3rd International Conference
″New Functional Materials and High Technology″
NFMaHT-2015
29-30 June 2015, Tivat, Montenegro

SOCIO-ECONOMIC ASPECT OF HAZARDOUS CHEMICALS ENVIRONMENTAL IMPACTS

Zvonko Brnjaš[1], Marijana Ćurčić[2], Predrag Dedeić[3]
[1] Institute of Economic Science, Belgrade, SERBIJA, e-mail: zvonko.brnjas@ien.bg.ac.rs
[2] University of Belgrade, Faculty of Pharmacy, Belgrade, SERBIA, e-mail: makitoxcurcic@gmail.com
[3] Belgrade Banking Academy, Belgrade, SERBIA, e-mail: predrag.dedeic@bba.edu.rs

Summary: *The paper deals with the issue of analysis and assessment of the socio-economic impacts of environmental pollution by the hazardous chemicals. Special emphasis was placed on the effects of pollution from specific groups of dangerous chemicals known as persistent organic pollutants, e.g. POPs chemicals. The characteristics of POPs, including persistence, bioaccumulation and high toxicity, are making the environmental impacts of these chemicals particularly complex and dangerous. The process of socio-economic analysis of hazardous chemicals impacts includes identifying anthropogenic activities which include dangerous chemicals; analysis their adverse effects on the environment and assessing their impacts. Number of methods and indicators for measuring of those impacts are developed in order to quantify and when possible monetize them.*

Keywords: *hazardous chemicals, persistent organic pollutant (POPs), ecological accidents, socio-economic impacts, socio-economic assessment.*

1. SOCIO-ECONOMIC IMPACTS OF HAZARDOUS CHEMICALS ENVIRONMENTAL CONTAMINATION

One of the greatest problems that the world is facing today is that of environmental contamination, increasing with every passing year and causing grave and damage to the earth. Environmental contamination consists of five basic types of pollution, namely, air, water, soil, noise and light. The scientific discipline that is dealing with the environmental contamination is ecology, specifically ecotoxicology. Namely, ecotoxicology exams the adverse effects of chemicals on the environment. We have experienced number of global ecological disasters, which unavoidably led to misbalance in eco systems and had as a consequence very negative impact on the human health [9, 11-13, 15].
In ecotoxicology, basis for risk assessment and management present the data on effects of chemicals on animals, plants and other living organisms obtained from standardized ecotoxicological studies.The toxic chemicals are of special concerns regarding their effects on environment. They can enter environment, as a consequence of anthropogenic activities or as an unintentional additional effects of various activities. However, when toxic chemicals ones enter the environment, they pose potential risk which need to be managed in order to minimize the probability of expression their adverse effects.
There are four basic steps in ecotoxiclogical risk assessment: first is hazard identification, second is adverse effects assessment through defining concentration-effect relationship; the third is exposure evaluation and the fourth one is characterization of the environmental risk. After performing those successive steps in risk assessment and stipulating the risk characterization it could be concluded whether the risks are acceptable for certain targeted living organisms or not. If the results of analysis show that risk is not acceptable it is necessary to take measures for managing the risks of

environmental contamination. Now socio economic analysis is coming as powerful tool and important and necessary part of this process and it is of great importance to perform it in right time having in minds all relevant factors [9, 11-13, 15].
The most often used parameters for environmental risk characterization is ratio between concentrations of chemicals in certain environmental areas (Predicted Environmental Concentration – PEC) and concentration for which is confirmed that adverse effect would not appear (Predicted No Effect Concentration - PNEC). When PEC overcome PNEC, risk will became unacceptable [9, 13, 15, 18, 19].
There are few main features of chemicals like persistency that reflects their life in the environment, i.e. time necessary to reduce their concentration on the half of the initial concentration. Bioaccumulation and bioconcentration imply potential of chemicals to enter living organisms, for examples concentration in fish could be hundred times higher than in water. Finally, biomagnifications show possibility of chemicals to magnify its presence through the food chain and therefore poses the risk to human health [9, 11-13, 15].

1.1. Contamination of different environmental compartments

Air pollution is by far the most harmful form of pollution in our environment. Air pollution is cause by the injurious smoke emitted by cars, buses, trucks, trains, and factories, namely sulphur dioxide, carbon monoxide and nitrogen oxides. Even smoke from burning leaves and cigarettes are harmful to the environment causing a lot of damage to man and the atmosphere. Evidence of increasing air pollution is seen in lung cancer, asthma, allergies, and various breathing problems along with severe and irreparable damage to flora and fauna [13, 14].
Water pollution caused industrial waste products released into lakes, rivers, and other water bodies, has made marine life no longer hospitable. Humans pollute water with large scale disposal of garbage, flowers and other household waste. Acid rain further adds to water pollution in the water. In addition to these, thermal pollution and the depletion of dissolved oxygen aggravate the already worsened condition of the water bodies. Water pollution can also indirectly occur as an offshoot of soil pollution – through surface runoff and leaching to groundwater [13, 14].
Soil pollution, which can also be called soil contamination, is a result of acid rain, polluted water, fertilizers etc., which leads to bad crops. Soil contamination occurs when chemicals are released by spill or underground storage tank leakage which releases heavy contaminants into the soil. These may include hydrocarbons, heavy metals, pesticides etc. [13, 14].

1.2. Chemicals of special concern

Among chemicals, of special concerns are persistent organic chemicals (*Persistent Organic Pollutant – POPs*) because they have all three mentioned features toxicity, persistency and bioaccumulation. These features made them to be one of the major issue in the field of environmental contamination and risk management including socio economic analysis. Socio economic analysis implies necessity for strategic action for managing these chemicals at the global level. As an action of international community for systemic and global solution for management of POPs chemicals Stockholm convention entered into the force in 2001, basically aimed to protect human health and environment from the risks that pose POPs chemicals pose [24].
In the first entering into the force 12 chemicals were defined as POPs, and Conference of the parties (COP) made a deal to take specific measures for removing POPs chemicals or their release into the environment. In years later, number of POPs chemicals increased up to 24 and still will increase with new “candidate chemicals” depending on experimental results and increasing the knowledge of certain chemicals. POPs chemicals are divided in three major groups depending on the source of their production or use [24].

1.3. POPs pesticides

POPs pesticides are highly toxic and exposure can take place through diet, environmental exposure, or accidents. They negatively affect humans, plant and animal species and natural ecosystems both in close proximity and at significant distances away from the original source of discharge.
Exposure to POPs pesticides in humans can cause several negative health effects includes:

- Death
- Cancers
- Allergies
- Hypersensitivity
- Developmental changes
- Damage to the central and peripheral nervous systems
- Disruption of the endocrine, reproductive, and immune systems
- A study published in 2006 suggests that an increased level of POP.s in human blood serum can be linked to Diabetes etc.

According to the U.S Environmental Protection Agency (EPA) there are links between POPs pesticide exposure and the increased frequency of diseases and/or abnormalities in wildlife species, including certain kinds of fish, birds, and mammals (http://www.epa.gov/international/ toxics/pop.htm#affect).
The negative effects of pesticides in the marine and coastal environments include changes in reef community structure, such as decreases in live coral cover and increases in algae and sponges and damage to seagrass beds and other aquatic vegetation from herbicides.

1.4. Unintentionally produced POPs chemicals (polychlorinated dibenzodioxins – PCDDs and polychlorinated dibenzofurans - PCDFs)

PCDDs are produced unintentionally due to incomplete combustion, as well during the manufacture of pesticides and other chlorinated substances. They are emitted mostly from the burning of hospital waste, municipal waste, and hazardous waste, and also from automobile emissions, peat, coal, and wood. There are 75 different dioxins, of which seven are considered to be of concern. One type of dioxin was found to be present in the soil 10 - 12 years after the first exposure.
Dioxins have been associated with a number of adverse effects in humans, including immune and enzyme disorders and chlorine, and they are classified as possible human carcinogens. Laboratory animals given dioxins suffered a variety of effects, including an increase in birth defects and stillbirths. Fish exposed to these substances died shortly after the exposure ended. Food (particularly from animals) is the major source of exposure for humans.
PCDFs are produced unintentionally from many of the same processes that produce dioxins, and also during the production of PCBs. They have been detected in emissions from waste incinerators and automobiles. Furans are structurally similar to dioxins and share many of their toxic effects. There are 135 different types, and their toxicity varies. Furans persist in the environment for long periods, and are classified as possible human carcinogens. Food, particularly animal products, is the major source of exposure for humans. Furans have also been detected in breast-fed infants.

1.5. New POPs chemicals: Polybrominated diphenyl ethers (PBDEs) and perfluorooctansuphonic acid (PFOS) and its salts

PFOS and PFOS related substances are included into Annex B of the Stockholm Convention on Persistent Organic Pollutants (POPs) for limited production and use (UNEP, 2009). Conclusion of the Stockholm Convention is that PFOS is very persistent substances with the bioaccumulation property even though it is not subject to classical principle of accumulating in the fatty tissues like other POPs chemicals. Unlike other chemicals, PFOS chemicals have a high affinity to bind to blood and liver proteins. These chemicals have properties to transfer on a long distances and meet the criteria for chronic toxicity on humans and other living organisms. PFOS and its derivates may be released into the environment from the production process and during industrial and consumer use, as well as during disposal of these chemicals, semi-finished products and products. Considering the fact that there are no known natural resources of PFOS chemicals it is deemed that their presence in the environment is solely as a consequence of human activity.

PFOS is persistent substance which is not subject to degradation in hydrolyses tests, photolysis nor biodegradation in any environmental conditions. Currently the only known degradation of these chemicals is on high temperature on incineration. PFOS has a high bioaccumulative potential, and is detected in many predators such as polar bears, some spices of eagles and martens. Alarmingly high concentrations of these chemicals are measured in arctic animals, far away from human activities. Based on available data, PFOS meets the criteria for long distance transport in the environment, which is evident from the monitoring data which point out to high levels of these chemicals in different parts of northern hemisphere, far away from the anthropogenic sources. PFOS is toxic for organisms in the aqueous medium wherein it showed that the most sensitive species are Mysidopsis bahia and Chironomus tentans. Macdonald and its associates measured NOEC (10 days) from 0.0491 mg/l for growth and survival of aquatic flies (Chironomous tentans). Authors concluded that the toxicity for PFOS is for 2-3 orders of magnitude higher for aquatic organisms chironomida than or other aquatic organism. Lowest value NOEC is an aquatic invertebrate were measured in the test with Mysidopsis bahia, and is of 0.25 mg/l.

PFOS fulfils the criteria for adverse effects on human health, bearing in mind that confirmed toxicity to mammals in repeated dose sub chronic and reproductive toxicity in rats with mortality of newly born individuals soon after birth. Studies suggest the adverse effects of PFOS related substances on reproductive health of humans, whereas high concentration of PFOS is detected in samples of serum and blood plasma in patients with lower quality sperm. Fei and his associates pointed out to potential correlation between high concentrations of PFOS in pregnant women and prolonged pregnancies. Many studies on animals pointed out to effects of PFOS chemicals on different system organs and functions such as triode function, endocrine system, immune system and congenital anomalies, while little research was conducted in order to determine toxicity of PFOS chemicals on human fetus. One of the studies points out to correlation between prenatal exposures to PFSO in serum of pregnant women and reduced fetal growth. It was also pointed out to correlation between concentration of PFOS and PFOA in umbilical cord blood and reduced weight at child birth. Hyperactive Disorders (Attention Deficit Hyperactivity Disorder - ADHD) has also been observed in children with high level of PFOS and PFOS related substances in serum.

PBDEs: PBDEs may enter the environment through emissions from various production processes, by evaporation from products containing them, by waste recycling or by releasing from the waste landfills (ATSDR 2004; EU 2001). PBBs enter into the environment through discarded or contaminated food and animal products, by accidental releases during transport or waste disposal of these chemicals. PBDEs and PBBs are detected in air, sediment, surface waters, fishes and other marine animals. Lower PBDEs congers show higher potential of bioaccumulation than the higher congeners and persist longer in the environment. Higher congers show potential to bond to sediment or soil particles more than lower congeners. PBDEs and PBBs do not dissolve easily in water and therefore they mostly bind to soli or sediment which decrease their mobility in soil, sediment or groundwater, but it increases their mobility in atmosphere where they are bonded to air vaporizing from the ground surface is expected to be low to moderate depending on the number of atoms of bromine in molecule. Homologues with higher number of atoms show lower volatility. Even though it is considered that PBDEs and PBBs are relatively stable chemical compounds, they may undergo photolytic debromination when exposed to ultraviolet light.

Potential routes of human exposure to PBDEs and PBBs include ingestion, inhalation and skin exposure. Having in mind that PBBs are no longer produced or used, general population may be exposed only through historical releases into the environment. Traces of PBDEs were detected in samples of human tissues, blood and mother's milk. EPA does not classify PBBs as cancerous as opposed to the US Department of Human Health that anticipate carcinogenicity for humans based on sufficient number of evidences from the studies on experimental animals. International Agency for Cancer research (IARC) classifies PBBs as probably cancerous for humans. EPA findings show that there is cancerous potential BDE-209 (decabromdyphenyl ether). In studies on mice's and rats showed the toxicity of these chemicals on neurological growth and development, reduction of body mass, kidney toxicity, thyroid gland, liver as well as adverse effects on skin. In animal studies as well as from epidemiological studies on humans it was known that some of the PBDEs and PBBs lead to endocrine disruption and have a potential to depose in fatty tissue. Studies also point out to potential reproductive toxicity i.e. teratogenicity of octa commercial mixture.

EPA has not established yet chronically oral reference dose (RfD) for PBBs, however it has for PBDEs and this value is 7 x 10^{-3} mg/kg/day for conger BDE-209, 3 x 10^{-3} mg/kg/day for octa homolog, 2 x 10^{-3} mg/kg/day for penta homolog 1 x 10^{-3} mg/kg/day for tetra homolog (BDE-47), 2 x 10^{-4} mg/kg/day for hexa homolog (BDE-153) and 1 x 10^{-4} mg/kg/day for penta homolog (BDE-99). Decabromdyphenyl ether was given a slope factor for cancerous effect on oral intake of 7 x 10^{-4} mg/kg/day by EPA.

In brief, socio-economic impact of POPs pesticides, unintentionally produced POPs or new POPs chemicals covers effects on human health, decrease of life standard, decrease of income and level of occupational protection measures, and also extra expenses related with the efforts to reduce impact of this type of POPs chemicals, their management and control. In details, it will be discussed in further sections [4].

Below, portion of the obtained results which pertain to the impact of hazardous chemicals such as POPs (pesticides primarily) which have been very frequently subject to these research activities [22].

Table 1: Results of International Research

Scope	Chemical	Health Effect	Monetized effects	Sources
Europe	Pesticides	Pesticide poisoning	€ 9.7 million of hospital costs and € 2.5 million of losses due to lost working hours	[1]
Germany	Pesticides	Acute pesticide poisoning	USD $ 14 million	[23]
USA	Pesticides	Acute pesticide poisoning, cancer and other chronic effects, death cases	USD $ 787 million	[16]
USA	Pesticides	Acute pesticide poisoning	USD $ 8 million of hospital costs and USD $ 17 million due to lost working hours	[16]
Ecuador, Carchi Province	Pesticides	Acute pesticide poisoning	Cost of private medical treatments: USD $ 17 per case	[24]
Thailand	Pesticides	Acute pesticide poisoning	USD $ 382.555	[10]
Zambia, Kuala Lumpur	Chemicals used in cotton fields	Acute pesticide poisoning	USD $ 2.1 million (lost working hours due to sick leaves 51.1%, medical treatment costs 40.7%, transport and other costs 8.1%	[3]

The research activities listed in the above Table have been, for the most part, characterized as fragmented, inconsistent and methodologically different in approach. This significantly impacts possibility to compare results obtained and also, as a rule, underestimation thereof. Therefore, for instance the results of the updated research about pesticide effects in the USA carried out in 1992 of USD $ 787 million, showed that the new results obtained in 2005 have been incomparably higher that the former. The new estimation has additionally included the costs of medical treatment of illnesses caused by pesticides (USD $ 1.1 billion), costs of increased resistance to pesticides (USD $ 1.5 billion), losses in crop yield (USD $ 1.4 billion), losses of disappearance of birds (USD $ 2.2. billion) and costs of removal of the consequences of ground water pollution (USD $ 2.0 billion). In principle, with more thorough and comprehensive scope of research activities examining the adverse effects of

chemicals, new areas of their effects come to surface which consequently increases the estimated costs.
Even tough, those researches are revealing numerous adverse effects of the hazardous chemicals and especially the POPs chemicals and are indicating huge adverse impacts on almost all components of the environment.

2. ANALYSIS OF THE SOCIO-ECONOMIC IMPACTS OF HAZARDOUS CHEMICALS ENVIRONMENTAL ADVERSE EFFECTS

Socio-economic impact analysis is one of the key components of the complex management process in which risks from environmental contamination by hazardous chemicals are identified and assessed. The main purpose of this analysis is to identify the key environmental risk issues related to the chemicals and in accordance with it to define, develop and put in action a set of measures for improvement of the socio-economic situation of impacted environment components, including protection of human health, remediating and recovering endangered ecosystem and biodiversity, and protected resources necessary for economic development of the society.
One of the very important precondition for the effectiveness of socio-economic analysis is inclusion most of (if not all) stakeholders affected by environmental contamination, since only comprehensive approach in risk management would provide sustainable development of the communities. The socio-economic analysis represents the analytical base, funded on the body of the scientific and professional knowledge, for initiating the risk management process in assessing the environmental contamination.

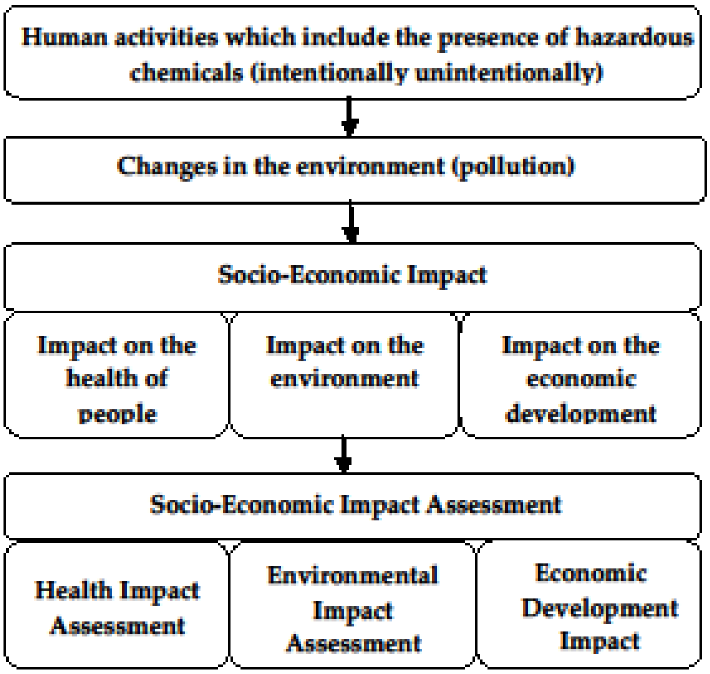

Figure 1: Socio-Economic Impacts of Chemicals

Socio-economic analysis is strategically oriented to the development of the society and economy, enabling insight in the current state, identifying the specific issue of interest, and restricting the adverse impact of environmental contamination. The aim of this analysis is to develop strategy and to propose measures for overcoming potential environmental contamination risks. The number of ecotoxicology accidents, as well as natural disasters is also pointing out the importance of the strategic planning for risk management. Strategic planning is a factor for minimizing damage from the accidents while socio economic analysis is one of the major components of these planning. Floods in Serbia during the 2014 were an example of natural disaster negative influence to living organisms, health of humans and all other relevant factors.

On the global level, one of the first cases which brought environmental pollution to the public attention was the pollution of Love Canal, on Lake Erie in New York, in the 1970s. From 1942 to 1953, several chemical companies dumped 20,000 metric tons of chemical waste at this site. As a consequence, eighty different chemicals, including dioxins and polychlorinated biphenyls (PCBs), started to leach through the soil, and residents have experienced many unexplainable health problems. Today federal laws stipulate that generators of hazardous waste are responsible for the proper storage and disposal chemicals from the "cradle to the grave." Environmental accidents continues to happen, among which on the global level the highest level of attention was attracted by the chemical disaster in Bhopal (1984), Chernobyl nuclear disaster (1986), as well as, Mexico gulf oil rig disaster (2010). Even though any of smaller accident should not be neglected having in mind its long lasting consequences to the human health agriculture, economy as a whole, biodiversity and other environmental areas. Moreover, ecological disasters or accidents are not necessary outcome of anthropogenic activities; natural disasters (like volcanic activity, fires, flood etc.) could be also the cause.

The process of socio-economic analysis of hazardous chemicals includes identification of anthropogenic activities in which these chemicals are present, and based on that, the assessment of the environmental changes (pollution) caused by these activities and their adverse impacts on human health, the environment and economic development of impacted communities (Figure 1).

3. ASSESSMENT OF SOCIO-ECONOMIC IMPACTS OF THE HAZARDOUS CHEMICALS ENVIRONMENTAL ADVERSE EFFECTS

All impacts noted in Figure 1 (socio-economic impact of chemicals), as well as, others not directly included in socio-economic analysis and estimation, could be divided in three groups:

- impact on human health
- impact on the environment and
- impact on the economic development.

All three aspects are in focus of particular investigation; however far away in focus is impact of POPs chemicals on human health, especially among general population and at the work place. Huge number of examinations is directed to the POPs impact on environment, and a little bit smaller amount to their impact on economic development.

3.1. Impact on humans

World health organization (WHO) proposed one of the most important efforts for quantifying adverse effects of chemicals to humans [17]. Adverse effects of chemicals to humans were quantified in this study using two basic indicators: lethality expressed as number and Disability-Adjusted Life Years (DALY), i.e. the number of lost days caused by attack on human health. According to WHO study, in 2004, approximately 4.9 millions of deaths (8.3% of total number) and 86 millions DALY (5.7% of total number) were consequences of analyzed chemicals effects to the environment and humans. By these indicators influence of fossil fuels burning and air pollution are also involved. Beside this, adverse effects of chemicals at the work place, acute poisonings and poisonings as consequence of plant protection products use resulted in 375, 240 and 186 thousands cases, respectively. Having in mind, that data are more than 10 years old (from 2004), and that number and amount of chemical in use constantly increase, as well as that lot of chemicals are not covered by this WHO analysis, and effects of chemicals on endocrine or immune system, it could be assumed that derived estimations are actually underestimated.

3.2. Environmental impact

One of the most important investigations in this field was performed in EU in 2008: *The Economics of Ecosystems and Biodiversity* [21]. According to the results of TEEB expenses for ecosystem and biodiversity protection at the global level are between *USA* $2.0 and *USA* $4.5 thousands billion per year. Expenses necessary for avoiding adverse effects of chemicals in order to reach the aims for biodiversity for the period between 2000 and 2050 as consequence of way of field use, decrease in the

soil quality because of climate changes caused by environmental contamination, needs for regulation climate changes, application of measures for keeping quality of soil and air, are estimated as 7% of global GDP.
Generally speaking, chemicals can exert adverse effects to the environment since interfere with the drinking water sources and food production, ecosystem, necessity for water and air cleaning to make these properties available to the population. However, this type of estimations is rarer than this one where adverse effects to human health are investigated. Also, examinations are mostly directed to the certain populations and their effects.
Another type of investigations are directed to the effects on different environmental media, water, soil, biodiversity, but not so often on chemicals influence on these compartments. Environmental resources do not have "price on the market", or are not quantified in the meaning of value expressed in money, this process should be done indirectly, either by evaluation of adverse effects, either by evaluation of costs for effects sanitation (i.e. lost in agriculture and fishery, costs for water treatment etc.).

3.3. Impact on socio economic development

In general, influence of chemicals, especially dangerous like POPs are, could be seen as decrease in production of one society since human health and natural sources are threatened [2]. These effects are the often assessed as percent of decrease in GDP because it is influenced by decrease in production and increase in keeping natural resources. For example it was assessed that yearly amount necessary for treatment of environmental contamination in Egypt in 2005 were 1.8% of GDP. In Mali expanses in 2002 spent for use of pesticides were 50% of GDP coming from agriculture. Furthermore, in China, for the treatment the adverse effects of chemicals to water was spent *USA* $ 485 million in 1997, while in USA same year expenses for the treatment of drinking water for reaching standards related with the approvable levels of pesticides in water were estimated to *USA* $ 400 million. Two years earlier, in 1995, readiness of US citizens to pay for the neutralization of chemical environmental contamination was assessed as range from *USA* $ 197 to *USA* $ 730.

4. CONCLUSION

Toxic chemicals and within them particularly persistent organic pollutants (ie. POPs chemicals), are representing a special danger for the environment. Identification, analysis and assessment of their impacts on the specific aspects of the environment are important aspects of risk management on the basis of which the set of appropriate prevention measures for future possible ecological accidents should be developed and activated. Taking into consideration all aspects of socio-economic analysis is necessary in preparing effective strategic plans for ecological accident management, where beside economic and financial benefits; reduction of environmental contamination could bring number of various benefits to the society as a whole. Socio-economic analysis of the hazardous chemicals impacts, particularly POPs, special emphasis is placing on their consequences on human health, on the economic development and the environment.
It should be borne in mind that the generating of the environmental pollution in modern societies is unavoidable and industrial nations will always produce a certain level of pollutants. Some of the pollutants, even potentially very harmful to the environment are at the same time very beneficial for individuals and communities. Good example for this is the use of pesticides which fall into one of a large group of POPs chemicals that, if used improperly, can have extremely negative effects on the environment, while at the same time they could have very positive impact, especially on poor and vulnerable communities, to provide necessary resources for life. In this context, one of the key dilemma of modern societies is not whether these substances should be used in everyday life, but how to find an optimal balance between the costs they generate in terms of its impacts on human health, economic development and ecosystems, and benefits that bring in terms of improving of communities and individuals quality of life, providing economic and social benefits.

REFERENCES

[1] Blainey, M., Ganzleben, C., Goldenman, G., & Pratt, I. (2008.): *The benefits of strict cut-off criteria on human health in relation to the proposal for a Regulation concerning plant protection products.* European Parliament Policy Department Economic and Scientific Policy. Available at: http://www.europarl.europa.eu/activities/committees/ studies/ download.do? file=22471

[2] Brnjas Z. (2012): Eko-finansije jedinica lokalne samouprave u Srbiji; *u: Ekonomski aspekti ekološke politike*, IEN/BBA, Beograd (*in Serbian*).

[3] Bwalya, S.M. (2010): *Sound Management of Chemicals in Zambia: A cost benefit analysis of agricultural chemical use in the Kafue Basin.* Environmental Council of Zambia. UNDP-UNEP Partnership Initiative. Available at: http://www.chem. unep.ch/ unepsaicm/ mainstreaming/ zambia/ default.html

[4] Draft Updated national implementation plan for Stockholm convention Serbia, 2015. www.ekominpolj.gov.rs

[5] Eduljee, G. H. (2000). Trends in risk assessment and risk management. *Science of the Total Environment*, *249*(1), 13-23.

[6] Finnveden, G., & Moberg, Å. (2005). Environmental systems analysis tools–an overview. *Journal of cleaner production*, *13*(12), 1165-1173.

[7] Gallo, Michael (2001). "History and Scope of Toxicology." In *Casarett and Doull's Toxicology: The Basic Science of Poisons,* 6th edition, ed. Curtis D. Klaasen. New York: McGraw-Hill.

[8] Greenberg, H. R., & Cramer, J. J. (Eds.). (1991). *Risk assessment and risk management for the chemical process industry*. John Wiley & Sons.

[9] Hansson, S. O. (2005). Seven myths of risk. *Risk Management*, 7-17.

[10] Jungbluth, F. (2000). *Economic Analysis of Crop Protection in Citrus Production in Central Thailand.* A Publication of the Pesticide Policy Project. Hannover, Germany. November 2000. Special Issue Publication Series, No. 4. Available at: http://www.ifgb.uni-hannover.de/2699.html

[11] Kavlock, Robert J., George P. Daston, Chris DeRosa, Penny Fenner-Crisp, L. Earl Gray, Steve Kaattari, George Lucier et al. "Research needs for the risk assessment of health and environmental effects of endocrine disruptors: a report of the US EPA-sponsored workshop." *Environmental health perspectives* 104, no. Suppl 4 (1996): 715.

[12] Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk analysis*, *8*(2), 177-187.

[13] Manahan, Stanley (1999). *Environmental Chemistry,* 6th edition. Boca Raton, FL: Lewis Publishers.

[14] Merkhofer, M. W. (1987). *Decision science and social risk management: a comparative evaluation of cost-benefit analysis, decision analysis, and other formal decision-aiding approaches* (Vol. 2). Springer Science & Business Media.

[15] Molak, V. (1997). Fundamentals of risk analysis and risk management (pp. 233-245). V. Molak (Ed.). New York: Lewis Publishers.

[16] Pimentel, D., Acquay H., Biltonen, M., Rice, P., Silva, M., Nelson, J., Lipner, V., Giordane, S., Horowitz, A., D'Amore, M, (1992). "Environmental and Economic Costs of Pesticide Use". *Bioscience*, 1992, No 42:10, pp. 750-760. Available at: http://www.jstor.org/pss/1311994

[17] Prüss-Ustün A, Vickers C, Haefliger P, and Bertollini R. (2011). "Knowns and unknowns on burden of disease due to chemicals: a systematic review". *Environmental Health*, 2011, 10:9. Available at: http://www.ehjournal.net/content/10/1/9

[18] Schulz, R. (2004). Field studies on exposure, effects, and risk mitigation of aquatic nonpoint-source insecticide pollution. *Journal of Environmental Quality*, *33*(2), 419-448.

[19] Slovic, P. (1987). Perception of risk. *Science*, *236*(4799), 280-285.

[20] Souza Porto, M. F., & Freitas, C. M. (1996). Major Chemical Accidents in Industrializing Countries: The Socio Political Amplification of Risk. *Risk analysis*, *16*(1), 19-29.

[21] TEEB (The Economics of Ecosystems and Biodiversity): *The Economics of Ecosystems and Biodiversity. An Interim Report*, (2008); Available at: http://ec.europa.eu/ environment/nature/ biodiversity/ economics/pdf/teeb_report.pdf

[22] UNOPS (United Nations Environment Programme), (2013), *Costs of Inaction on the Sound Management of Chemicals.* http://www.epa.gov/international/toxics/pop.htm#affect

[23] Waibel H., Fleischer G., and Becker H. (1999). "The economic benefits of pesticides: A case study from Germany". *Agrarwirtschaft*, 48 H. 6: 219-230.

[24] Web site: http://chm.pops.int/default.aspx

[25] Yanggen, D., Crissman, C., y Espinosa. P. (eds.). Los Plaguicidas: Impactos en producción, salud y medio ambiente en Carchi, Ecuador. CIP e INIAP. 199 pp. Centro Internacional de la Papa, 2003. Available at: http://www.share4dev.info/kb/output_view.asp?outputid=3408".