Phosphorus Fraction Distribution in Soils of Rice-Growing Areas of Three Blocks in Mayurbhanj District, Odisha

Abstract

The inorganic Phosphorus fraction in agricultural soils is essential for plant phosphate nutrition. Intricate microbiological, chemical, and biological processes go into the transformation of phosphorus. Adsorption onto Fe and Al oxides in acidic soils and the development of Fe and Al phosphate complexes with humic acids can both serve as barriers (Gerke, 1992). To understand the relationship between P fractions and soil properties, a study was conducted in the Mayurbhanj district of Odisha. Twenty-seven soil samples were collected from nine Rice growing areas of three different Blocks and analyzed by using standard laboratory techniques. The soils were found to be moderately acidic to slightly acidic in condition with low to medium organic carbon. All the soil samples were under Non-saline condition of Electrical Conductivity and suitable for crops. The study found that soil pH was the main factor influencing different P fractions, with Reductant soluble-P being the most predominant fraction, followed by Al-P, Fe-P, Ca-P, and Saloid-P. Al-P, Fe-P, and Ca-P were positively correlated with available-P, indicating their contribution to the soil's available P pool. The study also found that Reductant-soluble phosphate (RS-P) was the dominant fraction that fixed and released P from the soil, proving the fixation of P by sesquioxide in lateritic soil of Mayurbhanj district in Odisha.

Keywords: Phosphorous fractions; Soil properties.

INTRODUCTION

Phosphorus is necessary for crop output, quality, and plant growth. Due to low fertiliser usage efficiency and restricted soil P availability, farmers frequently use more Phosphatic fertilisers than plants actually need. Only 10–20 percent of the P applied with fertilisers is absorbed by plants in the year after application because the majority of the P is quickly fixed or precipitated into inaccessible forms (Vu et al., 2006). P fertilisers interact with soil elements to generate a number of forms. When P reacts with various soil components, the dominant fraction is influenced by the soil properties and becomes inaccessible. The quantity of extractable soil P, crop and soil P demand, and the capacity for P replenishment all affect the amount of P fertiliser needed. The methods currently used to quantify soil phosphorus (P) are mostly used for agronomic applications, determining soil P that is phytoavailable (Horta et al., 2010).

Both inorganic and organic phosphorus can be found in soil. Although this amount can range from 10 to 90 percent, agricultural soils typically contain 50 to 75 percent organic P(Sharpley & Smith, 1985). Inorganic P forms are linked to hydrous sesquioxides, amorphous and crystalline Al and Fe compounds in acidic, noncalcareous soils and to Ca-compounds in alkaline, calcareous soils. The many inorganic phosphates present in soils include easy soluble phosphate (S-P), aluminum phosphates (Al-P), iron phosphates (Fe-P), Reductant soluble phosphates (RS-P), and calcium phosphates (Ca-P) (Chang and Jackson, 1957). Strong acidic soils that have typically undergone extensive weathering are predominant in Al-P, Fe-P, and RS-P.

MATERIALS AND METHODS

Mayurbhanj, the largest district in Odisha, can be found there. Its coordinates are: 21° 17' N to 22° 34' N, and 85° 40' E to 87° 10' E. Additionally, it has abundant mineral resources, including bauxite, titanium, copper, and iron. The reaction of the soil is often acidic. The soil types found out are lateritic and sandy loam, both of which have a light texture and poor water retention. Twenty-seven soil samples were collected from nine Rice-growing areas in Betanati, Shamakhunta, and Barsahi blocks within Mayurbhanj district. The samples were taken at depths of 0–15, 15–30, and 30-45 cm, sieved to a 2 mm mesh size, and then analyzed for a variety of physio-chemical characteristics. Due to the low pH of all samples, Bray and Kurtz No.1extractant (Bray & Kurtz, 1945) was utilized to extract and analyze the available phosphate. The inorganic phosphorus was fractionated using a modified version of the Chang and Jackson (1957) method developed by Peterson and Corey (1966). According to Table 1, each extract ant solution was applied to the soils before they underwent a battery of tests. Following the application of a chlorostannous blue stain, the aliquot was tested for absorbance at a wave length of 660 m using a UV spectrophotometer. Using Pearson's correlation (r), it was possible to identify the relationship between the sample values.

Fig 1: Location map of Mayurbhanj District

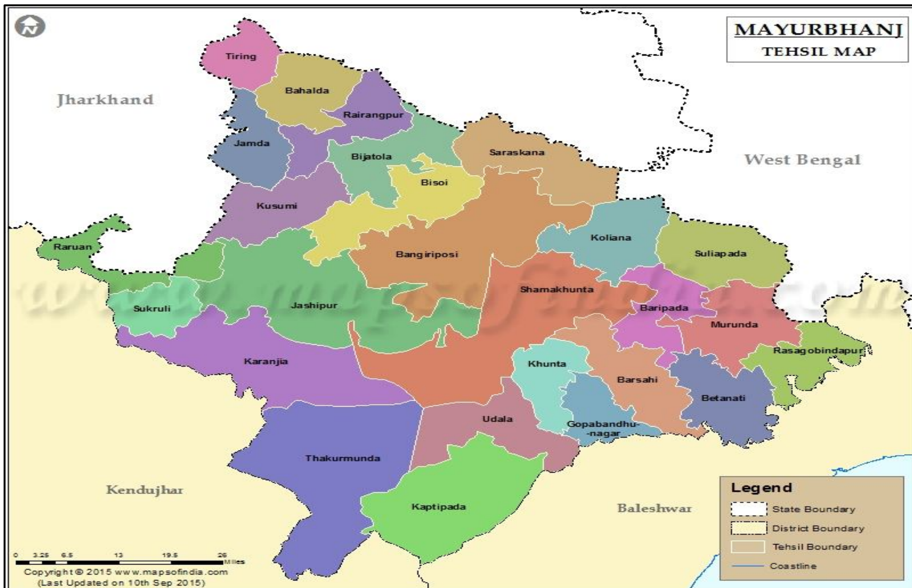

Table 1: Different methods for Fractionation of Soil Phosphorus

Fractions	Extract ant solution	Reference
Available P	Bray and Kurtz No.1extractant	(Bray & Kurtz, 1945)
Saloid bound-P	1 M NH_4Cl	(Petersen & Corey, 1966)
Aluminum bound-P(Al-P)	NH_4 OH with pH 8.2	
Iron bound-P(Fe-P)	0.1 M NaOH solution, NaCl Solution	
Reductant soluble-P(RS-P)	0.3 M Sodium citrate solution	
Ca bound- P(Ca-P)	0.25 M H_2 SO_4	
Mineral/ Inorganic -P	Conc. HCl	(Hesse, 1972)
Total-P	Vanadomolybdate method	
Organic-P	Total-P – Inorganic-P	

RESULT AND DISCUSSION

Sandy loam is the major soil type in Shamakhunta and Barsahi block's rice-growing areas varied with 67–76% sand, 9–16% silt, and 13–19% clay. Sandy clay loam makes up the soil in the Betanati block having a range of 61-70% sand, 5-10% silt, and 22-29% clay. At all soil depths, sand predominates as a component. Soil pH (1:2) varied from 5.2 to 6.03. Electrical conductivity (1:2) varied between 0.16 and 0.3 dS m^{-1} which is less than 1dS m^{-1},Salt content varied 0 to 0.1%, Non-saline in nature and salinity effects mostly negligible. Similar findings were shown by Digal et al., (2018). Soil Organic carbon in low range i.e. from 0.34 to 0.51%. Similar results found by Dash, (2016). In the Phosphorus Fractionation, the available Phosphorus varied from 3.2 to 9 ppm, Saloid P from 0.82 to 2.71 ppm, Aluminum-P from 15.2 to 19.6 ppm, Iron-P from 3.3 to 8.67 ppm, Reductant Soluble-P from 76.93 to 98.8 ppm, Calcium-P from 2.02 to 5.7 ppm, Inorganic-P from 134.3 to 104. Singson et al., (2012) have reported findings that are comparable.

Table 2: Correlation coefficients (r) among different soil parameters at 0-15cm depth

	pH	EC	OC	Saloid-P	Al-P	Fe-P	RS-P	Ca-P	Inorganic-P	Total-P	Organic-P	Available-P
pH	1											
EC	-0.14	1										
OC	0.12	0.11	1									
Saloid-P	-0.28	-0.15	-0.15	1								
Al-P	0.39	0.13	0.30	0.17	1							
Fe-P	0.50	0.20	0.68	0.16	0.29	1						
RS-P	0.14	0.25	0.48	0.27	0.33	0.46	1					
Ca-P	0.31	0.27	0.16	0.21	0.51	0.40	0.36	1				
Inorganic-P	0.26	0.21	0.62	0.23	0.22	0.43	0.91	0.77	1			
Total	0.16	0.20	0.62	0.26	0.59	0.88	0.93	0.70	0.93	1		

-P												
Organic-P	0.24	0.15	0.48	0.31	0.17	0.13	0.42	0.33	0.45	0.87	1	
Available -P	0.42	0.11	0.38	0.25	0.66	0.52	0.39	0.44	0.48	0.46	0.38	1

(Significance of r at 5%)

Saloid-bound P has been found to be the least abundant among the fractions, which has also been noted by other researchers before (Oongale, 1993; Pati & Mukhopadhyay, 2008) in various soil types and conditions.

Saloid-P ranged from 1.09 to 1.38%, Al-P from 12.16 to 11.44%, Fe-P from 4.74 to 2.85%, RS-P from 45.08 to 44.57%, Ca-P from 3.06 to 2.38%, and Organic-P ranged from 36.09 to 35.44% of Total-P in the Betanati block. Al-P > Fe-P > Ca-P > Saloid P is the typical order of the inorganic fraction's percentage contributions to Total-P.

Saloid-P ranged from 0.7 to 1.1%, Al-P from 11.17 to 12.42%, Fe-P from 3.3 to 3.6%, RS-P from 45.05 to 45.02%, Ca-P from 2.2 to 2.6%, and Organic-P ranged from 36.71 to 35.84% of Total-p in the soils under the Shamakhunta block. In general, Rs-P > Al-P > Fe-P > Ca-P > Saloid-P is the order of the inorganic fraction's percentage contributes to Total-P.

Saloid-P ranged from 0.8 to 0.9%, Al-P 11.8 to 12.42%, Fe-P 3.2 to 4.7%, RS-P 44.14 to 45.64%, Ca-P 2.6 to 2%, and Organic-P ranged from 36.78 to 35.9% of Total-p in the soils under the Barsahi block. Accordingly, Whole values fell into the following range: Rs-P > Al-P > Fe-P > Ca-P > Saloid-P.

Oongale, (1993) similarly found the prevalence of RS-P in red and laterite soils in West Bengal's acidic soils, and it attributed to a larger proportion of sesquioxides. All the inorganic fractions showed positive correlation among each other; in case of the Brays-extractable P only Al-P, Fe-P and Ca-P showed highly significant relationship (r=0.66), (r=0.52) and (r=0.44) indicating that these three fractions mainly contributed towards available P pool. The dominance of Al-P in contributing towards the availability of P has been reported by many authors (Oongale, 1993; Laxminarayana, 2007). Among the inorganic fractions of P, Sa-P had negative relation with pH, EC and organic carbon while all the fractions had positive relation with pH, EC and organic carbon. The total P showed highly significant relationship with RS-P (r=0.93), inorganic P with

RS-P (r=0.91) indicating that Reductant soluble phosphate was the most dominant fraction which fixed and released phosphorus from the soil and this proved the fixation of P by sesquioxides in lateritic soil in Mayurbhanj District, Odisha.

CONCLUSION

In the Mayurbhanj district, it can be concluded from the current study that Reductant soluble phosphate and iron phosphate predominated and that saloid-bound phosphate and calcium phosphate in lateritic soil were small-scale. The correlation equations demonstrated that the primary soil characteristic that affected the various P fractions was soil pH. The overall findings demonstrated that as soil depth increased, available P, organic P, and total inorganic-P levels declined. Al-P was the main contribution to the availability of phosphorus among the inorganic P fractions, while reductant soluble phosphate was the main fraction for the release of P. Following the analysis, it is suggested that soils with low phosphorous content be advised to apply organic manures and supplemented by applying phosphorous fertilisers in the designated crop to increase the levels of P in the soil. This is because Saloid P values should be raised from the forms of phosphorous. To mobilise fixed P into plant-available P and hence lower the P-fertilizer dose, more study is required.

REFERENCE

Bray, R. H., & Kurtz, L. T. (1945). DETERMINATION OF TOTAL, ORGANIC, AND AVAILABLE FORMS OF PHOSPHORUS IN SOILS. *Soil Science*. https://www.semanticscholar.org/paper/DETERMINATION-OF-TOTAL%2C-ORGANIC%2C-AND-AVAILABLE-OF-Bray-Kurtz/d159981f36764af240862124706dc9c23dd685f6

Dash, A. (2016). *SOIL PHYSICO-CHEMICAL CHARACTERISTICS NEAR THE MINING AREAS OF KEONJHAR*.

Digal, M., Mishra, A., Swain, N., Acharya, B., Saren, S., Prava, K., Dash, N., Swain, B., & Acharya. (2018). *Soil fertility status of some villages in Phiringia block of Kandhamal* *district under North-Eastern Ghat agro climatic zone of Odisha, India*. https://doi.org/10.13140/RG.2.2.23580.51840

Gerke, J. (1992). Orthophosphate and organic phosphate in the soil solution of four sandy soils in relation to pH-evidence for humic-FE-(AL-) phosphate complexes. *Communications in Soil Science and Plant Analysis*. https://www.semanticscholar.org/paper/Orthophosphate-and-organic-phosphate-in-the-soil-of-Gerke/42552b8c304f7edf3a1a52944133cf622741ae8f

Hesse, P. R. (1972). *A Textbook of Soil Chemical Analysis*. Chemical Publishing Company.

Horta, C., Roboredo, M., Coutinho, J., & Torrent, J. (2010). Relationship between Olsen P and Ammonium Lactate–Extractable P in Portuguese Acid Soils. *Communications in Soil Science and Plant Analysis - COMMUN SOIL SCI PLANT ANAL*, *41*, 2358–2370. https://doi.org/10.1080/00103624.2010.508296

Laxminarayana, K. (2007). Distribution of Inorganic P Fractions and Critical Limits of Available P in Rice Soils of Mizoram. *Journal of the Indian Society of Soil Science*, *55*, 481–487.

Oongale, J. H. (1993). Depth distribution of different forms of phosphorus in lateritic soils of coastal region. *Journal of the Indian Society of Soil Science*. https://www.semanticscholar.org/paper/Depth-distribution-of-different-forms-of-phosphorus-Oongale/3de6754f7ed233a91c03fddaf10d11310cf3a86b

Pati, R., & Mukhopadhyay, D. (2008). Inorganic phosphorus fractions in some acid soils under terai situations of West Bengal. *Research on Crops*, *9*, 57–60.

Petersen, G. W., & Corey, R. B. (1966). A Modified Chang and Jackson Procedure for Routine Fractionation of Inorganic Soil Phosphates 1. *Soil Science Society of America Journal*.

https://www.semanticscholar.org/paper/A-Modified-Chang-and-Jackson-Procedure-for-Routine-Petersen-Corey/0055c84e8601599e45777a1507a5334aa265e740

Sharpley, A., & Smith, S. J. (1985). Fractionation of Inorganic and Organic Phosphorus in Virgin and Cultivated Soils. *Soil Science Society of America Journal*. https://www.semanticscholar.org/paper/Fractionation-of-Inorganic-and-Organic-Phosphorus-Sharpley-Smith/9a0e83ffc2d72b168709fdf03184cb516ae0e2a3

Singson, L., Ghosh, S., & Patra, P. (2012). Distribution of Different Forms of Phosphorus in Surface Soils of Rice Growing Areas of Red and Laterite Zone of West Bengal. *Journal of the Indian Society of Soil Science*, *60*, 204–207.

Vu, D., Tang, C., & Armstrong, R. (2006). *Changes and availability of P fractions following 65 years of P application in a calcareous soil in a Mediterranean region*. https://www.semanticscholar.org/paper/Changes-and-availability-of-P-fractions-following-P-Vu-Tang/781e011113b355226ae4d4490c9945107bd6a66c