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DRINKING WATER QUALITY IN UZBEKISTAN: ENVIRONMENTAL CHALLENGES, REGIONAL DIFFERENCES, AND PUBLIC HEALTH RISKS (WITH A FOCUS ON KARAKALPAKSTAN)

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Abstract
The article analyzes the current state of drinking water quality in Uzbekistan, identifies key environmental challenges, regional differences and potential risks to public health. Special attention is paid to Karakalpakstan, the region most vulnerable to water problems due to the drying up of the Aral Sea, land degradation and reduced availability of safe drinking water. Based on data from the World Health Organization, the State Committee for Ecology of Uzbekistan and scientific research, the main water pollutants, their origin and impact on public health are considered. Recommendations are made to improve the quality of drinking water and reduce environmental risks.

Keywords: Drinking water, Uzbekistan, Karakalpakstan, environmental risks, water quality, the Aral Sea, public health, pollution, sanitary standards.

Introduction

Water is one of the key factors for ensuring public health and sustainable development. In Uzbekistan, the problem of drinking water quality is of strategic importance, since the country belongs to regions with limited water resources and a significant environmental burden. According to the World Bank, about 20 % of the country's population has difficulties accessing safe drinking water [1].

One of the most vulnerable regions is the Republic of Karakalpakstan, where the environmental crisis caused by the drying up of the Aral Sea has led to an increased concentration of salts, pesticides and heavy metals in the water of surface and underground sources [2]. This increases public health risks and requires scientific analysis.

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The relevance of studying the quality of drinking water is due to modern challenges: increasing agricultural burden, climate change, ecosystem degradation and an increase in the number of diseases associated with the use of contaminated water. Understanding regional differences and risk factors will make it possible to develop effective measures to protect public health and ensure sustainable water supply [3].

Materials and methods of research

The study is based on the analysis of:

- official statistical data of the Ministry of Water Resources of Uzbekistan;
- reports of the World Health Organization;
- research on hydrochemistry and ecology of Central Asia;
- comparative analysis of water quality by region;
- data of sanitary and epidemiological services.

The following indicators were considered: the amount of dissolved salts, concentrations of nitrates, sulfates, pesticides, heavy metals (Cd, Pb, As), microbiological indicators (E. coli), as well as regional differences in access to centralized water supply.

Research Results

General trends in Uzbekistan.

The analysis shows that the quality of drinking water in some regions does not meet sanitary requirements. In rural areas, about 33 % of water sources have high salinity and the nitrate content is higher than acceptable standards [4].

Main pollutants:

- increased water salinity (especially in the Lower Amu Darya);
- nitrates entering ground water due to intensive use of fertilizers [5];
- heavy metals: cadmium, lead and arsenic-mainly in the areas adjacent to the dried-up bottom of the Aral Sea.
- pesticide residues typical of cotton-growing areas [6].

The situation in Karakalpakstan

Karakalpakstan is the region with the most serious water quality problems. The following characteristics were identified:

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- **High salinity of water.** The average salinity of underground waters reaches 2-3 g / l with a norm of up to 1 g / l [7].
- **Increased content of toxic substances.** The concentration of nitrates exceeds the norm by 1.5-4 times; the arsenic content in some wells reaches 0.05 mg / l [8].
- **Problems with microbiological safety.** In rural areas, up to 40 % of water samples show the presence of Escherichia coli (E. coli) bacteria [9].
- **Limited access to quality water supply.** Only about 53 % of the region's population is connected to a centralized water supply system [10].

Analysis and discussion.

The quality of drinking water in Uzbekistan is formed under the influence of many factors, including natural conditions, anthropogenic impacts, and socio-economic circumstances. One of the key problems is the drying up of the Aral Sea, which began in the middle of the 20th century as a result of the active redirection of the waters of the Amu Darya and Syr Darya Rivers for irrigation of cotton plantations. The reduction of the water mirror area by more than 90 % led to the formation of the Aral Salt marsh plateau, a region with high concentrations of salts and chemical pollutants, including residues of pesticides and defoliants used in intensive agriculture [10]. Dust from salt marshes is carried by winds over long distances, settles on soils, vegetation and water bodies, which leads to gradual contamination of underground and surface waters.

Environmental stress is compounded by climate change. The average air temperature in Uzbekistan has increased by 1.5–2 °C over the past three decades, and precipitation has decreased by 10-15% in most regions of the country. These changes increase evaporation from water bodies and increase the concentration of dissolved salts in water sources. Especially vulnerable are underground waters in Karakalpakstan, where salinity reaches 2-3 g / l with an acceptable norm of up to 1 g / l, which creates a risk of chronic diseases in the local population [7].

Anthropogenic factors are equally important. Intensive use of chemical fertilizers and pesticides, insufficient development of water treatment systems and inefficient water supply infrastructure contribute to the contamination of drinking water. Nitrates coming from agricultural land are one of the main pollutants, causing methemoglobinemia in children and chronic diseases in adults [5]. Heavy metals such as arsenic, lead, and cadmium are found mainly in areas adjacent to the Aral

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Sea, where soil erosion and dust from salt marshes contribute to their migration to aquifers [8].

Regional differences in water quality in the country are obvious. In the eastern regions, including Tashkent and Andijan, there is a more modern water treatment and distribution infrastructure. More than 85 % of the population has access to a centralized water supply, and most of the water samples meet sanitary standards [4]. In western regions, such as Khorezm and Karakalpakstan, the situation is much worse: the level of centralized water supply does not exceed 50-55 %, and water is often characterized by high salinity and toxic substances content [10]. In some areas, the concentration of nitrates exceeds the permissible values by 2-4 times, and arsenic is five times higher than the norm [8].

The problem is compounded by soil degradation and salt marsh processes. A high degree of salinization of the earth disrupts the natural filtration of water, which accelerates the penetration of pollutants into aquifers. In the areas adjacent to the dried-up bottom of the Aral Sea, there is an accumulation of salts and toxic elements, which negatively affects the health of the population and reduces the efficiency of agricultural production.

Microbiological contamination is also a serious problem. Studies of sanitary and epidemiological services show that up to 40 % of water samples from wells and local sources contain Escherichia coli (E. coli) bacteria [9]. This increases the risk of acute intestinal infections, especially in the summer months, when high temperatures promote rapid growth of pathogens. In conditions of poor hygiene and low public awareness, these infections spread particularly rapidly among children and the elderly.

The consequences of drinking contaminated water are diverse. Long-term consumption of water with a high nitrate content can lead to the development of methemoglobinemia in children, decreased immunity and delays in physical development. Toxic exposure to arsenic causes an increase in the incidence of cancer, including skin, lung, and bladder cancer [11]. High water salinity puts additional stress on the kidneys, cardiovascular system, and liver, increasing the risk of chronic diseases [12]. Combined with microbiological contamination, this poses a complex threat to the health of the region's population.

Special attention should be paid to vulnerable groups of the population: children, pregnant women and the elderly. Children are exposed to the acute effects of nitrate

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and microbiological contamination, as well as chronic nutrient deficiencies due to poor absorption by the body. Pregnant women are at risk of toxic exposure to arsenic and other chemicals, which can lead to pregnancy complications and impaired fetal development. Older people suffer from chronic diseases, which are aggravated by the high content of salts and toxins in the water.

In addition, socio-economic factors increase the negative impact. In rural and remote areas of Karakalpakstan, the population has limited access to modern wastewater treatment facilities, and the economic inability to purchase filters or bottled water increases dependence on local sources, the quality of which is not guaranteed [10]. Lack of regular monitoring and poor public awareness of the risks worsens the situation, creating a long-term health threat.

Changes in the river regime and depletion of water resources in the Amu Darya lead to a decrease in the possibility of natural self-purification of water bodies, which increases the concentration of pollutants. In addition, existing irrigation systems often deal with water loss and contamination at the distribution stage. This creates an additional risk of toxins entering domestic sources and exacerbates the problem of drinking water.

It is also necessary to note the interaction of factors. High mineralization, nitrate and toxic metal content, microbiological contamination and climate stress do not act in isolation. Together, they create a synergistic effect, increasing the negative impact on the health of the population and the ecosystem of the region. The consequences manifest themselves in both acute and chronic aspects, ranging from infectious diseases to long-term consequences, such as cancer and kidney failure.

Measures to improve the quality of drinking water should take into account all these interrelated factors. Water treatment should include both physico-chemical and microbiological methods. Monitoring and early warning of pollution are essential for a timely response. At the same time, it is necessary to reduce the agrochemical load and restore the ecosystem of the Aral Sea region. Only a comprehensive approach will reduce public health risks and improve the sustainability of water supply in the region.

Conclusions

1. The quality of drinking water in Uzbekistan, especially in Karakalpakstan, is under serious environmental and sanitary pressure. The main problems are related

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to the drying up of the Aral Sea, soil degradation and insufficient water supply infrastructure.

2. Regional differences are significant: the eastern regions have a relatively safe water supply, while the western and Aral Sea regions suffer from high salinity and the presence of toxic substances.

3. Water pollution directly affects the health of the population, increasing the risk of chronic and acute diseases, including cancer, methemoglobinemia in children and intestinal infections.

4. To reduce risks, it is necessary to modernize treatment facilities, develop water supply infrastructure, implement water quality monitoring systems and reduce the use of agrochemicals in agriculture.

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