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Declining Soil Health through Unscientific Agricultural Practices: A Case of Sapar Mouza, Burdwan-I C.D. Block, West Bengal

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Abstract

Soil is a combination of rocks, mineral materials and organic matter. It serves nutrients to plants and micro organisms. Soil is the base of human life because it provides food for inhabitants of the earth. Sedentary human civilization has grown up on the bank of various rivers. In the earliest era of civilization, pasturing and primitive agriculture had also commenced on soil. With the passage of time agricultural procedure has changed from subsistence to intensive which leads to the intensification of crop production to complement the demand of increasing population. In the way of more production, land is being utilized for many folds in a year. At present, human society produces artificial chemical fertilizer and genetically modified crops, HYV (high yield varieties) seeds, uses pesticide to prevent pest and advanced irrigation system for cropping throughout the year to increase productivity. Modern tools have made cultivation easier .But the quality of soil, the backbone of human sustenance, has been reduced through greedy unscientific landuse practises.This study has focused on the soil quality of Sapar Mouza, Burdwan I C.D. Block. Almost 80 per cent of the land in this mouza is used for agriculture in double cropped paddy cultivation with intensive use of chemical fertilizer, pesticide and irrigation. Farmers cultivate the land with mainly three types of chemical fertilizer i.e. urea, DAP (Di-ammonium Phosphate) and potassium. This has negatively changed the quality of the soil. As a result, the productivity has been declining year after year and affected the socio-economic picture in the mouza. The objective of the investigation is to study dwindling of soil health due to unscientific agricultural practices which are responsible for declining agricultural productivity in the agricultural mouza.

Introduction

Soil, a product of nature covers the earth's land mass. To a farmer soil is a producer of foods and fibre, to a potter, soil is raw material and to a civil engineer, soil is the base for all constructional activities. Above all, soil is thought as a mother from the era of the *Vedas (1500-1200 BC)* and the *Upanishads (1000-300 BC.)*, supporting and nourishing all life on the earth. From the ancient time, human beings have used soil to fulfil his own needs to produce food, fibre and to construct shelter etc. But due to some unwise human activity, soils have dwindled down through the incorporation of unexpected materials in soil and as a result, soil a living organism, has degraded its health and quality. Agriculture, a compulsory human activity on soil, had been practiced as the law of nature with the help of natural materials to fulfil human needs. The greediness of human society has modified the agricultural processes to produce more with artificial methods and inputs with materials deviating from natural system. Agricultural activity has been practiced with high yield seeds (HYVs), genetically modified (GM) seeds, synthetic chemical fertilizer, pesticide and developed irrigation system to produce crops throughout year. Over use of soil and unwise soil practices have deteriorated the soil quality and nutrient deficiencies in soil. 'Improper use of N fertilizers due to high application rates, incorrect source and method of application, and poor timing of application have led to air and water pollution and economic losses' (Singh, 2008).

Objectives

The objectives of this study are as follows—

1. To determine the present soil properties of agricultural land in the Mouza.
2. To calculate Nutrient Index and Fertility Assessment of the Mouza.
3. To calculate the gap between optimum fertilizer requirement and actual fertilizer applied in the soil.

Study Area

Agriculture, mainly paddy cultivation, is the main economic activity in West Bengal. The Gangetic plain of Bengal is the most favourable place for the production of different crops but Burdwan district, in the centre of Bengal plain, is specialized for paddy cultivation due to clay or clay loam soil texture. Burdwan district is known as rice bowl of Bengal for predominance on rice production. After green revolution in India (1970s), agriculture is practiced with modern inputs of HYV seeds, fertilizer, pesticide and irrigation. These chemical fertilizer based agricultural practices are responsible for deterioration of soil health. The issue has been studied on Sapar Mouza (J.L. No. 101), Burdwan I C.D. Block, Burdwan. About 83 per cent land of the mouza is used for double cropped paddy cultivation.

Database and Methodology

The research work has been completed mainly by using primary data. Twenty soil samples have collected from the mouza and the properties have been tested by digital machines and techniques. Seventy farmers have been interviewed to reveal the causality of the soil condition. Literature surveys, selection of the study area, collection of mouza map and preparation of questionnaires have been done in pre-field survey. Field survey includes survey of farmers, collection of soil samples, and use of GPS for GCP (Ground Control Point) collection. In the post-field work, soil samples have been tested by pH metre, EC metre, flame photometer and Soil Kit Method, Compilation, analysis of tested data and interpretation of the findings through maps, diagrams has been done with the help of MS-Excel (2007) and Map Info 9.0.

Soil Characteristics of the Sapar Mouza

According to National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Kolkata (2000) the region has very deep, poorly drained, fine soils, occurring on very gently sloping low lying alluvial plain with loamy surface and associated with very deep poorly drained, and fine cracking soils. The soil of this area occurs on nearly level to very gently sloping lower alluvial plain.

Results and Discussions

Soil is the product of interaction among minerals, air, water, living organisms and chemical constituents. Minerals constituents are the main source of minerals in soil and these minerals are the source of nutrients supplier to plants. According to the nutrients availability in soil, plant nutrients are three types: macro element (required in large amount) i.e. nitrogen (N), phosphate (P) and potassium (K), secondary element i.e. sulphur (S), calcium (Ca) and magnesium (Mg), and micronutrients (Fe, Zn, Cu, Bo, Mn, Cl). Plants absorb nutrients from soil and for that reason nutrient should be supplied from outside to prevent deficiency of nutrients. Recently different types of synthetic commercial chemical fertilizers are available in market for supplying of nutrients mainly macro element in the field.

a) Soil pH

Soil pH is a measure of the acidity of the soil in terms of hydrogen ion concentration and mathematically defined as the negative logarithm of the hydrogen ion concentration or pH = - log H^+. It ranges from 1 to 14. pH = 7 implies neutral soil, pH < 7 acid soil and ph >7 alkaline soil. Soil acidity is mainly caused by the absorbed cations of H^+ and Al^{3+} (Brady, 1990) —

$$\boxed{\text{Micelle}}\, Al^{3+} \longleftrightarrow Al^{3+}$$

$$Al^{3+} + H_2O \longrightarrow Al(OH)^{2+} + H^+ \text{ (hydrolyzed)}$$

The soils of the mouza have been tested to be slightly acidic (4.96 - 6.36) (Table - 1). The lowest pH value (4.96) has been found in the south-west portion of this mouza while highest value has been found in the mid-western part. Out of 83.8% of agricultural land, 1.76%, 38.61% and 42.26% of agricultural land shows the pH range of 4.5 - 5.0, 5.0 - 5.5 and 5.5 - 6.0 respectively (Fig. 1). In general, suitable pH range for paddy is 6.0 to 7.0 and hence about 98.5%of agricultural land is not suitable for it. Ammonia is the main content in di-ammonium phosphate $(NH_4)_2HPO_4$ and urea $CO(NH_2)_2$. From ammonia, nitrite is formed through nitrification by nitrosomonas and nitrobactor bacteria and then hydrogen ions are released in soil that decreases the soil pH. Shortly after application, the ammonium binds to soil or organic matter. Eventually it is converted into nitrate by bacteria in the soil, thereby releasing three hydrogen ions into the soil solution. They are then free to react with other substances in the soil. Free hydrogen ions are very active and increases "acidity" in the soil (Vagts, 2005)—

$$2NH_4^+ + 4O_2 = 2NO_3^- + 4H^+ + 2H_2O$$

b) Soil Reaction and Availability of Plant Nutrients

Soil pH is also an important factor for amount of nutrient content. With the decrease of soil pH, NPK availability is directly affected. Some nutrients become insoluble to the plant root system in high or low soil pH. 'Most minerals and nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils. A pH range of approximately 6 to 7 promotes the most ready availability of plant nutrients' (Vagts, 2005). 'The pH range of 6.5 to 7.5 is optimum for the availability of most of the nutrient elements. At low pH (below 6.0) the soil is partly base-saturated and their availability decreases' (Biswas et al., 1994) (Fig. 2). Nitrogen becomes less available with pH < 7, phosphate with pH = 5.5 and potassium with pH < 6.5.

Oxidizable Organic Carbon

Organic carbon is the main component of organic matter present in the soil and plant tissue is the main source of organic matter. In agricultural field, crop residue and application of organic fertilizer is the main contributor of organic matter in soil. Plant tissue contains 25% dry matter and 44% of it is shared by carbon content. In a well aerated soil, oxidation of the organic compounds is represented as follows—

$$(C, 4H) + 2\,O_2 \overset{enzymatic}{=}_{oxidation} CO_2 + 2H_2O + \textit{energy}$$

‘

Soil organic matter is one of the major sources of nutrient element for plants and nitrogen is probably the most important' (Biswas et al.1994). It is the main source of nutrient supply (nitrogen and phosphorus) as CNP ratio of 100:10:1. In Sapar mouza, 21.47% of agricultural land with 0.50 - 0.75% organic carbon belong to medium fertility class (Fig. 3)(Table - 4). Interestingly, crop residue is source of organic carbon content because 73% of farmers cultivate with chemical fertilizer only and other 26 % farmers depend mainly on chemical fertilizer though they use both chemical and organic fertilizer at a ratio of 6:1.

c) Electrical Conductivity

Electrical conductivity is a measurement of dissolved material in a solution, which relates to the ability of the material to conduct electrical current through it. It is the most common measure of soil salinity caused by high levels of exchangeable sodium expressed in seimens per unit area (mS/cm or milliSiemens/cm). By agricultural standards, soils with an EC greater than 4 dS/m are considered saline. The tested soil properties have shown that electrical conductivity ranges between 0.16 to 0.35mS/cm (Fig. 4). This range is suitable for agricultural production.

Changes of Soil Properties over Time

Table - 2 shows three soil properties which are compared with the report of NBSS & LUP, 1986-87. It has shown the values with depth of soil and the pH of AP layer (0-15 cm) was 6.1 in 1986 - 87. Within three decades pH has declined to 5.4 that means within 26 years soil has become seven times acidic in Sapar mouza because of its sole dependency on mono crop cultivation in kharif as well as boro season with chemical fertiliser. 'The original source of soil organic matter is plant tissue and one tenth to one third of the plant tops commonly fall to the soil surface and incorporated into soil' (Brady, 1990). Crop residue also contributes a large portion of organic matter in soil every year by double cropping. Farmers are not eager to use organic fertilizer for vague faith and are unaware of the benefits of organic fertilizer.

Soil Nutrient Status in Sapar Mouza

Elements absorbed from the soil by the roots are generally known as plant nutrients or mineral nutrients (Sahai, 2004). The research work has focussed on measurement and analysis of macronutrients in the soil samples of the study area (Table - 3)—

a) Nitrogen

Nitrogen is one of the major nutrients for plants obtained from soil. Most of the soil nitrogen is in organic form. Proteins and other organic nitrogen compounds are associated with humus and with some silicate clays, which protect them from rapid microbial breakdown (Brady, 1990). The plant protein breaks down not only into carbon dioxide and water but also amino acids like glycine ($Ch_2\ NH_2\ COOH$) and cysteine ($CH_2HSCHNH_2COOH$). These nitrogen and sulphur compounds further break down into inorganic nitrogen ions such as NH_4^+, NO_3^- and SO_4^{2-} .Ammonium form of nitrogen (NH^{4+}) is less readily available to plants than nitrate fertilizer. The ammonical nitrogen has to nitrify in the soil and be converted into nitrate before it can be taken up by plants. Rice is the only crop which can utilize the ammonical nitrogen and in all cases nitrification has to take place before it can be utilized (Sahai, 2004)—

$$2NH_4^+ + 3O_2 = 2HNO_2 + 2H^+ + 2H_2O\ (\textit{Nitrosomonas})$$
$$2HNO_2 + O_2 = NO_3^- + 2H^+\ (\textit{Nitrobacteria})$$

Nitrification is a process of enzymatic oxidation of ammonia to nitrate by certain microorganisms in the so''

$$\overbrace{NH_4^+ \xrightarrow{[O]} HONH_2 \xrightarrow{-2H} \tfrac{1}{2}\,HONNOH \xrightarrow{[O]} NO_2^- + H^+ + energy}^{Nitrosomonas}$$
$$\overbrace{NO_2^- \xrightarrow{[O]} NO_3^- + energy}^{Nitrobactor}$$

Firstly ammonium (NH_4^+) is oxidized to nitrite (NO_2^-) by Nitrosomonas and then nitrite is further oxidized to form nitrate (NO_3^-) by nitrobactor. Nitrogen is one of the macronutrients for plant. Though nitrogen is available in air at 78 per cent, but plant cannot absorb it directly. The source of nitrogen is soil nutrient or fertilizer supplied for plant. Ammonium nitrogen (NH^{4+}) is generally unavailable to plant because it nitrifies to nitrate ion (NO_3^-). The ammonical nitrogen status of the mouza is that 59.49% of agricultural lands in Sapar mouza contain less than 40 kg nitrogen per hectare and 40.50% of lands contain 40-5 kg ammonium per hectare (Fig. 5). In the study, 59.62% and 18.66% of land contain nitrate nitrogen at a level of 12 - 24 kg and above 36 kg per hectare respectively. This is the result of nitrified ammonium provided through di-ammonium phosphate (Fig. 6)

B) Phosphorus

Next to nitrogen, phosphorus is the most critical element in influencing plant growth. “Unlike nitrogen, these are not supplied through biochemical fixation but must come from other sources to meet plant requirements” (Brady, 1990). Phosphorus is essential for energy transformation in the process of photosynthesis.

Phosphorus availability in soil is a great problem due to low phosphorus contain in soil, low phosphorus uptake and unavailable form of phosphorus in soil. The availability of phosphate to plant is determined by ionic form of phosphorus and the ionic form is determined by the pH of soil. "In acid soil solution the primary orthophosphate ions ($H_2PO_4^-$) dominate" (Basak, 2007) and react with iron (Fe) and aluminium (Al) to produce insoluble phosphate compound. In solution of pH 7.0 both $H_2PO_4^-$ and HPO_4^{3-} ions are found. The sources are: chemical fertilizer, animal manures, plant residues including green manure etc. Phosphate is the second nutrient which should be supplied from outside as fertilizer. The phosphate status in this mouza is that 11 per cent and 54.81 per cent of agricultural land contain less than 22 kg and 56 -72kg phosphate (P_2O_5) per hectare respectively. Only 10 per cent land contain more than 72 kg/ ha phosphate (Fig. 7).

c) Available Potassium

Potassium is third element for plant absorbed from soil. Available form of potassium is potassium ions (K^+), K_2O. Potassium is found in comparatively high levels in most mineral soils, except those of a sandy nature. Much of the potassium is getting lost by the process of leaching. In a representative humid region soil receiving only moderate rates of fertilizer, the annual loss of potassium by leaching is usually about 35 kg/ha (Brady, 1990). Potassium is also removed by crop at 140-180kg/ ha. Potassium is available in the form of K_2O for plant. Potassium range varies from 110-590 kg/ha (Fig. 8). 58.38% of agricultural land contains low potassium status (below 150 kg ha-1) where only 5.81 per cent land contains high potassium contents (above 340 kg ha-1).

$$H_2PO_4^- \text{ (very acid solution)} \underset{OH^-}{\overset{H^+}{\rightleftarrows}} H_2O + HPO_4^{2-} \underset{OH^-}{\overset{H^+}{\rightleftarrows}} H_2O + PO_4^{3-} \text{ (very alkaline solution)}$$

Fertility Assessment and Nutrient Index

Fertility is a state of soil properties responsible for crop production. Fertility classes vary from one state to another depending on soil conditions. The Dept. of Agriculture, Govt. of West Bengal has mentioned the state of soil properties which denotes soil fertility class (Table - 4). It is found by the mathematical expression of nutrient index after Motsara et al., 1982 as follows—

$$NI = \frac{1}{T}(Lx1 + Mx2 + Hx3)$$

where, NI= Nutrient Index, L=No. of soil sample falling in low categories of nutrient status, M= No. of soil sample falling in medium categories of nutrient status, H= No. of soil sample falling in high categories of nutrient status, T=Total No. of soil samples

Nutrient Index of Nitrogen

= (20x1)/20 =1

Nutrient Index of Phosphate

= (7x1 + 13x2)/20 = 1.65

Nutrient Index of Potassium

= (9x1+10x2+1x3)/20 =1.60

The average oxidizable organic carbon is 0.822% in soil which falls under high fertility class. Nitrogen and potassium status in the mouza is low. So, farmer should use fertilizer according to recommendation of Dept. of Agriculture, GOWB. The table shows the fertilizer recommendation.

Gap between Optimum Fertilizer Recommendation and Actual Fertilizer Applied

Soil fertility is the inherent capacity of a soil to provide the essential plant nutrients in adequate amount and in proper proportions for plant growth. Thus, the term soil fertility indicates nutrient status of a soil (Basak, 2000). Fertilizer which provide mainly macronutrients, are generally applied according to soil fertility. In kharif season, to cultivate *swarna, IR-20*, 80 kg ha^{-1} N, 40 kg ha^{-1} P and 40 kg ha^{-1} K is required. To complete this requirement, 86.95 kg ha^{-1} DAP, 139.89 kg ha^{-1} urea and 66.27 kg ha^{-1} muriate of potassium (MoP) is required. But farmers have applied 196 kg ha^{-1} DAP, 127.28 kg ha^{-1} urea and 94.49 kg ha^{-1} MoP which shows 225.41% DAP, 90.98% urea and 142.58% MoP application in respect of recommended fertilizer rate in kharif rice cultivation.

In *boro* season, to cultivate with *IR-64, IR-36*, 120 kg ha^{-1} N, 60 kg ha^{-1} P and 60 kg ha^{-1} K is required. To attain the amount, 130.43 kg ha^{-1} DAP, 209.86 kg ha^{-1} urea and 100 kg ha^{-1} MoP is required. But farmers have applied 150.27% DAP (196 kg ha^{-1}), 60.65% urea (127.28 kg ha^{-1}) and 94.49% MoP (94.49 kg ha^{-1}). This fertilizer application has shown illiteracy and unawareness of farmer about fertilizer application due to lack of proper training and education. Farmers have applied 93.82 kg ha^{-1} N, 90.16 kg ha^{-1} P and 56.69 kg ha^{-1} K which is ratio of 117.27% N, 225.4% P and 141.72% K of recommended fertilizer rate in kharif (Table - 5 and 6). In *boro* season, to cultivate *IR-64, IR-36*, farmers have applied 78.18% N (93.82 kg ha^{-1}), 150.27 % P (90.16 kg ha^{-1}) and 94.48% K (56.69 kg ha^{-1}) of recommended fertilizer rate. From the above table, it is clear that farmers apply more phosphate and potassium of 80.32 kg ha^{-1} and 13.38 kg ha^{-1} per annum respectively than its requirement. This excess amount of nutrients accumulates in soil and become insoluble (iron and aluminium hydroxyl phosphate, $Fe(OH)_2 H_2PO_4$, $Al(OH)_2 H_2PO_4$) and unavailable to plant. But deficient application of N is responsible for N deficiency in soil. Nitrogen deficiency prevail 12.36 kg ha^{-1} per annum. So, over dependency of chemical fertilizer is responsible for unbalanced nutrient application (Table - 7).

Causes of Fertilizer Mismanagement

a) Unskilled Farmer

Agriculture is a combined practice of botany, pedology, hydrology and different types of fertilizer inputs and reaction. It is essential to understand the quality of plants, soil health, timing of pesticide application and water requirement for crops through proper training, workshop and seminar. But out of 70 farmers in the mouza, only 9 per cent has proper training (Fig. 9) and rest of the farmers cultivate with the field based knowledge and trial and error method. It is necessary to train farmers about HYV seed use, application and timing of chemical fertilizer and pesticide.

b) Poor Literacy

Generally, educated persons are not eager to involve themselves in agriculture for low and uncertain income. In the mouza illiterate or persons educated up to primary level engage at 100 per cent where involvement of higher secondary educated person is reduced to 60 per cent where in PG level, participation has reduced to 40 per cent (Fig. 10). So basically, agriculture has become an enterprise of mostly illiterate and low educated people.

Conclusion

From the above discussion, it is evident that present day agriculture is highly dependent on chemical fertilizer but over use of fertilizer alter soil reaction towards acidic condition. As availability of plant nutrients depend on soil reaction, phosphate and potassium index has shown low fertility status. Excess phosphate and potassium transform into insoluble forms and precipitate in acid soil solution. Phosphate and potassium have been accumulated in soil where as nitrogen content of soil is declined through unbalanced fertilizer application. Over dependency and unscientific use of chemical fertilizer has deteriorated the soil properties of pH and NPK status. To neutralize soil reaction, it is recommended to apply lime or dolomite according to soil pH level and to apply optimum chemical fertilizer to sustain soil fertility for sustainable cultivation.

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Table – 1 : Categories of Soil pH

Soil p^H	Categories
Below 5.5	Acidic
5.5 - 6.5	Slightly acid
6.5 - 7.5	Neutral
7.5 - 8.5	Tending to become Alkaline
Above 8.5	Alkali

Table - 2: Comparative Analysis of Soil properties over Time (Annual Report, 1986-87, NBSS & LUP)

Depth (cm)	p^H (1:2.5) H_2O		Organic Carbon (%)		EC(1:2.5) H_2O	
	NBSS&LUP, 1986-87	Researcher, 2013	NBSS&LUP, 1986-87	Researcher, 2013	NBSS&LUP, 1986-87	Researcher, 2013
AP (0-15)	6.1	5.4	0.39	0.82	0.23	0.25
15-32	6.7		0.23		0.11	
32-80	7.0		0.23		0.17	
80-140	7.1		0.18		0.19	

Table – 3: Forms of Essential Elements Taken up by Plants

Element	Source	Abbreviation	Form absorbed
Nitrogen	Air/ Fertilizer	N	NH_4^+ (ammonium) and NO_3^- (nitrate)
Phosphorus	Soil/Fertilizer	P	$H_2PO_4^-$ and HPO_4^-(orthophosphate), P_2O_5
Potassium	Soil/Fertilizer	K	K^+, K_2O (potassium ion)

Table - 4: Fertility Categories and Soil Properties (Bhattacharyya, 2000)

Categories	Organic Carbon (%)	Available Nitrogen (Kg/ha)	Available P_2O_5 (Kg/ha)	Available K_2O (Kg/ha)
High	Above 0.75	Above 450	Above 90	Above 340
Medium	0.5 - 0.75	280 - 450	45 - 90	150 - 340
Low	Below 0.5	Below 280	Below 45	Below 150

Table – 5: Fertilizer Recommendation for the Dominant Crops in West Bengal (Bhattacharyya, 2000)

Crops	Fertility Class	NPK nutrients required in kg./ha			Time of application
		N	P_2O_5	K_2O	
Rice, Kharif, HYV Seeds, Swarna, IR-20 (125-135 days)	High	50	25	25	Basal-1/4N, full P&K Topdressing of N ½ at 15 DAT ¼ at 40-45 DAT
	Medium	60	30	30	
	Low	80	40	40	
Rice, boro IR-64, IR-36, Vikash, IET-4786	High	80	40	40	Basal-1/4N, full P&K Topdressing of N ½ at tilling ¼ at P.I.
	Medium	100	50	50	
	Low	120	60	60	

Table – 6: Comparison between Fertilizer Requirement and Application in Sapar Mouza

Type of fertilizer	DAP (18:46) (Kg/ha)		Urea (46%) (Kg/ha)		MoP (60%) (Kg/ha)	
	Required	Farmers provide (Avg.)	Required	Farmers provide (Avg.)	Required	Farmers provide (Avg.)
Kharif rice	86.95	196	139.89	127.28	66.67	94.49
Boro rice	130.43	196	209.84	127.28	100	94.49

Table – 7: Gap between Fertilizer Recommendation and Actual Fertilizer Application in Sapar Mouza

Crop	N			P			K		
	Recommended kg ha^{-1}	Applied kg ha^{-1}	%	Recommended kg ha^{-1}	Applied kg ha^{-1}	%	Recommended kg ha^{-1}	Applied kg ha^{-1}	%
Kharif	80	93.82	117.27	40	90.16	225.4	40	56.69	141.72
Boro	120	93.82	78.18	60	90.16	150.27	60	56.69	94.48
Unused, accumulated nutrients	200	187.64	93.82	100	180.32	180.32	100	113.38	113.38
		-12.36			80.32			13.38	

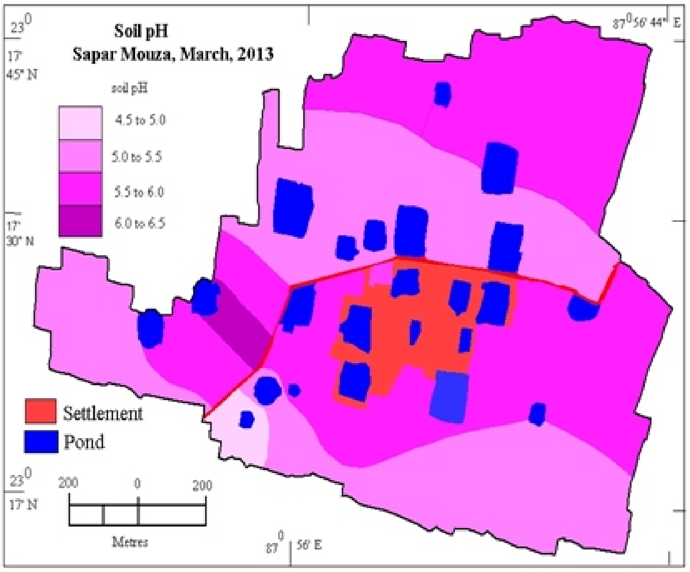

Fig. 1: Distribution of Soil pH in Sapar Mouza

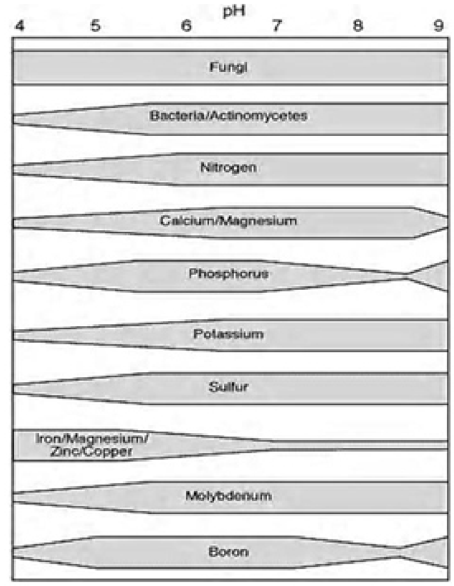

Fig. 2: Soil Reaction and Nutrient Availability

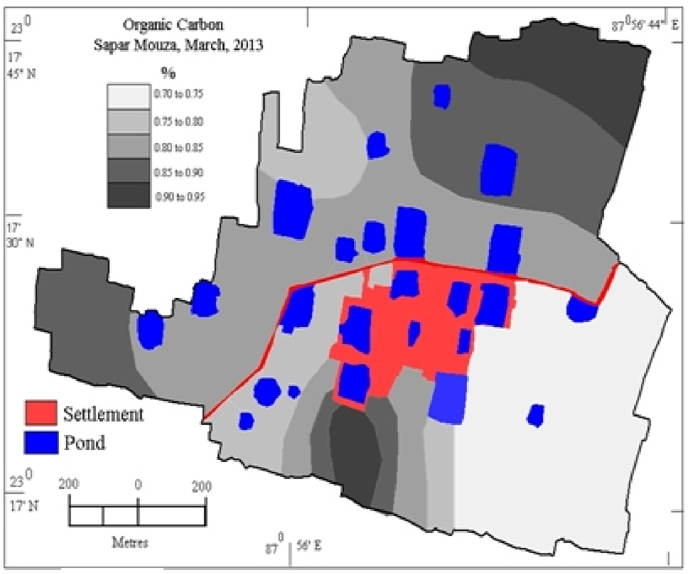

Fig. 3: Distribution of Organic Carbon in Sapar Mouza

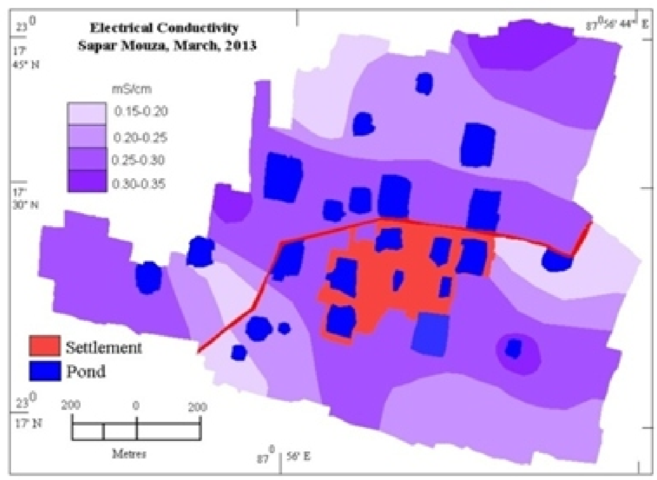

Fig. 4: Distribution of Electrical Conductivity in Sapar Mouza

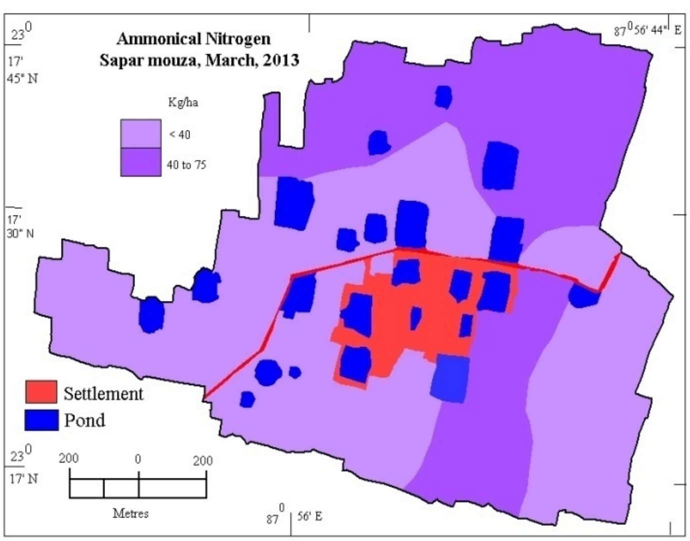

Fig. 3: Distribution of Ammoniacal Nitrogen in Sapar Mouza

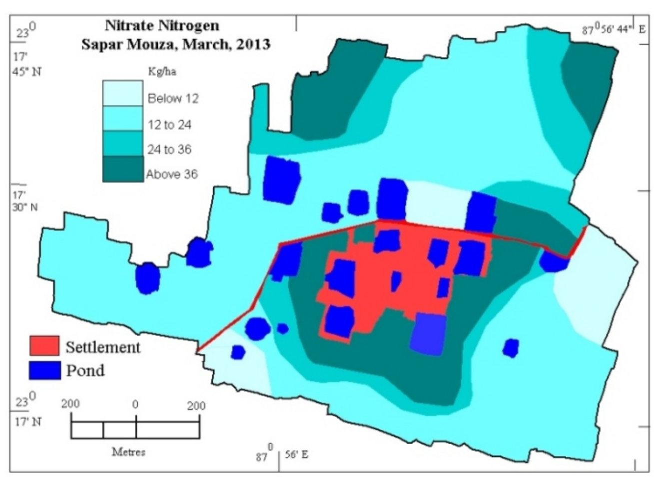

Fig. 4: Distribution of Nitrate Nitrogen in Sapar Mouza

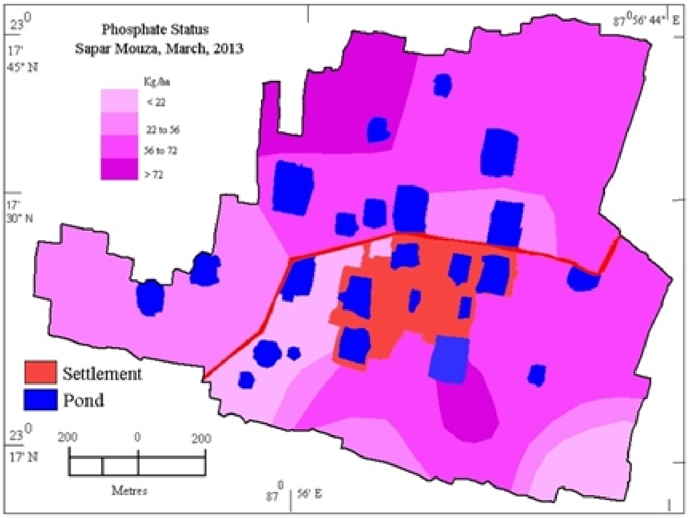

Fig. 7: Status of Soil Phosphate in Sapar Mouza

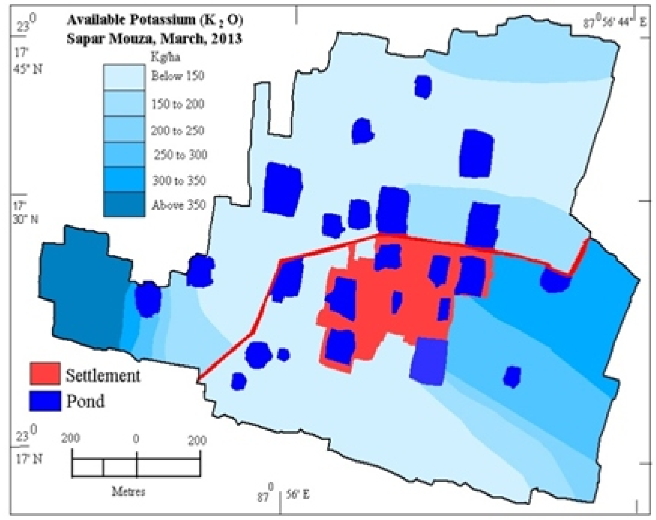

Fig. 8: Status of Available Potassium in Soils of Sapar Mouza

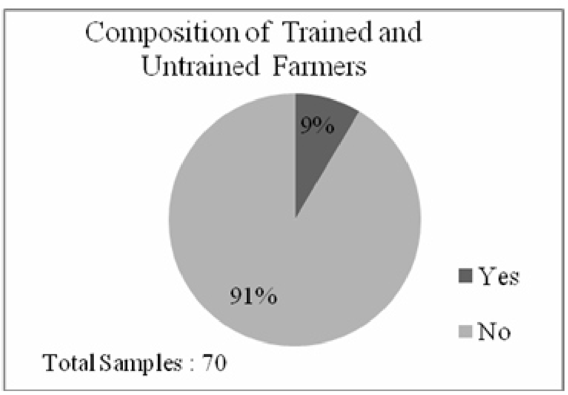

Fig. 9: Distribution of Trained and Untrained Farmers, Sapar Mouza

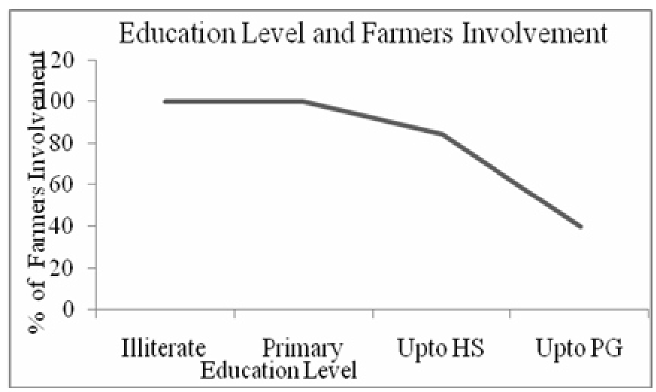

Fig. 10: Level of Education and Farmer's Involvement

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