P: ISSN NO.: 2394-0344 RNI No.UPBIL/2016/67980 VOL-4* ISSUE-6* September- 2019
E: ISSN NO.: 2455-0817 Remarking An Analisation

Phosphorus (P) Availability in Soil and Anthropogenic Influences. – A Case Study of Sarenga Block, Bankura District, West Bengal.

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Abstract

The earth crust contains about 0.1% Phosphorus (P). This amount is more than sufficient for plant requirement but the major problem in Phosphorus uptaken from the soil by root is very low due to very low solubility of most Phosphorus compounds, resulting in a low concentration of Phosphorus ions in soil solution at specific time. Availability of Phosphorus in agricultural soil mostly depends on some factors like Parent material of the soil, intensity of Weathering, soil pH, amount of Organic Matter, amount of Precipitation and Porosity of soil, P-fertilizer usage and Cropping intensity. But in agricultural field, it is very difficult to establish a clear-cut relationship between Phosphorus availability and influences of said factors. Every component of the soil is so interlinked that modification of one component affects other. So selection of controlling factors is not free from controversy. But with the help of these factors a broad generalization is possible. In this paper through a case study on Sarenga Block, Bankura District, West Bengal, I want to measure which factors are most important for Phosphorus availability in the soil. Correlation (r) value shows that P-fertilizer use and cropping intensity maintain a strong positive relationship with Phosphorus availability. On the otherhand soil pH, percentage of Organic Carbon depict a feeble relation. Soil texture and Parent material are also unimportant in this regard. This study proves the fact that any one component of the soil of agricultural field is not purely natural and soil nutrients are mostly controlled by fertilizer.

This paper is divided into four segments. The ***first section*** deals with the introduction of the study area. In the ***second section*** the methodology is described. ***Section three*** tries to identify the influence of different factors on availability of Phosphorus. Available Phosphorus in the form of P_2O_5 in the study area is discussed in ***section four.*** The paper ends with a conclusion.

Introduction

The Phosphorus is a major nutrient of soil and essential for plant growth, no other nutrient can be substituted for it. Phosphorus is a component of ADP, ATP, DNA and various RNA (Havlin L. John, 1956). It plays an important role in photosynthesis, respiration, energy storage and transfer process. Phosphorus involves in early root formation and growth through cell division and cell expansion. Grain, fruit and vegetable quality largely depend on it.

The earth crust contains about 0.1% Phosphorus (P). (Foth D. Henry,1958). This amount is more than sufficient for plant requirement but the major problem in Phosphorus uptaken from the soil by root is very low due to very low solubility of most Phosphorus compounds, resulting in a low concentration of Phosphorus ions in soil solution at one time. Plants can uptake only a little amount in a specific time in the form of P- ions by their root which is called available Phosphorus in the soils. This availability of Phosphorus in agricultural soil mostly depends on some factors like parent material of the soil, intensity of weathering, soil pH, amount of organic matter, amount of precipitation and porosity of soil etc. But in agricultural field, it is very difficult to establish a clear-cut relationship between Phosphorus availability and influences of said factors. In agricultural field every characteristics of soil are directly modified by farming practices and these are not static one, may change even in a same crop season. The study in Sarenga Block, South Bankura, West Bengal tries to identify the influence of Parent material, Soil pH, Organic Matter, Texture, P Fertilizer usage and cropping intensity on availability Phosphorus. And it is tested how much anthropogenic factors manipulate the availability of Phosphorus and what factor is dominating.

This paper is divided into four segments. The ***first section*** deals with the introduction of the study area. In the ***second section*** the methodology is described. ***Section three*** tries to identify the influence of different factors on availability of Phosphorus. Available Phosphorus in the form of P_2O_5 in the study area is discussed in ***section four.*** The paper ends with a conclusion.

Section – 1

Location of the Study Area

Sarenga Block, the region undertaken for the work, is such a region of Bankura District in West Bengal that has been considered as underdeveloped economic zone since long. Sarenga is a part of "Jangal Mahal" (forested part) of West Bengal. Due to remote location, forest as well as agricultural activities, it has a spatial dimension.

The Study area is located in the southern part of Bankura District in West Bengal between the latitude of 22.634 degree north to 22.915 degree north and longitude of 86.913 degree east to 87.105 degree east. (UTM Projection) It covers an area of 293.51 square Kilometers.

Simlapal Block is located in the northern part of Sarenga. Southern and Eastern boundary is formed with Medinipur District. Raipur Block makes its Western boundary. Sarenga is under the Khatra Sub division and this block has six Gram Panchayats namely: Bikrampur, Chiltore, Gargarya, Goalbari and Nuturpur.

Important Physical Characteristics of the Study Area

Soil quality is primarily related with physical earth. Hence, a short description of the physical feature of the study region is essential for understanding the theme.

Geology

Regarding geological structure, the study area has three different characteristics. Most of the area is dominated by unconsolidated sand, silt and clay materials. Western margin of the Sarenga is mainly covered with fine and medium sands. Few parts of the region have depicted the character of fragments of pebbles, boulders and gravels. Subsequently, due to weathering, laterite top cover is seen in many parts of the land. Subsurface geological survey reveals that there is a wide cover of boulder and granite bed especially in the northern part of Sarenga. Rest of the area has a thick sequence of sediments and clay.

Relief

The elevation of the study region ranges between 60 to 100 meters. Northern parts have a higher elevation which is slightly more than 100 meters. Land elevation gradually decreases to the west and south-west towards the river Kasai. Most of the land of Sarenga lies within the height between 60 to 80 meters. Geographically this region is the outer rim of the ChhotoNagpur plateau where modification process has been operated during prolonged time. Western margin of the block is said to be a part of Kasai river basin. According to NRDMS land classification major part of the Sarenga falls under the category of 'Residual Hillocks'. Western margin, along with the Kasai River, is called 'Flood Plain'. Eastern and Northern part fall under 'Dissected Plateau' category. Some lands under middle portion are called as 'Upper Undulating.

Climate

Climate of the study region represents the typical 'Monsoon' climate. The temperature, rainfall and humidity are quite high and which is favourable for the existing economy of agriculture. The summer temperature, on an average, is up to 40˚ C and it falls down 10˚ C during winter months. During the rains temperature shows downward trend. About 85% rain fall occurs during June to September. Total annual rainfall of the region is about 135 Cm. In this region there is much significance of rainfall because of the fact that during the rainy season high intensity of agricultural activity is observed.

Climate is considered as the most important soil forming factor. In this region, too, it is similarly true. Such hot and humid condition plays an important role in the secondary mineralization and process of lateralization. Due to erosion, transportation and deposition by water soil depth is also affected.

Drainage

Kasai is the important and only perennial river in this region. River Kasai is located along the western margin of the Sarenga and has formed the boundary with Raipur Block. According to the direction with general slope of the land two natural cannels exist in the region. One flows from north central to southern direction and merges with the main river Kasai near to Jetpara-Chotasalboni. This is 'Banshir Khal'. Another is 'Satbowni Khal' or 'Sitarampur Khal' flows south-eastern to south-western direction and finally merges with Kasai in the extreme southern part of the study region near Indiaberia-Parulia. These both cannels (Khal) are non-perennial. No other important drainage is found in this region.

Natural Vegetation

Considerable part of the Sarenga Block is covered with forest. The amount of total forest area is 5547.84 hectares. But the forest is not evenly distributed throughout the block. In the northan part, 1653 hec. forest area is seen under Neturpur Gram Panchayat. Maximum forested part is spread from central Sarenga towards South, except Gargaria Gram Panchayat. In this patch, 1504.83 hec. forest is under Goalbari Gram Panchayat, 1336.85 hec. is under Sarenga Gram Panchayat and 1045.96 hec. is under Bikrampur Gram Panchayat. It is mainly a forest of 'Sal' tress. But other tropical, monsoonal species are also available here. Among these 'Kendu', 'Palash', 'Babool', 'Mahua',' Bamboo' are noteworthy.

P: ISSN NO.: 2394-0344 RNI No.UPBIL/2016/67980 VOL-4* ISSUE-6* September- 2019
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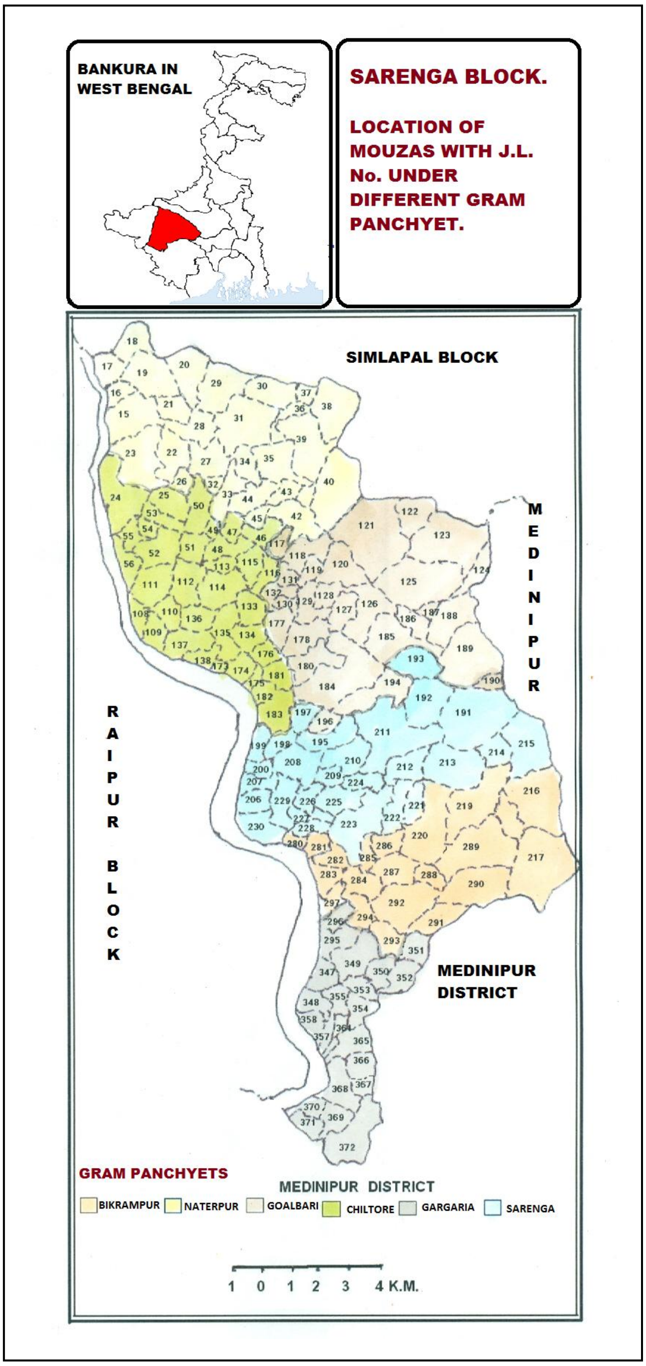

Section – 2

Methodology

The study is based on primary data except the fertilizer utilization and crop coverage data. The standardized soil samples are collected from each and every mouzas of Sarenga Block. 166 samples are collected from the field within the depth of 6 inches from the surface. After primary processing samples are tested in laboratory in following methods –

a) pH:

1. 10 gm. Soil passing 2 mm sieve taken in a 50 ml beaker.
2. 20 ml distilled water is added to the soil.
3. Soil water mixture intermittently is shaken with glass rod up to 30 minutes.
4. Reading is taken by pH meter.

b) Organic Carbon:

1. 1 gm. Soil sample is taken in a 500 ml conical flask.
2. 10 ml 1N $K_2Cr_2O_7$ solution is added slowly to the soil with continuous stirring for mixing the soil.
3. 20 ml conc. H_2SO_4 is added slowly.
4. It is allowed to stand for 30 minutes to complete the reactions.
5. 200 ml water and 10 ml orthophosphoric acid is added in the flask.
6. Then 1 ml diphenylamine indicator is added.
8. The solution is titrated with ferrous ammonium sulphate until the brilliant green colour appears.
9. A blank without soil is also run simultaneously.

Calculations

1. Weight of the soil = W
2. Volume of the $K_2Cr_2O_7$ = Vk
3. Volume of ferrous ammonium sulphate consumed in blank = Vb.
4. Volume of ferrous ammonium sulphate consumed in the sample = Vs.

Percentage of Organic Carbon

$$= \frac{Vk\ (Vb - Vs)}{Vb \times W} \times 0.003 \times 100$$

Actual % of Organic Carbon= % of Organic Carbon X 1.3

Organic Matter = Actual % Organic Carbon X 1.72

c) Available Phosphate (P_2O_5):

1. 2.5 gm soil sample is taken in a 150 ml conical flask.
2. 25 ml Bray's extractant (0.03 N NH_4F and 0.025 N HCl) is added to the sample.
3. Flask is shaken for 5 minutes in a horizontal shaker.
4. After shaking the solution is filtrated with No 1 Whatman filter paper.
5. 5 ml filtrated solution is taken in a 25 ml volumetric flask.
6. 5 ml molybdate reagent (dissolving 15 gm of ammonium molybdate in 300ml distilled water, then 350 ml 10 N HCl is added slowly and finally volume makes up to 1 Lit. by distilled water) is added
7. After few minutes waiting it is made up to 20 ml.
8. 1 ml working stannous chloride solution is added finally.
9. After 10 minutes waiting the intensity of blue colour is measured by colorimeter at 660 nm wavelength. This is optical density.
10. From the optical density the value of the ppm. is calculated from standard curve.

Preparation of Standard Curve

1. 0.1916 gm KH_2PO_4 is dissolved in distilled water and volume makes up to 1 lit. This is 100 ppm stock solution.
2. Taking 10 ml of this solution and volume makes up to 1 lit. This is 1 ppm solution.
3. From this 1 ppm solution 1, 2, 4, 6 ml solution is taken in a separate volumetric flask.
4. 5 ml b ray's extractant and 5 ml molybdate reagent are added and makes up to 20 ml.

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5. 1 ml working stannous chloride solution is added and volume makes up to 25 ml.
6. After 10 minutes reading is taken by colorimeter.
7. Optical Density value is plotted against concentration of P_2O_5

Calculation

1. Weight of the soil = 2.5 gm.
2. Volume of the extractant = 25 ml.
3. First dilution = 25/2.54 = 10 times.
4. Volume of the filtrated solution taken = 5 ml.
5. Volume makes up to = 25 ml.
6. Second dilution = 25/5 = 5 times.
7. Total dilution = 10X5= 50 times.
8. Concentration of P_2O_5 from standard curve = 'A' ppm.
9. Available P_2O_5 in soil = A X 50 ppm = A X 50 mg./Kg/
10. Available P_2O_5 in 1 Hectare soil = A X 50 X 2.24 Kg.
11. Available P_2O_5 in soil = A X 50 X 2.24 Kg./ Hec.

Section – 3

In this section effort is given to draw out inherent relationship among the soil pH, Percentage of Organic Carbon, Parent material, Phosphorus (P) fertilizer utilization and cropping pattern. It is well known that availability of P_2O_5 mostly depends on soil pH, Parent material, Percentage of Organic Carbon, Weathering and Precipitation. Out of 166 samples collected from different Mouzas show that there is no any clear cut relationship among the availability of P_2O_5 and others. Parent material varies in south-western Sarenga where it is mainly alluvium, rest of the soil mainly derived from Granite, Gneiss, highly affected by laterization process. Climatic condition is same throughout the study area. So from a careful observation of soil pH, percentage of Organic Carbon, P fertilizer usage and cropping pattern may be helpful to estimate the amount of human interference to modify the agricultural soil as well as availability of P_2O_5 in the soil.

In this regard 'correlation' statistical technique is used. Correlation values (r) are calculated using the variables of available P_2O_5 and soil pH, Available P_2O_5 and percentage of Organic Carbon, Available P_2O_5 and P Fertilizer usage, Available P_2O_5 and cropping intensity. These correlation values are calculated from all 166 samples. Not only that, out of 166 samples 10% samples (17 samples) are chosen based on lower availability of P_2O_5 and another 10% (17 samples) is chosen where P_2O_5 availability is high.

Results

Correlation value (r) shows that there is no relation or feeble negative relationship with the availability P_2O_5 and soil pH. (Table – 1). For all samples it is -0.283. These results are -0.030 and -0.298 for 10 Percent samples from lower and higher groups in terms of availability of P_2O_5 in the soil. Observation is also similar in case of availability of P_2O_5 and percentage of organic carbon. Correlation values for all samples, 10 percent from higher group and 10 percent of lower group in terms of availability P_2O_5 are 0.114, -0.234 and 0.056 respectively.

On the otherhand high positive correlation values are observed for P fertilizer usage and cropping intensity with the available P_2O_5. In case of P fertilizer usage for all mouzas/samples 'r' value is 0.973. 10 percent samples from both lower and higher groups in terms of availability P_2O_5 have a similar value which are 0.906, 0.910 respectively.

Availability of P_2O_5 in soil and cropping intensity are also positively correlated. Results (r) for all mouzas/samples, 10 percent samples from lower and 10 percent from higher groups in terms of availability P_2O_5 are 0.896, 0.851 and 0.918 respectively.

Table – 1.
Correlation (r) Values among Different Variables.

	Soil pH with Availability of P_2O_5.	% of O.C with Availability of P_2O_5.	P-Fertilizer Use with Availability of P_2O_5.	Cropping Intensity with Availability of P_2O_5.
For all Mouzas	-0.283189172	0.114250462	0.973562187	0.896584712
10% samples from lower Group.	-0.030369867	-0.234075865	0.906987192	0.850974131
10% samples from Higher Group.	-0.298611745	-0.056081972	0.910107458	0.918797961

Source: Author's Calculation

SARENGA BLOCK.

AVAILABLE PHOSPHORUS (P_2O5) STATUS IN THE SOIL

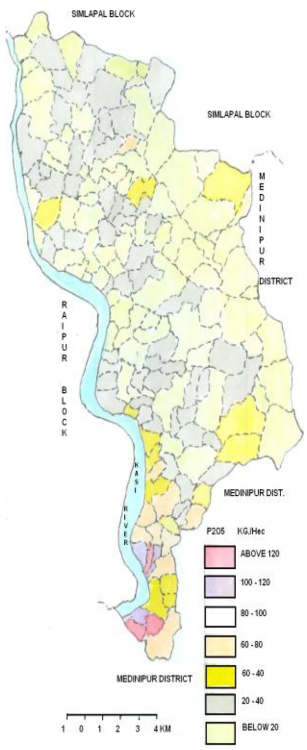

Table – 2.
Ten Percent Samples are Chosen Where Availability of P_2O_5 is Low and Other Characteristics of These Samples.

Sl	Mouzas	P2O5 Kg/Hec.	pH	% of O.C	Texture	P Fertilizer Kg./Hec.in Aman Paddy	Cropping Intensity.
1	Gagra	8.96	5.81	0.585	Sandy-Loam	20	102
2	Bhalukchira	8.96	5.15	0.487	Sandy-Loam	22	106
3	Nekrapahari	10.92	6.05	0.702	Silt-Loam	20	125
4	Ruphaghagra	13.44	4.78	0.702	Sandy-Loam	25	100
5	Payrasol	13.44	5.29	0.429	Sandy-Loam	25	104
6	Adharia	13.44	7.82	0.268	Silt-Loam	25	91
7	Gopalpur	13.44	5.75	0.643	Clay-Loam	27	105
8	Chhotajambedia	13.44	5.75	0.643	Clay-Loam	35	105
9	Sitalpur	13.44	6.01	0.507	Loam	30	99
10	ChhotoAmjhor	13.44	5.55	0.487	Loam	30	94
11	Damnisol	13.44	5.35	0.507	Silt-Loam	28	102
12	Karbanga	13.44	4.8	0.351	Sandy-Loam	30	125
13	Bardi-Kalapathar	17.92	6.37	0.392	Sandy-Loam	32	96
14	Dalambhija	17.92	5.23	0.487	Sandy-Loam	35	102
15	Bhagnadeuli	17.92	5.21	0.897	Loam	35	105
16	Bamundihi	17.92	5.18	0.042	Sandy-Loam	38	100
17	Saroskhol	17.92	5.91	0.391	Loam	40	98

Source: Laboratory Testing, Field Survey & Data from A.D.A Office.

Table – 3.
Ten Percent Samples are Chosen Where Availability of P_2O_5 is High and Other Characteristics of These Samples.

Sl	Mouzas	P2O5 Kg/Hec.	pH	% of O.C	Texture	P Fertilizer Kg./Hec.in Amon Paddy	Cropping Intensity.
1	Deuli	201.51	4.29	0.858	loam	50	185
2	Th akurbari	176.72	4.88	0.429	Sandy-Loam	48	187
3	Chandpara	132.16	5.1	0.585	Sandy-Loam	46	175
4	Panchhra	110.88	4.91	0.409	Sandy-Loam	45	180
5	Janapara	110.88	5.55	0.604	Silt-Loam	45	177
6	Bamundiha	109.76	5.14	0.682	Sandy-Loam	42	201
7	Gargaria	73.96	6	0.585	Sandy-Loam	42	200
8	Parulia	73.96	4.28	0.604	Sandy-Loam	42	187
9	Debgram	72.96	5.15	0.585	loam	45	225
10	Jakpur	68.98	5.08	0.76	Sandy-Loam	40	201
11	Majuria	67.72	4.95	0.429	Sandy-Loam	40	206
12	Makarkole	67.72	5.81	0.877	loam	40	197
13	Indaberia	63.86	5.65	0.585	Sandy-Loam	40	180
14	Belapol	49.28	5.3	0.39	loam	40	186
15	Jukhanala	45.32	4.75	0.916	loam	40	200
16	Baispata	45.32	4.66	0.682	loam	36	197
17	Tildaha	40.32	5.1	0.682	Sandy-Loam	35	155

Source: Laboratory Testing, Field Survey & Data from A.D.A Office.

Conclusion

An interesting picture is observed from the analysis of availability of P_2O_5 in soil and others so called controlling factors. Soil pH and percentage of organic carbon have a feeble relationship with the availability of P_2O_5. Soil pH is slight negatively related with the availability of P_2O_5. But theoretically we know that the pH 6 to 7 is ideal for phosphate availability. pH of the soil in the study region is mainly acidic. This acidic soil may negatively affect the availability of primary orthophosphate ions. But in the study region only 24.7% mouzas has the said pH value. Observation shows that in many mouzas have low pH with high phosphorus availability.

P fertilizer has the dominant role for the distribution of available P_2O_5 in the agro-fields throughout the study region. Through the use of chemical P and other fertilizers, soil characteristics are changing continuously. Increase of soil acidity is the most common example in this regard. Results also prove it.

A strong positive correlation is found in every case of availability of P_2O_5 and cropping intensity of the fields because high cropping intensity means high use of fertilizer, low cropping intensity is associated with lower usage of fertilizer. In field study we have identified this fact. For example, in northern part of the Sarenga Block the amount of available P_2O_5 is ranging from 4.48 Kg./Hec. to 35.84 Kg./Hec. where cropping intensity is also very low (91 to 96). On the otherhand in south-eastern part of the study region high availability of P_2O_5 associated with high cropping intensity is observed. In this area P_2O_5 ranges from 53.76 Kg./Hec to 109.76 Kg./Hec. Some fields show this amount up to 202.76 Kg./Hec where the cropping intensity is ranging from 197 to 225. Soil texture is also incorporated in the table No.-2 and 3 but it is not a numeric value. So calculation of correlation is not possible from this data. From the observation it is cleared that there is no any specific relationship with P_2O_5. So after analysing all the factors we can say availability of P_2O_5 in agricultural soil of Sarenga Block is very much related with P fertilizer usage rather than any other controlling factors. But it should be kept in mind that every component of the soil is so interlinked that modification of one component affects other. So selection of controlling factors is not free from controversy. But with the help of these factors a broad generalization is possible.

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