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Effect of Incubation Time on the Kinetics of Phosphate Desorption from Compost Enriched with Phosphate Rock

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THE OBJECTIVE of this study was to evaluate the kinetics of phosphate desorption from three types of phosphocompost differed in their rates of phosphate rock (PR), *i.e.*, 10, 15 and 20%. These systems were incubated for time span from one to 120 days. The obtained results clearly indicate that the application of 15% PR mixed with compost, led to increase P release by about 56% over control, however, the highest concentration of PR only led to increase P desorption by 20%. The application of 10% PR to compost, however, gave-lowest increase in P desorption compared to other rates applied. Concerning of different kinetic models, *e.g.*, modified Freundlich, parabolic Diffusion and Hoerl's models; the data gave conformity by having high R^2 and low SE for these models. The rate constants of Horel's model, the best fitted model, indicated that the rate of P desorbed from p-rock to compost was influenced by the rate of PR applied. These constants characterized by increasing in their values throughout the entire reaction period (120 days). At the same time, the rate constants of modified Freundlich equation which represent phosphate desorption from phosphocompost systems to amended media were characterized by increasing in rate values through the first 14 days followed by decreasing order in the rest of incubation time. The obtained results indicated that these model constants consistently influenced by some factors such as media pH, temperature and residence time.

Keywords: Phosphocompost, Phosphate release, Kinetic models.

High cost of soluble P fertilizers forcing many developing countries to turn increasingly to using phosphate rock (PR) resources to improve agricultural production. Several alternative approaches have been used or proposed to increase P availability in PR including: (1) incorporation of additives into PR (2) partial acidulation of PR (3) compaction of PR with water-soluble P fertilizers and (4) microbial methods (Van Straaten, 2002).

Composting manure and/or biological waste applied with PR has been shown to enhance the dissolution of the PR (Mishra & Bangar, 1986 and Singh & Amberger, 1998) and is practiced widely as a low-input technology to improve

the fertilizer value of manure (Mahimairaja *et al.*, 1995). However, although research has focused on the quality of compost organic matter (Adani *et al.*, 1997; Liang *et al.*, 1996 and Requena *et al.*, 1997) and on the forms and availability of compost nitrogen (N) (Kuo, 1995 and Sanchez *et al.*, 1997), little has been done to unravel the forms and availability of phosphorous. The hypothesis for the present study, therefore, was that composting would enhance the dissolution of the PR and the effectiveness of PR for plant P uptake and growth.

The aims of this study are to: (1) Evaluate the application of prepared compost to rock phosphate (phosphocompost) on the kinetics of phosphate desorption (2) Choosing the best fitted kinetic model(s) describes P release from phosphocompost organic materials; applied under arid conditions of new reclaimed areas; to specify the best and economic rate of PR should be applied.

Material and Methods

Compost preparation

Greenhouse experiment was conducted to evaluate P release characteristics from prepared compost amended with phosphate rock PR (phosphocompost). Plastic pots filled with 200 g of compost consisted of farmyard manure, chicken manure, groundnut residues and maize residues. These organic residues were added at rates of 1:1:1:1 (w/w). These materials were amended with PR at rates of 10, 15 and 20% on weight basis. The organic compounds were thoroughly mixed with some bio-fertilizers, yeast at rate of 5 ml/kg and composted or incubated for 4 months. Organic compounds initially weighted and kept at 60% of their WHC throughout the entire period of 120 days. Temperatures of different prepared composts were recorded using alcohol thermometer every two days within the first three weeks of composting, and every week until the end of the experiment.

Kinetic data was taken after 1, 14 and 120 days in 3 replicates. The chemical and nutritional properties of the studied phosphocompost are presented in Tables 1-3.

Kinetic study

At the end of each incubation time, 50g of organic composts were taken and prepared for the kinetic study. Kinetics of phosphate desorption was studied by placing 5.0 g of compost samples into 250 ml - Erlenmeyer flasks. A 50-ml of ammonium bicarbonate-DTPA was added. The flasks were vigorously shaken using end over end shaker for various time intervals, *i.e.*, 1, 5, 10, 30 min; 1, 2, 6 hr; 1, 2, 4, 7 days). The solution samples were separated from the suspension and analyzed for their phosphate content

Kinetic models used

Phosphate desorption data was examined by three kinetic equations representing both empirical and theoretical equations. The linear forms of these models are:

A. Hoerl eqution

$$q=at\text{^}b*e\text{^}(C*t$$

B. Parabolic diffusion equation

$$q= b + a\, t^{1/2}$$

C. Modified Freundlich equation equation

$$q = b\, t^{a}$$

where:

q = the amount of phosphate desorbed at time t
a &b = constants
t = time in minute

The conformity of desorption data to a particular kinetic equation(s) was judged by the higher coefficient of determination (R^2) and the lower of the standard error (SE) of the regression relation.

TABLE 1. The chemical characters of used organic materials.

Characters	Farmyard Manure (FYM)	Chicken Manure	Peanut Shell	Maize Residues
pH (1:20)	7.75	6.77	6.2	6.8
EC $dS.m^{-1}$ (1:20)	2.0	1	1	6.4
O.M. %	65.9	89.3	93.83	84.8
C / N ratio	24.24	19.0	75.76	74.69
Total Nitrogen %	1.58	2.73	0.72	0.66

TABLE 2. The chemical characters of used rock phosphate.

Characters	PR
pH(1:20)	6.2
EC(1:20)	2.0
Total (P_2O_5 %)	30.5
Soluble Na(ppm)	43.7
Soluble Ca(ppm)	334
Soluble Mg(ppm)	103
Soluble HCO_3(ppm)	54

TABLE 3. The chemical and nutritional properties of the studied phosphocompost.

Phosphocompost sample (PC)	pH (1:20)	EC $dS.m^{-1}$ (1:20)	C/N ratio	Total Macronutrients %			Available Macronutrients (ppm)		
				N	P	K	N	P	K
Compost 10%PR	9.4	1.4	1:18	1.5	2.2	1.2	590	800	8000
Compost 15% PR	8.4	0.9	1:22	1.7	2.3	1.4	620	1000	7000
Compost 20% PR	8.6	1.8	1:24	1.8	2.8	1.3	1260	1500	7450

Statistical analysis

Different statistical analysis was conducted in this study to evaluate the conformity of different models in describing P release by using SAS software (SAS institute, 1985). (The results are the mean values of three replicates).

Results and Discussion

Effect of residence time and rate of PR applied on the kinetics of phosphate desorption from phosphocompost organic material

Figure 1 represents the kinetics of phosphate release from compost enriched with PR applied at three rates 10, 15 and 20% (T1-T3) respectively, after 14 days of incubation. Because of the S shape observed for P desorption data in different treatments through the entire reaction time, the reaction time of 10080 min was divided into two stages, the first stage was the rate of P released through 1-60 min and the second one was the data obtained through the rest of time, *i.e.*, 120-10080 min.

Dividing the entire reaction time (A) into two stages, led to have almost straight lines in both short reaction time (B) and long one (C) in tested all treatments. Data shows the P release from PR tested individually gave the lowest values compared with other tested treatments. By mixing PR with prepared compost at different rates the P released was significantly increased. Data showed that the maximum phosphate desorbed from PR was 70 ppm, meanwhile mixing of PR at 10% (T1) with compost gradually increase up to 79 ppm particularly after 14 days.

Results indicated that increasing the rate of PR to 15% mixed with compost, gave a maximum concentration of P desorbed to 109 ppm which represented about 56% over the control (PR). However, the higher concentration of PR applied to prepared compost (20%) only increased desorbed P to 95 ppm which represented about 36% over the control treatment. Worth to mention that the same observation was reported by Rasha Ramzy (2007).

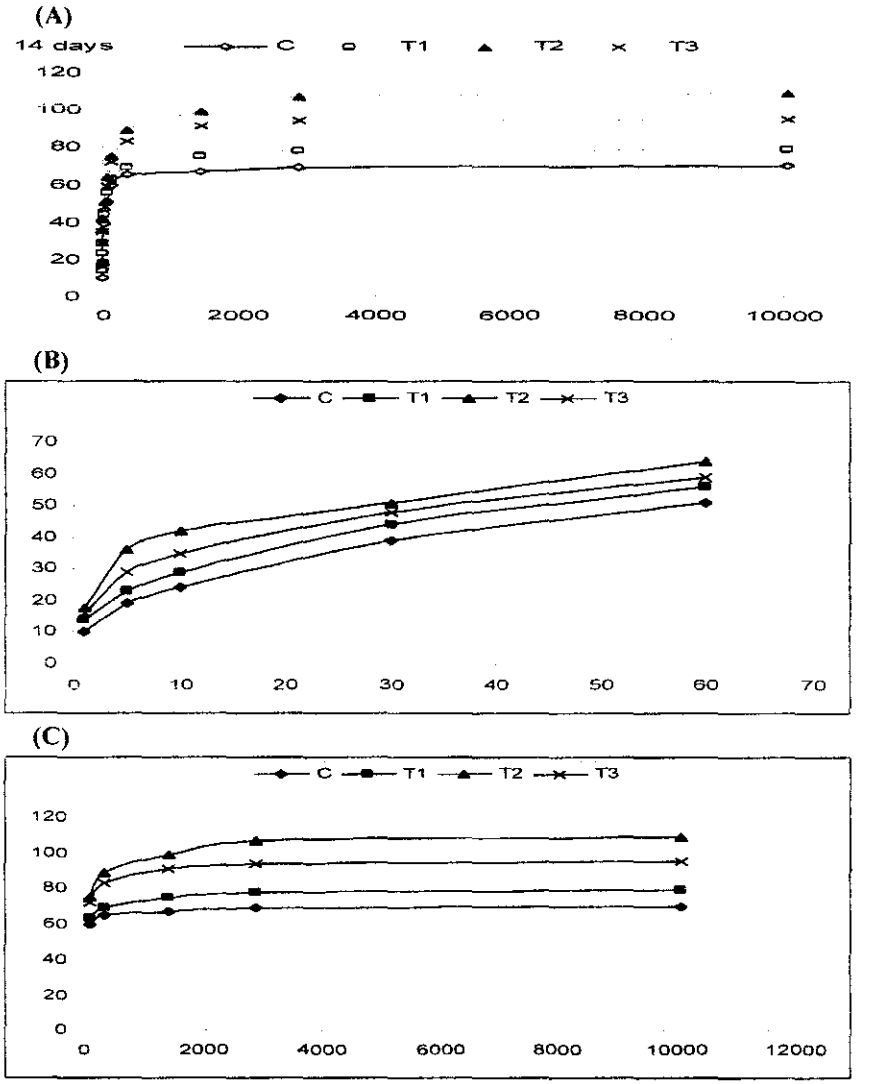

Fig. 1. Kinetics of P desorption from different treatments prepared after 14 days incubation time during the entire reaction time (A) or dividing the entire reaction into two stages B and C.

Kinetic parameters of phosphate desorption from phosphocompost as affected by rate of PR applied and period of incubation.

Modified Freundlich kinetic model

The results in Table 4 present the rate constants of the regression equations *i.e.* modified Freundlich kinetic equation which describe phosphate desorption from compost enriched with PR after 1, 14 and 120 days of incubation. The conformity of desorption data to a particular kinetic equation was judged by the highest coefficient

of determination (R^2) and the lowest standard error (SE) of the regression relation. The data indicated that, although the modified Freundlich equation (MFE) becomes the 3rd fitted equation in describing P release from different treatments; this kinetic model gave high significant (R^2) at different incubation time and in both entire reaction time and by dividing this period into two stags.

The superiority of modified Freundlich equation under wide range of reaction time in studying the rate of added P fertilizer and with different sources of P similarly, were obtained by many workers. Stevenson (1994) who studied P-release kinetics from soils varied in their clay and organic matter contents. Also, Ravan & Hossner (1994) studied soil phosphorus desorption kinetics from five soil samples having widely values in their pH, organic C and clay content. All of these authors concluded that Freundlich equation was the best model to describe the P desorption kinetic data over other used models.

Also the data in the same table represents the apparent desorption rate coefficient *a* and the initial release rate *b*, the slope and the intercept. The data documented according to the linear form of MFE for PR, the control treatment and the prepared compost enriched with PR at 10% (T_1),15% (T_2) and 20% (T_3), in both the entire reaction time (10080 min) and its dividing into 1st stage (1-60 min) and 2nd stage (120-10080 min). Both the apparent coefficient rate of phosphate desorption *a* and the reversibly adsorbed phosphate *b*, consistently increased with compost enriched with 15% PR. This increase was more evident after one day of incubation. The numerical values indicated that enriched compost with 15% PR, increased the same constant from 1.26 in control to 1.29 mg kg^{-1} min^{-1} after 1 day incubation, meanwhile increasing PR to 20% led to decrease the rate constant to be1.20 mg kg^{-1} min^{-1}.

The application of compost enriched with 10% PR, decreased the rate of P desorbed to 1.18 mg kg^{-1} min^{-1}. In contrast, the b values of different treatments which represents the capacity factor (Zaghloul, 1998), or the initial release rate when comparisons are made between constants of power function equations (Sparks, 1989). This constant increased different PR treatments by using over the control treatment PR. In T3, for example, after 1 day incubation the b value was 2.86 mg P kg^{-1} in T3. At the control treatment, however, it was 2.06 mg P kg^{-1}. At higher incubation time *i.e.*120 days, the same values were decreased to 2.14 and 1.64 mg P kg^{-1} in the same treatments, respectively.

According to the constants of the MFE, after 1 day of incubation, data presented in Table 4 showed that compost treated with 15% PR gave the highest value compared with other treatment reached to 1.34 mg P kg^{-1} min^{-1} against 1.25 mg P kg^{-1} min^{-1} for control. The results also showed that, increasing the incubation time to 14 days led to increase the a value to 2.98 mg P kg^{-1} min^{-1} against 2.29 mg P kg^{-1} $min^{-1}$for control treatment. It should be mentioned that both T1 and T3 gave higher values compared to control. At higher incubation time the same trend was also observed as T_2 was the highest treatment. The same trend was observed by Kuo (1995).

TABLE 4. Rate constants, coefficient of determination R^2 and standard error SE of power function equation of phosphate desorption from PR and PR-enriched compost treatments applied at different times of incubation.

1day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	1.26	2.06	0.81**	0.216	1.252	1.86	0.96**	0.134	1.059	3.41	0.94**	0.039
T1	1.18	2.76	0.89**	0.110	1.309	2.51	0.99**	0.046	1.0611	3.52	0.94**	0.062
T2	1.29	2.97	0.89**	0.128	1.340	2.71	0.98**	0.057	1.058	3.95	0.88*	0.088
T3	1.20	2.86	0.89**	0.123	1.335	2.61	0.99**	0.050	1.058	3.78	0.90*	0.079

14 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	1.23	2.73	0.82**	0.186	0.14	2.20	0.99**	0.018	1.03	3.95	0.91*	0.044
T1	1.21	2.96	0.86**	0.147	1.404	2.61	0.99**	0.025	1.05	3.91	0.95**	0.059
T2	1.46	3.23	0.90**	0.116	1.643	2.98	0.96**	0.08	1.08	4.05	0.92**	0.103
T3	1.21	3.10	0.89**	0.131	1.370	2.81	0.99**	0.03	1.06	4.02	0.88*	0.006

120 days

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	1.32	1.647	0.84**	0.23	1.70	1.08	0.98**	0.11	1.056	2.94	0.90**	0.12
T1	1.31	1.938	0.83**	0.25	1.68	1.37	0.98**	0.06	1.069	3.31	0.92**	0.08
T2	1.39	2.31	0.83**	0.22	1.95	1.78	0.99**	0.07	1.058	3.78	0.93**	0.07
T3	1.31	2.14	0.83**	0.23	1.67	1.57	0.98**	0.07	1.071	3.52	0.91**	0.09

The capacity factor represented by b parameter in this model at different stages showed that in 1st stage at different incubation times, treated compost with PR led to significant increase in b values as compared with control treatment. After 14 days, the b values were 2.98mg kg^{-1} in T2; the corresponding values were 2.61 and 2.81 mg kg^{-1} in T1 and T3, respectively. At this incubation time the control treatment value was 2.29 mg kg^{-1}. The same trend was also observed in other incubation time. The comparison between different incubation times of this parameter data indicated that b values were gradually increased through the first 14 days followed by decreasing order till 120 days.

The 2nd stage data given in the same table showed that again T2 gave higher capacity factor compared with other treatments applied. Increasing incubation time in this stage from 1day to 14 days led to a gradual increase in b constant from 3.95 to 4.95 mg kg^{-1}. The corresponding values were 3.52, and 3.91 mg kg^{-1} in T1 and 3.78 and 4.02 in T3. The lowest values were observed in control treatment. Increasing the incubation time over 14 days led to decrease in b constant values as compared with the data of the first 14 days. At higher incubation time (120 days) increasing the incubation time led to decrease the capacity factor to have the minimum values in all treatments. The respective numerical values of these treatments were 3.34, 3.78 and 3.52 mg kg^{1}.

Parabolic diffusion kinetic model (PDM)

The data in Table 5 represents the rate constants, R^2 and SE of parabolic diffusion equation. In this model, it is assumed that compost materials and its modifications applied to increase P release is mainly responsible for desorption of the phosphate and that the rate controlling process is diffusion of the sorbed P in that material constituent. It is further assumed that the tested material and the diffusion coefficient do not vary considerably.

The kinetic parameters *a* and *b* are presented in Table 5 for the P release from different compost materials enriched with PR and incubated for different incubation times. Both diffusion rate coefficient of phosphate release *a* and the *b* value representing the quantities of phosphate at zero time were affected by the period of soil incubation. For the entire reaction time, after one day, the results showed that in T2 the rate value was 39.19 mg P Kg^{-1} soil min^{-1}. Increasing the incubation time to 14 days led to increase this value to 63.36 mg P kg^{-1} min^{-1}. Increasing the incubation time up to 120 days, however, decreased the *a* constant to 32.49 mg P kg^{-1} min^{-1}. In other words, 50% decrease in rate of P desorbed was noticed by increasing the time of incubation. The same trend was also observed in other treatments. The obtained results were in the same trend observed by Rasha Ramzy (2007).

In the 1st stage which gave higher R^2 and lower SE values as compared with the 2nd one, data showed that one day later the T2 gave the highest a values as compared with the control treatment. The same trend was also observed in other treatments as well. In Table 5, after one day the a value of PR was 13.03 mg kg^{-1} min^{-1}, this value was increased by about 50% in T3 and about 30% in T1, meanwhile the same value was doubled in T2 treatment.

TABLE 5. Rate constants, coefficient of determination (R2) and standard error (SE) of parabolic diffusion equation of phosphate desorption from PR and PR-enriched compost treatments applied at different times of incubation.

1 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	9.89	20.4	0.49^{ns}	4.42	13.05	1.85	0.97**	1.72	4.62	36.04	0.79*	1.12
T1	14.67	28.9	0.58*	4.48	11.26	11.13	0.95**	2.19	16.9	46.02	0.71*	2.41
T2	29.19	40.2	0.56*	7.62	28.72	11.14	0.99**	1.19	71.68	70.46	0.64*	4.26
T3	26.42	34.9	0.56*	6.23	20.61	10.75	0.98**	1.61	33.4	59.32	0.67*	3.43

14 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	23.62	45.65	0.46^{ns}	7.155	16.72	1.80	0.98**	0.81	8.78	62.03	0.70*	1.8
T1	39.70	39.82	0.52^{ns}	7.160	38.68	8.77	0.86**	0.94	25.60	65.68	0.71*	3.19
T2	63.36	49.75	0.64*	8.266	57.82	18.06	0.95**	4.10	112.89	89.87	0.72*	6.59
T3	47.06	45.60	0.57*	8.23	47.45	13.36	0.98**	2.48	46.65	77.37	0.64 ns	5.13

120 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	12.25	16.34	0.59*	3.97	10.82	-0.11	0.99**	1.06	1.82	30.78	0.69 ns	2.89
T1	16.89	21.27	0.55*	5.07	16.81	0.78	0.98**	1.39	1.64	40.27	0.71*	2.60
T2	33.49	30.25	0.53^{ns}	7.46	33.40	0.48	0.99**	1.319	2.31	59.32	0.66 ns	3.43
T3	24.01	26.03	0.55*	6.23	27.14	0.25	0.99**	1.228	2.50	48.04	0.68 ns	3.41

Increasing the incubation time to 14 days, gave the same trend in all treatments applied involving PR (control treatment). In contrast, increasing incubation time of all tested materials *a* values were decreased. For example, after 120 days of incubation, the a value for T2 was 33.40 mg kg^{-1} min^{-1} against 57.82 mg $kg^{-1}min^{-1}$ for the same treatment incubated for 14 days. The same trend was also observed in T1 and T3 with different percentage of decreasing order. It should be mention that no obvious trend was observed in changing of b values; which represents the capacity factor of desorbed P as affected by incubation time; with general note that increasing of T2 compared with other treatments. In this part the 2^{nd} stage will not be discussed according to low R^2 and higher SE values with general observation in this stage similar to that observed in the 1^{st} stage.

Hoerl kinetic model

The data in Table 6 represents the rate constants of phosphate release a and b as quantified by the Hoerl equation from the compost enriched with PR applied at different rates, coefficient of determination R^2 and the standard error SE. The Hoerl kinetic equations gave highly significant R^2 at all levels of added PR fertilizer to compost. For the entire reaction time, after one day of incubation, the R^2 values ranged between 0.90** and 0.97**. The lowest value was detected for control treatment. The treatments; however, all gave the highest values. At higher incubation time of 120 days, the R^2 values of different treatments were decreased to reach 0.92**. Concerning the SE parameter, after one day of incubation the SE values were 0.08 for T1, T2 and T3. In control treatment, the SE of T1 and T3 slightly increased to 0.16 and 0.13. After 120 days, the SE values were increased to 0.19, 0.18 and 0.18 for T1, T2 and T3, respectively. Worth to mention that other incubation times gave the same trend for different treatments Kuo (1995).

Dividing the desorption data into the reaction periods from 1-60 min and 120-10080 min, Table 6 showed that Hoerl equation was superior to other kinetic equation tested, *i.e.*, modified Freundlich and diffusion kinetic equations. This equation had higher R^2 ranged between 0.98** and 0.99** in the 1^{st} and the 2^{nd} stages, beside the lowest the SE values in most cases.

In few cases, however, the MFE was seemly with Hoerl equation and both superior as compared with parabolic diffusion equation especially in the starting of reaction time. It is worthy to mention that the tested kinetic equation gave the highly insignificant R^2 values especially in the 1^{st} reaction time of 1-60 min with very few exceptions through the entire incubation times tested. According to R^2 and SE for both entire reaction time and its dividing into two stages, it could be concluded that kinetics of phosphate release from the compost enriched with PR at different rates may be best described by Hoerl equation at the all levels of PR applied and time of phosphocompost incubation (Rasha Ramzy, 2007).

The dissolution of P from phosphocompost consistently affected by rate of PR added to compost material. Data in Table 6 indicated that increasing the incubation time from one to 14 days in T_2 led to increase *a* value from 7.27 to 8.17 min^{-1} and from 6.03 to 7.77 min^{-1} in T_1, the same value in T_3 was increased from 6.95 to 7.33 min^{-1}. The control treatment values in all cases take the minimum value.

TABLE 6. Rate constants, coefficient of determination R^2 and standard error SE of Hoerl equation of phosphate desorption from PR and PR-enriched compost treatments applied at different times of incubation.

1 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	0.89	20.4	0.19^{ns}	4.42	13.03	1.85	0.97**	1.72	1.62	36.94	0.79*	1.12
T1	14.67	28.9	0.58*	4.48	11.76	11.13	0.95**	2.19	16.9	46.03	0.74*	2.41
T2	39.19	40.2	0.56*	7.62	28.72	11.14	0.99**	1.19	21.68	70.46	0.64*	4.26
T3	20.42	34.9	0.56*	6.23	20.61	10.75	0.98**	1.69	33.4	59.37	0.67*	3.43

14 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	23.62	35.65	0.16^{ns}	7.155	16.72	4.89	0.99**	0.81	8.78	63.03	0.70*	1.9
T1	39.70	39.82	0.52^{ns}	7.160	38.68	8.77	0.99**	0.91	35.60	65.68	0.71*	3.19
T2	63.36	49.25	0.64*	8.266	57.82	18.56	0.98**	4.40	112.89	89.87	0.72*	6.59
T3	47.06	45.60	0.57*	8.23	47.45	13.36	0.98**	2.49	46.66	77.37	0.64 ns	5.13

120 day

Treatment	Entire				1st stage				2nd stage			
	a	b	R^2	SE	a	b	R^2	SE	a	b	R^2	SE
PR	12.25	16.31	0.59^{ns}	3.97	10.82	-0.11	0.99**	1.06^{ns}	1.82	20.78	0.69 ns	2.89
T1	16.89	21.27	0.55^{ns}	5.07	16.81	0.28	0.98**	1.39	1.64	40.27	0.71*	2.60
T2	32.49	30.73	0.53^{ns}	7.46	33.40	0.48	0.99**	1.71^{ns}	2.34	59.57	0.66 ns	3.43
T3	24.01	26.03	0.55*	6.23	27.14	-0.25	0.98**	1.27^{ns}	2.50	48.94	0.68 ns	3.41

Unlike MFE or parabolic diffusion kinetic models, increasing of incubation time over 14 days led to gradual increase in *a* values. At higher incubation time, the rates of P dissolution values were increased in different treatments. After 120 days the results showed that *a* values were 11.82 min^{-1} in T_1 which represents almost the double of the same treatment value represented after 1 day of incubation. The data of T_2 treatment in the entire reaction time showed higher dissolution rate as compared with other treatments. The *a* value after 120 days was 21.1 min^{-1} which represents almost three times of the same treatment value calculated after 1 day of incubation. Application of high rate of PR (20%) in T_3 did not give the expected increase in dissolution rate compared with T_1 and T_2. The results showed that a value of T_3 was 12.95 min^{-1}. This value was very narrow with that obtained in T_1 which prepared by applying 10 %(of what?) to prepared compost. In other words, the rate of PR applied to compost was not the main factor controlled the dissolution rate of P from PR-compost system Mishra & Banger (1986).

The initial concentration of P in the beginning of reaction at different incubation time represented by b constant is presented in Table 6. The results indicated that, increasing the incubation time, led to gradual increase in b constant until 14 days of incubated treatments. After one day, the b constant of the entire reaction time was 2.63, 2.82 and 2.72 mg kg^{-1} for T1, T2 and T3, respectively. Increasing the incubation time to 14 days, increase the same value to 2.80, 3.11 and 2.92 mg kg^{-1}. At higher incubation time, data showed that b values were decreased to 1.69, 2.07 and 1.90 mg kg^{-1} in T1, T2 and T3 respectively.

Dividing the entire reaction time into two periods consistently influencing R^2, SE and the kinetic parameters represents the slope and intercept of the studied models. Data in Table 6 indicated that after one day of incubation R^2 values in the 1^{st} stage ranged between 0.96^{***} and 0.99^{***}, the lowest value was observed in PR treatment and the highest ones were for other treatments. The same values in the entire reaction time for these treatments were 0.96^{***}. Moreover, through the entire reaction data the same trend was also observed. After 90 days the R^2 values for T1, T2 and T3 were ranged between 0.98^{**} and 0.99^{**}, the same values of the entire reaction time were 0.92^{**}. Data also indicated that SE values were decreased by dividing the entire reaction time (Aharoni *et al.*, 1991).

After 120 days the SE for the entire reaction time were ranged between 0.18 and 0.19, in the 1^{st} stage, however, the corresponding values were ranged between 0.09 and 0.14 and again the highest value was observed in PR treatment, finally in should be mentioned that the same trend was observed in the 2^{nd} stage. In general, the kinetics of phosphate release from PR-compost system might be best described using Hoerl equation or confirm the suitability of Hoerl model to describe the kinetic data under different conditions. This equation also proved superior to describe the kinetic data of the studied level of added phosphate fertilizer and the time of incubating compost-fertilizer systems. Moreover, Hoerl equation showed superiority over MFE and Diffusion equation

in most cases. In few cases, however, the MFE and the parabolic diffusion equation were equally adequate (Rasha Ramzy, 2007).

Data in Table 6 implies that the comparison between *a* values in both 1^{st} and 2^{nd} stages indicated that most of P dissolution was observed in the 2^{nd} stage in all treatments and the highest values were observed in T2 followed by T3 and T1, the minimum value however was observed in PR treatment. In the 1^{st} 14 days, especially in 2^{nd} stage data showed that there is a gradual increase in a value with increasing incubation time. Increasing the incubation time from 1 up to14 days, showed that *a* values of T_2 in the 2^{nd} stage increased from 11.61, 19.56 and 23.56 min^{-1}.

After 14 days, the results indicated that a gradual decrease in *a* value followed by slight increase with some few exceptions observed throughout different incubation tested times. Worth to mention that in all cases, the control treatment gave the lowest value as compared with other treatments applied with keeping of the same trend of PR composted treatments.

Concerning b constant, the data indicated that at any incubation time the initial rate of P, values of the 2^{nd} stage were higher than that of 1^{st} stage. It should be mention that increasing or decreasing order of these values throughout the different incubation times studied was not observed in most cases. However, in the first 14 days data of the same constant showed clear trend of gradual increased in both stages.

In this study, the above mentioned results indicated that both MFE and diffusion equation were fitted to describe P release rate from the compost-PR system for different tested treatments. Moreover, both equations gave an indication to the different mechanisms controlled rate of P release such as chemosorption of P on function groups found in organic compost material and diffusion. These mechanisms almost the main mechanisms which control P release from this complex system. Moreover, according to Hoerl model, there is continues dissolution of P throughout the different incubation time; however, the rate of P release did not take linear trend. In other words, the rate of P release from PR-compost treatments take two trend shape such as the 1^{st} one was observed in the first 14 days and the second was observed throughout different incubation times. Another factor may affect on the control rate of P release from the studied system.

From the data depicted in Table 7 which represents the changes occurred in pH of phosphocompost through different incubation times, it could be implies that in T2, the increasing of incubation time from 1 to 14 days, produce a gradual increase in pH of compost-15%PR system from 6.48 to 6.77. The corresponding values were 6.54, 7.0 and 6.51, to 6.87 for T1 and T3, respectively. This result explains the increasing of P released from T_2 compared with T_1 and T_3. The same observation was reported by Mahimairaja *et al.* (1995).

TABLE 7. Changes occurred in soil pH as affected by incubation times of different tested treatments.

Treatment	0	7	14	30	45	60	90	120
T1	6.5	6.7	7.0	7.6	7.9	8.8	9.8	10.0
T2	6.5	6.7	6.8	6.8	7.6	8.3	9.3	9.4
T3	6.5	6.8	6.9	7.0	7.6	8.5	9.4	9.6

The application of 15% PR to compost enhanced P release from this system compared with 10 or 20 % PR. By increasing the incubation time over 14 days, an increase in pH according to the increase of ammonia concentrations (Fig. 2) was observed. This increasing of pH led to decrease P release from the studied organic phosphocompost.

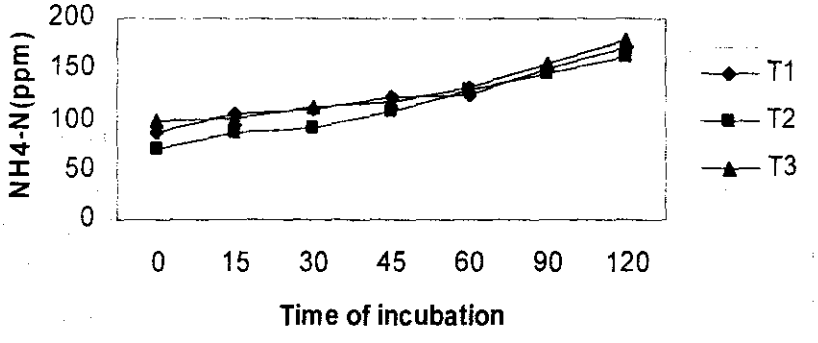

Fig. 2. Changes occurred in NH_4-N as affected by incubation times of different tested treatments.

Moreover, data depicted in (Fig. 3) showed that changing occurred in temperature of the studied systems throughout the entire reaction time, represents an increase in phosphocompost temperature in the first 14 days from 32, 32, 32 after one day to 40, 45 and 42°C in T1, T2 and T3, respectively. This result enhanced P release from the studied treatments through the first 14 days and also gave superiority to T2 over T1 and T3 to give highest P desorption rate. Increasing the incubation time over 14 days led to decrease in compost temperature materials according to minimizing the microbial activity for increasing the pH of the studied systems and subsequently decreasing the rate P desorption from these systems.

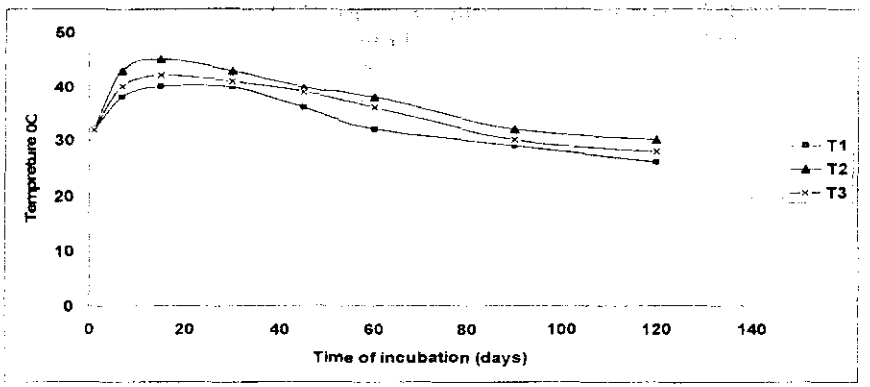

Fig. 3. Changing occurred in temperature of different treatments as affected by incubation time applied.

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تـأثير زمـن التحضـين علـى كينيتيكيـة أنطـلاق الفوسـفات مـن الكومبوست المعامل بالصخر الفوسفاتى

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يهدف هذا البحث الى دراسة كينيتيكية أنطلاق الفوسفات من ثلاث أنواع من الفوسفوكومبوست أختلفت فى محتواها من الصخر الفوسفاتى المضاف عند مستويات ١٠ ، ١٥ ، ٢٠ ٪ . حضنت هذة الانظمة لازمنة من يوم الى ١٢٠ يوم. أوضحت النتائج المتحصل عليها من الثوابت الكينيتيكية ان اضافة ١٥٪ من الصخر الفوسفاتى الى الكومبوست أدت الى زيادة أنطلاق الفوسفات بحوالى ٥٦٪ مقارنة بالكنترول فى حين أن المستوى الاعلى المضاف من السماد (٢٠٪) أدى الى زيادة مقدارها ٢٠٪ أما المستوى الادنى من الاضافة فقد اعطى اقل زيادة .

وفيما يتعلق بالمعادلات الكينيتيكية المختلفة المستخدمة أوضحت النتائج أن تلك المعادلات أوضحت معنوية عالية فى وصف النتائج المتحصل عليها ومنها الثوابت الكينيتيكية لمعادلة هوريل وهى احسن معادلة مقارنة بمعادلة فرندلش المعدلة والانتشار أظهرت أنطلاق الفوسفات من الصخر الى الكومبوست (النظام الاول) وتلك الثوابت قد تأثرت بالكمية المضافة من الصخر ، فى حين أن ثوابت معادلة فرندلش المعدلة والتى تصف أنطلاق الفوسفات من نظام الفوسفوكومبوست للبيئة المحيطة أظهرت زيادة معنوية فى الايام الاربعة عشر الاولى من التفاعل تلاها انخفاض فى الكمية المنطلقة بزيادة فترة التحضين ، وأوضحت النتائج المتحصل عليها بشكل قاطع أن ثوابت هذة المعادلة قد تأثرت بشكل قاطع ببعض العوامل مثل pH الوسط درجات الحرارة وزمن التفاعل وكافة الميكانيكيات التى أثرت على أنطلاق الفوسفات من وسط الفوسفوكومبوست والعوامل المؤثرة على الانطلاق تمت مناقشتها فى البحث .