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A Seasonal Study of Some Environmental Elements in Iraqi Marine Waters

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Abstract - Water samples were collected quarterly, and elements in marine water were analyzed between January 2022 and December 2022 using The Anwar boat. Eight elements were measured in addition to the salinity concentration. The highest concentration was for the elements zinc, cadmium, calcium, sodium, lead, copper, Nickel, potassium and salinity concentrations and values (0.235, 0.0124, 720, 610.3, 0.417, 0.2358, 0.1812, 58.179,49) mg/l respectively, and Lowest concentration (0.021, 0.001, 128.8, 472.6, 0.21, 0.021, 0.0083, 44.1,42) mg/l respectively, as the elements zinc, lead, and copper are present In the spring, and the elements cadmium, calcium, and potassium in the autumn, and the elements sodium, nickel, and salinity in the summer. Conducting a canonical analysis (PCA) showed that the elements copper, calcium, sodium, and nickel were positively correlated with salinity, while salinity was correlated with nickel in the summer, and the elements potassium, sodium, and calcium during the autumn, while the rest of the elements were negatively correlated with salinity. The ready-made statistical program (SPSS) was used, to notable variations. When performing the cluster analysis, it was revealed that there were three cluster groups.

دراسة موسمية لبعض العناصر البيئية في المياه البحرية العراقية

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المستخلص - تم جمع عينات المياه بشكل فصلي، وتم تحليل العناصر في المياه البحرية خلال الفترة من كانون الثاني 2022 إلى كانون الأول 2022 باستعمال قارب أنوار، وتم قياس ثمانية عناصر بالإضافة إلى تركيز الملوحة، اذ كان أعلى تركيز لعناصر الزنك والكادميوم والكالسيوم والصوديوم والرصاص والنحاس والنيكل والبوتاسيوم والملوحة بتركيزات (0.235 ، 0.0124 ، 720 ، 610.3 ، 0.417 ، 0.2358 ، 0.1812 ، 58.179 ، 49) ملغم/لتر على التوالي، وادنى تركيز (0.021 ، 0.001 ، 128.8 ، 472.6 ، 0.21 ، 0.021 ، 0.0083 ، 1، 44.1 ، 42) ملغم/لتر على التوالي، حيث تتواجد عناصر الزنك والرصاص والنحاس في فصل الربيع، وعناصر الكادميوم والكالسيوم والبوتاسيوم في فصل الخريف، وعناصر الصوديوم والنيكل والملوحة في فصل الصيف. وقد اظهر اجراء التحليل القياسي (PCA) ان العناصر النحاس والكالسيوم والصوديوم والنيكل ارتبطت ايجابيا بالملوحة بينما ارتبطت الملوحة بالنيكل في الصيف وعناصر البوتاسيوم والصوديوم والكالسيوم خلال الخريف بينما ارتبطت بقية العناصر سلبيا بالملوحة استعمل البرنامج الاحصائي SPSS لتحليل العناصر احصائياً وعند اجراء التحليل العنقودي تبين وجود ثلاث مجموعات عنقودية.

الكلمات المفتاحية: بيئة، المعادن الثقيلة، التحليل الكنسي، المياه البحرية، الخليج العربي

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Introduction

Although elements are frequently found in nature and are necessary for life, they can accumulate in living things and become poisonous because natural mechanisms are unable to remove them from ecosystems. Unlike most organic pollutants, natural materials (Mousavi *et al*., 2024; Al-Khafaji *et al*., 2021). Today, elements are of great importance because of their toxicity and cumulative behavior The primary source of interconnections between pathways of life is the natural cycle of water, which is both tolerant and sensitive to the ecosystem.

(Allami *et al*., 2020; IOM, 2024) When environmental conditions change, the silt may become a source of water contamination because it serves as a sink for elements. (Al-Edresy *et al*., 2019; Afzal *et al*., 2024). The industrial sector's rise has been linked to the population's recent rapid growth, which has raised the environmental concentration of trace metals. Heavy element pollution in water bodies south of Iraq has been the subject to numerous investigations. Because they have no physiological function in the body, trace metals including cadmium (Cd), arsenic (As), lead (Pb), mercury (Hg), and chromium are frequently considered toxicants. (Issa *et al.,* 2020; Victoria and Nnebini, 2025).

The environment contains cadmium due to a variety of human activities. Over the past century, this has resulted in a large number of recorded cases of metal exposure. (Jassim *et al*., 2021; Rathore, 2021). Cadmium is released into the environment by human activities such as burning fossil fuels, using phosphate fertilizers, and smelting and refining copper and nickel. Reusing electronic waste and processing non-ferrous metals are other sources of cadmium pollution. (Lorenz and Erickson ,2023; Jadaa and Mohammed, 2023).

Soil contamination results from the discharge of this metal into the atmosphere by zinc, lead, and copper miners. (Hoang *et al*., 2022; Jassim and Al-Amiri, 2023). Sometimes environmental factors are subject to climate changes, and because of them, major changes have begun recently (Al-Maliki *et al*., 2022; Abdel-Rahman, 2022). Many studies have been conducted on elements, including: (Nnaji *et al*., 2023; Saleh *et al.,* 2021; Musa *et al*., 2024; Ondrasek, 2025 ; Matei *et al*., 2025; Mohammed, 2021). The present study aims to determine the levels of elements in Iraqi seawater in light of climate change and salinity concentrations.

Description of the study area:

Iraq has a small coastline area on the Arabian Gulf that divides Iran from the Arabian Peninsula. Iraqi coastal waters occupy the northwest sector of the Gulf, which constitutes the estuarine portion of the Gulf. Iraq's coastline is only 105 km long, its continental shelf is 1034 km2, and its territorial waters are 716 km2. Estuaries are locations where freshwater and saltwater combine. (Parvez *et al.,* 2023).

Materials and Methods

Water samples were collected by boat Anwar, which is 22.5m long and 7.5m wide and has a capacity of 240 HP. It is equipped with a bottom trawl net length of 20m and a height of 2m, and the size of the net openings is 2.5cm. During seasonal visits in Iraqi marine waters between January and December of 2022, using the coordinates (29 ° 43'33.41 "N; 48 ° 43'43.46" E), Figure 1. shows a map of the study area.

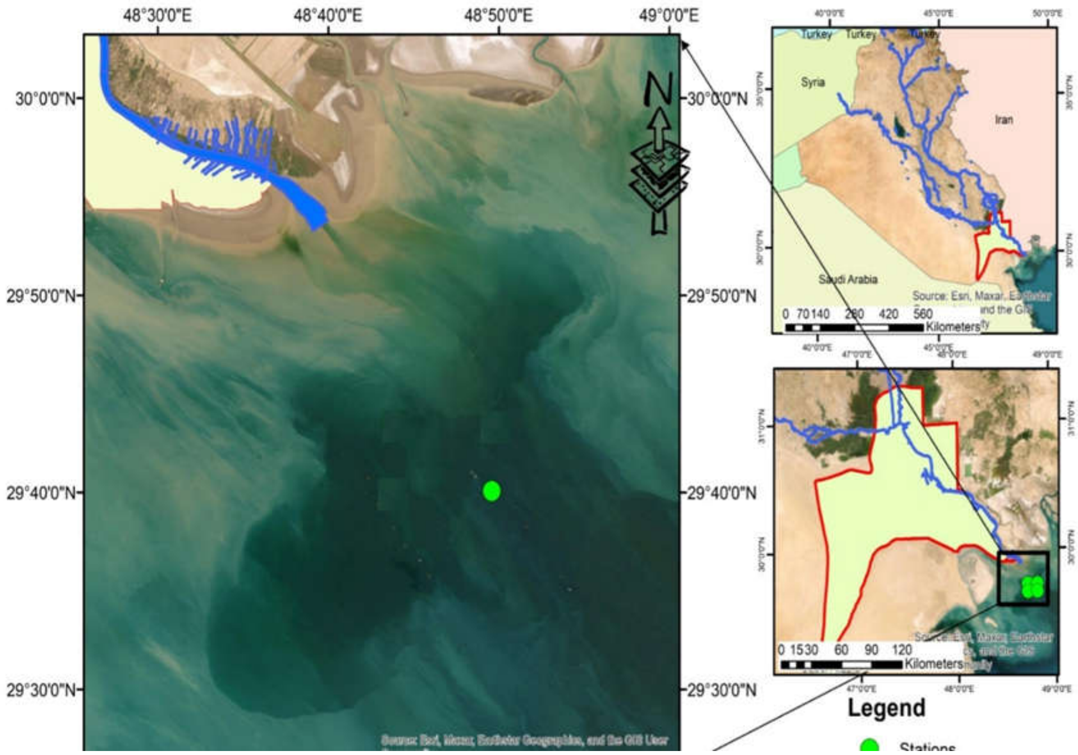

Figure 1. Explains the study area

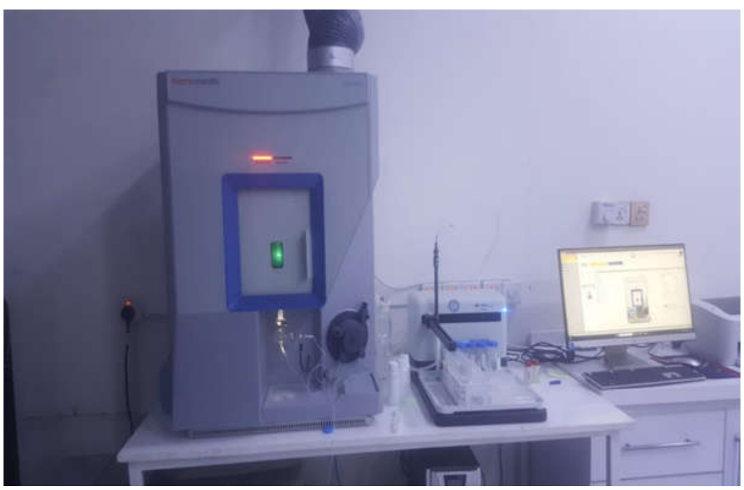

Plate 1. Explains the device for measuring environmental elements

The elements calcium, cadmium, zinc, potassium, Sodium, Lead, Copper, and Nickel were checked by a device ICP – OES, Thermo Fisher Scientific, Germany plat (1) in (mg / l) and were measured in the laboratory according to APHA, (1999). A salinity measuring equipment made by the German Lovibond business Senso-Direct 150 was used to measure the salt concentrations; the results are presented in useful salinity units. Salinity unit: Practical Salinity Unit (psu).

Statistical analysis

The observed concentrations of salinity and mineral elements were compared at a significance level of 0.05 using the pre-made statistical program (SPSS, 2000).

Results& Discussion:

Concentrations Zn and Cd:

The presence of zinc(Zn) in marine waters was the highest in the spring and reached 0.235 mg/l, while the lowest value was 0.0215 mg/l in winter. Cadmium (Cd)was at its Maximum level in the autumn and recorded 0.0124 mg/l in autumn, while it recorded 0.001 mg/l, its lowest level, in the spring (Figure.2). It is noted that heavy elements such as cadmium and zinc accumulate in organisms that live in fresh and marine waters. It is noted in the 2017 study by Ali *et al*., (2025).

That the concentrations of the above two elements increase in summer, and this is consistent with the present study, as the two elements increased in the summer. Cadmium is considered a non-essential element and is highly toxic in High concentrations, and its increase in the water system is considered water pollution (Kumar *et al*., 2021). This agrees with Jassim *et al*., (2023) that cadmium concentrations increase in the soil and coasts of Iraqi marine waters. This does not agree with Khazali, (2021).

According to research on Iraqi marine waters, zinc is a crucial metal since it is present in every organism's biological system and is used as a catalyst in several metalloenzyme reactions, including those involving leucine amino peptides, alcohol dehydrogenases, alkaline phosphates, carbonic anhydrase, and superoxide dismutase. (Rezaei *et al*., 2021). In the present study, the values of zinc varied from 0.0215 - 0.235 mg/l, and this is not consistent with the study of (Lorenz and Erickson 2023) as it was recorded at 0.1319 mg/l during their study of Iraqi marine waters, and it is consistent with the study of (Jassim and Al-Amiri, 2023). during their study of the Iraqi marine coasts. If registered 0.0861-0.1822mg/l, Zinc levels are higher than the local and global levels recorded in the present study.

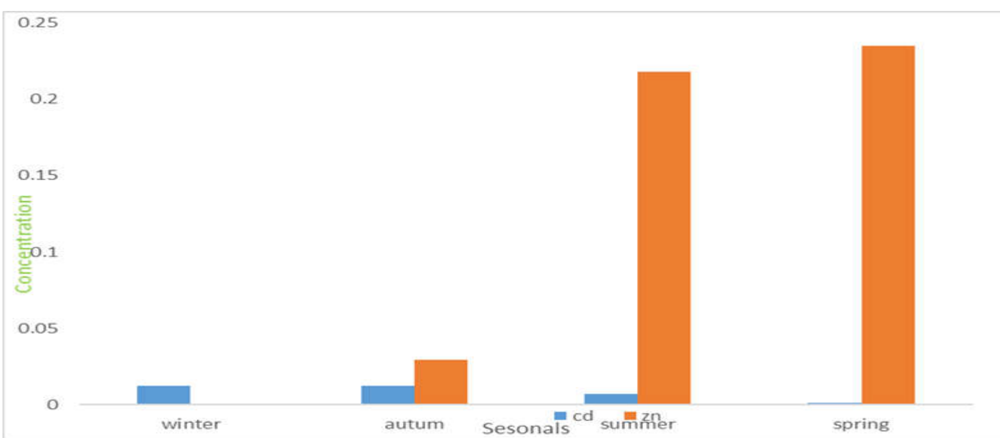

Figure 2. Show the concentrations of zinc (Zn) and cadmium (Cd) mg/l in sea water.

Concentrations Ca and Na:

The highest value for calcium (Ca) was 720 mg/l in autumn, and its lowest value was in summer and recorded 128.8 mg/l while the Maximum value for sodium (Na) was in the summer and recorded 610.3 mg/l, and the Minimum value for sodium reached in the spring and recorded 472.61 mg/l Figure 3. The highest concentration of calcium was recorded at 800 mg/l in October, while in the present study, the highest concentration was recorded at 720 mg/l in the autumn. Perhaps the reason is attributed to the lack of Shatt al-Arab discharges to marine waters.

The estimated ratios of sodium to chloride and the concentration of ions in the study area were very high, due to the influence of the Shatt Al-Arab, which is affected by human activities, including agricultural and water use. This is consistent with what Al-Dulaimi *et al.,* (2021) as it was less than the present study, the increase in sodium levels in the present study is due to an increase in chlorides and perhaps an increase in calcareous algae spread in marine waters, as well as an increase in coral reefs, as it recorded 610.3 g/l. Despite the increase in sodium concentrations in the present study, it does not agree with the study of (Yaseen *et al*., 2024). as it recorded 534.2 g/l during their study on marine waters**.**

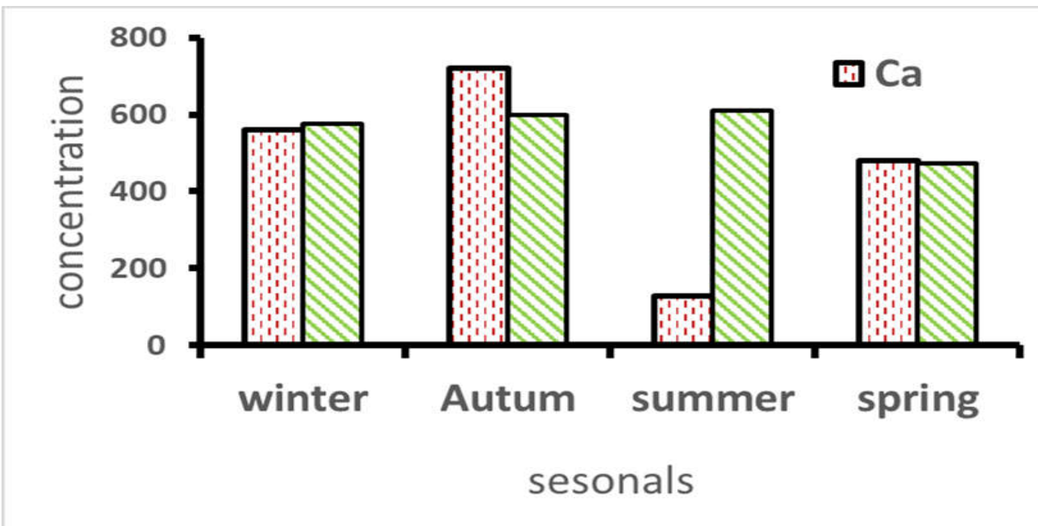

Figure 3. Illustrates the levels of Calcium (Ca) and Sodium (Na) in marine water

Concentrations Cu and Pb:

The presence of lead (pb) in seawater was recorded at its highest value during the present study semesters in spring, reaching 0.417 mg/l while the lowest value was 0.21505 mg/l during the winter, while the presence of copper (Cu) in the marine environment recorded its highest value in the spring. It was recorded at 0.2358 mg/l, while the lowest value was 0.0215 mg/l during the winter Figure 4 regarding the presence of lead at the same levels as the present study. The present study also agrees with the study above through the concentration of copper, as it was recorded at 3.38 µg/l, while it was recorded in the present study at 0.2358 mg/l. The elements depend on their readiness in the environment during the season, and the ions of these elements can combine with salts to form complex compounds that are deposited on the bottom. Therefore, sediments are the main storehouse for releasing elements into the water and then living things to accumulate their tissues (WHO,2011; Zhang *et al*., 2024).

The present study showed that lead levels fluctuate between seasons. This is due to the increase in marine navigation in the region, and it represents a navigational route for Iraqi and Iranian fishing boats. Additionally, because the area is known for its high levels of petroleum extraction and extraction activities, the higher levels on the sea surface represent the influence of lead emissions, while lead values in The present study are less than global and local studies and are consistent with the study of Hoang *et al*., (2022). within the marine coasts and is not consistent with the study of (Rathore , 2021) .

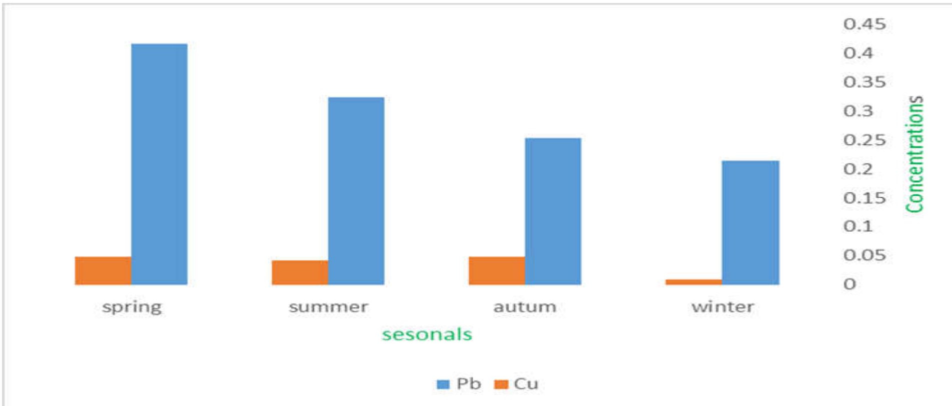

Figure 4. Illustrates the levels of Lead (Pb) and copper (Cu) in marine water.

Concentrations Ni:

According to Figure 5, the concentration of nickel (Ni) was highest in summer at 0.1812 mg/l, and it was lowest in the fall at 0.0083 mg/l. The nickel concentration in the present study was higher than in local and international studies, as the values varied between 0.008-0.181 mg/l. This may be attributed to oil spills in the region through the gathering of various ships before assembling and unloading them in their ports, and this is consistent with the studies of (Lorenz and Erickson, 2023; Yaseen *et al*., 2024). This result confirms what he has reached (Rezaei *et al*., 2021) while studying elements on the Indonesian coasts.

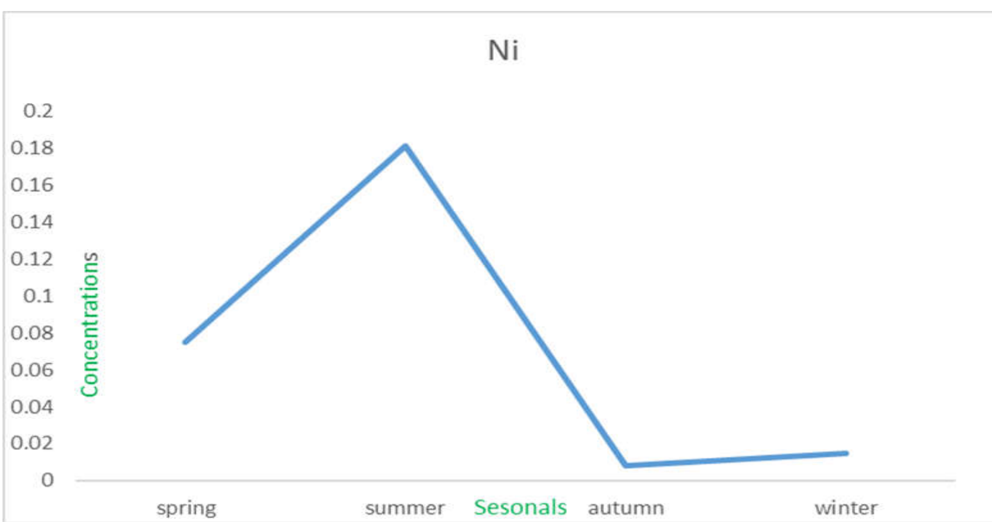

Figure 5. Illustrates the levels of Nickel (Ni) in marine water.

Concentrations Sa and K:

The Maximum salinity (Sa) concentration was in the summer and reached 49 psu, while the Minimum salinity concentration was 42 psu in the autumn The highest value of potassium (K) was in the autumn and amounted to 58.179 mg/l, and the lowest value was in the winter and amounted to 44.166 mg/l. Figure 6 came to the same conclusion: the increased salinity or saltiness of the water could damage flora and fauna and change the habitat of fish and birds. (Al-Shamary *et al*., 2020; Al Sulivany *et al.,* 2025), and lessen estuaries' ability to offer crucial functions like producing shellfish and preventing coastline erosion. (Galo and Resen 2024) reducing the nutritional status index of Iraqi(TSI) marine waters due to high salinity, which was confirmed by Galo and Resen, (2024).

During his study of Shatt al-Basra Canal, the salinity was between20.3ppt - 48.9. Due to the two aforementioned factors, the minimum salinity concentration in the Shatt Al-Arab estuary was 28.1 mg/l, which is regarded as a high salinity. This study agreed with Al-Shamary *et al*., (2020). during their studies in Iraqi marine waters. Boney fishes, sediment generation, and the cycling of inorganic carbon are some of the primary sources of calcium carbonate in the marine environment. (Musa, *etal*2020) The increase in human activities at both the temporal and spatial levels has led to element pollution in the sediments and coasts of rivers and seas (Nnaji *et al*., 2023), and their added other sources of calcium carbonate like coral reefs, and calcifying algae. also Sodium and potassium are constant in the oceans with average values of 0.5567 and 0.0206, respectively. It is noted that the increased levels of elements indicate that the water is polluted with these metals, and this is what was confirmed by Hoang *et al*., (2022).

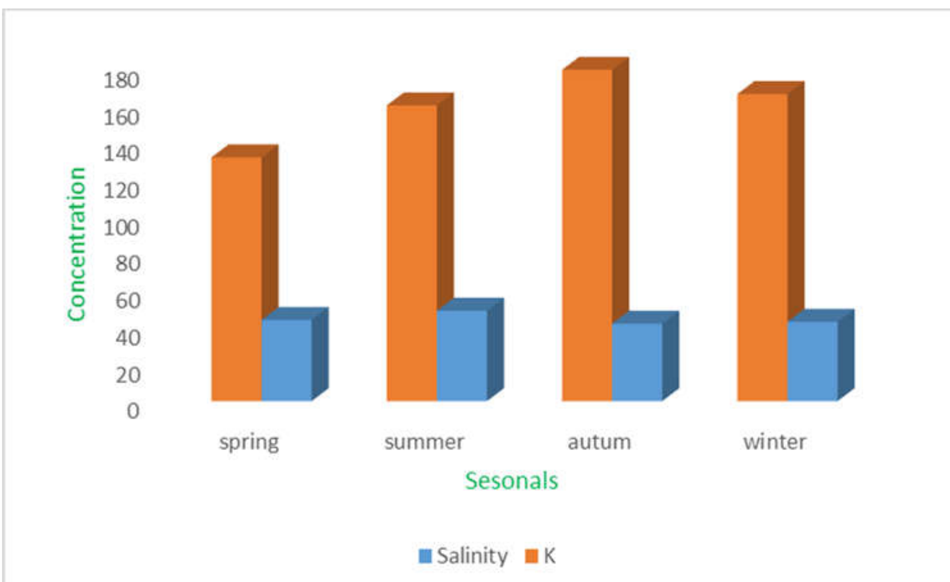

Figure 6. Salinity (Sa) and potassium(K) concentration levels in marine water

Figure 7 shows the canonical analysis of environmental elements with salinity and shows that the most significant correlation was with copper, then calcium and sodium, while there was a negative correlation with salinity concentration with cadmium, zinc, potassium, and lead.

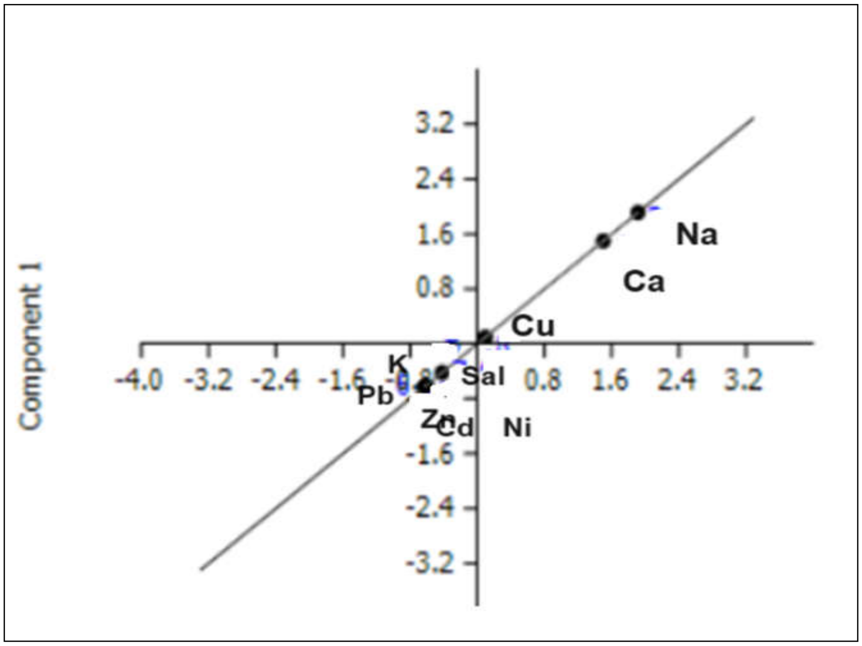

Figure 7. The Canonical analysis PCA of environmental elements and their association with salinity concentration is shown

Figure 8 shows the correlation of the element's potassium and nickel with salinity in a positive, significant, and positive correlation in summer, While the other elements had a negative link with spring and autumn, calcium and sodium had a positive correlation in the fall. shows a similarity level cluster analysis.

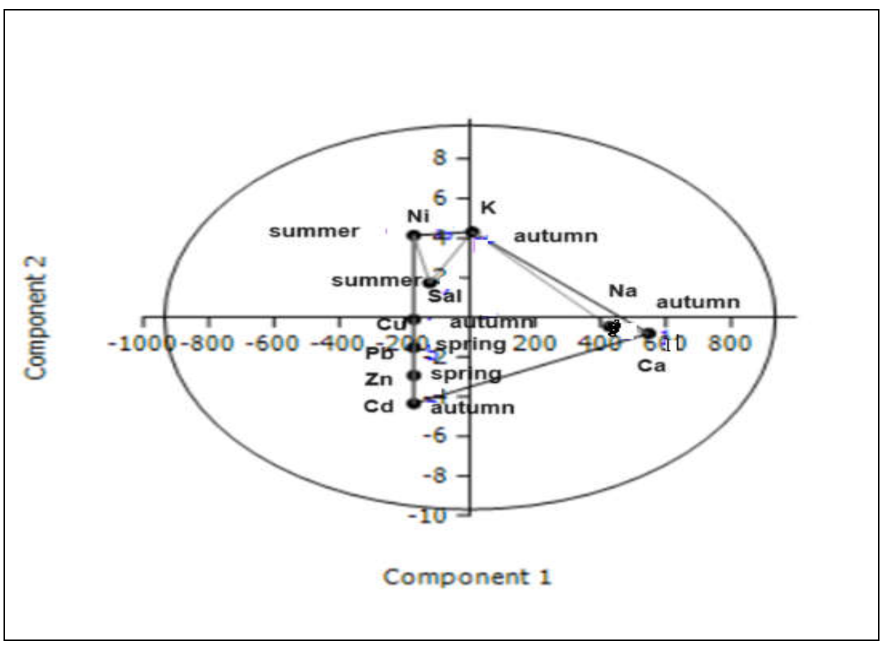

Figure 8. It shows the canonical analysis of the association of environmental elements and salinity with the seasons.

Three major groups are mentioned. Two secondary groups were included in the first main group at a 95% similarity threshold. At a 99% similarity level, cadmium, zinc, lead, copper, and nickel made comprised the first secondary group. Salinity concentration was included in the second secondary group at a similarity level of 95%, potassium was included in the second major group at a similarity level of 78%, and calcium and sodium were included in the third major group at a similarity level of 85% Figure 9.

This confirms what has reached (Ali *et al*., 2025). The presence of relatively strong and positive correlations between some major elements and clay contents in sediments between seasons is confirmed by statistical relationships. Additionally, Rezaei *et al*., (2021). confirmed that the search for elements is caused by the disintegration and damage of certain tissues of animals that live in the seas, and their increase leads to the disintegration and damage of tissues. During study of elements in the Arabian Gulf, confirmed that some organisms could be a biological monitor of metal pollution in the northeastern part of the Gulf.

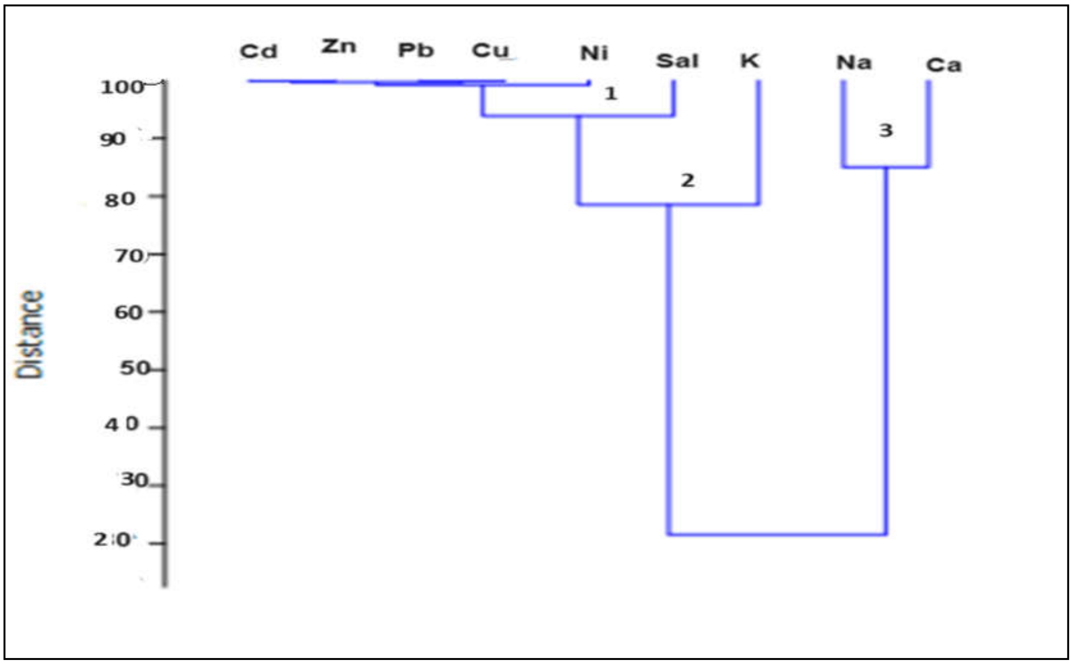

Figure 9. Cluster analysis of the degree of similarity between environmental elements and salinity concentration in marine water

Table 1. shows the measurement of some elements in the present study and their comparison with international organizations and previous studies. It is noted that the values in the present study for the elements calcium, sodium, and nickel are higher than the values Iraqi Standard limits. This is due to some natural reasons. Despite this, the Arabian Gulf is extremely vulnerable because of a number of natural factors, including limited water circulation brought on by isolation, high evaporation, and shallow water. (Galo and Resen, 2024).

Element pollution has led to air pollution in some cities, which has led to major climate changes, which has led to air pollution in some cities due to increased concentrations of some heavy metals in indoor environments (Khazali, 2021). Additionally, the research demonstrates that the use of microbes and plants in the bioremediation of settings contaminated with metals is successful in eliminating metals through detoxification or accumulation. This approach is cost-effective, varied, and eco-friendly. (Al-Dulaimi *et al*., 2021).

Table 1. It shows the values of the elements measured in the present study and compares them with other studies.

Period	Pb	Ni	Cu	Cd	Na	K	Ca	Salinity %	Zn	Reference
December 2018-September 2020	-	-	-	-	-	-	-	38-48	-	Al Sulivany *et al.,* (2025)
During summer 2021	0.2365-0.4682 mg/g	-	0.2146-0.3773 mg/g	0.0044-0.0015 mg/g	-	-	-	34.5 - 42.5	0.0861-0.1822 mg/l	Jassim,and Al-Amiri, (2023)
January-December 2018	-	-	-	-	346-5342 mg/l	28.1-472 mg/l	240-800 mg/l	43.1-47.3	-	Khazali, (2021)
Summer 2016	0.1728 m/l	0.144 mg/l	0.0144 m/l	0.0106 m/l	-	-	-	-	0.1319 m/l	Rathore, (2021)
January 2022-December 2022	0.21505-0.417 mg/l	0.0083-0.1812 mg/l	0.0215-0.2358 mg/l	0.001-0.0124 mg/l	472.61-610.3 mg/l	44.166-58.179 mg/l	128.8-720 mg/l	42-49 psu	0.0215-0.235 mg/l	Present study
	4 mg/l	0.07 mg/l	2 mg/l	0.003 mg/l	-	-	-	-	0.01 mg/l	WHO 2011
	≤5	-	≤1	0.005 mg/l	-	-		-	0.01 mg/l	CGL 2014
	3 mg/l	0.02 mg/l	1 mg/l	0.003 mg/l	200 mg/l	-	50mg/l	-	0.01 mg/l	(COSQC). 2009 IQS 2001

WHO: World Health Organization.
CGL: Canadian guidelines
IQS: Iraqi Standard limits.

Conclusion

Elements in the present study appear to be within the limits, except for calcium and zinc, which are higher than other environmental limits and may affect other environmental concentrations and organisms living in the marine environment There is a direct correlation between salinity and the elements copper, sodium, and calcium, and other elements such as lead, zinc, and cadmium that are also correlated**.**

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