INVESTIGATION OF THE POSSIBILITY OF REUSE OF WATER FROM A MAN-MADE RESERVOIR IN THE WATER SUPPLY OF ALMALYK MMC

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Annotation: The mining industry is a significant factor in the transformation of the environment and a source of geochemical stress on the natural complexes of mining territories. Acidic mine waters are one of the most common and serious issues in this area. Saturated with toxic metals, they are formed as a result of sulfuric acid weathering of sulfide minerals both during mining and after its completion. The duration of acidic water formation after the closure of the mine can be several tens or hundreds of years [1]. The purification of acidic mine waters is an important environmental task [2]. The main difficulty lies in the fact that it is necessary to purify large volumes of water, which are complex multicomponent systems with low pH and high concentrations of metals and sulfates [3]. In order to avoid uncontrolled environmental impacts, these waters must be collected, and the content of polluting components must be brought up to standard values before being discharged into rivers or reused in the technological processes of enterprises.

Key words: mining industry, man-made reservoir, ecology, research, chemical composition, purification, ion exchange technology, demineralization.

Introduction

There is a wide variety of industrial effluents in the world that require special research in relation to each industry. Undoubtedly, industrial enterprises are the main source of environmental problems associated with wastewater discharge that exist in the modern world. After all, manufacturing enterprises themselves involve the use of chemicals in various technological processes, which enter drains and further into reservoirs. This causes enormous harm to the surrounding world [4]. In natural conditions, water purification has been taking place in seas, rivers, and other reservoirs for millions of years. There was a natural process of self-regulation of living ecosystems and self-purification of water. It proceeded slowly, but evolution successfully coped with it. Now nature is no longer able to clean itself. The man-made load leads to an increase in the amount of waste. Prevention of pollution of water bodies by wastewater, as well as protection of surface waters from wastewater pollution, are the most important tasks facing modern society.

Uzbekistan is facing serious issues in the water sector, especially as the most populous country in Central Asia, experiencing a serious water shortage. This problem is aggravated by the increase in production capacities of industrial enterprises that take large amounts of water for production and inefficient use of water. And when industrial wastewater is discharged into urban sewers, the load on urban wastewater treatment plants increases. Based on this factor, it is important for each enterprise to solve problems related to their cleaning. Wastewater treatment of enterprises and waste waters of the resulting man-made reservoirs requires the introduction of new technologies that can minimize the negative impact on the environment. In this regard, modern, highly efficient water treatment equipment is currently being successfully developed, manufactured, and widely implemented in Uzbekistan. However, large enterprises of our republic, one of which is Almalyk MMC JSC, also face the above-mentioned problems. For example, in the last ten years, a pond with a volume of about 25,000 m^3 has been formed at the site of a spent zinc quarry in the highlands due to the accumulation of groundwater and natural precipitation (Figure 1).

Figure 1. A general view of the technogenic lake formed on the site of a spent zinc quarry, taken from the western side.

Maintaining the volume of the reservoir at almost the same level during the entire observation period indicates the absorption of a certain amount of water into the groundwater, which creates a major environmental problem for the city of Almalyk. The purpose of our research was a comprehensive study of the problem and finding the optimal solution to the possibility of reuse of purified water from this man-made reservoir in the water supply of industrial enterprises of Almalyk MMC JSC.

Methods

In order to study the mineralogical and chemical composition of the water in the reservoir under study, samples of up to 100 liters were periodically taken from October 2023 to July 2024. The sampling was carried out from a boat from various parts of the reservoir. The water layer was 1-4 meters (Table 1). Potentiometric studies and experiments on ion exchange water purification were carried out in the chemical analytical laboratory of the university TSTU Almalyk branch.

Industrially produced ionites KU-2-8 and AN-31 were used as ion-exchange resins. In the experiments, the generally accepted sorption-desorption conditions were observed [5, 6]. The sample analyses were performed in the central laboratory of Almalyk MMC JSC and the laboratory for Solving Water Supply Problems of the central scientific center of NMMC using flame emission spectrometry methods (on a TY-9900 (ICP-AES) brand device from DRAWEL), flame atomic absorption (on a Kvant-2A brand device from Kortek), and ionization in inductively coupled plasma. 23 components were identified in each sample. The content of acid residues was determined according to established standards.

Results and discussion

In the mining industry, along with the extraction of minerals, water is taken, the volume of which is several times higher than the volume of its consumption by other industrial enterprises. Therefore, the creation of drainless systems at mining enterprises is very relevant. Plans to increase production capacity by 2030 of Almalyk MMC JSC provide for an increase in water intake for newly created enterprises. In this regard, the use of repurified water from a man-made reservoir formed on the site of a spent zinc quarry seems both economically advantageous and environmentally in high demand, and its high location makes this project technically convenient. For the experiments, water samples were taken at different periods of the year. The biosphere of the reservoir is very poorly developed, which can be explained by the acidic pH of the water. During the observation period, the pH of the studied water samples ranged from 5.0 to 6.5. The results of the study of the chemical composition of the samples taken indicate high mineralization (from 1.2 to 1.4 g/l), as well as water hardness (Tables 1-3).

Table 1. The elemental composition of the averaged water samples taken from the surveyed reservoir in different periods of the year by flame emission spectrometry.

Defined components, mg/l																			
sampling time - 11.10.2023																			
Au	Pt	Ag	Rh	Ir	Ru	Al	Ca	Co	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Sb	Sn	Zn	Si
<1	<1	<1	<1	<1	138	30	575	<1	<1	<1	5	315	<1	2	5	<1	<1	1	1
sampling time -22.01.2024																			
<1	<1	<1	<1	<1	<1	27	483	<1	1	<1	<1	307	<1	<1	<1	<1	<1	3	18
sampling time -18.03.2024																			
<1	<1	<1	<1	<1	<1	19	350	<1	<1	<1	<1	319	<1	1	<1	<1	<1	5	<1
sampling time -17.07.2024																			
<1	<1	<1	<1	<1	<1	34	359	<1	<1	<1	<1	321	<1	2	<1	<1	<1	5	<1

Table 2. The elemental composition of the averaged water samples taken from the surveyed reservoir in different periods of the year by the method of flame atomic absorption.

Defined components																			
sampling time - 11.07.2023																			
Au	Pt	Ag	Rh	Ir	Ru	Al	Ca	Co	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Sb	Sn	Zn	Si
<1	<1	<1	<1	<1	138	30	575	<1	<1	<1	5	315	<1	2	5	<1	<1	1	1
sampling time -22.01.2024																			
<1	<1	5	<1	<1	<1	2	8	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	3	18
sampling time -11.03.2024																			
<1	<1	<1	<1	<1	<1	1	350	<1	<1	<1	<1	319	<1	1	<1	<1	<1	5	<1
sampling time -11.05.2024																			
<1	<1	<1	<1	<1	<1	3	359	<1	<1	<1	<1	321	<1	2	<1	<1	<1	5	<1

Table 3. The chemical composition of the averaged water samples taken from the surveyed reservoir in different periods of the year by the analytical method.

Defined components, mg/l					
sampling time - 11.07.2023					
CO_3^{2-}	Cl-	NO_2^-	NO_3^-	HCO_3^{2-}	SO_4^{2-}
10.2	175.9	0.02	145.5	13.4	3289.2
sampling time -22.01.2024					
8.3	190.5	0.03	151.8	13.7	3945.0
sampling time -11.03.2024					
8.0	185.2	0.02	146.1	13.6	3225.0
sampling time -11.05.2024					
8.9	190.5	0.02	138.3	13.7	3961.0

The composition of the water is sulfate (the concentration of sulfate ions is up to 3960 mg/l), chlorine is found in an amount of 155–190 mg/ll, and bicarbonate ions are no more than

14 mg/ll. The content of nitrogenous compounds is insignificant (Table 2). Among the cations, calcium is in the first place, then magnesium and aluminum are in the third place.

There are various methods of wastewater treatment in the scientific literature [7, 8]. As the analysis of developments in this direction shows, enterprises currently use mainly reagents, ion exchange, electrochemical (electrocoagulation), and other purification methods. The disadvantage of the reagent method is the duration and complexity of the processes, high consumption of reagents and significant operating costs, high metal consumption, and bulkiness of the installations used, which occupy significant production areas. The duration of chromium reduction by reagent methods, depending on its concentration in the initial effluents and the pH of the medium, ranges from 15 to 40 minutes; the consumption of reducing reagents is 150–250% of the theoretically necessary [7, 8]. During ion exchange purification, the duration of the process is 0.5-1.5 hours, and the possibility of repeated periodic regeneration of ionites, as well as the simplicity of design, determined the widespread introduction of this method in various enterprises [9]. The use of electrochemical purification leads to a reduced iron content in treated wastewater but to significant energy consumption (from 2 to 6 kWh per 1 m3 of wastewater) and metal (sheet metal for electrodes is used by 50–60%). The purification process significantly depends on fluctuations in wastewater flow and temperature, salt composition, and the concentration of pollutants, which requires verification and confirmation of the expediency of application in each specific case experimentally [10].

A comparison of the chemical composition of water used at the copper processing plant (MOF) and the copper smelter (MPZ) in the sulfur dioxide workshop (SCC) of Almalyk MMC JSC (Table 4) with the chemical composition of the studied reservoir (Table 1, 2) showed that its hardness is several times greater than those used in technological processes water cycles.

Table 4. The chemical composition of the process water used in the production of A.

Au	Pt	Ag	Rh	Ir	Ru	Al	Ca	Co	Cr_2	Cu	Fe	Mg	Mn	Ni	Pb	Sb	Sn	Zn	Si
Recycled water of MOF (CCP) AMMC																			
<1	<1	<1	<1	<1	<1	15	120	<1	<1	<1	4	11	<1	1	4	<1	<1	<1	1
Recycled water of MPZ (INVENTORIES), СКЦ (Expanded Clay Cement Wall Block) AMMC																			
<1	<1	<1	<1	<1	<1	11	230	<1	1	3	4	19	<1	1	4	<1	<1	<1	1

Based on the chemical composition of the water in the studied reservoir, the ion exchange method was chosen as a method of its purification. Industrially produced ionites of the KU-2-8 brand (cationite) and AN-31 brand (anionite) were selected as ion-exchange resins based on the literature analysis. Water purification was carried out by a dynamic method in two stages. First, metal ions were captured by cationite, and then acid residues were captured by anionite. Desorption of saturated cationite was carried out with a 2% aqueous NaCl solution and saturated anionite with a 5% aqueous NaOH solution. Table 5 shows that the purified water of the reservoir is 5 times softer than the used water at the enterprises of Almalyk MMC JSC (Table 4). In general, when cleaning, the hardness of water from the reservoir is reduced by 15 times.

Table 5. Chemical composition of a man-made reservoir before and after purification.

Defined components, mg/l																			
Au	Pt	Ag	Rh	Ir	Ru	Al	Ca	Co	Cr_2	Cu	Fe	Mg	Mn	Ni	Pb	Sb	Sn	Zn	Si
A sample of water taken from a reservoir																			
<1	<1	<1	<1	<1	138	30	575	<1	<1	<1	5	315	1	2	5	1	<1	1	1
Water after ion exchange purification (cationite)																			
<1	<1	<1	<1	<1	140	16	20	<1	<1	<1	5	3	1	2	5	<1	<1	<1	1
Water after ion exchange purification (anionite)																			
<1	<1	<1	<1	<1	116	11	23	<1	<1	<1	5	2	1	2	5	<1	<1	<1	1

Conclusion

The results obtained indicate the possibility of recycling water from reservoirs formed after mining operations on an industrial scale. Also, the developed technology can be widely used both for wastewater treatment in hydrometallurgical and machine-building enterprises.

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