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Plant Cover Diversity and Land use Impacts on Spatial Distribution of Chemical Soil Properties Using GIS

Bassem H. Mohsin[1] and Salloom B. Salim[2]

[1]Directorate of Agriculture in Karbala Governorate, Karbala, Iraq.
[2]Department of Soil Sciences and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq.
*Corresponding author e-mail: bassem.hammoudy1107a@coagri.uobaghdad.edu.iq
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Abstract

This study aims to investigate the effects of the difference in vegetation cover and land use on spatial distribution of soil electrical conductivity (EC), cation exchange capacity (CEC) and soluble ions. Soil samples from sixty sites were randomly selected on 14585 hectares area located at Algadwal Algharby in Karbala Governorate. Soil samples were collected to a depth of 0-0.3 m, air dried, ground and passed through a 2 mm sieve for laboratory analysis. The results showed that the EC values ranged from (1.02 to 53.40) dS m-1 and were greater in the fallow soil than the EC of soils with plant cover. Values of CEC ranged from (12.35 to 32.75) cmol+.kg-1 where lower CEC values were obtained under fallow soils compared to cultivated soils. Generally the coefficients of skewness and kurtosis revealed highly skewed distribution with leptokurtic and platykurtic distributions for the studied characteristics. Geostatistical parameters of the fitted semivariogram models resulted mostly in strong spatial dependence and circular matching model. The fallow soils contents from soluble ions were greater than that of the plant-covered soils due to increasing salinity.

Keywords: semiveriogram, leptokurtic, C EC, skewness, spatial dependence, plant cover, fallow soil, histogram, land use.

Introduction

Spatial variation of soil electrical conductivity

Soil electrical conductivity values were significantly affected by land use types, the lowest EC value under grassland could be related to the loss of base cations through leaching from the root zone since grassland soils had lower bulk density and higher porosity [1 , 2]. Tellen and Yerima [3] also found that electrical conductivity values ranged from 0.05 ds.m-1 under pastoral land use systems to 0.18 ds.m-1 under natural forest vegetation. Al-Moussawi and Al-Wali [4] also found that agriculture has a significant and significant role in reducing the electrical conductivity of the soil, as the comparison treatment gave the highest value of electrical conductivity with highly significant differences compared to the cultivated soils, as the value of its electrical conductivity reached 21.127 ds.m-1, while no significant difference appeared between the cultivated treatments, as the values of electrical conductivity of the soils of the fountain grass, Alfalfa and dactylon grass were 4.817, 4.268, 4.188 ds.m-1, respectively. This decrease in the electrical conductivity values is due to the depletion of some salts, which are considered as nutrients by the plant, in addition to the work of plant roots to penetrate and break up the soil, which increases its porosity and increases the size of the pores with the ease of water movement. As a result of repeated irrigation, this works to wash away the accumulated salts and remove them from the root zone, and then the electrical conductivity value of the cultivated soil decreases compared to the uncultivated soil [5].

Spatial variation of cation exchange capacity

Cation exchange capacity (CEC) did not show significant differences between land use and land cover systems. The highest CEC was recorded in natural forest soils, while the lowest was recorded in cultivated soils (51.03 cmol. charge. kg-1) and (50 cmol. charge. kg-1), respectively [6]. Soil CEC values decreased in agricultural land uses mainly due to lower organic matter content [7 , 8]. Soil CEC values were affected by land use, with values for forest, pasture, and cropland soils being (35.27, 28.87, and 24.67) cmol.charge.kg-1, respectively [9]. Analysis of variance results showed that the cation exchange capacity (CEC) of soils in the study area was significantly affected by land use types. The values under grass, cultivated land, forest, and pasture were (38.5, 33.2, 41.7, and 30.1) cmol.kg-1, respectively. The high and low CEC in forests and pasture lands may be due to the presence or absence of soil organic matter, or the high soil organic matter content in forest lands while it was lower in pasture lands. Moreover, the amount and types of clay particles are also the determining factors in soil CEC under different land use types [1, 10]. AL–Kurayshi and Suliman [11] showed that they obtained relatively low CEC results in the Latifiya project, ranging between (13.91 – 23.11) cmol.kg-1 due to the clay and organic matter content and the type of clay mineral. Muhaimeed *et al.,*[12] reported that the values of the exchange capacity of positive ions in the soils of the Abu Ghraib area were close values, ranging between 24-29 milliequivalents/100 grams of soil. These ratios are good because the soil has a medium-fine and soft texture and contains reasonable amounts of clay. Al-Shubaily and Wheib [13] and AbduL-Ameer *et al*., [14] found that the values of cation exchange capacity for Al-Musayyab project ranged between (14.36-36.98) centimoles.charge.kg-1, in Al-Hussainiya irrigation project (10.7-33.01) centimoles.charge.kg-1, and in Al-Suwaira project (9.9-37.82) centimoles.charge.kg-1. As for Isa and Sulaiman [15], he found that the cation exchange capacity within the Bahr Al-Najaf depression ranged between (5.03-15.01) centimoles.charge.kg-1. Abu Kahila [16] found that the cation exchange capacity in the western section (western plateau) within the borders of Najaf Governorate ranged between (3.26-21.40) centimoles.charge.kg-1 in surface samples. Al-Jubouri and Wheib (2020) found that the cation exchange capacity in the Salamiyat project ranged between (9.7-30.2) centimoles.charge.kg-1, as the value of the cation exchange capacity was significantly correlated with the clay content in the soil. Heeshan *et al.,* [17] indicated that the cation exchange capacity in Al-Alam district was distributed as follows: 19.1, 14.45, 13.91, 12.31, 11.17, and 9.79 centimoles.charge.kg-1 under the gypsum, palm trees, pomegranate trees, okra, irrigated wheat, and rain-fed wheat, respectively, compared to fallow land of 9.38 and 8.01 centimoles.charge.kg-1 for two sites. Yitbarek *et al.* [18] found that the soil CEC was higher in forest lands compared to adjacent pastures and cultivated lands. Yu-song *et al.* [19] showed that the cation exchange capacity under different land use systems was in the following order: barren land < sweet potato land < grassland < eucalyptus forest land < tea garden < rice paddy < vegetable land. The CEC was significantly higher in the topsoil of acacia forests, whereas, it was significantly lower in the soil of fallow sites [20].

Spatial variation of ions

Tufa *et al.,* [1] indicated that Ca content was highest in forest soil, followed by grasses, cultivated lands, and pastures, while Mg and K content were highest in forest soil, followed by cultivated lands, grasses, and pastures, and Na content was not significantly affected by land use type. Yitbarek *et al.,* [18] also found that soil Ca, Mg, K, and Na content were higher in forest soil than cultivated lands and pastures. Zhang *et al.,* [21] reported that Ca and Mg were significantly higher in forest soils than in croplands, and significantly higher in soils of natural shrubland and planted forests than in croplands. Tellen and Yerima [3] found no significant differences in Ca, Mg, K, or Na concentrations across six land use types (cropland, natural forest, natural savanna, eucalyptus plantation, afforestation, and pasture). Girma [9] reported the highest Ca, Mg, and K contents in forest soils, followed by pasture and croplands. The highest Na content was recorded in soils of pasture, followed by forest and croplands. Yu-song *et al.,* [19] showed that the K contents were, in the following order: eucalyptus forest < barren land < rice paddy < grassland < sweet potato < tea garden < vegetable land. Amonum *et al.,* [22] found that forest soils had the highest Ca and Mg contents, followed by teak and catropha plantations, and the lowest content was found in agricultural lands. K content was highest in forest soils, followed by catropha plantations, followed by teak and agricultural lands with similar contents. Na content was highest in catropha soils, followed by forest soils, followed by teak plantations and agricultural lands with similar contents. This could be attributed to leaching losses, low parent rock content and clay mineral content, as well as conversion of forest lands to other land uses, continuous cultivation, and inorganic farming practices. Akhtaruzzaman *et al.,* [20] found that Ca was the predominant cation, followed by Mg, K, and Na in soils with different plant species, with the highest levels found in acacia forest soils, followed by agricultural lands, and then fallow lands. Aziz and Abd Al-Latif [23] found that the concentration of Ca, Mg, and Na ions decreased during cultivation compared to the pre-cultivation state for the first three depths, while the concentration was higher at the last three depths when wheat and barley were cultivated. This may be due to the general leaching and accumulation of salts. [24] indicated that the Ca content in soils with vegetation cover was relatively high compared to fallow land. Yadav *et al.,* [25] reported that continuous cultivation and the use of acid-forming inorganic fertilizers deplete Ca and Mg. [26] indicated that the low values of Ca, Mg, and K may be attributed to leaching losses due to rainfall as well as low content in parent rocks. Malo et al., (2005) indicated that weathering intensity, cultivation, and the use of acid-forming inorganic fertilizers affect the distribution of potassium in agricultural lands and thus increase its depletion. [27] confirmed that in general, deforestation, leaching and limited recycling of animal waste and crop residues into the soil, very low use of chemical fertilizers, reduced fallow periods or continuous cropping and soil erosion contribute to the depletion of bases from the soil.

Materials and Methods

Study Area

The study was conducted in the Algadwal Algharby area located in Karbala Governorate at latitudes N 32.469486 and N 32.636545 and longitudes E 44.088949 and E 44.235619, with an area of 14585 hectares. Figure (1) shows the map of Iraq, the study site, sample locations, and the type of vegetation. The area was chosen because of the variation in its vegetation cover. Vegetation covers were identified as palm plus citrus trees, palm trees, crops and uncultivated fallow lands. The climate of the study area is hot with dry summer, cold in winter, with little rain, i.e. a desert climate with high temperatures, low humidity and very high evaporation potential as shown in table (1).

Soil Samples and Analysis

Disturbed soil samples were randomly obtained at 60 locations in the study area for laboratory analysis. Disturbed samples, obtained from 0-0.30 m depth, were air dried, smashed and passed through 0.002 m sieve The cation exchange capacity was determined in the laboratory by the sodium acetate saturation method (reaction 8.2) followed by displacement and replacement with ammonium acetate as reported in (Jackson, 1958). Electrical conductivity (EC)It was measured for a soil-water extract in a 1:1 solution using an EC meter (Electrical conductivity) model 720 WTW according to the method described in [28]. Calcium and magnesium were estimated using the Na-EDTA ferrous metal compound. Calcium and magnesium were determined together using EBT, and calcium using meroxide. Subtracting the former from the latter yielded magnesium [28]. Sodium and potassium were measured using a flame photometer [29]. Chloride ions were measured by a Spectrophotometer model Specord 205. Sulfates: Estimated using a spectrophotometer using the turbidity method described in Black, 1965.The data were analyzed statistically using Excel and SPSS programs. GIS software was also used to analyze the data using geostatistics to generate spatial distribution maps, semivariogram, and determine spatial dependence after determining the appropriate model.

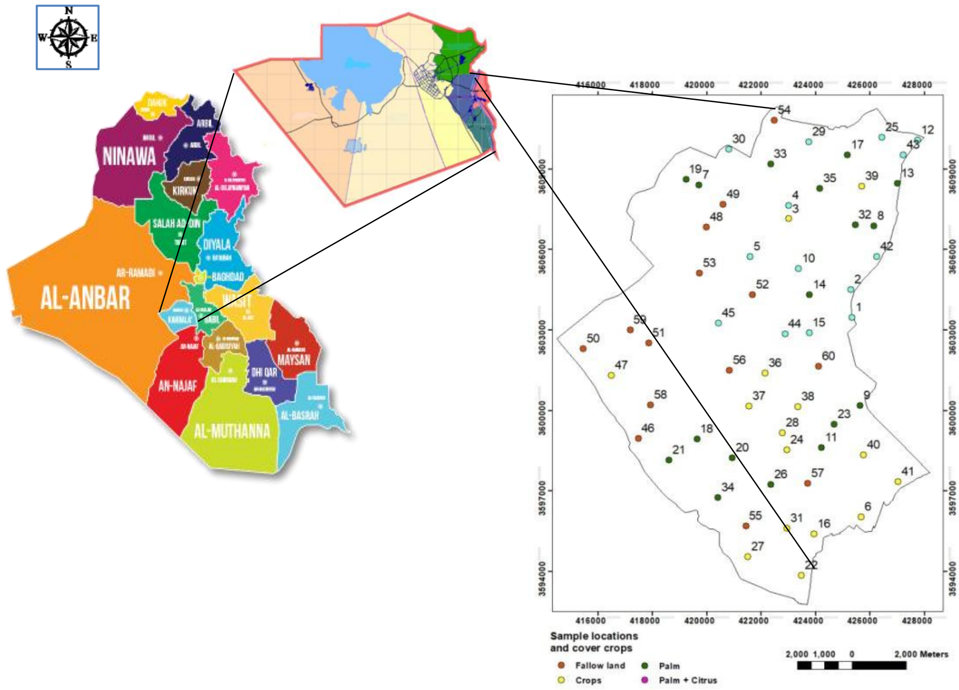


Figure (1): Site map fetch selected soil samples from 60 sites.

Table (1): Monthly average of climate data for the study area in Karbala Governorate for the period (1985 -2022).

Month	Temperature (c)			Humidity %	Wind		Rainfall (mm)	Mean wind speed (m/s)	Evaporation (mm)
	Max	Min	Mean		mean wind speed m/s	Direction			
January	16.5	5.7	11.1	70.9	2.1	W/NW	16.3	2.1	61.2
February	19.4	7.9	13.6	60.6	2.5	SE/NW	12.7	2.5	91.6
March	24.2	11.7	17.9	50.5	3	N/NW	16.4	3	162.1
April	31.2	17.8	24.5	41.6	3	N/NW	11	3	234.5
May	37.6	23.3	30.4	33	3	N/NW	2.1	3	319.6
June	42.2	27.2	34.7	27.7	3.7	N/NW	0	3.7	407.8
July	44.2	29.2	36.7	27.8	3.7	N/NW	0	3.7	435
August	44.6	29.6	37.1	29.7	2.9	N/NW	0	2.9	402.6
September	40.8	25.3	33.6	34	2.3	N/NW	0.2	2.3	301.2
October	34	19.8	26.9	44	1.9	N/NW	4.3	1.9	201.2
November	24.1	12.1	18.1	61.1	1.7	N/NW	13.8	1.7	100
Decembe	18.1	7.3	12.7	70.6	1.8	NW/SE	13.2	1.8	62.2

Results and Discussion

Electrical conductivity of soil EC

Table (2) shows the electrical conductivity of the soil (EC) ranged from (1.02) dS m^{-1} in the sample site (3 with vegetation cover crops) to (53.40) dSm^{-1} in the sample site (57 fallow). The electrical conductivity of the soil for the vegetation covers were (1.07 to 3.39) dS m^{-1}, (1.07 to 14.05) dS m^{-1}, (1.02 to 5.27) dS m^{-1} and (2.09 to 53.40) dSm^{-1} for palm plus citrus, palm, crops and fallow respectively.

Table (2): Some soil Chemical properties of the study area.

Sample No.	Crop Cover	EC	CEC	Ca	Mg	K	Na	Cl	SO4
		dS.m-1	cmol+.kg-1				mmol.L-1		
1	**Palm+Citrus**	2.63	12.46	7.446	0.227	0.894	24.775	4.581	24.084
2	**Palm+Citrus**	1.56	23.94	3.058	0.053	0.246	8.667	3.413	21.123
3	**Crops**	1.02	30.54	3.074	0.050	0.412	7.557	4.287	34.128
4	**Palm+Citrus**	2.05	18.12	6.757	0.176	0.595	8.333	3.795	52.079
5	**Palm+Citrus**	3.11	26.18	7.784	0.213	0.714	13.112	4.082	24.104
6	**Crops**	1.84	26.13	4.177	0.123	0.217	12.621	3.445	31.272
7	**Palm**	1.85	32.58	4.224	0.119	0.705	17.695	3.008	25.404
8	**Palm**	14.05	19.45	27.054	0.686	1.192	112.937	12.562	47.408
9	**Palm**	2.97	19.2	8.029	0.246	0.386	16.363	3.097	9.617
10	**Palm+Citrus**	2.72	19.72	12.715	0.240	1.295	21.952	4.884	26.220
11	**Palm**	2.66	18.98	11.880	0.145	0.443	5.998	4.043	24.395
12	**Palm+Citrus**	1.66	18.14	2.652	0.063	0.164	7.639	2.664	13.549
13	**Palm**	1.21	24.66	3.081	0.073	0.118	9.343	3.777	11.703
14	**Palm**	2.39	26.55	6.341	0.171	0.144	9.469	3.618	23.061
15	**Palm+Citrus**	1.71	18.64	4.580	0.084	0.146	9.351	4.210	14.588
16	**Crops**	2.82	32.56	23.452	0.308	0.504	22.273	2.863	26.262
17	**Palm**	1.07	18.53	3.204	0.072	0.462	6.486	4.434	16.319
18	**Palm**	2.12	30.48	12.768	0.13	0.137	8.552	3.397	44.98

Sam-ple No.	Crop Cover	EC	CEC	Ca	Mg	K	Na	Cl	SO4
		dS.m-1	cmol+.kg-1				mmol.L-1		
					8				8
19	**Palm**	3.13	18.55	19.708	0.248	0.694	24.990	3.743	33.429
20	**Palm**	1.72	28.65	4.987	0.141	0.516	7.711	4.630	33.596
21	**Palm**	1.17	18.78	2.989	0.056	0.210	10.636	4.047	25.114
22	**Crops**	2.47	32.66	6.038	0.275	0.370	19.994	4.371	43.907
23	**Palm**	4.11	22.59	16.043	0.309	0.422	36.740	5.787	68.539
24	**Crops**	5.22	15.34	24.339	0.319	0.315	54.734	7.895	27.451
25	**Palm+Citrus**	1.32	19.75	3.032	0.049	0.216	11.036	3.185	7.994
26	**Palm**	3.11	18.25	18.802	0.194	0.718	28.550	4.036	45.013
27	**Crops**	5.27	26.2	18.543	0.257	0.713	55.463	9.804	59.947
28	**Crops**	4.25	30.44	20.052	0.280	1.013	30.023	4.882	28.469
29	**Palm+Citrus**	3.39	20.2	16.725	0.310	1.569	24.562	4.616	30.442
30	**Palm+Citrus**	1.17	20.16	3.548	0.065	0.381	10.353	3.199	30.823
31	**Crops**	3.22	23.81	8.530	0.327	0.976	21.473	5.009	20.750
32	**Palm**	2.75	27.35	9.634	0.150	0.514	26.801	4.638	19.688
33	**Palm**	6.22	18.92	23.583	0.319	0.355	50.654	4.759	29.494
34	**Palm**	2.07	22.43	8.117	0.122	0.437	17.890	4.763	17.072
35	**Palm**	1.34	32.4	3.357	0.068	0.490	7.606	3.208	13.956
36	**Crops**	3.25	25.14	15.049	0.218	0.405	39.449	5.826	41.867
37	**Crops**	3.04	28.35	12.130	0.204	0.523	25.103	5.416	42.003
38	**Crops**	2.4	24.88	9.528	0.107	0.258	13.479	5.431	57.184
39	**Crops**	3.73	20.34	5.656	0.253	0.169	20.667	5.122	28.654
40	**Crops**	3.75	32.75	0.975	0.278	0.282	25.531	5.767	69.961
41	**Crops**	2.37	18.58	19.063	0.22	0.948	13.667	6.977	19.89

Sam-ple No.	Crop Cover	EC	CEC	Ca	Mg	K	Na	Cl	SO4
		dS.m-1	cmol+.kg-1				mmol.L-1		
					1				6
42	Palm+Citrus	3.17	30.62	12.791	0.270	1.027	20.952	6.082	49.149
43	Palm+Citrus	1.07	18.53	3.196	0.076	0.522	7.020	4.966	26.811
44	Palm+Citrus	1.77	20.1	3.882	0.088	0.564	8.506	3.909	27.829
45	Palm+Citrus	2.4	18.22	7.491	0.094	0.328	23.599	4.615	33.467
46	Fallow land	8.17	19.97	23.878	0.355	2.464	99.045	6.959	83.086
47	Crops	3.63	18.25	1.124	0.173	0.506	17.690	5.279	57.628
48	Fallow land	2.09	25.44	5.217	0.143	0.583	13.704	3.426	36.751
49	Fallow land	12.88	32.18	41.954	0.406	3.393	307.011	10.970	43.541
50	Fallow land	46.85	19.8	74.038	1.167	13.626	582.434	32.114	28.896
51	Fallow land	20.43	27.2	45.611	1.027	4.660	256.299	16.685	28.828
52	Fallow land	35.35	17.22	67.459	0.838	5.888	393.423	24.608	28.813
53	Fallow land	48.77	13.1	55.144	1.456	7.378	614.251	35.622	62.442
54	Fallow land	27.96	18.12	53.625	0.700	1.191	366.080	18.446	17.632
55	Fallow land	9.06	19.92	24.891	0.488	1.317	90.680	10.465	32.392
56	Fallow land	35.9	19.83	65.493	0.339	3.383	399.306	20.355	33.033
57	Fallow land	53.4	15.1	134.202	0.787	1.398	265.139	35.835	26.268
58	Fallow land	48.45	17.28	86.649	0.872	6.469	557.169	30.829	48.126
59	Fallow land	29.7	13.25	58.830	0.755	4.759	379.740	24.801	52.346
60	Fallow land	37.3	12.35	66.377	0.925	1.473	397.590	33.757	52.401

Table (3): Summary statistics for selected soil Chemical properties.

Soil properties	Min.	Max.	Mean	Standard deviation Std. Dev.	Coefficient of variation C.V%	Skewness	kurtosis
EC ds/m	1.02	53.4	9.14	14.06	153.84	2.056	2.966
CEC cmol/kg	12.35	32.75	22.33	5.695	25.505	0.391	-0.809
Ca	0.975	134.202	20.90	25.70	123.24	2.250	5.847
Mg	0.049	1.455	0.315	0.30	96.98	1.881	3.308
K mmol.L-1	0.117	13.626	1.369	2.268	165.33	3.525	14.867
Na	5.998	614.251	94.997	160.54	169	2.021	2.967
Cl	2.664	35.835	8.716	9.05	103.85	2.027	2.930
SO4	7.994	83.085	33.916	16.09	47.46	0.872	0.526

Table (4): Geostatistical parameters of the fitted semivariogram models for soil Chemical properties.

Soil roperties	Model	Range m	Nugget	Partial Sill	Sill	Spatial dependence value (%)	Spatial Dependence Level
EC ds/m	Circular	2312.54	0	185.95	185.95	0	Strong
CECcmol/kg	Circular	2396.63	18.544	13.952	32.496	36.33	Moderate
Ca	Circular	2204.92	58.51	611.31	669.82	8.033	Strong
Mg	Spherical	2314.2	0	0.081	0.081	0	Strong
K mmol.L-1	Circular	2204.92	0.32	2.27	2.59	10.996	Strong
Na	Circular	2204.92	0	20.9	20.9	0	Strong
Cl	Spherical	2312.54	0	76.99	76.99	0	Strong
SO4	Circular	4196.64	130.93	118.90	249.83	34.38	Moderate

It is noted that the average electrical conductivity was the highest in the fallow lands and the lowest in the soil of palm plus citrus plant cover. There is also variation depending on the plant cover, as the highest rates are observed in crop soils, followed by palm soils, followed by palm plus citrus plant cover soils. These results are consistent with the dry climatic conditions of the study area with high water table and poor drainage networks which enhance the salinization process. Variations in EC values may be attributed to the salt leaching below 30 cm in plant covered areas where irrigation water is applied. It may also be attributed to the fact that most of the lands with palm plus citrus and palm cover are located at the head of the irrigation channels where water scarcity is lower compared with areas located at the tails. The results of Table (2) and Figure (2a) show the spatial distribution map showing the dominance of electrical conductivity was as follows: (< 5, 5-15, 25-35, 15-25, 35-45 and > 45) dS m^{-1} for the dark green, green, yellow, light green, brown, and red colors respectively. Table (3) shows the statistics for selected soil chemical properties with an average EC of 9.14 dS m^{-1}, standard deviation of 14.06 and the coefficient of variation of 153.85%. This high value may be attributed to the high variance between soils with vegetation cover compared to fallow soils besides high coefficient values of skewness 2.056 and kurtosis 2,966. Figure (2b) shows a positive deviation from the normal distribution to the right, where the mean is greater than the median. Most of the electrical conductivity values fall within one dominant category 8.50 dS m^{-1}. This may be attributed to the fact that they are randomly distributed samples and are not subject to the hypothesis of normal distribution as a result of the trends in soil salinity variation in the study area. It also shows that the distribution of these samples is of the pointed type, as the Kurtosis value 2.966 is positive and very high, and the data are characterized by a more tapered distribution than

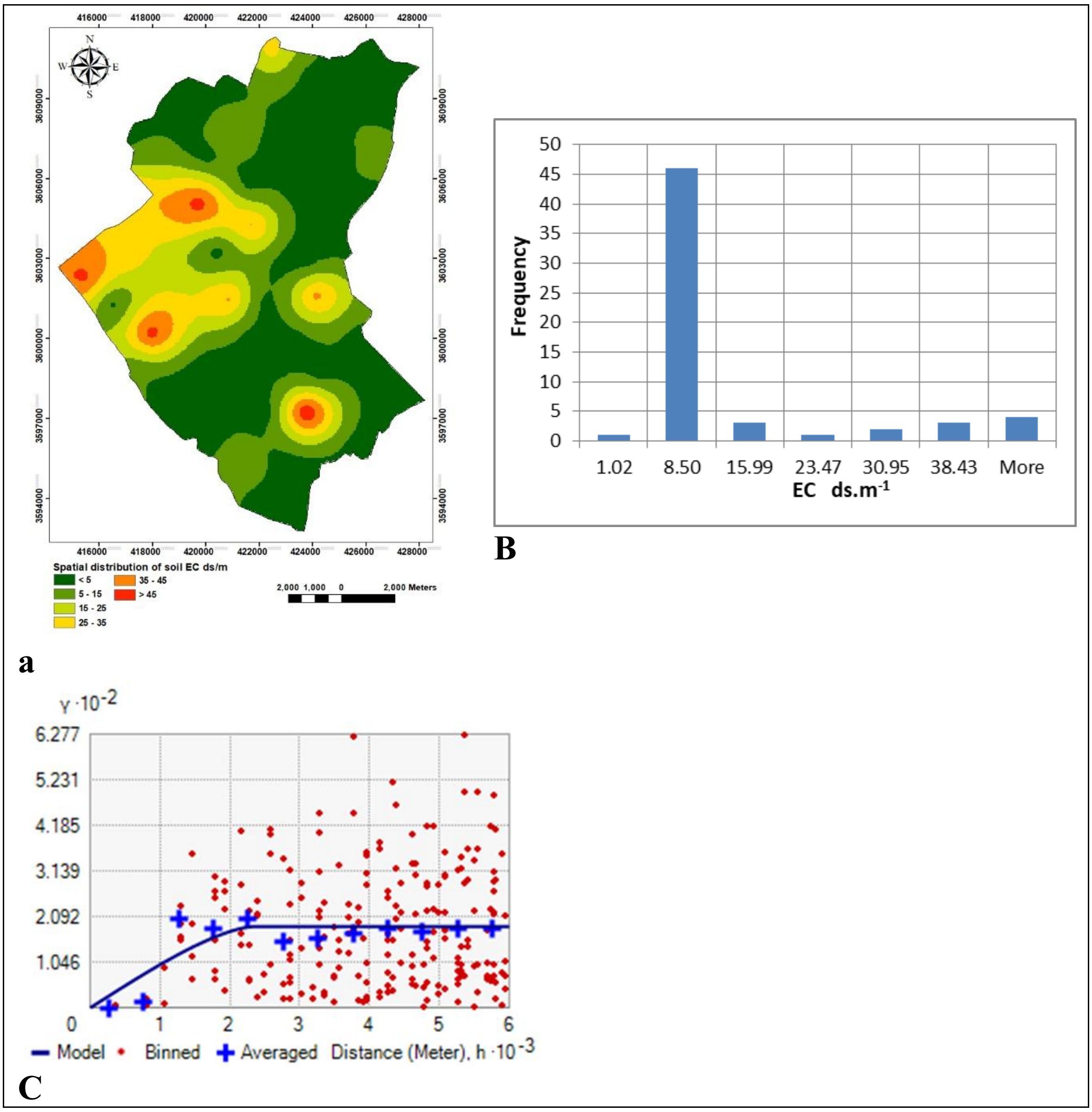


Figure (2): (a) Spatial distribution of EC, (b) Histogram of EC and (c) Semi variogram of EC.

the normal distribution and the presence of a higher probability of more concentrated extreme values. The effective distance (Range) to describe the variance of this characteristic is (2312.54) meters, as the spatial dependence of this characteristic increases with the increase of the semi-variance function until it reaches this distance, which is the highest value of spatial dependence, after which soil salinity becomes spatially independent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 0, 185.95, and 185.95, respectively. Figure (2c) and Table (4) show that the values of Nugget are less than the values of Partial Sill for soil electrical conductivity, indicating that the sampling sites were taken at shorter distances, and the homogeneous sites with spatial autocorrelation were originally located on scales larger than the distance between samples. The appropriate model to describe the variation of soil electrical conductivity is the circular model, and the spatial dependence is 0% strong, meaning that this characteristic is strongly spatially dependent and effect of nugget is very small.

Cation Exchange Capacity (CEC)

Table (2) shows that the CEC ranged from (12.35) $cmol^{+}.k\ g^{-1}$ in the sample site (60 fallow) to (32.75) $cmol^{+}.kg^{-1}$ in the sample site (40 with vegetation cover crops). Cation exchange capacity of the soil with vegetation cover was (12.46 to 30.62) $cmol^{+}.kg^{-1}$, (18.25 to 32.58) $cmol^{+}.kg^{-1}$, (15.34 to 32.75) $cmol^{+}.kg^{-1}$, and (12.35 to 32.18) $cmol^{+}.kg^{-1}$ ((palm plus citrus), palm, crops, and fallow) respectively. Average values of CEC are higher in the soils of agricultural lands and all vegetation covers compared to fallow lands. This variation may be contributed to the differences in clay content, type of clay minerals and organic matter content. Likewise, carbonate minerals may have an effect in reducing the CEC [30]. The results of Table (2) and Figure (3a) show the spatial distribution map with the dominance of the soil CEC ranges (20 to 24) $cmol^{+}.kg^{-1}$ in yellow. This spatial distribution is consistent with the spatial distribution of the soil clay content and relatively with the soil organic matter content. Table (3) shows that the mean value was (22.33) $cmol^{+}.kg^{-1}$, the standard deviation was (0.6955), and the coefficient of variation was (25.505)%. It is noted that the variance of this characteristic is close to the coefficient of variation for clay and organic matter. The coefficient of skewness was (0.391), with the cation exchange capacity values deviating to the right from the normal distribution, which means that the mean is greater than the median, as shown in Figure (3b). This may be attributed to the random distribution of samples, the presence of vegetation, or the formation conditions of these soils in terms of the parent material or the soil content of clay and organic matter. Most of the CEC values fall within three dominant categories (21.09, 26.92, and the highest 29.84) $cmol^{+}.kg^{-1}$, with a kurtosis coefficient of (-0.81) and a (flat) distribution, as no extremes appeared in the repetition of certain values. The effective distance (Range) to describe the variance of this characteristic is (2396.63) meters, as the spatial dependence of this trait increases with the increase of the semi-variance function until it reaches this distance, which is the highest value of spatial dependence, after which the values of the CEC in the soil become spatially independent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 18.544, 13.952, and 32.496, respectively. Figure (3c) and Table (4) show that the values of Nugget are greater than the values of Partial Sill for the values of the CEC, indicating that the sampling sites were taken at greater distances, and the homogeneous sites with spatial self-correlation, originally inherited or affected by the agricultural cycle and operations, were located on scales less than the distance between samples. The appropriate model to describe the variation of CEC was the circular model, and the spatial dependence was 36.33% (Moderate), meaning that this characteristic is spatially dependent on average, meaning that the effect of nugget is moderate.

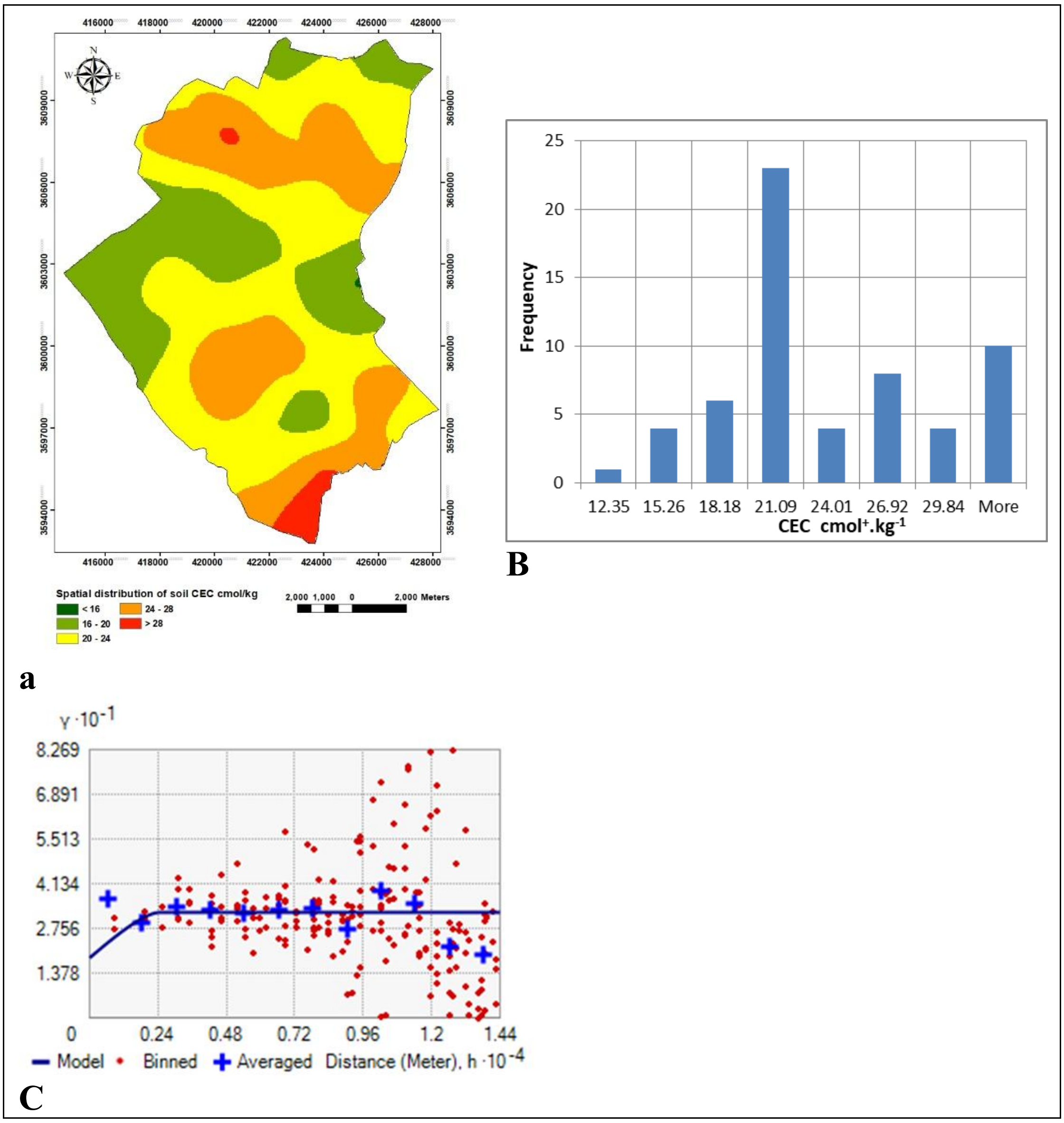


Figure (3): (a) Spatial distribution of CEC, (b) Histogram of CEC and (c) Semi variogram of CEC.

Soil Ions

Calcium

Table (2) shows that the calcium ion content (Ca^{++}) ranged from (0.975) $mmol.L^{-1}$ in the sample site (40 with vegetation cover crops) to (134.202) $mmol.L^{-1}$ in the sample site (57 fallow). The soil Ca^{++} content of the vegetation cover was (2.652 to 16.725) $mmol.L^{-1}$, (2.989 to 27.054) $mmol.L^{-1}$, (0.975 to 24.339) $mmol.L^{-1}$, and (5.217 to 134.202) $mmol.L^{-1}$ (palm plus citrus), palm, crops, and fallow) respectively. It is noted that calcium levels are higher in fallow soils compared to soils of agriculturally exploited lands and for all plant covers due to accumulation of this element in the fallow soil. Also higher calcium levels are noted in the soils of plant cover for crops, followed by palm trees, followed by palm trees plus citrus. This variations is attributed the availability of irrigation water and planting density and diversity. Table (2) and Figure (4a) show that the dominance of Ca^{++} was as follows: (< 25, 25-50, 50-75, 75-100 and >100) $mmol.L^{-1}$ for the dark green, light green, yellow, brown, and red colors respectively. The spatial distribution of calcium ions is relatively consistent with the spatial distribution of soil salinity. Table (3) also shows the values of average Ca^{++}, standard deviation, coefficient of variation, coefficient of skewness and coefficient of Kurtosis were 20.90 $mmol.L^{-1}$, 25.70, 123.24%, 2.250, (5.847) respectively. Value of the coefficient of variation of Ca^{++} is close to that of soil salinity due to the variation between the soils of agriculturally exploited lands with low to medium salinity compared to fallow lands, as a result of the influence of climatic factors, proximity and distance from irrigation projects. It also appears that the distribution of calcium samples is of the pointed type, as the flattening value is positive and very high, characterized by a larger pointed distribution than the normal distribution, the presence of a higher probability of extreme values and a more concentrated data set. The effective distance (Range) to describe the variation of calcium ion is (2204.92) meters, according to the order, as the values of spatial dependence for this ion begin with an increase in the semi-variance function until it reaches this distance, which is considered the highest spatial dependence, after which this ion is considered not spatially dependent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 58.51, 611.31, and 669.82, respectively. Figure (4c) and Table (4) show that nugget values are less than partial sill values for calcium, indicating that sampling sites were taken at shorter distances and that homogeneous sites with spatial autocorrelation, originally inherited or affected by vegetation cover and agricultural practices, were located on scales larger than the distance between samples. The appropriate model to describe calcium variance was the circular model, and the spatial dependence of calcium was (8.033)% strong, meaning that this trait is strongly spatially dependent, meaning that the effect of nugget is small.

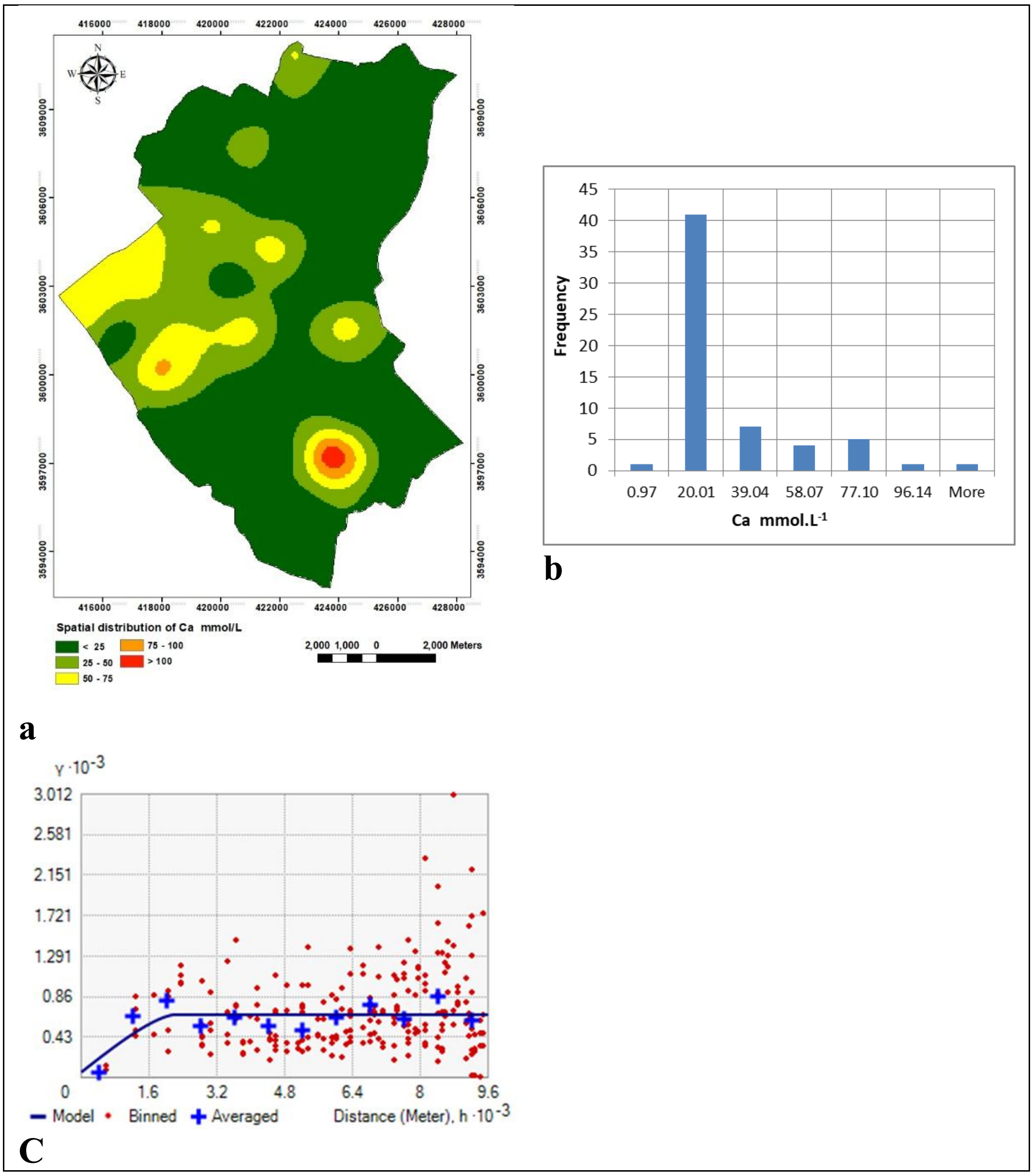
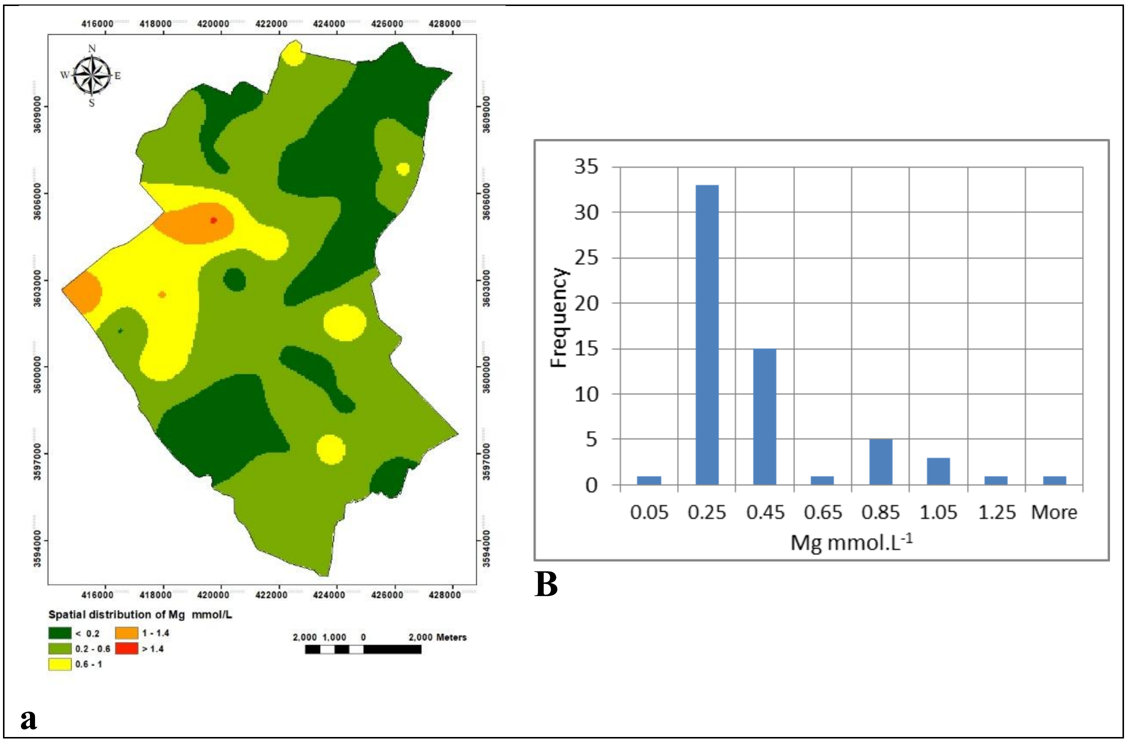


Figure (4): (a) Spatial distribution of Calcium, (b) Histogram of Calcium and (c) Semi variogram of Calcium

Magnesium

Table (2) shows the soil content of (Mg^{++}), which ranged from (0.049) mmol.L^{-1} in the sample site (25 with palm plus citrus) to (1.455) mmol.L^{-1} in the sample site (53 fallow). Table (2) shows that the soil Mg^{++} content of the vegetation was (0.049 to 0.310) mmol.L^{-1}, (0.056 to 0.686) mmol.L^{-1}, (0.050 to 0.327) mmol.L^{-1}, and (0.134 to 1.455) mmol.L^{-1} ((palm plus citrus), palm, crops, and fallow), respectively. Mg^{++} levels are higher in fallow soils compared to soils in agricultural lands and for all plant covers. This may be attributed to the higher salinity of fallow soils compared to soils with plant cover as affected by cultivation practices, plant cover diversity and availability of irrigation water. Table (2) and Figure (5a) show the dominance of Mg^{++} was as follows (0.2-0.6, < 0.2, 0.6-1, 1-1.4, > 1.4) mmol.L^{-1} for the light green, dark green, yellow, brown, red colors respectively.

The spatial distribution of Magnesium ions is relatively consistent with the spatial distribution of soil salinity. Table (3) also shows the values of average Mg^{++} , standard deviation, coefficient of variation, coefficient of skewness and coefficient of Kurtosis were 20.90 mmol.L^{-1}, 25.70, 123.24%, 2,250, (5.847) respectively. Values of this ion deviate to the right from the normal distribution as shown in Figure (5b). This may be attributed to the random distribution of samples, the presence or variation of vegetation cover and the extent of plant need for this ion. Most of the magnesium values fall within three dominant categories (0.25, 0.45, 0.85) mmol.L^{-1}. It also appears that the distribution of magnesium samples is (flat) as no extremes appear in the repetition of certain values. The effective distance (Range) to describe the variation of the magnesium ion is (2314.2) meters, as the values of spatial dependence of this ion begin to increase with the semi-variance function until they reach this distance, which is considered the highest spatial dependence, after which this ion is considered spatially independent. Figure 5c and Table (4) show that the nugget values are lower than the partial sill values for magnesium, indicating that the sampling sites were taken at shorter distances and that the homogeneous sites with spatial autocorrelation, originally inherited or affected by vegetation cover and agricultural practices, were located on scales larger than the distance between samples. The appropriate model to describe the magnesium variance was the spherical model, and the spatial dependence of magnesium (0)% is strong, meaning that this characteristic is strongly spatially dependent, meaning that the effect of nugget is small.



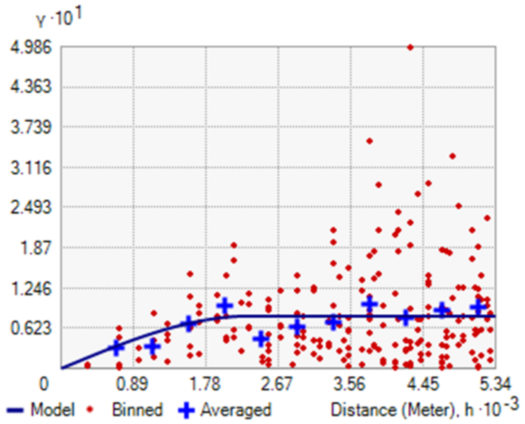


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Figure (5): (a) Spatial distribution of Magnesium, (b) Histogram Magnesium and (c) Semi variogram of Magnesium

Potassium

Table (2) shows the soil content of (K^+), which ranged from (0.117) mmol.L^{-1} in the sample site (13 with palm vegetation) to (13.626) mmol.L^{-1} in the sample site (50 fallow). Table (2) shows that the soil potassium content of the vegetation was (0.146 to 1.569) mmol.L^{-1}, (0.117 to 1.192) mmol.L^{-1}, (0.169 to 1.013) mmol.L^{-1}, and (0.583 to 13.626) mmol.L^{-1} ((palm plus citrus), palm, crops, and fallow), respectively. Potassium levels are observed to be higher in fallow soils compared to soils in agricultural lands and for all plant covers. This may be attributed to the higher salinity of fallow soils compared to soils with plant cover . There is also variation depending on the plant covers, as potassium levels are higher in palm and citrus soils, followed by palm trees, which are close to crop soils. Table (2) and Figure (5a) show the dominance of K^+ was as follows (< 2, 2-5, 5-8, > 11, 8-11) mmol.L^{-1} for the dark green, light green, yellow, red, brown colors respectively. The spatial distribution of the ion is relatively consistent with the spatial distribution of soil salinity with some differences due to the effect of organic matter and the degree of soil reaction. .Table (3) also shows the values of average K^+, standard deviation, coefficient of variation, coefficient of skewness and coefficient of Kurtosis were 1.369 mmol.L^{-1}, 2.268, 165.33%, 3.525, 14.867) respectively. Coefficient of variation of K^+ variation is close to the coefficient of variation of soil salinity due to the variation between the soils of agriculturally exploited lands with low to medium salinity compared to the soils of high fallow land. It is noted that the ion values deviate to the right from the normal distribution, as shown in Figure (6b). This may be attributed to the random distribution of samples, the presence or variation of vegetation cover, the extent of plant need for these ions, their preference in nutrition, or the variation in their ability to be washed out. Most of the potassium values fall within one dominant category (2.05) mmol.L^{-1}. It also appears that the distribution of potassium samples is of the pointed type, as the Kurtosis value is positive and very high, characterized by a more pointed distribution than the normal distribution, the presence of a higher probability of extreme values, and a more concentrated data set. The effective distance (Range) to describe the variation of potassium ions is (2204.92) meters, as the values of spatial dependence for this ion begin with an increase in the semi-variance function until it reaches this distance, which is considered the highest spatial dependence, after which this ion is considered not spatially dependent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 0.032, 2.27, and 2.59, respectively. Figure (6c) and Table (4) show that nugget values are less than partial sill values for potassium, indicating that sampling sites were taken at shorter distances and that homogeneous sites with spatial autocorrelation, originally inherited or affected by vegetation cover and agricultural practices, were located on scales larger than the distance between samples. The appropriate model to describe potassium variance was the circular model, and the spatial dependence of potassium (10.996)% was strong, meaning that this trait is strongly spatially dependent, meaning that the effect of nugget is small.

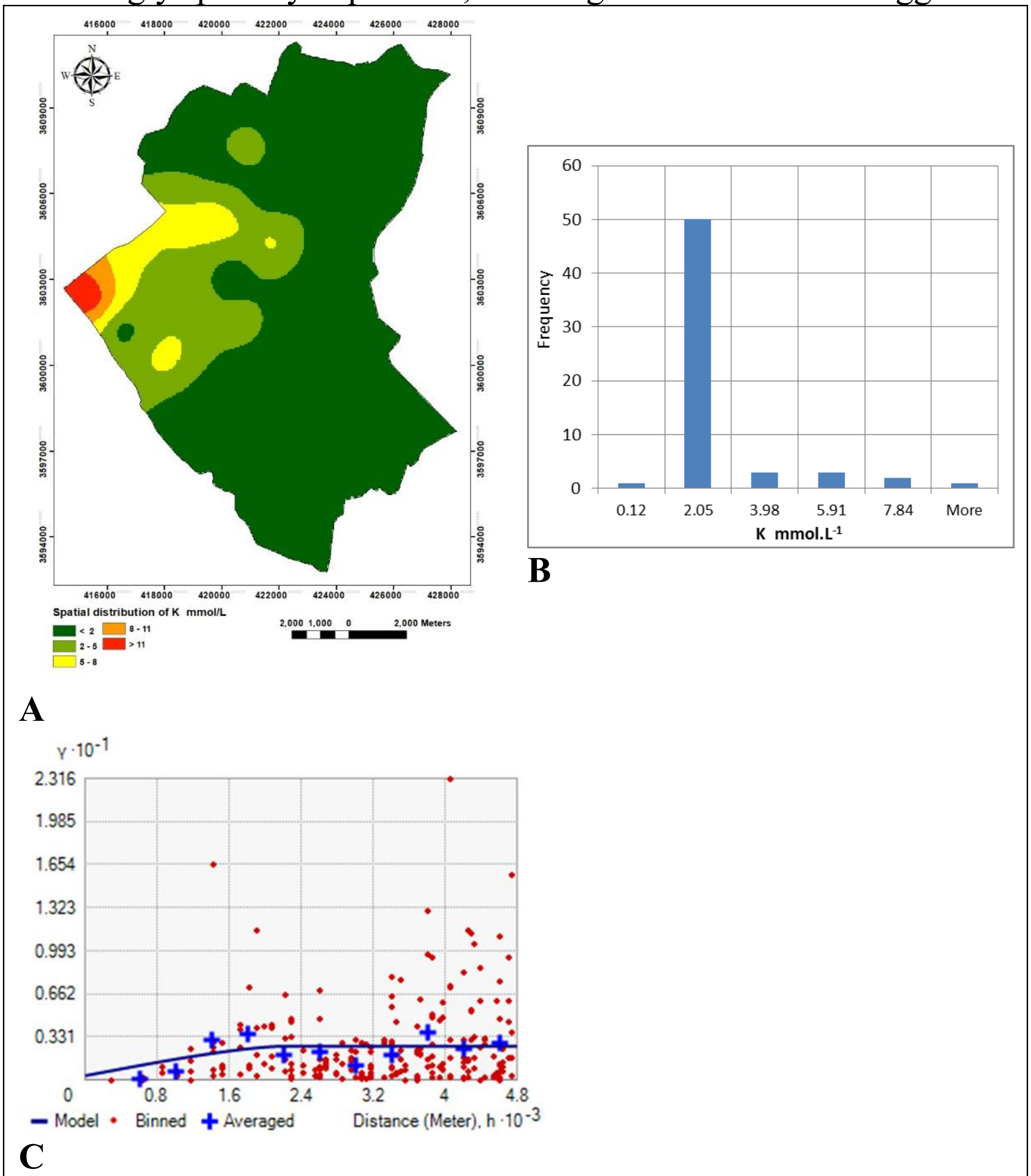


Figure (6): (a) Spatial distribution of Potassium, (b) Histogram of Potassium and (c) Semi variogram of Potassium

Sodium

Table (2) shows the soil sodium ion content Na^+, which ranged from (5.998) $mmol.L^{-1}$ in the sample site (11 with palm) to (614.251) $mmol.L^{-1}$ in the sample site (53 fallow). Table (2) shows that the soil Na^+ content of the vegetation was (7.020 to 24.775) $mmol.L^{-1}$, (5.998 to 112.937) $mmol.L^{-1}$, (7.557 to 55.463) $mmol.L^{-1}$, and (13.704 to 614.276) $mmol.L^{-1}$ (palm plus citrus), palm, crops, and fallow), respectively. It is noted that sodium levels are higher in fallow soils compared to soils of agriculturally exploited lands and for all plant covers. Table (2) and Figure (5a) show the dominance of Na^+ was as follows (< 100, 100-250, 250-400, 400-550, > 550) $mmol.L^{-1}$ for the dark green, light green, yellow, brown, red, colors respectively. The spatial distribution of the ion is relatively consistent with the spatial distribution of soil salinity with some differences due to the effect of organic matter and the degree of soil reaction. Table (3) also shows the values of average Na+, standard deviation, coefficient of variation, coefficient of skewness and coefficient of Kurtosis were 94.997 $mmol.L^{-1}$, 160.54, 169%, 2.021, 2.967) respectively. It is noted that the variation of the ions is close to the coefficient of variation of soil salinity, as they represent the salts of these ions, as it is due to the variation between the soils of agriculturally exploited lands with low to medium salinity compared to the soils of high fallow lands, as a result of the influence of climatic factors, proximity and distance from irrigation projects, and then the variation in the availability of irrigation water, the effectiveness of the drain network, the height of groundwater and its effect on washing operations, as well as the effect of organic matter and then its effect on the degree of soil interaction and its effect on the formulas of this ion. Figure (7b) shows a deviation in Na^+ to the right from the normal distribution to the random distribution of samples and the presence of vegetation diversity. Most of the sodium values fall within one dominant category (92.89) $mmol.L^{-1}$ with pointed type distribution , as the flattening value is positive and very high and the presence of a higher probability of extreme values. The effective distance (Range) to describe the variation of the sodium ion is (2204.92) meters, according to the order, as the values of spatial dependence for this ion begin with an increase in the semi-variance function until it reaches this distance, which is considered the highest spatial dependence, after which this ion is considered not spatially dependent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 0, 20.9, and 20.9, respectively. Figure (7c) and Table (4) show that nugget values are less than partial sill values for magnesium, indicating that sampling sites were taken at

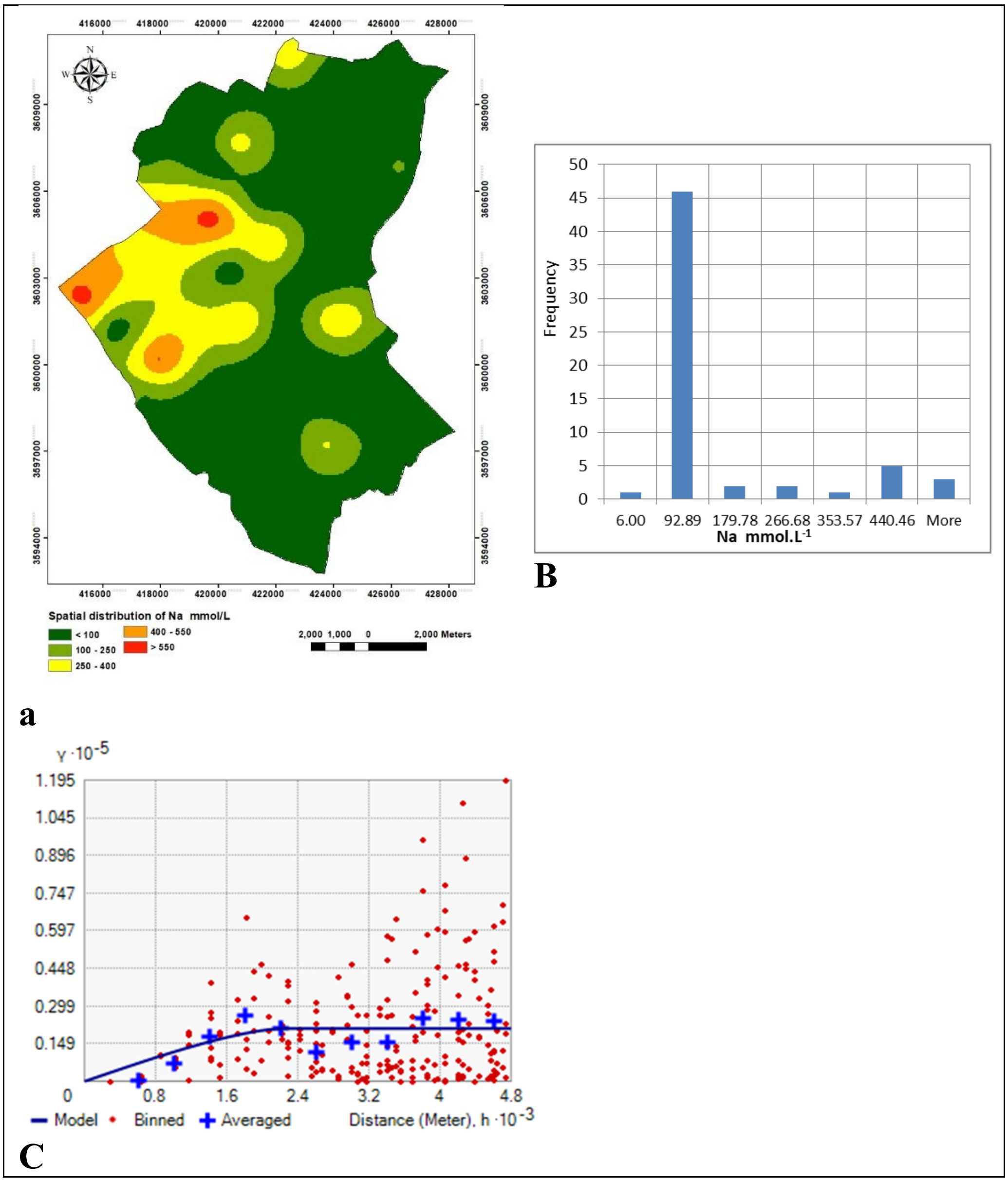


Figure (7): (a) Spatial distribution of Sodium, (b) Histogram of Sodium and (c) Semi variogram of Sodium

shorter distances and that homogeneous sites with spatial autocorrelation, originally inherited or affected by vegetation cover and agricultural practices, were located on scales larger than the distance between samples. The appropriate model to describe sodium variability was the circular model, and the spatial dependence of magnesium (0)% is strong, meaning that this trait is strongly spatially dependent, meaning that the effect of nugget is small.

Chloride

Table (2) shows the soil Cl^- ion content which ranged from (2.664) $mmol.L^{-1}$ in the sample site (12 with palm plus citrus) to (35.835) $mmol.L^{-1}$ in the sample site (57 fallow). Table (2) shows that the soil Cl^- content of the vegetation was (2.664 to 6.082) $mmol.L^{-1}$, (3.008 to 12.562) $mmol.L^{-1}$, (2.863 to 9.804) $mmol.L^{-1}$, and (3.426

to 35.835) mmol.L-1 ((palm plus citrus), palm, crops, and fallow) respectively. Higher Cl^- contents may be attributed to the higher salinity of fallow soils compared to soils with plant cover due to the effect of low rainfall rate and high temperatures . There is also variation depending on the plant covers, as higher chloride levels are observed in the soils of plant cover for crops, followed by palm trees, followed by palm plus citrus. This is attributed to variations in the parent material or variations in the availability of irrigation water and thus soil washing.

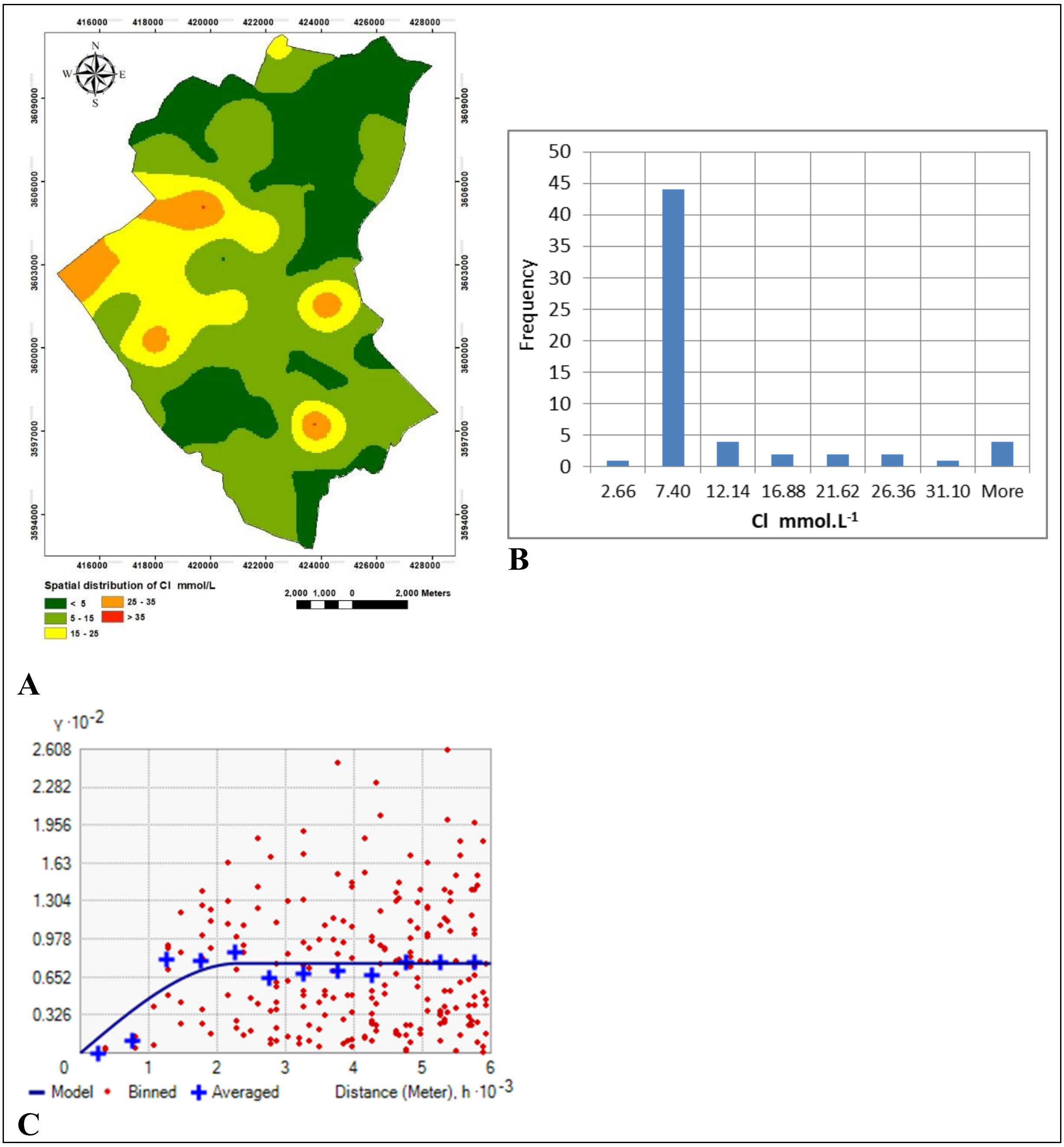


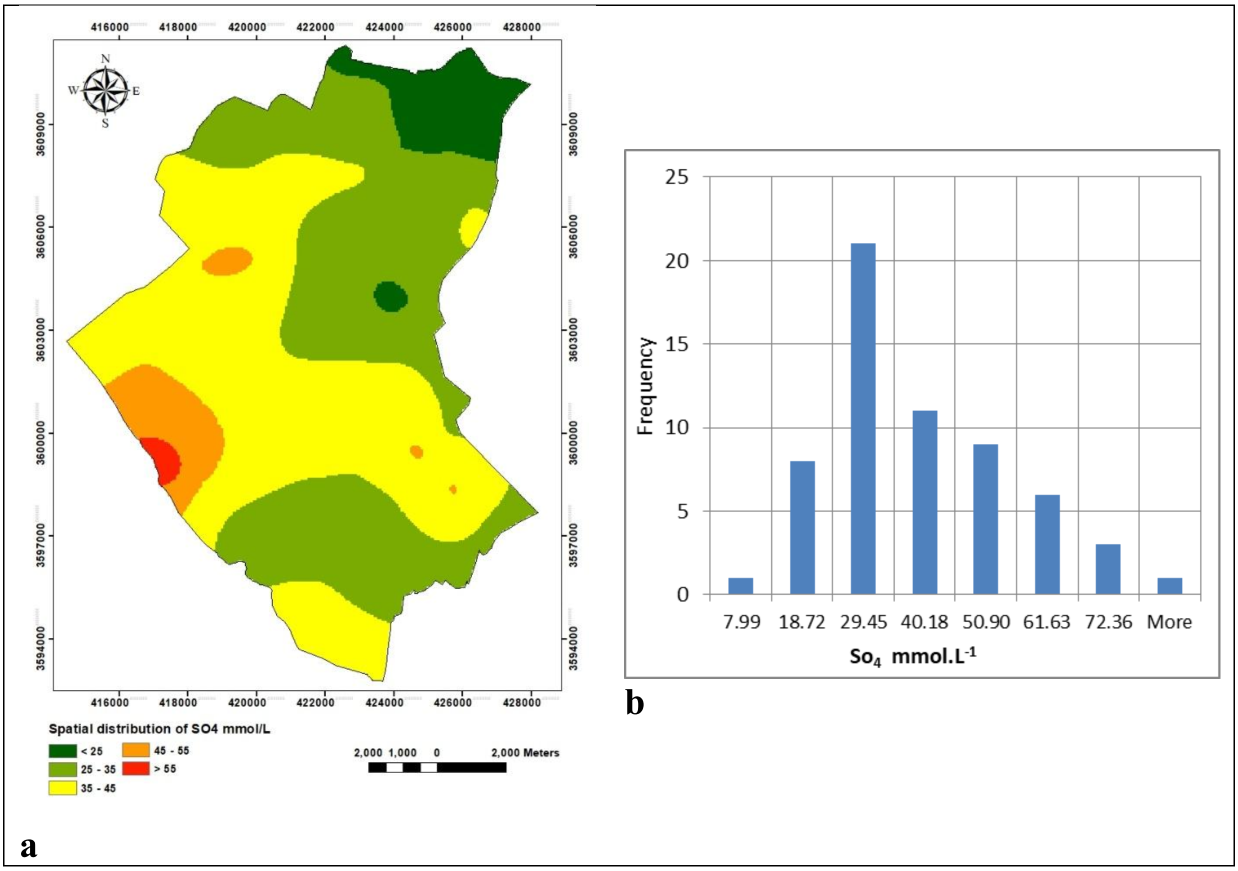
Figure (8): (a) Spatial distribution of Chloride, (b) Histogram of Chloride and (c) Semi variogram of Chloride

Table (2) and Figure (5a) show the dominance of Cl^- was as follows (5-15, < 5, 15-25, 25-35, > 35) $mmol.L^{-1}$ for the light green, dark green, yellow, brown, red, colors respectively.The spatial distribution of the ion is largely consistent with the spatial distribution of soil salinity with some differences due to the effect of organic matter and the degree of soil reaction.

Table (3) also shows the values of average Cl^-, standard deviation, coefficient of variation, coefficient of skewness and coefficient of Kurtosis were 8.716 $mmol.L^{-1}$, 9.05, 103.85%, 2.027, 2.930) respectively. It is noted that the variation of ions is close to the coefficient of variation of soil salinity, as they represent the salts of these ions, as it is due to the variation between the soils of agriculturally exploited lands with low to medium salinity compared to the soils of high fallow lands, as a result of the influence of climatic factors, proximity and distance from irrigation projects, and then the variation in the availability of irrigation water, the effectiveness of the drain network, the height of groundwater and its effect on washing operations, as well as the effect of organic matter and then its effect on the degree of soil interaction and its effect on the formulas of this ion. The ion values are observed to deviate to the right from the normal distribution as shown in Figure (8b). This may be attributed to the random distribution of samples, the presence of vegetation, or their varying ability to be washed out. Most of the chloride values fall within one dominant category (7.40) $mmol.L^{-1}$. It also appears that the distribution of the chloride samples is of the pointed type, as the kurtosis value is positive and very high, characterized by a more pointed distribution than the normal distribution, a higher probability of extreme values, and a more concentrated data set. The effective distance (Range) to describe the variance of the chloride ion is (2312.54) meters, as the spatial dependence values for this ion begin to increase with the semi-variance function until they reach this distance, which is considered the highest spatial dependence, after which this ion is considered not spatially dependent. Table (4) shows that the values of Nugget, Partial Sill, and Sill were 0, 76.99, and 76.99, respectively. Figure (8c) and Table (4) show that nugget values are less than partial sill values for chloride, indicating that sampling sites were taken at shorter distances and that homogeneous sites with spatial autocorrelation, originally inherited or affected by vegetation cover and agricultural practices, were located on scales larger than the distance between samples. The appropriate model to describe chloride variance was the spherical model, and the spatial dependence of chloride (0)% is strong, meaning that this characteristic is strongly spatially dependent, meaning that the effect of nugget is small.

Sulfates

Table (2) shows the soil content of SO_4^{--} ion which ranged from (7.994) $mmol.L^{-1}$ in the sample site (25 with palm plus citrus) to (83.086) $mmol.L^{-1}$ in the sample site (46 fallow). Table (2) shows that the soil content of sulfate for the vegetation was (7.994 to 52.079) $mmol.L^{-1}$, (9.617 to 68.539) $mmol.L^{-1}$, (19.896 to 69.961) $mmol.L^{-1}$, and (17.632 to 83.086) $mmol.L^{-1}$ ((palm plus citrus), palm, crops, and fallow) in order. It is noted that sulfate levels are higher in fallow soils compared to soils of agriculturally exploited lands and for all plant covers. This may be attributed to the high salinity of fallow soils compared to soils of lands with plant cover. This is due to the effect of irrigation water in washing away salts, low rainfall rates, high temperatures, and low soil organic matter content. There is also variation according to plant covers, as high sulfate levels are noted in soils of plant cover for crops, followed by palm trees, followed by palm trees plus citrus fruits. This is attributed to variations in the parent material or variations in the availability of irrigation water, which then washes away the soil, planting density, and depletion of nutrients by the plant during growth and the use of fertilizers. Table (2) and Figure (9a) show the dominance of soil sulfate was as follows (35-45, 25-35, 45-55, < 25, > 55) mmol.L^{-1} for the yellow, light green, brown, dark green, red, colors respectively. (The spatial distribution of this ion is largely consistent with the spatial distribution of soil salinity with some differences due to the effect of organic matter and the degree of soil reaction. The results of Table (3) also shows the values of average SO_4^{--}, standard deviation, coefficient of variation,coefficient of skewness and coefficient of Kurtosis were 33.916mmol.L^{-1}، 16.09, 47.46%, 0.872, 0.526) respectively.



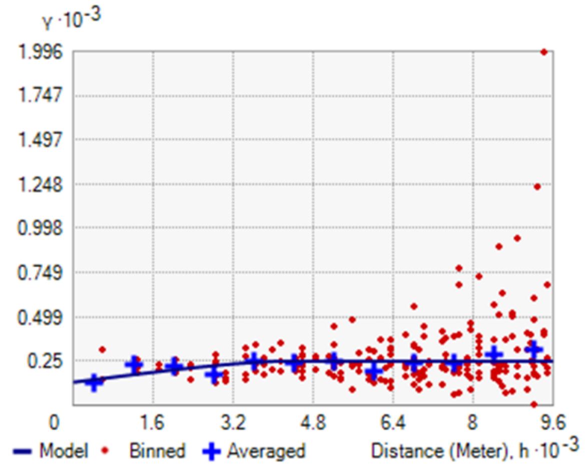


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Figure (9): (a) Spatial distribution of Sulfates, (b) Histogram of Sulfates and (c) Semi variogram of Sulfates

It is noted that the ion variation is close to the coefficient of variation of soil salinity, as it represents the salts of these ions, as it is due to the variation between the soils of agriculturally exploited lands with low to medium salinity compared to the soils of high fallow lands, as a result of the influence of climatic factors, proximity and distance from irrigation projects, and then the variation in the availability of irrigation water, the effectiveness of the drain network, the height of groundwater, and its effect on washing operations, as well as the effect of organic matter, and then its effect on the degree of soil interaction and its effect on the formulas of this ion. It is noted that the ion values are deviated to the right from the normal distribution as shown in Figure (9b). This may be attributed to the random distribution of samples, the presence or variation of vegetation cover, the extent of the plant's need for these ions and their preference in its nutrition, or the variation in its ability to be washed. Most of the sulfate values fall within three dominant categories (29.45, 40.18, 50.90) $mmol.L^{-1}$. It also appears that the distribution of sulfate samples is a (flat) distribution, as no extremes appear in the repetition of certain values. The effective distance (Range) to describe the variance of the sulfate ion is (4196.64) meters, as the values of spatial dependence for this ion begin to increase with the semi-variance function until it reaches this distance, which is considered the highest spatial dependence, after which this ion is considered not spatially dependent. Table (4) shows that the value of Nugget, Partial Sill and Sill was 130.93, 118.90 and 249.83, respectively. Figure (9c) and Table (4) show that the sulfate nugget is greater than the values of partial sill, indicating that the sampling sites were taken at greater distances, and the homogeneous sites with inherited spatial autocorrelation or those affected by the vegetation cover and agricultural practices were originally located on scales less than the distance between the samples. The appropriate model to describe the sulfate variation was the circular model, and the spatial dependence of sulfate was 34.38% moderate, meaning that this trait is spatially dependent on average, meaning that the effect of nugget is moderate.

Since the study area is under the same climatic conditions it seems that plant cover and land use are mainly responsible for spatiodistribution and differences of the studied soil characteristics. Micro climate and land use play significant effects on soil properties especially organic matter content, evaporation and temperature rates, rhizosphere, root growth and decay…etc. While CEC is inherited soil characteristic, EC is unsteady soil property due to land use, irrigation water management , water table level and salinity, climatic conditions…etc. Soluble ions are directly proportional to EC conductance in soil solutions. Soil heterogeneity occurs between and within spaces and it is not an easy task to evaluate and assess differences in most soil properties due to spationdependence. Classical and geostatistical statistics are approaches to overcome variation in studied characteristics. While CEC and SO_4^- showed acceptable, but not complete, agreement with the normal distribution hypothesis, parameters of statistical and geostistical analysis do not agree with the assumption of normal distribyion criteria for the rest of the studied characteristics., which may not be consistent with the geostatistical hypothesis.

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