Evaluation of Some Chemical and Physical Properties of Soils in Duhok City for Agricultural Purposes.

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Abstract

Improving soil fertility and returning nutrients that plants have absorbed into the soil are two fundamental components of sustainable crop production. To evaluate the soils of four different areas in Duhok-Atrosh, Amedi, Badi, and Semel research was conducted. To evaluate these soils for agricultural viability, several crucial factors must be considered, such as pH levels, salinity, and nutrient availability. Kurdistan's agricultural practitioners and policymakers may make educated judgments on land use planning, soil management techniques, and the advancement of sustainable agricultural development by carrying out a thorough evaluation of these factors. For Kurdistan's agricultural soils to remain productive over the long term and to adjust to changing environmental conditions, ongoing research and monitoring are essential. According to our research, soil acidity (pH) and fertility, including the amount of accessible nitrogen and organic matter, are suitable for agriculture in all four sites. Interestingly, though, the Atrosh soil had the highest amount of magnesium while the Amedi had the highest concentration of calcium and potassium. Amedi's low bulk density and high calcium and clay content make it suitable for intensive agriculture. Atrosh is productive, but it needs to be controlled because of its high bulk density. For improved fertility and structure, Badi and Semel need to increase their organic matter.

Keywords: Soil fertility ,Soil properties, NPK, Electrical conductivity (EC) ,SAR

Introduction

Soil is considered a fundamental element in agricultural production. therefore, soil Evaluation of its potential for specific uses are essential for any land evaluation. The quest for agricultural expansion necessitates a multifaceted approach, one that extends beyond traditional boundaries to explore new frontiers of productivity. Central to this pursuit is the identification and utilization of new soils, alongside enhancing the efficiency of existing ones. Although Kurdistan has a wide variety of soil types due to its diverse topography, a thorough grasp of their characteristics, constraints, and management techniques is necessary to realize their full potential [1].

Furthermore, the necessity to maximize the use of current soils grows more urgent as agricultural demands rise. In addition to increasing output, improving the efficiency of older soils through sustainable management techniques protects against soil erosion, deterioration, and the loss of vital nutrients. As a result, Kurdistan's agricultural growth requires a calculated combination of innovation, exploration, and stewardship, with soils acting as the primary Substrate on which this process is based [3].To maximize agricultural techniques and guarantee sustainable crop production, it is imperative that the chemical and physical characteristics of the soils in Duhok City be evaluated. Variable organic matter concentration, varying textures, including sand, silt, and clay fractions, and slightly moderate alkalinity are typical properties of the soils in this area. Important chemical parameters that impact crop production potential and soil fertility include soil pH, electrical conductivity (EC), organic matter (OM), total nitrogen (TN), accessible phosphorus (P), and potassium [14].It has been discovered that these traits differ geographically, highlighting the need for site-specific soil management strategies [19]. Physical attributes including bulk density and texture affect root penetration, aeration, and water retention [18].

This study aims to evaluate the agricultural potential of soils from four distinct locations in the Kurdistan province of Duhok: Atrosh, Amedi, Badi, and Semel. Through a comprehensive assessment of key soil properties such as pH, salinity, and fertility, the study seeks to identify location-specific differences in these properties and their implications for agricultural use. The research aims to assist the primary objective of fostering resilience, food security, and agricultural growth in Kurdistan through these activities.

Materials and methods

Study area

This study was conducted in the Duhok governorate, Kurdistan region, north of Iraq (figure.1). Geographically, this area is enclosed between latitude 36˚50'11" N and longitude 43˚20'08" E. Soil samples (NO. and table of coordinates) were collected from different farmland locations, including Atroh, Amedi, Badi, and Semel. We were collected at a depth 0-30 cm using shovel.
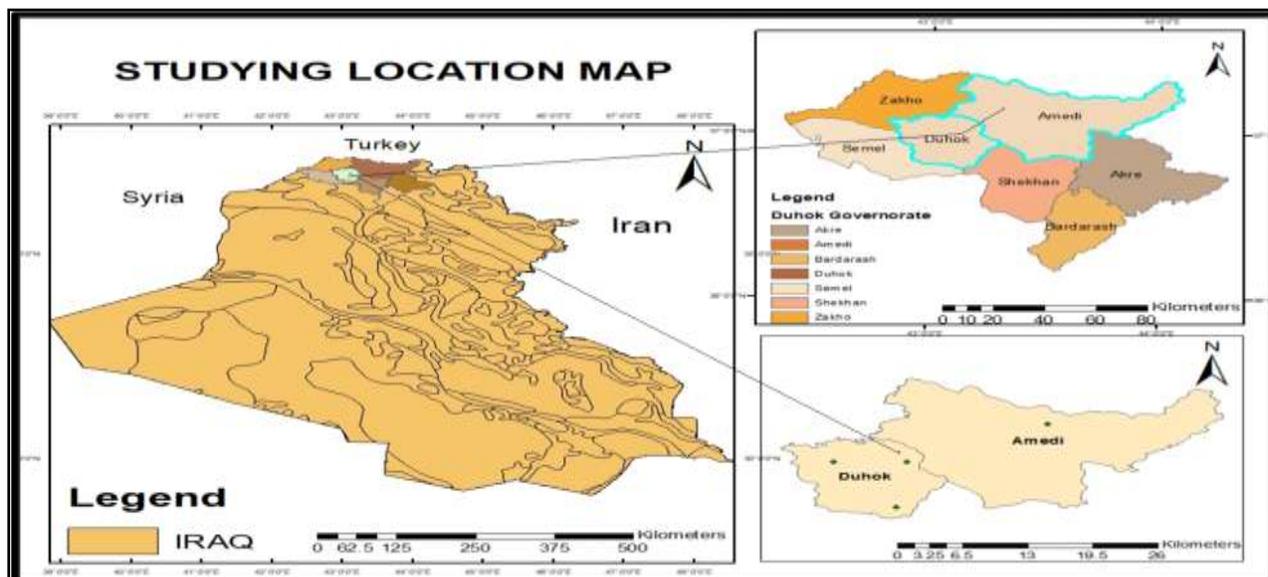
Figure1. The map illustrates the location of studied soil samples.

Laboratory analysis

Four different Soils were collected from distinct agricultural locations, (Atroh, Amedi, Badi, and Semel).Samples of soil were brought to the laboratory, allowed air dry, and then sieved through a 2 mm sieve to determine certain physical and chemical characteristics. For the purpose to confirm quality and accuracy, every sample was examined three times. The following parameters were measured: pH, electrical conductivity (EC), bicarbonate (HCO_3^-), and the main cations: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), Cl-, O.M., SAR, and NPK.

Analytical procedures were briefly explained as follows: pH was measured using a professional Bench top PH meter model (BP3001) as stated by [13].Electrical Conductivity (EC) was measured using a conductivity meter model (BC3020) and expressed by $ds.m^{-1}$ in accordance with [23].Major Cations: EBT was used as an indicator versenate technique, and calcium and magnesium were measured by titration using (EDTA 2Na) (0.01N) in the presence of murexide (ammonium purpurate) [23]. Sodium (Na^+) and potassium (K^+) were measured using the JENWAY/PFP7 flame photometry model. Bicarbonate (HCO_3^-) was evaluated by titrating 0.02N HCl with phenolphthalein as an indicator, and chloride was assessed by titrating $AgNO_3$ (0.05N) with potassium chromate (K_2CrO_4) as an indicator [10].The Walkley and Black method was used to determine the O.M [5].Using magnesium oxide (MgO) and potassium chloride solution (2N KCl), the soil's available nitrogen was determined. Using the Macro Kjeldahl digestion–distillation process, nitrate ions were reduced to ammonium (NH4) using Devarda alloy, distilled, and titrated with diluted hydrochloric acid (N 0.01) [8].

Accessible Using sodium bicarbonate (NaHCO3 0.5N) at pH 8.5, phosphorus (P) was extracted. Ascorbic acid and molybdate-ammonium were used to create the color, and a spectrophotometer set to 882 nm was

used to test the phosphorus level in accordance with Olsen's method. A flame photometer was used to measure the amount of potassium in the extract. The sodium adsorption ratio (SAR) measures the concentrations of sodium, calcium, and magnesium ions in a solution. The bulk density was measured using the paraffin wax method [16], and the particle size distribution was measured using a hydrometer [24]. Sodium adsorption ratio SAR involves the concentrations of sodium, calcium, and magnesium ions in a solution. It is typically expressed by the following equation according to [22].

The following equation is commonly used to express it, according to [22].

Results And Discussion

A thorough summary of the physical and chemical characteristics of the soils from the regions under study is given in Tables 1 to 3. Data on important physical attributes such bulk density, color, and texture are included in Table 1. Significant changes in texture, texture, and bulk density are found among the locations under study. All the soil samples' clay textures showed significant water retention but perhaps insufficient drainage. Semel (brown), Badi (reddish brown), Amedi (grayish brown), and Atrosh (dark gray) were the colors that

$$SAR = (Na) / \sqrt{(Ca + Mg)/2}$$

The cation concentrations are expressed in $(mmolc\ L^{-1})^{0.5}$

Statistical analysis

To identify important variations in soil characteristics. Here, we should discuss the procedure. To determine the link between the parameters SAR, Na, NPK, and other physiochemical features of the soils under study, correlation and regression were employed. The Minitab software program (22) was utilized for this purpose.

were distinguished. The color of the soil can reveal the amount of organic matter and mineral makeup [11].

The bulk density was 1.15 g/cm³ in Amedi and 1.61 g/cm³ in Atrosh. A high bulk density in Atrosh may indicate compaction or a decrease in organic matter, which could limit root growth and water infiltration [18].These differences may have an impact on the overall suitability for agricultural use, nutrient availability, and soil fertility.

Table 1. some physical properties of studied soils

Semel	Badi	Amedi	Atrosh	Units	Parameters
89	394	79	184	g kg⁻¹	**Sand**
227	205	355	385		**Silt**
684	401	566	431		**Clay**

CL	CL	CL	CL	**Texture class**	
brown	Redish brown	grayish brown	dark gray	**Colure**	
1.31	1.35	1.15	1.61	g/cm^3	**Bulk density (pb)**

According to Table (2)'s findings, the pH values were neutral everywhere; the soil's pH ranged from 7.29 to 7.73. As is common for calcareous soils in semi-arid regions, the soils in Amedi and Badi, respectively, were alkaline. Soils are inherited from the parent materials of CaCO3 [7]. because of the study area's high calcium carbonate content, which resists pH changes in the soil, little

Nonetheless, most of these samples were generally suitable for agricultural use and had extremely low electrical conductivity ratings.

The soluble and total extractable nutrients in the soils under study, such as sodium (Na$^+$), potassium (K$^+$), calcium (Ca^{+2}), magnesium (Mg^{+2}), chloride (Cl$^-$), carbonate, and bicarbonate (HCO3), are shown in Table 2. Variations in soil fertility and nitrogen cycling mechanisms are shown by the notable disparities in nutrient levels among the regions under study. Optimizing agricultural output and putting targeted fertilization tactics into practice require an understanding of these nutrient dynamics [2].

Although Semel had the highest value (0.34 mmolc L$^-$ ^{1}), all the soils had low amounts of Na$^+$, which was still within acceptable bounds and had a good structure for plant growth. Amedi's greatest K$^+$ (1.50 mmolc L$^-$ ^{1}) indicates good potassium availability, most likely due to parent

rainfall, and protracted dry spells. These findings agree with the results published by [26]. The EC values of 0.26 to 0.56 dS.m$^-$ ^{1} indicate that the soils in the Duhok area are not saline as a result. EC values < 0.6 dS.m$^-$ ^{1} were found in all samples, indicating non-saline conditions. However, Amedi had the highest EC (0.56 dS.m$^-$ ^{1}), suggesting localized salt deposition [16].

material or fertilization history. Amedi's high calcium content (2.5 mmolc L$^-$ ^{1}) contributes to its favorable fertility status. Due to either limited leaching or the impact of dolomitic rock, Atrosh has the highest concentration of magnesium (1.5 mmolc L$^-$ ^{1}) [27]. The high K$^+$ and Ca^{2+} levels in Amedi soil indicate significant potential for plant nutrient delivery, whereas the elevated Mg^{2+} in Atrosh may affect the Ca: Mg balance and require crop-specific sensitivity monitoring [12].The findings show that the bicarbonate (HCO3) level in the soils under study varied from 2.00 to 6.00 mmolc L^{-1}. Magnesium and calcium are sufficient for plant growth, particularly in Amedi.

According to the findings, the organic matter concentration of the soils under study varied between 0.39 and 2.63% in Badi and Atroshi, respectively. Because of the dry climate, limited rainfall, high temperatures, and decreased supplies of organic matter and nutrients from outside sources, there was variation in the amounts of organic matter in all soils. This is consistent with the findings of This aligns with [21]. Because of the

buildup of vegetative materials, the Atroshi area had the highest value. These findings align with the findings of [16].

Table 2. **Some chemical properties of the studied soils**

Semel	Badi	Amedi	Atrosh	Units	Parameters
7.60	7.73	7.29	7.52	1:2 extract	pH
0.29	0.27	0.56	0.26	$ds.m^{-1}$	EC
0.34	0.15	0.23	0.11		Na^+
0.71	0.73	1.50	1.26		K^+
1.1	1.00	2.5	0.5		Ca^{+2}
1.00	1.00	0.9	1.5	Soluble ions $mmol_c\,L^{-1}$	Mg^{+2}
2.00	4.00	2.00	6.00		HCO_3^{-1}
0.00	0.00	0.00	0.00		CO_3^{-2}
1.00	0.5	0.6	0.5		Cl^{-1}
0.42	0.39	1.28	2.63	%	O.M
0.33	0.15	0.17	0.11	$(mmol_c\,L^{-1})^{0.5}$	SAR
167.6	143.4	181.37	126.5	$g\,kg^{-1}$	$CaCO_3$

Table 3 presents correlation coefficients between various soil properties, providing insights into relationships and interactions among different variables. For example, correlations between Na^+, SAR, Sand , Silt , Clay , $CaCO_3$, and P the interconnectedness of soil physio-chemical properties. There were significantly and positively intercorrelated ($P< 0.05$) while Na^+ and SAR were more strongly and positively correlated ($P< 0.01$). Sand was not significantly related to any of the other characteristics.

Table 3.The relationship (r) between some physical and chemical properties of studied soils.

CaCO₃	Clay	Silt	Sand	SAR	Na⁺	O.M	
						-0.713	Na⁺
					0.823**	-0.633	SAR
				-0.463	-0.229	-0.226	Sand
			-0.473	-0.548	-0.622	0.912**	Silt
		-0.161	-0.793	0.897**	0.686*	-0.377	Clay
	0.750**	-0.120	-0.596	0.561	0.530	-0.506	CaCO₃
0.600*	0.451	0.717**	-0.845	0.010	-0.096	0.386	P

Furthermore,[9]found a significant correlation between SAR and Na, which they justified by citing soluble salts in soil solution (EC) and Na as the dominating cation. Their findings, however, were greater (3.58 − 9.69) than that found in the current investigation.

The SAR ranges from 0.11 to 0.33 (mmolc $L^{-1})^{0.5}$, with the maximum values of 0.33(mmolc $L^{-1})^{0.5}$ for Atrosh and Semel, respectively. The fact that 0.5 was found in Semel soil indicates that the soil in the Duhok region is not saline. The findings concurred with those of [4]who discovered SAR values ranging from 0.46 to 3.43

(mmolc $L^{-1})^{0.5}$ for non-saline soils. High exchangeable Na on clay particles may be the cause of this, as it raises the concentration of Na in the liquid phase and raises SAR[6]. [17] state that irrigation with water with SAR > 8 is generally not advised, however values of SAR in the range of 6–8 create issues that can be resolved with gypsum. In figure 9, [22] suggests that if there are no cations that save Ca, Na will occupy roughly 10% of the exchange sites, resulting in a SAR of 8. When integrating data from four soils, the p-value was less than (p<0.01), indicating a highly significant relationship between Na and SAR (figure 2).
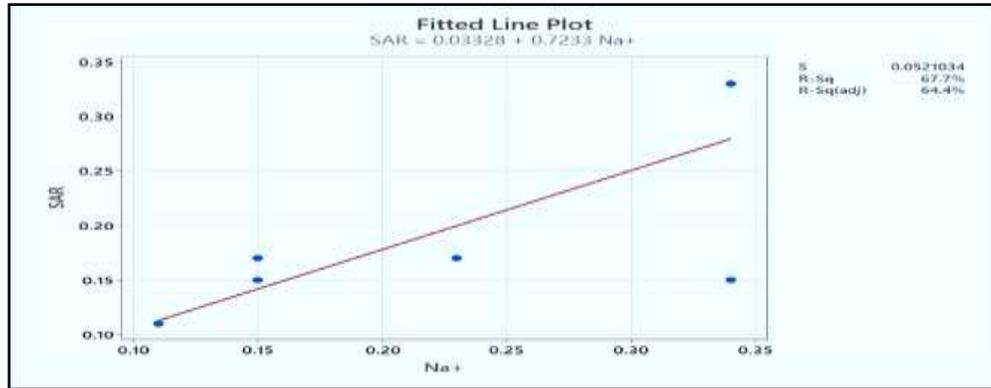
Figure 2. Relationship between the sodium (Na) and sodium adsorption ratio (SAR) for the studied soils .

Figure 3 displays the nitrogen (N), phosphorus (P), and potassium (K) soil levels in parts per million (ppm) for four Kurdistan locations: Atrosh, Amedi, Badi, and Semel. The amount of nitrogen that is available in soil varies greatly, ranging from 25.48 to 51 parts per million. Badi has the lowest available N (25.48 ppm), whereas Amedi has the most (51 ppm). The findings concurred with those of [20].whose findings were higher (20–80) than those of the present investigation.
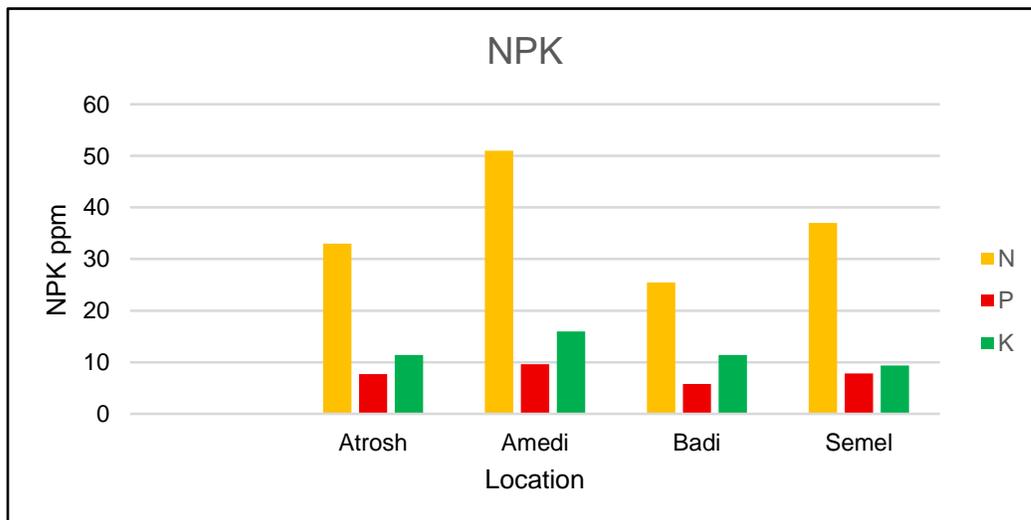

Figure 3. illustrates the available N,P, and K of studied soil.

Low available phosphorus, ranging from roughly 4 to 10 ppm (Olsen-P technique), is a prevalent characteristic of Duhok soils, particularly in the region's typical calcareous and alkaline soils. It is confirmed that all locations, including those in the Duhok area, exhibit P levels that can limit plant absorption, especially under high pH circumstances that diminish P availability,

because the available P values observed between 5.79 and 9.63 ppm fit within this known range. These observations agree with [14].Our findings indicate that the strong relationship between calcium carbonate (CaCO$_3$) and phosphorus (P) p-values less than 0.05 because our soils are calcareous soil, as shown in figure 4.
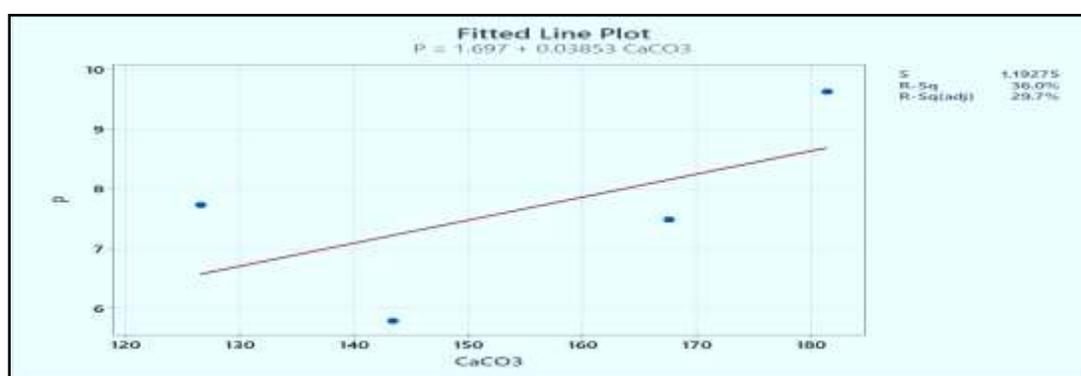
Figure 4. Relationship between the calcium carbonate (CaCO$_3$) and phosphorus (P) for the   studied soils .

Furthermore, the potassium (K) values ranged from 9.36 to 15.99 parts per million. There was a low rate of soluble K. The results agreed with [16]. In the investigation , the soil's potassium content dramatically dropped. The fact that plant roots absorb more potassium from the area close to their roots than from the area farther away may help to explain this. Conversely, it could be the consequence of increased microbial activity in general. These findings are consistent with those of [25].

According to the results recorded for Duhok and the surrounding areas, the figure supports recognized tendencies of low to moderate N and P and comparatively low K in Kurdistan's soils. Of the four, Amedi has the highest nutrient availability, indicating that even within Duhok province, local factors (soil type, organic matter, and management history) can significantly alter nutrient availability.

Conclusion

In the studied region, the distribution of all soil parameters was normal. In this study, the percentage of organic matter, clay, sand, available nitrogen, available phosphorus, and available potassium exhibited considerable regional dependence, while the pH, EC, and silt percentage showed moderate spatial dependence. Given that phosphate and potassium are generally insufficient in Duhok soils, all the places listed in the table should be regarded as possibilities for balanced fertilization. Enhancing nutrient availability and overall soil fertility can be achieved through crop rotation, adding organic matter, and controlling soil pH. The study also emphasizes the necessity of ongoing investigation and observation to adjust to changing environmental circumstances and guarantee the agricultural soils of Kurdistan's long-term sustainability.

Conflict of interest

The Authors do not declare conflict of interest.

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