RISK ASSESSMENT POLLUTION AND ECOTOXICOLOGICAL EFFECTS IN SITES ABANDONED MINING INDUSTRY IN ROMANIA

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Abstract: *The processing and storage of waste from the extractive industry in Romania was in many cases without preventive measures, due to the lack of legal framework, risk is affecting environmental quality. Therefore, currently several of abandoned mining sites have a significant impact on human health and the environment. The main impact on the environment derived from mining tailings ponds and waste dumps and preparation plants the decommissioned. The risk of soil and groundwater consisting of a variety of pollutants, in particular the heavy metals ions, cyanide, hydrocarbons, acidity, salinity, etc. The infiltration of contaminants into the soil and groundwater and surface air emissions has also some serious risk to human quality and environmental factors. This paper proposes the risk assessment and eco-toxicological effects they may have sites abandoned the mining industry in Romania on the health of the population and the environment.*

KEYWORDS: *abandoned site, sterile, risk, eco-toxicology, environmental factors, tailings pond, waste dumps*

1. INTRODUCTION

Mining activities are important human activities in terms of generating metal pollution sources. After mining stored in sterile environment rich in metals and their mobility is mainly by water flows and atmospheric contaminating ecological systems at large distances from the source. If mobility about hydrological main receivers is wetlands that can facilitate the dispersion of metals, being secondary sources of pollution.

The main pollution sources are: mining, farming and urban agglomerations. These activities lead to the release of pollutants into the environment. Ramada, 1989, Postolache, 2000, quoted by V. Dumitrescu, 2011 ranks pollutants into 3 major classes: physical, chemical and biological signals following classification:

a. the ionic inorganic compounds (metals and other inorganic ions);

b. organic pollutants (hydrocarbons, insecticides, herbicides, detergents, etc.);

c. organo-metallic compounds;

d. radioactive isotopes.

Heavy metals are considered harmful organisms are present in high concentrations (Martin, 1997 Onianwa 2001, Krishna and Govil, 2004, quoted by V. Dumitrescu, 2011). Ecological significance of heavy metals is important for toxicity, mobility and their accumulation. These elements can enter the hydrologic cycle through groundwater by leaching, and ground waters through runoff. It can accumulate in plants and then released into the atmosphere as a gas, it can aggregate Semi-permanent in clay or organic matter in the soil or sediment accumulation may have repercussions on human health in the long term (Sæther et al., 1997, Acero et al. Krishna and Govil 2003, 2004, quoted by V. Dumitrescu, 2011).

To designate metals ecological significance take into account the factor of anthropogenic disturbance. This factor is the ratio of annual global natural inputs and inputs due to human activities in the metal. Pb, Cd, Cu and Zn were the most lift anthropogenic disturbance factors (Forstner and Wittman, 1981, Ramada, 1992 Iordache, 2009, quoted by V. Dumitrescu, 2011).

It has been found by the skilled person that the mobility of heavy metals varies according to the chemical characteristics of each metal, and thus, the chemical structure may occur. The metals are usually found in the form of complexes with organic or inorganic ligands. Depending on the preference of metal for metal ion ligands are classified as Class A (also called hard), class B (also called weak) and intermediate (Postolache, 2000 IUPAC, 2002 Iordache, 2009, quoted by V. Dumitrescu, 2011). A metal can be Class A and Class B, depending on the oxidation state and coordinated ligands. This classification allows elucidation of metal complexes. The metals of type A are usually associated with oxygen or nitrogen ligands in the composition to form electrostatic bonds, whereas type B metals are associated with the CN ligands and sulfur in the composition, in particular to form covalent bonds (Pearson, 1973, Postolachi, 2000 quoted by V. Dumitrescu, 2011).

2 SOURCES OF METALS AND PROCEDURES FOR RELEASE

The main sources of heavy metal pollution are diverse such pollution problem arising mainly from exploiting deposits of coal and ferrous and non-ferrous metals as well as use by the human population, but also from other production (Postolache, 2000 , quoted by V. Dumitrescu, 2011). Therefore, metal pollution is not attributable exclusively mining activity, although it is prevalent in this case.

In Table 1 are some human activities that are sources of heavy metal pollution for eight common.

In conclusion, human activities increase metal flows through the overwhelming variety of activities, each having an important contribution to the disruption of these flows.

Table 1: Sources of pollution for eight common heavy metals (Agarwal, 2009, quoted by V. Dumitrescu, 2011)

Source	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Mining and processing of metal ores	✓	✓		✓		✓		✓
Metallurgy	✓	✓	✓	✓	✓	✓	✓	✓
Chemical industry	✓	✓	✓	✓	✓	✓		✓
Industry of alloys					✓			
Paint industry		✓	✓		✓			✓
Glass industry	✓				✓	✓		
Pulp industries and paper			✓	✓	✓	✓	✓	
Tanning of hides	✓		✓			✓		✓
Textile industry	✓	✓		✓	✓	✓	✓	✓
Chemical fertilizer industry	✓	✓	✓	✓	✓	✓	✓	✓
Cl-alkali industry	✓	✓	✓		✓	✓		✓
Petroleum refineries	✓	✓	✓	✓	✓	✓	✓	
Combustion coal	✓	✓	✓	✓	✓	✓		✓

Typically, metals are dispersed into the environment through air or water flows resulting from industrial activities. Waste streams resulting from socio-economic activities are important sources of metal pollution. Mobility of water in river basins contaminated with mine tailings or waste dumps such tailings is a way of dispersing metals in environmental systems (Agarwal, 2009, quoted by V. Dumitrescu, 2011).

Metal concentration can be correlated with hydrologic flow (Ciolpan, 2005, quoted by V. Dumitrescu, 2011). Hydrological processes that determine metal mobility are (Iordache, 2011, quoted by V. Dumitrescu, 2011):

1. leaching - the process is carried metal complexes soluble in the superior to the inferior metals are transported in aquifers

2. leaks

a. surface - can carry metal complexes soluble in water or metal mass adsorbed to soil erosion

b. underground - metal mobility can occur from leaking underground aquifers fed by percolation

Figure 2 presents the main ways of transport of heavy metals in sources of ecological systems tanks.

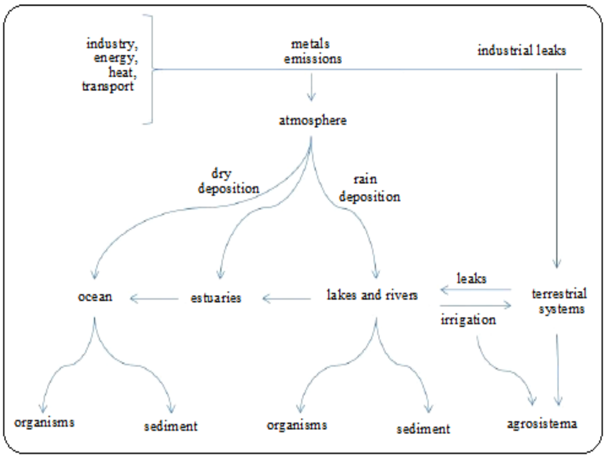

Figure 2 Dispersion of metals in the environment (adapted from Agarwal, 2009, quoted by V. Dumitrescu, 2011)

3 Ecotoxicity effects

Metals, in contrast to other contaminants that are used by organisms such micronutrients (e.g. Fe, Ca, Mg) as well as macro nutrients (e.g. Cu, Zn, Ni) (Fairbrother, 2007, cited V. Dumitrescu, 2011). Virtually any compound is toxic when it exceeds a certain threshold concentration may have disruptive effects on organisms. The degree of toxicity is quantified based on tests (Postolache, 2000, quoted by V. Dumitrescu, 2011).

If effects the heavy metal ecotoxicological are dependent on the time of action of the metal and acts in a very wide range of scales (from molecular level to complex ecosystems). Unfortunately, these effects are not directly proportional to the concentration of these metals, and for this reason are used as indicators of pollution (Iordache, 2009).

3.1. Effects at the individual

Toxicity due to high concentrations of metals exposure is difficult to understand and rarely quantified in the field (Fairbrother, 2007, quoted by V. Dumitrescu, 2011). The toxic effects of compounds dichotomy manifests depending on concentration and stress caused by toxic compound can be classified as (Postolache, 2000, quoted by V. Dumitrescu, 2011):

a. stress destructive;

b. physiological stress.

Stress is destructive specific lethal doses that result in death of the organism and physiological stress induces physiological abnormalities or loss of specific functions (Postolache, 2000, quoted by V. Dumitrescu, 2011).

Physiological stress is mainly caused by biochemical disturbances that occur at the molecular level. The metals may affect enzyme activity, alter the structure of the resulting DNA mutations reduce the fertility of the eggs (in fish), etc. (Iordache, 2009, quoted by V. Dumitrescu, 2011).

These biochemical changes can cause cellular and tissue effects. For example, biomass production is affected by the stress caused by lifting the metal concentrations.

In the case of plants the phenomenon of oxidative stress. A metal causes biochemical reactions cationic protein produced by moving centers, thereby disturbing or inhibiting enzyme activity. It is also possible to increase the concentration of highly reactive oxygen species (O_2, OH●, H_2O_2) leading to destruction of cell membranes, causing lipid peroxidation and apoptosis (programmed cell death in response to a particular gene signal) (Peralta, hollow 2009 Eraly, 2011, quoted by V. Dumitrescu, 2011). An example of a metal which promotes lipid peroxidation is Cu (Iordache, 2009, quoted by V. Dumitrescu, 2011).

Cadmium is considered one of the metals of ecotoxicological interest due to negative effects on the metabolism of plant and animal kingdom (Kabata-Pendias, 2001, quoted by V. Dumitrescu, 2011). Following toxicity tests demonstrated that nitrogen-fixing bacteria and crop toxicity grade was distributed according to the metals studied as follows:

Cd > Cu > Ni > Zn > Pb > Cr (Athar, 2001)

Phytotoxicity low for Cr and Pb was attributed to the fact that they are insoluble in most soil conditions (James and Bartlett, 1984, Athar, 2001, quoted by V. Dumitrescu, 2011), and increased toxicity of other metals is associated with their solubility in sol. In Figure 3 is shown the range of movement of the metal ions on the pH of the soil.

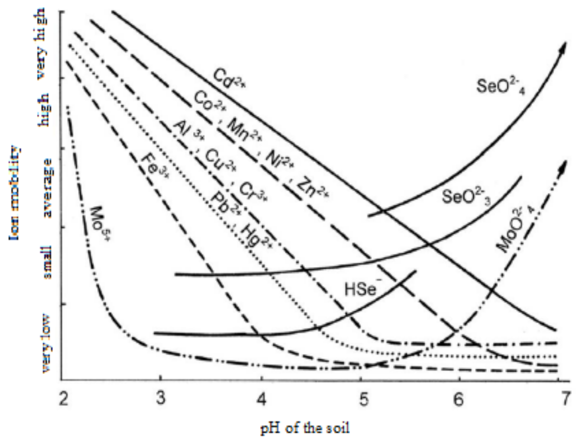

Figure 3 Mobility metal ions depending on the pH of the soil (Kabata-Pendias after 2001, quoted by V. Dumitrescu, 2011)

Heavy metals contamination of soils is often associated with low pH, and this helps to increase the acid content of fulvic acid that forms metal complexes bioavailability and highly mobile (Popa, 2005, cited Dumitrescu V., 2011).

If metals can be accumulated intracellular microorganisms associated with cell wall or immobilized extra-cellular mobilized by bacterial metabolic products or transformed and volatilized (Chen et al., 1995, Iordache, 2009, quoted by V. Dumitrescu, 2011).

Most heavy metals are mobilized in the food chain and affect both producers and consumers (Peralta, Videos, 2009, quoted by V. Dumitrescu, 2011). They are stored and sent them each trophic level trophic relationships based on higher order consumers. For example, Cr is stored in vacuoles in plant oligochetae the digestive tract in the exoskeleton of crustaceans; Pb accumulates in the liver and bone in a mammal; Hg is fixed in the brain and liver etc. (Peralta, Videos, 2009, quoted by V. Dumitrescu, 2011).

4 ENVIRONMENTAL RISK ASSESSMENTS

Environmental risk assessment is the process of estimating the consequences of integrated risk materializes, in combination with additional quantification of the probability of their occurrence and vulnerability to these risks.

Quantification of the three components of environmental risk assessment is to develop scales, which is associated numerical values. This assessment can be done in different ways, depending on the need for the decision maker, the ability to interpret and process awareness of the phenomenon or factor

Risk assessment is a systematic technique for organizing information and knowledge available on a level of scientific certainty, in conjunction with the data, models and assumptions necessary; technique is the facility to obtain objective conclusions on the risks, regardless of their nature.

The risk assessment was conducted in accordance with the "Order no. 184/1997 "on" Procedure for achieving environmental balance "and that the risk is the probability of an adverse effect in a specified time period. / 139 /

Risks of accidents or damage which may impact on the environment and on population Brad mining area are:

- Outbreak of fire or explosion of explosives depot, leading to deterioration of the ecosystem in the area with harmful effects on environmental factors;
- Loss of stability dump;
- Loss of stability of the tailings
- Contamination of groundwater;
- Closure of mining in the area;
- Destruction of historic sites.

Risk quantification is based on a simple classification system where the probability and severity of an event is classified downward.

Classification probability	Classification of gravity
3 = high	3 = major
2 = average	2 = serious
1 = low	1 = aboard

The risk factor is calculated by multiplying the probability by a factor of gravity to obtain a comparative figure. This will allow comparisons between different risks. The result is higher, the higher the priority that will be given to controlling risk.

The main purpose of risk assessment is to help establish risk control. Risk assessment involves identifying hazards and then assesses the risk which they present, by examining the likelihood and severity of damage that may arise from such dangers.

Information on assessment of pollutants, are given in the form of a checklist or matrix. The values of degree a risk to environment water, air and soil.

Activity taking place in the Brad is 60% dependent on the mining industry. Reduced activity in the mining industry today caused a shortage of jobs for local residents.

The quantifying a relationship between various economic, social, and cultural factors influence.

Is it possible that the defined ambient ERM exercise is necessary to carry out studies which aim to be justified.

Often, they appear constraints on time and resources needed for these studies.

Purpose and methods selected studies should consider addressing these constraints.

Even if the study is preliminary or final, he should always aim point.

To achieve the goal, studies must take into account particular aspects such as the interaction and interdependence between specific parts of the operations or the system to be studied and other parts of the same system and external systems. Limits will be set so that it can be taken into account these factors; the basic concern is chaining them in a flowchart.

✓ **Risk analysis**

The 5 elements of risk analysis processes are:

1 Understand and description

Stage of the analysis is the familiarity, knowledge of the system and its context and operational environment and its description.

The volume of work required of this stage is based on the approach of the staff and the level of detail required.

Familiarity with the process can be done by reconsidering documents, including drawings, maps, procedures, reports of previous studies and investigations documentation including Environmental Impact Assessment (EIA) and audit reports.

For the proposed and existing operations is essential to organize an inspection of the entire site.

System description should be thorough and complete, otherwise it is possible that all hazards are identified.

2 Hazards identification

Hazard identification should be a structured process to work systematically with the elements

facilities or system being studied (as identified during familiarization / description).

For each element of the whole system or the system will be given particular attention:

- Possible initial events or circumstances;
- Consequences of these events or circumstances;
- Availability of technical, operational and organizational security and control;
- The probability of an event or circumstance;
- The probability of conversion in significant adverse outcomes, in terms of surveillance and control.

The hazard identification should include:

a) all aspects of the potential dangers that may affect the environment, including, but not limited to:

- Surface water and groundwater;
- Settlements;
- Forests, farmland, pastures, along with related animals and their crops;
- Soil (contamination, erosion, degradation);
- Geological structures;

b) All types of hazards, including fires, explosions, toxic or polluting materials, changes

precipitation regime or water courses, introducing exotic plant or animal species or pathogen damage tailings.

c) The entire life cycle of the mine, including exploration and recovery (impact: acid mine water, tailings, may cause long-term);

d) All potentially affected area or system;

e) All relevant operations as defined;

f) emissions continue, not just the accidental;

g) All types of causative factors, including natural factors;

h) Hazards charged and controversial issues;

i) Waste and the semi-products and mining materials and equipment used in operations associated.

A typical environmental hazard caused by mining operations is shown in the list below:

- Destruction of vegetation (loss of rare species or habitat);
- Effect of soil (erosion caused by wind, water, dust);
- Acidification of soil sulfur;
- Damage (explosions, dust and vibration);
- Crushed rocks / rock and sludge (instability, acid water and dust);
- Subsidence (impact on cultural relics and natural)
- Sterile radioactive
- Potential toxic tailings (acid water, heavy metal ions, salts);
- Salts and other contaminants to waters from mining operations;
- Contamination of rainwater;
- Storage, handling and transportation of petroleum products or chemicals (spillage, fire, explosion);
- Effect of surface watercourses and groundwater;
- Storage and handling of explosives (explosion unintentional);
- The introduction of alien plants or animals or pathogens;
- Sources of ignition;
- Processing, storage, handling and transport of the mining and processing;
- Continuous emissions to air and water;
- Contaminants from activities associated (ponds, water storage tanks, pipes and conveyors);
- Safety inappropriate, sabotage, etc. (mechanical failure, human error, accidents, etc.).

This representative list is not exhaustive and can not be used as a checklist, as factors can change from one site to another.

In general hazard identification process can practice more entries. These should include:

• An inspection - type audit;

• Sessions meetings with relevant parties in the process of hazard identification;

• reconsideration of issues that concern the community of licenses and permits, the conditions to be complied with incidents, procedures and emergency maintenance, audits and previous studies.

3 Analysis of consequences

Consequence analysis includes both final results and the steps that led to these results.

For example, the effect of a storm on a pond, consequence analysis may cover:

- Consequences of the storm on the volume of water received TMF expansion possibilities spill and damage;
- Consequences of contaminants that can be released and their concentrations / duration receiving water after a leak or spill;
- The consequences of these concentrations / duration on the aquatic ecosystem.

For each element to consider several key issues. These may include the magnitude, extent, severity, duration, etc. For this part of the analysis is typical understanding of the effects of the initial event.

Consequence analysis is always a mix of quality and quantity.

By their nature, risk analyzes are multidisciplinary. Disciplines that can contribute to these analyzes are construction engineering, chemistry, hydrology, geology, toxicology, ecology, ecotoxicology, etc.

4 Analysis of probability

Analysis of probability means the probability of each step in the entire event. These probabilities include:

- The frequency of initiating event;
- Probabilities specific safety measures required;
- The probability that an event causing primary damage and cause significant damage, affecting safety;
- The probability that events coincide and cause each different problems;
- The probability of human error and appropriate and inappropriate responses;
- Probability of dangerous weather events;
- Calamities

Quantifying risk indicators and weights

Rigorous quantification of risk requires determining the probability of occurrence of damage causing uncontrolled loss of TMF content.

In Romania is used empirical risk assessment process developed (Stematiu, Constantinescu and Asman, 1998).

Quantifying the consequences of breaking

- Rapid and uncontrolled loss of the contents of a pond can have the following types of consequences:
- Fatalities (PVO);
- Effects on biological and physical environment (EM);
- Damage caused to third parties in the affected area (PMT);
- Damage of the Holder (PMD);
- Effects on Society Image (EI).

The risk analysis is sometimes used a global assessment of the extent and severity of the consequences, by assigning a value within 5 ... 10 steps stairs.

Quantifying the likelihood of breaking events on tree

The probability of fracture is determined from the summation of probabilities partial probabilistic tree adverse events related events. It starts from the base of the tree to the top. At each level the next higher probability of the event is given by:

• sum of the probabilities of events when they are independent and are connected by logical OR operator;

• the product of probabilities of events when they are conditioned and are linked by AND operator.

Typically risk measure is given by the annual rate risk and therefore is probable are annual probabilities of realization of events.

Quantification is conditional probability definition of primary events.

If contour dams on lowland ponds in assessing probabilities comes as a separate item and length, guard, beach, sufficiency of drainage, slope downstream slope, geomechanical characteristics of the filler can be different from one section to another, in especially when the dam evolves with deposition.

Annual probability of such an event is determined from the relationship Initial:

$$P[dig] = 1- (P[segment])n \qquad (1)$$

Where:

n - is the ratio of breakwater length and segment length basis;

P [dig] - annual probability of occurrence of a primary event initiating the whole dam;

P [segment] - annual probability of occurrence of an event based Initial segment.

If the tailings pond upstream rises through the construction of dams on the beach the previous stage booster, core segment and report separately for each phase is treated separately booster.

As a general rule, bear in mind that judgment and then quantifying engineering are more properly applied as the primary events are better defined.

Classification system in Romania tailings categories of importance:

A - of exceptional importance;
B - of particular importance;
C - normal importance;
D - of minor importance.

Risk classification criterion is expressed by an index of risk associated with pond called RB.

The hazard is defined based on the general formulation.

$$RB = PC \times CA \qquad (2)$$

Where:

PC - annual probability of breaking
CA - consequences of breaking

Depending on the risk index to determine the category of importance as follows (NTLH-021):

RB> 0.8 - pond category
0.8 - RB> 0,015 - pond B
0,015 - RB> 0.05 - pond of category C
RB - 0.05 - pond of category D

The consequences of belonging to a certain category of importance

Framing tailings dams and importance categories served in accordance with dam safety law (Law no.466 / 2001) to:

• determining the type of follow-up dams and tailings dams (special or current);

• prioritizing tailings dams and to establish assessment programs safe operating condition to their approval;

• establishing the list of high-risk dams;

• setting tasks of verification and control dams and tailings dams;

• establishing the obligations of owners of dams and other legal entities and individuals, the safe operation of these types of works and taking appropriate measures to reduce the risk.

5 CONCLUSIONS

In conclusion, the inputs of heavy metals in environmental systems are augmented by anthropogenic activities, resulting in the accumulation of metals in terrestrial and aquatic systems from biotic and abiotic processes of transport.

A major role of government is to promote law norms and standards in the field and control the observance of them in order to ensure sustainable development.

Environmental risk management is a component of all activities currently and any action presents a potential exposure.

In the application of environmental risk management is considered and layout optimization of resources in that business, which must have the effect of directly protecting the environment.

Environmental risk management include: the systematic application of policies, procedures and practices of hazard identification; anticipating hazards; Possible consequences of hazards; estimate risk levels (quantitative or qualitative); developing criteria for prioritizing risk levels based on objective criteria and relevant; decisions to minimize the risks identified.

Environmental risk management should be based on the principles of practice: creating a structure to deal with these issues; composition of a team working with appropriate training; cover all operations in their lifetime; Periodic risk assessments rigorous and comprehensive; integrating environmental risk management in other risk management systems; regular reassessment of risk management environment.

Environmental risk management should be applied to all phases of the mining cycle and mining operations all parties.

In accordance with generally accepted definition, risk is expressed as the product of the probability of an adverse event and the size of the consequences that appear when the event occurs. Consequences of breaking may be loss of human life, accidental pollution major ecological effects, human health and environmental damage, economic losses in the affected areas, cost recovery and rehabilitation of the tailings and the affected areas, damage to company image etc.

6. REFERENCERS

[1]. Audry, S., Grosbois, C., Bril, H., Schäfer, J., Kierczak, J., Blanc, G., *2010. Post-depositional redistribution of trace metals in reservoir sediments of mining/smelting-impacted watershed (the Lot River, SW France), Applied Geochemistry, 25: 778-794;*

[2]. Băbuţ, G., Moraru, *R. Risk management programme for the mining industry. Annals of the University of Petroşani – Mining Engineering, vol. 4 (XXVI), p. 106-113. Petroşani: UNIVERSITAS Pubblishing House, 2010.*

[3]. Ciolpan, *O., 2005. Integrated environmental monitoring systems, Ars Docendi Publishing, Bucharest, p. 70-75;*

[4]. Cutter L. *American hazardscapes. the regionalisation of hazards and disaster. Washington: Joseph Henry Press, 2001. 211 p.*

[5]. Eraly, D., Hendrickx, F., Backeljau, T., Bervoets, L., Lens, L., *2011. Direct and indirect effects of metal stress on physiology and life history variation in field populations of a lycosid spider, Ecotoxicology and Environmental Safety, doi: 10.1016 /j. ecoenv. 2011. 04. 014;*

[6]. Jianu, D., Iordache, V., Soare, B, Petrescu, L., Neagoe, A., *2011. The Role of Mineralogy in Hazard Potential of Mining Areas, in Kothe E, Varma A (Editori) Biogeointeractions in contaminated soils, Springer.*

[7]. Popa, M., *2005. Modern methods and techniques for determining environmental pollution with heavy metals - Analysis and case studies in the Zlatna House Book of Science, Cluj-Napoca, p. 11-20.*

[8]. Postolache, C., Postolache, C., *2000. Introduction to Ecotoxicology Publishing Ars Docendi Bucharest, p. 5-11, 20-40, 151-220;*