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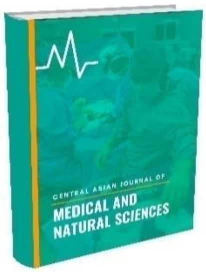

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Indicators of Biochemical Contamination of Water Sources in Uzbekistan

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Annotation: As a result of the intensive development of irrigation, industry, the creation of new large agricultural complexes, along with the growth of urban settlements, the quality of water for drinking and recreational sources is increasingly deteriorating. Thus, there is an urgent need for a wider use of tools for assessing the various degrees of biological and chemical contamination. The article discusses the main sources of pollution of rivers, lakes, drainage channels and reservoirs used for drinking and domestic purposes, as well as a classification of water pollution and indices that can be used to assess pollution.

Keywords: biological contaminants of water, chemical parameters, periphyton, water quality indicators, standards for water use.

Introduction. Over the past decades, one of the main environmental problems in Uzbekistan has been the intense pollution of rivers and canals by a variety of poorly treated effluents. Agriculture, which consumes 90% of the total annual river flow in the country, has the biggest impact on the quality of drinking water. A large amount of water is lost in the irrigation system to evaporation, infiltration or other losses, and this causes serious long-term environmental problems: poor drainage leads to soil erosion, excessive irrigation and high levels of evaporation lead to secondary salinization of water and soil, increased salinity leads to wastage biodiversity of water sources [**12**]. An increase in the level of mineralization and organic pollution of the return flow affects the decline in water quality, both in the main aquifer surface arteries and groundwater in Uzbekistan. According to Uzhydromet (Centre of Hydro-Meteorological Service at Cabinet of Ministers of the Republic of Uzbekistan) specialists, 90% of the quality indicators of water pollution are moderately polluted (class 3) or polluted (class 4), and 10% of water bodies are classified as clean water (class 2).

Another range of environmental problems in agriculture is related to the lack of a scientific approach to the use of fertilizers, pesticides or other chemicals used in agriculture. The lack of a legislative framework (normative documents) underlying the environmental monitoring of water sources leads to an excess of the maximum permissible concentrations of chemical/biological substances that have a direct negative impact on the life of aquatic communities, and indirectly on public health [**8**, **14**].

In addition, at present, a very important environmental problem is associated with the inefficient operation of treatment facilities; and poorly treated domestic and industrial waters are a source of infectious diseases or toxic poisoning [**2, 5**]. When classifying water use, 3 categories of water use are usually distinguished: household and drinking, domestic and fisheries. We will consider in the article what types of pollution exist, as well as what indicators (biological and chemical) are used to assess the quality of water in drinking water sources and domestic water use.

1. Types of pollution. Pollutants entering water sources are divided into: mineral, organic and toxicological. A comprehensive ecological classification of surface water pollution is considered by such authors as Oksiyuk and Zhukinsky, 1993 [**10**]. So, according to these authors: According to the salt/mineral composition, water bodies are divided into: fresh (0-3 g/l), brackish (3-18 g/l) and saline 18-45 g/l); by ionic composition: Ca^{2+}, Mg^{2+}, Na^{+}: hydrocarbonate, sulfate, chloride. To assess the ecological and sanitary state (trophic saprobity), the authors recommend using the following groups of indicators: hydrophysical (organoleptic, color, turbidity), hydrochemical (quantitative ratio of chemical elements in water), hydrobiological (species composition, abundance/biomass of aquatic communities - bioindication), microbiological (indicating the actual level of saprobity) and biogenic (indicating the actual level of trophicity). Table 1 shows microbiological and chemical indicators, by the concentration of which we can find out the level of organic pollution (saprobity) and trophicity of water bodies.

Table 1. Ranked values of hydrochemical and microbiological parameters that correspond to the levels of trophic saprobity of water pollution

Indicators and pollution classes	**I (oligo)**	**II (β-meso)**	**III (α-meso)**	**IV (poly)**	**V (hyper)**
Oxygen concentration, mg/l	10,0-8,5	8,4-6,5	6,4-4,5	4,4-2,5	>2,5
Ammonium nitrogen, mg/l	0,1-0,2	0,21-0,3	0,31-1,0	1,1-3,0	>3,0
Nitrates, mg/l	1-10,0	10,1-40,0	40,1-80,0	80,1-150,0	> 150
Nitrites, mg/l	0,001-0,01	0,011-0,05	0,051-0,1	0,11-5,0	> 5
Phosphates, mg/l	0,005-0,006	0,0061-0,03	0,031-0,1	0,11-0,6	> 0,6
Permanganate oxidation, mg/l	2,0-3,0	3,1-4,0	4,1-5,0	5,1-15	>15
pH	6.5-8.5	6.0-9.0	5.0-6.0; 9.0-10.0	5.0-6.0; 9.0-10.0	2.0-4.0; 11.0-13.0
Coli-titer	10,0-1,0	1,0-0,05	0,051-0,005	0,0051-0,001	<0,001
Total number of bacteria, per 1 ml	a*100	a*1000	a*10000	a*100000	a*1000000

However, the most dangerous category of water pollutants are toxicological pollutants, such as heavy metals, commonly found in industrial waters. Most aquatic organisms are more sensitive to the action of toxic substances than humans and warm-blooded animals. The accumulation of harmful inorganic compounds in fish tissues creates a threat of poisoning for people who eat such food. Mercury is accumulated by microorganisms, fish and their food resources to high concentrations. Cadmium was found in the tissues of fish 200 times more than was contained in the water; tissues of oysters from reservoirs accumulate lead, mercury, cadmium, zinc, copper and cobalt. Toxic metals in water bodies do not undergo self-purification, but, on the contrary, have a detrimental effect on flora and fauna and inhibit the processes of self-purification of water bodies. Their concentration in water bodies can decrease due to dilution, sedimentation at the bottom and partially assimilation by flora and fauna. The amount of precipitated substances increases with a decrease in the flow rate of the liquid [**6**].

According to the toxicity of exposure to substances, 4 classes of chemicals are distinguished: 1) extremely dangerous: beryllium, mercury; 2) highly hazardous: boron, bismuth, cadmium, cobalt, molybdenum, nitrites, selenium, lead, silver, DDT; 3) moderately hazardous: iron, manganese, copper, methanol, nitrates, chlorine, chromium; 4) low-hazard: hydrogen sulfide and sulfides, phenol, toluene, oil.

When water from polluted reservoirs is used for irrigation, non-ferrous metals are taken to the fields and concentrated in the upper most fertile humus-containing soil layer. The concentration of metals in this layer leads to a decrease in the nitrogen-fixing capacity of the soil and crop yields, the accumulation of metals above the permissible concentrations in feed and other products.

2. Indices for assessing water pollution. To assess water quality, both water pollution indices (WPI) based on chemical indicators and biotic indices are used, those that take into account the species composition and quantitative development of plant (periphyton, phytoplankton) and animal (benthos, zooplankton, fish) communities. The calculation of the WPI is based on the following rule of maximum allowable concentrations: when several substances with the same limiting sign of harmfulness, belonging to hazard classes 1 and 2, enter water bodies, the sum of the concentration ratios (C_1, C_2 ... C_m) of each of the substances in the water body to the corresponding MAC should not exceed one:

$$\frac{C1}{MAC1}+\frac{C2}{MAC2}+\ldots+\frac{Cm}{MACm}\leq 1$$

For an integral assessment of the impact of pollution on aquatic communities, biotic indices based on indicator species are calculated. Indicator species are selected in accordance with their sensitivity to changes in the ecological conditions of species habitat [**11**]. If the indicator species deviate in quantitative development from the “prosperous” state, then this is a signal to analyze: which of the physicochemical or toxicological factors influenced this, or has a permanent stressful effect on the ecosystem.

Based on the quantitative development of certain indicator species in the communities of algae, benthos, zooplankton and fish, water bodies correspond to the following pollution classes: pure water from mountain alpine springs (xeno-saprobic zone), slightly polluted water from mountain rivers flowing near settlements (oligosaprobic zone), (β-meso-saprobic zone and α-meso-saprobic zone) polluted waters of lowland rivers (middle and lower reaches) affected by industrial or agricultural effluents and dirty waters (polysaprobic zone) - water of collector-drainage reservoirs, enriched with organic matter or toxic waste from poorly treated domestic or industrial effluents. Usually, as the level of pollution increases, the number of "stenobiont" oligosaprobic species decreases, while the number of "eurybiont" polysaprobic species increases.

Due to the increase in anthropogenic factors of environmental pollution, there is an urgent need for a wider use of tools for assessing various pollution of water sources. Back in the 30s of the twentieth century, the Russian scientist S.N. Duplakov noted the paramount importance of periphyton as an indicator in the sanitary-biological assessment of waters. The indicator value of periphyton in water bodies is determined by taxonomic and functional diversity, which makes it possible to judge the quality and degree of water pollution [**4**].

Periphyton is an exceptionally suitable object for research in the field of ecology, and is also of paramount importance as an indicator in the sanitary-biological assessment of waters. Thus, with an increase in the total level of pollution in the periphyton, there is a gradual decrease in the absolute number of producers with a simultaneous increase in the absolute number of consumers and decomposers, which, for example, in rivers heavily polluted with organic matter, completely determine the composition and structure of periphyton communities.

The high informative capacity of the periphyton and, consequently, its high indicator capacity are primarily due to the complex species composition of organisms represented by numerous and ecologically diverse species. Therefore, indicator communities of various hydrobionts are of great importance in assessing the ecological state of various water bodies.

Materials and methods. The most suitable for collecting periphyton are neutral substrates (stones, concrete structures, etc.), scrapings were made using a scraper, knife, scalpel, and tweezers. The collection of fouling from the thallus of higher aquatic vegetation was carried out only in cases where there were no other substrates [**15**].

A small amount of the selected material, together with water, was placed in a wide-mouthed jar with a lid with a capacity of 0.2-0.5 l and with a large supply of air. If it was impossible to deliver a live sample to the laboratory, it was preserved at the sampling site with 40% formalin.

In the laboratory, the samples taken before processing were placed in a Petri dish and the material was disassembled using a dissecting needle and tweezers. Then a small amount of the material was placed on a slide, covered with a coverslip, and analysis (identification of microorganisms) was carried out using an optical microscope according to generally accepted methods [**7**].

To determine the species composition of algae, freshwater algae determinants were used in accordance with the analyzed group of aquatic organisms and other generally accepted determinants [**13**].

Simultaneously with the determination of the species composition of the periphyton, the frequency of occurrence (abundance indicator) h for each species was estimated on an eye scale: from 1 point (single specimens in a sample) to 9 points (very often found in the field of view) [**1**].

The most convenient, as applied to periphyton organisms, it is recommended to use the method of indicator organisms by Pantle and Buck in the modification of Sladecek [**11**]. This method takes into account the frequency of occurrence (abundance) of hydrobionts “h” and their indicator significance “S” (saprobic valency). The determination of the relative frequency of occurrence "h" is carried out according to the eye scale. The indicator significance “S” and the saprobity zone are determined for each species according to the lists of saprobic organisms.

The biotic periphyton index was developed on the basis of material collected mainly from the Syrdarya river basin, and is largely regional in nature, adapted to the regional characteristics of the rivers of Central Asia. The development of the BPI is based on the ranking of the biological responses of the periphyton to changes in the complex of abiotic conditions and the chemical composition of water - from the zone of formation to the zone of active dispersion and pollution of surface runoff, as well as the digital coding of various states of periphyton biocenoses in the form of points: from 10-9 (very clean water) to 1-0 (very dirty water). BPI has a zero value under conditions of pronounced toxic stress [**15**].

For studies of water fouling, the biotic periphyton index (BPI) is used, which is necessary for assessing the ecological state and quality of water bodies.

Results and discussion. Based on information about the species composition of aquatic organisms found in certain waters, one can get an idea of how clean or polluted the latter are.

Therefore, organisms characteristic of zones of various pollution are called bioindicators of the degree of pollution.

The indicator role of hydrobionts is characterized not only by the fact of their presence or absence in a water body, but also by the degree of quantitative representation [**3**].

Anthropogenic pollution causes changes in the composition and structure of aquatic communities, expressed in a change in the dominant complexes of organisms, simplification of the ecological structure, and the appearance of highly saprobic species in the composition of dominants [**9**].

Conclusion. In the environmental and sanitary assessment, a sanitary and topographic survey of the catchment area that feeds the water source, as well as factors that can worsen water quality, plays an important role. The sanitary and hygienic study of any water source actually begins with it. The relief of the terrain, the composition of the soil, the presence of forests, the location of settlements, industrial enterprises, and the agricultural use of the territory are being studied. Of particular importance is the study of the degree of settlement of the territory, since the higher the population density, the more waste of organic origin is formed and the more real the possibility of their getting into the reservoir and the occurrence of water epidemics.

It is necessary to obtain information about the use of the reservoir for national economic purposes, paying special attention to water transport and fisheries, the use of reservoirs for sports purposes, and the level of morbidity in the population of the area. Hydrometric measurements (depth, flow velocity, water flow, etc.) are of great importance.

Water is the most valuable natural resource. The growth of cities, the rapid development of industry, the intensification of agriculture, the significant expansion of irrigated land, the improvement of cultural and living conditions, and a number of other factors are increasingly complicating the problem of water supply. The shortage of clean fresh water is already becoming a global problem. Systematic monitoring of the water fund is necessary, as a result, the use of various methods listed above will help to comprehensively monitor the state of water resources for the benefit of humans and the environment.

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