Exp. Theo. NANOTECHNOLOGY 9 (2025) 311-325 https://doi.org/10.56053/9.S.311

Spatial analysis of environmental pollutants distribution for case study Al-Taji region in Baghdad city using remote sensing techniques

Sundus A. Abdullah Albakri[1,*], *Aya F. Ibrahim*[2], *Hawraa A. Hussein*[3]

[1,2]Department of Remote Sensing & Geographic Information System, College of Science, University of Baghdad, Baghdad, Iraq
[3]Department of Geophysics, Al-KARKH University of Science, Baghdad, Iraq.
[*]) Email: Sundusalbakri70@gmail.com

Received 21/1/2025, *Received in revised form* 3/2/2025, *Accepted* 11/2/2025, *Published* 15/3/2025

In this project, GIS and remote sensing techniques were used to detect soil of Baghdad. The field work is in Al-Taji (2022-2023). An XRF device is used to measure the concentrations of heavy metals in the soil. This study also confirmed that inverse distance weight (IDW) geostatistical methods can quickly estimate the map element distributions used in environmental health risk assessment. Spatial analysis will be done to illustrate the main regions of concentrations distribution for heavy pollutants .The XRF measurements of the minerals showed (Zn, Pb, Sr, Fe, Mn, Ni, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, V, Cu) in Al Taji soil showed that the concentrations of some of these elements exceeded the standard value such as (Na, Ca, Ni, Sr, Cl, S, Zn, Cu,) Using the ASD device, the spectral reflectivity of soil samples is measured in the areas of Taji. It is found that the reflectivity increased in wet areas and decreased in the desert areas with respect to soil. The study is characterized by the presence of two strange elements that studies could not find ten years ago, clarified the presence of the element (Sr), which is close to the properties of nuclear in the soil and the presence of element (V) showed that the conditions experienced by this region, whether military or environmental, are what helped the presence of these elements. A spatial distribution map is drawn for the spread of Minerals in the soil of Al-Taji in Baghdad using the IDW method.

Keywords: Environment; Pollutions; Spectral; Sustainable; Remote sensing.

1. INTRODUCTION

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Environmental pollution is one of the most serious problems facing humanity and other life forms on our planet today. "Environmental pollution is defined as "the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected"[1]. Soil pollution also known as land pollution is the contamination of the soil or the land that prevents growth of natural life, which includes land used for cultivating, wildlife as well as habitation. Common causes of soil pollution include non-sustainable farming practices, hazardous wastage and seepage into the soil, mining as well as littering. Soil pollution can result in reduced growth of agriculture as well as poisoning of the land and nearby water [2]. This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. Spectral Reflectance is the measure of the wavelength of the electromagnetic energy reflected from a surface in a given waveband to the energy incident in that waveband [3].Environmental nanotechnology deals with various physical, chemical, and biological remediation methods by applying the nanoscale fragments to remove or reduce pollutants from soil [4].Therefore, different studies have focused on using the principles of nanotechnology and combining it with chemical and physical modification of the surface of the materials in an effort to obtain engineered materials that can overcome many of the challenges involved with the remediation of contaminants.[4,5].This study focuses on the use of environmental spatial analysis techniques to study the distribution and concentration of pollutants in the study area, their causes and their danger to the environment and the life of living organisms, and what are the proposed treatments in the future.

2. STUDY AREA

The administrative regions of Baghdad consist of ten districts and thirty-two sub- districts as shown in figure 1. The districts are be chosen for the study, Al-Taji district regions in Baghdad governorate. Baghdad which is located in the center of Iraq between (longitude 44°2157.96E; latitude 33 1854.72N) [4][5]. Al- Taji is a sub- district in Al- Kadhimiya district, formerly north of the Iraqi capital, Baghdad, in Salah Al- Din Governorate. Most of Al- Taji's area is agricultural land. There are some government departments and factories in Al- Taji, such as the Al- Taji gas plant, the Nasr Company for Military Industries, and the Al- Taji stadium [6]. It is also under construction. The area of Al- Taji sub- district is 388 square kilometers, equivalent to 155,200 dunums, and its borders are the Tigris River in the east, the Tarmiyah district in the north, Al- Anbar Governorate in the west, and the district center Al- Kadhimiya and that Al- Salasil district in the south as shown in figure.1 and figure 2.

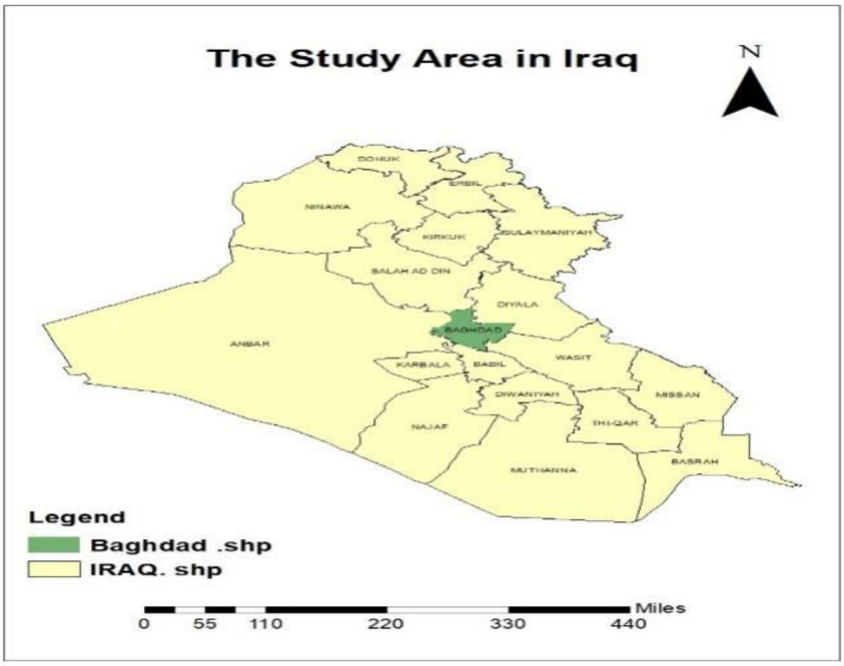

Figure 1 Iraq's map showing the locations of study areas.

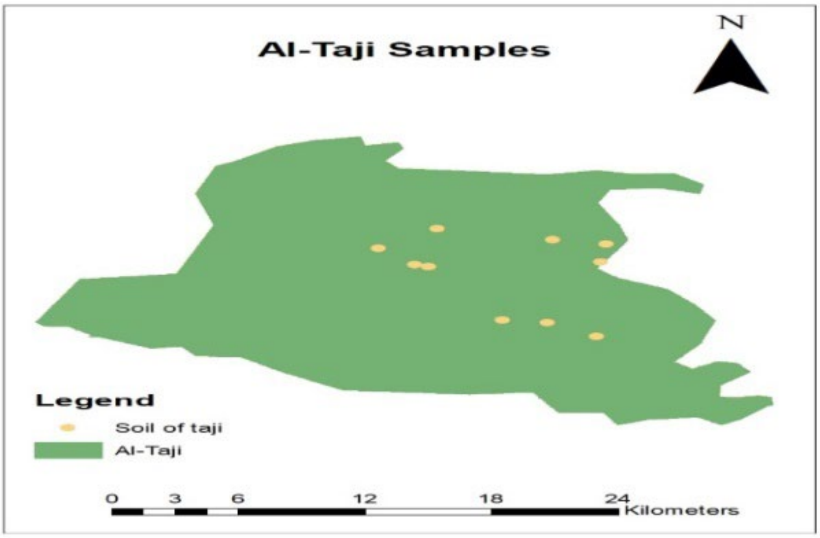

Figure 2 Al-Taji district map with samples.

3. METHODPLPGY USED

Some steps can be adopted in this work as the following:

1. Selection of the study areas, including the districts of Al-Taji.
2. Sample collection.
3. Sample processing.
4. Available devices (X-Ray Fluorescence (XRF), Spectrometer Device (ASD).
5. Reflectivity curve analysis.

6. Determine areas of high and low ratios.
7. Conduct spatial analysis of pollutants and make a final map of the approved samples.

4. RESULTS AND DISCUSSION

In this study the Element concentrations (Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Pb, V, Zn, Sr, Mn, Fe, Ni, Cr, Cu) and reflectivity are measured using an XRF device and an analyzer Spectrophotometer (ASD). Ten samples of surface soil 5-10 cm (depth) are taken from Al-Taji area in Baghdad Governorate in Iraq. Samples are taken during November 18, 2022. As shown in Table 1.

Table 1 Summary of the metals concentrations in (PPM) in Soil sample of Al-Taji district using XRF.

No.	Area name	Cr	Fe	Cu	Zn	Sr	Rb	Mn	Ni	Na	Mg	Al	Si	P	S	Cl	K	Ti
1	Al-taji1	64.181	15.48	0	120	340	31.634	230	51.014	1.26	6.05	9.06	33.08	130	1.47	5.08	3.1	940
2	Al-taji2	74.448	15.6	0	57.023	290	38.968	240	44.796	540	5.6	8.74	32.52	260	220	160	3.22	880
3	Al-taji3	180	15.01	0	47.928	280	31.27	220	56.057	900	5.83	9.19	35.92	130	210	210	2.98	1.02
4	Al-taji4	100	16.05	28.528	49.969	320	38.032	230	47.13	580	5.17	8.57	29.88	130	850	370	3.08	970
5	Al-taji5	120	9.84	25.617	41.455	470	22.826	160	41.293	1.39	4.22	6.19	27.55	190	4.79	5.35	3.14	690
6	Al-taji6	96.13	15.54	37.594	64.367	310	44.45	250	0	670	5.66	10.28	38.3	320	1.69	240	3.81	930
7	Al-taji7	120	11.47	0	34.319	300	24.068	190	36.791	960	4.07	8.26	35.29	100	850	1.3	2.64	850
8	Al-taji8	90.268	15.53	0	45.047	320	35.084	240	57.954	540	5.35	8.86	31.88	110	250	300	3.06	880
9	Al-taji9	120	14.26	0	49.13	290	27.382	240	44.738	730	4.92	8.99	34.86	87.963	580	0	2.86	490
10	Al-taji10	110	12.27	0	0	450	32.133	190	44.581	9.09	5000	7.44	28.77	70.071	1.82	15.59	2.38	980
Standard Values (ppm)		200	37	20	50	150	60	800	40	6000	6000	71	330000	800	800	100	13000	13000

The increase percentage of magnesium in the soil due to the excessive use of fertilizers in the area as shown in the figure 3. The soil, which increases the amount of magnesium ready for the plant [7]. The percentage of sodium in the soil solution may increase due to the deposition of calcium and magnesium from the soil solution in the form of poorly soluble compounds such as lime and gypsum. The increase in the sodium element in the soil due to precipitation, as shown in the figure 4.

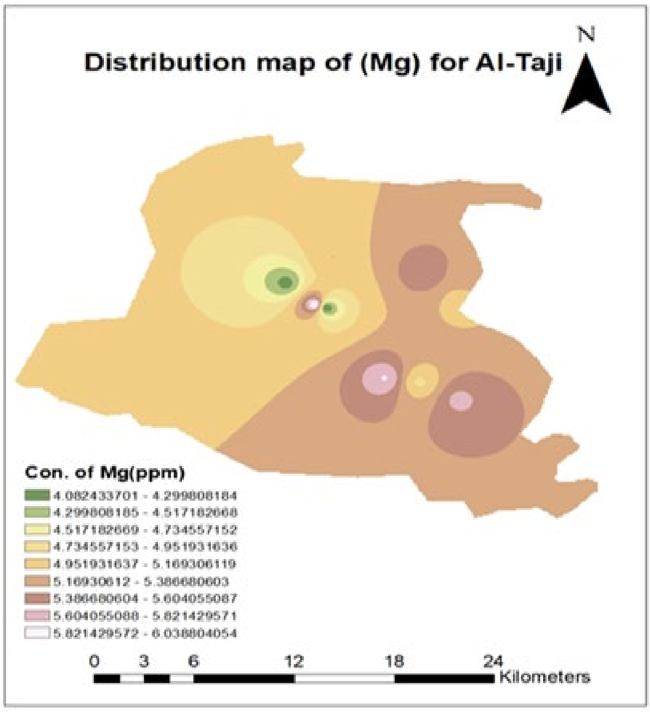

Figure 3 Interpolation of (Mg) concentrations in soil of Al-Taji.

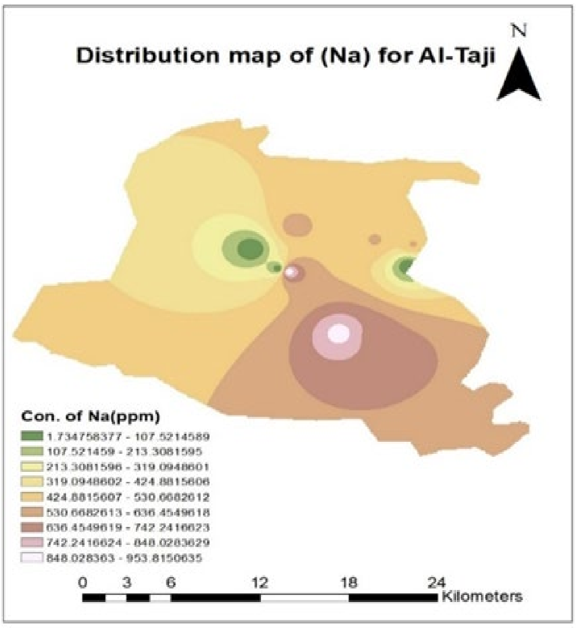

Figure 4 Interpolation of (Na) concentrations in soil of Al-Taji using IDW method.

Aluminum is considered one of the elements harmful to plants, as it reduces their growth, especially in acidic soils. Therefore, an increase in the concentration of positive aluminum ions in this soil leads to a defect in the growth of plant roots. Soil acidity leads to the hydrolysis of aluminum compounds [6]. The increase in the aluminum element in the soil of this area due to weapons Waste in Taji camp. Silicon increases soil productivity and plant vitality and helps resist diseases. It is used in the manufacture of fertilizers and pesticides [7]. Interpolation can be done for (Al) and SI concentrations in soil of Al-Taji regions using IDW method. The increase in the silicon element in this area due to the presence of factories for building materials and glass, as shown in the figure 5 and figure 6.

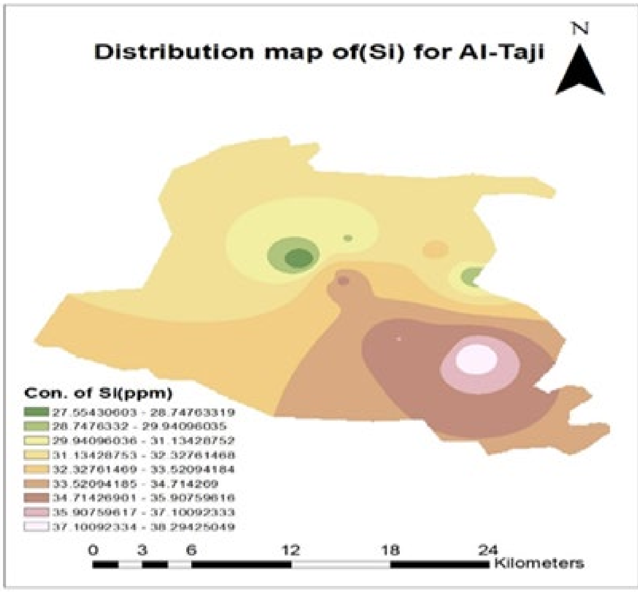

Figure 5 Interpolation of (Si) concentrations.

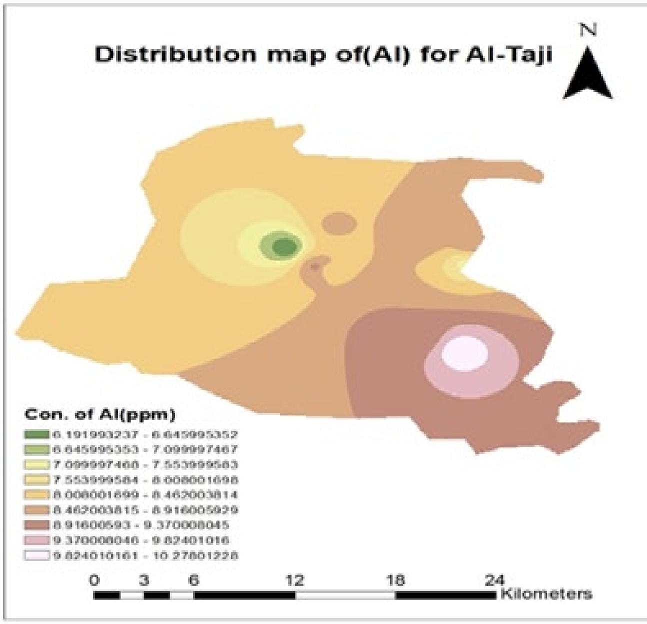

Figure 6 Interpolation of (Al) concentrations.

Phosphorus is available in lands that are abundantly fertilized in previous years with phosphorous fertilizers, as it is easy to fix phosphorus in the soil [8]. Interpolation of (P) concentrations in soil of Al-Taji using (IDW) method. The increase in the phosphorous element in this area as a result of the increase in fertilizers in the soil and because it is an agricultural area as shown in fig.7. Sulfur is a mineral fertilizer, as mineral fertilizers contain sulfur as sulfates (sulfates), and sulfates are chemical fertilizers that are ready as nutrients that are easily absorbed by plants [9]. The increase in the sulfur element in this area due to fertilizers, fungicides, and insecticides, as shown in the fig. 8.

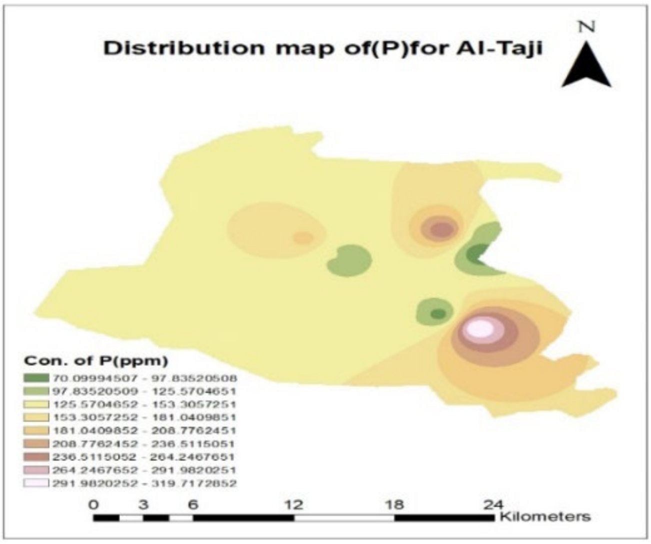

Figure 7 Interpolation of (p) concentrations.

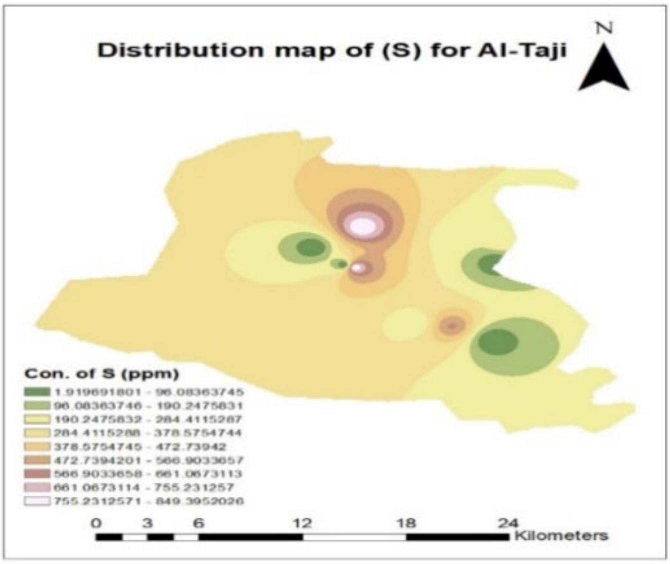

Figure 8 Interpolation of (S) concentrations soil.

Chlorine is found everywhere in nature. It is present in the soil in the form of soluble salts of sodium, potassium, calcium an d magnesium, Chlorine is available in nature and in many fertilizers. In general, the farmer does not need to spray chlorine on the crops [10], the increase in chlorine in the soil of this area due to the presence of fertilizers in the soil, as shown on the figure 9. The large increase in the magnesium element within agricultural soils may lead to problems in plants. As the process of absorbing the magnesium element decreases, the increase in the magnesium element in this area is due to the excessive use of fertilizers, as shown in the picture [11], the increase potassium in the soil of this region, and use the result of fertilizers to feed plants and industrial waste, as shown in figure 10.

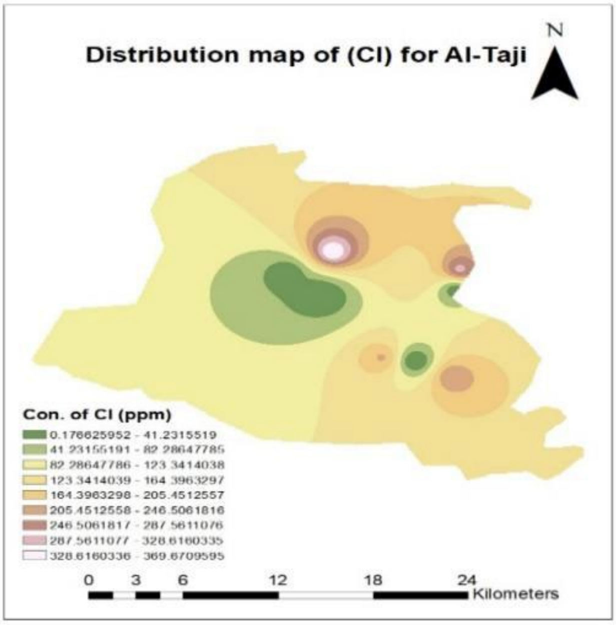

Figure 9 Interpolation of (CI) concentrations.

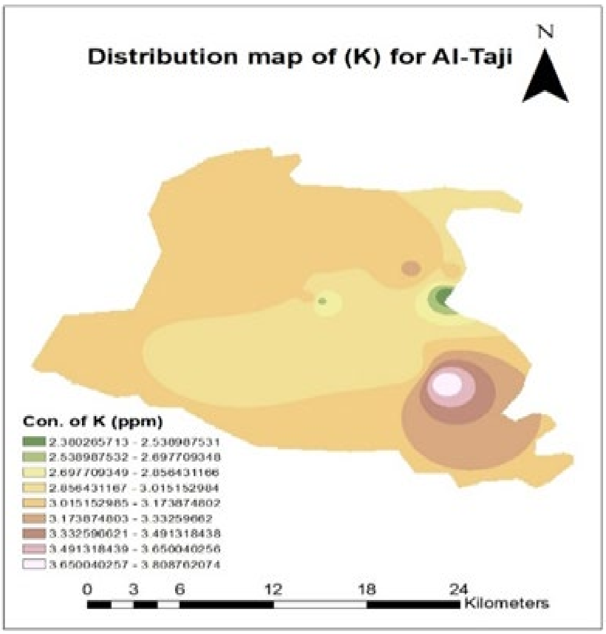

Figure 10 Interpolation of (K) concentrations.

Feeding the plant with calcium has a vital role in producing high-quality agricultural crops, in addition to its distinctive function in using it as soil conditioners in many cases. In dry areas, which originated from a very high amount of calcareous origin, due to the abundance of compounds and sediments that contain calcium [12]. The increase in the calcium element in the soil due to the increase in soil acidity in this area, as shown in the figure 11. Titanium enhances the uptake and utilization of nitrogen, phosphorus and potassium by plants and thus plays a role in increasing yields and improving fruit quality. It is used in fertilizers [13]. The increase in the titanium element in the soil due to the presence of military factories in the area, as shown on the figure 12. Interpolation adopted of (Ca) and (Ti) concentrations in soil of Al-Taji using (IDW) method.

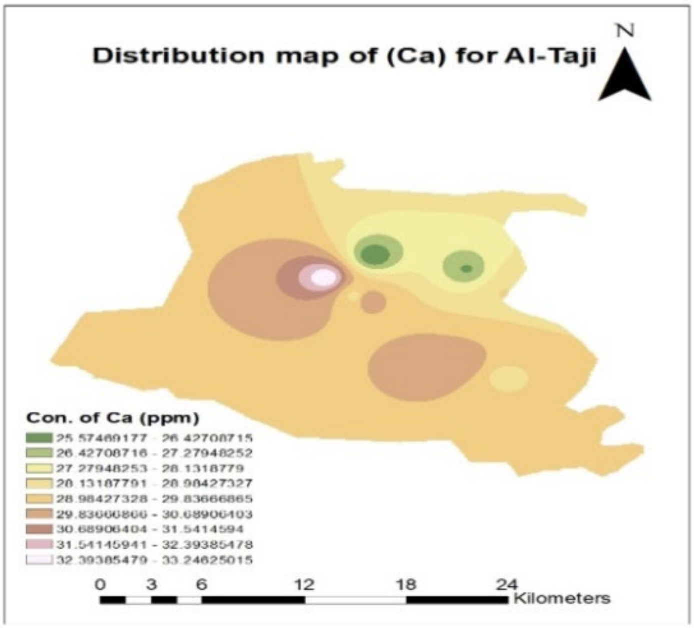

Figure 11 Interpolation of (Ca) concentrations**.**

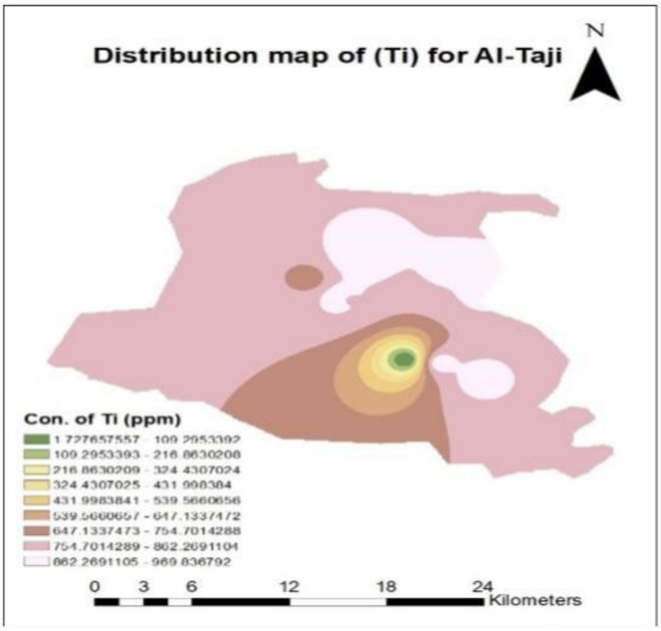

Figure 12 Interpolation of (TI) concentrations.

Chromium increases in the soil due to the growth resulting from industrial growth, the characteristics of oil and the chemical industries, and the focus has been placed on the chromium in the soil greatly, by focusing on the natural composition of the rocks and the sediments that make them up, and may lead to the presence of chromium in the soil on growth [13]. The increase in the chromium element in the soil due to the chemical factories in this area, as shown in the figure 13. Manganese is one of the seventeen essential elements for plant growth and reproduction. It is also classified as a micronutrient that plants need in small amounts only. Despite this, manganese plays a very important role in plant growth [12]. The increase in the manganese element in the soil due to the remnants of military factories in the area, as shown in the figure 14.

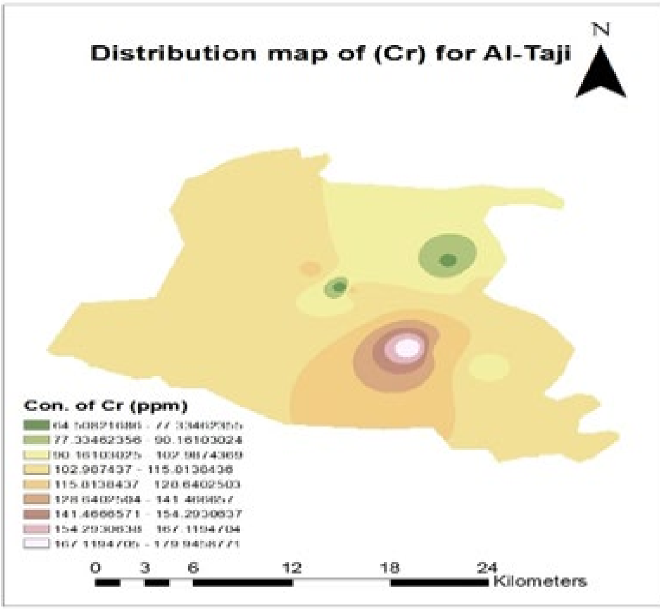

Figure 13 Interpolation of (Cr) concentrations**.**

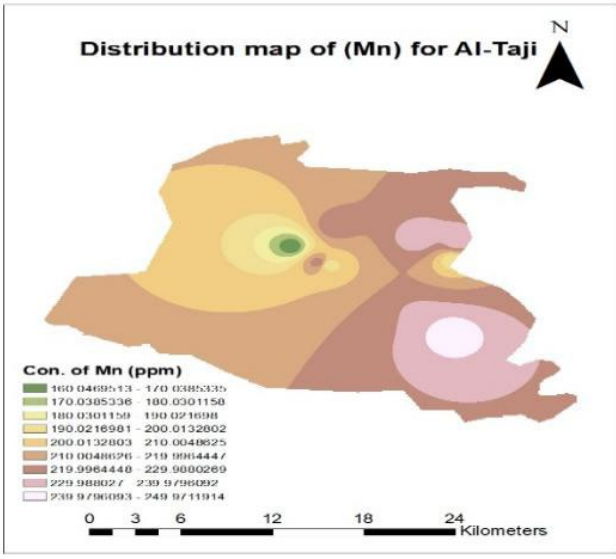

Figure 14 Interpolation of (Mn) concentrations.

Iron is an essential element for the growth and development of cultivated plants for some plants in large amounts [14], Interpolation of (Fe) and (Ni) concentrations in soil of Al-Taji using (IDW) method done to illustrate the percentages of values of it as shown in figures 15 and 16. The increase in the iron element in the soil due to the type of red soil, so iron is in high proportions, and also due to the remnants of military factories in the region, as shown on the figure 15. Nickel is one of the elements that plants need in very limited proportions, as increasing its concentration works on plant growth [15,16]. The increase in the nickel element in the soil due to the presence of military factories in the area, as shown on the figure 16.

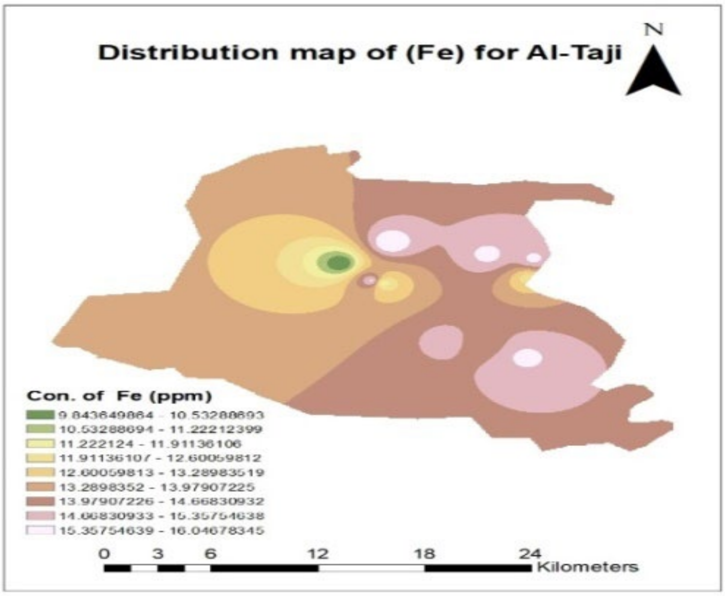

Figure 15 Interpolation of (Fe) concentrations.

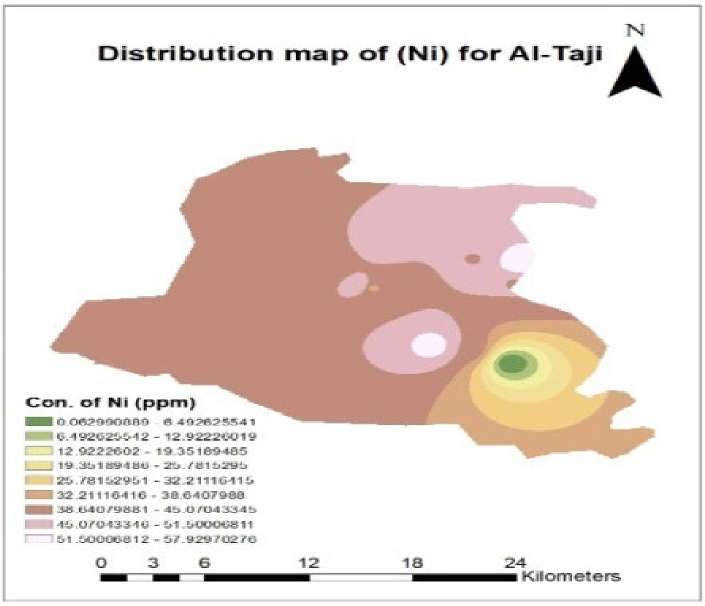

Figure 16 Interpolation of (NI) concentrations.

Zinc is an essential element for plant growth as it is involved in the reactions that lead to the formation of hormones necessary for normal cell growth [17], The increase in the zinc element in the soil due to the presence of factories for batteries in the area, as shown on the figure 17. Rubidium is one of the rare elements in nature and is considered unnecessary for living organisms. It reacts easily in water and is not considered toxic, but it is potentially dangerous [18]. The increase in the rubidium element in the soil due to the presence of glass factories in the area, as shown on the figure 18.

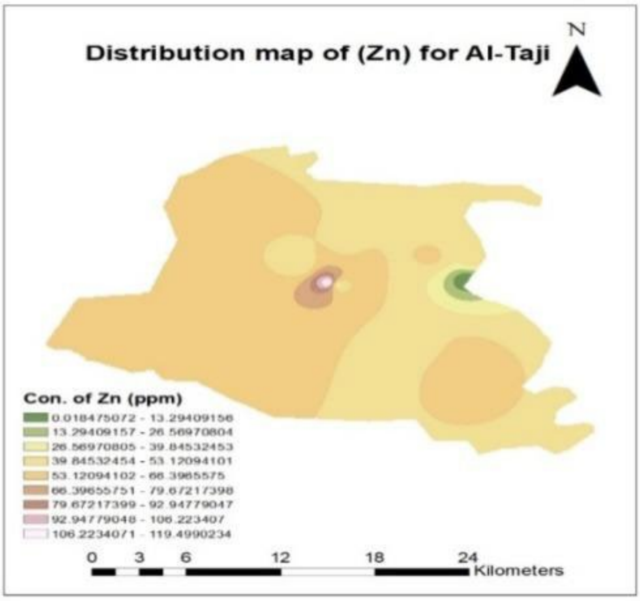

Figure 17 Interpolation of (Zn) concentrations.

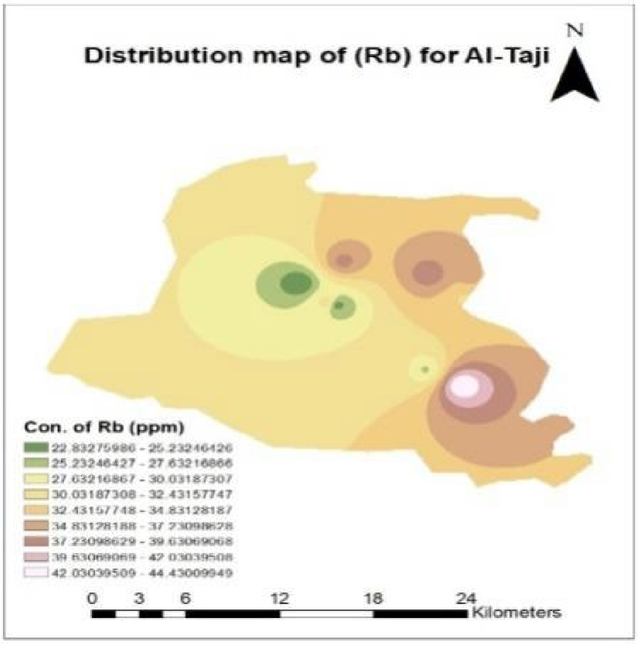

Figure 18 Interpolation of (Rb) concentrations.

Strontium is relatively abundant in the Earth's crust, It ranks fifteenth among the elements in the Earth's crust, This makes it abundant like fluorine and barium [18]. Interpolation are be adopted of (Sr) and (V) concentrations values in soil of Al-Taji using (IDW) method. The increase in the strontium element in the soil due to the presence of factories such as fireworks factories and glass factories in the area, as shown on the figure 19. Vanadium is a chemical element in the periodic table, and it is a hard and toxic metal. It is used in making nuclear reactors and ceramics [19-21]. The increase in the element of vanadium in the soil due to the presence of remnants of military factories in the area, as shown on the figure 20.

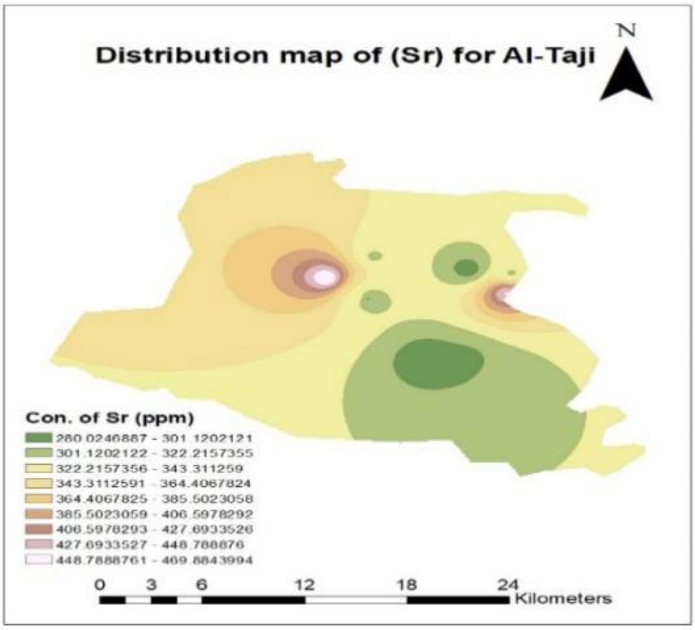

Figure 19 Interpolation of (Sr) concentrations.

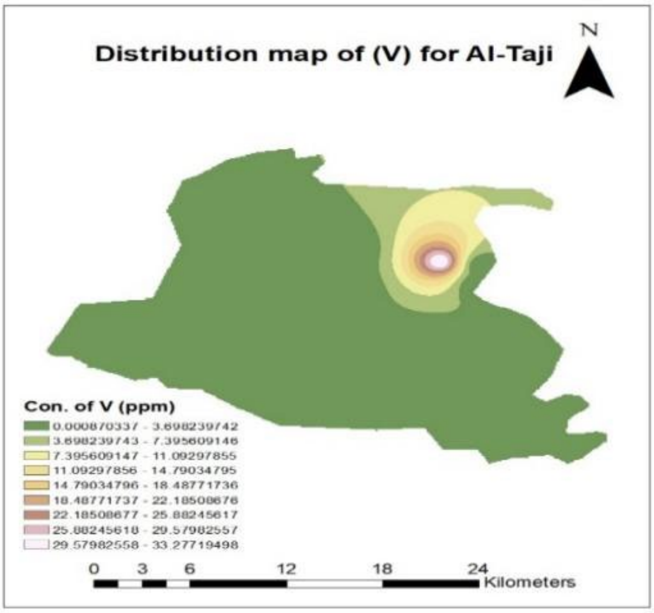

Figure 20 Interpolation of (V) concentrations.

The study is characterized by the presence of two strange elements that studies could not find ten years ago, but that [5],illustrated for two years ago clarified the presence of the element (Sr), which is close to the properties of nuclear in the soil and the presence of element (V) showed that the conditions experienced by this region, whether military or environmental, are what helped the presence of these elements, especially with regard to military equipment and the destruction of many of them after 2003 and also the presence of the army camp and army training such as the Taji camp helped so. The reason for the increase in reflectivity in the soil is due to wet or clay and agricultural soils, and the reason for the decrease in reflectivity is due to sandy soils and soils exposed to high temperatures that have high reflectivity, as shown in the figure 21.

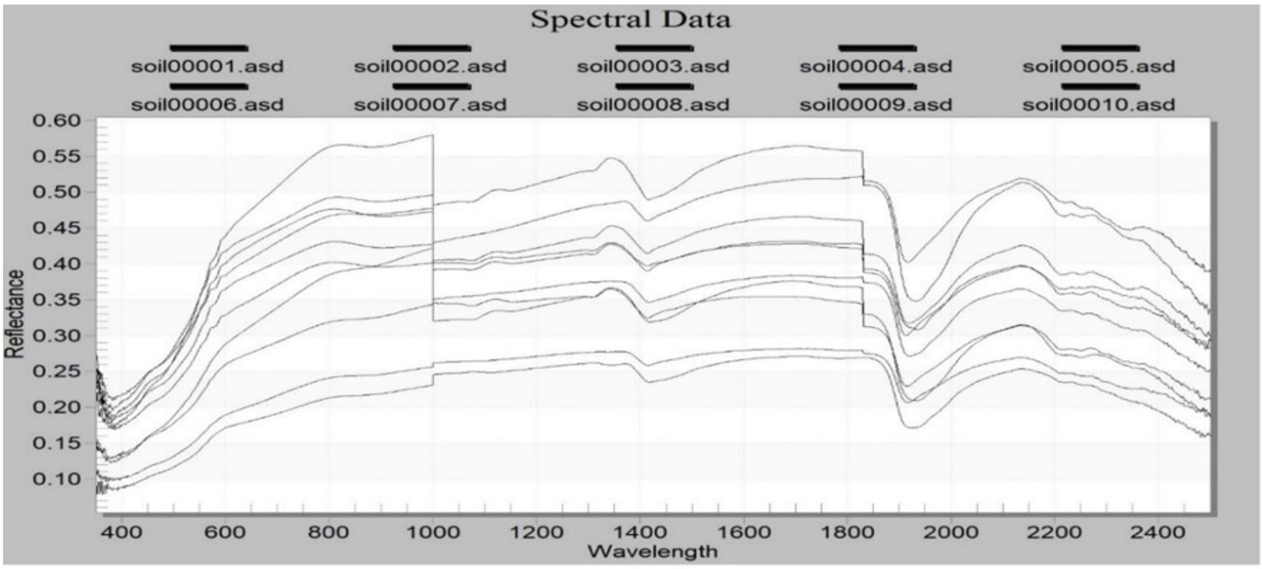

Figure 21 Illustrates original spectral reflectance curves for soil samples of Al-Taji.

5. CONCLUSIONS

By analyzing the soil samples of the Taji region using the (XRF) device, it was found that the percentages of the elements (Mg, S, Cl, Ca, Ni, Zn, Sr, Cu) increased due to the increased use of fertilizers and pesticides and the increase in soil acidity in some areas and factory waste. The presence of the element Vandium (V) in sample No. 2 in a natural proportion due to the presence of a natural proportion of the remnants of military factories. The presence of element (V) showed that the conditions experienced by this region, whether military or environmental, are what helped the presence of these elements, especially with regard to military equipment and the destruction of many of them after 2003. Using the (ASD) device, the spectral reflectance was measured for the soil samples of Al-Taji and it was found that the spectral reflectivity increased in some areas due to the sandy soil and the spectral reflectivity decreased due to the clay soil.

ACKNOWLEDGMENTS

The authors express gratitude to their respective universities for providing encouragement and infrastructure.

References

[1] R.Sh. Jaafar, A. Yousif, Z.A. Abdulnabi, A.Z. Alhello, H.T. Al-Saad, Eco. Env. & Cons. 25 (2019) 35
[2] M.A. Sultan, The 1st International Applied Geological Congress, 2010
[3] M. B. Musa, S. A. Abdullah Albakri, M. A Sultan, Iraqi Journal of Physics, 23 (2025) 114
[4] Ghazal Tuhmaz, Exp. Theo. NANOTECHNOLOGY 8 (2024) 33
[5] M. Tadres, Exp. Theo. NANOTECHNOLOGY 8 (2024) 11
[6] S.A. Hussain, S.A. Abdullah, A.A. Al Maliki, J. Phys. Conf. Ser. 2114 (2021) 012086
[7] Z.J. George, E. Changes, Plant Soil 243 (2002) 209

[8] E.F. Khanger, B.A. Al Razaq, R.R. Ismail, Z.F. Rasheed, IOP Conf. Ser. Mater. Sci. Eng. 757 (2020) 012030
[9] K.W. Yoo, S.P. Wang, J. Phys. Conf. Ser. IOP Publishing, 2021
[10] G. Rasool, G. Khattack, J.K. Bhatti, A., Pakistan J. Agric. Res. 8 (1987) 29
[11] S.K. Al-Mamoori, Basrah J. Eng. Sci. 17 (2017) 48
[12] J. Ryan, G. Estefan, A. Rashid, Soil and Plant Analysis Laboratory Manual, 1977
[13] M.H. Nabavi, M. Kashefi, J. Ornamental Hort. Plants 3 (2013) 25
[14] K.J. Stasicka, Z. Environ. Pollut. 107 (2000) 263
[15] R.D. Turner, R. Warne, M.S.J. Dawes, L.A. Vardy, S. Will, G.D. J. Environ. Manag. 183 (2016) 806
[16] B.J. Alloway, Zinc in Soils and Crop Nutrition, 2nd ed., International Zinc Association/International Fertilizer Industry Organization, Brussels/Paris, 2008
[17] H.M. Rantamaki, S. Puputti, E.M. Tyystjarvi, T. Tyystjarvi, E., J. Exp. Bot. 57 (2006) 1809
[18] L.K. Zaunbrecher, R.T. Cygan, W.C. Elliott, J. Phys. Chem. A 119 (2015) 5691
[19] J. Solecki, I.S. Chibowski, Pol. J. Environ. Stud. 11 (2002) 157
[20] J. Christ, M. Filips, S. Artois, R. Nowak, M. Reed, W. Knoll, Exp. Theo. NANOTECHNOLOGY 7 (2023) 87
[21] Muhammad Ismail, Wang Xiangke, Ali H. Reshak, Dania Ali, Aneeba Amjad, Qaisar Khan, Muhammad Ishaq, Abdul Ahad Khan, Zeshan Zada, Exp. Theo. NANOTECHNOLOGY 7 (2023) 95