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АКАДЕМИЯСЫ» РҚБ

ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ
HALYK
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**«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ**

БАЯНДАМАЛАРЫ

ДОКЛАДЫ

**РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ КАЗАХСТАН»
ЧФ «ХАЛЫҚ»**

REPORTS

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OF THE REPUBLIC OF KAZAKHSTAN
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ALMATY, NAS RK

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
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STUDY OF CHEMICAL POLLUTION LEVEL IN WATER RESOURCES OF ALMATY CITY

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Abstract. Nowadays pollution of water bodies is an urgent problem. The natural regime of water is disturbed by dumping of wastes on Almaty water bodies. There is also a high share of river water pollution by pipe runoff, domestic wastes, industrial wastes. The purpose of this work is to determine the level of chemical pollution of Almaty rivers. Therefore, the study of water pollution of the main rivers that provide water supply to the city of Almaty is an urgent issue. The rivers Bolshaya Almatinka and Malaya Almatinka flow through the city, as well as their tributaries - Esentai (Vesnovka), Ak-Kayin, Remezovka, Zharbulak (Kazachka), Karasu, Kargaly (Kargalinka). The river Esentai flows into the Bolshaya Almatinka, then flows into Kaskelen, the river Malaya Almatinka flows into the Kapshagai reservoir. In accordance with the goal set, the objectives of the study were determined. The rivers Bolshaya Almatinka, Malaya Almatinka and Yesentai were the object of the study. The study revealed different levels of pollution by chemical substances. Monitoring on heavy metals of sources of household and drinking water supply of Almaty city was carried out. In the research laboratory on quality assessment and food safety of Almaty Technological University water samples were taken from the rivers Bolshaya Almatinka, Malaya Almatinka and Yesentai. Organoleptic properties of the composition of the selected samples were determined and heavy metals were detected. Heavy metals from river water samples were determined using spectrophotometer KFK 3.01. As a result of the

research, heavy metals in the rivers of Almaty city were identified and their dynamics and degree of accumulation in certain periods of time were studied. The rivers of Almaty while flowing through the territory of the city had significant chemical pollution exceeding MPC.

Keywords: water pollution index, heavy metals, MPC, average concentration, organoleptic properties

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АЛМАТЫ ҚАЛАСЫНЫҢ СУ РЕСУРСТАРЫНЫҢ ХИМИЯЛЫҚ ЗАТТАРМЕН ЛАСТАНУ ДЕҢГЕЙІН ЗЕРТТЕУ

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Аннотация. Қазіргі уақытта су объектілерінің ластануы өзекті мәселе болып табылады. Судың табиғи режимі қалдықтарды Алматы су объектілеріне төгу жолымен бұзылады. Өзен суларының құбырлар ағынымен, тұрмыстық қалдықтармен, өнеркәсіптік кәсіпорындардың қалдықтарымен ластану үлесі де жоғары. Бұл жұмыстың мақсаты Алматы өзендерінің химиялық заттармен ластану дәрежесін анықтау болып табылады. Сондықтан Алматы қаласын сумен қамтамасыз ететін негізгі өзендер суының ластануын зерттеу өзекті мәселе болып табылады. Қала арқылы Үлкен Алматы және Кіші Алматы өзендері, сондай - ақ олардың салалары-Есентай (Весновка), Ақ-қайын, Ремезовка, Жарбұлақ (Казачка), Қарасу, Қарғалы (Қарғалы) өзендері ағып өтеді. Есентай өзені Үлкен Алматыға, одан әрі Қаскелең өзеніне құяды, Кіші Алматы өзені Қапшағай су қоймасына құяды. Зерттеу нысаны ретінде Үлкен Алматы, Кіші Алматы және Есентай өзендері болды. Зерттеу химиялық заттардың ластануының әртүрлі деңгейлерін анықтады. Қойылған мақсатқа сәйкес зерттеу міндеттері анықталды. Алматы қаласын шаруашылық-ауыз сумен жабдықтау көздерінің ауыр металдары бойынша мониторинг жүргізілді.

Алматы технологиялық университетінің тамақ өнімдерінің сапасы мен қауіпсіздігін бағалау жөніндегі ғылыми-зерттеу зертханасында Үлкен Алматы, Кіші Алматы және Есентай өзендерінің суларының сынамалары алынды. Іріктелген сынамалар құрамының органолептикалық қасиеттері анықталып, ауыр металдар анықталды. Өзен суларының сынамаларынан ауыр металдар (Fe, Cu, Zn) КФК 3.01 спектрофотометр құралының көмегімен анықталды. Зерттеу нәтижесінде Алматы қаласының өзендерінде ауыр металдар анықталды, сондай-ақ олардың белгілі бір уақыт кезеңдеріндегі жинақталуы дәрежесі мен динамикасы зерттелді. Алматы өзендері қала аумағы арқылы ағып жатқан кезде ШРК-дан асатын айтарлықтай химиялық ластануға ие болды.

Түйін сөздер: судың ластану индексі, су сапасының көрсеткіші, ауыр металдар, ШМК, орташа концентрация, органолептикалық қасиеттер

Қаржыландыру: *Бұл зерттеу сыртқы қаржыландыруды алған жоқ*

Алғыс: *Авторлар қажетті зерттеулер жүргізгені үшін Алматы технологиялық университетінің тамақ өнімдерінің сапасы мен қауіпсізді-гін бағалау зертханасының қызметкерлеріне алғысын білдіреді.*

Мүдделер қақтығысы: *Мүдделер қақтығысы жоқ.*

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ИССЛЕДОВАНИЕ УРОВНЯ ЗАГРЯЗНЕНИЯ ХИМИЧЕСКИМИ ВЕЩЕСТВАМИ ВОДНЫХ РЕСУРСОВ ГОРОДА АЛМАТЫ

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Аннотация. В настоящее время загрязнение водных объектов является актуальной проблемой. Естественный режим воды нарушается путем сброса отходов на алматинские водные объекты. Высока также доля загрязнения речных вод стоком труб, бытовыми отходами, отходами промышленных предприятий. Целью данной работы является определение уровень загрязненности химическими веществами рек Алматы, так как изучение загрязнения воды основных рек, обеспечивающих водоснабжение города Алматы, является актуальным вопросом. Через город протекают реки Большая Алматинка и Малая Алматинка, а также их притоки – Есентай (Весновка), Ак-Кайин, Ремезовка, Жарбулак (Казачка), Карасу, Каргалы (Каргалинка). Река Есентай впадает в Большую Алматинку, далее впада-ет в Каскелен, река Малая Алматинка впадает в Капшагайское водохрани-лище. В соответствии с поставленной целью определены задачи исследо-вания.

В качестве объекта исследования были реки Большая Алматинка, Малая Алматинка и Есентай. Исследование выявило различные уровни загрязнения химическими веществами. Проведен мониторинг по тяже-лым металлам источников хозяйственно-питьевого водоснабжения горо-да Алматы. В научно-исследовательской лаборатории по оценке качества и безопасности пищевых продуктов Алматинского технологического университета были отобраны пробы вод рек Большой Алматинки, Малой Алматинки и Есентай. Определены органолептические свойства состава отобранных проб и выявлены тяжелые металлы. Тяжелые металлы из проб речных вод определяли с помощью прибора спектрофотометра КФК 3.01. В результате исследований выявлены тяжелые металлы в реках г. Алматы, а также изучена их динамика и степень накопления в определенные периоды времени. Реки Алматы при протекании по территории города имели значительное химическое загрязнение, превышающее ПДК.

Ключевые слова: индекс загрязнения воды, тяжелые металлы, ПДК, средняя концентрация, органолептические свойства

Финансирование: данное исследование не получало внешнего финансирования.

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Конфликт интересов: конфликта интересов нет.

Introduction

At the modern stage of urbanization, which is becoming global, water occupies a special place and importance in the normal functional activity of humans, living organisms and living things. Unfortunately, most of the particularly voluminous water reserves in the hydrosphere (the volume of the hydrosphere is 2.2 times larger than the lithosphere) are sources of water unsuitable for human consump-tion. This situation, which today poses the problem of fresh water to mankind as a global problem, it is predicted that in the coming decades most of the world's pop-ulation may face the problem of fresh water. The qualitative changes in climate, water in rivers, lakes are now creating global scale problems. The southern capital with a population of more than 2 million people, an industrial center, is one of the most beautiful cities. These waters are used in industry and institutions, houses and apartments and contain various elements, chemicals, metals, petroleum prod-ucts, detergents. Currently, the agglomeration of Almaty city is among the most ecologically disadvantaged areas of the Republic of Kazakhstan, where all natural

environments are highly polluted with toxic chemical substances of soil, water, vegetation, and atmosphere. In the restoration of the ecological state of the city, special attention is paid to small rivers of Almaty city, as they are a true natural filter, as well as used as the main source of water in water supply zones, hydropower, recreation. Water from the rivers of Almaty city is characterized by high levels of pollution, especially heavy metals. There are 22 river and 4 artificial river reservoirs in Almaty city. There are 1252 objects located in the water protection zone of the rivers of Almaty. It was found that 1090 residential houses, 27 cafes, 20 stores, 5 wind farms, 45 garages, 26 enterprises and organizations are located in them. Air pollution negatively affects the health of citizens, soil crust, flora and fauna, surface and underground water. Therefore, the level of bacteriological pollution of Almaty's rivers has reached a high level (Zamora–Ledezma et al. 2021). The total length of river channels is 220.8 km, total area of water bodies —1116 hectares. The largest rivers of Almaty are: the Big Almaty River, the Small Almaty River, further the Yesentai River. The sources of water supply of the city are surface sources — Big and Malo-Almaty lakes, underground sources — Almaty, Talgar, Malo — Almaty fields. It is established that in the river Malaya Almatinka copper is 2.5 times higher, phenol is 2 times higher. The content of lead is about 1.1 MPC, and the content of other heavy metals is below MPC. In the Yesentai River, the maximum permissible concentration (MPC) of copper is 3 times higher. The Malaya Almatinka River runs along the northern side of the Zailiyskiy Alatau ridge, belongs to the basin of Lake Balkhash, the catchment area of which is 118 km^2 and reaches 710 km^2 at its confluence with the Kaskelen River (Bolisetty et al., 2019; Kumar et al., 2019; Review, 200; Enrique, 2007).

According to the latest data, the level of pollution of the water protection zone of Almaty rivers with heavy metals has reached a high level. For example, on the rivers Bolshaya Almatinka and Yesentai the permissible maximum high concen-trations of copper have reached 3 times, on the river Malaya Almatinka — 2.5 times, phenol — 2 times. The dynamics of presence and level of accumulation of heavy metals (Cd, Pb, Cu, Zn) in the mentioned rivers in the period from 2021 to 2022 were studied and it was found that they are present in all three. For example: copper increased from 11 to 12 MPC in all years. Lead pollution was noted in the river Malaya Almatinka (1.1km), Bolshaya Almatinka (1.9km). The content of other heavy metals was below MPC (Alzhanova, 2003; Water resources of Kazakhstan in the new millennium, 2007; Sall, 2020; Kilaru, 2009; Kiran, 2022; Fu, 2020).

The ways of getting into the hydrosphere of heavy metals from the water environ-ment polluted by man are different. Heavy metals include elements with metallic properties and relative atomic mass above 50. Another criterion is density equal to or greater than the specific gravity of iron (7.8 g/cm^3). The most dangerous elements are: chromium (51.9); nickel (58.7); cobalt (58.9); copper (63.5); zinc

(65.4); arsenic (74.9); cadmium (112.4); mercury (200.6); lead (207.2). The chemical composition of water also affects the living organism. It is estab-lished that natural waters can contain various trace elements (iodine, bromine, flu-orine, selenium, strontium, molybdenum, cobalt, etc.). Possessing high biological activity, they determine the normal course of many physiological and metabolic processes in the human body, participate in mineral metabolism and as catalysts of various biochemical reactions affect the overall metabolism. Micronutrients enter the human body from the external environment, their amount in the body directly depends on the presence in the soil, water, plants, etc. Deficiency or ex-cess of certain trace elements in water and food products can lead to the violation of various functions and diseases. In addition to trace elements, the human body is affected by a large number of different salts in water. Thus, highly mineralized water contributes to the increase of hydrophilicity of body tissues, water retention in the body (Shakhawat et al. 2016). The taste of water compared to pure drinking water has 4 senses of taste (sweet, bitter, salty, sour). The other senses are related to taste. They are sweet, metallic, chlorine, ammonia and others. The evaluation of odor and taste is determined on a 5-point scale. Odors and unpleasant tastes are intensified at high temperature (Alimkulov et al., 2016; Water resources of Kazakhstan: assessment, forecast, management, 2012; Dostai, 2012; Dostai, et al., 2012; Qasem et al., 2021).

Water odor is one of the sensitive indicators of water quality, the change of which indicates pollution. In addition, a slight degree of water pollution can be deter-mined by changes in odor, which exceeds the sensitivity of the developed chem-ical methods of investigation (Dostai et al., 2012). The odor of water is related to the presence of odorous substances in it through various currents. Almost all liquid organic substances give water a characteristic odor of dissolved gases, or-ganic suspensions, and mineral salts. Odors can be natural (swamp, sulfur, rotten) and artificial (chlorine, phenol, oil, etc.) (Kenshimov et al., 2005; Posthuma et al., 2019).

To determine chromaticity, the water under test is compared with artificial stan-dards prepared from a mixture of potassium chloroplatinate and cobalt chloride (platinum-cobalt scale) or potassium bichromate and cobalt sulfate (chromium-co-balt scale). The coloration of water corresponding to the coloration of a solution that contains 0.1 mg of platinum in 1 ml is called the degree of chromaticity.

Table 1. Color scale of drinking water

Name of color category	Water color, degrees
Very small	Up to 25
small	25–50
medium	50–80
high	80–120
very high	over 120

Materials and methods

To conduct the study, locations for collecting water samples with different assumed degree of pollution are selected. Water samples for heavy metal content in the Yesentai River were taken in 2 locations along the riverbed, at its intersection with Al-Farabi Avenue (No. 1) and Ryskulov Street (No. 2). On the Bolshaya Almatinka River were used data from 3 points: No. 1–9.1 km above the city, No. 2–0.5 km below the AHBK discharge, No. 3–0.5 km below the city. Water samples of the Malaya Almatinka River were analyzed for heavy metals content at 3 points: No. 1–0.5 km below the Mekhkombinat discharge, No. 2–2.0 km above the city, No. 3–4.0 km below Almaty city. In discussion and analysis of the database on heavy metal pollution of Almaty rivers.

Complex indicators of drinking water quality are characterized by certain attributes. Physical indicators of drinking water quality include temperature, taste, odor, turbidity and color. They determine the organoleptic quality of water. Chemical indicators are characterized by the chemical composition of water. The nature of odor was determined by the perceived odor (soil, chlorine, petroleum product, etc.) and the odor was evaluated according to the point system and intensity. The following indicators were found in the samples studied: in the samples of the large river Almaty odor intensity — no odor, the nature of odor manifestation — not observed, odor intensity score — 0-1 point. From the samples of the Esentai River odor intensity — weak, the nature of odor manifestation — weak grass-soil, odor intensity score — 2 points. In the samples of the Malaya Almatinka River odor intensity — weak, the nature of odor manifestation —weak grass-soil, odor intensity rating — 2 points. Water color was determined by photometric method by comparing the investigated water sample with distilled water. The color of the water sample of the Yesentai River is 18.88 degrees, which does not exceed the index according to SNiP 2.01.14–83 for drinking water. The color of the water sample from the Malaya Almatinka River is 19.60 degrees, which does not exceed the SNiP 2.01.14–83 for drinking water.

The Bolshaya Almatinka River (1.9 km) flows through mountainous, plain and transitional uplands. The watershed is considered to be a mountainous zone, which makes up 46 % of the river's territory. Water purity in this zone is at an average level.

Water transparency was determined by photometric method, comparing

the water sample with distilled water.

The color is determined by comparing the test sample with reference water. Table 1 presents a special color scale of drinking water. Turbidity of water determines the composition of fine suspension of insoluble particles, also — the presence of sediment, measured in microns and millimeters; determined after filtration of the sample by suspended, coarsely dispersed substances and dried residues — transparency is measured mainly visually by the level of turbidity of the water column. Turbidity is determined photometrically, depending on the quality of the light beam passing through it.

Water pollution index, as well as other indicators, are of great scientific, theoretical and purely practical importance. They are the main diagnostic method to identify the fact of pollution and its quantitative measure. Thanks to this, it is possible to understand whether the water can be used, for what specific purposes, and whether it is necessary to take measures for the ecological rehabilitation of the water body.

Samples were taken from different points of rivers, and a complex quality indicator — water pollution index (WPI) — was determined on the example of rivers (Bolshaya Almatinka, Malaya Almatinka and Yesentai) taken for studying surface water quality. WPI is one of the most important characteristics of water. It is the average ratio of the concentration of a particular pollutant to its MAC. WPI quantitatively shows how polluted the water in a river is.

"Very clean" waters are class I (WPI less than or equal to 0.3), "clean" waters are class II (WPI 0.3 to 1), "moderately polluted" waters are class III (WPI 1 to 2.5), "polluted" waters are class IV (WPI 2.5 to 4), "dirty" waters are class V (WPI 4 to 6), "very dirty" waters are class VI (WPI 6 to 10), and "extremely dirty" waters are class VII (WPI greater than 10).

For this purpose, samples were taken at certain intervals and measurements were carried out in accordance with the adopted methodology. As a result, a specific value is obtained, depending on which the degree of surface fresh water pollution is judged.

The assessment is carried out in accordance with the requirements of the guiding document RD 52.24.643–2002. This document specifies methodological principles and instructions for assessing the degree of pollution of surface waters of a particular water body (natural or artificial).

According to the methodology, sampling is carried out with subsequent analysis and identification of the fact of exceeding the MPC, for example, for iron content. The degree of exceedance is determined, e.g. 4.3 more than the established MPC norm. The number of cases per year or other period when these violations were detected is determined.

As a result, the water is assigned a certain class and discharge. The best grade is "conditionally clean". Such a liquid does not contain substances with concentrations exceeding the MPC.

However, its purity cannot be 100 % guaranteed due to unforeseen factors (e.g. acid rain, sewage discharge).

The formula and methodology for calculating WPI depends on the water being studied, in this case for surface freshwater. In any case, the WPI is calculated taking into account data on a strictly limited number of pollutants. For example, determine the exceedance of MPC for 10 components and work only with these data, calculating their arithmetic mean.

In the case of surface water, the index is calculated according to the following formula:

$$WPI = \left(\sum_{i=1}^{n} \frac{C_i}{MPC_i}\right)/6$$

As can be seen from the formula, the WPI measurement is carried out in several steps.

Determine the concentration of a specific pollutant Ci. Divide the obtained value by the MPC of this component (described in regulatory documents). Obtain the sum of such divisions for each pollutant from i=1 to n (the number of determined substances is always strictly limited, in this case is 6). Then divided by 6, i.e. the total number of pollutants (n = 6).

Heavy metals were determined in the Research Institute of Food Safety ATU, which has methods of analysis (electrochemical and spectrometric) and the necessary equipment for water quality control. Heavy metals from river water samples were determined using a spectrophotometer KFK 3.01.

Results and discussion

The level of pollution of the river Bolshaya Almatinka in 2021, as shown in Table 2, is 1.43 (3 class), ie has an average level of character. In 2022, this indicator is 1.57 (3 class), we can observe an increase in pollution level.

Table 2. Pollution level of the Bolshaya Almatinka River 2021-2022

Name of water object	Water Pollution Index (WPI) - water quality characteristic		The content of pollutants exceeding MAC for 2022		
	2021	2022	impurity	average concentration, mg/l	multiplicity of MAC increase
Bolshaya Almatinskaya River	1,43 (3 cl.) medium contaminated	1,57 (3 cl.) contaminated	Cu (II)	0,4	0,9
			Fe (III)	0,8	1,1
			Pb (IV)	0,9	1,0
			Cd (II)	0,10	0,4

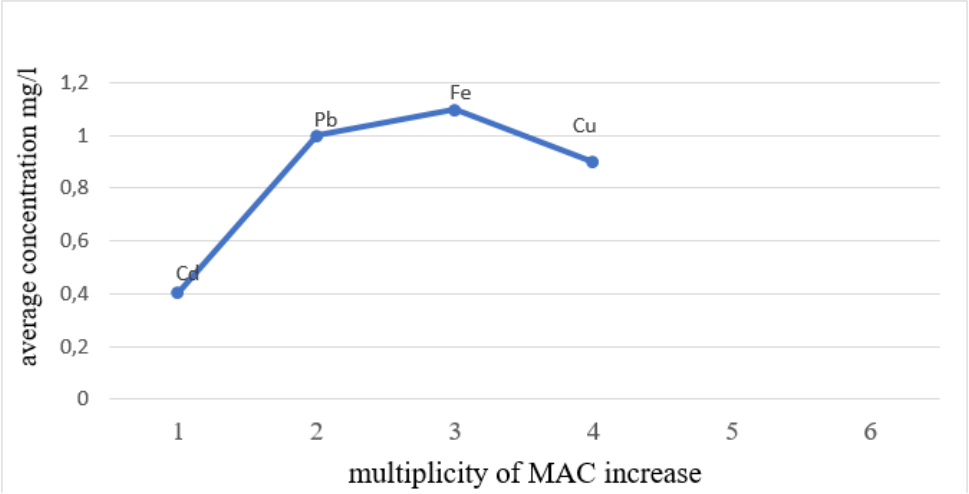

Figure 1 - Level of water pollution by impurities in the Bolshaya Almatinka River

As a result of the photometric study the following indicators were obtained: the transparency of water samples from the Bolshaya Almatinka River is 2.42 ml/dm^3, which corresponds to SNiP 2.01.14–83 2.5 ml/dm^3. Transparency of water samples from the Yesentai River is 2.45 ml/dm^3, which corresponds to SNiP 2.01.14–83 2.5 ml/dm^3. The transparency of water samples from the Malaya Almatinka River is 2.5 ml/dm^3, which corresponds to SNiP 2.01.14-83 2.5 ml/dm^3.

Heavy metals were detected in the composition of the studied surface water samples. The content of heavy metals in the samples taken from the research objects is presented in the table (Table 3). The danger of water pollution by these elements is associated with the fact that heavy metals in water are not detected organoleptically, i.e. are not noticeable by taste, smell and color.

Table 3. Average content of heavy metals in water of Almaty rivers

Name of water object	Quantity of pollutants compared to MAC, 2022	
	Heavy metals	Average MAC concentration, g/l
Average water index of Almaty rivers	Pb	0,001
	Cd	0,005
	As	0,001
	Al	0,004
	Cu	0,001
	Fe	0,001

The content of copper and iron from impurities in terms of pollutants raising MAC for 2022 is equal to 0.0049 and 0.0080 mg/l. The multiples of MAC elevation are equal to 4.9 and 1.1. Lead content is 0.00087 mg/l and cadmium content is 0.0010 mg/l, the MAC uplift multiples are 1.0 and 0.4. The content

of arsenic is 0.0012 mg/l. Only concentration of some chemical substances in waters of rivers Bolshaya Almatinka, Malaya Almatinka and Yesentai increases from MAC. The concentration of cadmium in the sample of the river Bolshaya Almatinka is 0.0061±0.003 mg/l and increased 6 times the MAC. On the concentration of copper in all samples under study exceeds the MAC level in the sample of the river Bolshaya Almatinka copper content is 0.0201±0.003 mg/l and exceeds the MAC by 20 times. Copper content in the sample of the Esentai River is 0.0191±0.003 mg/l and exceeds the MPC by 19 times. Copper content in the sample of the Malaya Almatinka River is 0.03±0.008 mg/l and exceeds the MPC 30 times. In samples in the control zone the level of MPC was not exceeded. According to literature sources, the cause is the ingress of copper in natural waters, as well as water from chemical plants, metallurgical industry, aldehyde reagents.

Table 4. Water pollution level in Malaya Almatinka 2021–2022

Name of water object	Water Pollution Index (WPI) - a characteristic of water quality		The content of pollutants that increase the content of MPC, for 2022		
	2021	2022	impurity	average concentration, mg/l	multiplicity of MAC increase
Malaya Almatinka River	1,68 (3 cl.) medium contaminated	1,47 (3 cl.) medium contaminated	CuF_2, Cu_3N_2, $Cu(NO_3)_2$	0,0043 0,0092 0,0021	4,3 1,2 1,1

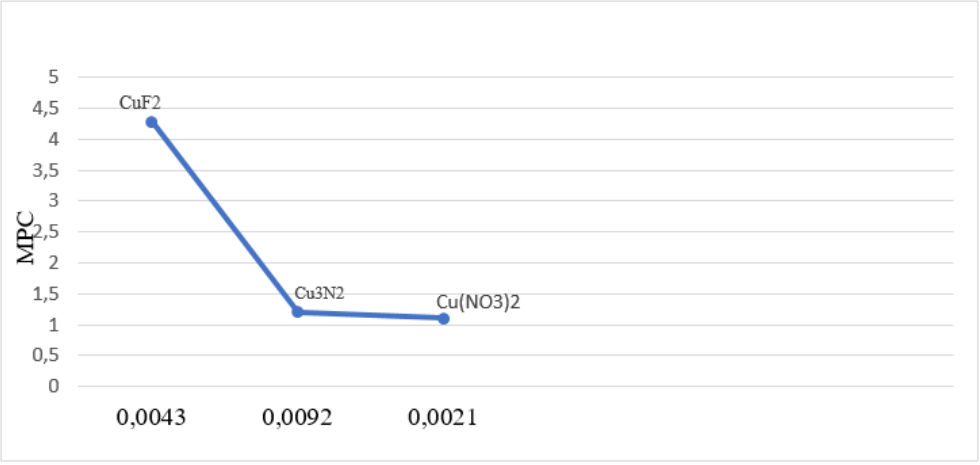

Figure 2 - Level of water pollution by impurities in the Malaya Almatinka River

As shown in Table 4, the water pollution index of the Malaya Almatinka River in 2021 is equal to - 1.68 (3kl), and in 2022 is equal to 1.47. This indicates a "moderately polluted" level for water quality characteristics. According to calculations for 2022, the water quality of the rivers Malaya Almatinka, Bolshaya Almatinka and Yesentai is considered "moderately polluted" (class 3, WPI — 1.52–2.60). In all rivers possible amounts of copper were traced, about 4.3 — 5.1 MAC. The content of fluoride and nitride nitrogen exceeding 1 MPC was monitored on the Small Almaty Lake, on the Big Almaty Lake — 1.1 MPC, iron content (pollution index on the Small Almaty Lake — 1.68, Yesentai - 1.58, Big Almaty Lake — 1.43).

The next object of study Esentai (Vesnovka) is a river in the Ili basin, left tributary of the Malaya Almatinka River. It originates from the northern slope of Zailiyskiy Alatau and flows through Almaty city. Its length is 43 km. The average annual water discharge is 0.06 m^3/s. It has 8 tributaries with a total length of 19 km. Along the river 7 ponds were built [11].

Table 5. Water pollution level of the Yesentai River 2021–2022

Name of water object	Water Pollution Index (WPI) – a characteristic of water quality		The content of pollutants that increase the content of MPC, for 2022		
	2021	2022	impurity	average concentration, mg/l	multiplicity of MAC increase
Yesentai River	1,57 (3 кл.) medium contaminated	2,60 (4 кл.) contaminated	Cu	0,0051	5,1

According to calculations for 2021, the water quality of the rivers Malaya Almatinka, Bolshaya Almatinka and Yesentai is considered "moderately polluted" (class 3, WPI — 1.52–2.60). All rivers showed possible amounts of copper, about 4.3 — 5.1 MAC (Table 5).

The content of fluoride and nitride nitrogen exceeding 1 MPC was monitored on the Small Almaty Lake, on the Big Almaty Lake — 1.1 MPC, iron content (pollution index on the Small Almaty Lake — 1.68; Yesentai — 1.58; Big Almaty Lake — 1.43).

Table 6. Special characteristics of water with different types of iron according to SNiP 2.1.4.1074-01

Type of iron	Tap water	Water after infusion
divalent	pure	red-brown precipitate
trivalent	colored	red-brown precipitate

colloidal	yellow-brown	does not form a precipitate, cannot be filtered
dissolved organic	yellow-brown	does not form a precipitate, not filtered
dissolved inorganic	jelly-like formations opalescent film in the pipe system	

The odor of water is related to the presence of odorous substances in it through various currents. Almost all liquid organic substances give water the characteristic odor of dissolved gases, organic suspensions, and mineral salts. Odors can be natural (swamp, sulfur, rotten) and artificial (chlorine, phenol, oil, etc.).

Table 7. Determination of water odor according to SNiP 2.1.4.1074–01

Score	Terms	Characteristic definition
0	definite	Odorless
1	very weak	An odor that is not detected by the consumer but is detected by observation in a laboratory
2	faint	An odor that is detected by the consumer if they pay attention to it, but not realized if they do not pay attention to it themselves
3	perceptible	An odor that is easy to notice and that may cause negative feedback about it
4	definite	An odor that is unpleasant and which is not recommended for drinking
5	very high	An odor so strong that the water is unfit for drinking

Laboratory analysis of water taken in April 2021 revealed that many indicators are above the norm, especially in terms of metals and sulfates. Thus, the pH level was 9.33 with the norm of 6.0–8.5, magnesium — 51.0 mg/dm^3 (norm — 40–50), copper — 0.01 mg/dm^3 (norm — not more than 0.005), sodium — 290 mg/dm^3 (norm — 120), sulfates — 182.3 mg/dm^3 (norm — not more than 100). All this indicates that the river is not in the best condition, it is constantly exposed to pollution by solid waste, which led to imbalance in the ecosystem of the reservoir (Table 7).

Table 8. Institutions located in water protection zones of Almaty rivers

s/n	Water protection zones	quantity
1	residential buildings	1090
2	cafes	27
3	stores	20
4	Wind protection stations	5
5	garage	45
6	businesses and organizations	26

Conclusion

The water issue in Almaty has always taken a back seat to problems with air, soil and greenery. But improper development, human factor and production processes meanwhile pollute water and threaten the health of citizens. The problem of not only water quality but also water quantity is important. The main reserves of water resources of the republic are concentrated in surface and underground sources. Water reserves in the country and cities are not infinite. But this is not only our problem: already now about one billion people around the world do not have direct access to clean drinking water. The level of water supply averages 20 thousand cubic meters per 1 square kilometer of the country's territory.

The information base of the study was scientific and statistical documentation of surface water monitoring of rivers in Almaty. The presence of heavy metals (Cd, Pb, Cu, Fe) in the rivers of Almaty was shown, their dynamics and degree of accumulation were studied from 2020 to 2022. Copper pollution of Almaty rivers was significant: from 11 to 12 MPC in all 3 rivers and in all analyzed years. Pb pollution was observed in the Malaya Almatinka River (1.1 MPC) and in the Bolshaya Almatinka River (1.9 MPC). The content of other heavy metals was below MPC. Thus, chemical pollution of the Malaya Almatinka River can be attributed to the average, as there was an excess of MPC, the content of other metals did not exceed the MPC. Analysis of water samples of the Big Almatinka river for Cd content showed MPC 0.005 mg/ml, the obtained values of Cd pollution were significantly lower than MPC. Exceedance of Pb pollution (2nd class of hazard, MPC 0.005 mg/ml in the Yesentai River was not observed.

In the 1st half of 2022, the water quality of the rivers Bolshaya Almatinka, Malaya Almatinka and Yesentai decreased compared to the previous year. Along the rivers debris is piled up, some parts of the water, water quality decreases day by day, and most importantly, downstream water enters the groundwater of the city. Thus, pollution of rivers of Almaty city by heavy metals is considered significant (in all 3 rivers), other heavy metals were present, but their content was within MPC and did not pose a threat to aquatic inhabitants of rivers.

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