Original Article

Journal of Plant Stress Physiology 2015, 1: 58-61
http://scienceflora.org/journals/index.php/jpsp/
doi:10.5455/jpsp.2015-06-05

Environmental assessment of small rivers in the Kiev region (Ukraine) according to the health and hygienic indicators

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Received 4.6.2015
Revised 10.11.2015
Accepted 14.11.2015
Published 01.12.2015

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ABSTRACT

The study of water in reservoirs of Ukraine through passive monitoring methods permit to detect heavy metals in the proportion that far exceeds the maximum allowable concentrations. The aim of our article is to analyze the state of aquatic ecosystems of the small rivers of Kiev region according to the toxicological indices. The objects of our research are the superficial waters of the small rivers of Kiev region. Materials and research methods. The ecological assessment of the mentioned was conducted in the different seasons on the basis of analytical research program according to the sanitary indicators. Our researches were made in the Institute of agro-ecology and environmental usage of the national academy of agrarian sciences of Ukraine during 2007-2010. The heavy metals' content in the water was determined by the extraction of 1 N acid HNO3, and its quantity in the solutions-extracts was found by the atomic adsorption spectrometry. There was analyzed the state of aquatic ecosystems and there was made their ecological assessment based on sanitary indicators. This article presents the results of monitoring of some toxic substances in several small rivers in Kiev region considering the influence of anthropogenic factors. In conclusion nowadays we can provide the ecological safety using waste-free technologies with full utilization of all the raw materials' constituents. In our future research area we plan to elaborate the ecological control methods of the quality of superficial waters for the small rivers of Kiev.

KEY WORDS: Heavy metals, pollution, runoff, the surface waters, water quality

INTRODUCTION

In recent years, it was estimated that with the exception of some arid areas, people should not worry about the lack of water; however, the rate of the water consumption is increasing as well as the problem of potable water availability is arising.

In Ukraine, there is no water, which would not be changed by human activity and its consequences. In most cases, these interventions lead to "the water aging." The degradation of resources is often due to eutrophication of anthropogenic origin, which sometimes leads to the presence of a large amount of nutrients in the reservoirs (Konstantynov, 1986; Lynnyk, 2004).

Some of the most important chemical pollutants of the surface water are heavy metals (HM). A large number of the elements refer to HMs according to their formal definition. For several years, there have been conducted the researches of the presence of some HMs in Ukrainian waters using the passive surveillance methods. It is possible to identify the cations of metals such as nickel, lead, iron, manganese, chromium, zinc, copper, cadmium, cobalt in amounts that exceed by far the standards of maximum allowable concentrations (MAC).

Sources of water pollution are the domestic wastes (phosphorus, organics, etc.), agricultural (nitrates, phosphorus, pesticides, etc.), and industrial discharges (HMs: Lead, cadmium, nickel, mercury, etc.). Cobalt and lead pollutants fall in the sources of water from metallurgical and chemical effluents. Cadmium, lead, and zinc are found in the industrial effluents of mills, synthetic fibers', mineral paints, textile and paper plants, etc. Even

if today most companies in Ukraine are closed, the surface water pollution will not diminish because of the HM sediments. In addition, the HM is also present in fertilizers and pesticides that may get later in the water through runoff of an agricultural land (Lynnyk, 2004; Nezgoda, 2008). Therefore, the study of the sources and pathways of these substances in surface waters, their distribution and their content in water should be one of the prior and necessary conditions for the practical implementation of the key tasks associated with the rational use, protection and efficient reproduction of the water resources. Hence, the main objective of the study is to determine the content of the main poisonous elements in small rivers in the region of Kiev and a complete environmental assessment for hygienic, quality, and health of water bodies. Usually, the accurate measuring results are prerequisite to ensure their compliance with the limit values, which are always indicated as metal content. However, even in the water, it is quite difficult to distinguish metals' content and the amount of contaminants of natural and anthropogenic origin. To give a reply to this co-analytic task, you must have methods for the determination of pollutants, and particularly of HMs' ions in the water (Nezgoda, 2008). The analysis of water sources was determined according to the certified methods in the laboratory of the Institute of Agro-Ecology and Environmental usage.

MATERIALS AND RESEARCH METHODS

The object of the research is the surface water in the small rivers of Kiev region. Their ecological assessment was conducted in the different seasons on the basis of analytical research program according to the sanitary indicators. Our researches were made in the Institute of Agro-Ecology and Environmental usage of the National Academy of Agrarian Sciences of Ukraine during 2007-2010. The HMs' content in the water was determined by the extraction of 1 N acid HNO_3, and its quantity in the solutions-extracts was found by the atomic adsorption spectrometry (GOST 2874-82 - Drinking water. Hygienic requirements and quality control. 1985; GOST 18293-72 - Drinking water. Methods for determination of lead, zinc and silver content. 1974).

Water examples were analyzed according to the GOST (State standard, means of all industrial and commercial standards recognized by the Russian Federation): GOST 4388-72 - Drinking water. Methods of the determination of copper mass concentration (1974), GOST 4974-72 - Drinking water. Methods of the determination of manganese content (1974), GOST 18293-72 - Drinking water. Methods for determination of lead, zinc, and silver content (1974), GOST 2874-82 - Drinking water. Hygienic requirements and quality control (1985). The statistical processing of the results was made on the basis of the variance and regression analysis.

Table 1: Mean values for concentrations of HM in water

Indicator	Concentration of HM in some rivers, mg/dm^3			
	Buchka river	Vita river	Lypova river	Moshunka river
Pb	0.0125	0.0121	0.0223	0.0601
Cu	0.0427	0.0261	0.0371	0.013
Zn	0.0272	0.0284	0.0214	0.0227
Cd	0.0096	0.008	0.0199	0.0101
Mn	0.012	0.008	0.012	0.011

HM: Heavy metals

Experimental Technique

According to the monitoring of surface water HM content in Kiev region, it was concluded that the water of these rivers is quite poor in nutrients that contained low concentrations of Cu, Zn, Mn Table 1]. Most of the water sources are situated within the Ukrainian fundamental crystalline formation. It was observed that the concentration of Cu was between 0.013 and 0.042 mg/dm^3, Zn - 0.021 mg/dm^3 and 0.027 mg/dm^3, Mn - 0.008 and 0.012 mg/dm^3. The main metals that contaminated the reservoir of Polissia are Cd and Pb, their content is several times higher than the required standards (MAC). Thus, all the sites studied showed a significant excess of cadmium (from 0.0096 mg/dm^3 to 0.0101 mg/dm^3, yet the MAC is 0.001 mg/dm^3), indicating a probable excess of HMs in untreated wastewater or insufficient treatment of effluents in the residential areas.

There was a significant increase in the concentration of lead in Moshunka river, its amount was 2 times higher compared to the norm (0.0601 mg/dm^3), may be caused by the discharge from the households and the industries.

Although the results show some deficiencies in the assessment of the ecological status of HM content in surface waters, they still do not give answers to general questions about the water quality in the small rivers. To consider these issues, we must take into account the requirements of the quantitative and qualitative chemistry and connected to the results obtained from the chemical analysis of water and their ecological interpretation. One of the approaches to the quality evaluation of the underground water that can be taken into account was developed by Romanenko.

Although these calculations are complicated enough, they allow comparing the water quality of significantly different rivers.

As most of these rivers belong to the water bodies where fishing is developed, environmental standards are used to regulate fisheries management and are directly related to the determination of HM concentrations in natural water and, therefore it is necessary to start in the areas with a potential fishing capacity (PFC) [Table 2]. These data indicate the little concentration of Mn in water, so for a given metal, this capacity not only exhausted but also exceeded 0.0007 mg/dm^3. The concentration of the soluble forms of zinc in the studied samples was 0.02 mg/dm^3, which is 2 times the MAC thus the water PFC is completely exhausted for Zn. For soluble forms of metals, such as Cd, Pb, and Cu, FCP should be also completely exhausted because their average concentration exceed the standards of MAC.

For the toxicological evaluation of water quality were used calculation methods of integrated assessment of water pollution according to the content of HMs in the water bodies of Buchka river, Vita river Lypova river, Moschunka river. Comprehensive assessment of water pollution was also calculated using integrated quality indicators [Table 3].

Taking into account these degrees of pollution of water, there was carried out the environmental assessment on the water state in the small rivers based on the HM indicators [Table 4].

Table 2: Potential environmental capacity with regard to metals

Indicator	Concentration of HM, mg/dm^3				
	Pb	Cu	Zn	Cd	Mn
C$^-$	0.0267	0.0297	0.0249	0.0119	0.0107
Fishing MAC	0.01	0.001	0.01	0.005	0.01
FCP	0.0207	0.0287	0.0149	0.0069	0.0007

MAC: Maximum allowable concentration, HM: Heavy metals

Table 3: The level of pollution of the water according to the values of complex indicators

The level of contamination	Integrated sanitary assessment	
	Cleaning, CU	Health-toxicological, CU
Allowable	1	1
Moderate	1.0-3.0	1.0-3.0
High	3.0-6.0	3.0-10.0
Very high	>6.0	>10.0

CU: Clean up

Table 4: The degree of pollution of small rivers according to the HM indicators

Small river	Health-toxicological situation, CU	The level of contamination
Buchka river	2.79	Moderate
Vita river	2.42	Moderate
Lypova river	5.57	High
Moshunka river	6.05	High

CU: Clean up, HM: Heavy metals

The degree of water pollution of the Vita river and the Buchka river was moderate; values vary within 2.42-2.79. Water contamination of the Lypova river and the Moshunka river is characterized by an increase of the contamination level. This is explained by the fact that HM ions accumulated in the aquatic areas are potentially mobile. This type of situation requires special cleaning methods. When characterizing the state of reservoirs, our data indicated that the category of all heavy elements in the water bodies correspond to the third category ("polluted"), fifth level ("moderately polluted"). The water pollution progresses when the HMs is mobile.

CONCLUSIONS

Therefore, the results of the study have shown that the level of contamination of the small rivers in the Kiev region by the HM ions was moderate and high according to the sanitary norms. This was due to the lixiviation of HMs from the untreated effluents.

To reduce the environmental impact and the safety of the environment, it is necessary to use new waste treatment technologies and full utilization of all the basic constituents of the wastes. However, at the current level of technological development, it is difficult to elaborate such technology because the main objective of water resources protection is to meet the quantitative standards of the effluents' control.

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