PHOSPHORUS FRACTIONS AS CORRELATED TO SOME SOIL PROPERTIES IN SOME SOIL SERIES OF EGYPT

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ABSTRACT

Characterization study were carried out to evaluate the relationship between total, organic and inorganic P fractions and some physicochemical properties of six soil series representing the main soil types of Egypt (typic torri fluvents, typic haplucalcids and typic torri psaments). The obtained results could be summarized as follows: The inorganic P fractions, *i.e,* saloid, Al-P, Fe-P, occluded P and Ca-p in soil series varied from 2.85 to 22.8, 30 to 164, 8.2 to 28.0, 24.7 to 130.9, and 121 to 871 mg kg^{-1}, respectively. Ca-P contributed to 71.5 % of total inorganic P and 1.13 % only for saloid P. The abundance of different inorganic P forms was in the order Ca-P> Occluded P > Al-P> Fe-P> saloid P suggesting that, Ca-P and occluded P are the major P fractions to contribute P nutrition by plants. The fractions of Ca-P and Occluded P found to be positively coinciding with CEC and OM and negatively with pH and $CaCO_3$ responsible for P precipitation over P adsorption as $CaCO_3$ and pH increased in soil. Whereas, Al-P fraction were mainly associated with clay and organic matter content of soils. The higher contents of organic P in the soils of Minia and Giza could be due to heavy later addition of P fertilizer and high organic matter as compare to other soil series. The inorganic P fractions contributed to 89.4 % of total P and 10.6 % only for organic P in the studied soil series. Total P content ranged from 255 to 1300 mg kg^{-1} in South Tahrir and Giza. However, available P ranged from 6.65 to 29.2 mg kg^{-1} depending on soil properties. In most soil series, soil content of available P is higher in Giza, Minia and Gazert Uddhab and marginal in Janaklis and South Tahrir. Highly significant positive correlation was found between available and total P of most of the studied soil and each of clay + silt, CEC, OM and available water, whereas significant negative correlation was found with sand and pH.
Keywords: organic P, available P, soil properties, soil series, Al-p, Ca-p, Occluded P.

INTRODUCTION

Phosphorus in organic compounds is held by covalent bonds so it can not be ionized. Phosphorus divided according to Barber (1984) into: (1) phosphorus as ions and compounds in the soil solution; (2) phosphorus adsorbed on the surface of inorganic soil constituents; (3) phosphorus minerals both crystalline and amorphous; and (4) phosphorus as a component of soil organic matter. Mengel and Kirkby (1987) stated that, from the viewpoint of plant nutrition, there are three main soil phosphate fractions. The first fraction is the phosphate dissolved in soil solution. The second fraction is the phosphate in the labile pool, which is the solid phosphate and held on surfaces so that it is in rapid equilibrium with soil solution phosphate. The third fraction is the insoluble phosphate and can be released very slowly into the labile fraction. Jungk *et al.* (1993) mentioned that the major fractions of soil P known to contribute to P nutrition of plants are sorbed P, Ca-P; mainly P compounds of apatite nature, and organic P. The acquisition of these P sources may depend on plant species and soil type. Xiufu and Yost (2004) showed that only strip-P, inorganic, and organic of the seven fractions

were necessary and sufficient to describe the P dynamics in Mollisol, Vertisol, Ultisol, and Oxisol. Concepción and Delgado (2005) studied P forms by sequential chemical fractionation in soils typical of Mediterranean areas, establishing correlations between P fractions and soil properties. The ratio of the P fraction, which includes the more labile P forms (essentially adsorbed) to combined non-organic P fractions was negatively correlated with soil pH and positively correlated with the portion of combined Fe fractions related to poorly crystalline oxides. Adhami *et al.* (2006) reported that, the abundance of different P forms was in the order Ca_2-P<Fe-P<AL-P<O-P<Ca-P. Ca_2-P was highly correlated with Olsen-P and Exch-P. Ca_2-P, Olsen-P, and Exch-P showed a relationship with CEC, citrate–bicarbonate–dithionite extractable Fe, and Al in highly calcareous soils of Iran. Al-P and Fe-P accounted for 10 and 5 % of the sum of the inorganic P fractions, respectively, and Fe-P showed a strong relationship with Fe oxides, whereas Al-P showed a significant relationship with oxalate-extractable Al.

The present investigation was undertaken to study: (i) determination of P fractions in soil using sequential fractionation methods and (ii) the relationships between the P fractions and some physicochemical properties of different soil series of some Egyptian governorates.

MATERIALS AND METHODS

1. Sampling:

Six soils, representing a wide range in physicochemical properties of some soil series of some governorates of Egypt, *i.e,* Giza (Experimental farm, Cairo university and Gazerat Uddahab), Minia (Malawi district), Boheirah (Janakils, South Tahrir and North Tahrir) were sampled from 0 to 15 cm in depth, and mixed. The soil samples were composted from three sub-samples. The soils were dried and ground to pass 0.84-mm sieve, and used for different measurements.

2. ANALYSIS:

a) Physical analysis: such as particles size distribution, bulk density, field capacity and welting point were carried out according to stander methods of **Rebecca (2004).** Soil available water capacity was calculated as the difference between the matrix potentials of -0.03 and -1.5 MPa.

b) Chemical analysis: total soluble salts, pH, EC, exchangeable Na^+ , K^+, Ca^{++}, and Mg^{++}, cation exchange capacity, $CaCO_3$ and organic matter were determined according to **Rebecca (2004).**

c) Soil phosphorus fractionation: soil sample were sequentially extracted for inorganic fractions using a modified Olsen and Sommers (1982) procedure. Triplicate 0.5 g samples were weighed into 40-ml screw-capped centrifuge tubes, and 30.0 ml of extractant were used for fractionation. The extractants, in sequential order were: (i) 1.0 M NH_4Cl, 30 min shaking to remove saloid P (2) 0.5 N NH_4F, pH 8.5, 24 hrs shaking to remove Al-P (3) 0.1 N NaOH + 1.0 N NaCl, 17 hrs shaking to remove Fe-P (4) Dithionite-Citrate-Bicarbonate, 1 hrs shaking to remove Reductant soluble Fe-P and 1.0 N NaOH + 1.0 N NaCl, 17 hrs shaking to remove Occluded Al-Fe-P, this extraction in total called occluded P (5) the extraction for two time by 0.5 N H_2SO_4, 1 hrs to remove Ca-P. Total soil P was determined by the Na_2CO_3

fusion method. Organic P was calculated as the difference between total P and inorganic P fractions in the extracts. Available P was also extracted by 0.5 M NaHCO$_3$ at pH 8.5 according to Rebecca (2004).

d) Statistical analysis: simple correlation coefficients were computed between different phosphorus fractions and each of soil constituents; namely, sand, silt, clay, CaCO$_3$, OM, EC, CEC, and pH. All statistical analysis were performed using SAS Inst. (1995) and multiple regression analysis were employed to evaluate the relative importance of soil physical and chemical variables as predictors of total measured phosphorus fractions in soil. Statistical significant is reported at the 0.05 and 0.01 probability levels.

RESULTS AND DISCUSSION

1. Characterization of the studied soils

The result of physicochemical properties of the collected soil samples are shown in Table (1). A trial was undertaken to classify the studied soil according to its morphological description and chemical properties (Soil Survey Staff, 1998).

Table 1: Some physicochemical properties of the investigated soils

Taxa. unit	Typic torri Fluvents	Typic torri fluvents	Typic torri fluvents	Typic haplucalc-ids	Typic torri psaments	Typic haplucalc-ids
Soil series	Giza	Gazerat Uddahab	Minia	Janaklis	South Tahrir	North Tahrir
Clay %	29.20	23.60	35.20	12.50	9.80	24.45
Silt %	30.10	26.30	30.60	4.00	2.20	30.34
F. Sand %	36.80	46.50	30.50	40.70	13.40	40.41
C. Sand %	2.20	2.60	1.30	42.80	73.90	1.80
Textural class	Clay loam	Silty loam	Clay loam	Loamy sand	Sand	loam
Field capacity %	47.00	38.30	49.50	30.60	23.90	34.00
Wilting point %	22.90	16.00	19.30	11.00	9.75	15.50
Available water %	24.10	22.30	30.20	19.60	14.15	18.50
Bulk density g/cm^3	1.25	1.31	1.30	1.58	1.70	1.28
pH (1: 2.5)	7.95	7.75	7.85	8.15	8.05	8.20
EC dS m^{-1}	3.15	1.41	3.26	1.70	2.02	2.86
CEC c mol (p$^+$) kg^{-1}	33.24	26.60	31.68	9.53	10.05	15.11
O.M %	1.48	1.16	1.70	0.69	0.85	0.20
CaCO$_3$ %	3.34	2.15	2.85	13.00	0.37	24.50

The mechanical composition of soil sites studied was clay loam for Giza and Minia, loamy sand for Janaklis and sandy for South Tahrir, silty loam for Gezerat Uddhab and Loamy for North Tahrir. The soil solution concentration of phosphorus was influenced by soil texture. Thompson and Troeh (1982) pointed out that fine-textured soils hold more water than coarse-textured soils and are therefore likely to contain more phosphorus in solution. Havlin *et al*., (1999) stated that soils containing large quantities of clay will fix more P than soils with low clay content. The available water in soil was higher in Minia and Giza and lower in North and South Tahrir. Reducing the soil water content decreased phosphorus uptake due to the diminishing the movement of P to root by reducing the thickness of water

films, which increases the diffusion both lengths Gahoonia *et al.*, (1994). The frequency distribution of pH in all examined soil series ranged between 7.75 and 8.20, which indicates that these soils are slightly alkaline to alkaline. The most favorable pH for phosphorus availability is near neutral to slightly acid.

Data on EC showed that the investigated soil series was slightly saline and CEC (C mol. P^+ Kg^{-1}) was low for Janaklis (9.53), South Tahrir (10.05), and North Tahrir (15.11). Whereas, CEC was medium in soil site of Gezerat Uddhab (26.6), Mina (31.68) and Giza (33.24). The organic matter content ranged between 0.2 and 1.70 %. The $CaCO_3$ content varied from 0.37 to 24.5 % in the studied soil series. The distribution pattern of $CaCO_3$ could be attributed to in the origin of soil deposits, as the lowest content exists in the sandy soil in South Tahrir, while the highest one was found in the calcareous deposits in North Tharir. Calcium carbonate plays an important role in P immobilization and dicalcium phosphate is known to be the main initial product of applied fertilizer, but under the alkaline pH of calcareous soils it converts to more basic and less soluble calcium phosphates. Laytha and Blommer (1988) indicated that, $CaCO_3$ found to have a high capacity for P adsorption and appear to be the primary geochemical agent capable of fixation and retentions of P in the soil.

2. Effect of cations and anions:

Among soluble cations, calcium was highest in Giza soil and lowest in the soil of Gazerat Uddhab. Whereas, sodium cation the highest in the soil of North Tahrir (16.95 me l^{-1}) and Giza (12.10 me l^{-1}) in Table (2).

Table 2: Cation, anion balance and exchangeable ions of the investigated soils

Parameters	Giza	Gazerat Uddahab	Minia	Janaklis	South Tahrir	North Tahrir
Soluble Cations (me l^{-1})						
Ca⁺⁺	11.68	6.40	10.50	10.60	8.60	9.84
Mg⁺⁺	7.40	3.20	7.85	4.45	5.40	1.30
Na⁺	12.10	3.90	11.90	1.90	4.50	16.95
K⁺	0.60	0.80	1.15	0.30	0.40	0.92
Soluble Anions (me l^{-1})						
HCO⁻₃	7.36	3.28	7.05	6.35	6.99	8.05
Cl⁻	11.20	6.85	12.78	3.99	5.10	15.60
SO⁻₄	13.22	4.17	11.57	6.91	6.81	5.36
Exch. Cations (me 100g⁻¹soil)						
Ca⁺⁺	24.66	20.20	22.43	6.65	5.85	11.10
Mg⁺⁺	5.68	3.99	5.95	1.90	3.15	2.05
Na⁺	1.85	1.31	2.00	0.68	0.70	1.00
K⁺	1.05	1.10	1.30	0.30	0.35	0.96
E.S.P	5.56	4.92	6.31	7.14	6.97	6.62
E.Mg.P	17.09	15.0	18.78	19.94	31.34	13.57

Divalent cations enhance P adsorption relative to monovalent cations. Bicarbonate and chloride anions (me l^{-1}) was higher in North Tharir (8.05 and 15.60) and lower in Gazerat Uddhab (3.28) and Janakils (3.99). Inorganic and organic anions can compete with P for adsorption sites and organic anions from sources can affect the P adsorption-desorption reactions in soil. The impact of organic anions on reduction of adsorption P is related to

their molecular structure and pH. Organic anions form stable complexes with Fe and Al, which reduces adsorbed P (Havlin *et al.*, 1999). The total exchangeable cations were higher in Giza (33.24) and Minia (31.68) and lower in South Tahrir (10.05) and Janaklis (9.53). Tunesi *et al.* (1999) concluded that in soils with a high reservoir of exchangeable cations, precipitation is the predominant mechanism in the reduction of available P.

3. Inorganic and total-P:

Saloid P:

Data in Table (3) indicated that saloid P in soil bodies found to be very low. It ranged between 2.85 and 22.80 mg kg^{-1} in different soil bodies. It contributes by about 1.13 % of total inorganic P in soil. It was higher for Giza due to the heavy later application of P fertilizer. The lowest value of saloid P was generally, recorded in South Tahrir soil. Relatively higher amounts of Saloid P may be due to higher clay and organic matter content in Minia and Giza. This was further justified by the positive correlation that was observed between saliod P and clay + silt and CEC. Statistical analysis from Table (5) revealed significant negative correlation between saloid P and sand and ESP.

Al-P:

Al-P in soil series varied from 30 to 164 mg kg^{-1} in South Tahrir and Minia, respectively (Table 3). It contributes by about 13.6 % of total inorganic P in soil. Statistical analysis from Table (5) revealed a highly significant positive correlation between Al-P and clay + silt, cation exchange capacity and organic matter indicating that clay and organic matter might have adsorbed this fraction due to their high surface area. However, significant negative correlation observed with sand. This indicates that, the content of Al-P in soil governed by clay, OM, CEC, and sand content in soil.

Fe-P

The content of P associated with NaOH and NaCl (Fe-P) was low and did not exceed 28 mg P kg^{-1} soil in Gazerat Uddahab. It contributes by about 1.94 % of total inorganic P in soil. Thus this fraction with the previous two fractions, generally found to represent minor pool of the total P concentration of the investigated soil. Fe oxides play an active role in P release and fixation especially in calcareous soil and apart of the P occluded in them is present in relatively mobile forms, such as in stable surface complexes, or confined to pores close to the Fe oxide surface from where diffusion can take place (Ryan *et al*, 1985). Benjamin *et al.*, (2003) concluded that, saloid bound P (loosely held soil-P). Al-P and Fe-P fractions play a determined role in the nutrition of plants.

Occluded P:

Occluded P in soil bodies varied from 24.7 to 130.9 mg kg^{-1} soil in South Tahrir and Giza, respectively (Table 3). It contributes about 11.8 % of total inorganic P in soil. Statistical analysis revealed a significant positive correlation between this fraction and clay and organic matter indicating that phosphorus might be present in its occluded form on the surfaces of both clay and organic matter by retention phenomena. This is can be justified by a highly significant positive correlation between this fraction and clay + silt, available water and CEC, significant correlation with OM and negative

correlation with pH and sand in Table (5) indicating these factors are responsible for the amount of occluded P in the studied soil.

Ca-P:

Data presented in Table (3) stated that soil extractable P fraction was predominantly present in the H_2SO_4-P fraction. The amount of P in this fraction ranged between 121.2 and 871.0 mg P kg^{-1} soil in South Tahrir and Giza, respectively. It contributes about 71.5 % of total inorganic P in soil. This may be due to the release of hydrogen ion in the extraction media can compete with P for the same adsorption sites and there by increase p availability in soil (Iyamuremye *et al.* 1996) to allow, more complete use of soil P by plants. The differences in the contents of this fraction might be due to the differences in the organic matter and clay content of soils. Further, this was supported by significant positive correlation between this fraction and organic matter, clay + silt and cation exchange capacity and a significant negative correlation with sand, ESP and pH. Similar type of observation was recorded by Adhami *et al.* (2006).

Table 3: Inorganic phosphorus forms (mg kg^{-1}) estimated in the investigated soils

Soil series	Saloid - P	Al-P	Fe-P	Occluded P			Ca-P			Total inorganic p
				*Rd-Sl Fe-P	**Occl. Al-Fe P	Total	$H_2SO_4 -$ P 1st	H_2SO_4 –P 2nd	Total	
Giza	22.80	141	9.3	90.7	40.2	130.9	788	83.0	871	1175
Gazerat Uddahab	6.50	77	28.0	79.0	39.5	118.5	761	69.0	830	1060
Minia	6.99	164	10.4	86.4	36.6	123.0	772	75.0	847	1151
Janaklis	3.90	61	10.1	31.0	8.0	39.0	150	11.0	161	275
South Tahrir	2.85	30	8.2	20.0	4.7	24.7	112	9.20	121	187
North Tahrir	6.30	120	18.4	60.0	14.6	74.6	260	18.7	279	500
Total P fractions	49.30	593	84.4	--	--	512.5	--	--	3109	4348
% of p fraction to total	1.13	13.64	1.94	--	--	11.97	--	--	71.50	--

*Rd-Sl Fe-P: Reductant soluble Fe-P,
**Occl. Al-Fe P: Occluded Al-Fe P.

4. Organic-P

Considering the organic P fraction in soil, it includes nucleic acids, inositol hexaphosphate, phospholipids, metabolic phosphates such as phosphorylated sugar and phosphoproteins. Data presented in Table (4) show that the values of organic P ranges between 36 and 130 mg kg^{-1}. The highest value of organic P was found in the surface layer that represents the soil of Minia and Giza, while the lowest one belongs to the coarse – textured soil of North Tahrir. It contributes about 10.6 % of total P in soil.

The higher contents of organic P in the soils of Minia and Giza, this behavior may be due to continuous addition of fertilizer and high organic matter contents in this soil. The wide variations of organic P in the studied soil series may be attributed to geogenic factors rather than pedogenic ones, *i.e.,* may be ascribed to the intern changes in the nature of parent materials rather than to soil. The statistical analysis shows that organic P

is significantly correlated with clay and OM and CEC. The sorption of organic P (nucleotides and inositol hexaphosphate) is positively correlated with both organic matter and Fe and Al content of the soil by Leytem *et al.,* (2002). In contrast, It was negatively correlated with sand, pH and $CaCO_3$ in Table (5). Benjamin *et al.,* (2003) concluded that, soil organic P concentrations were positively correlated with organic carbon, clay, and oxalate extractable metals (Al, Fe, Mn), and negatively correlated with mean annual temperature and soil pH.

5. Available P:

The soil P continuum could be separated into discrete fractions of differing availability and the availability of this fraction would be consistent in soils of differing degrees of weathering. Water-soluble fraction contains P, which is loosely held by surface associations and therefore is the most mobile P forms were observed as P mg kg^{-1} soil. Existence of such low amounts of plant available P in Janaklis (1.65), South Tahrir (1.35) and North Tahrir (2.72) may be caused by high pH and $CaCO_3$ in Janaklis and North Tahrir.

The use of bicarbonate for the extraction of the available P is provided by the consideration that plant root produce CO_2, which forms bicarbonate in the soil that may solubilize soil P (Tiessen and Moir, 1993). Data presented in Table 4 show that the value of chemically available P content varies from 6.65 to 29.2 mg kg^{-1}. These data indicate that the highest value of available P is associated with the soil of Giza, which are higher in CEC and organic matter while the lowest available P content characterized the soils of South Tahrir. The biologically available P consist of labile bound represents soil solution P, soluble phosphate originating from calcium phosphate and weekly adsorbed P on the surfaces of sequioxides or carbonates (Phiri *et al.* 2001). The statistical evaluation in Table (5) of available P extracted by sodium bicarbonate is positively and highly significant correlated with each of clay + silt, available water, CEC and OM and negatively correlated with sand, ESP and pH. This confirms the finding of Concepción and Delgado (2005).

6. Total phosphorus:

Besides soil content of total P is not large most of it is relatively unavailable to plants, since a large fraction of the P is found in a mineral form not readily availably for absorption by plants. Therefore, P absorption by plants, takes place from the soil solution that should be renewed several times each day to maintain adequate P supply for these plants, Barber, 1984.

Data in Table (4) showed the Total P content of the studied soil series ranged between 255 and 1300 mg kg^{-1}. The lowest values characterize the soil series of South Tahrir, Janaklis and North Tahrir, respectively due to their high content of sand and $CaCO_3$ content especially in North Tahrir and Janaklis. The wide range of P content is apparently associated with soil texture and it's probably dependent on type of parent materials from which the soil was formed.

Table 4: Available, inorganic, organic and total P fractions (mg kg^{-1}) in the investigated soils

Soil series	Available P extracted by		Inorganic P	Organic P	Total P
	(1:10) soil : water	(0.5 M) NaHCO$_3$			
Giza	4.20	29.20	1175	125	1300
Gazerat Uddhab	3.75	27.10	1060	90	1150
Minia	3.98	27.95	1151	130	1281
Janaklis	1.65	7.80	275	65	340
South Tahrir	1.35	6.65	187	68	255
North Tahrir	2.72	13.92	500	36	536

Statistical analysis in Table 5 shows that total P is positively and highly significantly correlated with clay + silt, OM and CEC but negatively and significantly correlated with sand, pH and ESP.

Table 5: Correlation coefficient between soil properties and phosphorus fractions

Phosphorus fractions	Clay + silt	sand	Available water	Organic matter	Ca CO$_3$	pH	EC	CEC	ESP
Saloid P	0.540*	-0.544*	0.367	0.455	-0.185	-0.227	0.536*	0.693**	-0.523*
Al-P	0.918**	-0.934**	0.822**	0.474*	0.114	-0.221	0.853**	0.773**	-0.291
Fe-P	0.296	-0.250	0.027	-0.190	0.150	-0.355	-0.447	0.160	-0.646**
Occluded P	0.912**	-0.927**	0.824**	0.676**	-0.259	-0.681**	0.467	0.972**	-0.798**
Ca P	0.812**	-0.839**	0.825**	0.801**	-0.464	-0.813**	0.361	0.982**	-0.828**
Inorganic P	0.862**	-0.886**	0.846**	0.770**	-0.387	-0.758**	0.434	0.989**	-0.799**
Organic P	0.522*	-0.588*	0.801**	0.979**	-0.703*	-0.721**	0.446	0.853**	-0.471*
Available P	0.865**	-0.884**	0.815**	0.742**	-0.374	-0.758**	0.415	0.984**	-0.830**
Total P	0.848**	-0.876**	0.854**	0.796**	-0.416	-0.765**	0.441	0.992**	-0.785**

** Significant at 1% level and * Significant at 5 % level

7. Regression equation between phosphorus fractions and soil properties:

The multiple regression have been established between phosphorus fractions from one side and clay, silt, sand, pH, EC, CEC, CaCO$_3$ and OM on the other side in Table (6) and (7). The obtained values of correlation of determination (R^2) of all equations are highly significant. Moreover, the P fractions could be predicted mathematically from the other known physical and chemical soil properties by solving the obtained multiple regression equation.

Regression analysis showed positive effect from Clay content on available, inorganic and organic P fractions in soils. These results could be attributed to: i) the clay itself may be a source of this element, ii) clay minerals (fine fraction) have highly cation exchange capacity iii) clay may play role of absorption of P and its distribution in soil profiles. Calcium carbonate showed positive effect on water soluble and inorganic P and negative effect on NaHCO$_3$ and organic P. Whereas, Available and organic P affected positively by OM, pH and CEC.

Table 6: Multiple regressions of soil constituents with phosphorus fractions

Phosphorus fractions	Intercept	Clay + silt	sand	Available water	Organic matter	CaCO₃	R²
Saloid P	-103.79	1.20	1.04	-3.59	61.52	2.06	0.918***
AL-P	300.85	-2.35	-3.44	-5.49	151.40	7.33	0.987***
Fe-P	-163.09	2.03	1.75	4.26	-74.40	3.04	0.792
Occluded –P	-347.64	4.97	3.27	4.77	-34.64	-3.29	0.944***
Ca-P	-5339.46	57.81	48.82	29.74	89.41	-17.05	0.966***
Inorganic P	-3131.95	43.18	28.27	50.86	-412.32	-36.68	0.953**
Organic P	30.02	-0.11	-0.22	-0.59	77.52	0.76	0.979***
Ava. P (water:soil)	-18.06	0.21	0.176	0.03	1.24	0.002	0.973**
Ava. P (NaHCO₃)	-164.17	1.84	1.54	0.62	5.32	-0.34	0.967***
Total P	-3351.60	45.02	30.22	48.45	-272.28	-33.57	0.956***

*** Significant 0.1 %, ** Significant 1% level, * Significant 5 % level and Ava. available

Table 7: Multiple regressions of soil properties with phosphorus fractions

Phosphorus Fractions	Intercept	pH	EC	CEC	ESP	R²
Saloid P	-20.85	0.36	5.31	0.03	-5.67	0.599*
AL-P	-345.47	28.31	25.82	3.96	11.09	0.897**
Fe-P	-5.42	12.01	-3.09	-0.21	-10.35	0.710*
Occluded –P	-99.35	24.16	1.41	3.66	-14.51	0.968***
Ca-P	2739.20	-11.76	114.03	-1.19	-385.33	0.787*
Inorganic P	-764.74	113.79	-66.17	44.61	-34.01	0.988***
Organic P	-10.44	-27.02	-25.27	5.88	39.98	0.952***
Ava. P (water: soil)	-3.07	0.81	0.08	0.09	0.43	0.964***
Aver. P (NaHCO₃)	10.22	0.380	-0.55	0.90	-1.90	0.982**
Total P	-822.42	85.05	-89.95	51.08	13.33	0.933**

*** Significant 0.1 %, ** Significant 1% level, * Significant 5 % level and Ava. available

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صـور الفوسفور وعلاقتها ببعض خـواص الارض فى بعض المواقع الارضيه من مصر

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اجريت دراسه متخصصه لتقييم العلاقه بين الفوسفور الكلى ، العضـوى والغير العضـوى وبعض الخواص الفزيوكيميائيه لستة مواقع ممثله لبعض انواع الاراضى فى مصر . النتائج المتحصل عليها يمكن ان تلخص فى الاتى:

- الفوسفور الغير العضوى مثل المذاب بكلوريد الامونيوم ، المرتبط بالالومنيوم ، المرتبط بالحديد، المرتبط داخل معادن الطين والمرتبط بالكالسيوم فى المواقع الارضيه يتراوح من 2.85 - 22.8 ، 30 - 164 ، 8.2 - 28 ، 24.7 - 130.9 و 121 - 871 مللجم لكل كجم ارض على الترتيب.

- الفوسفور المرتبط بالكالسيوم يساهم بحوالى 71.5 % من الفوسفور الغير عضوى و1.13 % فقط للفوسفور المذاب بكلوريد الامونيوم.

- وفرة صور الفوسفور الغير عضوى كانت كـالاتى: الفوسفور المرتبط بالكالسيوم > الفوسفور المرتبط داخل معادن الطين > الفوسفور المرتبط بالالومنيوم > الفوسفور المرتبط بالحديد > الفوسفور المذاب بكلوريد الامونيوم. يتضح من هذا ان الفوسفور المرتبط بالكالسيوم والمرتبط داخل معادن الطين هما الاكبر مساهمه فى امداد النبات بالفوسفور والتى كانت موجبة العلاقه مع السعه التبادليه الكاتيونيه والماده العضويه ولكنها سالبة العلاقه مع درجة الحموضه وكربونـات الكالسيوم المسئوله عن ترسيب الفوسفور فى التربه. بينمـا الفوسفور المرتبط بـالالومنيوم كـان اساسا له علاقه موجبه مع محتوى الطين والماده العضويه فى الارض.

- زيادة محتوى الارض من الفوسفور العضوى فى المنيا والجيزه ربما كـان من الاضـافات الكثيفه السابقه لاسمدة الفوسفور ومحتوى التربه من المـاده العضويه مقارنـة ببـاقى مواقع الارض تحت الدراسه.

- الفوسفور الكلى يتراوح من 255 الى 1300 مللجم لكل كجم ارض فى جنوب التحرير والجيزه بينمـا الفوسفور الميسر تـراوح مـن 6.65 الـى 29.2 مللجم لكـل كجم اعتمـادا علـى خـواص الارض.

محتوى التربه من الفوسفور الميسر فى اغلب المواقع الارضيه كـان اعلى فى الجيزه ، المنيا ، جزيرة الدهب ومحدود فى جناكليس وجنوب التحرير.

- وجدت علاقه موجبة عالية المعنويه بين الفوسفور الميسر والكلى فى مواقع الدراسـه والطين + السلت ، السعه التبـادليـه الكاتيونيـه ، المـاده العضـويه والمـاء الميسر وعلاقـه سـالبة المعنويه مـع الرمل ودرجة الحموضه.

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