Ecological characteristics and hydrochemistry of the Bozsuv canal in Tashkent city

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Abstract. Clean and safe water is essential for human health and well-being. However, growing human activities are leading to severe water pollution, deteriorating its quality, particularly in big cities. The water quality directly affects aquatic systems, including rivers, lakes and canals, public health and biodiversity. This study aims to explore the ecological characteristics and hydrochemical changes in the water flow of the Bozsuv canal, which is one of the most vital sources of water to Tashkent, the capital city of Uzbekistan. The research highlights the seasonal variations in key chemical indicators such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrite (NO_2^+), and total hardness (TH) that impact water quality. By analyzing water samples from incoming and outgoing flows of the Bozsuv canal, the study ehibits significant increases in water hardness and pollutant concentrations from March to August, which subsequently decrease towards the end of the year. The results indicate the need for regular monitoring and effective pollution control measures essential to prevent further deterioration and to ensure the sustainability of water resources.

1 Introduction

Water, as a renewable resource, is considered the most precious and vital natural resource for human survival. It is not only vital element for agricultural and industrial development, but also has a central role in ecosystem sustainability, thereby sustaining the life cycle on the planet [1, 2]. However, despite its great significance, the increasing global population with associated urbanization processes is putting a great pressure on this priceless resource. This is, particularly, evident in arid and semi-arid regions, where access to freshwater is coming out as a serious issue and water scarcity and pollution are widespread. According to literature review estimations, nearly 1.1 billion people on a global scale lacks direct access to pure and healthy drinking water, with approximately 5 million deaths annually linked to diseases caused by polluted water [3]. Despite the apparent abundance of water in the form of rivers, lakes, dams, shallow and deep aquifers, only merely 3% of the Earth's total water is considered suitable, and less than 0.01% is directly accessible for human use [4]. Therefore,

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it is of great importance to protect and manage existing water resources effectively for sustainable use in the context of water scarcity and increasing human activities.

Freshwater salinization has drawn significant worldwide attention due its global nature, thus becoming a serious environmental concern. In particular, the areas characterized by arid and semi-arid climate are more prone to this issue where it can rapidly progresse due to agricultural and mining activities [5]. Central Asia, with its predominant arid and semi-arid climate, has been among the most drought-prone regions on the planet and faces severe challenges in freshwater availability and salinization [6]. In this area, the impacts of climate change coupled with rapid urbanization process, long-term inefficient agricultural practices (overfertilization, salt leaching, runoff discharge into clean water bodies), and poorly maintained (updated and dysfunctional) drainage systems should be the main driving forces of freshwater salinization and degradation [7]. In addition to this, the projections of World Resources Institute reveal that constantly increasing average temperature with declining precipitation levels will likely lead to a noticeable water reduction by 2050s in two major rivers in the region, which are Amu darya and Syr darya rivers, as both are fed by snowmelt and precipitation, thereby amplifying water stress and posing serious challenges [8]. Thus, it should be both the agenda and the top priority for local governments in Central Asia to monitor existing water resources and implement preventive measures based on scientific observations.

Uzbekistan, a double landlocked country in Central Asia, is heavily reliant on water supplied by transboundary rivers as the country lacks natural water resources. With the combination of climate change, dilapidated irrigation infrastructure, rapid urban growth, and industrialization, existing water resources are under increasing pressure in the country, presenting local challenges for farmers and local population [9]. To successfully address these challenges, Uzbekistan has adopted sustainable development strategies (SDS) that highlight protecting the natural environment and water as central objectives for achieving sustainable agriculture. A key focus is ensuring that both the quantity and quality of water used in agricultural and urban sectors should meet the established worldwide environmental standards [10]. Following these sustainable development strategies, numerous local studies have been performed by local scientists to better assess the water quality of transboundary rivers, local lakes, and drainage water for potential reuse [11, 12, 13]. Nevertheless, urban canals, crossing the urban areas where human impact is evident remain less studied, thereby drawing scientific attention. This is particularly significant given that canals passing through cities are vulnerable to pollution from domestic, industrial, and surface runoff sources.

Tashkent, as the capital and largest city in Uzbekistan by population, is a rapidly expanding metropolitan area with a population exceeding 3 million [14]. The several canals pass through the city such as Bozsuv, Qorasuv, Salar, and other water bodies. They are used by the city for recreation, drainage, sometimes for wastewater. The Bozsuv canal, among them, has a significant importance due to its size, length, and reach. Beginning from the right bank of the Chirchiq River, the canal flows through key districts of Tashkent Region and Tashkent City before discharging into the Syr Darya River. Passing through highly populated and industrialized areas, the canal is becoming increasingly polluted with diverse pollutants from domestic, and industrial sources. For that reason, water quality and environmental characteristics of the Bozsuv canal have become a matter of concern for public health and environmental sustainability. Alterations in water parameters, such as increased levels of nitrites (NO_2^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and total dissolved solids (TDS), could have an adverse impact on aquatic ecosystems and limit the use of the water necessary for agriculture and domestic consumption in its lower reaches. Furthermore, seasonal climatic variations, especially high temperatures during summer, and urban runoff (mostly wastewater from small industries) contributes to fluctuations and its water quality. Despite its pivotal role in agriculture and small enterprises, few studies have explored its seasonal

chemical composition changes. Thus, this study aims to fill the research gap by analyzing hydrochemical variations of the Bozsuv canal in different months. Water samples were taken from two points where the canal enters (incoming) and exits the city (outgoing), and key indicators such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrite (NO_2^+), and total hardness (TH) were analyzed in a laboratory.

2 Materials and methods

2.1 Study area

Tashkent is the capital and most populous city of Uzbekistan, with a population exceeding 3 million as of April 1, 2024, and the largest urban area in Central Asia [14]. Geographically it is situated in the northeastern part of the country, close to the Kazakhstani border, serving as both an economic and cultural crossroads for not only for Uzbekistan but also other Central Asian countries. However, this rapid urbanization is leading significant ecological problems for Tashkent. Air pollution, one of the most serious issues for residents of the city, has become widespread and worsened in recent years due to increasing number of private transportations. The city has been consistently listed among the top 10 most polluted capital cities (sometimes the most polluted) for the last five years. The local authorities claim that this high level of pollution is primarily due to industrial emissions, transport traffic, and infrastructure buildings. As Tashkent increases in terms of population, addressing the problems associated with air quality, and water pollution will be the primary agenda to ensure the sustainable development of the city [15]. Several canals, namely Korakamish, Bozsuv, Salar and Qorasuv flow through Tashkent from neighboring regions. Bozsuv is an ancient canal that originates from the Chirchiq River. Flowing from the right bank of the Chirchiq River, Bozsuv extends in a northeast-southwest direction, passing through the Kibray, Zangiota, and Yangiyol districts of Tashkent Region, as well as parts of Tashkent City and Kazakhstan. It subsequently flows into the Syr Darya River near Chinoz. The canal is 159 kilometers long. At its source, the water discharge is 310 m^3/sec, but below the 10th hydropower station (HPS), the flow is reduced to 110 m^3/sec, with excess water being discharged back into the Chirchiq River. The canal bed is winding and varies in width from 10 to 20 meters, deepening up to 30 meters in the lower reaches. From both sides of Bozsuv, 23 canals have been constructed, with water discharges ranging from 0.5 m^3/s to 35 m^3/s. These canals are used for irrigation and industrial use in their lowest parts [16].

2.2 Water analysis and sampling

The research methods and practical approaches were conducted in accordance with the State Standards approved by the Ministry of Health of the Republic of Uzbekistan. The research methods were carried out in the Sanitary and Epidemiological Station Laboratory. The study focused on determining the concentration of certain chemical substances in the Bozsuv canal water at the points where the water enters and leaves the city. Therefore, water samples were collected each month from January to December in 2024. Water samples were collected at the beginning of each month from these designated points. The State Standard methods, which have been coordinated and approved by multiple ministries, are widely applied in scientific and experimental research. The following laboratory experiments were conducted under controlled conditions: (a) determination of nitrite (NO_2^+) concentration, (b) Determination of Ca/Mg concentration, (c) Total hardness measurement. The total hardness is measured using the following equation:

$$\text{Total Hardness (mg/L as } CaCO_3) = (Ca^{2+} \times 2.5) + (Mg^{2+} \times 4.1).$$

Where Ca^{2+} and Mg^{2+} are in mg/L (milligrams per liter), and the constants, 2.5 and 4.1, are conversion factors to express hardness as equivalent mg/L of calcium carbonate.

3 Results and discussion

Water quality monitoring is one of the key components of effective water resource management. Continuous measurement of water parameters enables responsible authorities to develop preventive strategies for potential problems. In this study, we assessed the water hardness and nitrite concentration in the Bozsuv canal of Tashkent city.

In general, hardness in water is mainly driven mainly by compounds of calcium and magnesium, and by a variety of other metals. According to FAO guideline, water with hardness 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft is soft; 61-120 mg/L as moderately hard, 121-180 mg/L as hard and more than 180 mg/L as very hard. On the other hand, nitrite in water, either drinking or irrigation, can be found as a result of human and other activities. The microbial oxidation of ammonia to nitrite is the primary nonhuman source. Inorganic fertilizers and human and animal wastes (from livestock operations and septic tanks) are the primary human sources. Concentrations of nitrate in surface water seldom exceed 1 mg/L except in areas of severe contamination. The nitrite in groundwater and surface water is negligible compared with the nitrate; in oxygenated waters, nitrite is rapidly converted to nitrate.

Based on the monthly observations, as shown in the Figure 1, it is evident that water in the entry section of Bozsuv canal is classified soft throughout the year with a moderate fluctuation. It is also clear that water hardness can be changeable depending on a season or climatic conditions such as precipitation and hot weather. For example, water hardness in January was 1.6 gm/L. However, in February, it was 2.3 gm/L, increasing to 0.7 mg/L. The hardness of water in the canal could be attributed to usual high snowmelt in at the end of this month. Moreover, heavy rains could have flushed out some minerals from public water systems, thereby elevating the hardness of water.

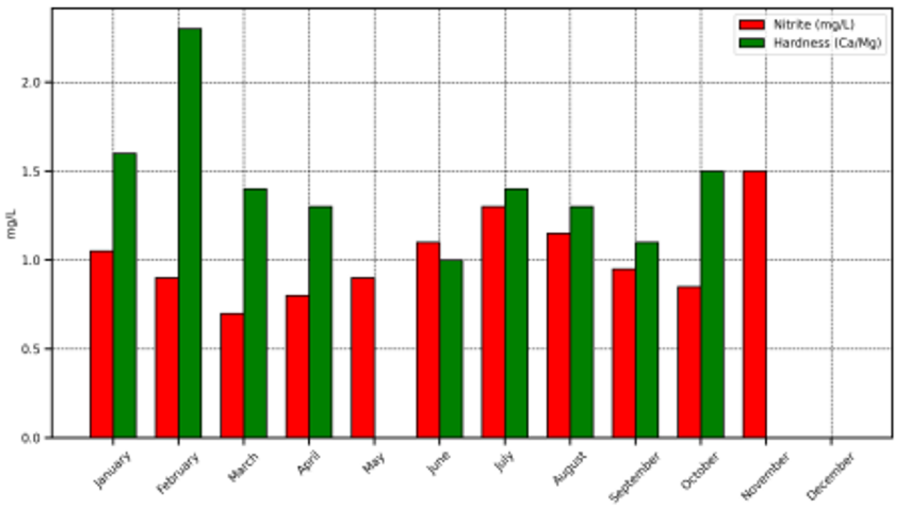

Fig. 1. Water hardness and Nitrite of Bozsuv (entry section).

Beginning from March, water hardness exhibited a relatively stable trend to October, with values ranging from 1 mg/L to 1.5 mg/L. In December, although the water was tested for Calcium and Magnesium, it did not show any concentration. This is because, cold weather either could have affected the water by making Calcium and Magnesium less soluble.

Meanwhile, the nitrite concentration showed a relatively increasing trend from January (1.05 mg/L) to July (1.3 mg/L), but a decrease was observed from August (1.15 mg/L) to October. In November (0.85 mg/L), the nitrite concentration was the highest, which was 1.5 mg/L, among other observed periods. The reason why the nitrite concentration was in November is that the precipitated rainfall could have leached the soil and created runoff. Therefore, during this month, the concentration might have reached up to 1.5 mg/L.

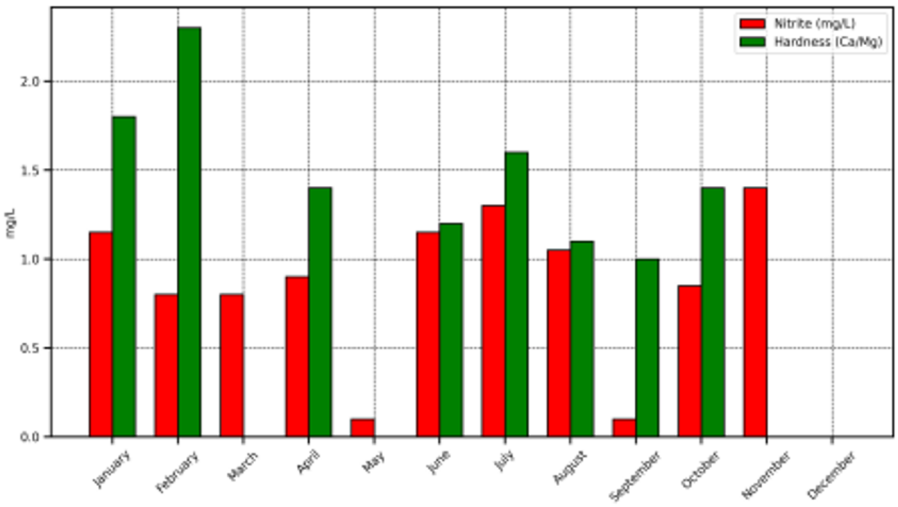

Fig. 2. Water hardness and Nitrite of Bozsuv (exit section).

At the exit section of canal from Tashkent city, the same trends (Water hardness and Nitrite concentrations) showed a nearly similar pattern, but with slight differences (Figure 2). The water hardness in January was 1.8 mg/L, which was 0.20 mg/L higher than that at the entry section. Then, from February to October, it showed mild fluctuations with a sharp decline in March and May. Nevertheless, water hardness remained similar to trends observed at the entry section.

However, in terms of Nitrite concentrations, there were both increasing and decreasing trends observed. In January, for instance, it was 1.05 mg/L at the entry section. However, it increased to 1.15 mg/L at the exit section of the canal, elevating to 0.10 mg/L. This could be runoff and precipitation in the Tashkent city that contributed nitrite concentration to be slightly high. From February to onward, until July, the nitrite concentration increased, reaching up to 1.3 mg/L, prior to decreasing in September. After that, it rose again to 1.4 mg/L at the exit section. In general, both the water hardness and the nitrite concentration showed similar trends at the two points with a slight difference in some months.

4 Conclusion

In this paper, the ecological characteristics and seasonal water quality of Tashkent city canal were studied based on monthly water monitoring data. The results indicate that the concentrations of Nitrite (NO_2^+) at the entry section of the canal lightly decreased until March. From April to July, however, Nitrite (NO_2^+) concentrations gradually increased, with a slight reduction from August to October, and ultimately peaked in November. The exit part of the canal showed similar patterns of variation. In contrast, Total Hardness (TH) remained high throughout the year, with the maximum vaue recorded in February at both the entry and exit sections. In conclusion, the both Nitrite (NO_2^+) and Total Hardness (TH) changes could be attributed to seasonal patterns of temperature and precipitation, particularly in winter and summer. Therefore, it is necessary to take into account and monitor the number of facilities and entities discharging waste into the canal.

However, in this study, since we explored only two components, several questions remain unanswered; 1) how do climatic patterns drive the variability of water hardness and nitrite concentration, 2) what are the main sources of Calcium, Magnesium and Nitritre, 3) What is the potential for using canal water for drinking and other purposes. Addressing these questions successfully would provide a more comprehensive understanding of the factors influencing water quality

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