Available online at http://bjas.bajas.edu.iq
https://doi.org/10.37077/25200860.2024.38.1.20
College of Agriculture, University of Basrah

Basrah Journal of Agricultural Sciences

ISSN 1814 – 5868 Basrah J. Agric. Sci., 38(1), 248-260, 2025 E-ISSN: 2520-0860

Depth Function of Available Phosphorus and Potassium Distribution in Different Mid-Mesopotamian Plain Saline Soils

Kusay A. Wheib, Afrah K. Al-Jubouri, Husian A. Isa* & Wejdan T. Kadhim

Department of Soil Sciences and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad , Baghdad, Iraq.

***Corresponding author email: H.A.I**.: husain.a@coagri.uobaghdad.edu.iq; **K.A.W.:** Kusay.wheib@coagri.uobaghdad.edu.iq , **A.K.A.:** afrah.k@coagri.uobaghdad.edu.iq; **W.T.K.:** wejdan.t@coagri.uobaghdad.edu.iq

Received 21st March 2025; Accepted 26th May 2025; Available online 30th June 2025

Abstract: Saline soils in Alsweira greater area representing mid-Mesopotamian plain saline soils were selected to study the effect of salt accumulation on available potassium and phosphorus in soil as a depth function. Strip transect area representing sever salt affected areas was located and soil samples was chosen along that transect. Results showed that soil salinization phases in the area was Chloridic and sulphatic salinization, therefore it affected the salt distribution in soils. The most dominant salt compound was sodium chloride in Chloridic salinization soils, while sodium sulphate was the dominant salt compound in sulphatic salinization areas. Results showed that the content of available phosphorus was fairly low while available potassium showed different ranges in soil. Available potassium was significantly positive correlated to electrical conductivity (ECe) while available phosphorus was significantly negative correlated with ECe. These results were figured as depth functions of these available nutrients in soil where the highest content of available potassium was in the upper horizon decreasing with depth, while available phosphorus showed a significant decrease with depth as soil salinity decreases with depth.

Keywords: available k, available p, salinization phase, salt distribution, soil salinity.

Introduction

Salt-affected soils have received wide attention recently due to the steady increase in population, which is accompanied by a severe deterioration in arable land at a rate of 1-2% per year (Hossain, 2019). ICARDA, 2014, indicated that the problem of salinization is the main problem in the decline in agricultural production, as the organization indicated that there are more than 1,125 million hectares of salt-affected lands in the world, concentrated in the soils of arid and semi-arid regions. Anderson, 2010, confirmed that salt-affected soils are mainly characterized by a high basic reaction when sodium ions dominate the soil solution compared to other bases. However, Hashem *et al.*, (2014) showed that increasing the concentration of salts in the soil leads to a decrease in the soil content of calcium and magnesium ions compared to its sodium content. The potassium content also witnesses a significant increase coupled with an increase in chloride and sulphate ions in it. Wong *et al.*,

(2010) explained that increasing the soil content of salts reduces the decomposition of organic matter in the soil, which leads to an increase in its content compared to soils not affected by salts due to inhibition of the activity of biological activities in it. Wheib & Ibrahim (2012) studied the morphological and micromorphological characteristics of some soils affected by salts in the Iraqi alluvial plain. They noted that there is diversity in the salt composition of the study soil samples. The results of the scanning electron microscope and the polarizing microscope showed the spread of chloride-salinity soils in the west of the alluvial plain, extending to chloride-sulphuric-salinity soils in the middle of the Iraqi alluvial plain. Their study also showed the dominance of dark- sabkha soils in both locations at higher rates than the dominance of light sahura soils. Organic materials added to the soil reduce the exposure of phosphorus to factors that help in its deposition and retention, in addition to the fact that they contain phosphorus, which is released through absorption by the soil as calcareous soil is revitalized, along with the production of organic acids and carbon dioxide gas. The carbon dioxide dissolves in water to form carbonic acid. These acids lower the soil pH and enhance the solubility of phosphorus compounds that are only slightly soluble, thereby promoting the release of phosphorus into the soil. Al-Hadethi (2024) has studied the application of phosphorus in saline sodic soils, and the confirmed that the application of acidic materials with phosphogypsum increases the availability of phosphorus and potassium to plant in these soils. Mam-Rasul (2020) and Al-Jaff, (2024) have studied the impact of carbonate minerals on the availability of potassium in calcareous soils, and he excluded that the adsorption of potassium showed maximum increase with the increase of carbonate minerals. Al-Jubory & Al-Khafaji (2024) found that there was a negative relationship between phosphorus availability and salt accumulation, where phosphorus was significantly affected by the increase of soil salinity, sodium adsorption ratio, and clay content. Nahmoud & Al-Rubaai (2019) studied the availability of potassium in saline soils, and they confirmed that saline soils in Iraq have adequate amount of available potassium. Abbas & Wheib (2021) confirmed that land use affects to availability of phosphorus and potassium in cereal crop areas in Mesopotamian plain, where the highest content of these nutrients where in areas fertilized with phosphorus and potassium, while they also mentioned the decrease in available phosphorus in salt affected soils. Since salt accumulation have a great impact on the availability of available potassium and phosphorus, this study aimed to study availability of these nutrients in saline soils besides describing their depth function in saline soils in mid-Mesopotamia. Many local studies were conducted on salt affected soils dealing with the effect of salinity on the availability of nutrient under soil management practices to reclaim these soils (Mahmoud & Alrubaie, 2019, Saleh *et al*., 2019, Al-Najar & Abbas, 2009)

Materials & Methods

Area of Study: Eight soil pedons were selected along a transect passing through different saline soils in Alsweira district covering a transect length of 6.00 km, these soils are strongly affected by salinity and representing most of the saline soils in the studied area. Figure 1 shows selected samples on this transect in alsweira grater area. Soil profiles were excavated and morphologically described as saline soils, and samples were collecte from each soil horizon and for each soil profile according to Soil Survey Staff (Burt, 2014), packed in plastic bags for laboratory analysis.

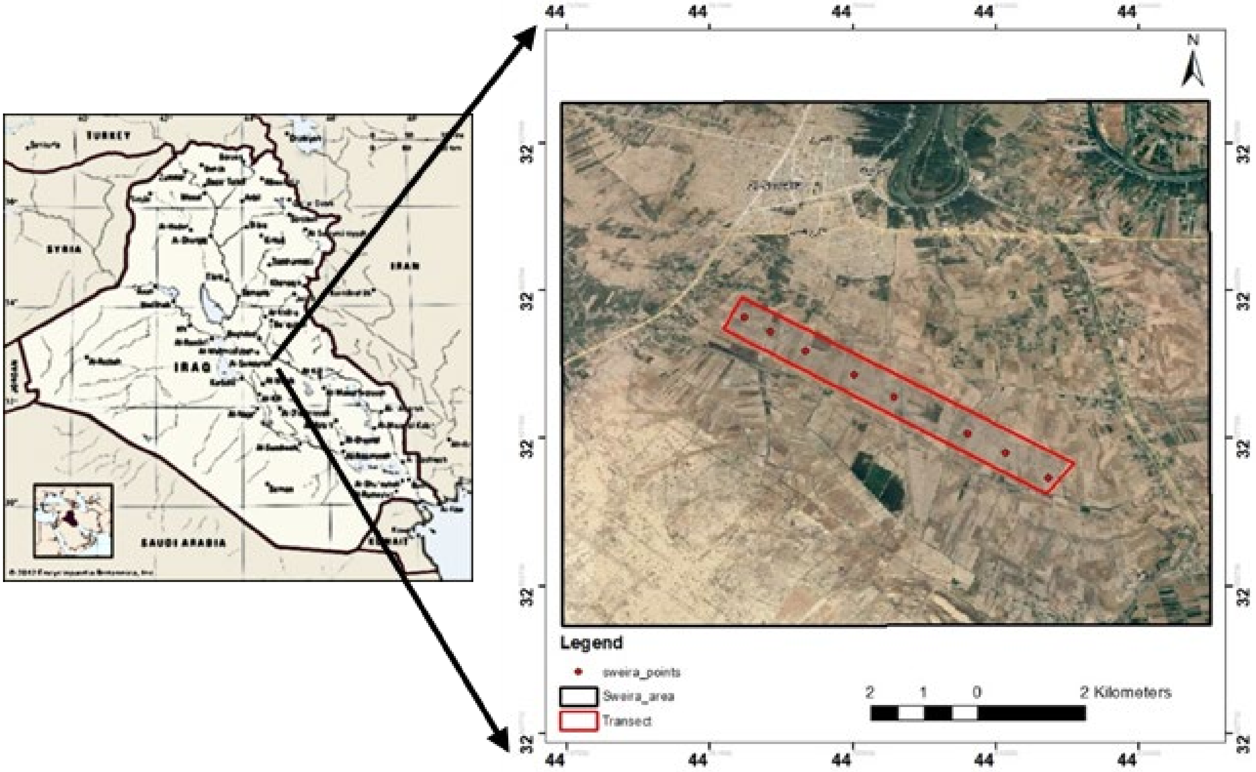


Fig. (1): Transect of study in greater Alsweira district

Measured properties

selected samples were air dried, grinded, and prepared to measure particle size distribution according to Day (1965) mentioned in Black (1965), Soil Electrical conductivity (ECe), Cations and Anions in soil solution, and Exchangeable sodium percentage (ESP) according to Richards *et al*., (1954). Also, available potassium and phosphorus were measured due to Page *et al*., (1982). Hypothetical distribution of salts was also calculated according to Al-Zubaidi (1989) to determine the salinization phase of the selected saline soils.

Statistical analysis

means, standard deviation, and coefficient of variance were calculated for the available potassium and phosphorus using the statistical methodology mentioned in Microsoft office package, namely MS Excel manual, according to Microsoft Corporation (2016).

Results & Discussion

Soil Properties and salt distribution

measured properties values of the selected saline soils are shown in table 1. The highest soil electrical conductivity reached 113.08 dS m-1 in the surface horizon (A1) of the seventh pedon while the lowest value was 13.21 dS m-1 in the subsurface horizon (C3) of the first pedon. Pedon seven was representing sulphatic salinization phase (table 2) while the first pedon was representing a chloridic phase of salinization. The most dominant salt compound in Chloridic salinization was sodium chloride while sodium sulphate prevailed the sulphatic salinization phase. Some other salts were shown in both salinization phases (figure 2). Electrical conductivity was decreasing with depth as a result of accumulating salts in the upper layers of the soil in arid and semiarid areas soils due to the active capillary fringe that participate in accumulating salts in heavy textured soils. It is obvious that some salinization phases tend to be Chloridic-sulphatic according to the values of Cl/SO4 ratios. Pedons 1, 2, 3, and 6 represent Chloridic phase salinization while pedons 4, 5, 7, and 8 represent sulphatic salinization phase. Soil reaction showed a significant correlation with electrical conductivity ($R2=0.467$, $p<0.05$) as salt accumulation function. Figure 3a shows this relationship. This result was also confirmed by many studies Nasir & Wheib (2022), Al-Jubouri & Wheib (2020), Reddi (2013)). Soil electrical conductivity also correlated significantly ($R2=0.749$, $p<0.01$) with exchangeable sodium percentage (figure 3b). In fact, it is not necessarily that ECe correlates to ESP as the content of sodium in comparison to calcium and magnesium show in soil solution. Sometimes the highest values of electrical conductivity come from higher concentrations of calcium and magnesium in soil solution which decrease the ESP values. Hence, when ECe correlates to ESP, it refers to higher concentrations of sodium in soil Farahmand *et al*., (2012), Zaman *et al*., (2018), Gharaibeh *et al*., (2021).

Table (1): Measured soil properties

Pedon	Horizon	depth cm	ECe dS m^{-1}	pH	ESP	Soil Texture
1	P_1A	12	30.40	7.6	18.45	SiL
	P_1C_1	36	25.93	7.7	15.58	SiL
	P_1C_2	65	21.50	7.6	13.58	SiCL
	P_1C_3	85	13.21	7.8	12.07	SiCL
2	P_2A	15	32.52	7.5	29.46	LS
	P_2C_1	40	27.51	7.7	22.49	LS
	P_2C_2	72	16.73	7.7	18.68	SiL
	P_2C_3	95	14.89	8.2	14.91	SiL
3	P_3A	16	62.87	7.3	45.87	SiCL
	P_3C_1	48	50.53	7.3	48.57	SiCL
	P_3C_2	69	48.44	7.6	52.02	CL
	P_3C_3	82	47.30	7.5	52.20	CL
	P_3C_4	108	34.89	7.8	23.79	SCL
4	P_4A	14	79.14	7.2	57.26	SiCL
	P_4C_1	45	67.06	7.2	50.46	SiCL
	P_4C_2	73	73.13	7.3	54.43	CL
	P_4C_3	92	51.79	7.7	50.08	SiCL
5	P_5A	14	106.8	7.2	63.93	SiC
	P_5C_1	42	67.50	7.2	43.10	SiC
	P_5C_2	69	49.57	7.5	48.67	SiCL
	P_5C_3	85	43.29	7.4	33.22	SiCL
	P_5C_4	115	34.08	7.9	26.17	SiL
6	P_6A	15	94.24	7.3	62.21	SiL
	P_6C_1	45	36.92	7.6	32.75	SiC
	P_6C_2	75	29.92	7.9	38.02	SiC
7	P_7A	16	113.0	7.4	59.71	SiC
	P_7C_1	52	37.29	7.8	35.81	C
	P_7C_2	70	31.96	7.7	35.39	C
	P_7C_3	96	27.58	8.1	41.65	SiC
8	P_8A	12	76.77	7.3	54.10	SiC
	P_8C_1	52	67.48	7.8	49.97	SiCL
	P_8C_2	76	56.40	7.7	46.65	SiCL
	P_8C_3	96	38.34	8.2	43.92	SiL

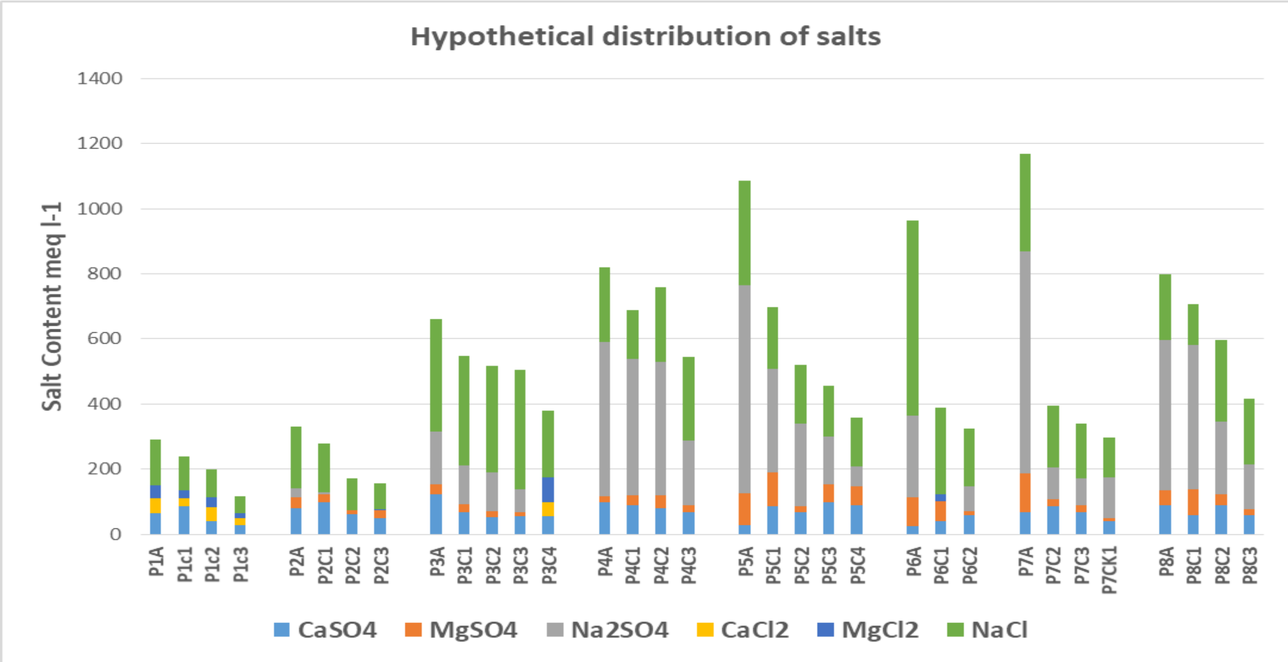
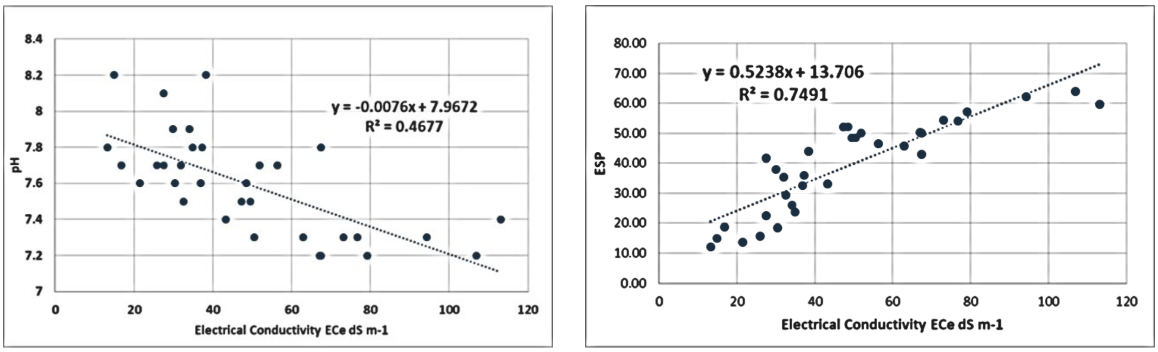


Fig. (2): Hypothetical distribution of salts

Back to hypothetical distribution of salts, potassium, carbonate and bicarbonate ions were neglected in calculations because of the negligible values of them. Cations and anions used for these calculations were Ca^{+2}, Mg^{+2}, Na^{+}, Cl^{-}, and SO_4^{-2}. Cations and anions where matched in concentrations to distribute the hypothetical bonding of cations with anions to compound salts. Table 2 shows the concentrations in meq l^{-1} of salts in the selected saline soils. Some sulphatic salinized soils showed higher content of chlorides salts, and this tend to be more sulphatic chloridic salinization process as noticed in pedons 7 and 8. Calcium and magnesium chlorides showed no existence or fair content as calcium and magnesium first bond to sulphate and due to the lower contents of these cations, the whole quantity bonds to sulphate leaving chloride to bond with sodium instead.



a *b*

Fig. (3): Relationship between ECe (dS m^{-1}) with pH (a), and ESP (b)

Table (2): Phase of salinization and hypothetical distribution of salts

Pedon	Horizon	depth	Cl/SO4	salinity	$CaSO_4$	$MgSO_4$	Na_2SO_4	$CaCl_2$	$MgCl_2$	NaCl
		cm		phase	meq L^{-1}					
1	P_1A	12	3.41	Chloridic	65.00	0.00	0.00	47.00	38.00	140.00
	P_1c_1	36	1.87	Chloridic	85.00	0.00	0.00	25.00	26.00	102.00
	P_1c_2	65	4.05	Chloridic	39.00	0.00	0.00	43.00	32.00	85.00
	P_1c_3	85	3.08	Chloridic	28.00	0.00	0.00	23.00	14.00	51.00
2	P_2A	15	1.34	Chloridic	79.00	34.00	28.00	0.00	0.00	189.00
	P_2C_1	40	1.16	Chloridic	99.00	23.00	7.00	0.00	0.00	150.00
	P_2C_2	72	1.29	Chloridic	63.00	11.00	1.00	0.00	0.00	97.00
	P_2C_3	95	1.07	Chloridic	48.00	27.00	0.00	0.00	1.00	79.00
3	P_3A	16	1.10	Chloridic	123.00	29.00	162.00	0.00	0.00	346.00
	P_3C_1	48	1.54	Chloridic	68.00	25.00	118.00	0.00	0.00	337.00
	P_3C_2	69	1.87	Chloridic	52.00	19.00	118.00	0.00	0.00	327.00
	P_3C_3	82	2.63	Chloridic	56.00	11.00	72.00	0.00	0.00	366.00
	P_3C_4	108	5.65	Chloridic	57.00	0.00	0.00	42.00	76.00	206.00
4	P_4A	14	0.38	Sulphatic	99.00	18.00	475.00	0.00	0.00	228.00
	P_4C_1	45	0.29	Sulphatic	88.00	33.00	418.00	0.00	0.00	149.00
	P_4C_2	73	0.43	Sulphatic	79.00	42.00	407.00	0.00	0.00	231.00
	P_4C_3	92	0.89	Sulphatic	69.00	19.00	199.00	0.00	0.00	259.00
5	P_5A	14	0.42	Sulphatic	29.00	96.00	641.00	0.00	0.00	319.00
	P_5C_1	42	0.37	Sulphatic	85.00	105.00	317.00	0.00	0.00	192.00
	P_5C_2	69	0.53	Sulphatic	68.00	19.00	252.00	0.00	0.00	180.00
	P_5C_3	85	0.52	Sulphatic	99.00	54.00	146.00	0.00	0.00	157.00
	P_5C_4	115	0.74	Sulphatic	89.00	57.00	63.00	0.00	0.00	150.00
6	P_6A	15	1.64	Chloridic	25.00	88.00	251.00	0.00	0.00	599.00
	P_6C_1	45	2.81	Chloridic	39.00	63.00	0.00	0.00	22.00	265.00
	P_6C_2	75	1.21	Chloridic	59.00	12.00	75.00	0.00	0.00	179.00
7	P_7A	16	0.34	Sulphatic	69.00	118.00	681.00	0.00	0.00	299.00
	P_7C_1	52	0.92	Sulphatic	87.00	22.00	96.00	0.00	0.00	191.00
	P_7C_2	70	0.98	Sulphatic	69.00	19.00	84.00	0.00	0.00	169.00
	P_7C_3	96	0.70	Sulphatic	39.00	11.00	125.00	0.00	0.00	123.00
8	P_8A	12	0.34	Sulphatic	89.00	45.00	463.00	0.00	0.00	201.00
	P_8C_1	52	0.22	Sulphatic	59.00	78.00	444.00	0.00	0.00	126.00
	P_8C_2	76	0.72	Sulphatic	88.00	35.00	224.00	0.00	0.00	250.00
	P_8C_3	96	0.92	Sulphatic	59.00	19.00	138.00	0.00	0.00	200.00

Available Potassium and Phosphorus:

Available potassium and phosphorus (mg kg-1) were measured in soil samples where table 3 shows their values. Some saline soils showed high available potassium especially in the surface horizons, while other soils showed medium to low content of available potassium in the subsurface horizons according to the classification of ranges of extension department of Minnesota University (University of Minnesota Extension, 2024). The surface horizons showed higher content of available potassium as their content of total salts in term of electrical conductivity was very high as they were classified as strongly saline soils, thus the values showed high coefficient of variance (48.59-85.60 %). Available phosphorus reflected lower content in saline soils, where it ranged between 4.99-8.37 mg kg^{-1}. The surface horizons showed lower content of available phosphorus in comparison in the subsurface horizons as these values were affected by the salt accumulation in the upper horizon. The low content of available phosphorus led to lower coefficients of variance (6.19-17.20) as they are computed from their values. The desirable content of available phosphorus in none saline soils ranges between 20-40 mg kg-1 LaBarge (2022), Abbas & wheib (2021) while in saline soils it drops down to 10 mg kg-1 Guan *et al*.,(2024), where the higher content of salts in soil the lower content of available phosphorus in soil. Therefore, available content of phosphorus in selected saline soils is considered low. Studied Saline soils typically contain high concentrations of potassium, chloride, and sulfate ions, which tend to increase with rising soil salinity as this was confirmed by many studies (Qadir *et al*., 2000, Wakeel, 2013; Osman & Osman, 2018)

Depth function of available potassium and phosphorus

Figure 4 shows the distribution of available potassium and phosphorus with depth. Depth functions of available potassium showed a decrease with depth while available phosphorus showed an increase with depth. The reason goes under the effect of salts accumulated in the surface horizons rather than the subsurface ones. Where in case of available potassium the values increased as the soluble potassium salts accumulated in the surface horizons where providing soil exchange surfaces with great amount of potassium, while phosphorus compound accumulated in the surface horizons are considered none or very low soluble compound, thus most phosphorus in these horizons are trapped in fixed forms of phosphorus (Mahmood *et al*., 2013&Mehfooz *et al*., 2023). Also, clay content showed an impact on salt accumulation, where the highest values of clay content the highest values of ECe, as this was confirmed by many researchers (Kragas *et al*., 2020, Al-Bayati *et al*., 2025, Mahdee *et al*., 2023)

Table (3): Available potassium and phosphorus in soil

Pedon	Horizon	depth cm	Av. K mg kg^{-1}	Av. P mg kg^{-1}
1	P_1A	12	162.73	5.71
	P_1c_1	36	51.14	7.32
	P_1c_2	65	85.48	7.69
	P_1c_3	85	79.89	8.37
mean			94.81	7.2725
SD			47.71	1.13
CV			50.33	15.52
2	P_2A	15	136.98	5.97
	P_2C_1	40	54.24	5.32
	P_2C_2	72	51.14	5.35
	P_2C_3	95	85.48	6.69
mean			81.96	5.8325
SD			39.82	0.65
CV			48.59	11.07
3	P_3A	16	437.41	5.11
	P_3C_1	48	162.73	6.77
	P_3C_2	69	119.81	7.46
	P_3C_3	82	94.06	6.63
	P_3C_4	108	65.28	6.34
mean			175.86	6.46
SD			150.53	0.86
CV			85.60	13.32
4	P_4A	14	248.57	5.07
	P_4C_1	45	214.23	5.06
	P_4C_2	73	51.14	5.06
	P_4C_3	92	42.56	5.71
mean			139.13	5.23
SD			107.53	0.32
CV			77.29	6.19
5	P_5A	14	162.73	5.33
	P_5C_1	42	154.15	5.4
	P_5C_2	69	171.31	5.18
	P_5C_3	85	111.23	6.88
	P_5C_4	115	42.56	5.83
Mean			128.40	5.72
SD			53.26	0.69
CV			41.48	12.05
6	P_6A	15	248.57	4.99
	P_6C_1	45	111.23	6.62
	P_6C_2	75	85.48	6.83
Mean			148.43	6.15
SD			87.68	1.01
CV			59.07	16.39
7	P_7A	16	306.08	5.19
	P_7C_1	52	162.73	5.37
	P_7C_2	70	89.32	6.64
	P_7C_3	96	95.47	7.41
Mean			163.40	6.15
SD			100.76	1.06
CV			61.67	17.20
8	P_8A	12	197.06	5.12
	P_8C_1	52	197.06	5.73
	P_8C_2	76	67.58	5.8
	P_8C_3	96	42.56	6.64
mean			126.07	5.82
SD			82.61	0.62
CV			65.53	10.73

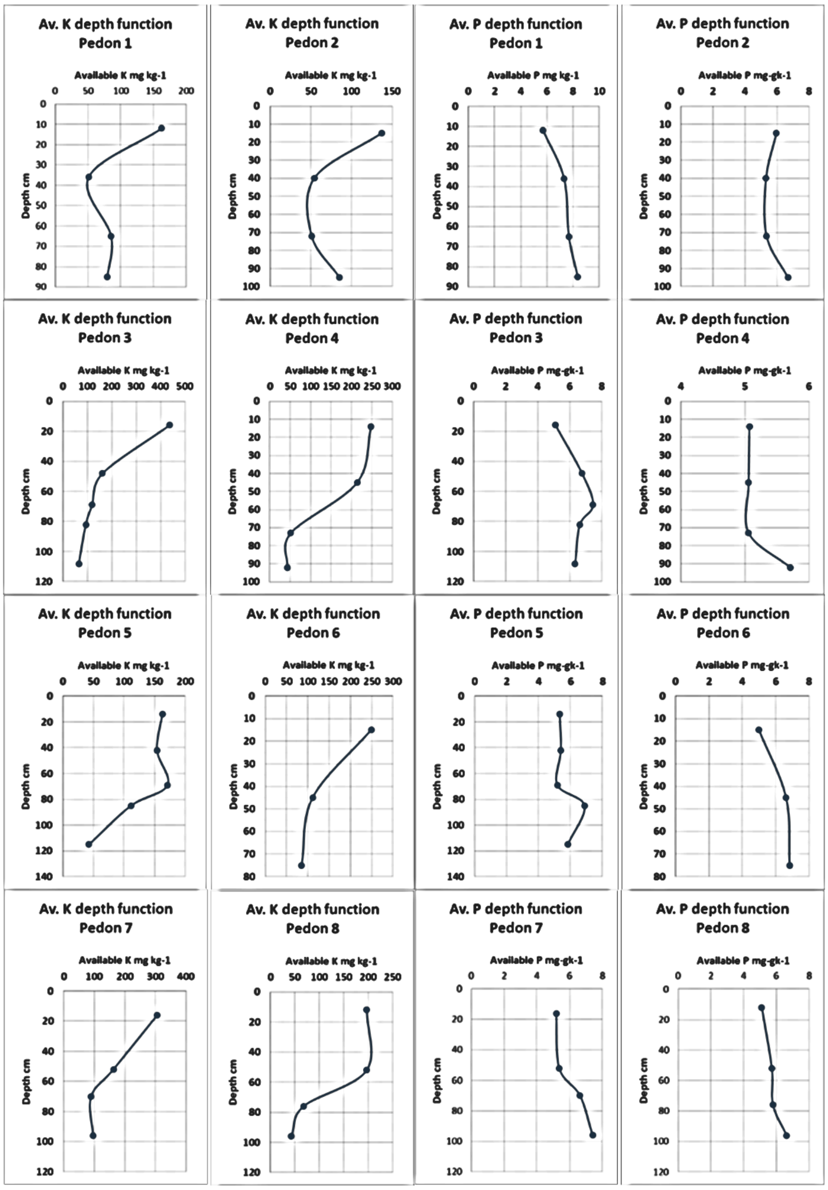


Fig. (4): Available potassium and phosphorus in term of depth function

Available potassium and phosphorus in relation to soil properties: Figure 5 indicates that there was a significant positive relationship of available potassium with ECe, and EPS. Where values of coefficient of determination R2 was 0.506 and 0.238 (p<0.01, <0.05) respectively, where that refers to the fact of the higher accumulation of salts the higher content of available potassium. The relationship of available potassium shoed lower significance level due to the antagonism effect of sodium on potassium activity in saline soil solution and exchange complexes Hayward & Wadleigh, (1949), Ahmed & Jabeen, (2005), Cheng *et al*., (2024).

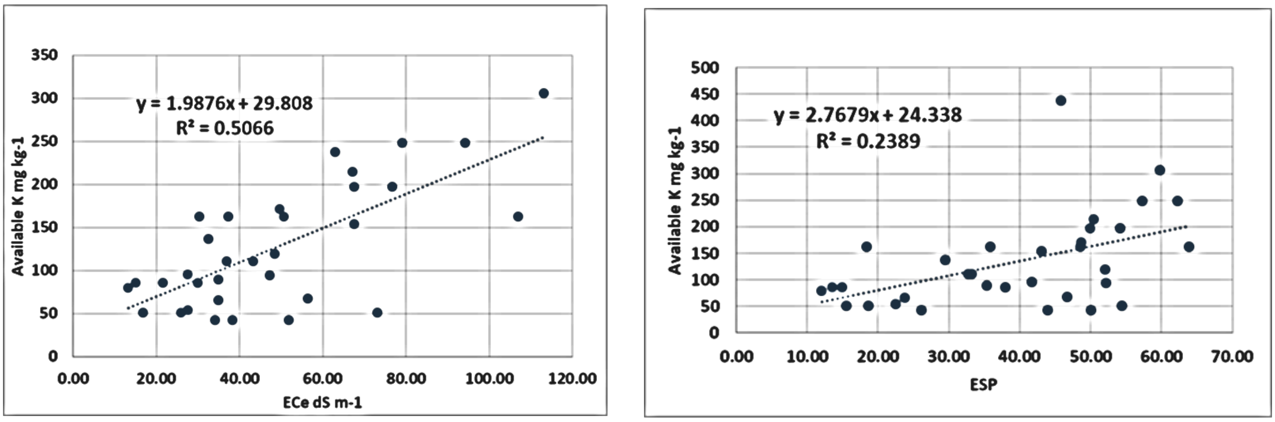


Fig. (5): Relationship of available potassium with ECe and ESP

On the contrary, available phosphorus behaviour was the opposite, where there was a significant negative relationship with ECe and ESP (R2= 0.394 and 0.258, $p<0.05$), respectively, (figure 6). That indicates that the more salt accumulation and sodium in soil the more fixation of phosphorus occur in soil Liu *et al*., (2024) and Huo *et al*., (2023).

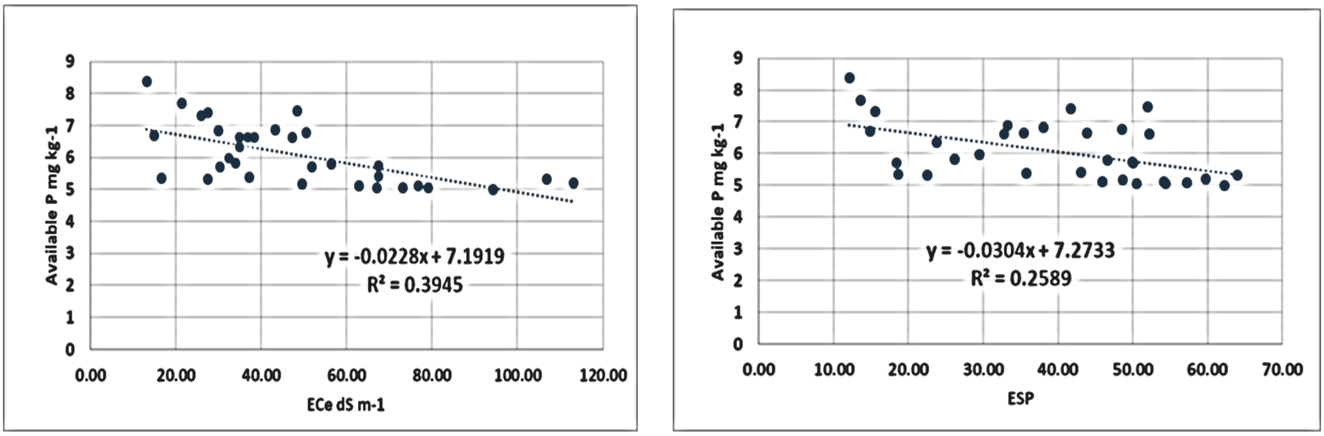


Fig. (6): Relationship of available phosphorus with ECe and ESP

Conclusion

strongly saline soils showed different amount of available potassium and phosphorus, also, the distribution of these available nutrients in soil with depth reflected different behaviour than the regular behaviours of their distribution in none saline soils. Despite the salinization phase, salt accumulation in term of ECe and ESP showed an impact on the content of available potassium and phosphorus.

Acknowledgements

We extend our sincere gratitude to the head and staff of the Department of Soil Science and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad, for granting us the opportunity to carry out this project.

Contributions of authors

K.A.W.: wrote, reviewed, and translated the research, conducted the statistical analysis.

A.K.A.: analyzed the soil samples and printed the research.

H.A.I.: reviewed the results, and published the research.

W.T.K.: provided the samples, prepared them for analysis, contributed to the laboratory work, and printed the figures and tables.

ORCID

H.A.I.: https://orcid.org/0000-0002-4177-1878

Conflicts of interest

The authors declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Ethical approval

This study did not involve human participants, animals, or sensitive personal data. Therefore, ethical approval was not required.

References

Abbas, M., & Wheib, K. A. (2021). Effect of spatial variability of some soil hydrological and physical properties in the distribution of some nutrients of Kifel-Shanafiya Project/Iraq. *AGRIS - International System for Agricultural Science and Technology*. The Arab Center for the Studies of Arid Zones and Dry Lands. FAO. [DOI: Not Available]

Ahmad, R. A. F. I. Q., & Jabeen, R. (2005). Foliar spray of mineral elements antagonistic to sodium—a technique to induce salt tolerance in plants growing under saline conditions. *Pakistan Journal of Botany, 37*(4), 913.

Bayati, A.H.I., Hammad, J.A., Majdoub, R. & Jabbar, S.A., 2025, February. Pedological Study and Productive Capacity of Some Soils Within the Euphrates River Sediments at The City of Al-Ramadi in Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1449, No. 1, p. 012097). IOP Publishing.

Al-Hadethi, A. A. (2024). Yield and its components of corn at saline sodic soil washed with enriched water by a combination of phosphogypsum and humic acids. *Iraqi Journal of Agricultural Sciences, 55*(4), 1475–1485

Al-Jaff, B. O. (2024). Using center of gravity equation for mica and smectite in evaluation of K-status in some soils of Iraqi Kurdistan Region. *Iraqi Journal of Agricultural Sciences, 55*(3), 1110–1119.

Al-Jubory, H. H., & Al-Khafaji, Q. D. (2024). Reactions of potassium adsorption and availability in saline soils within Nineveh Governorate, Iraq. *Asian Journal of Soil Science and Plant Nutrition, 10*(4), 604–614.

Al-Jubouri, A. K., & Wheib, K. A. (2020). Effect of soil salinity on spectral reflectance of red and NIR wavelengths in AL-Salamiyat project. *Plant Archives, 20*(2).

Al-najar, M.A.H. & Abbas, K.I., 2009. Effect of availability some elements in different soil in Basrah regions on some properties of date palm phoenix dactylifera (l.) Fruits cv sayer. *Basrah journal of agricultural Sciences*, *22*(2).

Al-Zubaidi, A. H. (1989). *Soil salinity - Theoretical and applied foundations.* Ministry of Education and Scientific Research, University of Baghdad.

Anderson, D. (2010). Solonetzic soils of the Prairie Region. *PSandC Prairie Soils and Crops Journal, 3*, 65–72.

Black, C. A. (1965). *Methods of soil analysis part 1: Physical properties.* American Society of Agronomy, Inc., Madison, Wisconsin, USA.

Burt, R., Soil Survey Staff (2014) Kellogg soil survey laboratory methods manual. *United States department of agriculture (USDA), natural resources conservation service (NRCS), soil survey investigations report*, *42*.

Cheng, Y., Zhang, T., Gao, W., Kuang, Y., Liang, Q., Feng, H., & Galymzhan, S. (2024). An excessive K/Na ratio in soil solutions impairs the seedling establishment of sunflower (*Helianthus annuus* L.) through reducing the leaf Mg concentration and photosynthesis. *Agronomy, 14*(10), 2301. https://doi.org/10.3390/agronomy14102301

Day, P. R. (1965). Particle fractionation and particle-size analysis. In *Methods of Soil Analysis: Part 1 Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling* (9th ed., pp. 545–567).

Farahmand, A., Oustan, S., Jafarzadeh, A., & Aliasgharzad, N. (2012). Salinity and sodicity parameters in some salt-affected soils of Tabriz plain. *Water and Soil Science, 22*(1), 1–15.

Gharaibeh, M. A., Albalasmeh, A. A., Pratt, C., & El Hanandeh, A. (2021). Estimation of exchangeable sodium percentage from sodium adsorption ratio of salt-affected soils using traditional and dilution extracts, saturation percentage, electrical conductivity, and generalized regression neural networks. *Catena, 205*, 105466. https://doi.org/10.1016/j.catena.2021.105466

LaBarge, G. (2022). Developing phosphorus and potassium recommendations for field crops. *Ohio State University Extension, Agriculture and Natural Resources.*

Guan, X., Chen, J., Liu, G., & Wang, X. (2024). Soil phosphorus forms in saline soil after the application of biomass materials. *Agronomy, 14*(2), 255. https://doi.org/10.3390/agronomy14020255

Hashem, A., Abd_Allah, E. F., Alqarawi, A. A., Al Huqail, A. A., & Egamberdieva, D. (2014). Alleviation of abiotic salt stress in *Ochradenus baccatus* (Del.) by *Trichoderma hamatum* (Bonord.) Bainier. *Journal of Plant Interactions, 9*(1), 857–868. https://doi.org/10.1080/17429145.2014.913303

Hayward, H. E., & Wadleigh, C. H. (1949). Plant growth on saline and alkali soils. *Advances in Agronomy, 1*, 1–38.

Hossain, M. S. (2019). Present scenario of global salt-affected soils, its management and importance of salinity research. *International Research Journal of Biological Sciences, 1*, 1–3.

Huo, W., Peng, Y., Maimaitiaili, B., Batchelor, W. D., & Feng, G. (2023). Phosphorus fertilizer recommendation based on minimum soil surplus for cotton growing in salt-affected soils. *Field Crops Research, 291*, 108799. https://doi.org/10.1016/j.fcr.2023.108799

ICARDA. (2014). *Managing soil salinity to boost food security*. https://www.icarda.org

Kargas, G., Londra, P. & Sgoubopoulou, A., (2020). Comparison of soil EC values from methods based on 1: 1 and 1: 5 soil to water ratios and ECe from saturated paste extract-based method. *Water*, *12*(4), p.1010.

Liu, T., Dong, X., Guo, K., Wang, J., Liu, X., & Sun, H. (2024). Effects of fertilizer types and application levels on phosphorus availability of saline soils and crops: A meta-analysis. *Land Degradation and Development, 35*(13), 4068–4080. https://doi.org/10.1002/ldr.3889

Mahdee, H.S., Ati, A.S. & Rahim, B.R., 2023, December. Role of clay minerals on saturated hydraulic conductivity in different region of Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1262, No. 8, p. 082006). IOP Publishing.

Mahmood, I. A., Arshad Ali, A. A., Muhammad Aslam, M. A., &Armghan Shahzad, A. S., Tariq Sultan, T. S., & Fayyaz Hussain, F. H. (2013). Phosphorus availability in different salt-affected soils as influenced by crop residue incorporation.

Mahmoud, M. A., & Al-Rubaai, S. M. (2019). Evaluation of the potassium availability in saline soils using the traditional chemical criterion. *Biochemical and Cellular Archives, 19*(1).

Mam-Rasul, G. A. (2020). Potassium adsorption in calcareous soils of Kurdistan region of Iraq. *Iraqi Journal of Agricultural Sciences, 51*(Special).

Mehfooz, M., Bibi, S., Irshad, M., Hussain, Z., Mohiuddin, M., & An, P. (2023). Phosphorus extractability from saline and non-saline soils using different extraction methods. *Arabian Journal of Geosciences, 16*(3), 164. https://doi.org/10.1007/s12517-023-09849-4

Microsoft Corporation. (2016). *Microsoft Excel*. https://office.microsoft.com/excel

Naser, R. S., & Wheib, K. A. (2022). Effect of salt composition on spectral reflectance and salinity indices of soil. *Indian Journal of Ecology, 49* Special Issue (20), 75–82.

Osman, K.T. & Osman, K.T (2018). Saline and sodic soils. *Management of soil problems*, pp.255-298.

Qadir, M., Ghafoor, A. and Murtaza, G., (2000). Amelioration strategies for saline soils: a review. *Land Degradation and Development*, *11*(6), pp.501-521.

Reddi, B. A. (2013). Why is saline so acidic (and does it really matter?). *International Journal of Medical Sciences, 10*(6), 747. https://doi.org/10.7151/ijms.v10i6.7529

Richards, L. A. (1954). *Diagnosis and improvement of saline and alkali soils* (No. 60). Soil and Water Conservation Research Branch, Agricultural Research Service, U.S. Department of Agriculture.

Saleh, S.M., Sultan, S.M & Dheyab, A.H., (2019). Study of morphological, physical and chemical characteristics of salt affected soils using remote sensing technologies at Basrah Province. *Basrah Journal of Agricultural Sciences*, *32*, pp.105-125.

University of Minnesota Extension. (2024). *Potassium for crop production*. https://extension.umn.edu

Wakeel, A., (2013). Potassium–sodium interactions in soil and plant under saline-sodic conditions. *Journal of Plant Nutrition and Soil Science*, *176*(3), pp.344-354.

Wheib, K. A., & Ibrahim, O. N. (2012). Study of morphological and micromorphological properties of some salt-affected soil in the middle of Iraq. *Iraqi Journal of Agricultural Sciences, 43*, 106–118.

Wong, V. N., Greene, R. S. B., Dalal, R. C., & Murphy, B. W. (2010). Soil carbon dynamics in saline and sodic soils: A review. *Soil Use and Management, 26*(1), 2–11. https://doi.org/10.1111/j.1475-2743.2009.00258.x

Zaman, M., Shahid, S. A., Heng, L., Shahid, S. A., Zaman, M., & Heng, L. (2018). Introduction to soil salinity, sodicity, and diagnostic techniques. In *Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques* (pp. 1–42).

دالة عمق توزيع الفسفور والبوتاسيوم الجاهز في بعض الترب المتملحة من وسط السهل الرسوبي العراقي

قصي عبد الرزاق وهيب وافراح كاظم سلمان وحسين عبد علي عيسى ووجدان طالب كاظم

قسم علوم التربة والموارد المائية، كلية علوم الهندسة الزراعية، جامعة بغداد

المستخلص: تم اختيار بعض الترب المتملحة في منطقة الصويرة الواسعة والتي تمثل بعض ترب السهل الرسوبي العراقي المتملحة لدراسة تأثير تراكم الاملاح على البوتاسيوم والفوسفور الجاهزين في التربة كدالة عمق. تم تحديد مسار شريطي التي تمثل مناطق شديدة التأثر بالملح وتم اختيار عينات التربة على طول هذا المسار. أظهرت النتائج أن مراحل تملح التربة في المنطقة كانت ملوحة كلوريدية وكبريتية، وبالتالي فقد أثرت على توزيع الملح في التربة. كان المركب الملحي الأكثر هيمنة هو كلوريد الصوديوم في الترب الملحية الكلوريدية، بينما كان كبريتات الصوديوم هو المركب الملحي السائد في مناطق التملح الكبريتي. أظهرت النتائج أن محتوى الفوسفور الجاهز كان منخفضًا إلى حد ما بينما أظهر البوتاسيوم الجاهز مديات مختلفة في التربة. كان البوتاسيوم الجاهز مرتبطًا بشكل إيجابي ومعنوي بالايصالية الكهربائية (ECe) بينما كان الفوسفور المتاح مرتبطًا بشكل سلبي بشكل كبير بالايصالية الكهربائية (ECe). وقد تم حساب هذه النتائج كدوال عمق لهذه العناصر الغذائية الجاهزة في التربة حيث كان أعلى محتوى من البوتاسيوم الجاهز في الأفق العلوي يتناقص مع العمق، في حين أظهر الفوسفور الجاهز انخفاضًا كبيرًا مع انخفاض ملوحة التربة مع العمق.

الكلمات المفتاحية: تملح التربة، طور التملح، توزيع الاملاح، الفسفور الجاهز، البوتاسيوم الجاهز.