International Journal of Plant & Soil Science

Volume 35, Issue 17, Page 314-319, 2023; Article no.IJPSS.102507
ISSN: 2320-7035

Phosphorus Fraction Distribution in Soils of three Rice-Growing Blocks of Mayurbhanj District in Odisha State, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i173213

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers,peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102507

Original Research Article

Received: 01/05/2023
Accepted: 03/07/2023
Published: 07/07/2023

ABSTRACT

In the month of June in three distinct blocks of the Mayurbhanj district, the twenty-seven soil samples were collected from nine different rice-growing areas at three depths and analyzed. In accordance to the findings, the soils were found to have low to medium levels of organic carbon and to be moderately acidic to slightly acidic in nature. 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 Phosphorus fractions, with Reductant soluble-P being the

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mostpredominant fraction, followed by Al-P, Fe-P, Ca-P, and Saloid-P. Al-P, Fe-P, and Ca-P were positively correlated with available Phosphorus, indicating their contribution to the soil's available Phosphorus 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 Phosphorus by sesquioxide in lateritic soil of Mayurbhanj district in Odisha.

Keywords: Rice-growing areas; phosphorous fractions; sesquioxide; lateritic soil.

1. INTRODUCTION

Phosphorus is necessary for crop output, quality, and plant growth. Due to low fertilizer usage efficiency and restricted soil Phosphorus availability, farmers frequently use more Phosphatic fertilizers than plants actually need. Only 10–20% of the Phosphorus applied with fertilizers is absorbed by plants in the year after application because the majority of the Phosphorus is quickly fixed or precipitated into inaccessible forms [1]. Phosphatic fertilizers interact with soil elements to generate a number of forms. When Phosphorus reacts with various soil components, the dominant fraction is influenced by the soil properties and becomes inaccessible. The quantity of extractable soil Phosphorus, crop and soil Phosphorus demand, and the capacity for Phosphorus replenishment all affect the amount of Phosphaticfertiliser needed. The methods currently used to quantify soil Phosphorus are mostly used for agronomic applications, determining soil P that is phytoavailable[2].

Both inorganic and organic phosphorus can be found in soil. Although this amount can range from 10 to 90 %, agricultural soils typically contain 50 to 75% organic Phosphorus [3]. 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.

2. MATERIALS AND METHODS

Mayurbhanj, the largest district in Odisha, which comprises of 26 blocks. It's coordinates are: 21° 16' 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. Due to these distinct soil characteristics, 27 soil samples were taken from each village's three rice-growing zones, Singlamundali, Dhanpur, and Bhimda, which are located in the Betanati, Shamakhunta, and Barsahi blocks, respectively, of the Mayurbhanj district at 3 depths of 0–15, 15–30, and 30-45 cm. The samples were taken by soil auger, 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 [4] 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 Petersen and Corey [5]. According to Table 1, each extractant 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.

Table 1. Different methods for fractionation of soil phosphorus

Fractions	Extract ant solution	Reference
Available P	Bray and Kurtz No.1extractant	(Bray & Kurtz, 1945) [4]
Saloid bound-P	1 M NH4Cl	(Petersen & Corey, 1966) [5]
Aluminum bound-P(Al-P)	NH4 OH with pH 8.2	(Petersen & Corey, 1966) [5]
Iron bound-P(Fe-P)	0.1 M NaOH solution, NaCl Solution	(Petersen & Corey, 1966) [5]
Reductant soluble-P(RS-P)	0.3 M Sodium citrate solution	(Petersen & Corey, 1966) [5]
Ca bound- P(Ca-P)	0.25 M H2 SO4	(Petersen & Corey, 1966) [5]

Fractions	Extract ant solution	Reference
Mineral/ Inorganic -P	Conc. HCl	(Hesse, 1972) [6]
Total-P	Vanadomolybdate method	(Jackson, 1941) [7]
Organic-P	Total-P – Inorganic-P	(Jackson, 1941) [7]

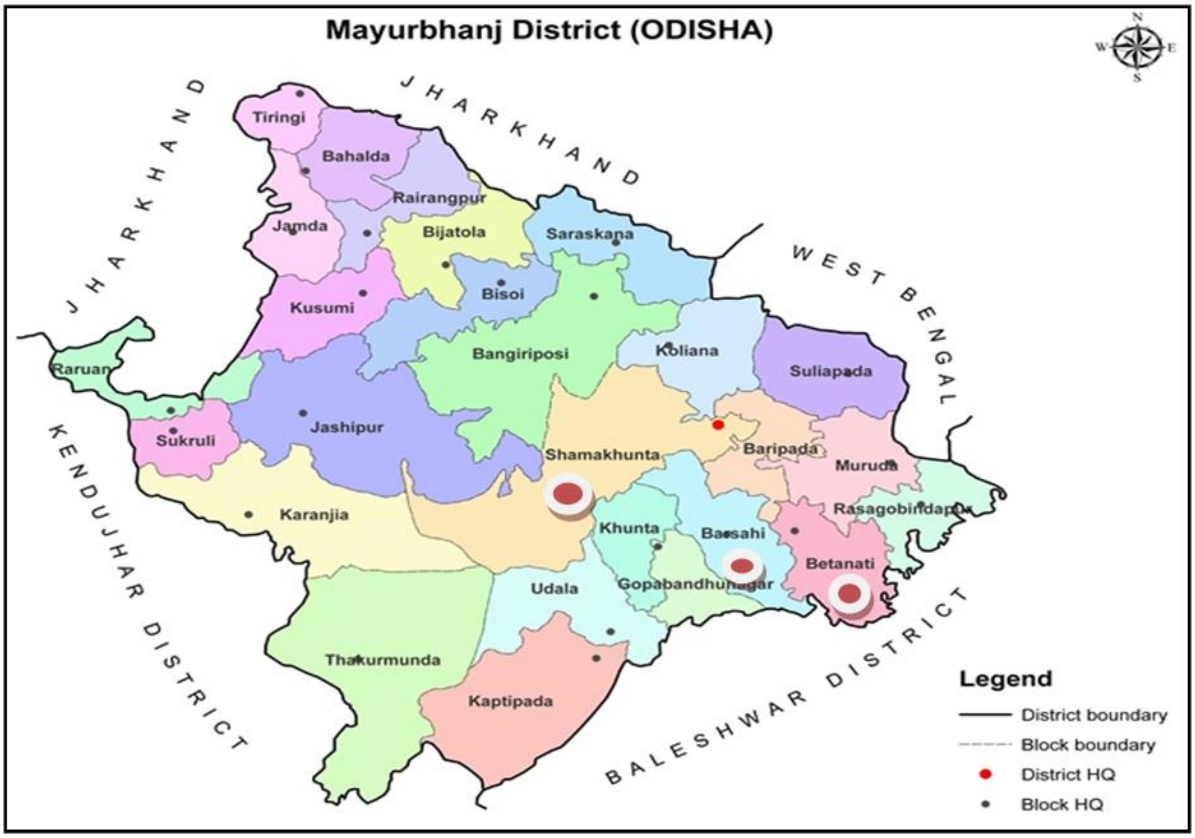

Fig. 1. Mayurbhanj District Map showing study area

3. RESULTS 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. [8]. Soil Organic carbon in low range i.e. from 0.34 to 0.51%. Similar results found by Dash [9]. 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. [10] have reported findings that are comparable.

Saloid-bound P has been found to be the least abundant among the fractions, which has also been noted by other researchers before [11,12] 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.

Table 2. Correlation coefficients (r) among different soil parameters at 0-15 cm 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-P	0.16	0.20	0.62	0.26	0.59	0.88	0.93	0.70	0.93	1		
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-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 [11] 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 [11,13]. 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.

4. CONCLUSION

In the Mayurbhanj district, it can be concluded from the current study that Reductant soluble phosphate and iron phosphate predominated and that Saloid-P and Calcium-P in lateritic soil were small-scale. The correlation equations demonstrated that the primary soil characteristic that affected the various Phosphorus 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 Phosphorus fractions, while Reductant soluble phosphate was the main fraction for the release of Phosphorus. Following the analysis, it is suggested that soils with low phosphorous content be advised to apply organic manures and supplemented by applying phosphorous fertilizers in the designated crop to increase the levels of Phosphorus in the soil. This is because Saloid P values should be raised from the forms of phosphorous. To mobilize fixed Phosphorus into plant-available Phosphorus and hence lower the P-fertilizer dose, more study is required.

ACKNOWLEDGEMENT

I want to take this opportunity to express my gratitude to Vice Chancellor Prof. Dr. R.B. Lal and the members of my advisory committee for providing me with the right direction throughout my academic career. I also want to express my debt of gratitude to the department's head and employees for their support of the research in soil science and agricultural chemistry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/102507