Journal of Plant Development Sciences
Meerut, India

RESEARCH

COMPARATIVE STUDY SOIL FERTILITY EVALUATION ON WATERSHED WITH THE APPLICATION OF REMOTE SENSING TOOLS AT THE RED LATERITIC ZONE OF WEST BENGAL

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Received-22.05.2024, Revised-10.06.2024, Accepted-25.06.2024

Abstract: Soil is the basic condition of all life on earth. Soil nutrients are the main source of soil fertility that promotes plant growth. Soil nutrients have become an irreplaceable resource in recent years, which should be increased due to the increase in the use of inorganic fertilizers, domestic and industrial sewage, etc. Mapping the regional variability and quality of soil nutrients is important especially when the main source of agriculture is soil fertility, remote sensing and global positioning system are the most useful tools for farming and decision making. A remote sensing database is useful for monitoring agricultural production. It provides detailed information on agricultural operations such as identification and classification of different crops, monitoring of crop condition, crop growth, area and yield estimation, mapping of soil properties and precision farming. Ten fertility estimates were analysed and mapped using a geographic information system (GIS) from a (GPS-based) soil sample collected from farmers' fields. The pH of the soil samples varied from slightly acidic to very acidic. Soil organic carbon ranged from very low to very high. Available nitrogen was low, available phosphorus was generally medium to very high and available potassium was very low to low, and sulphur was low to adequate. The nutrient map available with ArcGIS shows this clearly in some areas. The purpose of this work is to study the applications of geoinformatics to assess the availability of soil nutrients and soil fertility in precision agriculture in areas with rainfall.

Keywords: Land survey, GIS, Remote sensing, GPS, Soil fertility

INTRODUCTION

Agriculture is one of the most important activities supporting human life in the world, which is constantly changing from an ancient archaic system to modern precision agriculture. On a global scale, agriculture has shown the potential to increase food supply in the near future due to faster than expected growth in demand. In this context, soil is the most important and valuable natural resource that supports life on earth. Fertile and productive soils are essential ingredients for stable societies because they support plant growth for food, fibre, feed, medicine, industrial products, energy and an aesthetically pleasing environment. Soil fertility refers to its ability to support plant growth. Productive fertile soil can support optimal plant growth from seed germination to maturity by providing sufficient soil for plant root development, water and air for root development and growth, chemical elements to meet plant nutritional needs, and anchorage for nascent roots. Plant structure in today's world, however, one of the biggest concerns is soil contamination and contamination. Soil degradation has been shown to occur due to both natural and anthropogenic factors, which in turn affect productivity. As the population continues to grow, human-caused disruption to the Earth's ecosystem to produce food and fibre increases the need for soil to provide essential nutrients (Sharma *et al*. 2003). The natural ability of the soil to produce sufficient nutrients is reduced as plant productivity increases due to increased human nutritional needs. Excessive and unbalanced use of chemical fertilizers has adversely affected the soil, causing a decrease in organic carbon, a decrease in soil microbial flora, an increase in acidity and alkalinity and hardening of the soil. This situation causes a significant loss of soil fertility. Nutrient availability depends on several factors such as soil types, pH and organic matter content. Soil fertility

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changes under the influence of cultivation, manure and fertilizers. Soil nutrient mapping for nitrogen, phosphorus and potassium was done using soil test data from soil research laboratories across the country (Ghosh and Hasan, 1979). In fact, soil test-based fertility management is an effective tool to increase the productivity of agricultural lands with high spatial variability. In that context, GIS-based soil fertility mapping has proven to be a promising alternative. A geographic information system (GIS) is a computer system for collecting, storing, querying, and displaying geographic information. Therefore, a detailed soil fertility assessment based on the GPS-GIS system must be done so that the soil can be used for cultivation in the best way. GPS-GIS are an advanced tool for studying on-site nutrient management that can be effectively used to monitor and regulate soil fertility. The solution to ensure food security for all people in the world without affecting the ecological balance of agriculture is to adapt new research tools, especially aerial remote sensing, and combine them with both traditional and advanced technologies such as geographic information systems (GIS). Sustainable development of agriculture is one of the most important goals in all countries of the world, both developed and developing countries. Therefore, the fertility of intensively cultivated high-yielding lands must be evaluated. Using the Global Positioning System (GPS), the status of available nutrients in the soil helps to formulate site-specific balanced fertilizers and to understand the soil fertility status spatially and temporally (Sharma *et al*., 2003).

PROPOSAL AND OBJECTIVES

Proposal: Soil testing is a prerequisite to assess fertility in different cropping systems and to develop appropriate strategies to manage soil fertility and increase production of different crops. To maintain soil health, it is proposed to assess soil fertility in different land use systems representing 2A2D5b6 and 2A2D5b7 micro-watersheds, Puncha District, Purulia District (Dekker and De Weerd, 1973). Diagnosing nutrient deficiencies and toxicity helps implement appropriate remedies to maintain soil health (Doran, 2002). Currently, most of the farmers in Puncha Block of Purulia 2A2D5b6 and 2A2D5b7 micro-watersheds are not aware of the need for soil testing and the lack of soil analysis database has resulted in unbalanced and inappropriate application of fertilizer doses. Diagnosing macronutrient concentrations in soil is important for implementing appropriate strategies to alleviate deficiency/toxicity and malnutrition problems in humans and domestic animals. Against this background, this project proposes to assess the internal quality of soil in various land uses representing almost all places in Puncha block of Purulia district as follows:

Objectives:

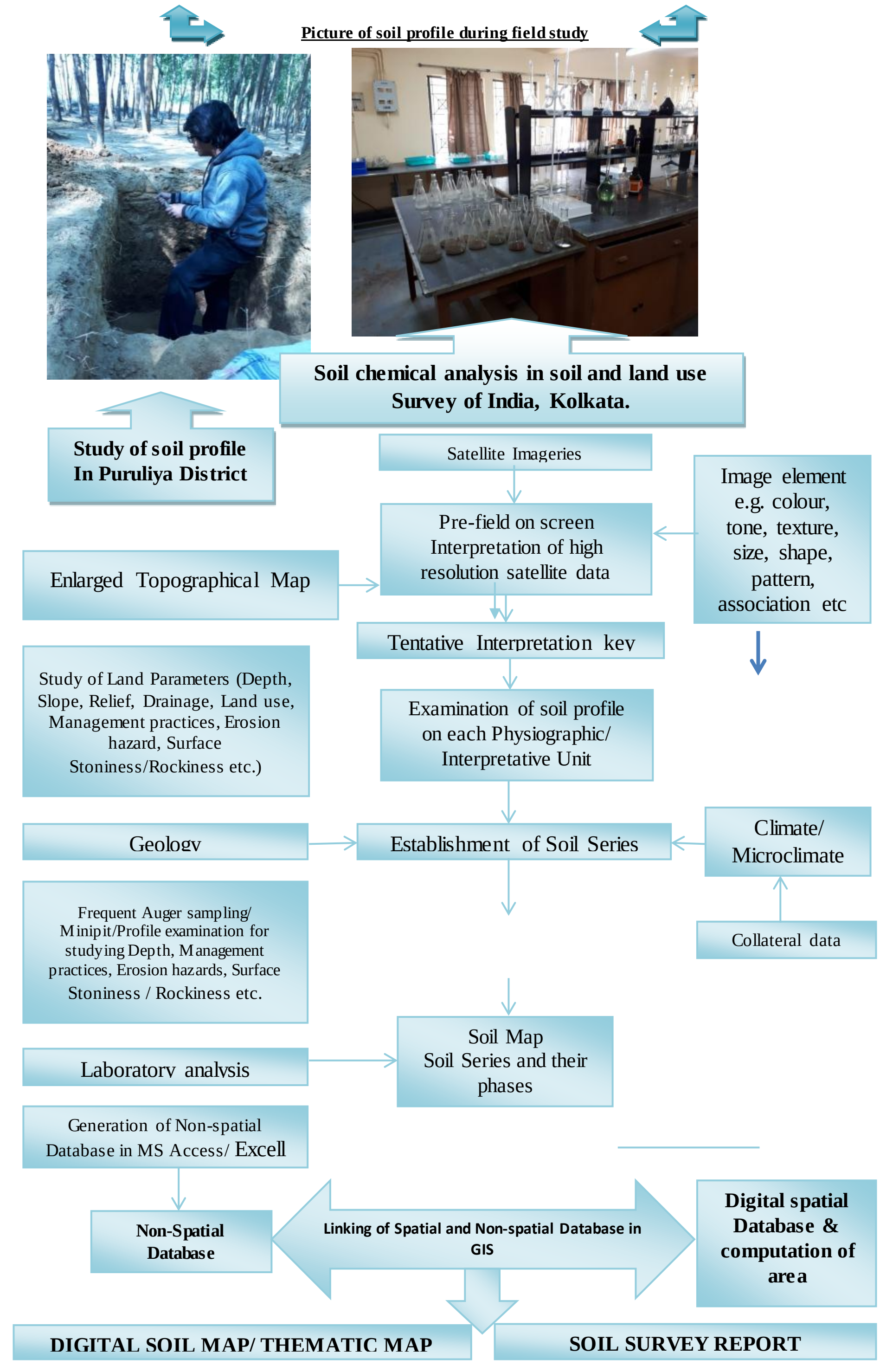
- Assess soil fertility in different land use systems for sustainable production of agricultural and horticultural crops in Purulia region.
- Diagnose the nutritional situation and outline areas of deficiency in the Purulian region.
- Increase the productivity of soil nutrients or soil chemical factors that limit plant growth.
- Prepare soil fertility maps of Puncha block of Purulia district determining deficiency, sufficiency and toxicity limits for each soil property
- Increase the efficiency of fertilizer use by indicating the appropriate amounts for different soils and crops.

MATERIALS AND METHODS

A detailed soil survey of the area was carried out in the All India Soil and Land Use Survey (1970) and Soil Survey Manual USDA Manual no. 18 (1951) according to the procedure given in the land surveying manual. Detailed soil mapping with soil types and phases was delineated using satellite imagery (Weismiller and Kamingsky, 1978).

Soil map: Detailed soil mapping of the study area was done based on satellite image data (LISS IV, IRS P6) at a scale of 1:10,000. External Interpretation: Geocoded satellite image data has been digitally interpreted in relation to standard image elements such as colour, tone, texture, size, shape, pattern, aspect ratio and location in collaboration with the Survey of India (SOI). Identification and delineation of different geomorphic/landscape units, cultivation/land cover, soil management and erosion risk boundaries, topographic mapping and interpretation of satellite images were carried out to detect image variability. This is how the original interpretation key was framed, which was also based on different combinations of pictorial elements and physiographic units (Weismiller and Kamingsky 1978).

Field Interpretation: Image analysis performed prior to the completion of a field survey. The delineation of each mapping unit was verified and corrected, and the final soil map of the micro watersheds was successfully developed. Further, the field sheets were processed using ArcGIS 10.2 software and a digital spatial ground database was created at a scale of 1:10,000. The same geodatabase file and their association with the polygon feature class are marke Calculating area after projecting polygonal features. Thematic maps are created after the ground map is completed (Manchanda *et al*., 2002).



Methodology for Detailed Soil Survey in GIS and Remote Sensing

RESULTS AND DISCUSSIONS

Soil Chemical Analysis

Assessment of soils fertility: Status includes assessment of available nutritional status, i.e. the proportion or amount of nutrients that are directly available in the soil for later consumption by crops. This exercise is often called a soil test and is used to determine the optimal fertilizer application rate. Collection of a representative soil sample: A flat field was tested in a zigzag pattern. ii. At the sampling site, samples were collected in a plastic container by removing the surface fluff with a lifter or shovel, a sampling tool (Auger). iii. By making a V-shaped cut to a depth of 15 cm, 1 cm/1" of soil was scraped or removed with a khurp on both sides to a depth of 15 cm. This scraped soil was collected in a plastic bowl. This sample is called the "primary" sample. The weight of such primary samples should be approximately the same. After collecting at least a few samples, they were mixed in a plastic container. Samples are labeled in a bowl and the sample is divided into approximately 4 equal parts. Discard the two opposite parts and the remaining 2 parts of the samples were thoroughly mixed again and again divided into 4 equal parts and the 2 opposite parts were again discarded. This procedure is continued until ½ to 1 kg of sample remains in the bowl. This is called a pooled sample, which actually represents the range. The most suitable containers for soil samples are 6x9" polyethylene bags made of approximately 0.13 mm thick film, which can be closed by twisting or tying the neck or with a rubber band or tape (Malewar and Randhva 1978).

Preparing the soil sample for testing

The error of soil sampling in the field is usually greater than the error of laboratory analysis. The most popular request for soil samples for each field is about every three years, with lighter soils tested more frequently. Therefore, it is important that the soil sample is representative of the area. In addition, care must be taken during the subsequent laboratory processing, because a small amount (1-10g) of the large soil mass of the field actually goes to the laboratory analysis (Motsara, 2002).

i Samples were spread out to dry on a clean cloth, plastic or brown paper sheet.

ii. Large wetlands were broken up.

Precautions for soil sampling

- All soil debris must be removed prior to soil sampling
- Store the sample in a clean bag.
- Sampling of low cabins, fertilizer costs, near trees and fertilizer zones is avoided.

Determination of soil pH

Determination of pH is actually a measurement of hydrogen ion activity in the soil-water system. It is defined as the negative logarithm of hydrogen activity. Mathematically, it is expressed as follows:pH = - log a H+Soil pH indicates the reaction of the soil, ie. acidic, neutral or basic. Nutrient availability is regulated by soil reaction

Determination of available nitrogen

A known mass of soil is mixed with an alkaline potassium permanganate solution ($KMnO_4$) and distilled. The organic matter in the soil is oxidized by the resulting oxygen released by potassium permanganate in the presence of sodium hydroxide, and the released ammonia condenses and is absorbed in a known amount of boric acid with a mixed indicator to form ammonium borate. , the excess of which is titrated with normal sulfuric acid.

Reagents

i. 0.32% potassium permanganate solution ($KMnO_4$).

ii. 2.5% sodium hydroxide (NaOH).

iii. 2% boric acid solution containing 20-25 ml of mixed indicator per liter.

iv. Mixed indicator: 0.066 g of methyl red + 0.099 g of bromocresol green is dissolved in 100 ml of 95% alcohol.0.02 N sulfuric acid (H_2SO_4).

Procedure

i. 5 g of the prepared soil sample was weighed and placed in a beaker.

ii. The tube is loaded in the still and the other sides of the tube are kept in a 250 ml Erlenmeyer flask with 20 ml of 2% boric acid mixed with the indicator.

iii. 25 ml of potassium permanganate (0.32%) and sodium hydroxide solution (2.5%) are automatically added to the distillation unit program.

iv. The sample was heated at a constant rate under steam, and the released ammonia was absorbed in 20 ml of a stirred indicator solution containing 2% boric acid, which was kept in a 250 ml Erlenmeyer flask.

Determination of Available Phosphorus

Phosphorus is extracted from the soil using Bray No 1 solution as an extractant. The extracted phosphorus is measured calorimetrically based on the reaction with ammonium molybdate and the development of the "Molybdenum Blue" colour. The absorbance of the compound is measured with a spectrophotometer at 882 nm and is directly proportional to the amount of phosphorus extracted from the soil. Instrument:

i Mechanical shaker

ii. Spectrophotometer

Reagents

Bray No. 1 Extraction Solution: Dissolve 1.110 g of AR-pure ammonium fluoride in 0.025 NHC1 per liter.1.5% Dickman and Bray

Reagent: Dissolve 15 g of AR grade ammonium molybdate in 300 mL of hot water, cool and add exactly 350 mL of 10NHCI. Make the volume one liter.40% $SnCl_2$, stock

solution: Weigh 10 g of pure stannous chloride into a 100 mL beaker. Add 25 ml. HC1 and dissolve by heating. Cool, transfer to an amber bottle and store in the dark after adding a small piece of metal Zn (AR grade) to prevent oxidation. Dilute an appropriate amount of 100 mg P L-1 solution 50 times to obtain a 2 mg P L-1 solution (Lindsay and Norvell 1978).

Procedure

i. Weigh 5 g of soil sample into a 150 mL Erlenmeyer flask.

ii. Add 50 ml of Bray P-1 extract and shake for 5 minutes.

iii. Quickly filter through Whatman No.1 absorbent paper to collect the filtrate in 10 minutes.

iv. Transfer a 5 mL portion to a 25 mL volumetric flask.

v. Add 5 mL of ammonium molybdate solution shake slightly and dilute to approximately 22 ml.

vi. Add 1 ml of dilute $SnCl_2$ (0.5 ml diluted to 66 ml), mix with gentle shaking and adjust to the mark.

Table no. 12 representative ground texture results in all series between.

Discussion: The soils of Morandih, Nischintpur, Bhangabandh and Darikata seem to belong to clay textural classes. This means that this soil has moderate to high available water for plants, moderate to high drainage potential, and moderate to high water transportability, which indicates favourable conditions for better crop growth.

8.2. pH estimation:

pH is usually measured with a pH meter, where the potential of an electrode (glass electrode) indicating hydrogen ions is measured potentiometrically against a reference electrode saturated with calomel, which also acts as a salt bridge. Today, most pH meters have a single connected electrode. Before measuring soil pH, the instrument must be calibrated with a standard buffer solution of known pH. Because pH is also affected by temperature; therefore, the pH meter must be adjusted to the temperature of the solution using the temperature adjustment knob.

Table 1. Representing the results of pH of all series along with the area.

Series name	Area (ha)	pH (1:2.5)	Ratings
HATIMARA	395	5.12	Highly Acidic
MORANDIH	112	5.56	Highly Acidic
NISCHINTPUR	111	5.47	Highly Acidic
PHUPHUNDI	47	5.82	Moderately Acidic
PUKHURIA	230	5.21	Highly Acidic
PURA	7	4.38	Strongly acidic
BHANGABANDH	191	5.1	Highly Acidic
CHAKALTA	154	4.97	Highly Acidic
DARIKATA	48	5.7	Slightly Acidic
DUMKADIH	35	6.67	Slightly Acidic
ROC	10		
TANK	32		
Habitation	36		

The results are compared with the help of the ratings, mentioned below:

Soil pH	Interpretation
0 – 3.4	Acid Sulphates
3.5 – 4.5	Strongly Acidic
4.6 – 5.5	Highly Acidic
5.6 – 6.5	Moderately Acidic
6.6 – 6.9	Slightly Acidic
7	Neutral
7.1 – 8.5	Moderately Alkaline
>=8.6	Strongly Alkaline

Discussion: The series of Micro-Watersheds of 2A2D5b6 and 2A2D5b7 Micro-Watersheds of Purulia Puncha Block range in pH from slightly acidic to very acidic. The Pura range has a very acidic pH of 4.39, followed by Chakalta. Since the pH is below 5.5, the availability of Fe and Al is also high. About 84.6% of the soil is highly acidic. Application of lime is essential for proper crop growth.

1-2	Critical for salt sensitive crops
2-3	Critical for salt tolerant crops
>3	Injurious to most crops

Discussion: The E.C values of Micro Watersheds 2A2D5b6 and 2A2D5b7 of Puncha block of Purulia district are quite low, which means that E.C does not affect the growth of the crop grown in the respective village areas.

8.4. Assessment of organic carbon: An appropriate amount of soil is decomposed with chromic acid and sulfuric acid, in which the use of the heat of dilution of the sulfuric acid in the soil is melted and the organic matter in the soil is oxidized. The excess of unreduced chromic acid in soil organic matter is determined by titration with a standard ferric ammonium sulphate solution using diphenylamine as an indicator. In this exercise, chromic acid is used as an oxidizing agent for organic matter oxidized in soil in the presence of excess H2SO4. The heat of dilution of H2SO4 acts as a standard ferrous sulphate solution.

Table 2. Representing the results of **O.C %** of all series along with the area.

Series name	Area	Organic Carbon (%)	Ratings
HATIMARA	392	0.27	Low
MORANDIH	113	0.16	Very low
NISCHINTPUR	110	0.62	Medium
PHUPHUNDI	47	0.75	High
PUKHURIA	230	0.42	Low
PURA	7	0.36	Low
BHANGABANDH	195	0.29	Low
CHAKALTA	154	0.28	Low
DARIKATA	49	1.3	Very High
DUMKADIH	35	0.48	Low
ROC	10		
TANK	32		
HABITATION	34		

The results are compared with the help of the ratings, mentioned below,

Soil OC%	Interpretation
0 – 0.24499	Very Low
0.25 – 0.4909	Low
0.51 – 0.7599	Medium
0.76 – 1.00	High
>= 1.001	Very High

Discussion: O.C % of 2A2D5b6 and 2A2D5b7 Micro-Watersheds, Puncha Block, Purulia District varies from very low to very high. And in NISCHINTPUR series, O.C% is Medium and in DARIKATA series OC% is very high compared to other series.

Estimation of available nitrogen

A known mass of soil is mixed with an alkaline potassium permanganate solution (KMnO4) and distilled. The organic matter in the soil is oxidized by the resulting oxygen released by potassium permanganate in the presence of sodium hydroxide, and the released ammonia condenses.

Table 3. Representing the results of Available Nitrogen of all series along with the area,

Series name	Area	Available nitrogen (Kg/ha)	Ratings
HATIMARA	391	148.52	Low
MORANDIH	112	131.71	Low
NISCHINTPUR	110	156.8	Low
PHUPHUNDI	47	206.97	Low
PUKHURIA	230	163.07	Low
PURA	7	144.25	Low
BHANGABANDH	192	150.52	Low
CHAKALTA	154	145.25	Low
DARIKATA	49	255.96	Low
DUMKADIH	35	156.8	Low

The results are compared with the help of the ratings, mentioned below:

Available Nitrogen in soil (Kg/ha)	Interpretation
0 – 139.99	Very Low
140 – 280	Low
280.001 – 560	Medium
560.001 – 700	High

Discussion: The availability of Nitrogen of 2A2D5b6& 2A2D5b7Micro Watersheds, Punchablock, Purulia district ranges in low.

Estimation of available Phosphorous: Phosphorus is extracted from the soil using Bray No 1 solution as extractant. The extracted phosphorus is measured colourimetrically based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' colour. The absorbance of the compound is measured at 882 nm in a spectrophotometer and is directly proportional to the amount of phosphorus extracted from the soil.

Table 4. Representing the results of Available Phosphorous of all series along with the area.

Series name	Area	Available phosphorous (Kg/ha)	Ratings
HATIMARA	394	15.008	Medium
MORANDIH	114	55.61	Very High0
NISCHINTPUR	110	22.36	Medium
PHUPHUNDI	47	87.36	Very High
PUKHURIA	230	35.32	High
PURA	7	65.16	Very High
BHANGABANDH	191	37.632	High
CHAKALTA	154	62.75	Very High
DARIKATA	49	13.664	Medium
DUMKADIH	35	69.68	Very High
ROC	10		
TANK	32		
HABITATION	34		

The results are compared with the help of the ratings, mentioned below,

Available Phosphorous in soil (Kg/ha)	Interpretation
0 – 4.999	Very Low
5– 10	Low
10.001 – 25	Medium
25.001 – 40	High
>40.001	Very High

Discussion: Nitrogen availability is low in 2A2D5b6 and 2A2D5b7 Micro Watersheds, Puncha Block, Purulia District.

Estimation of available phosphorus: Phosphorus is extracted from soil using Bray No 1 solution as extractant. The extracted phosphorus is measured calorimetrically based on the reaction with ammonium molybdate and the development of the "Molybdenum Blue" colour. The absorbance of the compound is measured with a spectrophotometer at 882 nm and is directly proportional to the amount of phosphorus extracted from the soil.

Table 5. Which represent the available phosphorus content results for all series in the range area.

Series name	Area (ha)	Available phosphorous (Kg/ha)	Ratings
HATIMARA	393	11.76	Very Low
MORANDIH	114	68.10	Low
NISCHINTPUR	110	37.16	Low
PHUPHUNDI	47	103.30	Low
PUKHURIA	230	47.83	Low

PURA	7	51.03	Low
BHANGABANDH	192	22.84	Very Low
CHAKALTA	154	29.70	Very Low
DARIKATA	49	20.048	Very Low
DUMKADIH	35	101.16	Low
ROC	10		
TANK	32		
HABITATION	35		

The results are compared with the help of the ratings, mentioned below,

Available Potassium in soil (Kg/ha)	**Interpretation**
0 – 59.999	Very Low
60 – 120	Low
120.001 – 280	Medium
280.001 – 560	High
>=560.001	Very High

Discussion: Availability of potassium varies from very low to low in 2A2D5b6 and 2A2D5b7 Micro-Watersheds, Puncha Block, Purulia District. And 55.98% of the earth's area, the available potassium surface is very low.

Assessment of existing sulfur content: Sulfur in mineral soils occurs mainly as adsorbed SO4 = ions, apart from some soil materials. Phosphate ions (such as monocalcium phosphate) are generally preferred to replace adsorbed SO4 = ions. Extraction is also done with CaCl2 solution. However, for a more efficient replacement of SO4 = ions, the former is preferred. The use of Ca salts has a clear advantage and easy filtration. The turbidity of SO4= in the extract can be assessed metrically using a colorimeter/spectrophotometer.

Table 6. Which represent the available sulphur results for all series along with the region.

Series name	Area(ha)	Available Sulphur (ppm)	Ratings
HATIMARA	392	4.8	Low
MORANDIH	112	15.83	Adequate
NISCHINTPUR	110	9.51	Low
PHUPHUNDI	47	8.125	Low
PUKHURIA	230	6.99	Low
PURA	7	9.97	Low
BHANGABANDH	191	9.4	Low
CHAKALTA	154	3.59	Low
DARIKATA	49	3.7	Low
DUMKADIH	35	6.15	Low
ROC	10		
TANK	32		
HABITATION	35		

The results are compared with the help of the ratings, mentioned below,
Low – 0-10 ppm
Marginal – 10-15 ppm
Adequate - > 15 ppm

Discussion: The availability of sulphur of 2A2D5b6& 2A2D5b7Micro-Watersheds, Punchablock, Purulia district and ranges in low to adequate.

SUMMARY AND CONCLUSION

Soil fertility assessment is an important and integral part of agricultural production systems and has an increasingly important role in managing environmental pollution problems related to plant nutrients. Successful application of soil fertility assessment and management principles and practices to maintain soil fertility on farmland increases profitability and minimizes the environmental impact of nutrient use, which are the primary goals of soil fertility management. Approaches to soil fertility assessment and management continue to evolve. Important challenges ahead are: (i) how new technologies should be analysed and integrated into current practices, (ii) how environmental soil test results can be applied to assess the value of conservation or conservation best management practices. Restore the environment or reduce soil-related health risks.

However, the ultimate value of these increasingly advanced technologies lies in our ability to interpret the results and (iii) optimal management of soil quality and minimization of environmental impacts are important not only for sustainability but also for human survival. The constant removal of nutrients from the soil by various means requires constant replacement to maintain productivity. This replacement (fertilization) requires specialist knowledge to truly maximize yield, minimize costs and minimize adverse effects on soil/plants. Of the available methods, soil testing appears to be the easiest way to predict a farmer's fertilizer needs.

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