Monitoring surface water pollution using biological markers

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Abstract. Establishing the ecological status of continental aquatic ecosystems must be based on biological quality elements, considering the hydromorphological, chemical, physico-chemical and specific pollutants markers that influence these biologic markers. The evaluation of such elements can show the presence of natural conditions, their minor alterations or the extent of the anthropogenic impact and quality status of water bodies at a certain period of time. It is not possible to test and monitor water quality in all places at all times, but there are ways to indirectly infer water quality using biomarkers. The biomarker is an organism or community of organisms that act through modifications to the presence of a toxic substance or concentrate the toxic substance. The biomarker organisms can use to identify and qualify the effects of environmental pollutants. The marker organism is any biological species that defines a trait or characteristic of the environment.
Key Words: biomarkers, eco-toxicology, green algae pollution, monitoring, water quality.

Introduction. Biomarkers are species, populations or groups of species, which due to their variability (biochemical physiological, ethological or ecological) allow the description of an ecosystem status and reveal as early as possible, the natural or anthropogenic modifications thereof. The idea of biomarker species has been used since last century. As concerns the emergence of different types of aquatic ecosystem degradation have appeared, the identification of biomarkers that provide information about the stability of ecosystems and maintaining biodiversity was sought.

Regarding the pollution markers, they are of 2 types: sensitive species indicating the presence of a pollutant by the appearance of lesions or malformations; and accumulator species, which concentrate the pollutant in their bodies. There is also another category, i.e. species that proliferate and become abundant in polluted areas.

Some species can survive in clean water only, others can withstand shallow loaded and some may even survive in heavily polluted waters.

Pollution biomarkers have the advantage, compared to instrumental monitoring, of providing a response to the combined effect of certain pollutants, unlike separate instruments measuring the quantity of each pollutant.

Oxygen is an important parameter that influences the type of organisms that can be found in a river. All organisms need oxygen, but each species has its own needs: some have greater needs, for example, species living in streams, others use low concentrations. If the oxygen concentration in the river decreases, most sensitive species will disappear and the low concentrations-loving species will experience a greater development. In heavily polluted waters, characterized by large lack of oxygen or no oxygenated, no organism can be found. These findings have led to a system of biological markers of rivers, pollution's saprobe system ("sapros" = putrefaction).

Aquatic pollution. Water, air and soil, constituents of the biosphere, are known as environmental factors. Each of them develops a specific fauna and flora which, in order to survive, must enjoy an environment as clean and healthy. Water quality is established by standards, due to the importance they present for the life safety and economic activities. Water quality is expressed by markers stabilized and calculated from analyses conducted for both surface water and the groundwater.

The diversity of pollutants is very high, by the process they result from (industry, transport, agriculture). Polluting agents act differently on living organisms. The nature of the pollutants, their presence in the mixture, their concentration, their mutual influences and the duration of their action comprises a first group of influence. The conditions in which the pollution that is, temperature, humidity, speed of relief and pollutant have differentiated effects on organisms (Teodorof et al 2007).

Water resources are 1.37 billion km^2, of which 97.2% are found in the oceans and 2.7% in groundwater and surface water. Surface water is only 0.002%. From freshwater, only 1.44% are liquid, the remaining are glaciers.

Romania has scarce water resources, about 1700 t/capita, as opposed to the European average of 4000-5000 t/capita. These resources are characterized by uneven spread in the territory.

There are several sources of water pollution. The industry discharged into natural waters organic and inorganic chemicals, plant and animal debris, solvents, hydrocarbons. Organic pollution occurs usually from pulp and paper mills, which eliminate about 3000 l of polluted water / sec. Although the purification is carried out with a high efficiency, large amounts of pollutants still remain. Inorganic pollution resulting from chlorine products, chemicals, crude oil, ores, hydrometallurgical industries (Teodorof et al 2009).

Water pollution is reduced to three categories of nature polluters: physical, chemical, and biological (Antonescu 1984) (Figure 1).

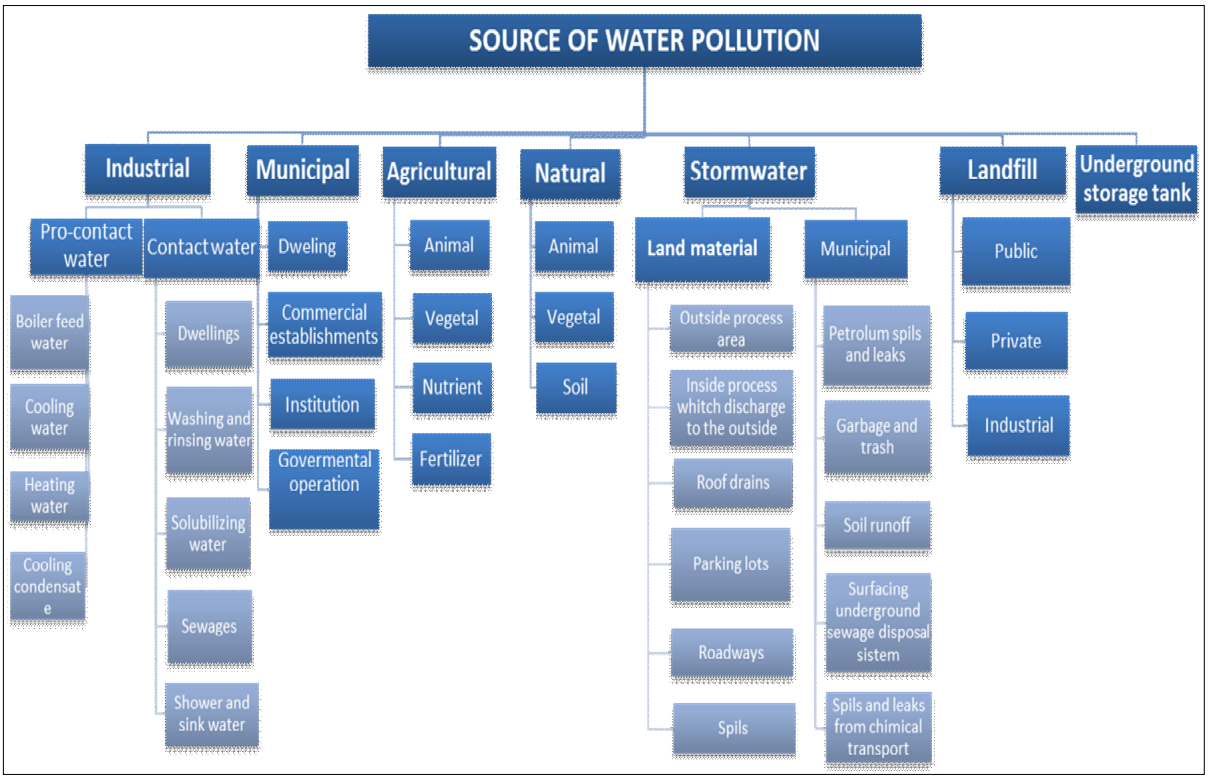

Figure 1. Classification of the sources of water pollution (Water Quality control Handbook).

Algae as biomarkers. Plants are often used as biomarkers, both in terms of major environmental factors such as temperature, humidity, chemical reaction, amount of nitrogen, but are used for the recognition of the presence and nature of the pollutants. The factors determining and limiting the growth of algae are light, temperature and nutrients in the water, among the abiotic ones; competition, pressure of grazing animals and parasitism of the biotic ones. Many of the algae that grow in continental aquatic ecosystems can adapt to large variations, between the broad range of the environmental factors, with high ecological plasticity. In order to be used as biomarkers, a particular biological system must meet a series of specific criteria (Momeu & Peterfi 2009).

Relevance is the first such criterion and is relates to whether the marker is credible and able to highlight the effects of changing the environmental conditions by testing it on all individuals who are in similar ecological conditions as the tested organism. A biomarker must be characterized by a high degree of sensitivity, meaning that it must respond quickly to changes in the environment. In this regard, the algae used for testing, of the genus *Scenedesmus*, are very sensitive and used in a number of toxicity testing.

The relevance of the biomarker biological response is directly proportional to the systemic level of the pollutant which acts it, or cellular, or at an organ, organism or population level. The lowest sensitivity is found at the cellular level.

Bio marking can be considered an induced anthropogenic molecular and biochemical response manifested by changing the physiological parameters, the effects being observed at one or more levels of the biological system. High reactivity of algae in the presence of pollutants is due to their morphological simplicity to higher plants, meaning they do not have a proper vascular system, absorbing water and nutrients all over their body surface.

In the bio monitoring process of water pollution including heavy metals, the organisms of a particular water system are collected and analysed in the form of various biological responses to various chemical exposures.

Aquatic algae are the main primary producers in aquatic ecosystems and play an important role in maintaining the balance of the whole ecosystem. Algae can give direct indication of water quality. The exposure to toxic amounts of heavy metals can cause the disturbance of the metabolism and biological functions of algae, can inhibit photosynthesis, reducing cytocrome, mutations at the cellular level and even death algae. Which is more important, once heavy metals are accumulated in these organisms, they will enter the food chain too and can influence the lives of other higher organisms. The level of water pollution and the type of pollution can be analysed and identified by the analysis of algal species in terms of biological and physiological responses.

They serve as excellent markers of pollution because they are related to biotope, which they cannot leave when pollution is severe and cannot return after the conditions improve.

Algae are able to integrate the effects of all pollutants in a given place and time. Algal cells assimilate nutrients available under the influence of all other constituents present in the effluent. Inhibitory effects of various stimulants or harmful compounds or elements are therefore involved and reflected in the results of the bioassay. Using algal bioassay for the fertility studies of water and even soil, due to these advantages, has become a far exploited method (Momeu & Peterfi 2009).

Algae are not only successfully used in bio monitoring, but also in phyto-remedy technology to restore the water quality due to their high bioaccumulation capacity.

Among the bio monitoring techniques of aquatic ecosystems, there are various methods and techniques that can be adopted depending on the aimed purpose. For example, the dynamic analysis of organisms, the determination of heavy metals, the measuring of enzymatic activities, the analysis of biomarkers such as photosynthetic pigments of algae. All alterations in physiological functions, the abundance of species, the algal population meet the conditions of the aquatic ecosystem.

Bioaccumulation is an important process by which chemicals affect the life of organisms. Bioaccumulation occurs when an organism absorbs a toxic substance at a greater rate than the body can eliminate the substance. Processes like absorption of elements, the storage and disposal of the substance takes place during bioaccumulation (Momeu & Peterfi 2009).

Eco toxicity testing using microalgae metals may present some interference such as changing the amount of metal with the elimination of metabolites by the algae. Furthermore, in order to obtain a 50% effective concentration (EC50) value based on cell counting or testing of the chlorophyll large amounts of metal ions in the water are required. Therefore, sensitive parameters responding to the presence of small amounts of metals in certain relevant concentrations are ecologically necessary. The genus *Scenedesmus*, a cosmopolitan genus living in clean and contaminated waters. The effects of metals on this algae was studied in terms of growth and development of this genus. Such a studied effect was the effect of copper as a growth inhibitory agent. *Scenedesmus* genus is is a cosmopolitan genus that can be found in polluted oligotrophic, mesotrophic, eutrophic waters due to the presence of metals. They are paired in the cenobii every 2-4-8 cells, but it was noted that in some ecological and physiological conditions there not are grouped in cenobii (Voltolina et al 1999). This phenotypic plasticity may be due to the pressure of the environment, reacting to these stress conditions through different

physiological mechanisms. Sensitive biomarkers for water quality monitoring and studies are needed in this regard were and are made by turning his attention to the morphological and physiological adaptations of algae used in monitoring applications and Ecotoxicology, algae have been shown to have great potential in estimating effects of pollutants. Toxicity tests involve the use of carefully selected cultures, in which the organism is subjected to test different concentrations of the toxic agent. Ideally, the organism does not produce the tested elements that affect the structure of metal ions, but it is known that such microscopic algae remove the compounds altering the speciation of metals, their accessibility and thus the algal response. The *Scenedesmus acuminatus* species was investigated for phenotypic alterations caused by the stress caused by Cu. Toxicity was determined as the number of cells in the cenobium. Thus on one hand, the detection and quantification of morphological response is easily obtained and cheap, but on the other hand it will represent a valuable contribution to environmental monitoring studies. It is also known that the tolerance of some species to metal activity varies with factors such as the environment composition the removal of some organic ligands and if the body has been exposed to metal. A number of mechanisms are triggered by the presence of metal toxicity to the environment (Voltolina et al 1999).

Methods and means for monitoring surface water quality. Water quality is defined as a set of conventional physical, chemical, biological and bacteriological expressed in value, allowing the classification theereof in terms of quality, needed to satisfy a particular purpose.

For the quality assessment there is used a limited but significant marker of quality: physical, chemical and biological, established through effective monitoring system. The main purpose of water quality monitoring is to check whether it is suitable for use (Gavrilescu & Olteanu 2003).

The monitoring activity is carried out scientifically, with high accuracy techniques and equipment by specialists in various fields, however the interpretation of data collected in the field must be made in a unitary manner.

The Integrated Monitoring System is a complex system of data acquisition and environmental quality information obtained from measurements and systematic observations, which provide the possibility to control pollution (Gavrilescu & Olteanu 2003).

There is a wide range of quality markers which makes grouping and classifying them difficult and varied.

Currently, there is has been implemented in Romania a National Integrated Monitoring System since 2006 regarding the quality of surface waters conducted in accordance with Article 8 of the Water Framework Directive, according to which all European Union Member States should establish monitoring programs to know and classify the "condition" thereof, for each river basin.

A dynamic and complex process, an integrated water monitoring system involves the distinct stages:

- establishing the monitoring subsystems;
- establishing investigation environments;
- establishing spatial structure;
- defining monitoring types;
- establishing monitoring parameters;
- establishing monitoring frequency.

Conclusions. The protection of surface water quality plays a major role, taking into account that water, long regarded as an inexhaustible and renewable resource has become increasingly obvious and proves one of the limiting factors in the socio-economic development. The main goal of water is quality, which is currently a major concern in water management, the monitoring activity has a determining role, representing a tool in developing water policies and providing the corresponding management. The prevention of water pollution can be achieved starting with a surveillance and testing system,

followed by the implementation of measures to reduce water pollution such as the large-scale introduction of clean technologies in industrial processes, reducing the quantity of wastewater discharged into rivers, introducing the practice of water recycling, recovering useful materials from waste water, thus ensuring true advantage of sources of raw materials, improved the treatment efficiency by improving technologies, facilities and the operation thereof. Algae can provide direct information on water quality. The water pollution level and the type of pollution can be analysed and identified by the analysis of algal species in terms of biological and physiological responses. The water quality protection is a permanent action, in which each member of society must bring a conscious and responsible contribution.

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