Characterization of enriched phosphatic sludge and studies on nutrient releasing pattern from enriched phosphatic sludge under submerged condition

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Abstract

A laboratory experiment was conducted to characterize the enriched phosphatic sludge (EPS) and to determine the nutrients release pattern from different levels of enriched phosphatic sludge under flooded condition. Soil sample were collected at the depth of 0-15 cm from "B" block, Zonal Agricultural research Station, V. C. Farm, Mandya. Soil sampling area lies between 76^{0}82'01" to 76^{0}82'08" E longitude and 12^{0}57'03" to 12^{0}57'05" N latitude with an average elevation of 699-715 m above SML and incubation study carried out during 2016 at UAS, GKVK, Bengaluru. Seven different levels of EPS (0, 125, 250, 500, 750, 1000 and 1250 kg ha^{-1}) was adopted in this experiment with three replication by using factorial complete randomized design. Enriched phosphatic sludge supplied by Aditya Birla chemical fertilizers private limited was characterized for various parameters. The analysis of the samples revealed that the pH value of enriched phosphatic sludge was alkaline in reaction (8.03) and medium in salt content (0.97 dS m^{-1}) and OC (11.30 %).The enriched phosphatic sludge had high quantity of phosphorus (6.88 %) and the total N, K, Ca, Mg and S contents were also appreciable in the enriched phosphatic sludge (1.51, 1.20, 1.50, 1.10 and 1.20 %, respectively). Heavy metal content in sludge was much lower than that indicated for PROM (phosphate rich organic manure) and other organic fertilizers listed in the FCO amendment.Significantly higher available nutrients release (NPK) were recorded in treatment T_7 which received 1250 kg EPS ha^{-1}.

Keywords: Enriched phosphatic sludge, characterization, nutrients and incubation.

Introduction

To increase crop yields, enhance soil fertility, reduce environmental pollution and achieve sustainable agriculture, soil fertility needs to be maintained at an appropriate level, or restored if it has decreased (Diacono and Montemurro, 2010; Fageria, 2007). In farming systems with low inputs of chemical fertilizers and pesticides, this can be achieved by rotating leguminous and non-leguminous crops and by addition of organic compounds or organic amendments (OA) which are rich in nutrient content. The application of OAs is common in traditional agriculture systems. These OAs enhance plant growth and may reduce the need for mineral fertilizers (Mohanty *et al.*, 2011), which reduces costs for farmers. Organic amendments restore and reclaim degraded soils by maintaining organic matter and sustaining soil fertility for agricultural production, particularly in the long-term, by slowly releasing nutrients (Tejada *et al.*, 2009). Thus, OAs recycles nutrients and organic matter to support crop productivity and maintain soil quality (Whalen *et al.*, 2001). The cycling of nutrients through the decomposition of organic materials is important in all ecosystems. Release of nutrient from OAs mainly depends on the C:N ration, nutrient content, soil moisture , microbial activity etc. However in the soil fertility management of many tropical and sub tropical farming systems, organic sources play a dominant role because of their short-term effects on nutrient supply to crops (Palm *et al.*, 2001). There is now a considerable literature reporting decomposition and nutrient release patterns for a variety of organic materials. This information has been drawn together so that it can be used for improvement of soil fertility through better management of organic inputs (e.g. Giller and Cadisch, 1997; Palm *et al.*, 2001) and understanding has emerged of how resource quality factors influence the release patterns.

These OAs can be composted or non-composted organic wastes from agriculture, industry, municipal operations, seaweed, or blood and bone meal (Quilty and Cattle, 2011). Among organic amendments enriched phospatic sludge (EPS) is one it contains about 6.88 per cent phosphorus, 11.30 per cent of organic carbon, about 1.5 and 1.2 per cent of N and K respectively. There is no literatures are available with respect to release pattern of nutrient from EPS under flooded condition so this work was conducted with an objective to know the nutrient release pattern from enriched phosphatic sludge under flooded condition during 120 days after incubation.

Materials and method

Location of soil sampling

The soil sample were collected at the depth of 0-15 cm from "B" block, Zonal Agricultural research Station, V. C. Farm, Mandya. Soil sampling area lies between $76^0$82'01" to $76^0$82'08" E longitude and $12^0$57'03" to $12^0$57'05" N latitude with an average elevation of 699-715 m above SML.This area under canal irrigation. Rice is the major crop of the area in *Kharif* season followed by rice. The sample was processed for further experimental purpose, soil was air dried, crushed, powdered and sieved with 2 mm mesh size. The initial soil sample data were presented in Table 2.

Experimental Details

Raw sludge generated from the ortho-phosphoric acid manufacturing plant, located at Karwar, Karnataka and it was further enriched with pressmud, sea weed extract and plant growth promoting substance by Aditya Birla chemical fertilizers private limited and EPS was collected from Aditya Birla chemical fertilizers private limited for experimental purpose.

Lab experiment was conducted at Department of Soil Science and Agricultural Chemistry laboratory, University of Agricultural Sciences (UAS), Bengaluru during 2016. Experiments were laid out in factorial complete randomized design with seven treatments *viz*., T_1: Absolute control (Soil alone), T_2: Soil + 125 kg^{-1} EPS ha^{-1}, T_3: Soil + 250 kg^{-1} EPS ha^{-1}, T_4: Soil + 500 kg^{-1} EPS ha^{-1}, T_5: Soil + 750 kg^{-1} EPS ha^{-1}, T_6: Soil + 1000 kg^{-1} EPS $ha^{-1}$and T_7: Soil + 1250 kg^{-1} EPS $ha^{-1}$with three replication.

Two hundred grams of processed soil was taken and filled in 500g capacity plastic pots and calculated amount of EPS (0, 125, 250, 500, 750, 1000 and 1250 kg ha^{-1}) were added to each treatments separately and pots are keep it under laboratory condition for period of 120 days. The moisture content was maintained at flooded condition and the loss of moisture was maintained regularly by weighing each pot till 120 days. Eight set of sampling were maintained separately and destructive soil sampling was done at 15, 30, 45, 60, 75, 90, 105 and 120^{th} day after incubation (DAI) and each time one set of sampling was taken and these samples were analyzed for pH, N, P and K.

Analysis of pH, N, P and K

Soil samples collected from each set of sampling were processed and subjected for analysis of soil reaction (pH), available nitrogen (alkaline potassium permanganate method), available phosphorus (Bray's method) and available potassium (neutral normal ammonium acetate extraction).

Soil pH

pH was determined in enriched phosphatic sludge (2 mm sieved) and water suspension of 1:10 ratio by using combined glass electrode pH meter (Jackson, 1973).

Available nitrogen

Available nitrogen in soil was determined by alkaline potassium permanganate distillation method as described by Subbiah and Asija (1956).

Available phosphorus

Available phosphorus content of soil was extracted using Olsen's extractant and the concentration of phosphorus in the extract was determined by Ascorbic acid method (Jackson, 1973).

Available potassium

Available potassium was extracted from soil using neutral *N*ammonium acetate at 1:5 soil to extractant ratio and the concentration of potassium in the extract was determined by flame photometer Elico CL-361 (Jackson, 1973).

Statistical analysis

The observations recorded in these studies were analyzed statistically for test of significance following the Fisher's method of Analysis of variance (ANOVA) as outlined by Panse and Sukhatamane (1967). The level of significance on 'F' test was tested a five percent. The results have been discussed based on critical difference at P=0.01. Wherever the treatment differences were found non-significant, it is denoted as 'NS'.

Results and discussion

Characterization of enriched phosphatic sludge (Table 1)

Enriched phosphatic sludge (EPS) supplied from ortho-phosphoric acid manufacturing industry owned by Aditya Birla Chemical and Fertilizer, Limited, located at Karwar, Karnataka. The enriched phosphatic sludge was characterized in order to ascertain its suitability as a soil conditioner in crop production.

Table: 1 Characterization of enriched phosphatic sludge

Parameter	Value
MWHC (%)	38.10
pH (1:10)	8.03
EC (1:100) d S m^{-1}	0.97
OC (g kg^{-1})	11.30
N (%)	1.51

P (%)	6.88
K (%)	1.20
Ca (%)	1.50
Mg (%)	1.10
Sulphur (%)	1.56

Perusal of the data presented in the Table 1 revealed that the WHC of EPS was 38.10 per cent due to higher organic carbon content of 11.30 per cent. The pH of EPS was alkaline in reaction (pH 8.03) and medium in EC (0.97dS m^{-1}). The alkaline reaction of the EPS might be due to enrichment of sludge with pressmud which is generally alkaline in reaction (Jitendra *et al.*, 2014). With respect to nutrients content of EPS was higher in total phosphorus (6.88 %) than any of the conventional organic manures (FYM, city compost or rural compost) and the total N, K, Ca, Mg and S contents were also in appreciable amount (1.51, 1.20, 1.50, 1.10and 1.56 %, respectively) in the EPS.

Changes of nutrients content in soil due to application of enriched phosphatic sludge under flooded condition

Soil reaction (Fig. 1)

Effects of different levels of EPS application on soil pH are presented in Fig. 1. Soil collected for incubation study slightly alkaline nature pH (8.03) and it was decrease with increase in incubation period up to 60 DAI and thereafter it was stagnated up to the end of incubation period. However, among the treatments higher pH values (7.46, 7.59, 7.65 and 7.68 at 15, 30, 45 and 60 DAI, respectively) were recorded in treatment T_7 (EPS @ 1250 kg ha^{-1}) and lower pH was recorded in the treatment T_1 (7.09, 7.18, 7.20and 7.21 at15, 30, 45and 60 DAI, respectively). The higher pH recorded with application of 1250 kg o EPS ha^{-1} may be due to release of basic cations upon flooding, the consumption of protons during decomposition of added organic matter and alkaline nature of EPS. Similar to the present investigation the increase in pH upon submergence was reported by Ponnamperuma (1967).

The higher values of pH may also be explained by proton (H^+) exchange between the soil and the added organic materials (Tang *et al.*, 1999). Another mechanism that was proposed to explain the increase in soil pH by such organic materials as poultry manure is the specific adsorption of humic materials and/or organic acids onto the hydrous surfaces of Al and Fe oxides by ligands exchange with corresponding release of OH^- (Hue *et al.*, 1986). The subsequent decrease in soil pH with increasing time of submergence was also observed by Opala *et al.* (2012). This decrease in soil pH with time may be due to the nitrification of nitrifiable N, which is an acidifying process (Paul *et al.*, 2001).

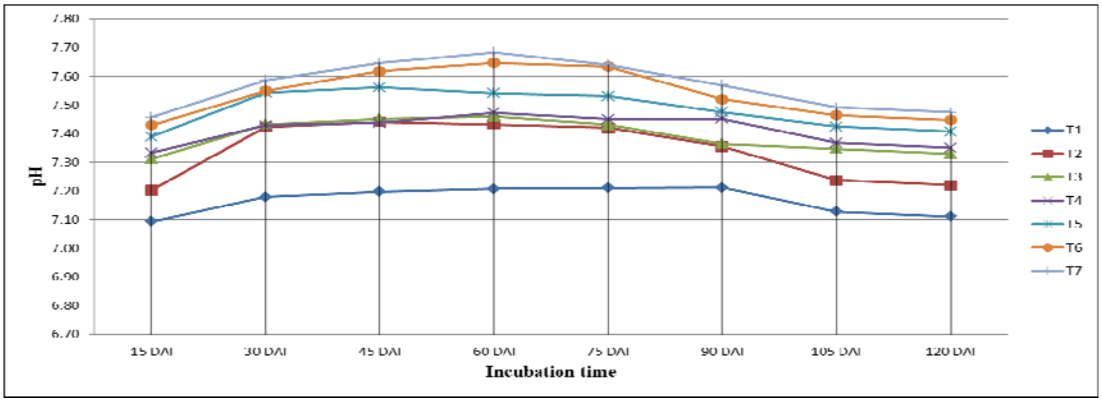

Fig. 1. Effect of different levels of enriched phosphatic sludge application on soil pH during 120 days of incubation under flooded condition

Note: T_1: Control (Soil), T_2: Soil + 125 kg EPS ha^{-1}, T_3: Soil + 250 kg EPS ha^{-1}, T_4: Soil + 500 kg EPS ha$^{-1,}$ T_5: Soil + 750 kg EPS ha^{-1}, T_6: Soil + 1000 kg EPS ha^{-1} and T_7: Soil + 1250 kg EPS ha^{-1} .

Available nitrogen content (Table 2 and Fig. 2)

During initial period of incubation 15 and 30 DAI, available nitrogen content was not significant. But from 45 to 75 DAI the available nitrogen content of soil under flooded condition was increases with increasing levels of EPS and days of incubation period. However, during 45 to 75 DAI period of incubation significantly higher available N content (292.59, 301.99 and 305.52 kg ha^{-1} at 45, 60 and 75 DAI, respectively) was recorded in treatment T_7 (1250 kg EPS ha^{-1}) than control and T_2 and it was on par with rest of the treatments. Further, slight decrease in available N content was recorded after 75 DAI. The increase in available N content might be attributed to release of N from applied EPS consequent to its mineralization.

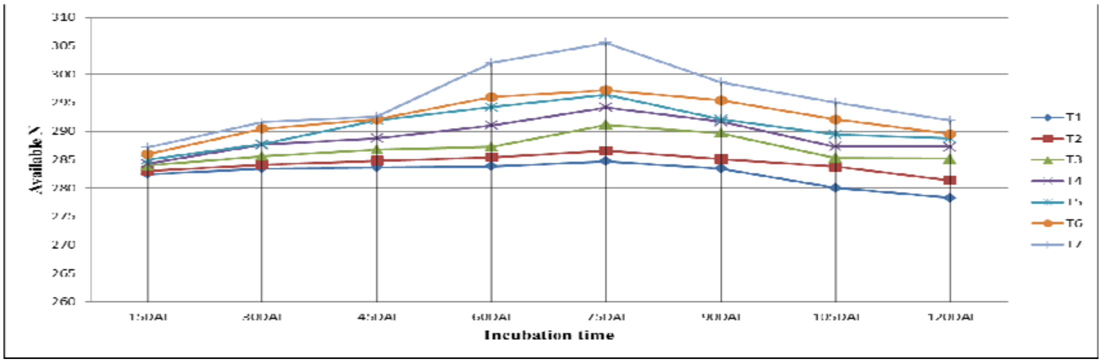

Fig. 2. Effect of different levels of enriched phosphatic sludge application on available nitrogen (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Note: T_1: Control (Soil), T_2: Soil + 125 kg EPS ha^{-1}, T_3: Soil + 250 kg EPS ha^{-1}, T_4: Soil + 500 kg EPS ha^{-1}, T_5: Soil + 750 kg EPS ha^{-1}, T_6: Soil + 1000 kg EPS ha^{-1} and T_7: Soil + 1250 kg EPS ha^{-1}

The slight decrease after 75DAI may be attributed to the utilization of N by increasing microbial population and simultaneous loss through denitrification and volatalization. At the later stages, the rate of denitrification loss of N exceeds the rate of mineralization of organic N as a result the values were lower (Zaman, 2002). The results of the present investigation are similar to those reported by Rahman *et al.* (2013) who have reported that the N mineralization from manure and crop residues was initially very low. Mineralization was increased with the increase of incubation period up to 7 weeks and there after it declined with time. In waterlogged soils, the maximum amount of N was mineralized during the period between 28 and 42 days of incubation (Keeney and Nelson, 1982).

Available phosphorus content (Table 3 and Fig. 3)

Available phosphorus content of soil was increased with increasing levels of EPS and time of incubation. The available P content increased progressively with time of incubation and thus the higher value was recorded at 90 DAI and thereafter slightly declined but it was still higher than initial level.Available P content was ranged from 23.13 to 59.58 kg ha^{-1} in treatment T_7 which received EPS @ 1250 kg ha^{-1} and lower P content was ranged from 18.51 to 18.83 kg ha^{-1} in control.

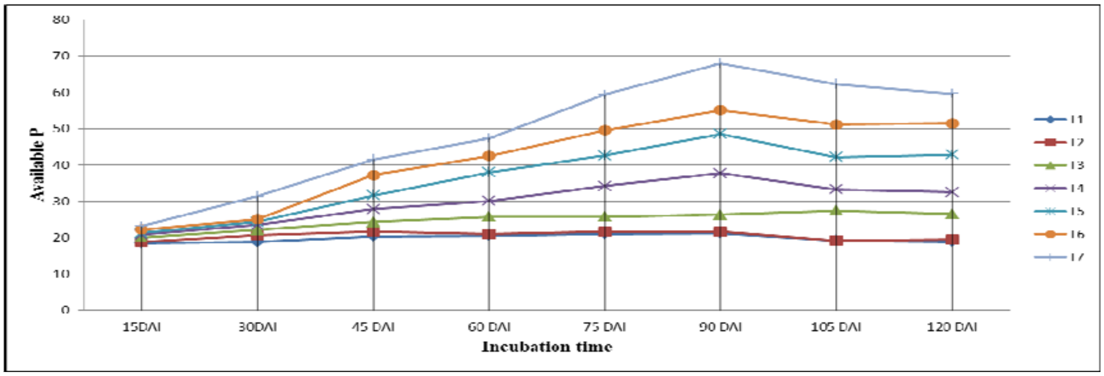

Fig. 3. Effect of different levels of enriched phosphatic sludge application on available phosphorus (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Note: T_1: Control (Soil), T_2: Soil + 125 kg EPS ha^{-1}, T_3: Soil + 250 kg EPS ha^{-1}, T_4: Soil + 500 kg EPS ha$^{-1,}$ T_5: Soil + 750 kg EPS ha^{-1}, T_6: Soil + 1000 kg EP S ha^{-1} and T_7: Soil + 1250 kg EPS ha^{-1}

The extent of P release with addition of 1250 kg EPS ha^{-1}to soil ranged from 4.61 to 46.75 kg ha^{-1} during the entire period of incubation when compared to the release of P from untreated soil (control). The higher P release due to application of EPS might be attributed to its total P content (6.88 %). The increase in the concentration of available P as a result of application of organic materials may be due to the effective chelating process of Al and Fe in soil by organic matter functional groups (Alvarez *et al.*, 1997; Bhattacharyya *et al.*, 2005) suppressing precipitation of P with Al and Fe as respective phosphate, besides mineralization of organic P from the added organic materials (Haynes and Mokolobate, 2001). The decline in available P content with time might be due to P sorption by soil Opala *et al.* (2012).

Available potassium content (Table 4 and Fig. 4)

Effect of EPS application on available potassium was low during initial period of incubation (at 15 DAI) later on it increased with increase in incubation time and attained higher value at 75 DAI and declined thereafter. Increase in available potassium content from 15 to 75 DAI was ranged from 165.79 to 175.05 kg ha^{-1} in treatment T_7 (1250 kg EPS ha^{-1}) and it was significantly higher than that recorded in control (160.58 to 163.76 kg ha^{-1}). Available K content in all treatment was slightly decreased from 75 to 120 DAI.

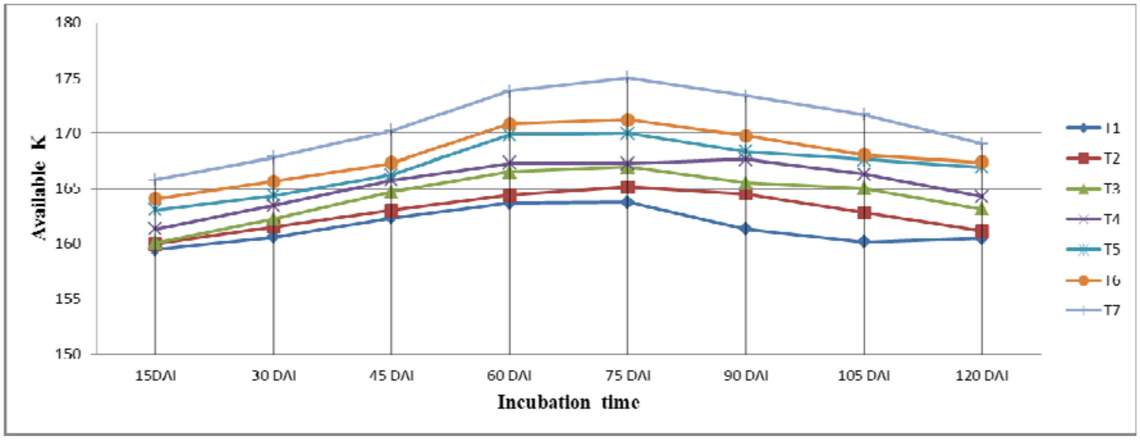

Fig. 4. Effect of different levels of enriched phosphatic sludge application on available potassium (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Note: T_1: Control (Soil), T_2: Soil + 125 kg EPS ha^{-1}, T_3: Soil + 250 kg EPS ha^{-1}, T_4: Soil + 500 kg EPS ha^{-1}, T_5: Soil + 750 kg EPS ha^{-1}, T_6: Soil + 1000 kg EPS ha^{-1} and T_7: Soil + 1250 kg EPS ha^{-1}

Initial increase of potassium in soil was mainly due to continuous release of potassium upon decomposition of EPS and also release of organic acids during decomposition of ESP might have helped in the release of bound form of potassium to soil.

Conclusion

Soil pH under submergence was maintained neutral even though EPS contains higher Ca and Mg. Significantly higher available N was recorded in treatment T_7 (1250 kg EPS ha^{-1}). The available P content increased progressively with period of incubation and thus the higher value was recorded in treatment T_7 which received 1250 kg ha^{-1} EPS at 90 DAI and the extent of K release with addition of 1250 kg EPS ha^{-1} to soil ranged from 6.31 to 11.29 kg ha^{-1} when compared to the release of K from untreated soil.

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Table 2. Effect of different levels of enriched phosphatic sludge application on available nitrogen (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Treatments	15	30	45	60	75	90	105	120	Mean
	DAI								
T_1: Control (Soil)	282.42	283.40	283.63	283.82	284.72	283.40	280.00	278.24	**282.45**
T_2: Soil + 125 kg EPS ha^{-1}	283.04	284.10	284.80	285.41	286.51	285.10	283.76	281.37	**284.26**
T_3: Soil + 250 kg EPS ha^{-1}	283.94	285.61	286.73	287.20	291.13	289.61	285.27	285.15	**286.83**
T_4: Soil + 500 kg EPS ha^{-1}	284.28	287.63	288.74	291.02	294.18	291.63	287.27	287.20	**288.99**
T_5: Soil + 750 kg EPS ha^{-1}	284.97	287.73	291.89	294.22	296.42	266.07	289.36	288.75	**287.43**
T_6: Soil + 1000 kg EPS ha^{-1}	285.96	290.42	292.06	295.99	297.20	295.42	292.06	289.48	**292.32**
T_7: Soil + 1250 kg EPS ha^{-1}	287.16	291.53	292.59	301.99	305.52	298.53	295.03	291.87	**295.53**
Mean	**284.54**	**287.20**	**288.63**	**291.38**	**293.67**	**287.11**	**287.54**	**286.01**	
	Treat	**Days**	**T X D**						
S.Em±	**1.83**	**1.95**	**5.17**						
CD @ 1 %	**5.05**	**5.40**	**14.29**						

Table 3. Effect of different levels of enriched phosphatic sludge application on available phosphorus (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Treatments	15	30	45	60	75	90	105	120	Mean
	DAI								
T_1: Control (Soil)	18.51	18.79	20.36	20.57	21.06	21.20	19.20	18.83	**19.82**
T_2: Soil + 125 kg EPS ha^{-1}	18.91	20.72	21.74	20.98	21.67	21.60	19.20	19.49	**20.54**
T_3: Soil + 250 kg EPS ha^{-1}	20.07	22.16	24.33	25.76	25.76	26.35	27.38	26.54	**24.79**
T_4: Soil + 500 kg EPS ha^{-1}	20.83	23.46	27.80	30.12	34.24	37.75	33.25	32.55	**30.00**
T_5: Soil + 750 kg EPS ha^{-1}	21.34	24.34	31.63	37.96	42.56	48.58	42.18	42.85	**36.43**
T_6: Soil + 1000 kg EPS ha^{-1}	22.20	25.05	37.26	42.47	49.59	55.10	51.18	51.48	**41.79**
T_7: Soil + 1250 kg EPS ha^{-1}	23.13	31.33	41.53	47.33	59.39	67.95	62.30	59.58	**49.07**
Mean	**20.71**	**23.69**	**29.24**	**32.17**	**36.33**	**39.79**	**36.38**	**35.90**	
	Treat	**Days**	**T X D**						
S.Em±	**0.27**	**0.29**	**0.76**						
CD @ 1 %	**0.74**	**0.80**	**2.10**						

Table 4. Effect of different levels of enriched phosphatic sludge application on available potassium (kg ha^{-1}) content of soil during 120 days of incubation under flooded condition

Treatments	15	30	45	60	75	90	105	120	Mean
	DAI								
T_1: Control (Soil)	159.48	160.58	162.31	163.66	163.76	161.31	160.13	160.45	**161.46**
T_2: Soil + 125 kg EPS ha^{-1}	159.96	161.52	163.00	164.4	165.14	164.52	162.8	161.13	**162.81**
T_3: Soil + 250 kg EPS ha^{-1}	160.07	162.22	164.68	166.53	166.95	165.51	165.01	163.13	**164.26**
T_4: Soil + 500 kg EPS ha^{-1}	161.28	163.45	165.75	167.3	167.26	167.64	166.31	164.25	**165.41**
T_5: Soil + 750 kg EPS ha^{-1}	163.06	164.38	166.25	169.81	169.98	168.33	167.61	166.94	**167.05**
T_6: Soil + 1000 kg EPS ha^{-1}	164.08	165.66	167.28	170.86	171.21	169.76	168.03	167.37	**168.03**
T_7: Soil + 1250 kg EPS ha^{-1}	165.79	167.82	170.24	173.83	175.05	173.41	171.68	169.02	**170.86**
Mean	**161.96**	**163.66**	**165.64**	**168.06**	**168.48**	**167.21**	**165.94**	**164.61**	
	Treat	**Days**	**T X D**						
S.Em±	**0.90**	**0.96**	**2.54**						
CD @ 1 %	**2.48**	**2.65**	**7.02**						