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Evaluation of the Quality of Aquatic Environment on the Heavy Metals Bioaccumulation by Aquatic Organisms

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Abstract

The review of the more important investigations has been devoted to study of the toxicity of TM for aquatic life and its accumulation by the sensitive biological components of aquatic ecosystems, estimation of water quality of experimental and natural environment and protective of aquatic life are presented.

Keywords: Environment; Accumulation of heavy metals; Anthropogenic pollution; Water quality

Mini Review

In the modern era of intense anthropogenic pollution of the biosphere, negative changes in the state of the aquatic environment are observed throughout the world. Among the pollutants entering the aquatic environment, heavy metals (HM) currently play a priority role, possess toxic and cumulative effect. HM concern to highly toxic pollutants and have been studied extensively the last decades because of their effects on the environment and the living organisms. Metals such as: Fe, Mn, Zn, Cu, Pb, Ni, Cr, Co, Cd, Mo, V, Ti, Hg are ubiquitous in the environment, as result of both naturally occurring and anthropogenic sources, while at the same time and under certain conditions, they may be toxic to aquatic life even at low concentrations [1]. The problem of increasing anthropogenic pollution of water bodies poses task of effectively assessing the quality of their water and condition of populations of the biological components of aquatic ecosystems.

The United States Environmental Protection Agency (USEPA) has established nationally applicable water quality criteria (WQC) for metals that are designed to be protective of aquatic life [1]. Many of the HM are vital for the metabolism of living organisms, are part of enzyme systems that catalyze metabolism, but the accumulation of their increased concentrations become toxic and cause various pathology (tissue necrosis, tumor formations, mutagenesis and oters) or even mortality. A review of a certain aspects of the heavy metals effects in freshwater mussels is presented [2]. The freshwater pearl mussels have been recommended as good bioindicators for evaluation past and present water quality conditions [3]. Many investigations have been devoted to the experimental detection of acute and chronic toxicity of TM for aquatic organisms, using the biotic ligand model (BLM) [4-7]. BLM is a mechanistic approach that greatly improves possibility to generate water quality criteria for metals in the natural aquatic environment. Metal accumulation by aquatic organisms has commonly been expressed as linear regression equation of the form $Y = ax^n$. This means that bioaccumulation of investigated elements (Y) is proportional to its concentration in water (x) and increases at an exponential (n) equal to the slope of the log-log regression [6]. Equation of the type $Y=ax^n$ are referred as the simplest empirical relationships between metal accumulation and metal in the environment, and adequately describes accumulation in many circumstances, but it should not be absolutized. The influence of factors, such as PH, alkalinity, DOC (dissolved organic carbon), trophic conditions and other, can cause deviations from these simple linear relationships. Application of BLM for toxicity estimate at low metal concentrations when modeling the toxicity of a single contaminant is useful, but results in lower predicted toxicity for mixtures of multiple metals at high concentrations.

A whole range of ecological factors and varying hydrochemical parameters usually act on water body under natural environment, therefore, field studies of the effects of toxicants are more effective than model studies. In the Russia has used the system of water quality for maximum permissible concentrations chemical elements. In addition, the classifications of water quality by biological, chemical, and toxicological-genetic indicators have been developed, and on basis of complex of these classifications has been developed an integral classification, according to which quality classes from I to VI correspond to degree of water pollution from clean to very dirty [8]. An adequate assessment of water quality must be carried out in combination with standard chemical methods and biogeochemical diagnostic of metal accumulation of the indicator organisms. The most sensitive to pollution of aquatic environmental are freshwater mollusks. They filter large volumes of water, accumulating high concentrations of chemical elements, among them toxic HM in their tissues and shells. The chemical composition of the soft tissues reflects of the recent seasonal situation of environment, while the shell integrates the multiannual process and long-term situation of environment over the mollusk lifespan [9]. This makes it possible to use the mollusks as reliable indicators of the state of aquatic environment [10-12].

For purposes of ecological monitoring of aquatic ecosystems of different region and geochemical provinces at field studies, method of the biogeochemical diagnostics of metal accumulation was developed and approved for few species of mollusks [10,12]. The content in water and its accumulation in the body and shells of mollusks of Fe, Mn, Zn, Ti, Cu, Pb, Ni, Cr, Co, Cd, Mo, V and Hg were investigated. Coefficients of saturation (CS) and intensity accumulation (IA) of HM were calculating. The relation CS/IA is the main, informative index of bioaccumulation (IB) of HM, which reflects the result of a complex process of multicomponent interactions of metal ions in biotic ligands (mollusk gills) in large range of the content HM in water. Reliable connection of IB values with content HM in water (R^2 = 0.975) and IB with FPA (frequency of pathology appearances) in organisms of population (R^2= 0713-0.998, $p<0.005$) was revealed. It is allows estimate the ecotoxicological state of populations in the natural aquatic environments in range of content HM in water from 0.01to 0.60 mg/L and accordingly IB from 0.11 to 2.0 and >2.0 as «safe-unsafe-dangerous-threatening» and «critical». The water quality with the same environment was estimating as «clean, weakly, moderate-strongly polluted» and «dirty» and «very dirty» [11]. Thus, the IB reflects the result of the complicated process of a multi-component interactions of metal ions in biotic ligands. The method of biogeochemical diagnostic of HM accumulation can use and for predicting the consequences of the state of mollusk populations and aquatic environment with a further increase, up to critical, anthropogenic pollution of water bodies and ecological risk for aquatic ecosystems.

Moreover, with help biogeochemical diagnostics of HM accumulation in shells of subfossil mollusks from archaeological excavations was estimated the state aquatic paleoenvironment (Amur River basin) in the relatively recent past (Holocene, 2000-1500kya) [12]..

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