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# Evaluation of environmental pollution by heavy metals in the waters of Al-Ezz River north of Basrah

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**Abstract -** This study was conducted on the Al-Ezz River in the Al-Qurna district, north of Basra city, seasonally from Autumn 2022 to summer 2023 at five stations along the river. The purpose of the study was to assess the river's pollution and determine the highest concentrations of certain heavy elements in its water; Cobalt (Co), Cadmium (Cd), Manganese (Mn), Zinc (Zn), Iron (Fe), Chromium (Cr), Lead (Pb) and Copper (Cu). The highest concentrations of these elements were (0.095, 0.238, 0.323, 1.461, 1.592, 2.801, 8.015, 695.423) mg/l, respectively, while the lowest concentrations of heavy elements were (Co= Not Detected, Fe= Not Detected, Mn= Not Detected, Cd= 0.010, Zn= 0.033, Pb= 0.062, Cr= 0.129) mg/l. The strongest correlation is between lead and iron (r=0.99). Cadmium shows a positive correlation (r=0.97) with chromium, while copper has a positive correlation (r=0.97) with cobalt. There is a strong positive correlation between iron (r=0.99) and manganese, as well as between manganese (r=0.99) and iron. Zinc also exhibits a positive correlation (r=0.99) with cobalt, and chromium (r=0.98) shows a positive correlation with cadmium and cobalt (r=0.99) with zinc.

## تقييم التلوث البيئي بالعناصر الثقيلة لمياه نهر العز شمال البصرة

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**المستخلص -** اجريت هذه الدراسة لنهر العز في قضاء القرنة شمال مدينة البصرة فصلياً ابتداءً من الخريف 2022 ولغاية الصيف 2023 في خمسة محطات ممتدة على طول النهر لغرض تقييم تلوث النهر وتحديد اعلى تركيز لبعض العناصر الثقيلة في مياه هذا النهر (الكوبلت والكادميوم والمنغنيز والزنك والحديد والكروم والرصاص والنحاس (0.095 و 0.238 و 0.323 و 1.461 و 1.592 و 2.801 و 8.015 و 695.423 مليغرام/لتر على التوالي اما اقل تركيز لمعدلات العناصر الثقيلة (0.062 و 0.010 و 0.459 و ND و ND و 0.033 و 0.129) مليغرام/لتر على التوالي. اقوى علاقة ارتباط لعنصر الرصاص مع عنصر الحديد (r=0.99) اما الكادميوم يرتبط بعلاقة إيجابية (r=0.97) مع عنصر الكروم، وعنصر النحاس له علاقة إيجابية (r=0.97) مع عنصر الكوبلت، وعلاقة الحديد (r=0.99) مع المنغنيز، وهناك علاقة لعنصر المنغنيز (r=0.99) مع الحديد، وعلاقة إيجابية للزنك (r=0.99) مع الكوبلت والكروم (r=0.98) مع الكادميوم والكوبلت (r=0.99) مع الزنك.

**الكلمات المفتاحية:** نهر العز، تلوث المياه، المعادن الثقيلة، شمال البصرة.

## Introduction

Surface waters worldwide are increasingly imperiled by heavy metal contamination. While these metals are naturally occurring, elevated concentrations often resulting from human activities such as industry (Rodriguez, 2018), agriculture, and urbanization pose significant threats to ecosystems and wildlife (Smith and Daniels, 2019).

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As these heavy metals infiltrate our water systems, they can bio-accumulate in organisms, potentially leading to severe environmental and health consequences (Kumar and Lee, 2020).

Addressing this urgent issue necessitates a harmonized approach, combining regulatory, technological, and community-driven efforts (Chen, and Gupta, 2021).

Heavy elements encompass most elements with atomic numbers greater than twenty and have density exceeding 5 g/cm³. Heavy elements are considered some of the most hazardous pollutants to the environment. They are natural components of soil and can be naturally found therein. However, their danger increases when they remain in the soil, leading to the contamination of plants and vegetables those humans consume, ultimately affecting their health (Ali *et al.*, 2019).

While certain elements such as copper, zinc, and iron are essential nutrients for living organisms that are indispensable, they can become toxic to living entities when present in high concentrations as pesticides and pharmaceuticals can also have adverse effects on surface water quality and the environment (Singh *et al*., 2011).

Heavy elements have diverse sources, including both natural and anthropogenic origins. Natural sources encompass processes like weathering of mineral-rich rocks, soil leaching, wildfires, natural disasters, agricultural lands, as well as storm events. Human activities contribute to heavy element sources through the use of pesticides, chemical fertilizers, disposal of laboratory and industrial waste, and other activities that impact the soil surface (Smith *et al*., 2020).

Water pollution is a major human health concern, as consuming contaminated water can lead to the transfer of pollutants into our bodies, causing serious health problems such as infectious diseases, respiratory issues, and gastrointestinal disorders (Lin *et al*., 2022).

## Materials and Methods

Water samples were collected from five stations seasonally (Fig. 1) using 2 L plastic bottles, which were filled with water to their full capacity after being rinsed with the respective station's water.

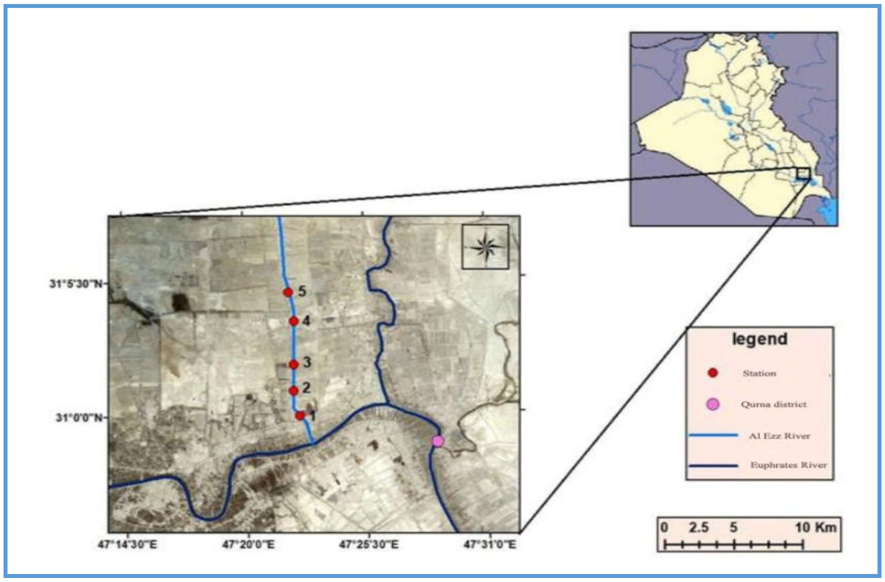

Figure 1. Map of the location of the study area

The bottles were then tightly sealed and transported to the laboratory for preparation for heavy metal concentration measurements 100 ml of each sample was taken and mixed with 5 ml of concentrated nitric acid. The mixture was then heated until it was almost dry. After that, another 5 ml of nitric acid was added to ensure complete digestion of the sample.

The sample was then allowed to cool and transferred to special polyethylene containers. The sample was diluted with ion-free distilled water to a specific volume and prepared for measurement using Flame Atomic Absorption Spectrometry (FAAS). The results were expressed in units of mg/l (Clesceri, 1998).

## Results

### Lead:

Figure (2) shows the study results revealed that the total lead concentration in water samples from five stations ranged as follows: Station 1 (2.171-1.349 mg/l), Station 2 (5.402-1.291 mg/l), Station 3 (5.524-0.094 mg/l), Station 4 (7.220-0.062 mg/l), and, Station 5 (8.015-0.104 mg/l).

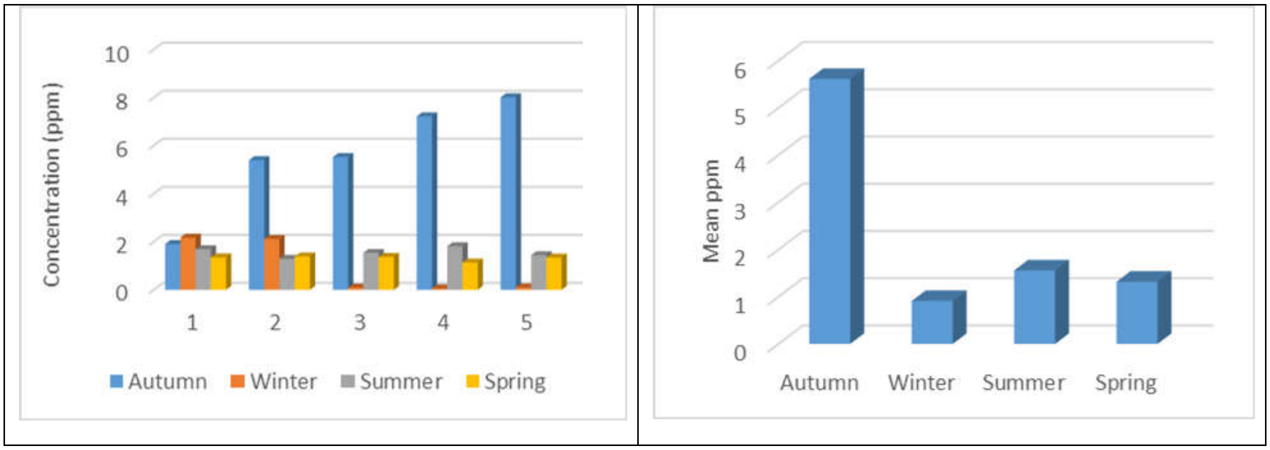

Figure 2. Seasonal variations and annual averages of lead concentrations (mg /l) in total water samples.

The highest average value (8.015 mg/l) was recorded at Station 5 during the fall season, while the lowest average value (0.062 mg/l) was observed at Station 4 during the winter season. The statistical analysis results indicated a correlation showing relationship between the lead element in water samples from the study area and iron (r=0.98) and manganese (r=0.92) at station one. In station two, a correlation was observed between lead and iron (r=0.98), as well as manganese (r=0.95). Station three showed a correlation between lead and iron (r=0.99), as well as manganese (r=0.97). In station four, lead correlated with iron (r=0.98) and manganese (r=0.97). There is also a correlation between lead and iron (r=0.97) and manganese (r=0.96) in station five. Therefore, the most vital correlation relationship for the lead element in water was with iron.

### Cadmium:

The study results revealed that the total concentration of cadmium in water samples from five stations varied as follows: Station one ranged from (0.021 to 0.010 µg/ml), station two ranged from (0.218 to 0.012 µg/ml), station three ranged from (0.225 to 0.011 µg/ml), station four ranged from (0.238 to 0.021 µg/ml), and station five ranged from (0.155 to 0.016 µg/ml).

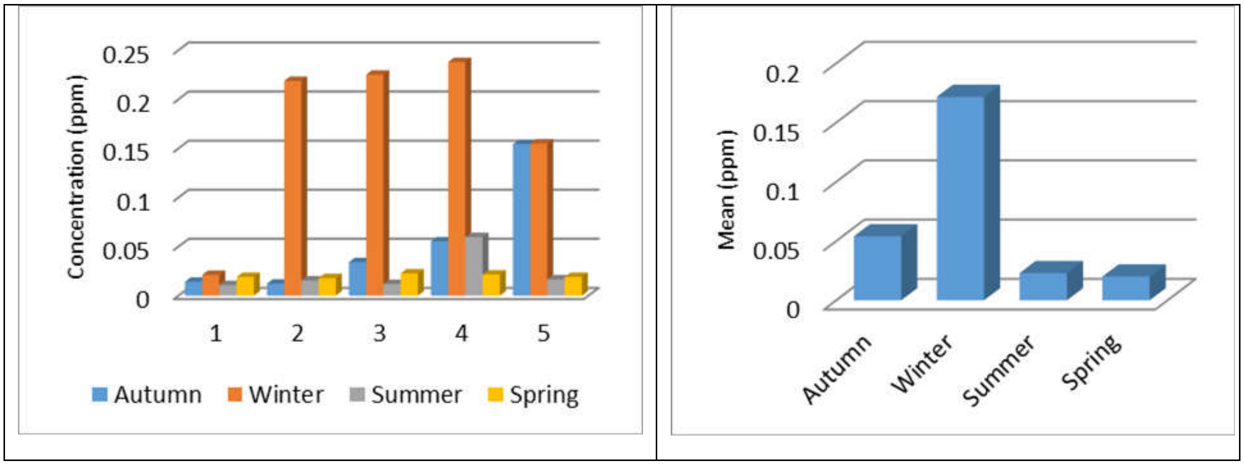

Figure 3. Seasonal variations and annual averages of cadmium concentrations (mg/l) in total water samples.

The highest average value (0.238 µg/ml) was recorded at station four during the winter season. The lowest average value (0.010 µg/ml) was observed at station one during the spring season (Fig. 3). The statistical analysis results indicated a correlation between the presence of cadmium in water samples from the study area and the following elements: zinc (r=0.89), copper (r=0.84), and cobalt (r=0.74) at station one. For station two, a correlation was observed between cadmium and chromium (r=0.98), zinc (r=0.90), copper (r=0.93) and cobalt (r=0.88).

At station three, a correlation was found between cadmium and copper (r=0.96), cobalt (r=0.84), and zinc (r=0.81). In station four, cadmium was correlated with chromium (r=0.97), copper (r=0.88), and cobalt (r=0.64). Additionally, at station five, cadmium exhibited correlations with copper (r=0.96), chromium (r=0.92), and cobalt (r=0.78). Therefore, the strongest correlation observed for cadmium in the water samples was with chromium.

## Copper:

The study results indicated that the total copper concentration in water samples from five stations varied as follows: Station 1 (695.423 mg/l), Station 2 (695.423 mg/l), Station 3 (695.423 mg/l), Station 4 (695.423 mg/l), and finally, Station 5 (695.423 mg/l). The highest average value (695.423 mg/l) was observed at Station 3 during the fall season, while the lowest average value (0.459 mg/l) was recorded at Station 5 during the spring season (Fig. 4).

The statistical analysis results revealed a correlation indicating the presence of a relationship between the copper element in water samples from the study area and cobalt (r=0.97) and cadmium (r=0.84) at station one. In station two, a correlation was observed between copper and cobalt (r=0.96), as well as zinc (r=0.95), chromium (r=0.94), and cadmium (r=0.93). Station three showed a correlation between copper and cadmium (r=0.96), as well as cobalt (r=0.71) and zinc (r=0.65). In station four, copper correlated with chromium (r=0.96), cobalt (r=0.93), and cadmium (r=0.88).

There is also a correlation between copper and cadmium (r=0.96), as well as cobalt (r=0.88), chromium (r=0.83), and zinc (r=0.75) in station five. Therefore, the strongest correlation relationship for the copper element in water was with iron.

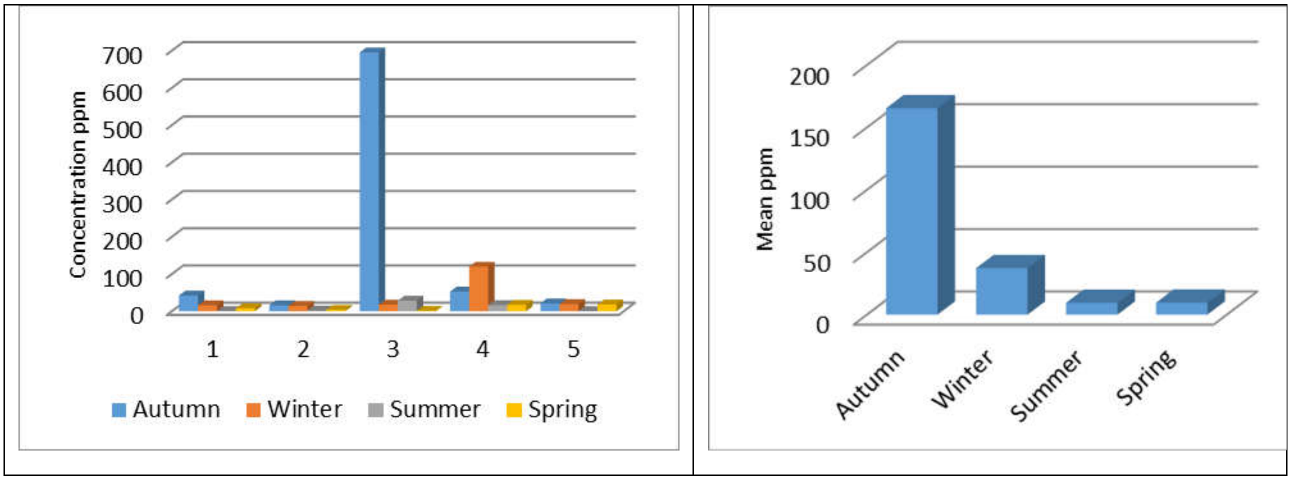

Figure 4. Seasonal variations and annual averages of copper concentrations (mg/l) in total water samples.

**Iron:**

The study results revealed that the total iron concentration in water samples from five stations varied as follows: Station 1 (1.592-0.141 mg/l), Station 2 (1.351-0.437 mg/l), Station 3 (1.227-0.057 mg/l), Station 4 (ND-0.432 mg/l), and finally, Station 5 (ND-0.690 mg/l).

The highest average value (1.592 mg/l) was recorded at Station 1 during the fall season. The lowest average value, which is below the minimum detectable concentration of the device, was observed in Stations 4 and 5 during the spring and summer seasons, respectively (Fig. 5).

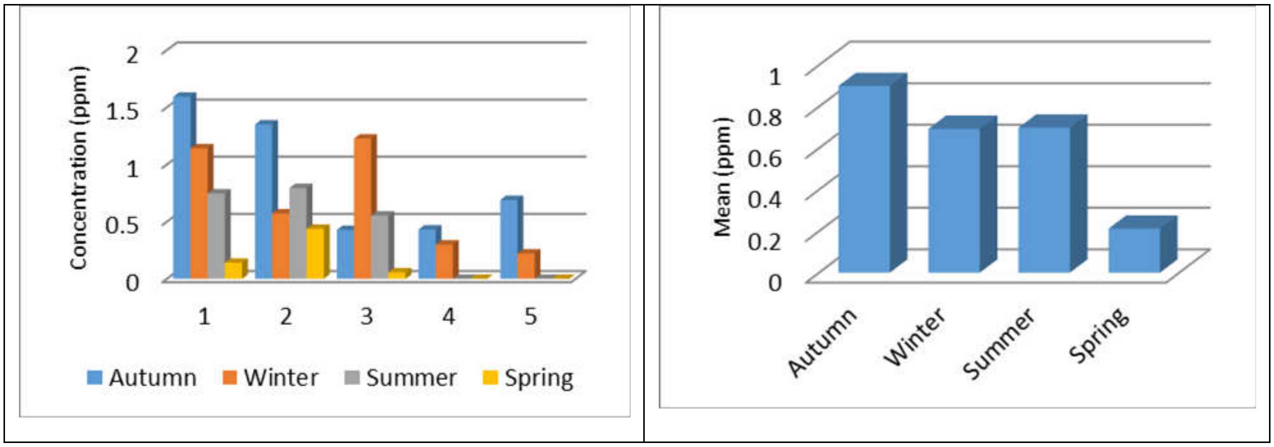

Figure 5. Seasonal variations and annual averages of Iron concentrations (mg /l) in total water samples.

The statistical analysis results revealed a correlation indicating the presence of a relationship between the iron element in water samples from the study area and lead (r=0.98) and manganese (r=0.88) in station one. In station two, a correlation was observed between iron and manganese (r=0.99), as well as lead (r=0.98). Station three showed a correlation between iron and lead (r=0.99), as well as manganese (r=0.95).

In station four, iron correlated with lead (r=0.98) and manganese (r=0.95). There is also a correlation between iron and lead (r=0.97) and manganese (r=0.92) in station five. Therefore, the strongest correlation relationship for the iron element in water was with lead.

**Manganese:**

The study results indicated that the total manganese concentration in water samples from five stations ranged as follows: Station 1 (ND-0.323 mg/l), Station 2 (ND-0.110 mg/l), Station 3 (ND-0.304 mg/l), Station 4 (ND-0.044 mg/l), and finally, Station 5 (ND-0.019 mg/l). The highest average value (0.323 mg/l) was observed at Station 1 during the fall season.

The lowest average value was below the minimum detectable concentration of the device, which was the case for all stations during the spring season and for Station 4 during the summer season (Fig. 6). The statistical analysis results indicated a correlation between the manganese element in water samples from the study area and lead (r=0.92) and iron (r=0.88) in station one. In station two, a correlation was observed between manganese and iron (r=0.99), as well as lead (r=0.95).

Station three showed a correlation between manganese and lead (r=0.97), as well as iron (r=0.95). In station four, manganese correlated with lead (r=0.97) and iron (r=0.95). There is also a correlation between manganese and lead (r=0.96) and iron (r=0.92) in station five. Therefore, the strongest correlation relationship for the manganese element in water was with iron.

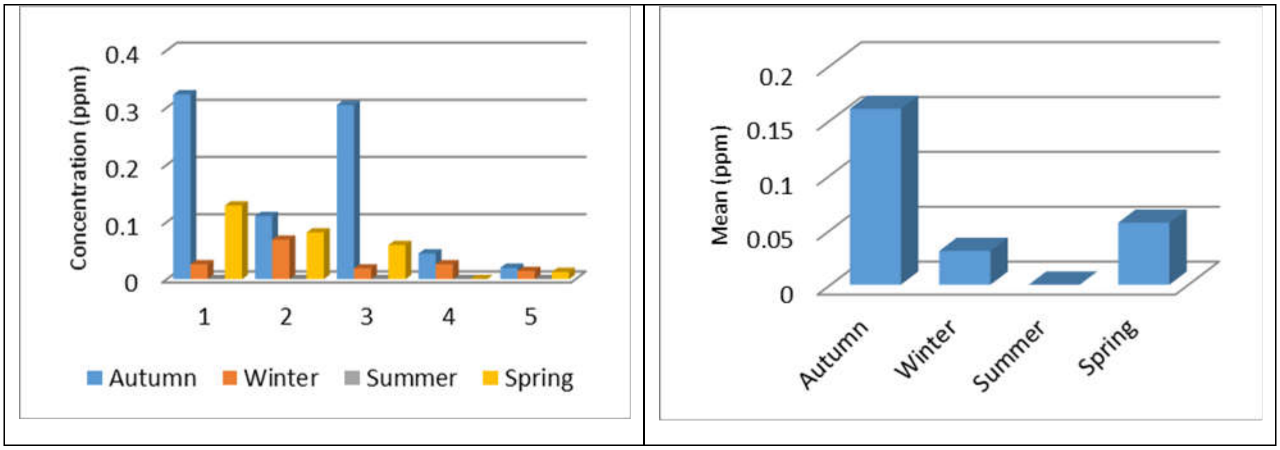

Figure 6. Seasonal variations and annual averages of manganese concentrations (mg /l) in total water samples.

**Zinc:**

The study results revealed that the total zinc concentration in water samples from five stations ranged as follows: Station 1 (1.161-0.453 mg/l), Station 2 (1.461-0.262 mg/l), Station 3 (0.764-0.111 mg/l), Station 4 (1.265-0.178 mg/l), and finally, Station 5 (0.927-0.033 mg/l). The highest average value (1.461 mg/l) was recorded at Station 2 during the fall season.

The lowest average value (0.033 mg/l) was observed at Station 5 during the fall season (Fig. 7). The statistical analysis results revealed that there is a correlation between the zinc element in water samples from the study area and cadmium (r=0.89) in station one.

As for station two, a correlation was observed between zinc and cobalt (r=0.99), copper (r=0.95), cadmium (r=0.90), and chromium (r=0.86). In station three, zinc showed a correlation with cobalt (r=0.99), chromium (r=0.86), cadmium (r=0.81), and copper (r=0.65). In station four, zinc correlated with cobalt (r=0.75). There is also a correlation between zinc and cobalt (r=0.94), copper (r=0.75) in station five. Thus, the strongest correlation relationship for the zinc element in water was with cobalt.

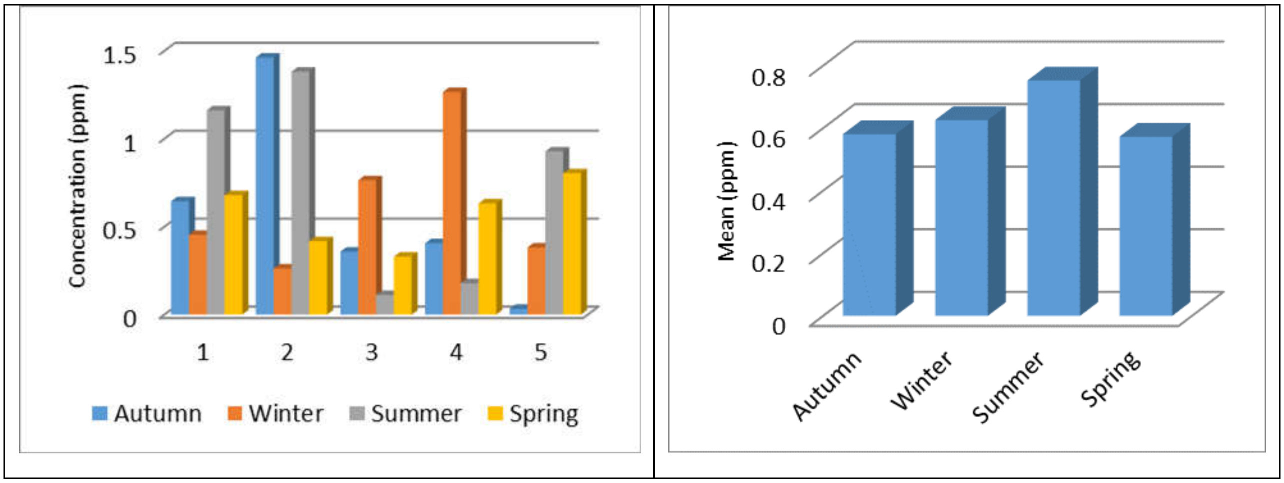

Figure 7. Seasonal variations and annual averages of zinc concentrations (mg /l) in total water samples.

**Chromium:**

The obtained results from this study revealed that the concentration of chromium in water samples representing five stations varied as follows: station one ranged from (0.840 to 0.140 µg/ml), station two ranged from (1.25 to 0.226 µg/ml), station three ranged from (1.045 to 0.150 µg/ml), station four ranged from (2.693 to 0.377 µg/ml), and station five ranged from (2.801 to 0.129 µg/ml). The highest average value (2.801 µg/ml) was recorded at station five during the winter season. The lowest average value (0.129 µg/ml) was observed at station five during the autumn season (Fig.8).

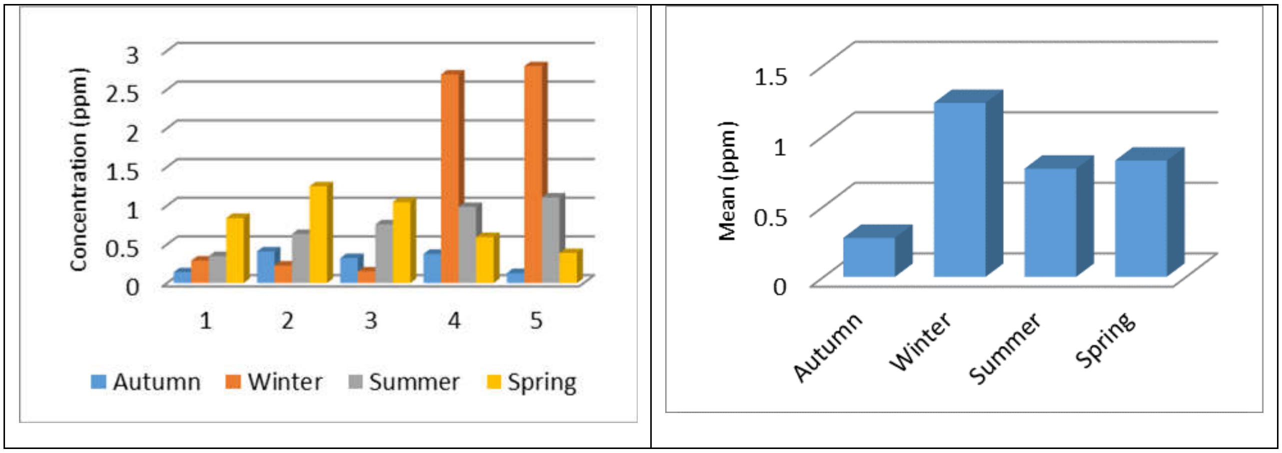

Figure 8. Seasonal variations and annual averages of Chromium concentrations (mg /l) in total water samples.

The results of the statistical analysis revealed a correlation between the presence of chromium element in water samples from the study area and cobalt (r=0.74) at station one. In station two, a correlation appeared between chromium and cadmium (r=0.98), copper (r=0.94), zinc (r=0.86), and cobalt (r=0.86). In station three, a correlation was observed between chromium and zinc (r=0.86) as well as cobalt (r=0.78). In station four, chromium was correlated with cadmium (r=0.97), copper (r=0.96), and cobalt (r=0.80). Furthermore, in station five, there was a correlation between chromium and cadmium (r=0.92) as well as copper (r=0.83). Consequently, the strongest correlation relationship for chromium in water was found with cadmium.

## Cobalt:

The study results revealed that the total concentration of cobalt element in water samples from the study area for five stations ranged as follows: station one (ND-0.095 µg/ml), station two (ND-0.095 µg/ml). As for stations three, four, and five, the concentration of cobalt was lower than the lowest detectable limit by the device. The highest concentration value of cobalt in the water was (0.095 µg/ml) (Fig. 9).

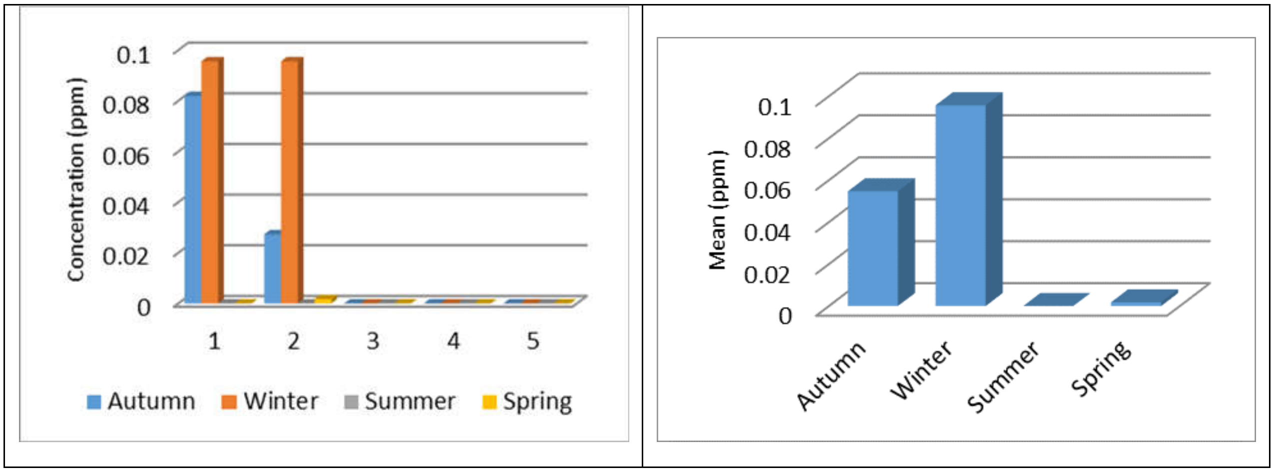

Figure 9. Seasonal variations and annual averages of cobalt concentrations (mg /l) in total water samples.

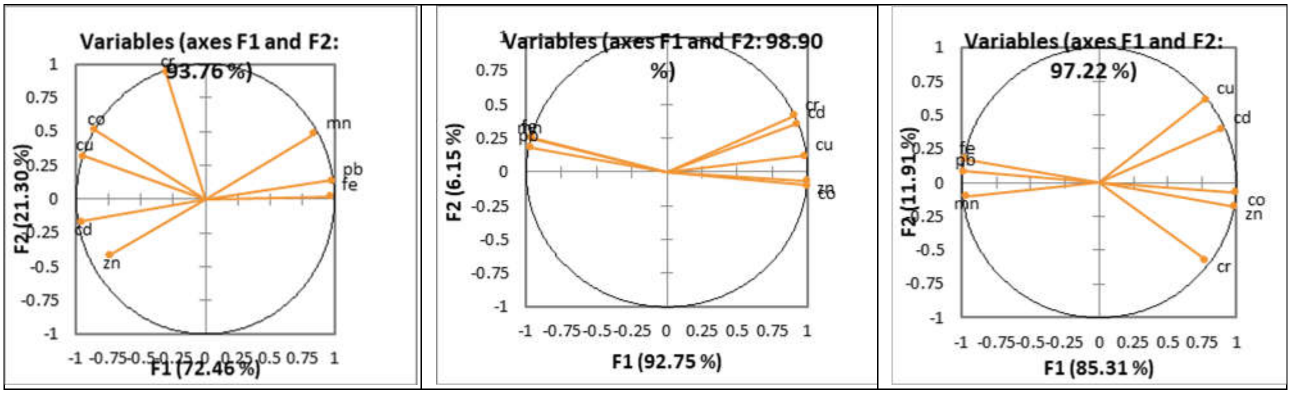

Figure 10. XL STAT analysis of the correlation coefficients between heavy metals.

The statistical analysis results demonstrated that there is a correlation between the cobalt element in water samples from the study area and copper (r=0.97), chromium (r=0.74), and cadmium (r=0.74) in station one. As for station two, a correlation was observed between cobalt and zinc (r=0.99), copper (r=0.96), cadmium (r=0.88), and chromium (r=0.86). In station three, cobalt showed a correlation with zinc (r=0.99), cadmium (r=0.84), chromium (r=0.78), and copper (r=0.71). In station four, cobalt correlated with copper (r=0.93), zinc (r=0.75), and cadmium (r=0.64). There is also a correlation between cobalt and zinc (r=0.94), copper (r=0.88), and cadmium (r=0.78) in station five. Consequently, the strongest correlation relationship for the cobalt element in water was with zinc.

## Discussion:

The results of the study demonstrated that the concentration of heavy elements in water is influenced by various factors, many of which stem from multiple sources, including nearby industrial and oil-related activities. In the study area, water is negatively impacted by the nearby oilfield west of Al-Qurna 2, leading to increased concentrations of heavy elements in the water. Winds carrying fuel combustion emissions and oil waste contribute to the contamination of water with heavy elements. Additionally, the presence of a vehicular pathway adjacent to the river affects the concentration of heavy elements, resulting in an elevated cadmium level in the waters of the Al-Ezz River. Nevertheless, these concentrations remain relatively low (l/0.2ml) compared to those found in the area's sediments. Furthermore, the use of chemical fertilizers in neighboring farmlands also affects the concentration of heavy elements in the water. These chemical fertilizers, used to enhance soil fertility, contribute to the presence of heavy elements in the water stream (Robert-Sainte *et al*., 2009).

During irrigation processes on these lands, chemical fertilizers are carried into the river, thereby polluting agricultural areas in general. In addition to this, the discharge of sewage water and the use of fungicides and insecticides also contribute to pollution. The flow of these pollutants into the river constitutes a form of agricultural pollution, effectively turning water into a means of disposing of agricultural waste and chemicals. These practices introduce various pollutants into the river, resulting in negative effects on water quality and the aquatic environment, potentially impacting aquatic organisms and biodiversity (Alloway, 2012). As the scope of these factors widens, they pose a threat to the suitability of river water for human use.

The exacerbation of these polluted conditions could lead to deterioration in the quality of river water, rendering it unable to meet human needs. Furthermore, the use of small, non-coated boats by some fishermen, the use of prohibited toxic substances for fishing, and the disposal of both organic and inorganic waste in the water have contributed to an increase in heavy element concentrations in the study area's water. Such practices elevate pollution levels and impact water cleanliness and quality, thus affecting aquatic life and impeding the diverse uses of such water. Based on the monitoring results of heavy metal concentrations at five stations, it is evident that the highest concentration is the copper concentration for all five stations, which is (42.253, 15.845, 695.422, 119.718 and 21.126) mg/L, respectively. This is attributed to various human activities and the liquid and solid waste that is discharged into the rivers, contributing to the addition of copper to the water.

## Recommendations

1. Oblige oil companies and industrial facilities to treat their waste before disposing it into the environment.
2. Organize seminars and workshops that bring together industrial and agricultural sectors, along with expert professors in pollution, and relevant departments responsible for pollution control. This is to shed light on the dangers of disposing of untreated water in rivers and discarding industrial waste that leads to water, soil and air pollution.
3. Promote environmental awareness among farmers, agricultural workers, and fishermen about the necessity of utilizing organic fertilizers instead of chemical ones, and reducing the use of toxins in fishing.
4. Intensify research concerning radioactive pollution, agricultural pesticide contamination, toxins used in fishing, oil pollution, and other forms of pollution across the entire Basra Governorate.

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