated in the survey those with a university degree or more (30.05%), followed by those with completed high school (25.91%), higher professional education (23.83%) and the last, the ones with high school or less (20.21%).

The next question was connected to certificates or recognition concerning lean and green management which companies could hold. There were more than one answer possible.

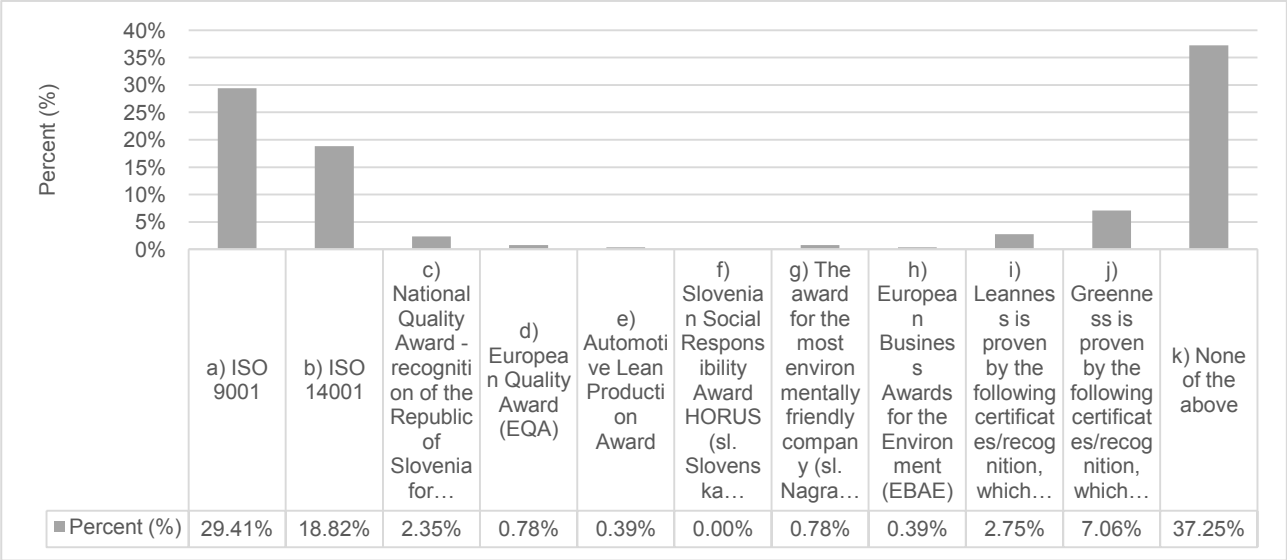

Figure 2: Data related to certificate or recognition obtained by surveyed companies

Figure 2 shows that 255 respondents answered this question of which most of the companies holds ISO 9001 (29.41%) and ISO 14001 (18.82%). 7.06% of respondents claim that they prove greenness by the following certificates/recognitions, which are not on the list and 2.75% claim that they prove leanness by the following certificates/recognitions, which are not on the list. 2.35% held the National award for quality - the recognition of the Republic of Slovenia for business excellence, 0.78% held the European Quality Award (EQA), and the prize for the most environmentally friendly company. 0, 39% of the companies held the Automotive Lean Production Award and European Business Award for the Environment (EBAE) and no one holds the Slovenian award for social responsibility HORUS.

Figure 3presents data related to the respondent"s opinion with regard to the implementation of lean and green concepts within their companies.

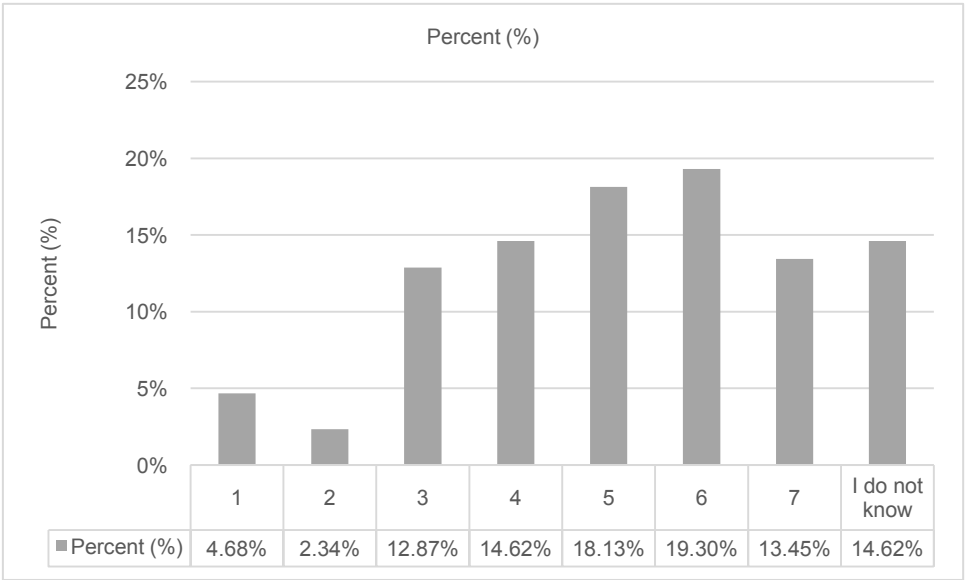

Figure 3: Data related to the respondent's opinion with regard to the implementation of a lean concept in their own company

The results show that for the opinion on the implementation of lean concept in their own company, the respondents on the 7 point Likert scale usually rated very highly, with level 6 (19.30%) and 5 (18.13%), but at least with grade 2 (2.34 %) and 1 (4.68%). The answer "I do not know" was given by 14.62% of the respondents. The arithmetic mean of the responses is 5.24.

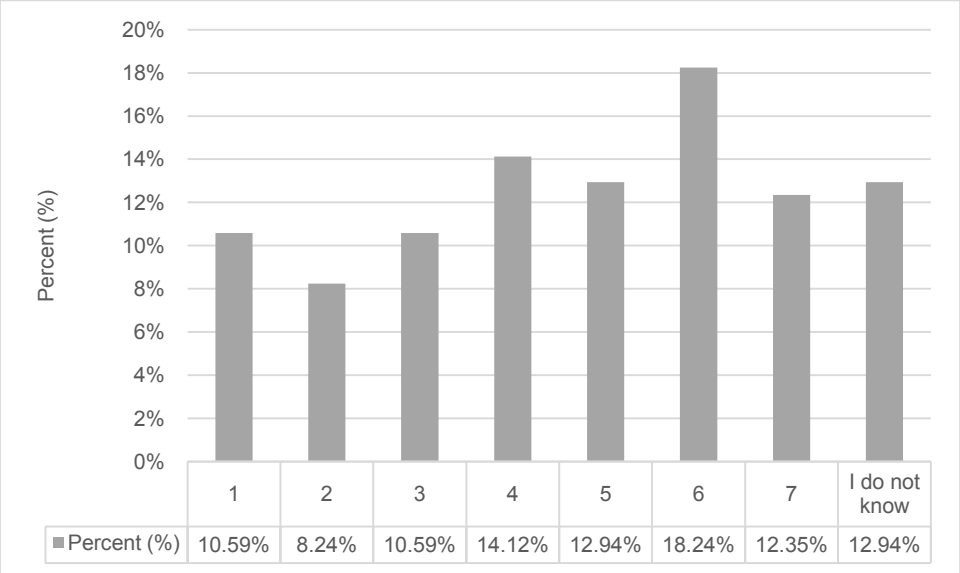

Figure 4: Data related to the respondent's opinion with regard to the implementation of a green concept in their own company

The results show that for the opinion on the implementation of green concept in their own company, the respondents rate on 7 point Likert scale usually as very high, with a rate of 6 (18.24%) and 4 (14.12%), but at least with grade 2 (8.24%), 1 and 3 (10.59%). The answer "I do not know" has given 12.94% of the respondents. The arithmetic mean of the responses is 4.79.

5. CONCLUSION

Survey findings indicate that most respondents come from manufacturing activities (45.75%) and most of the respondents from micro enterprises (35.85%). The first results are logical since the area of manufacturing is one of most developed and also largely represented Slovenia"s sectors. Also, majority of Slovenia"s companies are micro companies.

Approximately 80% of the surveyed companies are not part of an international corporation which provides an insight on a national level.

Most of our survey participants work in top management (senior managers and heads of logistics), are highly educated and are on average 35 years old. There were also almost equal parts of female and male participants participating in the survey.

In the analysis we were interested in any certificates or recognition regarding lean and green paradigms, which Slovenian logistics companies could hold. The results indicate that most of the companies hold ISO 9001 (29.41%) and ISO 14001 (18.82%) standards. Approximately 7% and 3% of respondents claim that they prove greenness/leanness by the following certificates/recognitions, which are not on the list. Approximately 2% hold the National award for quality - the recognition of the Republic of Slovenia for business excellence, less than 1% hold EQA, and the prize for the most environmentally friendly company. Only a few hold the Automotive Lean Production Award and EBAE and no one holds the Slovenian award for social responsibility HORUS.

From this on we conclude that surveyed Slovenian logistics companies obtain more certificates/recognitions concerning lean than green, also most of them prove their leanness/greenness by the mentioned ISO standards. The future research question remains which are the other certificates or recognitions with which they prove leanness/greenness within their own companies.

We were also curious about the respondents‟ opinion in regard to the implementation of lean and green concepts within their companies. The results show that on the opinion on the implementation of lean concept in their own company, the respondents on the 7 point Likert scale rated very highly (mean 5.24). On the implementation of green concept in their own company, the respondents also rated very highly (mean 4.79). From this we conclude that surveyed Slovenian logistics companies state that they mainly implement lean and green concepts within their companies. Our findings may be useful to suggest some missing areas or unresolved issues in our knowledge of lean logistics and green logistics. Also, in any business area, a new thought process will be embraced by many new practitioners who will put their own way of thinking on our survey results.

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ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY: TRENDS AND PRACTICES

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Abstract: *The last few decades were marked by the growing concern for the ever growing pollution of the environment. This forced professionals in all fields - the industry, the government, institutions and the non-government sector - to put more of their attention on strategies and management which aim to reduce these negative impacts and achieve the goals of sustainable development. This reflects the key role of environmental management, for the establishment of a company-wide environmental management programs and systems contributes to a significant reduction in negative environmental impacts and the efficient use of resources and energy. To support these listed requirements of sustainable development, this paper introduces the impact of environmental management trends and practices on sustainability.*

Keywords*: environmental management, sustainability, sustainable development, environmental management trends, environmental management practices*

1. INTRODUCTION

Environmental problems have reached their critical point in the 21st century (Bonnett, 2007; Mert, 2006; Robert , Flood , & Carson , 1993) and continue to grow rapidly: global warming, worsening living conditions, disruption of the ozone layer, the impact of conservation, increase of solid waste, radioactive contamination, destruction of forests, the extinction of plant and animal species... (Petrović, 2012). In parallel, an increase in the global population has led to an increase in inefficient consumption of natural resources (Vigon et. al., 1992).

Also, in the last few decades, it has become clear that environmental issues and the questions of environmental protection shape the future, not only of the industry, but of all human activities (Petrović, 2013). The growing public environmental awareness and concern for environmental protection has led to the conclusion that the issues and environmental problems cannot be solved at the national, but instead on an international level, and that actions must be carried out that will influence the government to enact environmental laws, policies and standards (Bary, 2007; Ehrenfeld, 1994).

It's environmental management's task to achieve the necessary reduction and elimination of negative impacts on the environment wherever possible, in order to achieve the goals of sustainable development, and bearing in mind the concept of sustainable development which is based on the principle of intergenerational justice, which is defined as meeting the needs of present generations without jeopardizing the ability of future generations to also meet their needs (WCED, 1987). The role of environmental management is particularly important because it represents a broad area that is developing rapidly, and its issue affects not only all people, but all their activities because of its key role in achieving sustainable development (Barrow, 2006). Further on, economic and social demand of environmental sustainability urges companies to embrace the strategic importance of environmental management trends and practices for competitive advantage (Sroufe, 2003; Yang Lin, Chan, & Sheu, 2010).

2. SUSTAINABILITY

At the United Nations Conference on Environment and Development (UNCED) (Earth Summit, 2002) participating countries agreed to start with the development and adoption of national sustainable development strategies. The consequence of that were amendments to the definition of sustainable development – together with environmental protection, economic and social goals added, having in mind that all these three pillars are of the same importance for achieving development and sustainability on local and global level (Berg, 2009; Roseland, 2000; Roseland, 2005).

Later on, these frameworks are improved with values that refer to natural, physical, economic, human, social and cultural capital (Roseland, 2005). Also, it was concluded that young people have a crucial role in the process of democratic decision making and public participation in all activities connected with sustainable development and sustainability (UNECE, 1998; Borojevic, Petrovic, & Vuk, 2014; Borojević, Petrovic, & Vuk, 2015).

Further on, there is much discussion about how one "defines" sustainability, and related concepts (WCED, 1987; Pezzey, 1989; Costanza, 1991; Pearce & Atkinson, 1993; Costanza & Patten, 1995). Besides that, all definitions of sustainability must meet the following criteria (Sustainable Measures, 2016):

- "Living within the limits.
- Understanding the interconnections among economy, society, and environment.
- Equitable distribution of resources and opportunities."

Some definitions of sustainability are:

- Sustainability refers to "improving the quality of human life while living within the carrying capacity of supporting eco-systems." (IUCN, 1991; WWF, 1991)
- Sustainability is defined "as long-term health and vitality of a region, including the cultural, economic, environmental and social aspects as one whole." (Sustainable Seattle, 2016)
- "Sustainability calls for a decent standard of living for everyone today without compromising the needs of future generations." (UN, 2016)
- "Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations." (EPA, 2016)

In the context of sustainability, we should definitely mention a new sustainable development agenda for the period of 2015-2030 - Transforming our world: the 2030 Agenda for Sustainable Development as well as its The 17 Sustainable development goals (UN, 2015):

- Goal 1: End poverty in all its forms everywhere.
- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3: Ensure healthy lives and promote well-being for all at all ages.
- Goal 4: Ensure inclusive and quality education for all and promote lifelong learning.
- Goal 5: Achieve gender equality and empower all women and girls.
- Goal 6: Ensure access to water and sanitation for all.
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all.
- Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation.
- Goal 10: Reduce inequality within and among countries.
- Goal 11: Make cities inclusive, safe, resilient and sustainable.
- Goal 12: Ensure sustainable consumption and production patterns.
- Goal 13: Take urgent action to combat climate change and its impacts.
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources.
- Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
- Goal 16: Promote just, peaceful and inclusive societies.
- Goal 17: Revitalize the global partnership for sustainable development.

These objectives are the new trends of sustainability, which should affect the actions over the next 15 years in areas of critical importance for humanity and the planet.

3. ENVIRONMENTAL MANAGEMENT TRENDS AND PRACTICES FOR SUSTAINABILITY

By the late 20th century the need for structured environmental management became evident because of global pollution, loss of biodiversity, soil degradation, and urban growth. These developments are not easily tangible even though advances have been made in understanding the structure and functions of the environment, in monitoring impacts, data handling and analysis, modeling, assessment, and planning. Basically, environmental management aims to coordinate and focus such developments, to improve human wellbeing, and lessen or prevent further damage to Earth and its organisms (Barrow, 2006).

Environmental management is related to environmental planning. Further, the focus of environmental management is on: implementation, monitoring, auditing, practice and coping with real world environmental issues. Environmental management is a field of study dedicated to understanding human-environment

interactions and the applications of science in solving environmental problems and achieving sustainable development goals.

We see that environmental management is an approach to environmental stewardship which integrates ecology, policy making, planning and social development and includes: the prevention and resolution of environmental problems; establishing and nurturing institutions that effectively support environmental research, monitoring and management; warning of threats and identifying opportunities; sustaining and, if possible improving, existing resources; where possible improving "quality of life"; identifying new technology and/or policies that are useful (Barrow, 2006). So, environmental managers are those whose livelihood is primarily dependent on the application of skill in the active and self-conscious, direct or indirect, manipulation of the environment with the aim of enhancing predictability and proactive acts in a context of social and environmental issues.

There isn't just one universal definition of environmental management, because of its very broad scope and the diversity of involved specialties.

However, environmental management has following characteristics: it is generic term; it promotes sustainable development; it is a multidisciplinary and interdisciplinary approach; it integrates science, policy making and planning; it concerns ranges from local to global; it shows opportunities, threats and problems; it emphasizes stewardship, rather than exploitation.

Some definitions of environmental management are:

- Management of the environmental performance of organizations, bodies and companies (Sharratt, 1995).
- Environmental management – a generic description of a process undertaken by systems-oriented professionals with a natural science, social science, or less commonly, an engineering, law, or design background, tackling problems of the human-altered environment on an interdisciplinary basis from a quantitative and/or futuristic viewpoint (Barrow, 2006).
- A multi-layered process associated with the interaction of state and non-state environmental managers with the environment and with each other (Wilson & Bryant, 1997).

Further on, environmental management systems (EMSs) create a culture of continuous improvement, employee empowerment, waste minimization, and pollution prevention (Dües, Tan, & Lim, 2013). Also they irepresent instruments of environmental management with a high degree of formalization and unification. ISO (The International Organization for Standardization) defines environmental management system (EMS) as a management framework for reducing environmental impacts and improving organizational performance over time. The system follows a repeating cycle (Figure 1). The cycle repeats, and continuous improvement occurs.

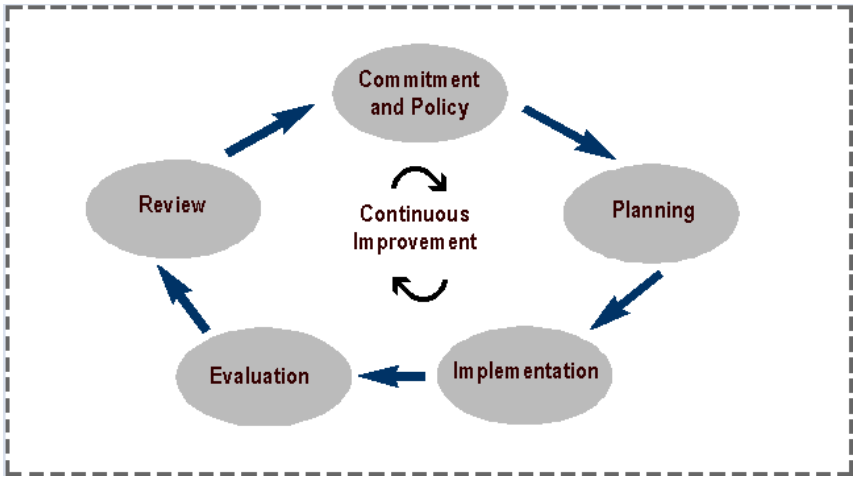

Figure 1: The continuous improvement cycle (Melnyk, Sroufe, & Calantone, 2003)

The summarized dimensions of environmental management systems are given in Table 1.

Table 1: Summarized dimensions of environmental management systems (Ross & Associates Environmental Consulting, Ltd., 2004)

Dimension	Environmental management system
Overall Type	Management system framework - Environmental management systems (EMS)
Waste Elimination Objectives	Eliminate environmental impacts and risks
Organizational Ownership/ Primary Participants	Environmental professionals, with involvement of all employees where appropriate
Drivers/Motivation	Need to better or more cost-effectively manage environmental compliance, risk, and performance, and to demonstrate this to external customers/stakeholders
Methods/Tools	Programs, processes and procedures designed by organization to support management system framework, and to meet objectives and targets
Culture Change	Employee-involved problem-solving culture; empowerment of decision-making to address needs where they occur
Improvement	Continual improvement, based on Plan-Do-Check-Act model

On the first place, the aim of environmental management is to promote sustainable development (Dorney, 1989). Also, firms which have successfully reduced their environmental impacts through implemented environmental management trends and practices also implemented practices for better sustainability of their businesses. Environmental management trends and practices have the goal of improving the organizations environmental and business performance.

Having in mind the previous studies from relevant industry, academic and non-profit entities, key environmental management trends and practices for sustainability are summarized below:

- elimination of waste and emissions,
- pollution prevention,
- maximizing energy efficiency,
- maximizing productivity,
- minimizing utilization of natural resources,
- resource management,
- investing in renewable sources of energy,
- introducing the lean manufacturing,
- introducing Kaizen approach,
- introducing green logistics,
- industrial ecology,
- cleaner production,
- sustainable production,
- clean manufacturing practices,
- energy-efficient design of equipments and products,
- water conservation,
- water management,
- reduction in the amount of packaging,
- usage of eco-friendly packaging materials,
- eco-design,
- design for environment,
- minimizing transport and travel,
- promoting environmental sustainability,
- interesting in developing eco-friendly buying behaviors,
- reducing carbon footprint,
- reusing,
- recycling,
- using more recycled materials,
- minimizing waste generation,
- waste management,
- zero waste strategy,
- environmental initiatives,
- mitigate climate changes,
- environmental reporting (voluntary as well as mandatory),
- reporting greenhouse gas emissions,
- reporting energy production,

- reporting energy consumption,
- energy management,
- usage of clean energy,
- usage of environmental performance indicators (EPI),
- building green image of company,
- environmental impact assessment,
- life-cycle analysis and life-cycle assessment (LCA),
- environmental security,
- sustainability reporting,
- adjustment with environmental regulations,
- managing corporate sustainability reputation,
- green marketing,
- sustainable marketing,
- environmental labelling,
- environmental risk management and assessment,
- increasing environmental and sustainability knowledge and understanding for all other workers,
- integrating sustainability throughout organisations and value chains.

4. CONCLUSION

During the end of the 20th century and into the 21st century environmental management emphasizes negative environmental impacts minimization and therefore have gained in popularity. Thus, trends and practices of environmental management became essential part of sustainable development as sustainable sound management that is trying to be well balanced with the Earth's capacity. Also, environmental management enhances environmental efficiency of the organization and the effectiveness of the organization's business which is also reflected in the area of cost reduction.

Several papers and researches summarized how an implementation of environmental management trends and practices show significant environmental improvements by more resource and energy efficiency. This paper contributes to this growing body of knowledge by identifying not only a role of integrating environmental management in a significant reduction of environmental burden, but also by summarizing all achievable environmental trends and practices as an excellent solutions for achieving sustainability.

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MULTIATTRIBUTE METHODS AS A MEANS FOR SOLVING LAKE POLLUTION PROBLEMS

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Abstract: *The pollution of lake resources restricts its use for human need or a natural function in the ecosystem. Many lake pollution problems are solved using multiattribute methods, and for some problems, researchers use more than one method to overcome disadvantages of application of only one single method. Short literature review of application of multiattribute methods for lake pollution problems is conducted in this paper. This review pointed out two most commonly used methods for this type of problems - Promethee and AHP method, and therefore basic concept of these methods is presented.*

Keywords*: multiattribute methods, AHP, promethee, water resources, lake pollution*

1. INTRODUCTION

Natural resources are raw materials that come from Earth and exist without any human actions. Water as a natural resource refers to the groundwater and surface water in the environment. Humans have the great need for fresh water which represents around 2.5% of all water on Earth (Postel et al., 1996). Part of fresh water is locked in glaciers and ice caps, and the rest is in lakes, rivers, atmosphere etc. Fresh water can be considered as a renewable resource when the usage, treatment and release of water is in a balance with its capacity, which is necessary for its regeneration. Its significance is reflected in the fact that water is essential precondition for life of humans, animals, plants, etc. Because of that it is important to continuously implement various measures to protect water quality.

In rural areas people usually live around different sources of fresh water and food, which is near mountains, rivers and lakes. As the number of people continuously rises as well as their needs, the pressure on this resources in the environment is much stronger. Human activity is one of the main causes of water resources pollution. These activities lead to fast increase of ecological problems, nature resources and environment in which humans live and act. Biggest problems in rural inhabited areas, especially the ones near sources of fresh water, is the absence or undeveloped sewage systems or proof septic tanks as well as other protection measures which leads to soil contamination.

Rainfall, snowfall or melting of snow are common causes of runoff which is flow of water over earth's surface. Surface runoff can implicate environmental pollution through transport of water pollutants such as chemicals and sediments from roads and ground surface which end up in rivers, lakes or other water streams. On the other hand, groundwater collects contaminants from the soil and supply lakes with high level of nutrients and toxic compounds and makes the water unacceptable for any use and leads to eutrophication.

Eutrophication is one of the most widespread water quality problems in the world. Human negative influence on nature and lack of protection measures for fresh water reservoirs such as lakes, is one of the causes of eutrophication. Its main indicators are excessive plant and algal growth in water body as a response to increased levels of nutrients. This phenomenon indicates that there are crucial structural and functional changes of water ecosystem which result in toxic compounds and lack of oxygen that can cause death of aquatic animals and therefore is not fit for human use.

Eutrophication of waters is the phenomenon of an ecosystem becoming more productive by nutrient enrichment, stimulating primary producers. It is usually characterized by algal blooms, causing water quality deterioration and fish kills. It is becoming a global environmental crisis (Wang & Wang, 2010).

Focus of this paper will be on short review of multiattribute method application on one of the most common fresh water resources that humans use - lake pollution problems. These problems are mainly multiattribute and because of large number of available methods it is necessary to perform a review of multiattribute method applications to similar problems. In that way it is possible to point out most commonly used methods and apply them in purpose of bringing a good decision after reviewing results of different methods.

Multi-criteria decision analysis (MCDA) provides a systematic methodology in combining different inputs in order to rank selected alternatives and compare them. The development of MCDA methods has been motivated not only by a variety of real-life problems requiring the consideration of multiple criteria, but also by practitioners' desire to propose enhanced decision-making techniques using recent advancements in mathematical optimization, scientific computing, and computer technology (Wiecek et al., 2008). This paper pointed out two most commonly used methods for lake pollution problems - Promethee and AHP method. These approaches differ significantly in the way of how values are assigned and combined, meaning that the processes have different information and knowledge requirements and the calculated scores have different mathematical properties and thus slightly different meanings. Practitioners often view one of the various approaches as most appropriate due to the priority they place on its relative strengths and weaknesses (e.g.,Figueira et al., 2005; Beltonand Stewart, 2002).

This paper is organized as follows: literature review of multiattribute methods for lake pollution problems and most important findings are given in section 2. Sections 3 and 4 describe Promethee and AHP methods. Section 5 provides the concluding remarks.

2. MULTIATTRIBUTE METHODS REVIEW FOR LAKE POLLUTION PROBLEMS

It is not the purpose of this paper to give an exhaustive review of multiattribute methods application on the problem of lake pollution. Most of the work in this area is very much oriented towards water resource management, and there are few applications concerning lake pollution. We decided to structure this paper around some carefully selected examples of research studies and research.

Some of common types of water management decisions being supported with multiple criteria analysis techniques include (Hajkowicz & Higgins, 2008):

- Selection of alternative water supply and storage infrastructure options. Eder et al. (1997) use MCA to select locations and design options for hydro-electric power plants on the Danube River in Austria.
- Selection of water restoration or enhancement projects in light of constrained budgets. Al-Rashdan et al. (1999) prioritize projects designed to improve the environmental quality of the Jordan River using MCA.
- Allocating a fixed water resource amongst competing uses. Flug et al. (2000) use MCA to select water flow options for Glen Canyon Dam in Colorado providing for recreation, biodiversity, fishing and cultural uses.
- Selecting water management policies for an entire city or region. Joubert et al. (2003) use MCA to help choose water supply augmentation and demand management policies for the city of Cape Town in South Africa.

Water resource management decisions are typically guided by multiple objectives measured in different units, and therefore makes a multiple criteria analysis (MCA) a well suited decision support tool (Chung, Hong, Lee, & Burian, 2011). Despite an abundance of algorithms to solve an MCA problem once it has been structured, there are few methods to help analysts and decision makers choose criteria and decision options in the first place (Hajkowicz & Collins, 2007).

Water management covers a wide range of activities, in which technical, economic, environmental and social issues are involved (Anagnostopoulos et al, 2005). Given the complexity of the decision process, much attention has been paid to multiple criteria decision-making (MCDM) approaches in order to enhance the ability to make sound decisions in water resources management. Authors in (Anagnostopoulos et al, 2005) discuss that there is no method for choosing among them the most appropriate MCDM methods for a given decision problem and the choice is mostly subjective. Authors evaluate four alternative irrigation projects for the East Macedonia- Thrace District using the AHP and PROMETHEE multicriteria methods. The projects evaluation is based on economic, social, environmental and cost criteria.

More information about different applications of MCDM in water supply management can be found in Lai et al. (2008). For example, MCDM techniques have been applied to optimize policy selection in the remediation of contaminated sites, the reduction of contaminants entering aquatic ecosystems, the optimization of water and coastal resources, and the management of other resources (Huang et al., 2011).

From a wide range of MCDM methods, the most suitable ones for the design of alternative comparison are PROMETHEE and AHP (Balali, Zahraie & Roozbahani, 2014), and therefore we conducted a short survey on these methods regarding water resource problems, especially problems related to lake management.

AHP is widely used in water resources industry. For example, management and planning for a large watershed may include issues related to water quality and quantity, forest management, wildlife

management, and recreation. Input is required from subject matter experts in each of these disciplines in order to establish priorities and make informed decisions regarding spatial and temporal distributions of resources. In addition to its breadth of application, the AHP is relatively easy to apply, to understand, and to interpret (Schmoldt et al., 2013).

Authors in (Sener et al., 2010) select a landfill site for the Lake Beysehir catchment area in such way that the lake is protected. The Beysehir Lake is the largest freshwater lake and drinking water reservoir in Turkey. To determine the most suitable landfill site that must combine social, environmental and technical parameters, an AHP was combined with a geographic information system (GIS) to examine several criteria, and each criterion was evaluated with the aid of AHP.

In (Li, 2007) author researches the system that involves defining indicators in the following fields: society, economy, resources, environment and ecology. These indicators are proposed for eco-environmental quality assessment in Chaohu Lake basin. A hierarchical model with four levels is established and the weights of indicators and attributes are determined by combining Delphi method with the AHP.

In (Su et al, 1997) AHP was applied in water environmental quality assessment of the Songhua River, and the authors show that it has logicality, practicability and system that are appropriate to the real water environmental quality assessment.

The AHP provides a systematic method for comparison and weighting multiple criteria and alternatives that exists in integrated watershed management. An advantage of the AHP is that it is capable of providing numerical weights to options where subjective judgments of either quantitative or qualitative alternatives constitute an important part of the decision process. Such is often the case with IWM (De Steiguer et al.,, 2003).

Eutrophication is the most widespread water quality problem in many countries. Symptoms such as high level of chlorophyll, an excessive seaweed blooms, occurrence of anoxia and hypoxia have occurred in many areas in China (Xing, 2005). Evaluation of the trophic state of a lake is in fact a multivariate comprehensive decision making process quantifying the qualitative problem. Authors in (Xing et al., 2005) choose the trophic state index in order to assess the trophic state of the Lake Dianchi and they use AHP for weights calculation of the pollution indicators.

Authors in (Zhang, 2007) evaluate environmental comprehensive quality of water and sediment of Xuanwu Lake, Nanjing, China. An improved AHP method had been developed and the weights of pollution factors were completely related to the objective monitoring data through the standardization of these procedures. This improved AHP method can avoid arbitrariness of subjective judgment and can reflect the real influential factors of environment pollution in different periods or regions (Zhang et al., 2007).

Many water quality management decisions involve uncertain information, multiple and often conflicting objectives, and limited resources. In (Korfmacher, 1997) author presents an application of AHP to the selection of a water quality model for Lake Okeechobee in Florida. The aim of selected water quality model is to help guide research and management efforts at reducing algal blooms on the lake.

Authors in (Calizaya et al., 2010) apply AHP to solve the MCDA problem in the Lake Poopo basin and to identify the alternatives using the highest expected utility value in order to support stakeholders in managing their water resources.

In the study conducted by Hajkowicz and Collins (Hajkowicz & Collins, 2007) eight types of MCA application in water resource management were identified, and by reviewing the characteristics of the problem considered in this paper, two types of applications are a match:

- Project appraisal. These studies use MCA to rank or score a set of water management projects which often involve some form of water condition restoration activity. For example, Al-Rashdan et al. (1999) use Promethee and Nominal Group Technique to prioritize a set of projects aimed to improve the environmental quality of the Jordan River.
- Water quality management. These papers involved an application of MCA primarily involving the evaluation of options aimed specifically at improving water quality. They often involve human and ecosystem health objectives. An example comes from Lee and Chang (2005) where MCA is used to develop a water quality management plan for the Tou–Chen River Basin in northern Taiwan.

Papers reviewed in (Hajkowicz & Collins, 2007) employed 61 unique MCA techniques. The majority of studies applied more than one MCA method, usually to test the sensitivity of the result and in the authors

point out that the most commonly applied methods were fuzzy set analysis, compromise programming (CP), the analytic hierarchy process (AHP), ELECTRE and PROMETHEE.

In (Abu-Thaleb & Mareschal, 1995) authors describe the application of the PROMETHEE V multicriteria method to evaluate and select from a variety of potentially feasible water resources development options, so that the allocation of limited funds to alternative development projects and programs can proceed in the most efficient manner. The criteria set indicates that a successful combination of water options must include projects and programs that minimize groundwater extraction, ensure groundwater quality and quantity, have a high probability of cost recovery, maximize the supply of water and promote water conservation and efficiency.

A list of the papers on the topic of Hydrology and Water Management can be found in (Behzadian et al., 2010) and, according to the authors, most of the papers have been devoted to the sustainable water resources planning, water management strategies assessment, and irrigation planning using PROMETHEE applications.

3. PROMETHEE METHOD

The PROMETHEE method (Preference Ranking Organization Method for Enrichment Evaluations) is one of the most recent multi-criteria decision aid methods, developed by Brans in 1982 (Brans, 1982). The PROMETHEE includes PROMETHEE I for partial ranking of alternatives and PROMETHEE II for complete ranking of alternatives.

The basic principle of PROMETHEE II is based on a pair-wise comparison of alternatives along each recognized criterion. Alternatives are evaluated according to different criteria, which have to be maximized or minimized. The implementation of the PROMETHEE II requires two additional types of information (Behzadian, M., et al., 2010):

- Information on the relative importance (i.e. the weights) of the criteria considered. PROMETHEE II assumes that the decision-maker is able to weight criteria appropriately, at least when the number of criteria is not too large (Macharis, J., et al., 2004);
- Information on the decision-makers' preference function, which decision maker uses when comparing the contribution of the alternatives in terms of each separate criterion. In order to facilitate the selection of a specific preference function, Vincke and Brans (1985) proposed six basic types of criteria: (1) usual, (2) U-shape, (3) V-shape, (4) level, (5) V-shape with indifference and (6) Gaussian (Brans & Vincke, 1985). These six types are particularly easy to define. For each criterion, the value of an indifference threshold, *q*, the value of a strict preference threshold, *p*, and the value of an intermediate value between *p* and *q*, *s*, has to be defined (Brans & Mareschal, 2003).

Experts' opinions are set on various parameters such as selection and weight of the criteria. The team of experts who has cooperated in this research includes architects and information managers who are involved in hotel building design and operational research projects. The PROMETHEE method is implemented in five steps (Behzadian, M., et al., 2010):

Step 1. Determination of deviation based on pair-wise comparison (1):

$$d_j(a,b) = g_j(a) - g_j(b);\ \ j = 1,...,n \tag{1}$$

Where $d_j(a,b)$ denotes the difference between the evaluation of *a* and *b* on each criterion.

Step 2. Application of the preference function (2):

$$P_j(a,b) = F_j\left\lfloor d_j(a,b)\right\rfloor;\ \ j = 1,...,n \tag{2}$$

Where $P_j(a,b)$ denotes the preference of alternative *a* with regard to alternative *b* on each criterion, as a function of $d_j(a,b)$

Step 3. Calculation of an overall or global preferences index (3):

$$\forall a,b \in A,\ \pi(a,b) = \sum_{j=1}^{n} P_j(a,b)w_j \tag{3}$$

Where $\pi(a,b)$ of *a* over *b* (from 0 to 1) is defined as the weighted sum $p(a,b)$ of for each criterion, and w_j is the weight associated with j^{th} criterion.

Step 4. Calculation of outranking flows/ The PROMETHEE I partial ranking (4):

$$\phi^+(a) = \frac{1}{n-1}\sum_{x\in A}\pi(a,x) \text{ and } \phi^-(a) = \frac{1}{n-1}\sum_{x\in A}\pi(a,x) \quad (4)$$

Where $\phi^+(a)$ and $\phi^-(a)$ denote the positive outranking flow and negative outranking flow for each alternative, respectively.

Step 5. Calculation of net outranking flow/ The PROMETHEE II complete ranking (5):

$$\phi(a) = \phi^+(a) - \phi^-(a) \quad (5)$$

Where $\phi(a)$ denotes the net outranking flow for each alternative.

4. THE ANALYTIC HIERARCHY PROCESS (AHP)

Analytic Hierarchy Process – AHP was developed by Thomas Saaty in the early '70s of the last century (Saaty, 1977; 1980), in order to solve complex problems whose elements are: objectives, criteria, sub-criteria and alternatives. It is popular and widely used method for organizing and analyzing complex decisions, based on mathematics and psychology. AHP considers quantitative and qualitative attributes and combines them through the decomposition of complex problems into a model that has the form of a hierarchy. Each level of the hierarchy consists of elements that are influenced by the level above and which can be mutually compared hierarchically structured model of decision-making is generally made up of objectives, criteria and alternatives. The objective is on the top of the hierarchy, the criteria are compared to one another in relation to the set objective, while at the last level, the comparison of alternatives is made in relation to the criteria. AHP keeps all parts of the hierarchy in a relationship, so it is easy to see how a change in one factor affects other factors.

The main objective of this method is ranking of several alternatives, as well as the choice of the best one from a set of available ones, in situations where decision-making involves a larger number of decision makers, and where there are a larger number of criteria in different time-periods. The ranking/selection is made in relation to the set target.

The methodology of the AHP can be explained in following steps (Saaty, 1977; 1980):

Step 1: The problem is decomposed into a hierarchy of goal, criteria, sub-criteria and alternatives.

Step 2: Data are collected from experts or decision-makers corresponding to the hierarchic structure, in the pairwise comparison of alternatives on a qualitative scale. Experts can rate the comparison as equal, marginally strong, strong, very strong, and extremely strong.

Step 3: The pairwise comparisons of various criteria generated at Step 2 are organized into a square matrix. The diagonal elements of the matrix are 1. The criterion in the *i*-th row is better than criterion in the *j*-th column if the value of element (*i, j*) is more than 1; otherwise the criterion in the *j*-th column is better than that in the *i*-th row. The (*j, i*) element of the matrix is the reciprocal of the (*i, j*) element.

Step 4: The principal eigenvalue and the corresponding normalized right eigenvector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalised eigenvector are termed weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives.

Step 5: The consistency of the matrix of order n is evaluated. Comparisons made by this method are subjective and the AHP tolerates inconsistency through the amount of redundancy in the approach. If this consistency index fails to reach a required level then answers to comparisons may be re-examined. The consistency index, *CI*, is calculated as:

$$CI = (\lambda_{\max} - n)/(n-1) \quad (6)$$

where $\lambda_{\max}$ max is the maximum eigenvalue of the judgment matrix. This *CI* can be compared with that of a random matrix, *RI*. The ratio derived, *CI/RI*, is termed the consistency ratio, *CR*. Saaty (Saaty, 1977; 1980) suggests the value of *CR* should be less than 0.1.

Step 6: The rating of each alternative is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to get global ratings.

The AHP produces weight values for each alternative based on the judged importance of one alternative over another with respect to a common criterion.

5. CONCLUSION

Decision making in urban environmental management can be complex, principally because of the inherent trade-offs between environmental, ecological and economic factors. The eutrophication is natural phenomenon, and during the last 3 decades there are many techniques used in eutrophication problem-solving (Svircev, Krstic, Markovic, Plavsa & Lazic, 2008).

Eutrophication of lakes and reservoirs is a degradation process originating from the introduction of nutrients from agricultural run-off and untreated industrial and urban discharges. Accelerated eutrophication of lakes and reservoirs experiencing during last century in most parts of the world represents a serious degradation of water quality (Qin, 2009).

Application of multicriteria decision analysis in water resource management is widespread and growing (Hajkowicz & Collins, 2007). The use of MCDA techniques provides a reliable methodology to rank alternative, but none of them is considered the best for all kinds of decision-making situations. Based on Balali et al., (Balali, Zahraie & Roozbahani, 2014), we conducted a short survey on the PROMETHEE and AHP methods regarding water resource problems, especially problems related to lake management.

There aren't many applications of MCDA methods for lake eutrophication problem, but the studies conducted for the lake management problems are applicable to this particular problem. The literature review illustrated the value of the approach, but refinement and validation of the methods must continue such that they can eventually be incorporated into policy making. Recommendations for further research include real case application of selected methods for the eutrophication lake problem.

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REACHING ENERGY EFFICIENCY THROUGH ENVIRONMENTALLY RESPONSIBLE HARDWARE AND SOFTWARE DEVELOPMENT

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Abstract: *Today's world is overflowing with electronic devices. There are more electronic devices in the world than humans. Such proliferation of electronic devices is increasing the electric energy consumption. As a result there are high levels of environmental degradation coming out of the increased energy demand. Considering that further proliferation of electronic devices is expected, the means of reaching more energy efficient electronic devices are examined. This paper analyses both hardware and software development options that can lead to lower energy demand. The aim is to evaluate practices of how hardware components are being built and the necessary inclusions in order to achieve a higher level of energy efficiency, as well as the kind of software development guidelines which should be followed in order to reach the same goal. Finally the paper answers the question of whether there are certain tradeoffs in pursuing the desired ends.*

Keywords*: environment, ecology, energy efficiency, smart computing*

1. INTRODUCTION

We are currently living in a world where pollution as a problem is growing worldwide. It's becoming something that is affecting both flora and fauna. By destroying natural habitats it is making conditions even worse for humans and animals alike. Numerous causes have led to these conditions. These examples are listed below (Bose, 2010):

- Air pollution is the most dangerous form of pollution. It is caused by many factors. Uncontrolled burning of fuel which is essential for our everyday lives and industrial activities; which emits an enormous amount of chemical substances in the air every day;
- Water pollution occurs due to several factors; the industrial waste dumped into the rivers and other water bodies cause an imbalance in the water leading to its severe contamination and death of both marine flora and fauna.
- Soil pollution is occurring due to the unwanted chemicals being absorbed in to the soil due to human activities. The use of insecticides and pesticides absorbs the nitrogen compounds from the soil making it unfit for plants to derive nutrition from.

Another cause which is appearing in the 21st century is the fact that now there are more electronic devices than humans which is increasing the electric energy consumption. Nowadays almost everyone has a computer because of the mass production and reasonable prices which are not helping the situation. The ICT's share in electricity consumption in national economy scales has continuously increased during the past decades (Kohler & Erdmann, 2004).

Three types of environmental degradation are caused by ICT products and infrastructures can be discerned: global resource depletion, energy use, and the emission of toxic substances over the lifecycle (consisting of production, use and disposal). For example, to make a single 32 MB DRAM memory chip of approximately 2 grams you need: 1.6 kg of fossil fuels, 27 g of diverse chemicals, 700 g of elemental gases, and 32 kg of fresh water. On top of that, to combine all of these materials we also need 41 MJ of energy per chip in the production chain of silicon wafers (Williams, Ayres, & Heller, 2002). For a complete personal computer including a CRT-monitor, the input of abiotic raw materials goes up to 1500 kg (Köhler & Erdmann, 2004).

And last but not the least important problem is the ignorance of people and their attitude that only the big companies are the ones who are polluting and destroying the environment. They are not aware that by looking after their consumption they can help a lot and make a big difference if we look at the population of one city or region.

In the last couple of decades, important attempts have been made to decrease the net power and energy consumption of electronic devices especially those which are battery powered. The idea of low-power hardware construction is a dominant field of research and multiple attempts for power and energy minimization and reduction have been made. However, since most of the hardware functions are controlled

by software, it is of fundamental importance to study the software impact on the hardware energy consumption (Großschädl, Avanzi, Savaş, & Tillich, 2005).

In information communication technologies, when arguing the modes of reaching energy efficient computing authors note two main fields with room for improvement, these being:

- Energy efficient hardware development
- Energy efficient software development

When considering energy efficient software development, guidelines for such software development are a relatively novel area of study, but they are continually improving, with the biggest concerns centered on the trade-off of performance versus energy efficiency. Different authors propose different approaches to overall energy efficient software development, but they all center around three specific goals (Roy & Johnson, 1997):

- reduction of the cost or frequency of memory accesses,
- selection of the least expensive instructions or instruction sequences,
- processor-specific optimizations.

When talking about energy efficient hardware development, for such development, a very important question of how to save energy comes to mind. Can we predict how much energy we are using, by determining our total energy consumption? (Landsiedel, Wehrle, & Götz, 2005).

2. IMPLEMENTATION AND SIGNIFICANCE

Goodman (2000) notes that today's processors come with an option of adjustable clock frequency and supply voltage. The adjustable voltage-frequency properties can be used with an appropriate voltage scheduler which decreases the energy usage in the period when computer response is less needed. It is possible to simultaneously dynamically adjust the supply voltage and clock rate of the processor in order to significantly reduce the energy consumption of the CPU during periods of low activity in which the computer user does not require full operability.

Phase-change memory (PCM) is one of the alternative types of memory that can replace flash memory in next-generation non-volatile memory devices. (Derbyshire, 2011; Wuttig & Yamda, 2007; Hamann, O'Boyle, Martin, Rooks, & Wickramasinghe, 2006). A phase-change material such as chalcogenide can be reversibly shifted between its crystalline and amorphous states through heating by applying appropriate voltage pulses, which cause a change in the resistance state. (Wuttig and Yamda, 2007; Loke, Lee, Wang, Shi, Zhao, Yeo, & Elliott, 2012). The measure of merit, with high switching speed, good endurance, excellent retention properties, low fabrication cost, and inherent scalability, makes PCM more appealing than flash memory. (Loke et al., 2012).

There are different kinds of research being conducted, concentrating on separate parts of the computer system and as a result of that these parts are being optimized independently (Tiwari, Malik, Wolfe, & Lee, 1996), which leads to dubious interpretations. On one hand it can be noted that in this way higher efficiency can be reached, while studies show that independent optimizations of system parts are less efficient and can be counterproductive (Wood & Newborough. 2005). For example Landsiedel et al., (2005) show that passive RFID system protocols must not be assessed independently because it leads to less accuracy, unless they are evaluated in the context of their codependence on implementing circuits they run on. This is due to the fact that both the circuit and the protocols have to be adjusted in their energy consumption efficiency based on their designed physical limitations, therefore meaning that both parts of the system have to be addressed simultaneously.

Different studies have researched the energy consumption of CPUs during different operating tasks including: sensing, routing, sending and receiving information, all being main CPU activities. Such studies present the opportunity to identify and address the energy consumption demanded by different procedures and most importantly the procedures that require the highest energy consumption. Landsiedel, et al. (2005) note that low level data handling, scheduling and timer handling consume are at the top of the list of procedures by the level of energy they consume just swing by a mere fact that they are not time efficient and hence demand longer processing. This has led authors to conclude that in order to increase energy efficiency in these procedures, the time that the processor spends dealing with them has to be decreased, and more specifically it means that in order to improve sensor node applications, energy efficiency ratio and the operating system implementation has to be improved. (Landsiedel et al., 2005).

3. HOW MUCH ENERGY ARE WE TALKING ABOUT?

If we were to apply a smart metering technology in our houses we would not only improve our knowledge of the appliances in our home, but would also start making our energy consumption more efficient. These devices would measure the electricity consumption of up to 16 the home appliances. The data would be transferred from the appliance to a main local collector unit (LCU) using radio waves. Each LCU stores a meter identity number and the current meter reading and the central POEM unit collects data from the LCU. The data is then sent down the telephone line for analysis elsewhere, when the phone is not in use. This system is purely a data collection system and the presentation of energy information to the customer is not its primary function. Marvin, Chappells, and Guy (1999), suggests that smart meter technologies could potentially help consumers to use their energy more effectively. The application of smart metering technologies in-home has the potential to reduce gas and electricity consumption and carbon emissions as well as domestic fuel bills (Darby, 2006). Cook (1979) reported a 12% decrease in electricity usage in households with an FEM

Additionally studies have shown that when pervasive computing is considered, the environmental impact that comes to be analysed in correlation with it, it can be noted that there are different degrees of ICT impacts to the environment. These impacts can be classified in three levels of environmental impact (Fichter, 2001; Schauer, 2003; Köhler & Erdmann, 2004):

- First-order effects: These include all environmental impacts that are a resulting consequence of ICT hardware lifecycle, starting from the idea, design plan, construction, production, usage and the final disposal.
- Second-order effects: These are the impacts that come as a cascade consequence of ICT usage. The use of ICT causes parallel processes that are also leaving an impact to the environment. With regard that many hardware components' production has been moved overseas in recent decades due to cheaper labor. The shipping of these components and industrial production and extraction of raw materials needed for the production are also having a huge impact and are usually left understated.
- Third-order effects: as a result of the proliferated use of ICT in daily life, economic structures and their many outcomes still cannot be predicted, in spite of their indirectly manifestation the expression of first- and second-order effects.

Due to the fact that ICT plays on increasingly important role within the everyday societal behavior it is of the highest importance to accurately measure the performance of all sorts of electronic devices. This is especially important when all sorts of ICT networks are in question such as sensor networks since energy is a scarce resource. The factor of the biggest significance to be measured is energy consumption, and evaluation of abilities for reaching higher energy efficiency of hardware is crucial, as well as finding ways of producing more durable hardware and hardware with a longer life span as well as introducing protocols that will be less time consuming for the CPUs. Products and devices now commonly come embedded with their environment which at the point when energy circuits stop functioning demands disposal of the entire devices just because parts of them are not responding, leading to product replacement and then consequently to a marked increase in usage of new raw materials for making new products. In the long run the entire process demands a behavioral change as well as a change in terms of how we perceive ICT devices and how we address their further usage (Landsiedel et al., 2005).

4. DISSCUSION

The growing demand for electronic devices, especially mobile ones, will continue to exist in the future as well. Considering that such growth is a result of several aspects, how we as a society deal with that will be of utmost importance. The causes are various; on the one hand we have been witnessing the change of lifestyle worldwide where individuals used to be able to participate within social structures offline, without missing out on their social and economical wellbeing. Nowadays in western capitalist liberal societies it is almost unimaginable to fully be integrated into society, work environment, and maintain a culturally relevant information feed without constantly being online. This has caused and will continue to cause dependence on electronic devices. Simultaneously, within these cultures the exists a general dependence on electronic devices, home appliances, and especially CPU run platforms and computers which will only continue to rise. On the other hand we see that societies that haven't had that kind of early ICT influence proliferation are heading the same route.

As the number of devices will increase inevitably the issue that has to be addressed is how these devices will be powered, or more specifically from which sources the energy will be drawn. Regarding that the global energy demand is expected to increase significantly in the upcoming decades. Moreover, in a world with a growing resource scarcity the main question that comes up is the ability to utilise present resources more efficiently.

More efficient energy usage is definitely one of the prime environmental questions, shifting from traditional energy resources such as fossil fuels will decrease the global carbon footprint enormously, but that does not mean that the story ends there. Regarding the growing global population and the expected average number of electronic devices per capita even though shifting to alternative energy sources will help in fighting environmental degradation, hardly will it suffice as an isolated act. Additional steps are necessary. Although alternative energy sources are clean in comparison to fossil fuels, that doesn't mean they are stripped of all the negative environmental effects. Reaching energy efficiency on a micro level just might give the desired results on a global level.

5. **CONCLUSION**

In the end it has to be noted that with growing pollution levels resulting from the increase in resource exploitation for the sole purpose of generating energy for powering regular daily activities dependent on CPU run electronic devices has to be addressed.

There are two ways of addressing it that are predominant in literature. One is by addressing the sources of energy, while the other is by addressing the demand itself.
Addressing the demand itself is contingent on two factors as well. The first factor is advocating a change in behavioural habits by raising the awareness of the issue. The second, from the point of view of this paper, is that although some behavioural changes are possible the civilisation is hardly going back to acknowledging the offline mode. This means that energy efficiency of the observed devices will become the most important issue regarding the entire problem presented here.

It can be stated that individual improvements of computer systems can give desired results, but in order to achieve optimal efficiency a holistic approach to ICT has to be endorsed. This is the reason why many authors advocate, both hardware and software development which is more energy responsible. In terms of hardware it can be concluded that adjustable supply voltage and clock rate system protocols made simultaneously can lead to creating more energy efficient computer units. In terms of software, changing the energy demand is based on creating the software with operations that demand less processing time and are less display intensive while also combining the operations that can be done simultaneously.

Finally, for many years it was thought that in order to achieve everything mentioned above tradeoffs in terms of user satisfaction are necessary. It therefore has to be concluded that such tradeoffs in terms of user experience might have been the issue in earlier stages of ICT development when CPU units were much slower, and hardware in general less durable. Nowadays this isn't the issue any more and especially with further development of the entire branch such tradeoffs will become scarce if any.

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SELECTION OF EFFICIENT LOCATIONS FOR MEDICAL WASTES INCINERATION PLANTS

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Abstract: *The aim of this paper is to propose a methodology for selection of potential locations for facilities to incineration of medical waste. Medical waste is one special kind of hazardous wastes. If mishandled, it could cause disease spread and pollution of air and soil. The Republic of Serbia at the moment disposes medical waste on landfills or exports it to countries that have incineration facilities. Different factors can affect the selection of a suitable location for incineration facilities. These factors must be considered concurrently for the identification of efficient facilities locations. In this paper we use data envelopment analysis (DEA) as an approach for selection of locations for medical wastes incineration plants.*

Keywords*: medical waste, Incineration, data envelopment analysis (DEA), efficient locations, selection of district*

1. INTRODUCTION

National guide for safe medical waste management considers medical waste as every waste that originates from medical, dental, veterinarian, pharmaceutical or similar practices. This waste is a heterogeneous mix of simple garbage, infective waste, pathology and anatomy waste, pharmaceutical and laboratory waste, disinfectants and packaging, as well as radioactive and hazardous chemical waste. Medical waste may consist (partially or fully) of human or animal tissues, blood and other body fluids, secretion and excreta, medicines and other pharmaceutical products, swabs, cotton pads, gauze, bandages, needles, scalpels and other sharp instruments (Ministry of health of Republic of Serbia (MoH RS), 2008). In European catalogue, medical waste is registered under number 18 00 00 with subsets (SG, 2010a)

Until 2007 year, medical waste was sterilized in certain health institutions, most common in autoclaves that were very old. In health institutions, that were not able to sterilize medical waste, it was mixed with communal waste and disposed at city landfills (MoH RS, 2008). Ministry of health of Republic of Serbia together with the Ministry of agriculture and environmental protection, in the year 2007 started a project of "Technical support in medical waste management". Project was financed by the European Union, and in 72 medical centers, 78 autoclaves and shredders for medical waste sterilization were installed. Also, 25 vehicles for transport of medical waste were purchased, and conducted the training of workers for classification of generated medical waste. Apart from installed autoclaves and shredders for sterilization of medical waste, in the Republic of Serbia there are no modern facilities for medical waste treatment (SG, 2010b).

Hazardous medical waste that cannot be treated or disposed in an environmentally sound and efficient manner, due to the lack of technical capabilities and facilities in the Republic of Serbia, is being exported for treatment or disposal, in accordance with the law and regulations governing waste management, or international transport of waste (SG, 2010c).Trans boundary movements and disposal of medical waste is regulated by Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal (1989). The agreement implies that the only legitimate transportation of hazardous waste is exported from the countries that do not have waste treatment facilities or qualified staff for safe disposal of waste, to the countries that have such facilities (MoH RS, 2008).

Incineration (burning) is appropriate for the elimination of the majority of medical wastes including some types of chemical wastes except radioactive wastes. During the incineration process of medical wastes, they are converted into gas (CO_2, NO_2, CO and other gases) and ashes (MoH RS, 2008). Incineration plants are any stationary or mobile technical units where waste is incinerated with or without recovery of the heat produced by combustion. In the incineration plants, high temperature oxidation of the waste and other thermal processes are conducted (SG, 2012a).

The goal of this paper is to propose a methodology for selection of efficient locations for medical wastes incineration plants. The paper is organized as follows. After introduction part, sections 2 and 3 refer to the

problems of potential locations and selection criteria. Section 4 gives theoretical background about DEA method. Section 5 illustrate the proposed methodology in the case of the Republic of Serbia.

2. SELECTION OF THE DISTRICT FOR INCINERATION PLANTS FOR MEDICAL WASTE

In terms of administrative and territorial division, the Republic of Serbia is divided into provinces, regions, administrative areas, the City of Belgrade, cities and municipalities. The Republic of Serbia has 30 administrative areas, 24 cities, 30 urban municipalities, 150 municipalities, 6,158 villages and 193 urban settlements (Statistical Office of the Republic of Serbia, 2015).

Table 1: Regions per number of cities, population, area, population density, number of cities/municipalities with more than 40.000 residents (Statistical Office of the Republic of Serbia, 2015) and number of health institutions (MoH RS, 2016).

Region	Number of cities	Population	Area km^2	Population density per 1 km^2	Number of cities/municip. with more than 40.000 res.	Number of health institutions
Vojvodina	6	1 659 440	21 614	89,4	13	92
Beograd	1	1 931 809	3 234	513,1	17	54
Šumadija & Western Serbia	10	2 031 697	26 493	76,7	14	101
South & Eastern Serbia	6	1 563 916	26 248	59,6	12	93
Kosovo & Metohija	1	-	10 910	-	-	-

Considering that the region Šumadija and Western Serbia takes the central place in the Republic of Serbia, has the most registered health institutions, largest area, population and most of the cities, as well as most of the cities/municipalities with more than 40.000 residents, it is chosen as the region where it is needed to determine efficient locations for medical waste treatment. Region Šumadija and the Western Serbia is divided into 8 districts, and has 14 cities/municipalities with more then 40.000 residents (Statistical Office of the Republic of Serbia). Those cities are considered separately as possible efficient locations for medical waste treatment.

3. SELECTION OF EFFICIENT LOCATIONS

As the long term objective of the Strategy of Waste Management is to ensure the capacity for burning (incineration) of organic industrial and medical waste, it is necessary to make a choice of efficient locations (SG, 2010b). First, it is necessary to determine the region within which it is still necessary to allocate potential locations, as input for further analysis and the criteria by which the efficient location will be determined. A schematic procedure for the selection of efficient locations is shown in the figure 1.

The criteria for determining efficient locations within the region are:

- The amount of generated medical waste that needs to be transported to the determined location - in order to eliminate the potential risk of spillage of the medical waste during its transportation. It is necessary to choose a location that requires the least amount of transport of medical waste. The amount of waste for the location contains the total waste generated in all of the cities gravitating to the given city as the center of medical waste collection in the area;
- The duration of the transport from all other locations to the given location - the location is necessary to occupy the best position in order to provide connections to other locations, requiring the shortest time of transport;
- Air pollution - the environment is one of the dimensions that must be taken into consideration in choosing efficient locations. Since incineration of medical waste involves the creation of certain gases such as CO_2, NO_2, CO and other gases, it is necessary to choose locations that have the least air pollution, specifically have the lowest risk of crossing the permissible limits of pollutants;
- The unemployment rate - as the waste incineration plant, from its construction and operation, requires certain trained staff, the location with the highest unemployment rate should be chosen, in order to achieve better economic effects;
- The safety from natural disasters - as a consequence of natural disasters, damage can be great to the plant and may represent a danger for environmental pollution, due to danger of medical waste. It is necessary to look for a location with the highest safety for the environment in the case of a natural disaster.

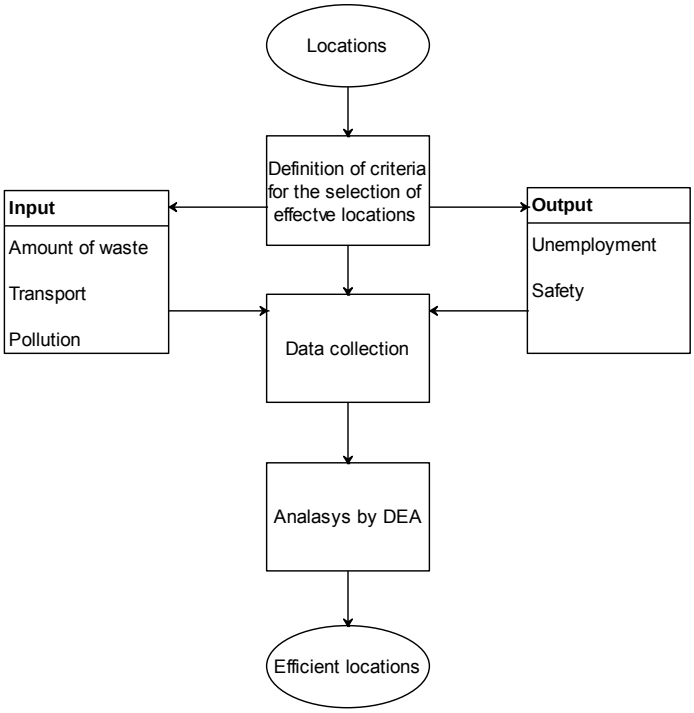

Figure 1: The process for selecting efficient locations

4. DEA

Data envelopment analysis (Charnes, Cooper, & Rhodes, 1978) was introduced for measuring relative efficiency of non-profit units, whose performance depends on multiple inputs and multiple outputs. These inputs and outputs are usually difficult to measure. Data envelopment analysis has lately received considerable attention in the construction of composite indicators. DEA can be defined as a linear programming technique used to find the optimal set of relative weights (u,v) that will give the highest possible efficiency ratio of outputs to inputs for the decision-making units (DMUs) being evaluated. Let us suppose that the following parameters are known:

n - number of DMUs

m - number of inputs

s - number of outputs

x_{ij} - known amount of i-th input of DMU$_j$ $(x_{ij} > 0, i = 1,2,...,m, j = 1,2,...,n)$,

y_{rj} –known amount of r-th output of DMU$_j$ $\left(y_{rj} > 0, r = 1,2,...,s, j = 1,2,...,n\right)$.

Having known parameters given above, Charnes, Cooper, and Rhodes (1978) formulated a mathematical model trying to maximize the relative efficiency h_k of DMU$_k$ (k=1,..,n) by optimizing weight of inputs v_i $(i = 1,...,m)$ and weight of outputs u_r $(r = 1,...,s)$. The calculation is more complicated if the model of fractional programming is used rather than the linear programming model. The linear model (1-4) and the dual linear program (5-8), corresponding to the model (1-4), are given below:

The linear model

$$(\max) h_k = \sum_{r=1}^{s} u_r y_{rk} \quad (1)$$

s.t.

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \quad (2)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1,2,\ldots,n \quad (3)$$

$$u_1,...,u_s \ge 0,\ v_1,...,v_m \ge 0 \quad (4)$$

Dual linear model

$$(\min) Z_k \quad (5)$$

s.t.

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rk},\ r = 1,...,s \quad (6)$$

$$Z_k x_{ik} - \sum_{j=1}^{n} \lambda_j x_{ij} \ge 0,\ i = 1,...,m \quad (7)$$

$$\lambda_j \ge 0,\ j = 1,...,n \quad (8)$$

In the model (1-4), DMU maximizes the virtual output under the constraint that its virtual input is equal to 1. The constraint given by eq. (3) indicates that the optimal weights for the DMU_k must satisfy the condition that the virtual output of each of *n* DMUs cannot be greater than its virtual input. If the objective function is equal to 1, then virtual outputs of all inefficient DMUs will be less than the virtual inputs. If the value of the objective function is less than 1, the efficiency reference set for DMU_k can be constituted. It consists of DMUs with virtual output equal to virtual input and it forms frontier for measuring the level of efficiency. As already mentioned, virtual inputs $\sum_{i=1}^{m} v_i x_{ik}$ and virtual outputs $\sum_{r=1}^{s} u_r y_{rk}$ of DMU_k, are calculated as the sum of the product of known inputs $x_{ik}, i=1,...,m$ (outputs $y_{rk}, r=1,...,s$) and assigned weights, considered as variables in the model (1-4). The model (1-3) should be solved *n*-times, once for each DMU.

The objective function (5) shows the efficiency level of DMU_k. Its value is the same as an objective function value of primal model (1-4). Dual variables, $\lambda_j, (j=1,...,n)$ show the importance that is assigned to DMU_j ($j=1,...,n$), in defining the input-output mix of a hypothetical composite unit (efficiency reference set). The observed DMU_k is directly compared to a hypothetical composite unit. If DEA tries to minimize Z_k of DMU_k and it cannot find $\lambda_j, j=1,...,n$ multipliers that will generate an efficiency level below 1 (100%), DMU_k is evaluated as a relatively efficient unit (Z_k=1). In such case, λ_k is the only multiplier with a value greater than 0 ($\lambda_j = 0,\ j=1,...,n,\ j \neq k$).

In the DEA literature, a number of approaches have been proposed to introduce additional restrictions on the values that the multipliers can assume.

$$\alpha_i \leq \frac{v_i}{v_{i_o}} \leq \beta_i,\ i=1,...,m$$

$$\delta_r \leq \frac{\mu_r}{\mu_{r_o}} \leq \gamma_r, r=1,...,s$$

Here, v_{i_o} and μ_{r_o} represent multipliers which serve as "numeraires" in establishing the upper and lower bounds represented here by α_i, β_i and by β_r, γ_r for the multipliers associated with inputs *i*= 1, …, *m* and outputs *r* = 1, …, *s* where $\alpha_{i_0} = \beta_{i_o} = \delta_{r_o} = \gamma_{r_o} = 1$. The above constraints are called Assurance Region (AR) constraints as in Thompson et al. (1990).

5. CASE STUDY

The chosen region of Šumadija and Western Serbia has 14 potential locations for incineration plants. The DEA method was applied for the selection of efficient locations. The criteria defined in Section 3 are used as DEA inputs and outputs. Every location has three inputs: quantity of transported waste, transport time and pollution of the sites and two outputs: the unemployment rate and safety of the sites from natural disasters.

5.1. Amount of waste (x_{1j})

In Serbia, there is no precise data about the amounts of medical waste in the health care institutions. In order to determine the amount of medical waste generated in a particular location, we use estimated number of beds at each location. In the hospitals in Serbia, there are 15,000 beds (c_{bed}), with an average occupancy of 72% ($c_{occup.}$), while the assessment is that one bed generates 0.7 kg of waste per day ($c_{waste.bed.}$) (SG, 2010b). The number of beds were calculated based on total population 7,186,862 ($c_{popul.}$) and the number of residents in each location ($c_{popul.,j}$), which represents the total population of all the cities/municipalities in the field belonging to a given location (Statistical Office of the Republic of Serbia). Using the notation and equations given below, the amounts of waste that needs to be transported from other locations to the given location were calculated and shown in Table 5.

p_j – number of beds in the j-th location

w_j – amount of waste in the j-th location

$$p_j = c_{bed} \frac{c_{popul.,j}}{c_{popul}}$$

$$w_j = p_j \cdot c_{occup.} \cdot c_{waste.bed}$$

$$x_{1j} = \sum_{i \neq j,\, j=1}^{n} w_i$$

5.2. Transportation time (x_{2j})

Medical waste must be transported by specialized vehicles with a capacity of transport equal to the net weight of 80 kg of waste (Institute of Public Health of Serbia "Dr Milan Jovanovic Batut"). The time required for transport from one location to another is shown in the table 2 (Google Maps). Using the following equations, we get the values shown in Table 5.

Table 2: Time of transport in minutes

Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Užice (1)	0	100	160	163	81	58	159	173	164	132	99	167	134	117
Valjevo (2)	100	0	86	63	83	107	163	177	195	164	130	218	81	128
Loznica (3)	160	86	0	64	168	192	200	214	242	251	217	304	167	208
Šabac (4)	163	63	64	0	127	151	154	168	195	209	175	263	119	162
Gornji Milanovac (5)	81	83	168	127	0	29	98	113	116	85	51	139	57	53
Čačak (6)	58	107	192	151	29	0	106	120	108	77	43	125	80	63
Jagodina (7)	159	163	200	154	98	106	0	34	62	82	106	195	94	50
Paraćin (8)	173	177	214	168	113	120	34	0	45	71	104	182	105	60
Kruševac (9)	164	195	242	195	116	108	62	45	0	36	70	148	133	88
Trstenik (10)	132	164	251	209	85	77	82	71	36	0	38	132	126	70
Kraljevo (11)	99	130	217	175	51	43	106	104	70	38	0	101	107	59
Novi Pazar (12)	167	218	304	263	139	125	195	182	148	132	101	0	191	147
AranĐelovac (13)	134	81	167	119	57	80	94	105	133	126	107	191	0	60
Kragujevac (14)	117	128	208	162	53	63	50	60	88	70	59	147	60	0

z_j – the number of vehicles for the waste transport from j – th location

q – the capacity of vehicles

d_{jk} – the time required for transport from j – th to k – th location

$$z_j = \frac{|\, w_j \,|}{q}$$

$$x_{2j} = \sum_{j=1}^{n} z_j d_{jk}, k = 1, \ldots, n$$

5.3. Pollution (x_{3j})

Because of the lack of data about pollution at each location for each pollutant, the pollutants that we were observed are SO_2, NO_2 and CO. Emission of polluting substances by locations are shown in Table 3. Data marked with (i), (ii), (iii) and (iv) are taken from the Annual air quality report in the Republic of Serbia for 2014, 2013, 2012, 2011 (Ministry of Agriculture and Environmental Protection, 2014; 2013; 2012; 2011). Other data was evaluated by using available data about the emission of pollutants by one company and the number of companies at the appropriate location. The input data for this criterion is based on annual average emissions. Categories of air quality indicate whether the pollutant exceeds a limit value or reaches a tolerance value (Ministry of Agriculture and Environmental Protection, 2014). Air quality indicator for each pollutant was determined as percentage of the corresponding limit value. Then, maximal value of air quality indicator among all pollutant was assigned to each location, because they carry the highest risk of crossing the limit (threshold) values. Input data of pollution are shown in Table 5.

A – set of pollutants

g_{aj} – average annual emission of a-th pollutants in j-th location, $a \in A$

t_a – limit value for emission a-th pollutants in j-th location, $a \in A$

$$x_{3j} = \max_a \left(\frac{g_{aj}}{t_a} \right)$$

Table 3: The annual average emission of pollutants

Location	SO_2 μg / m^3	NO_2 μg / m^3	CO mg / m^3
Užice	6,50[i]	32,20[i]	1,65[i]
Valjevo	17,30[i]	21,70[i]	1,69[i]
Loznica	21,60[iii]	23,90[iv]	0,60[i]
Šabac	30,10[III]	19,60[I]	1,35[I]
Gornji Milanovac	5,55	9,62	0,44
Čačak	8,10[i]	8,80[i]	1,27[i]
Jagodina	7,51	13,01	0,60
Paraćin	13,00[ii]	26,70[ii]	0,60[ii]
Kruševac	12,80[ii]	15,10[ii]	1,30[i]
Trstenik	5,23	9,05	0,42
Kraljevo	5,60[i]	35,10[III]	0,50[III]
Novi Pazar	6,21	10,75	0,49
AranĐelovac	5,55	9,62	0,44
Kragujevac	14,10[iii]	26,90[ii]	0,60[ii]
Limit value	50[i]	40[i]	3[i]

5.4. Unemployment (y_{1j})

The unemployment rate is the number of unemployed people ($c_{unemp..,j}$) as a percentage of the labour force ($c_{lab.force..,j}$) (Statistical Office of the Republic of Serbia). The value of this output is shown in Table 5. The equation used for calculating these values is following:

$$y_{1j} = \frac{c_{unemp.,j}}{c_{lab.force.,j}}$$

5.5. Safety (y_{2j})

Safety was observed as the probability that some natural disaster in observed location does not happen. The main natural disasters in Serbia are earthquakes, floods, landslides and forest fires. For the territory of each location, a number of risk points from certain natural disasters was determined by using the map of risk of natural disasters (Emergency management sector). The number of risk points is shown in the table 4.

Table 4. Number of risk points in the city / municipality

Location	Earthquakes	Floods	Landslides	Fires
Užice			6	2
Valjevo		2	2	3
Loznica	1	1		1
Šabac		2	1	1
Gornji Milanovac	1	1	1	2
Čačak		1	1	2
Jagodina		2	2	2
Paraćin				
Kruševac		4	2	
Trstenik	1		3	
Kraljevo		2	3	3
Novi Pazar		2	1	2
AranĐelovac		1		2
Kragujevac	1	1	1	2

The probability of occurrence of earthquakes, floods, landslides and fires are 0.0971, 0.7734, 0.0288 and 0.1007, respectively (e_b). These values were determined on the basis of the evidence for the territory of Europe (International Federation of Red Cross and Red Crescent Societies). Notation and equation for obtaining values for this output are given below, while the final values are shown in Table 5.

B – set of natural disasters

f_{bj} – number of risk points from b-th natural disasters in the j-th location

$$y_{2j} = 1 - \frac{\sum_{b} f_{bj} e_b}{\sum_{j=1}^{n} \sum_{b} f_{bj} e_b}$$

5.6. Result analysis

Based on previously presented calculations, the values of defined inputs and outputs are obtained (Table 5).

Table 5: The values of inputs and outputs

Location	Inputs			Outputs	
	Amount of waste	Transport time	Pollution	Unemployment	Safety
Užice	5017,73	9291	0,805	0,1894	0,9792
Valjevo	5339,86	9749	0,56333	0,1724	0,8939
Loznica	5486,32	14292	0,5975	0,3322	0,9459
Šabac	5337,43	11742	0,602	0,2126	0,9067
Gornji Milanovac	5713,94	7201	0,24044	0,1534	0,9387
Čačak	5358,02	7274	0,42333	0,1994	0,9441
Jagodina	5468,85	9260	0,3253	0,2634	0,8995
Paraćin	5597,55	9723	0,6675	0,2768	1,0000
Kruševac	5316,27	9829	0,43333	0,3006	0,8246
Trstenik	5671,17	9001	0,2263	0,2094	0,9898
Kraljevo	5401,67	7720	0,8775	0,2241	0,8922
Novi Pazar	5392,39	13514	0,26873	0,3687	0,9011
AranĐelovac	5644,52	8910	0,24044	0,2439	0,9457
Kragujevac	5195,4	7636	0,6725	0,2829	0,9387

DEA CCR model was solved without limit of weights and with (AR) limit of weight for the transport, which must be higher or equal to the weight for the amount of waste and pollution. The resulting efficiency and ranks of each location are shown in Table 6. In the first case seven efficient location were obtained (Užice, Gornji Milanovac, Čačak, Trstenik, Novi Pazar, AranĐelovac and Kragujevac), while in the second case three efficient locations were obtained (Gornji Milanovac, Čačak and Kragujevac). The minimum efficiency is 0.9012 (Valjevo) in the first and 0.7142 (Šabac) in the second case. Average efficiency for the first and second case is 0.9778 and 0.8849, respectively. In DEA CCR-AR model, we note that these limitations contribute significantly less to the average and the minimum efficiency, resulting that some locations have become inefficient or have significantly lower efficiency. Based on obtained results, Gornji Milanovac, Čačak and Kragujevac can be considered efficient locations for medical wastes incineration plants.

Table 6. Efficiency and ranks of each location

Location	CCR model		CCR- AR model	
	Efficiency	Rank	Efficiency	Rank
Užice	1	1	0,9156	5
Valjevo	0,9012	14	0,7926	12
Loznica	0,9901	9	0,7618	13
Šabac	0,917	13	0,7142	14
Gornji Milanovac	1	1	1	1
Čačak	1	1	1	1
Jagodina	0,9832	10	0,8331	11
Paraćin	0,9804	11	0,8871	8
Kruševac	0,9945	8	0,9000	7
Trstenik	1	1	0,9027	6
Kraljevo	0,9225	12	0,9185	4
Novi Pazar	1	1	0,8843	9
AranĐelovac	1	1	0,8792	10
Kragujevac	1	1	1	1

6. CONCLUSION

Improper disposal of medical waste carries great risks for the pollution of the environment. Therefore, the Republic of Serbia should focus on the issue of its treatment. Since current medical waste treatment is based on sterilization and fragmentation, then disposal in a landfill, or export, construction of incinerators is certainly

necessary. Locations in which possible adequate treatment of medical waste having incinerator is possible, should meet a variety of environmental, social, economic and technical criteria. In this paper, the quantity of waste, time of transport, pollution, unemployment and safety in case of natural disasters were observed as criteria for the selection of efficient locations. By using these criteria as DEA input and output, we have obtained efficient locations for the construction of such a plant. Analysis was performed in accordance to the CCR model, and CCR model with restrictions on weight. In the first case, the result indicates seven efficient locations, while the second case recommends three efficient locations. It is possible to perform further analysis in order to allocate one efficient location by solving optimal location problem or by application of super efficiency. A choice of efficient locations for incineration of medical waste can contribute to better management of medical waste in the territories of the Republic of Serbia.

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SUSTAINABILITY OF THE FASHION INDUSTRY: HOW DOES THE YOUTH FEEL

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Abstract: *The 21st century is characterized by an ever-growing concern over environmental problems, which is present through all human life and activities. This results in "louder" and stronger demands from environmentally aware consumers for environmentally friendly and "green" products. Therefore, it is no wonder that the fashion industry had to abide to these demands, answering them with new concepts of sustainable or so-called "slow fashion", which as its result lowers the negative impact of fashion on the environment. Other than concepts of sustainable fashion, in this paper we showed the results of a research based on the case study of sustainability of the international fashion company H&M, and the youth's opinion and attitudes on the company's sustainability practices and the sustainability of the fashion industry as well. An analysis of the results was carried out using the SPSS 22 software package.*

Keywords*: sustainability, fashion industry, sustainable fashion, slow fashion, youth, H&M*

1. INTRODUCTION

The fashion industry has gone through a lot of changes, with the most significant ones in the last 20 years, when the boarders of the industry started shifting (Djelic & Ainamo, 1999). Since then, the changes in the dynamic of the fashion industry, such as the fading of the mass production, increased number of fashion seasons, as well as modified structural characteristics of the supply chain, drove the sellers to strive to reduce their costs and achieve the flexibility of design, quality, delivery and speed of entering the market (Doyle, Moore, & Morgan, 2006).

Today's fashion market is highly competitive and the constant need for new products caused the inevitable step by the manufacturers – increased number of seasons, i.e. higher frequency of coming out with new and "fresh" products. This implies a shorter life cycle and bigger sales profit (Sydney, 2008). In addition, the desire for variety and instant gratification of needs, with the knowledge of prices and the market by customers, has led customers to prefer brands such as Zara and H&M (National Post, 2009). Several studies have observed the various aspects of the relationship buyer-producer through "fast fashion", aspects such as the design of the garment in relation to the fast response of the manufacturers (Forza & Vinelli, 1996), the role of the supplier in the rapidly changing industry (Doyle, Moore, & Morgan, 2006), consumer behaviour (Bruce, & Daly, 2006) and financial performance (Hayes & Jones, 2006). However, it seems that there is discord in the literature concerning the concept of "fast fashion" among studies of this type of fashion, because only a few focused on the aspects that concern consumers and what actually steers those changes in the fashion industry (Barnes & Lea-Greenwood, 2006).

Innovations that occur at the intersection of the fashion and technology industries are amazing and transformative. In many cases, the fashion industry today resembles nothing like the one of a decade ago, and will change more in the next decade. One of rising trends in the fashion industry is certainly the rise of sustainable fashion. The fashion industry realizes we cannot continue this trend of polluting the planet, and has slowly started the road towards more sustainable fashion which includes a total rethink of how many clothes we really need in our closets, more recycling and reduction of the use of pollutants.

2. SUSTAINABILITY AND FASHION INDUSTRY

"Second to oil, fashion and textiles is the most polluting industry in the world. Every stage in a garment's life threatens our planet and its resources. It can take more than 20,000 liters of water to produce 1kg of cotton, equivalent to a single t-shirt and pair of jeans. Up to 8,000 different chemicals are used to turn raw materials into clothes, including a range of dyeing and finishing processes." (BOF, 2016)

On the other hand, “over the past decade, sustainability and ethical conduct have begun to matter in fashion (Emberley, 1998; Moisander & Personen, 2002); companies have realized that affordable and trend-sensitive fashion, while typically highly profitable, also raises ethical issues” (Aspers & Skov, 2006; Joy, Sherry Jr, Venkatesh, Wang & Chan, 2012). Sustainability represents a primary issue of the 21st century and is often in relation to corporate social responsibility (Aguilera, Rupp, Williams, & Ganapathi, 2007).

When it comes to sustainability, it should be noted that there is no single accepted definition, although this term is usually associated with the following three interpretations:

- Sustainability refers to those activities that can last endlessly without casein damage to the environment (Fletcher, 2008).
- Sustainability presents not doing to others what we do not want done to us (Partridge, 2011).
- Sustainability presents satisfying the needs of present generations without comprising the future generations’ abilities to satisfy their needs (WCED, 1987).

None the less, the most comprehensive definition was the one by (2007): “Sustainability is about much more than our relationship with the environment; it’s about our relationship with ourselves, our communities, and our institutions.”

We can conclude that sustainable fashion, supports living harmoniously with nature, employs trained artisans in safe and humane working conditions (Partridge, 2011). Also, sustainable fashion “demands a new way of thinking, which involves slowing down fashion cycles, understanding why and how a garment is made, seeking workable solutions in an era of urgency and crisis and redefine our scholarly approach to issues related to dress, body, and culture” (Root, 2009).

Considering all the above, it can be concluded that “fast fashion” is by no means sustainable since it is distinguished by cheap materials that have a harmful impact on the environment, as well as very short life cycle of its products, which quickly leads to the stage of waste if not recycled. Therefore, many authors are calling sustainable fashion – “slow fashion” (Clark, 2009; Fletcher, 2008; Patel & Davidson, 2003; Patel & Tebelius, 1987; Tran, 2008), as a logical name that is the opposite of fast fashion, bearing in mind that “slow fashion” is characterized by sustainable production and consumption, eco design, waste management, recycling and reusing, connected with quality, environmental awareness and balance, as well as something durable and made from recycled or organic materials (Holt, 2009). The issues of “slow fashion” are making garments that last longer in such material and style with the philosophy: less, but of the best. That is how “slow fashion” perfectly coincides with the concept of sustainable consumption.

3. THE RESEARCH

In order to provide a highlight of sustainability in the fashion industry, which became the main problem of this industry in the previous couple of years, partly thanks to Andrew Morgan’s documentary “The True Cost” and the launch of the H&M Conscious program and the recycling program, the poster will feature the case study of the company H&M. The showed case study is dealing with the practices of sustainability of this company, as well is its contribution to the Sustainability Report 2014 (H&M, 2016a; H&M, 2016b).

3.1. Methodology

In order to provide an overview of how much the younger generation exactly is familiar with the sustainability of fashion, and whether it is important to them, the authors of the paper surveyed their colleagues from the University of Belgrade – Faculty of Organizational Sciences, Serbia on their attitudes on the sustainability of the fashion industry. An analysis of the results was carried out using the SPSS 22 software package. This research featured 321 participants (out of which 206 participants were female and 115 were male).

3.2. Results

Turning fashion into a more sustainable industry “remains an uphill battle, with plenty of technological, systematic, and business struggles to overcome” (Vogue, 2016). At Glasgow Caledonian University, New York, Simon Collins, former dean of the Fashion School at Parson’s New School for Design, and Julie Gilhart, respected freelance fashion consultant, discussed some of these issues in their second “Fashion Garage” event conversation, giving free advice to young designers, with the focus of the most recent one being on making the production more environmentally friendly:

1. The product should always come first.
2. Use social media to your benefit.
3. Accept that consumer shopping habits won't change.
4. Focus on materials.
5. Vote with your wallet.

Having in mind all of this, the sustainable organization of H&M and their road to sustainability is commendable, and is characterized by (H&M, 2016b):

- *Conscious materials for a more sustainable fashion future* – the use of organic natural and recycled materials.
- *Cotton* – organic and recycled cotton. The company H&M is one of the leading users of organic cotton in the world.
- *Water* – promotion of responsible use of water along the product's lifecycle, from how cotton farmers water their crops, to how customers wash their clothes. The World Economic Forum states the water crisis as the risk with the biggest global impact. The H&M's partnership with WWF is ground-breaking – the water stewardship strategy goes far beyond the factory lines.
- *A fair living wage to garment workers* – responsible partners, working conditions, commitments, protecting childhood.
- *Animal welfare* – improving of the animal welfare in the supply chain, from involvement to education and training of suppliers and farmers.
- *Less use of planet's resources.*
- *Garment collecting* - changing the way of make, use and dispose of clothes. Of the thousands of tonnes of textiles that people throw away every year, as much as 95% could be re-worn or recycled.
- *Business concept* - fashion and quality at the best price in a sustainable way.

In order to evaluate the familiarity of the participants with the sustainability practices and actions, after a set of general questions, the following questions the participants marked on a rating scale from 1 to 5, based on the truthfulness of the statement, and we calculated the percentage of them that answered positively to these questions either with a 4 (I agree) or a 5 (I absolutely agree). The results based on the answers given by participants to our eight questions are shown in the Table 1.

Table 1: The results on the poll, featuring the questions on sustainability of the fashion industry

Question	Participants with positive attitudes toward sustainability in the fashion industry [%]
1. "When I buy clothes, I think of the way it was manufactured"	33.4
2. "If I knew that the workers that made the garment were treated poorly, it would make me rethink of buying the product"	96.7
3. "I believe that the fashion industry pollutes the environment"	86.4
4. "If I knew that the company was environmentally friendly, I would feel better about buying the product even if it was more expensive"	64.5
5. "I own clothes labelled as environmentally friendly"	46.7
6. "I know that H&M is environmentally friendly"	89.8
7. "I have participated in the H&M recycling program"	24.3
8. "I believe that the sustainability of the fashion industry is important"	93.4

4. DISCUSSION AND CONCLUSION

Having in mind that 2 billions of poisonous pesticides are used each year for farming the cotton meant for the textile industry – more than for any other agriculture crop and the fact that textile industry uses more water than any other branch of industry (except agriculture), and the amount of pesticides that get released into the

air during the production of the cotton necessary for the textile industry each year represents 16 percent of the total global amount of insecticides, for these reasons, we can see the importance of good sustainable practices of the company and brand H&M i.e. Hennes&Mauritz, which showed that you can have both a profitable business and a sustainable one with these following “green consequences”:

- Better for the Earth.
- Better for people.
- Better for animals.
- Lasts longer.
- Easier and cheaper.
- Organic.

The results gained from our research show that even though at the first moment, the unaware youth does not think of the consequences and the background of the items they shop for (only 33.4 percent of the younger generation thinks about the way a garment was manufactured), as soon as the implications of their actions are brought to their attention, it is easy to change their mind (96.7 percent claims that if they knew that the workers were treated poorly it would make them rethink the purchase).

In addition, the participants showed that sustainability and environmentally friendly aspect of the manufacturing process does play a role in their shopping, as long as the price is still in their price range (64.5 percent of the participants said that if they knew that the product is environmentally friendly they would buy it even if it was more expensive).

Also, from our research, we can clearly see that the marketing campaign and the advertisement of a sustainable organization and its sustainability actions is very important, and that a good example of a this is precisely the one followed by H&M, because 89.8 percent of the participants of this research said that they are aware of the fact that this company is environmentally friendly.

However, our research has showed that this campaign still has to be worked on further because only a small number of students surveyed (24.3 percent) has actually participated in the H&M recycling program, while only 46.7 percent of the students owns environmentally friendly clothes.

Lastly one of the main goals of this research was to show that the younger buyers do care about sustainability of the fashion industry, and in that we have succeeded – 93.4 percent of the participants agree.

Fashion itself, shoes, dresses, suits and skirts, may seem irrelevant when compared to the real problems mankind is facing everyday in the 21st century such as: climate change, nuclear catastrophes, wars, poverty, and lack of drinkable water, disease and hunger. But when we take in concern the fact that the fashion industry around the world employs millions of people (from the fashion company workers, to models, photographers, journalists and retail store clerks), and that fashion is an unavoidable part of our everyday lives, ignoring the social and environmental impact of this industry would be very negligible on our part.

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THE ATTITUDES OF ENVIRONMENTALLY EDUCATED STUDENTS ABOUT A NEW GLOBAL DEVELOPMENT AGENDA

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Abstract: *The aim of this paper is to shine light on the attitudes of environmentally educated postgraduate students about a new development agenda – 2030 agenda for sustainable development, and its 17 urgent goals. In order to evaluate postgraduate students' attitudes the authors used the Delphi method. The usage of the Delphi method is suggested having in mind that a lot of authors agree that this method has high applicability for sustainability foresight, as well having in mind the fact that it is one of the best-known qualitative methods of forecasting in the long run, especially when quantitative methods are not adequate, as it happened in this case.*

Keywords*: environmentally educated students, a new global development agenda, postgraduate students' attitudes, delphi method*

1. INTRODUCTION

Today, the environmental education represents a necessary education to shape a sustainable future. This means that the environmental education must include key sustainable development issues into the curriculum of the subject, with clear goals in order to motivate the student not only to learn, but to change their attitudes, behaviour and take environmental actions for sustainable development (UNESCO, 2016).

In light of the above, the authors of the paper chose to do their research on how environmentally educated students value goals of a new global development agenda.

For the panel group the authors chose postgraduate students enrolled at the Management of Environmental Protection course at the University of Ljubljana – Faculty of Administration, the Republic of Slovenia. For the purpose of this research the authors used the Delphi method for measuring students' attitudes about 17 sustainable development goals of a new global development agenda – 2030 Agenda for Sustainable Development.

2. A NEW GLOBAL DEVELOPMENT AGENDA – THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

Sustainable development (SD) has been discussed extensively in the theoretical literature since the concept was adopted as an overarching goal of economic and social development by UN agencies, by the Agenda 21 nations, and by many local governments and private-sector actors (WCED, 1987). The literature includes many alternative theoretical and applied definitions of sustainable development. The theoretical work spans hundreds of studies that are based on economic theory, complex systems approaches, ecological science and other approaches that derive conditions for how development paths can meet SD criteria (IPCC, 2007).

Several definitions have been presented to describe the principle of sustainable development; the most frequently quoted being the one presented in the Brundtland Report (Brundtland, 1987). According to this report sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It contains within it two key concepts:

- the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

More operational principles of sustainability were presented by the former Chief Economist for the World Bank, Herman E. Daly. These principles are known as Daly's rules and they define the condition of ecological sustainability:

- renewable resources such as fish, soil, and groundwater must be used no faster than the rate at which they regenerate;

- non-renewable resources such as minerals and fossil fuels must be used no faster than renewable substitutes for them can be put into place; and
- pollution and wastes must be emitted no faster than natural systems can absorb them, recycle them, or render them harmless (Smith, 2010).

The General Assembly of the United Nations adopted the new resolution on 25th September of 2015. This resolution is a new sustainable development agenda for the period of 2015-2030: Transforming our world: the 2030 Agenda for Sustainable Development: "The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what they did not achieve. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental." (UN, 2015)

The 17 Sustainable development goals are (UN, 2015):

- Goal 1: End poverty in all its forms everywhere.
- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3: Ensure healthy lives and promote well-being for all at all ages.
- Goal 4: Ensure inclusive and quality education for all and promote lifelong learning.
- Goal 5: Achieve gender equality and empower all women and girls.
- Goal 6: Ensure access to water and sanitation for all.
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all.
- Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation.
- Goal 10: Reduce inequality within and among countries.
- Goal 11: Make cities inclusive, safe, resilient and sustainable.
- Goal 12: Ensure sustainable consumption and production patterns.
- Goal 13: Take urgent action to combat climate change and its impacts.
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources.
- Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
- Goal 16: Promote just, peaceful and inclusive societies.
- Goal 17: Revitalize the global partnership for sustainable development.

3. DELPHI METHOD

Technology forecasting in developed countries is a process focused on recognizing critical generic technologies, and most likely it will exert great influence on economic, environmental, and social development in general. However, for underdeveloped and developing countries, the role of technology forecasting is of great importance for identifying technology niches – technology domains in which it is possible to accomplish a competitive position on the world market (Albright, 2002). Technology forecasting began to play an important role in companies' strategic planning, as well as in their race for comparative advantage. Technology forecasts use different methods among which is the Delphi method that presents one of the most widespread methods for intuitive forecasting.

Delphi method is the most commonly known forecasting method that is based on series of written questionnaires with feedback and re-voting (Popper, 2008). There are two participant roles: the design group (sometimes just one person) that makes the questionnaires and the consensus of the expert group, and the expert group – a panel that answers the questionnaires. The members of the panel do not meet face-to-face; they are characterized by three important conditions: anonymity, iteration with controlled feedback, and statistical response. This is not an opinion survey, but rather, a way of systematically finding out and summarizing expert judgment in successive rounds of the Delphi forecasts (Mullen, 2003).

Despite some limitations, it has been recommended that studies employing the Delphi should be continued in order to further refine the technique and to explore its application. The first idea for applying the Delphi method in forecasting events in education came from the article "The Delphi Technique: A Possible Tool for Predicting Future Events in Nursing Education" by Bramwell L. and Hykawy E. in which the authors have presented the potential use of the Delphi method in this area (Bramwell & Hykawy, 1999). Despite the limitations they indicated, one suggestion supported by the panellist in the study was important, which is of special interest for the society in transition. They have suggested that the Delphi method seemed to have

promising application as a tool for teaching people to think and discuss about the future in a more complex way than they ordinarily would.

The Delphi method is one of the best-known qualitative methods of forecasting in the long run, especially when quantitative methods are not adequate. It is applied for forecasting the probability and time of the emergence of future events. In order to give a prognosis, a group of experts identifies and defines the given event, the probability of its development and possible time of future event. Delphi method is also important because of the impartiality of participants bearing in mind that opinions and presumptions of forecasting experts are based on collecting data through polls, i.e. on filling out the questionnaires. Experts fill out questionnaires independently of each other, which gives this method the impartial character when it comes to judgment (Makridakis, Wheelwright, Hyndman, & 1998).

The Delphi method is an attractive method for graduate students completing masters and PhD level research. It is a flexible research technique that has been successfully used in our paper to explain Postgraduate Students' Attitudes about Sustainable Development Goals. Delphi studies have been useful in educational settings in forming guidelines, standards, and in predicting trends (Skulmoski & Hartman, 2007). The Delphi method works especially well when the goal is to improve our understanding of problems, opportunities, solutions, or to develop forecasts.

Delphi studies have been useful in educational settings in forming guidelines, standards, and in predicting trends. The Delphi Technique will be useful for educators in developing curricula and learning experiences to prepare our students for future careers. Delphi studies are extremely useful for collecting data from students and alumni regarding the curriculum, and information science trends, and funding (Green, 2014).

4. POSTGRADUATE STUDENTS' ATTITUDES ABOUT SUSTAINABLE DEVELOPMENT GOALS – A CASE STUDY

For our research we chose the students of the University of Ljubljana – Faculty of Administration, which have in the November of 2014/2015 school year attended the course Management of Environmental Protection, and which joined the research only when they have successfully finished the course.

At this course, a framework and a curriculum for good environmental higher education are developed on a wide scale of scientific and practical knowledge of environmental science and sustainable development as a good benchmark for the adequate improvement of students' knowledge at postgraduate level, as well as a promotion of higher order thinking skills in a cooperative context for learning and evaluation (Petrovic et al., 2014). Having this in mind, the curriculum of this subject accents the following topics: the resources of the Earth, particularly soil, water, minerals, etc., the implications of the resource distribution in determining the nature of societies and the rate and character of economic development, the role of science and technology in the development of societies and the impact of these technologies on environment, cooperative international and national efforts to find solutions to common global issues, and to implement strategies for a more sustainable future, processes of planning, policy-making and action for sustainability by governments, businesses, non-governmental organizations and the public (NAAEE, 1996; Petrović, 2012; FOS, 2016).

4.1. Methodology

In this paper, we discussed the application of the Delphi method in evaluation of postgraduate students' attitudes about 17 sustainable development goals of a new global development agenda by using a five point scale (1 – *the most significant*, 2 – *very significant*, 3 – *significant*, 4 – *not so significant*, 5 – *the least significant/insignificant*).

We suggested the use of the Delphi method, having in mind that Bramwell and Hykawy (1999) have suggested that the Delphi method seemed to have promising application as a tool for teaching people to think and discuss about the future in a more complex way than they ordinarily would. It can be concluded that this method has high applicability for sustainability foresight, as well as it is one of the best-known qualitative methods of forecasting in the long run, especially when quantitative methods are not adequate, as it happened in this case.

4.2. Instruments

In order to evaluate the results of the questionnaire, we used statistical analysis for calculation of the arithmetic mean rating, variance and standard deviation:

- Calculation of the arithmetic mean rating (t_n) was made using the following equation :

$$t_n = \frac{1}{n}\sum_{i=1}^{k} f_i \cdot t_i \quad (1)$$

where k is the number of different rating scores, f_i is a number of experts that evaluated observed item with rating score t_i, and n represents the total number of experts ($n = \sum_{i=1}^{k} f_i$).

- Calculation the variance and standard deviation were made using the following equations:

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{k} f_i t_i^{\,2} - t_n^{\,2} \quad (2)$$

$$\sigma_n = \sqrt{\sigma_n^2} \quad (3)$$

where $\sigma_n^{\,2}$ is variance and σ_n is standard deviation.

5. RESULTS AND DISCUSSION

After calculating the results of students from the first questionnaire, arithmetic mean and variance were calculated. Summarized results of the first questionnaire are given in Table 1. As a significant agreement in responses has been detected, the second round of questioning was not necessary.

Table 1: The results of the first questionnaire

No.	Sustainable development goals	Arithmetic mean (t_n)	Variance (σ^2_n)
1.	End poverty in all its forms everywhere	1.47	0.77
2.	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	1.13	0.25
3.	Ensure healthy lives and promote well-being for all at all ages	1.6	0.91
4.	Ensure inclusive and quality education for all and promote lifelong learning	1.93	0.61
5.	Achieve gender equality and empower all women and girls	2.13	0.79
6.	Ensure access to water and sanitation for all	1.13	0.12
7.	Ensure access to affordable, reliable, sustainable and modern energy for all	1.67	0.48
8.	Promote inclusive and sustainable economic growth, employment and decent work for all	1.67	0.48
9.	Build resilient infrastructure, promote sustainable industrialization and foster innovation	2.33	0.90
10.	Reduce inequality within and among countries	2.20	0.96
11.	Make cities inclusive, safe, resilient and sustainable	2	0.67
12.	Ensure sustainable consumption and production patterns	2.27	0.58
13.	Take urgent action to combat climate change and its impacts	1.87	0.50
14.	Conserve and sustainably use the oceans, seas and marine resources	1.67	0.48

15.	Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss	1.73	0.60
16.	Promote just, peaceful and inclusive societies	2.13	0.53
17.	Revitalize the global partnership for sustainable development	2.27	0.58

Based on the responses gathered, we can conclude that, in the opinion of the respondents, the most important goals of sustainable development are to:

1. Ensure access to water and sanitation for all – with the arithmetic mean of 1.13, and variance of 0.12 which is more than a good mark and shows a fair compliance when it comes to the students' attitude.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture – with the arithmetic mean of 1.13, and variance of 0.25 which again shows the same complient attitudes as before.
3. The third place “share” the following goals - to ensure access to affordable, reliable, sustainable and modern energy for all and to promote inclusive and sustainable economic growth, employment and decent work for all and to conserve and sustainably use the oceans, seas and marine resources – with their arithmetic mean being 1.67, their variance 0.48, which are excelent marks and present a fair compliance between the students.

6. CONCLUSION

The key aim of the research presented in this paper has been to provide an idea of implementing the Delphi method in evaluating environmentally educated postgraduate students’ attitudes about a new global development agenda and sustainable development goals, and proving that the Delphi method could be a good tool for the measurement of environmental education and the education for sustainable development achievements as well.

Gained results from our research pointed out that this kind of use of the Delphi method can provide good results having in mind that the results gathered, not only show a compliance in the students' responses, which speaks of the good background knowledge they gained during their studies at the course of Management of Environmental Protection, but also that the Delphi method can be used for further analysis of the reasons behind their assigning high marks to specific goals of sustainable development, which depicts the image of the students' attitudes towards these goals.

A more in depth analysis of these results demands a larger number of respondents, and not students from only one university, but instead conducting a broader and more detailed research, which should be a possible direction of future research, especially when having in mind that “a basic premise of education for sustainability is that just as there is a wholeness and interdependence to life in all its forms, so must there be a unity and wholeness to efforts to understand it and ensure its continuation” (UNESCO, 2012).

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