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Impact of Emissions from Al-Kut Brick Factory on the Chemical Properties of Groundwater

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Abstract:

A field study was applied to determine the impact of brick factories in Wasit Governorate on groundwater pollution with heavy metals in the areas surrounding the factories during the period from August 25, 2023, to April 15, 2024. Water samples were collected from three locations located 250, 500, and 3000 meters from the source of pollution. Chemical analyses were performed on these samples. The results showed local and seasonal variations in the concentrations of heavy metals in the water, leading to an increase in the overall concentration of lead, cadmium, chromium, cobalt, and copper in the studied locations of the water samples near the brick factories and in a southeasterly direction. The brick factory's emissions indicate a significant level of heavy metal pollution in water samples. This pollution stems from gases and vapors emitted from the factory and their transfer to the water at the studied sites via the prevailing northwesterly winds. These metals have exceeded internationally permissible limits. Comparing our study's results for heavy metal concentrations in water samples from the studied sites with international and local standards, we find that the concentration of lead, chromium, and cobalt in the water, particularly in the southeastern direction of the brick factory, for both months exceeded the limits set by international and local organizations for all study sites, as measured by the comparison model. This is attributed to the increased concentration of these metals in the water due to emissions from the brick factory and the atmospheric transfer of heavy metals to the water in the southeasterly direction. The values of lead, cadmium, chromium, cobalt and copper concentrations in the water were generally low in August 2023 compared to April 2024. This is probably due to the variation in climate metals, as the increase in wind speed and the decrease in rainfall in August caused to some extent an increase in the transport distance of the particulates resulting from the emissions of the brick factory.

Keywords: Emissions, Brick Factories, Groundwater, Heavy metals.

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1. Introduction:

Water pollution is any physical, chemical, or biological change in water quality, whether direct or indirect, that negatively affects living organisms or renders the water unsuitable for drinking and other intended uses. Water pollution significantly impacts human life and other living organisms. Many factories dispose of their waste and industrial byproducts by dumping them into water bodies such as oceans, seas, and rivers, making the water less suitable for its intended uses, such as drinking and agriculture. These wastes include petroleum derivatives, industrial waste, municipal waste, chemical fertilizers, pesticides, pathogenic organisms, and radioactive materials. A large quantity of hazardous chemicals, especially heavy metals, are released into rivers worldwide due to continuous global population growth and the expansion of industry and agricultural production. (Islam et al., 2014).

Proximity to and distance from the source of pollution plays a significant role in water pollution by heavy metals. Al-Omar (2017) found elevated concentrations of the heavy metals cobalt, cadmium, nickel, and lead in the water, reaching 0.27, 0.81, 0.13, and 1.35 mg/L, respectively. These levels are higher than the international limits for cobalt and cadmium in water. He attributed this to emissions from brick factories and the increased concentration of these metals, especially in river areas near the pollution source. Similarly, Al-Jumaili and Ahmed (2018) indicated that heavy metals are present in low concentrations in water when it is far from the pollution source, but these concentrations may increase closer to the source. Heavy metals such as lead, cadmium, zinc, and nickel are among the most dangerous pollutants of soil, water, and air, and are among the most important sources of this pollution. Factory waste and byproducts, fuel combustion, and vehicle exhaust (Saleh, 2012).

Brick factories are a significant source of environmental pollution for soil, water, and air. Most of the emitted pollutants consist primarily of smoke, which is high in particulate matter, in addition to carbon oxides, nitrogen oxides, sulfur oxides, and unburned hydrocarbons. Ash and soot particles also constitute a high percentage of these pollutants. Furthermore, fuel combustion produces a large number of heavy and trace metals such as Ni, Pb, Cd, Cr, Zn, Cu, Mn, and Co, which fall onto the land and water surrounding the factories, leading to their pollution (Abd et al., 2015). Given the significant pollution caused by these industrial facilities to the environment and all its components, this study aims to examine the impact of emissions from Al-Kut brick factories on groundwater pollution and to assess its pollution status with some heavy metals (Pb, CD, CO, Cr, CU).

2. Materials and Methods

2.1. Study Area

The study area encompassed the lands surrounding the Al-Kut brick factories in Wasit Governorate, which includes several brick factories. Water samples were collected in August 2023 and April 2024 from the southeast side of the factories.

2.2. Collect the samples

To investigate the pollution levels of gases, smoke, and volatile vapors emitted from the Al-Kut brick factories, water samples were collected on August 25, 2023, and April 15, 2024, at the end of the rainy season. Samples were taken from the southeast, following the prevailing wind direction in the area (designated A), at three distances from the pollution source: 250m, 500m, and 3000m (designated A1, A2, and A3, respectively).

2.3. Water Sample Analysis

Water samples were collected from water bodies. In the region, water samples were collected from three locations at distances of 250, 500, and 3000 meters from the southeast. These samples were placed in plastic bottles and refrigerated pending analysis.

Table (1) Water Sampling Locations

Location name	Horizontal distance from the source of pollution (m)
A1	250
A2	500
A3	3000

Heavy metals (Pb, Cd, Co, Cu, Cr) were estimated according to APHA (1998), and several international and local standards were used to determine the suitability of the water for various uses.

3. Results and Discussion

Lead (Pb) Concentration in Water Samples in the Study Area for August 2023 and April 2024

The results of the study, shown in Figure (1), indicate a difference in lead concentration in water samples for August 2023 depending on the distance from the pollution source, as well as the location where the water samples were taken relative to the Al-Kut Brick Factory. In the southeastern direction, at the first and second locations, lead recorded its highest value of (0.203 and 0.100) mg L^{-1} respectively, compared to the third location (the control sample), which recorded the lowest value of lead in the water samples at (0.00) mg L^{-1}. However, in the April 2024 samples, in the southeastern direction, the lead concentration in the water samples increased at all studied locations compared to August 2023. The lead concentration in the water samples reached (0.387, 0.209, and 0.103) mg L^{-1} for the first location. The second and third are in succession, and this is attributed to the increased concentration of pollutants falling on areas close to the source of pollution compared to areas far from it, and the role of the prevailing winds in the study area.

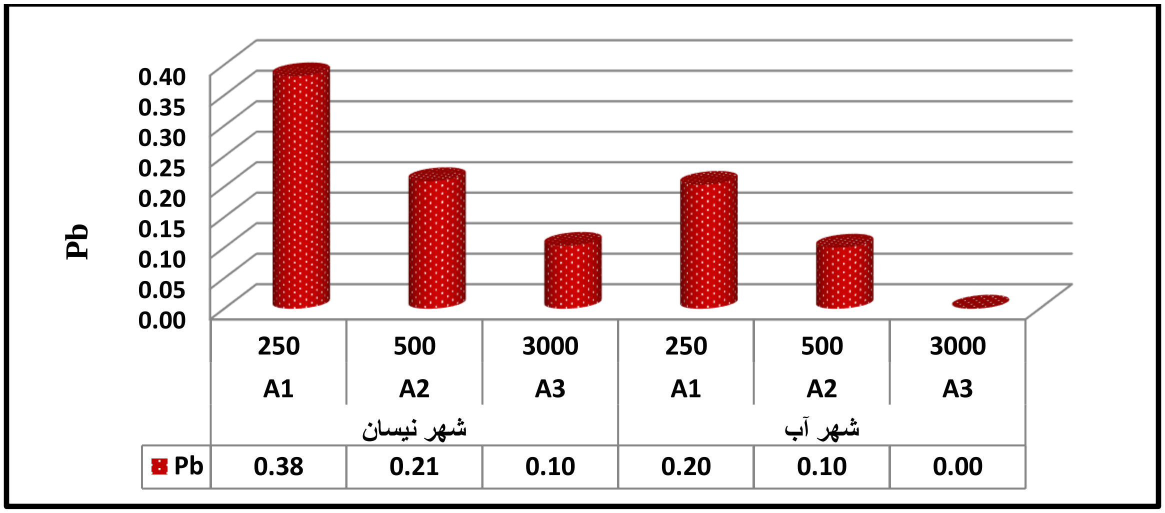

Figure (1) lead concentrations in water samples (mg L^{-1}) from various study sites for August 2023 and April 2024.

Table (2) global and local limits for heavy metal content in drinking water (mg L^{-1})

Determinants	Pb	Cd	Cu	Cr	co
WHO (2011)	0.01	0.003	0.0063*	0.05	-
USEPA (2009)	0.015	0.005	2.000	0.10	-
River and Public Water Pollution Control System (1967)	0.1	0.005	1.3	0.1	0.5

The increased lead concentration in water samples from locations near brick factories and to the southeast indicates significant lead pollution. This pollution is attributed to gases and vapors emitted from the factories and their transfer to the water in the studied locations via the prevailing northwesterly winds in the region. Our findings are consistent with those of Al-Omar (2017), who also found higher lead concentrations in water samples near brick factories compared to more distant locations. Similarly, they align with Abbas's (2020) findings of higher lead concentrations in water samples near the pollution sources of the Euphrates Chemical Plant and the Al-Sadda Cement Plant in Babylon Governorate, compared to a control model. Both researchers attributed the cause to the vapors and gases emitted from the factories' chimneys as a result of burning fuel and raw materials used in manufacturing.

These findings are consistent with those of Abbas (2020). Comparing the results of our study on lead concentration in water samples from the studied sites with international standards (Table 2), we find that lead concentration in the water, particularly in the southeast direction of the brick factory, exceeded the limits permitted by international and local organizations for all study sites, as measured by the comparison model. The increased lead concentration in the water is attributed to emissions from the brick factory and the atmospheric transfer of metals into the water.

3.1. Cadmium (Cd) Concentration in Water

The results of the study (Figure 2), indicate a variation in cadmium concentration in water samples from August 2023 at the studied locations, depending on their distance from the pollution source. In the southeast direction, at the first horizontal distance, cadmium recorded its highest value at (0.183) mg L^{-1}, and at the second horizontal distance, it was (0.140) mg L^{-1}. This is compared to the last horizontal distance (the control sample), which recorded the lowest cadmium value in the water samples at (0.040) mg L^{-1}. As for April 2024, in the southeast direction, at the first horizontal distance, cadmium recorded its highest value at (0.206) mg L^{-1}, and at the second horizontal distance, it was (0.185) mg L^{-1}. This is compared to the last horizontal distance (the control sample), which recorded the lowest value. The amount of cadmium in the water samples was (0.092) mg/L $^{-1}$.

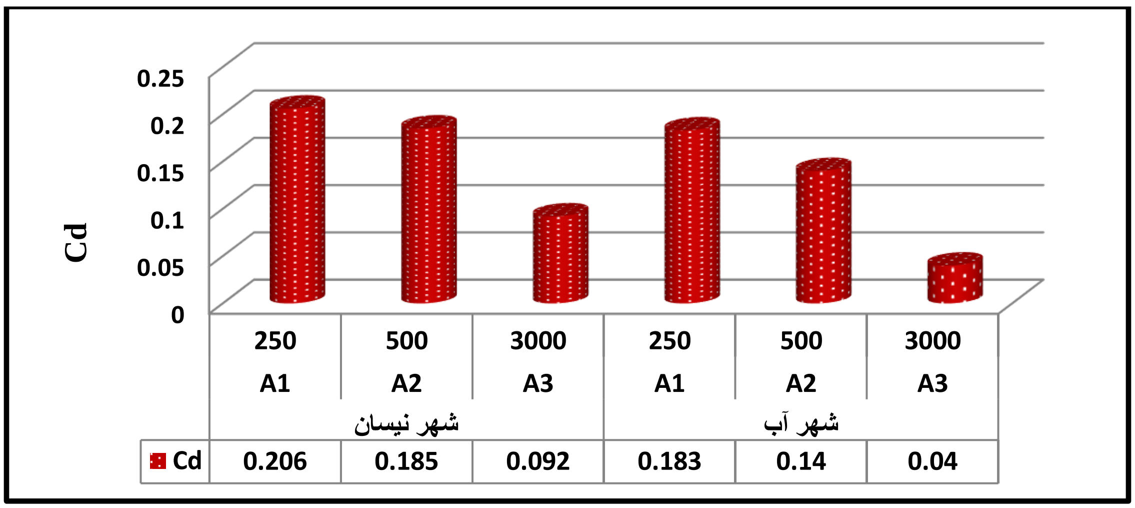

Figure (2) cadmium concentration in water samples (mg/L) from different study sites for August 2023 and April 2024.

The increased cadmium concentration in water samples from sites near brick factories and towards the southeast of the field indicates a high level of cadmium pollution in the water samples. This pollution is attributed to gases and vapors emitted from the brick factories, which fall onto the surface of the water at sites near the factories. Our study's results are consistent with those of Abbas (2018), who found an increased cadmium concentration in water samples from sites near brick factories compared to more distant sites. Similarly, Abbas (2020) found an increased cadmium concentration in water samples from sites near the Euphrates Chemical Plant and the Kufa Cement Plant in Babylon Governorate, compared to a control group. He attributed this to the vapors and gases emitted from the factories' chimneys as a result of burning fuel and raw materials used in manufacturing. These results are also consistent with those of Farhan

(2020), who found an increased concentration... Cadmium levels were found in water samples contaminated with wastewater from the Wasit Thermal Power Plant at locations near the plant compared to more distant locations. This aligns with the findings of Tripathi et al. (2003) when they measured the concentrations of heavy metals (Zn, Cu, Cd, and Pb) in the air, soil, and water of Mumbai, India. Heavy metals can precipitate on soil and water surfaces and may reach rivers and other water bodies through leaching and runoff. When comparing the results of our study on cadmium concentration in water samples from the studied locations for both months with international, US Environmental Protection Agency (EPA), and local standards (Table 2), we find that the cadmium concentration in the water and in the southeastern direction of the brick factory for both months did not exceed the limits permitted by international and local organizations for all study locations.

3.2. Copper (Cu) Concentration in Water

The results of the study, shown in Figure (3), indicate a variation in the concentration of copper in water samples for August 2023 from the studied sites, depending on their distance from the pollution source. In the southeast direction and at the first horizontal distance, copper recorded its highest value, reaching (0.158) mg L^{-1}, and at the second horizontal distance, (0.143) mg L^{-1}, compared to the last site (the comparison model), which recorded the lowest value of cadmium in the water samples, reaching (0.012) mg L^{-1}.

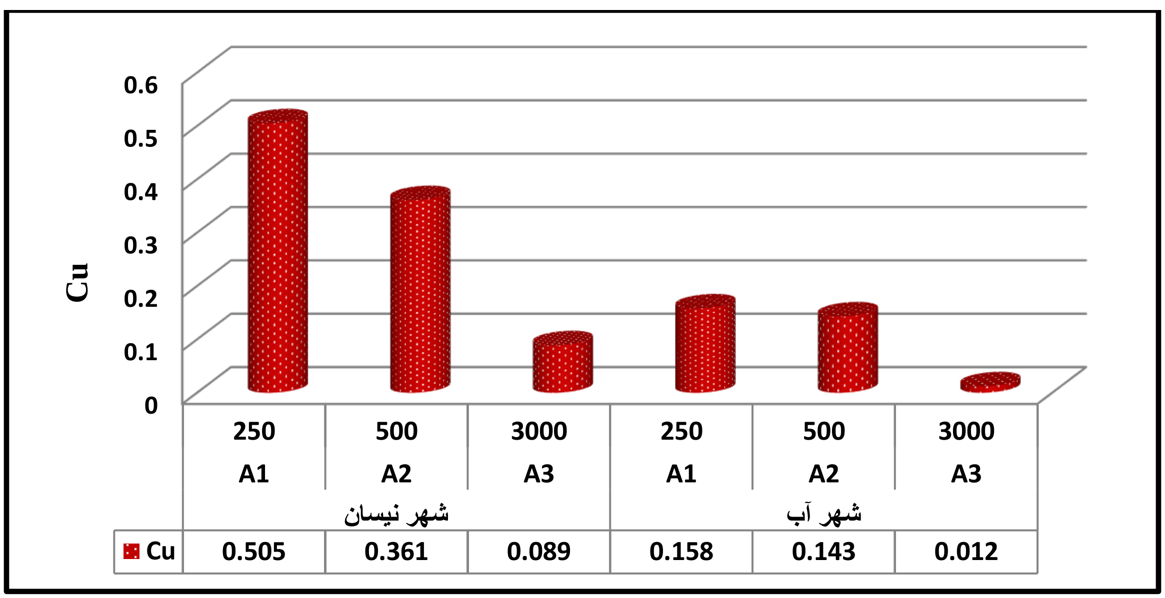

Figure (3) copper concentration in water samples (mg/L) from various study sites for August 2023 and April 2024.

As for April 2024, in the southeast direction and at the first horizontal distance, copper recorded its highest value at (0.505) mg L^{-1}, and at the second horizontal distance (0.361) mg L^{-1}. This is compared to the last location (the control sample), which recorded the lowest value for cadmium in the water samples at (0.089) mg L⁻¹. The increased copper concentration in water samples at locations near brick factories and in the southeast direction of the field indicates a significant level of copper pollution in the water samples. This pollution is attributed to gases and vapors emitted from the brick factories, which fall onto the water surface at locations near the factories. The results of our study are consistent with those of Abbas (2018), who found an increased concentration of copper in water samples at locations near brick factories compared to more distant locations. Similarly, they are consistent with those of Abbas (2020), who found an increased concentration of copper in water samples at locations near the Euphrates Chemical Plant and the Kufa Cement Plant. In Babil Governorate, based on the comparison model, the reason was attributed to the fumes and gases rising from the chimneys of the two factories as a result of burning fuel and raw materials used in the industry. Comparing our results for copper concentration in water samples from the studied sites for both months with international standards and those of the US Environmental Protection Agency (EPA), we find that the copper concentration in the water, particularly in the southeastern direction of the brick factories, did not exceed the limits permitted by international and local organizations for all study sites.

3.3. Chromium (Cr) Concentration in Water

The results of the study, shown in Figure (4), indicate an increase in the concentration of chromium in water samples for August 2023 at locations near the pollution source. In the southeast direction, the highest chromium concentration was recorded at 0.156 mg L^{-1} in the first horizontal distance, and at 0.143 mg L^{-1} in the second horizontal distance. This contrasts with the last location (the control sample), which recorded the lowest chromium concentration in the water samples at 0.012 mg L^{-1}. As for April 2024, the highest chromium concentration was recorded at 0.236 mg L^{-1} in the southeast direction, and at 0.186 mg L^{-1} in the second horizontal distance. This contrasts with the last location (the control sample), which recorded the lowest chromium concentration in the water samples at 0.095 mg L^{-1}.

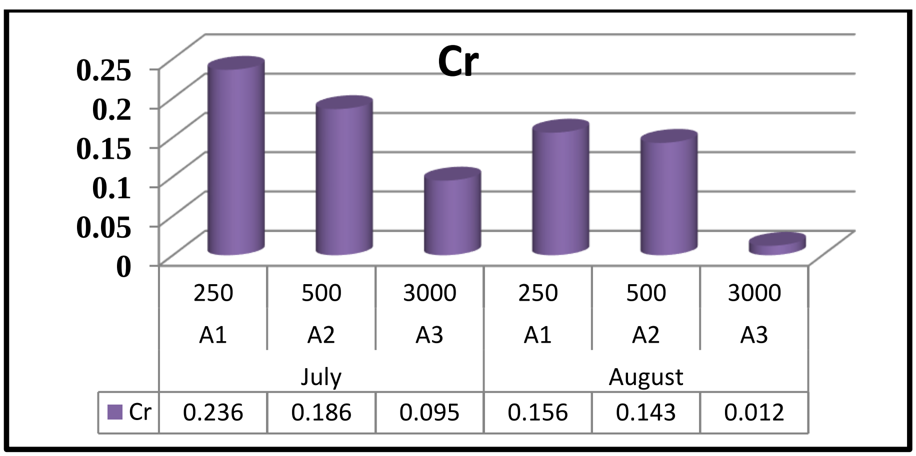

Figure (4) chromium concentration in water samples (mg/L) from various study sites for August 2023 and April 2024.

The increased chromium concentration in water samples from sites near brick factories, particularly to the southeast, indicates significant chromium contamination. This is attributed to the prevailing wind patterns in the area, which carry gases and vapors emitted from the brick factories and fall onto the surface of the water at nearby sites. When comparing the chromium concentration in the water samples with the WHO (2011) and USEP (2009) standards and local standards (Table 2), we find that the chromium concentration in the water samples in the first and second horizontal distances of the southeast direction of the brick factory exceeded the permissible limits compared to the control treatment, which was below the permissible limits (Figure 4) for both months. The results of our study are consistent with what Farhan (2020) found, that the chromium concentration in the Tigris River waters and for all study sites did not exceed the Iraqi standards for the river pollution control system of 1967. Also, the chromium concentration was lower than the limits allowed by the Food and Agriculture Organization of the United Nations (2009) (FAO). These results are consistent with what Juma and Al-Anbari (2010) showed, who indicated that the chromium concentration did not exceed the limits allowed by the Food and Health Organization and the World Health Organization (2003), despite the pollution caused by the smoke and gas of the factories and brick factories of Al-Nahrawan near the river.

3.4. Cobalt Concentration in Water

The study results, shown in Figure 5, indicate an increase in cobalt concentration in water samples from August 2023 at locations near the pollution source. In the southeast direction, the highest cobalt concentration was recorded at 0.091 mg L^{-1} in the first horizontal distance, and at 0.05 mg L^{-1} in the second horizontal distance. This is compared to the last location (the control group), which recorded the lowest cobalt concentration in the water samples at 0.01 mg L^{-1}. As for April 2024, the highest cobalt concentration was recorded at 0.154 mg L^{-1} in the southeast direction, and at 0.126 mg L^{-1} in the second horizontal distance. This is compared to the last location (the control group), which recorded the lowest cobalt concentration in the water samples at 0.083 mg L^{-1}.

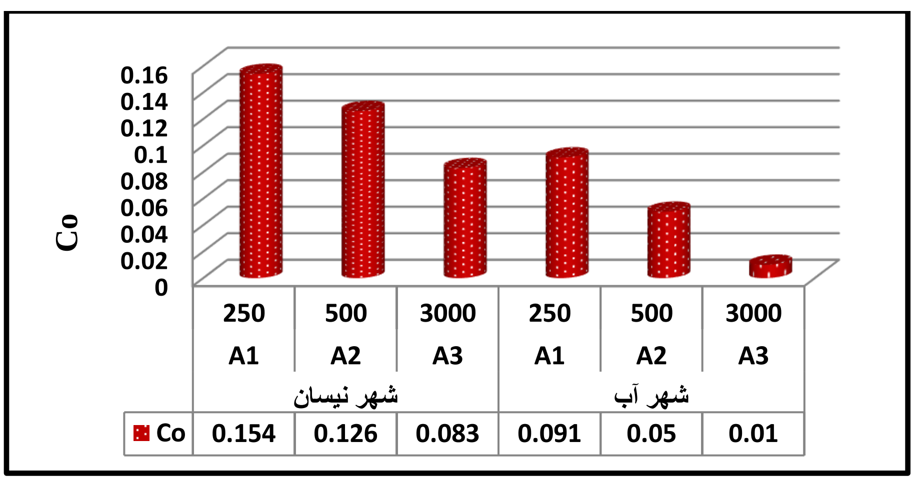

Figure (5) cobalt concentration in water samples (mg/L) from various study sites for August 2023 and April 2024.

The increased cobalt concentration in water samples from sites near brick factories and to the southeast of these factories indicates significant cobalt contamination. These results are consistent with Al-Omar's (2017) findings of increased cobalt levels in water samples from sites near brick factories in Maysan Governorate. When comparing the cobalt concentration in water samples with the Iraqi limits for the river pollution control system of 1967 (Table 2), we find that the cobalt concentration did not exceed the permissible limits for August 2023, while in April 2024 it was higher than the permissible limits. The results of our study were consistent with what Al-Hakkak (2021) found regarding the cobalt element in water samples exceeding the permissible limits approved by the WHO (2011) and the Iraqi limits for the river pollution control system of 1967 in the locations near the Wasit thermal power station compared to the distant locations. This is also due to the type of fuel used in the plant, which may lead to an increase in the concentration of this element in the gases and vapors that rise and then fall onto the river water, which ultimately leads to its pollution (Chen, 2002).

4.Conclusions

The study concludes that these metals have exceeded internationally permissible limits. Comparing our study's results for heavy metal concentrations in water samples from the studied sites with international and local standards, we find that the concentration of lead, chromium, and cobalt in the water, particularly in the southeastern direction of the brick factory, for both months exceeded the limits set by international and local organizations for all study sites, as measured by the comparison model. This is attributed to the increased concentration of these metals in the water due to emissions from the brick factory and the atmospheric transfer of heavy metals to the water in the southeasterly direction. The values of lead, cadmium, chromium, cobalt and copper concentrations in the water were generally low in August 2023 compared to April 2024.

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