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SPATIAL DISTRIBUTION OF SOME MICROELEMENTS IN SOIL IN THE AL-RIFAI DISTRICT OF THE DHI QAR GOVERNORATE

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Abstract

This study was conducted in the Al-Rifai District, north of Dhi Qar Governorate in the southern region of Iraq (longitudes 46°11'10.21" to 46°21'45.98" east and latitudes 31°44'38.835" to 31°46'9.889" north). Thirty auger hole sites were identified to a depth of 0-30 cm and the coordinates of ten pedons determined using a GPS device. The horizons of the pedons were described in a basic morphological manner, and samples were collected from each site for laboratory analyses. The maps were produced in the Arc GIS 10.4 program according to the inverse distance weight method, and maps of the spatial distribution of the available microelements of Fe, Zn, and Cu were drawn. The results indicated that the highest content of iron available in the soil of the study area was at the Ap horizon of pedon 1 and the lowest content was at the C3 horizon of pedon 9. The highest content of available zinc in the study area was at site 24, while the lowest was at horizon C3 of pedon 10. For copper, the highest content was at site 20, while the lowest was at horizon C3 of pedon 10.

Keywords: Spatial distribution, Availability of microelements, Sustainable agriculture, GIS, Preparing maps.

التوزيع المكاني لبعض العناصر الصغرى لترب قضاء الرفاعي في محافظة ذي قار

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الخلاصة

اجريت هذه الدراسة في قضاء الرفاعي شمال محافظة ذي قار الواقعة في المنطقة الجنوبية من العراق، ويمتد بين خطي طول "46°11'10.21 الى "46°21'45.98 شرقاً ودائرتي عرض "31°44'38.835 الى "31°46'9.889 شمالاً، تم تحديد 30 موقع حفرة متقابية بألة الحفر المثقابي (الاوكر) لعمق 0 – 30 سم وبعد ذلك تم الكشف عن عشر بيدونات وحددت احداثياتها بواسطة جهاز GPS، ووصفت افاق البيدونات وصفاً مورفولوجياً اصوليا وتم استحصال العينات من كل موقع وافق لأجراء التحاليل المختبرية اللازمة عليها.

تم انتاج الخرائط في برنامج Arc GIS 10.4 وفق طريقة وزن المسافة المعكوسة ورسمت خرائط التوزيع المكاني للعناصر الصغرى الجاهزة لكل من Fe وZn وCu، وقد اشارت النتائج الى ان اعلى محتوى للحديد الجاهز في ترب منطقة الدراسة كان عند الافق Ap من البيدون 1، اما اقل محتوى كان عند الافق C3 من البيدون 9، اما اعلى محتوى للزنك الجاهز في منطقة الدراسة عند الموقع 24، اما اقل محتوى للزنك الجاهز كان عند الافق C3 من البيدون 10، و بينت نتائج ان اعلى محتوى للنحاس الجاهز في منطقة الدراسة كان عند الموقع 20، بينما اقل محتوى للنحاس الجاهز كان عند الافق C3 من البيدون 10.

كلمات مفتاحية: التوزيع المكاني، جاهزية العناصر الصغرى، الزراعة المستدامة، GIS، اعداد خرائط.

Introduction

The study of spatial distribution is important in understanding and identifying the physicochemical and biological characteristics of soil and how to take soil samples. Understanding the spatial distribution of different soil properties can aid in developing a model for studying soil characteristics and in preparing various explanatory soil maps. The study of spatial distributions of different soil properties will provide a logical explanation for their distribution, as well as predict the values of different soil properties at sites from which field soil samples were not taken. It also assists in knowing what is available from soils and their types, and the consequences on the integrity of the sample obtained for the study (2). It shows us the variations in soil, whether physical or chemical, in different places in the landscape perspective. These variations are due to reasons such as gradual and sudden climate change, as well as the topography and the material of origin. Biological aspects also create many variations, especially in cultivated soils caused by various human activities such as fertilization and types of plowing and watering.

Soil is a heterogeneous substance formed by natural factors and is subject to all natural laws. Variations and spatial distribution of soil qualities may be regular or irregular and the characteristics can vary horizontally as well as vertically with depth (1). It plays an essential role in growing crops, but its characteristics are constantly changing (14). Soils rich in nutrients are among the most valuable natural resources and closely linked to the prosperity and economic strength of a country. A basic element of sustainable agriculture is the wise management of soil resources. It is worth noting that soil varies spatially, and this variation often determines its management and fertilizer recommendations in providing nutrients specific to a particular site (16). Soil should be examined using known traditional techniques and methods in order to maintain its fertility and keep the cost of fertilizers to a minimum (9). For techniques applied in monocultures, in which the climate is constant, soil properties are the main factors affecting crop production. As such, the main reason for differences in crop properties is variation in soil properties. Moreover, crops that are managed evenly can have spatially variable yields. The reason for this can be attributed to slight variations in soil properties (8). Widespread variations in soil properties are affected by a number of factors such as parent material, topography, climate, and management techniques (9).

Farmers can use more efficient management techniques in order to achieve sustainability in agricultural production through detection of spatial variations in chemical properties within agricultural fields (12). Iron, Fe, copper, Cu, and zinc, Zn, are among the micronutrients that plants need. Most scientists refer to the basic plant components required in lower concentrations as micronutrients, although they are no less important than macronutrients. Local or secondary nutrients are found in small quantities within the soil and plants, and they serve as the basis for both auxiliary enzymes and enzymes. A deficiency in one or more micronutrients has a harmful effect on crop growth, production, and quality. In addition, adding micronutrients through fertilizers or foliar spraying as well as microbial inoculations into the soil have become essential (17).

Over the past ten years, GIS mapping of soil variations has gained wide appeal and continues to be the focus of many research studies (9). Identifying changes that occur in the soil, determining soil boundaries, and conducting in-depth tests is one of the main aims of drawing soil maps. Soil maps can also be used in soil management processes, precision agriculture, geographic information systems applications, and production modeling. In recent decades, there has been a noticeable increase in the use of geographic information systems techniques for various local, regional, and global agricultural applications (7). Global agricultural production is increasingly dependent on geographic information systems (GIS) applications as they help farmers manage their lands more effectively, reduce expenses, and increase returns (4). Therefore, the objective of this study was to prepare maps showing the spatial distribution of some microelements present in the soils in Al-Rifai district of the Dhi Qar Governorate using geographic information systems.

Materials and Methods

A field visit was made to the study area, and the sampling sites were determined using a GPS device. Then, 10 pedons and 30 sites to a depth of 0-30 cm were identified for the study area based on the use of the land. Samples were obtained from each site, numbered, and brought to the laboratory for testing. The samples were air-dried, ground, passed through a 2 mm sieve, and placed in bags and numbered. After that, the nutritional elements available in each sample were estimated.

Estimating Fe, Zn, and Cu using DTPA atomic absorption spectroscopy at pH 7.3, according to (11).

After obtaining quantitative data for the values of microelements from the laboratory, a file was created using Excel. The geographic information system program Arc GIS 10.4 was used to create a Ship file, deduct the study area, and convert the coordinates from the sexagesimal system to the UTM metric system for the purpose of producing maps. Distribution of the spatial location of each element was carried out according to the inverse distance weighting method (spatial interpolation) IDW, and the weighted average calculated for each element in each of the pedons.

Results and Discussion

Spatial distribution of available iron: Tables 1 and 2 show that the iron content of the soil in the study area ranged between 1.09 -7.31 mg kg^{-1}, with the lowest content in the C3 horizon of pedon 9 and the highest in the Ap horizon of pedon 1. This difference is attributed to the effect of agricultural operations on the surface horizon and the lack of them at the pedon 9 site. Also, the high pH values in these soils reduced the availability of microelements and affects their content in the soil.

Table 1: Micronutrients present in the soil of the study area.

Pedon	Horizon	Fe	Zn	Cu	Pedon	Horizon	Fe	Cu	Zn
		mg kg^{-1}					mg kg^{-1}		
P1	Ap	7.31	4.39	3.25	P6	Ap	3.75	2.98	**2.59**
	C1	3.39	2.90	2.80		C1	3.00	2.55	**3.45**
	C2	2.50	1.93	2.19		C2	2.75	1.89	**2.43**
	C3	1.89	1.00	1.53		C3	1.25	1.33	**1.53**
P2	Ap	6.25	5.89	3.13	P7	Ap	4.00	3.18	**2.35**
	C1	2.25	3.31	2.40		C1	3.10	2.61	**3.00**
	C2	2.00	2.00	2.11		C2	2.85	1.76	**1.98**
	C3	1.55	0.89	1.44		C3	1.79	1.72	**0.75**
P3	Ap	5.53	3.39	3.00	P8	Ap	2.15	3.31	**6.05**
	C1	4.00	2.10	2.33		C1	4.69	2.71	**3.89**
	C2	1.97	1.70	2.05		C2	3.00	2.00	**2.86**
	C3	2.56	1.25	1.39		C3	2.45	1.60	**1.73**
P4	Ap	6.00	5.00	2.95	P9	Ap	2.93	1.57	**1.95**
	C1	3.51	1.15	2.25		C1	2.00	1.21	**1.41**
	C2	1.33	1.89	1.99		C2	1.20	1.09	**1.00**
	C3	2.85	0.95	1.50		C3	1.09	1.04	**0.85**
P5	Ap	4.39	4.89	2.89	P10	Ap	3.00	1.40	**2.00**
	C1	2.95	1.63	2.39		C1	1.97	1.13	**1.09**
	C2	2.69	3.25	1.93		C2	1.13	1.06	**1.04**
	C3	1.43	1.45	1.56		C3	1.15	1.00	**0.74**

Table 2: Micronutrient elements in the surface samples of auger holes for soils in the study area.

Site No.	Fe	Zn	Cu	Site No.	Fe	Zn	Cu
	mg kg^{-1}					**mg kg^{-1}**	
1	6.59	5.59	3.35	16	2.09	3.88	**2.69**
2	7.41	3.25	2.89	17	2.68	4.18	**1.58**
3	4.35	4.17	3.00	18	5.19	5.55	**3.49**
4	5.25	5.00	2.55	19	6.75	2.53	**2.97**
5	7.00	5.89	1.98	20	7.41	3.77	**3.77**
6	6.43	2.75	2.51	21	3.39	5.46	**3.51**
7	6.72	3.79	3.09	22	2.79	4.18	**2.99**
8	3.25	2.89	3.75	23	4.00	3.81	**3.49**
9	3.70	5.90	2.44	24	5.69	6.09	**2.69**
10	6.59	4.41	2.00	24	2.59	5.16	**3.15**
11	7.31	6.00	2.29	26	4.85	1.33	**2.69**
12	4.17	5.53	3.55	27	5.69	4.00	**1.53**
13	7.63	4.75	2.88	28	6.73	2.45	**1.25**
14	3.51	3.95	1.79	29	1.44	1.55	**1.66**
15	4.65	5.92	3.40	30	1.89	1.66	**2.35**

Table 3 and Figure 1 show the three ranges in the spatial distribution of iron found in the soil of the study area. The moderate range 2.1- 4.0 mg kg^{-1} comprised the largest area at 2391.97 hectares or 78.96% of the total area, the low range (<2 mg kg^{-1}) occupied 319.97 hectares (10.56% of the total area) while the well range (>4.0 mg kg^{-1}) occupied 317.35 hectares (10.47% of the total area). Iron is one of the important elements used in studies of soil genetics. Its distribution is affected by source material, soil texture, and the content of organic matter in the soil. Its solubility and availability depend on the degree of interaction of the soil pH and carbonate minerals, as the basic medium and oxidation conditions encourage its precipitation. The middle acid and reducing conditions increase its solubility (13).

Table 3: Area and percentage of iron content in the soil of the study area.

Class	Range mg kg^{-1}	(hectares) Area	Percentage %
Low	<2	319.97	**10.56**
Moderate	2.1 – 4.0	2391.97	**78.96**
Good	>4.0	317.35	**10.47**
Sum	-	3029.29	**100**

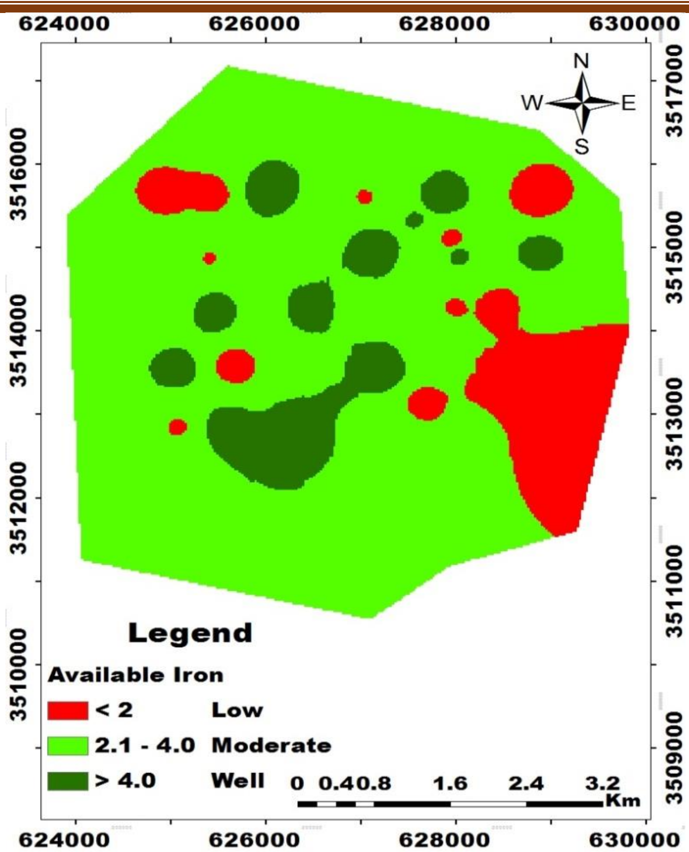

Figure 1: Spatial distribution of iron in the soil of the study area.

Spatial variation of available zinc: Tables 1 and 2 show the zinc content in the soil ranging between 0.74 – 6.05 mg kg^{-1}, with the lowest and highest content in horizon C3 of pedon 10 and horizon Ap of pedon 8, respectively. Zinc content in the study area soil was very low. This could be attributed to the poor limestone sediments, which have high pH values, thus reducing the availability of microelements. Iron and zinc have an inverse relationship due to their competition for exchange sites (1 and 3).

As seen in Table 4 and Figure 2, there were two ranges in the spatial distribution of zinc in the soil of the study area. The high content area with range > 3.0 mg kg^{-1} was the largest at 1952.37 hectares or 62.79% of the total area while the moderate content area (1.5 - 3.0 mg kg^{-1}) occupied 1156.92 hectares or 37.21% of the total area. The reason for its good content is attributed to the soil of the study area being mostly of moderately fine texture and having good clay content, which increases and affects the readiness of zinc in the soil. Also, the increased content in surface soil is due to the relationship between zinc and soil organic matter resulting from the decomposition of plant remains and the effect of agricultural operations on the surface (3).

Table 4: Area and percentage of zinc content in the soil of the study area.

Class	Range mg kg^{-1}	(hectares) Area	Percentage %
Moderate	1.5 - 3.0	1156.92	**37.21**
Good	> 3.0	1952.37	**62.79**
Sum	-	3029.29	**100**

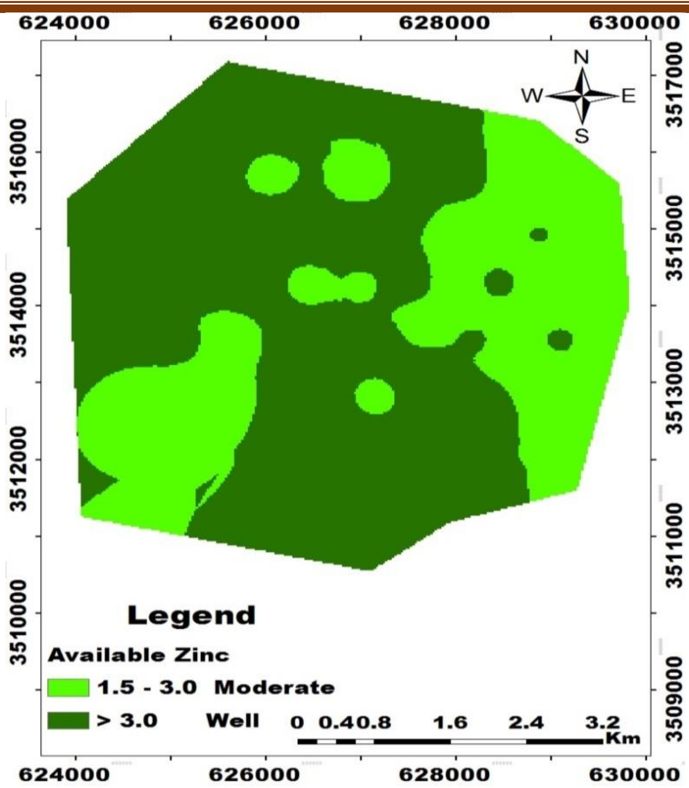

Figure 2: Spatial distribution of zinc content in the soil of the study area.

Spatial distribution of available copper (Cu): Tables 1 and 2 show that the copper content in the soil of the study area ranged between 1.00 - 3.77 mg kg^{-1}, with the lowest content in horizon C3 of pedon 10 and the highest in site 20. Copper content in the soil is attributed to the presence of carbonate minerals which leads to raising the degree of interaction of soil pH and the precipitation of copper in the form of copper carbonate, which leads to a reduction in its availability in the soil. In addition, high levels of nitrogen and phosphorus interfere with the copper element, thus reducing its availability (3).

Table 5 and Figure 3 show the spatial distribution of the copper element in the soil of the study area at three occupation ranges. The largest area comprising 2524.77 hectares or 81.20% of the total area had an average range of 2.10 - 2.93 mg kg^{-1} of copper while the lowest at 1.24 - 2.09 mg kg^{-1} occupied the smallest area of 201.16 hectares or 6.47% of the total area. Copper is one of the necessary and important micronutrients in assessing soil fertility, although plants only need small quantities (6 and 14).

Table 5: Area and percentage of copper content in the soil of the study area.

Class	Range (mg kg^{-1})	Area (hectares)	Percentage %
Low	1.24 - 2.09	201.16	**6.47**
Moderate	2.10 – 2.93	2524.77	**81.20**
Good	2.94 – 3.78	383.36	**12.33**
Sum	-	3029.29	**100**

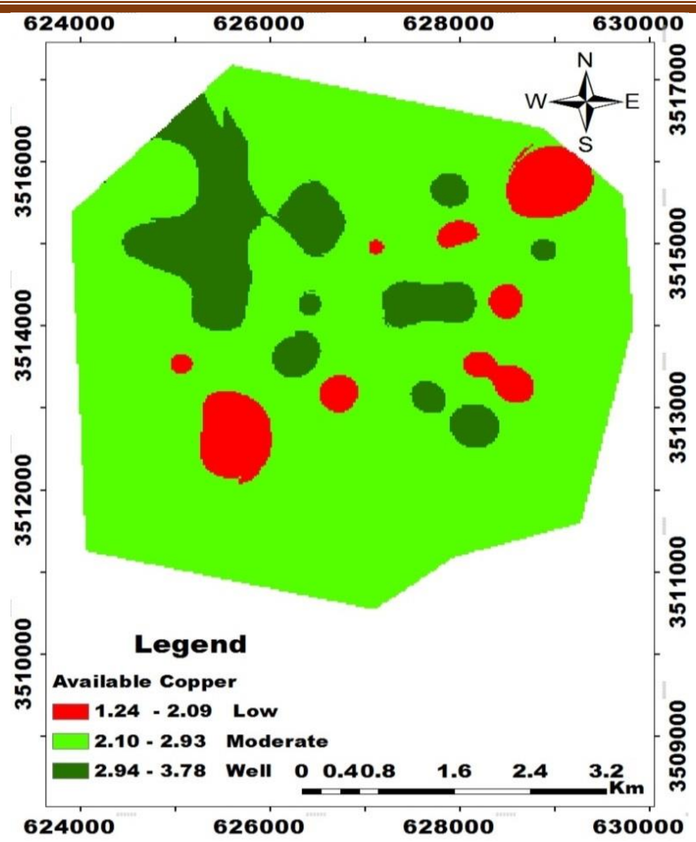

Figure 3: Spatial distribution of copper content in the soil of the study area.

Conclusions

This study illustrates the importance of geographic information systems technology in mapping nutrients from an administrative perspective as well as its time, effort, and cost reduction capability in formulating appropriate strategies for soil fertilization systems.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

Author 1: methodology, writing—original draft preparation; Authors 2 and Authors 3: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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