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EFFECT OF ADDED ROCK PHOSPHATE AND COMPOST ON SOIL PHOSPHORUS FRACTIONS AFTER DIFFERENT INCUBATION PERIODS

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ABSTRACT: Surface clay Soil samples were collected from EL Hamoul, Kafr El-Sheikh governorate and air dried. Each of plastic pot from the experiment pots was filled with 500 grams from these samples. Three rates from rock phosphate (0, 1 and 3%) and three from compost (0, 2, and 4%) were added to and mixed with these experiment soil samples in the pots and incubated in three periods (0, 30 and 90 days) in the lab condition. This experiment was arranged in three replicates using a completely randomized block design. Samples from these applications were taken after each of the three incubation periods. Phosphorus fractions were measured in the taken samples according to Hedley sequential fractionation scheme. The determined P fractions were: (1) P-$NaHCO_3$, (2) P-NaOH, (3) P-HCl/H_2SO_4, (4) P-residual and (5) Total P. Obtained results could be summarized as follows. The increasing rates of added compost led to an increase in P-$NaHCO_3$ fraction comparing with control treatment. While the increasing rates of added rock phosphate led to a decrease in this fraction and gave the lowest value. The addition of compost and rock phosphate together led to increase in P-$NaHCO_3$ fraction more than each of them alone. The increase of the incubation period led to an unnoticeable and insignificant decrease in this fraction of phosphorous. P-NaOH fraction represents 2.8 % of the total phosphorous. P-HCl/H_2SO_4 fraction increased with increasing incubation periods, phosphate rock and compost were. The residual P fraction was decreased with increasing incubation period.

Key words: Phosphorus fractions, rock phosphate, compost, incubation periods .

INTRODUCTION

Phosphorus is a key nutrient element for the growth and development of crops. It is a key element in universal biogeochemical cycles. Phosphorus occurs mainly in hydroxy-apatite {$Ca_5(PO_4)_3(OH)$} and fluoro-apatite {$Ca_{10}(PO_4)_6F_2$}, as orthophosphate. The solubility of P is controlled by Fe (III), Al (III) and Ca. The influence of the solid phase, whether as a suspended particles or sediments, is of considerable importance in regulating the dissolved P phase of natural waters systems. Sediments properties, such as pH and redox potential could have caused significant variation of phosphorus release potential (Gao et al., 2005), beside mineral-water equilibrium, sorption processes, organisms (bioturbation) and bottom sediment characteristics.

It is worth mentioning that, fertilization became expensive. Therefore, it is necessary to consider the use of some natural rocks such as feldspar, rock phosphate especially with acid treatment for easing the release of elements contained in these materials. Phosphorus is provided mainly by soil, however, it can easily be immobilized in it, and the seasonal application rate of phosphate fertilizer for crops is only 10-25%. (Liu et al., 2012).

The rock phosphate (RP) could be used as a direct application fertilizer with or without other amendments. The utilization of RP is more suitable than the manufacturing phosphoric acid and other soluble fertilizers such as single superphosphate (SSP) or triple one (TSP). Rock Phosphate is a natural mineral fertilizer requiring minimum processing and environmentally benign. It could be more efficient than soluble fertilizers in terms of recovery of phosphate by plants, even for short term crops in soils where the soluble P is readily leached, as in sandy soils and also, possibly for long-term crops in other soils (Rajan et al., 1994*)*. Application of rock phosphates in arid and semi-arid regions is not common, because of its low availability in most of their soils that having alkaline reaction with relatively high pH and low organic matter.

In many studies, humic and fulvic acids preparations were reported to increase the uptake of mineral elements to promote the root length and to increase the fresh and dry weights of crop plants *(*Chen et al., 2004). Due to the positive effect of humic substances on the visible growth of plants, these chemicals have been widely used by the growers instead of other substances. Composting organic materials with rock phosphate (RP) has been shown to enhance the solubility of P from RP and is practiced widely as a low-input technology to improve the fertilizer value of manures *(*Ibrahim et al., 2008).

This work aims to study the effect of added organic substances (compost) and rock phosphate after different incubation periods on phosphorus forms in the studied soil.

MATERIALS AND METHODS

Soil samples were collected from the surface layer of a farm located at El Hamoul, Kafr El-Shikh governorate. The collected soil samples were air dried and ground to pass through 2 mm thieve. Some physiochemical properties for this soil were analyzed according to Burt (2004) and presented in Table (1). Some main minerals contents of added rock phosphate are presented in Table (2). Some physiochemical properties of added compost are shown in Table (3).

Table (1): Some properties for the studied soil.

Particle size distribution %			Texture class	PH (1:2.5)	EC (1:5) dSm^{-1}	OM %	CEC Meq/1oog
Sand	Silt	Clay					
31.11	8.02	60.87	Clay	7.6	1.8	2.01	39.7

Table (2): Total P_2O_5 in the added Rock Phosphate.

Total P_2O_5 %	20.35

Table (3): Some properties for the added compost.

EC (1:10) dSm^{-1}	PH (1:10)	OC %	C/N ratio	BD* gcm^{-3}	Moisture %	Ash %	WHC** %
10.5	8.6	35	12.6	0.35	11.8	42	160

BD*= Bulk density, WHC: Water holding capacity.

A plastic pot (with 20 cm inter diameter and 30 cm height) were filled with 500 g of prepared fine earth. The added rock phosphate rates were 0, 1 and 3%. The added compost rates were 0, 2 and 4%. These additives were good mixed with soil samples in the pots and prepared for 3 incubation periods namely 0, 90 and 180 days. This experiment was arranged by 81 unites having 27 treatments in three replicates using a completely randomized block design. The treated soil samples in pots were moisten at 60 % of water holding capacity under the laboratory condition during the experiment. Samples were taken from the different treatments after each incubation periods to determine the fractionations of phosphorus.

Hedley sequential fractionations scheme was applied to estimate the fractionations of phosphorus in the tested soil samples according to Sui et al. (1999). The obtained data were statistically analyzed by ANOVA according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The estimated different phosphorus fractions in the studied soil after different treatments with rock phosphate, compost and incubation periods are presented In Table (4). The effect of these treatments with their different rates could be discussed as follows.

Effect of treatments on total phosphorus fraction:

Data in Table (4) showed that, the values of total phosphorus (TP) were varied widely between different treatments and rates. The lowest total phosphorus (TP) value was obtained in the soil without any additives (0-treatments at the first incubation period). The highest TP value was obtained with the addition of 1 % RP and 4 % compost at the longest incubation period. The difference between TP mean values resulted from PR and compost treatments were significant especially between phosphate rock treatments. While the differences between these values that affected by incubation periods were insignificant.

In this respect Shaheen et al. (2007) established that, the values of total P were differed widely between Burullus Lagoon soils depending on the type of deposits and their physiochemical properties. Where the total P was negatively correlated to sand content and positively correlated to silt and clay content. Thus, P is probably associated with the finer soil fractions as it previously reported by (McCullum, 1996).

The relationship between TP mg.Kg^{-1} and added rock phosphate rate % and can be expressed by the following equation:

$$TP = 2247 + 934.4\ RP \quad (R^2=0.94)$$

This equation exposed that, the increasing TP rate was 934.4 mg.Kg^{-1} when RP added with 1%. The effect of added compost (%) on TP can be expressed by the following equation:

$$TP = 2814 + 339.5\ Compost \quad (R^2=0.96)$$

This equation showed that TP increased by rate of 339.5 mg.Kg^{-1} after 1 % compost addition. The relationships between TP and incubation periods can be expressed by the following equation:

$$TP = 3311 + 60.7\ 1^{st}.P \quad (R^2=0.67)$$

This equation explain that, the TP increased by 60.7 mg.Kg^{-1} after one month incubation period.

Effect of treatments on other phosphorus fractions

Data in Table (4) showed that, the phosphorous fractions extracted from the soil can be arranged as follows:

P-HCl/H_2SO_4 > P-digested > P-$NaHCO_3$ > P- NaOH

Table (4): Effect of the studied treatments on phosphorus fractions.

Additives		Incubation periods (months)														
PR %	Compost %	0					3					6				
		Phosphorus fractions (mg.Kg-1)					Phosphorus fractions (mg.Kg-1)					Phosphorus fractions (mg.Kg-1)				
		$NaHCO_3$	NaOH	HCl+ H_2SO_4	Digested	Total	$NaHCO_3$	NaOH	HCl+ H_2SO_4	Digested	Total	$NaHCO_3$	NaOH	HCl+ H_2SO_4	Digested	Total
0	0	131	64	667	515	1664	132	63	643	907	2024	127	77	675	669	1841
	2	174	68	643	791	1971	143	92	611	656	1784	151	71	611	469	1580
	4	215	60	627	868	2070	170	89	659	489	1714	203	77	707	785	2101
Mean		173	64	646	725	1902	149	81	638	684	1841	160	75	665	641	1841
1	0	118	57	1198	695	2526	125	68	1326	656	2683	133	64	1230	707	2611
	2	131	64	1158	1248	3051	153	75	1214	965	2887	154	71	1310	746	2794
	4	215	71	1206	605	2593	164	86	4631	695	7201	183	83	4848	675	7494
Mean		155	64	1187	849	2723	147	76	2390	772	4257	157	73	2463	710	4300
3	0	111	77	1916	888	3692	137	73	2645	990	4796	140	87	2476	965	4569
	2	140	84	2749	1466	5431	154	86	2757	1119	5115	161	89	2492	1003	4660
	4	644	77	2822	1016	5739	723	92	2452	990	5346	167	95	2315	933	4368
Mean		298	79	2496	1123	4954	338	83	2618	1033	5086	156	90	2428	967	4532
G mean		209	69	1443	899	3193	211	80	1882	830	3728	158	79	1852	772	3557

The obtained results indicated that, P-HCl/H_2SO_4 is the highest P fraction at all incubation periods, while the lowest fraction was P-NaOH. The highest values of P-HCl/H_2SO_4 fraction was found after 3 months incubation period followed by 6 months period. Also, the largest values of P-$NaHCO_3$ form was obtained after three months. whereas the largest amounts of P-digest fraction was obtained in soil without incubation.

On the other hand, data in Table (4) showed that, most of P fractions was increased with increasing the added rates of RP and compost. Which, the increasing rate of added compost led to increase in P-$NaHCO_3$ fraction. While the increasing addition of rock phosphate led to a decrease in this fraction and gave the lowest values. Moreover, the addition of compost together with rock phosphate led to a clear increase in P-$NaHCO_3$ fraction more than each of them alone. While, the increase of the incubation period led to a decrease of this P part.

Al-Oud (2011) found that, the availability of phosphorus was significantly increased in calcareous soil treated with rock phosphate and different rates of organic manure.

Several studies found that, the addition of organic amendments such as compost led to increase of the available phosphorus in soil (Scherer & Sharma, 2002; Qian & Schoenau, 2000). There are a direct and indirect positive effect for the addition of compost. The direct positive effect could be ascribed to the phosphorus released from compost. The indirect effect could be returned to the production and release of organic acids and stimulation of microbial activity that can decrease the soil ph. This effect could be led to increasing the release and mobilization of phosphorus in soil (Ayaga et al., 2006; Fuentes et al., 2006; and Khan and Joergensen, 2009).

The following equation can express the relationship between PR % and P-$NaHCO_3$:

$$\text{P- }NaCO_3=142.62+37.47\text{ PR (\%)}\quad (R^2=0.85)$$

This equation pointed out that, the rate of increment in P-$NaHCO_3$ fraction was 37.47 mg.Kg^{-1} when PR was added by 1 %. On the other hands, the relation between P-$NaHCO_3$ fraction and added compost rate can be expressed by the next equation:

$$\text{P- }NaCO_3 = 107.58+42.5\text{ Com(\%)}\quad (R^2=0.85)$$

This equation confirmed that, the increment rate in P-$NaHCO_3$ fraction was 42.5 mg.Kg^{-1} when compost was added by 1%.

The effect of incubation periods on P-$NaHCO_3$ fraction can be expressed by the following equation:

$$\text{P- }NaCO_3 = 218.13 - 8.5156\text{ In.Per (months)}\quad (R^2 = 0.71)$$

This equation indicate that, the decreasing rate of P-$NaHCO_3$ was 8.52 mg.Kg^{-1} after one month incubation period.

The lowest value of P-NaOH fraction was obtained in the soil in the control treatment of incubation and compost with addition of 1 % RP. While the highest value of this fraction was obtained with the addition of 3 % RP and 4 % compost after 6 months incubation period. P-NaOH fraction represented 2.8 % of the total phosphorous. The P-NaOH fraction is related with unorganized oxy-hydroxide surfaces and crystalline Al- and Fe-oxides. Generally, this fraction is uneasy due to fluctuating redox conditions that cause mobilization or immobilization of P from this fraction depending on the soil environment status (Jalali and Sajadi Tabar, 2011). It was observed that, the P-NaOH values were the lowest fraction compared with the other phosphorus fractions. This could be due to the low levels of Fe and Al contents in Egyptian

soils. Many previous studies showed that, the increase rates of added P led to a significant increase in Fe- and Al-bound fraction. The formation of this fraction could be attributed to the strong complexation of exchangeable Al and Fe with P (Von Wandruszka, 2006).

The increasing rates of P-NaOH fraction can be deduced from the increasing rates any of the incubation periods, rock phosphate or compost.

The effect of RP on P-NaOH fraction can be expressed by the following equation:

P-NaoH = 70.85 + 4.03 PR% (R_2 = 0.76)

This equation revealed that, increasing of phosphate rock rate by 1 % led to increasing in P-NaOH by 4.03 mg.Kg^{-1} . The following equation can be stated the relationship between P-NaOH fraction and applied compost rate %:

P-NaOH=70.83+ 2.70 Compost% (R^2=0.95)

From this equation, It could be concluded that, the increase of applied compost rate by 1 % led to increase in P-NaOH by 2.70 mg.Kg^{-1}. Wright (2009) noticed that, the increase of organic matter applications resulted in important enhance of Fe- and Al-bound P fraction. Also, it was reported that, inorganic fertilizers are one of the major inputs of Fe- and Al-bound P fraction in soil. Some investigators found that, the less labile inorganic and organic P forms content was higher in the soil treated with compost than in that untreated (control) one. This could be attributed to the precipitation and fixation as well as synthesis of stable organic P (Garcıa-Gil et al., 2000; Park et al., 2004; Shen et al., 2011).

The following linear equation can be explaining the effect of incubation periods on the extracted P-NaOH fraction:

P-NaoH= 71.00+1.74 Incub.Per (R^2 = 0.68)

This equation indicated that, there was a positive relationship between incubation periods and P-NaOH fraction. This fraction increased in soil by 1.74 mg.Kg-1 after one month incubation period.

The lowest value of P-HCl/H_2SO_4 fraction was found in the soil without RP addition having 2% added compost after 3 months incubation period. While the highest value was obtained in the soil treated with 1 % RP and 4 % compost after 6 months incubation period.

Most of P applied to the soils is not taken up by plants but accumulates in them as various forms of inorganic and organic P, that is commonly referred to the ‘legacy P’ (Stutter et al., 2012; Condron et al., 2005; Frossard et al., 2000).

The relation of RP % with P- HCl/H_2SO_4 fraction can be formulated by the following equation:

P-HCl/H_2SO_4=96.6+568.45 PR% (R^2 = 0.81)

This equation revealed that, the increase of added RP by 1 % led to increase in P-HCl/H_2SO_4 by 568.45 mg.Kg^{-1}. On the other hands, the relation between P-HCl/H_2SO_4 fraction and added compost % can be expressed with the next equation:

P-HCl/H_2SO_4 = 1309.4 + 208.06 Com% (R^2 = 0.83)

This equation confirmed that, the increment of P-HCl/H_2SO_4 fraction content was 208.06 mg.Kg-1 when compost applied with 1%. On the one hand, the effect of incubation periods on P-HCl/H_2SO_4 fraction can be expressed by the following equation:

P- HCl/H_2SO_4=1521.1+68.139 IncPe(R^2=0.69)

This equation establish that, the increasing rate of P-HCl/H_2SO_4 was 68.139 mg.Kg-1 after one month incubation period.

The lowest P-digest (residual) fraction content was gotten in soil without RP, and 2% compost applications after 6 months incubation period. While the highest content was obtained in soil treated with 3% RP and 2% compost without incubation period. Generally, the results revealed that, the increase of RP or compost with increasing incubation period led to increase in residual P fraction.

The effect of RP on residual P fraction can be express with the next equation:

Residual-P (mg.Kg^{-1})=672.13+121.17 PR% (R^2 = 0.99)

This equation revealed that, the increase of added RP by 1 % led to increase in residual P by 121.17 mg.Kg^{-1}.

The relationship between residual P fraction and applied % compost can be expressed by equation:

Residual P(mg.Kg^{-1})= - 40.017X^2 +161.86X + 776.76 (R^2 = 0.99)

It can mentioned that, the increase of applied compost up to 2 % led to increase in residual P by 940.4 mg.Kg^{-1}, then it decreased to 783.9 mg.Kg^{-1} with increasing compost application up to 4 %.

The effect of incubation periods on the residual phosphorous fraction can be expressed by following linear equation:
Residual P (mg.Kg^{-1}) = 896.93 - 21.08 Incub.Per (R2 = 0.99)

From this equation, it can be concluded that, there was a negative relationship between incubation periods and residual P fraction. The residual P fraction was decreased by 21.08 mg.Kg-1 after one month incubation period.

REFERENCES

Al-Oud, S. S. (2011). Improving phosphorus availability from phosphate rock in calcareous soils by amending with: organic acid, sulfur, and/or organic manure. Ozean Journal of Applied Sciences, 4(3): 227–235.

Ayaga, G., A. Todd and P. C. Brookes (2006). Enhanced biological cycling of phosphorus increases its availability to crops in low-input sub-Saharan farming systems. *Soil Biology and Biochemistry*, *38*(1): 81–90.

Burt, Rebecca, Ed. (2004). Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42, Version 4.0, USDA-NRCS, Lincoln, Nebraska.

Chen, Y., C. E. Clapp and H. Magen (2004). Mechanisms of plant growth stimulation by humic substances: The role of organo-iron complexes. *Soil Science and Plant Nutrition*, *50*(7): 1089–1095.

Condron, L. M., B. L. Turner and B. J. Cade-Menun (2005). Chemistry and dynamics of soil organic phosphorus. *Phosphorus: Agriculture and the Environment*, *46*: 87–121.

Frossard, E., L. M. Condron, A. Oberson, S. Sinaj and J. C. Fardeau (2000). Processes governing phosphorus availability in temperate soils. *Journal of Environmental Quality*, *29*(1): 15–23. https://doi.org/10.2134/jeq2000.00472425002900010003x

Fuentes, B., N. Bolan, R. Naidu and M. D. L. L. Mora (2006). Phosphorus in Organic Waste-Soil Systems. *Revista de La Ciencia Del Suelo y Nutrición Vegetal*, *6*(2): 64–83. https://doi.org/10.4067/S0718-27912006000200006

Gao, L., H. Yang and J. M. Zhou (2005). Phosphorus release from sediments in Dianchi Lake under different environmental conditions. *Soil (Chin)*, *37*(2): 216–219.

Garcıa-Gil, J. C., C. Plaza, P. Soler-Rovira and A. Polo (2000). Long-term effects of municipal solid waste compost application on soil enzyme activities

and microbial biomass. *Soil Biology and Biochemistry*, *32*(13): 1907–1913.

Gomez, K. A. and A. A. Gomez (1984). *Statistical procedures for agricultural research*. John Wiley & Sons.

Ibrahim, M., A. U. Hassan, M. Iqbal and E. E. Valeem (2008). Response of wheat growth and yield to various levels of compost and organic manure. *Pakistan Journal of Botany*, *40*(5): 2135–2141.

Jalali, M. and Tabar, Samaneh S. (2011). Chemical fractionation of phosphorus in calcareous soils of Hamedan, western Iran under different land use. *Journal of Plant Nutrition and Soil Science*, 174(4): 523–531.

Khan, K. S. and R. G. Joergensen (2009). Changes in microbial biomass and P fractions in biogenic household waste compost amended with inorganic P fertilizers. *Bioresource Technology*, *100*(1): 303–309. https://doi.org/10.1016/j.biortech.2008.06.002

Liu, P., J. Bai, Q. Ding, H. Shao, H. Gao and R. Xiao (2012). Effects of water level and salinity on TN and TP contents in marsh soils of the Yellow River Delta, China. *Clean–Soil, Air, Water*, *40*(10): 1118–1124.

McCullum, R. E. (1996). Soil phosphorus and potassium. *The Nature and Properties of Soils, 2nd Ed. NC Brady and RR Weil (Eds.). Prentice-Hall International, Inc*, 445–487.

Park, B., J.H. Ahn, J. Kim and S. Hwang (2004). Use of microwave pretreatment for enhanced anaerobiosis of secondary sludge. *Water Science and Technology*, *50*(9): 17–23.

Qian, P. and J. J. Schoenau (2000). Fractionation of P in soil as influenced by a single addition of liquid swine manure. *Canadian Journal of Soil Science*, *80*(4): 561–566.

Rajan, S. S. S., O'connor, M. B., and A. G. Sinclair (1994). *Partially acidulated phosphate rocks : Controlled release phosphorus fertilizers for more sustainable agriculture*. 69–78.

Scherer, H. and S. Sharma (2002). Phosphorus fractions and phosphorus delivery potential of a luvisol derived from loess amended with organic materials. *Biology and Fertility of Soils*, *35*(6): 414–419.

Shaheen, S. M., C. D. Tsadilas and S. Stamatiadis (2007). Inorganic phosphorus forms in some entisols and aridisols of Egypt. *Geoderma*, *142*(1–2): 217–225. https://doi.org/10.1016/j.geoderma.2007.08.013

Shen, J., L. Yuan, J. Zhang, H. Li, Z. Bai, X. Chen, W. Zhang and F. Zhang (2011). Phosphorus dynamics: From soil to plant. *Plant Physiology*, *156*(3): 997–1005. https://doi.org/10.1104/pp.111.175232

Stutter, M. I., C. A. Shand, T. S. George, M. S. A. Blackwell, R. Bol, R. L. MacKay, A. E. Richardson, L. M. Condron, B. L. Turner and P. M. Haygarth (2012). Recovering phosphorus from soil: A root solution? *Environmental Science and Technology*, *46*(4): 1977–1978. https://doi.org/10.1021/es2044745

Sui, Y., M. L. Thompson and C. Shang (1999). Fractionation of phosphorus in a Mollisol amended with biosolids. *Soil Science Society of America Journal*, *63*(5): 1174–1180. https://doi.org/10.2136/sssaj1999.6351174x

Von Wandruszka, R. (2006). Phosphorus retention in calcareous soils and the effect of organic matter on its mobility. *Geochemical Transactions*, *7*(1): 1–8.

Wright, A. L. (2009). Phosphorus sequestration in soil aggregates after long-term tillage and cropping. *Soil and Tillage Research*, *103*(2): 406–411.

تأثير اضافة الفوسفات الصخري والكمبوست على صور فسفور التربة بعد فترات تحضين مختلفة

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الملخص العربي:

تم جمع عينات سطحية (٠–٣٠ سم) من تربة طينية من أحد حقول مركز الحامول بمحافظة كفر الشيخ، ولقد جففت تلك العينات هوائياً، ووزن منها في كل اسطوانة بلاستيكية خمسمائة جرام، أضيفت ثلاث معدلات من صخر الفوسفات (٠، ١، ٣ %)، وثلاث معدلات من الكمبوست (٠، ٢، ٤ %) وحضنت تلك التربة لثلاث فترات (٠، ٣٠، و٩٠ يوم) في جو المعمل، ,طبق في تنفيذ تلك التجربة نظام الصفوف تامة العشوائية، ولقد أخذت عينات من التربة بعد كل فترة من فترات التحضين المختلفة، قدرت فيها صور الفوسفور المختلفة، ولقد استخدمت طريقة Hedley لتجزئة صور الفوسفور التالية: ١) P-NaHCO3، ٢) P-NaOH، ٣) P- HCl / H2SO4، ٤) P-residual، ٥) Total P، ويمكن تلخيص النتائج فيما يلي:

أدت الإضافة المتزايدة للكمبوست إلى زيادة الصورة $P-NaHCO_3$ مقارنة بالكنترول، في حين أدت إضافة صخر الفوسفات إلى انخفاض في هذه الصورة وأعطت أدنى قيمة. أدت إضافة الكمبوست والفوسفات الصخري معًا إلى زيادة تلك الصورة $P-NaHCO_3$ أكثر من الكمبوست أو صخر الفوسفات منفرداً، كما أظهرت النتائج أن زيادة فترات التحضين أدت إلى انخفاض غير معنوى وغير ملحوظ في هذا الجزء من الفوسفور، وأوضحت النتائج أن نسبة P-NaOH تمثل ٢.٨٪ من الفسفور الكلى، كما أوضحت النتائج زيادة نسبة الصورة $P-HCl / H_2SO_4$ مع زيادة فترات التحضين وصخر الفوسفات والكمبوست. كما أظهرت النتائج انخفاض نسبة الفوسفور المتبقى مع زيادة فترة التحضين.

السادة المحكمين

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