A COMPARATIVE STUDY ON SOIL QUALITY OF CONVENTIONAL VS. ORGANIC FARMING

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ABSTRACT

Extensive application of external agricultural inputs to agricultural production systems lead to deterioration of soil quality. In this context the present study aims at analysing the soil quality of some selected conventional and organic agro-ecosystems of Dimoria Tribal Development Block, Kamrup, Assam, in order to assess the impacts of agrochemicals application in terms of its physic-chemical properties with special emphasis on heavy metal contamination. The study reveals that there are no significant differences between organic and conventional management for most of the soil physical and chemical properties measured.However, soil samples from the conventionally managed system exhibited significantly higher values of electrical conductivity (EC) and higher concentrations of K, Cu and Zn, than the organic systems, which were likely the result of chemical fertilizer application.In terms of NPK availability the soil status can be regarded as of moderate quality. The average contents of heavy metals in surface soils (0-15 cm depth)of both organic and conventional systemsranges in the following order; Cd < Ni < Cu < Cr < Zn.For the fields sampled, it can be concluded that there is little direct benefit on soil physical condition for organic farming practices but equally there is no detrimental effect.

Keywords: Conventional Farming, Heavy Metals, Organic Farming, Soil Quality.

I. INTRODUCTION

Soil is a fundamental resource base for agricultural production systems. Besides being the main medium for plant growth, soil functions to sustain plant productivity, maintain environmental quality, and provide for plant, animal and human health. In general, soil quality refers to the soil's capacity to perform specific functions (SSSA 1987). In agriculture, it refers to the soil's ability to sustain production (Lal, 1994).

The term soil quality has been coined to describe the combination of chemical, physical and biological characteristics that enables soil to perform a wide range of functions.

The current industrial agriculture system promotes the reliance on agrochemicals, bothsynthetic fertilizers and pesticides, while neglecting to consider their negative effects on theeconomy of local communities, human health and environment. The long term use of highlevels of agrichemical to boost yields has made it difficult to sustain the same rate of yieldgrowth, and yields approach the economic optimum levels. Environmental pressures areincreasing as existing land and water resources come under threat from rapid urbanization.Land is being withdrawn from agricultural production, creating additional pressures for thereallocation of water now used in agriculture. Furthermore, the need to use large amounts ofpesticides to control pests and weeds has raised environmental and human health concerns.Agrochemicals pose health and environmental risks, and they can pollute rivers and lakesthisexpensive agriculture system: farmers are already fertilizing soils and protecting crops withorganic and sustainable techniques that work with nature, not against it, and can provide foodfor all (Pretty et al. 2003, Badgley et al. 2007).

Organic farming has gained ground world wide and has expanded in the last decade due to environmental, economic and social concerns (Araujo *et al.*, 2008). Organic farming has been proposed as an alternative agricultural system to help solve the environmental problems arising from conventional management, such as frequent pesticide applications, excessive inputs of chemical fertilisers, soil degradation and the presence of pesticide residues in food (Stockdale *et al.*, 2001).

Agricultural sustainability depends on productive soil. During the last several decades, much research has focused on increasing productivity and protecting environmental quality under different farming systems. These studies show that conventional farming's use of chemical fertilizers and pesticides has increased crop yields and enhanced food security around the globe (Pang & Letey 2000). However, despite the high yields associated with it, conventional farming's ability to sustain soil fertility and environmental quality has been called into question (Pang & Letey 2000). Conventional farming systems are reported to be associated with a decline in soil structure and soil aggregation, a decrease in water infiltration and an increase in soil bulk density, soil salinity, nitrogen leaching and ground water contamination (Logsdon et al. 1993, McGarry et al. 2000).

Sustainable management is crucial to the maintenance of soil structure and organic matter (SOM) levels are important if the continued availability of water and nutrients and standards of soil workability are to be sustained (Pulleman *et al*. 2003). There is an abundance of recent literature comparing organic and conventional farms with respect to soil properties, microbiology and nutrient analysis (Armstrong Brown *etal.* 2000; Marinari *et al*. 2006; Mulumba and Lal 2008; Pulleman *et al*. 2003; Parfitt *et al*. 2005). Pulleman *et al*. (2003) compared soil structure and organic matter dynamics on conventional (non-organic) and organic arable farms. It is well understood that the key to long-term success in organic farming is good soil management.

Scientific assessment of soil quality is essential to monitor the sustainability of agricultural systems.Soil's physical and chemical properties can be used as indicators for making soil-quality assessments and for determining the sustainability of farming systems.

In this context the present study aims at analysing the soil quality of some selected conventional and organic agro-ecosystems of Dimoria Tribal Development Block, Kamrup, Assam, in order to assess the impacts of agrochemicals application in terms of its physic-chemical properties with special emphasis on heavy metal contamination.

The specific objectives of the study were:

i. to explorethe main soil properties and topsoil accumulation of heavy metals in some selected conventional and organic agro-ecosystems under long-term cultivation in Dimoria Tribal Development Block, Assam, and

ii. to compare the quality of the soil in terms of its nutrient status.

II. METHODOLOGY

2.1 Study Area

The study area, Dimoria is a part of Kamrup district located in the fringe of Meghalaya plateau with peculiarities of unity among diversity. The area enjoy hot and humid climate with annual rainfall of about 1740 mm. The seasonal variation of temperature is observed in this area. July is the warmest month and January is the driest month of the year. The average temperature in the summer is about 32^{o}c while winter is about 10^{o}c.

Dimoria has some of the most impressive hills and hillocks like Dhoumara pahar in the south, Mata pahar, Dhaudang pahar etc., scattered throughout the region lying mostly in the north-south and east-west directions. They are covered with broad leaves evergreen forests, deciduous forest and a variety of fire trees. The area has various type of soil with their respective characteristics. Large quantities of alluvial soils are brought down from the nearby hills, which contain some of their physical and chemical properties. In the low-lying swamps, especially among the flood plain of Kolong and Digaru River, marshy soils are seen which contain high percentage of humus. So, the area is rich in agriculture. The principal crops are paddy, wheat, oil seed and so forth. The hilltops are covered with a thin layer of red soil. On the slope of the hill, tribes do jhum cultivation. Moreover the area also has many Tea Estates.

The people of this region practice different land use systems like Food agriculture, Bamboo plantation, Horticulture, Agro-forestry, Natural forest, Shifting cultivation, etc. Several agrochemicals (synthetic fertilizers, pesticides etc.) of different chemical nature are known to be used in different land-use systems which may be associated with a number of environmental concerns viz. persistence in the environment, accumulation of heavy metals, toxicity in soil, vegetation and water supplies and impact beyond the target organism including bioaccumulation and its implication for human health.

2.2 Sampling and Analysis

2.2.1 Selection of sampling station

For the purpose of this study, samples were collected from some selected conventional and organic agro-ecosystems of the area. In all study areas, the same method was used to collect soil samples. In total 5 stations were selected. One station each from organic and conventional paddy fields and organic and conventional vegetable farms and one from natural forest representing control sample.

2.2.2 Sampling procedure

In order to collect soil samples (0-15 cm depth) grasses, mosses, litter and other plant residues were removed from soil surface. Collection of soil samples was done by using an auger. In each case, a triangular block was cut with the help of the auger. Soils were collected in plastic bags, which were sealed and labeled properly.

Three soil samples from a rooting depth of 15 cm were collected randomly from each sampling station. Three samples from each site were also taken from 0 to 15 cm layer for bulk density determination.

Soil samples were brought to the laboratory for analysis. Before analysis, the samples were spread out thinly on a piece of hard paper for drying in air in a shade. The big lumps were broken down, and plant roots, pebbles and other undesirable matters were removed. After the soil become completely dry, and after homogenization, half of each sample was passed through a 2-mm mesh screen. The samples were preserved in clean sealed polythene bags for analysis. The other half was sieved through a 500 μm mesh (Fritsch laboratory sieving set used) and used for determining soil "total" Cd, Cr, Cu, Ni, Pb, and Zn.

2.2.3 Soil quality parameters and methodology for their study.

A large number of parameters are generally used to characterize the soil quality criteria. The most important consideration should be those properties of soil, which influence the movement and retention of water that contribute to store and supply of nutrients. In this study some selected physical and chemical parameters were determined. The different parameters that were used to assess soil quality of different land uses are shown in **Table 1**.

Table 1: Soil properties under study with their methods of measurement

Soil properties	Methods
Bulk density	Core sampling method (Blake and Hartge, 1986)
Texture	Feel method
Temperature	Soil thermometer
Moisture content	Moisture meter
pH	Potentiometrically in 1:2.5 (*v*/*v*) soil suspension in water (pH meter)
Electrical Conductivity	Conductivitimeter
Organic matter	Titrimetric method (Walkley and Black, 1934).% Soil organic matter
Nitrate nitrogen	Spectrophotometric method
Available phosphorus	Spectrophotometric method
Available potassium	Flame photometer method (1986)

2.2.4 Heavy metal analysis of soil samples

For determining metal concentration in soil, at first the soil samples were prepared for digestion. For digestion, 1gm of soil from each sample was taken and mixed with 1ml sulphuric acid, 10ml nitric acid and 4ml perchloric acid and heated in a hot plate in digestion chamber at temperature 100°C. When a white fume appears it indicates the completion of digestion process. Then the samples were filtered by Whatman filter paper and kept in a narrow mouth plastic bottle. The total volume of prepared samples was made upto10ml and analyzed by Atomic Absorption Spectroscopy (AAS). During digestion process all the apparatus was cleaned properly and glass wares

was washed with tap water and then distilled water to prevent cross contamination.
In AAS, for the determination of heavy metals Cd, Cr, Cu, Ni, Pb, and Zn the calibration is done by standard solution of each metal.

III. RESULTS AND DISCUSSION

The soil quality has been discussed with respect to some representative physic- chemical parameters. The results of the analysis has been shown on **table 2, 3**and **4** and discussed on the basis of existing literature. Depending on soil conditions like nutrient availability, pH, aeration, temperature, moisture etc. the soil quality varies.
The soil in both the organically and conventionally managed systemswas characterized as clay- loam and sandy-clay- loam and was uniform in morphological and physical properties.**(Table-2)**

TABLE 2: Mean ± SE of selected soil (0-15 cm) physical properties in the land use systems

Properties	**Land use systems**				
	Vegetable Farm (1) CONVENTIONAL	**Vegetable Farm (2) ORGANIC**	**Rice Field (1) CONVENTIONAL**	**Rice Field (2) ORGANIC**	**NaturalForest (Control)**
	Mean S.E	**Mean S.E**	**Mean S.E**	**Mean S.E**	**Mean S.E**
Temperature (°C)	20.33 ±0.66	20.66 ±0.33	21.33 ±0.33	28.0 ±0.33	21.67 ±0.33
Moisture (%)	3.61 ±0.14	7.0 ±0.80	12.31 ±0.42	17.0 ±4.90	22.24 ±8.34
Bulk density (g/cm^3)	1.38 ±0.02	1.34 ±0.03	1.07 ±0.07	1.34 ±0.03	1.33 ±0.02
Water-holding capacity (%)	51.21 ±0.27	65.51 ±1.16	54.40 ±0.25	51.17 ±0.20	55.81 ±1.49
Texture	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam	Silt loam

The soil in both the systems was acidic in nature. SOM is usually considered to be one of the most important properties of soils due to its significant impact on other biological and physicochemical soil properties. Thus, it is noteworthy that there was no significant difference in the levels of SOM between the two management systems.**(Table-3)**.

With the exception of the EC values and concentrations of K,the variables evaluated did not present significant differences under the two management systems **(Table-3).** As EC is strongly influenced by management practices, it can be used as an indicator of the extended use of fertilizers in soil. An increase in the EC in conventionally managed soils could be due to the higher input of salts (in the forms of chemical fertilizers and/or pesticides).

TABLE 3: Mean ± SE of selected soil (0-15 cm) chemical properties in the land use systems.

Properties	Land use systems				
	Vegetable Farm (1) CONVENTIONAL	Vegetable Farm (2) ORGANIC	Rice Field (1) CONVENTIONAL	Rice Field (2) ORGANIC	NaturalForest (Control)
	Mean S.E	Mean S.E	Mean S.E	Mean S.E	Mean S.E
pH	5.41 ±0.02	5.30 ±0.09	6.08 ± 0.47	6.26 ±0.32	5.13 ±0.79
E.C (μS/cm)	193.2 ±0.66	176.4 ±3.15	185.5 ±0.95	165.85 ±1.53	156.05 ±1.77
Organic Matter (%)	1.28 ±0.15	2.15 ±0.12	2.73 ±0.1	2.81 ±0.25	3.04 ±0.04
NO3 N (mg/kg)	4.5 ±0.47	6.0 ±0.81	4.18 ±0.10	4.6 ±0.25	1.9 ±0.00
AP (Kg/ha)	3.24 ±0.30	2.21 ±0.47	5.88 ±0.48	3.52 ±0.2	7.93 ±18.29
AK (Kg/ha)	158.7 ±0.13	117.27 ±3.43	130 ±4.78	82.5 ±19.7	43.29 ±9.33

The concentrations of the soil available Pb, Cu, Cr, Ni, Cd and Zn determined by ASS are presented in**Table-4.**The soil of the organically cultivated Land-use systems exhibited significantly lower Cu and Zn concentrations than that of the conventional ones. The application of various agrochemicals, such as pesticides (copper containing fungicides) and synthetic fertilizers (containing both Cu and Zn), in the conventional systems could account for the increased soil content of these metals through foliar run off.

TABLE 4: Mean ± SE heavy metal concentration of selected soil (0-15 cm) in the land use systems

Heavy metal conc. (mg/kg)	Land use systems				
	Vegetable Farm(1) CONVENTIONAL	VegetableFarm(2) ORGANIC	Rice Field (1) CONVENTIONAL	Rice Field (2) ORGANIC	Natural Forest (Control)
	Mean S.E	Mean S.E	Mean S.E	Mean S.E	Mean S.E
Cd	0.16 ±0.04	0.83 ±0.083	0.21 ±0.03	0.16 ±0.00	BDL
Cr	46.06 ±0.06	42.16 ±0.08	32.13 ±0.08	8.03 ±0.05	BDL
Cu	18.53 ±0.08	4.66 ±0.12	27.16 ±0.12	15.5 ±0.15	BDL
Ni	24.13 ±0.06	29.06 ±0.03	21.56 ±0.12	21.23 ±0.03	BDL
Pb	BDL	BDL	BDL	BDL	BDL
Zn	94.46 ±0.14	35.13 ±0.23	99.83 ±0.16	65.4 ±0.45	BDL

BDL: Below detection limit

IV. CONCLUSION

In the present study, the major objective of the research wasto explore the soil quality of two differentlly managed agricultural systems viz.(conventional and organic agro-ecosystems) in order to assess the impacts of agrochemicals application in terms of its physic-chemical properties with special emphasis on heavy metal accumulation.

The study reveals that there are no significant differences between organic and conventional management for most of the soil physical and chemical properties measured. However, soil samples from the conventionally managed system exhibited significantly higher values of electrical conductivity (EC) and higher concentrations of K, Cu and Zn, than the organic systems, which were likely the result of chemical fertilizer application. In terms of NPK availability the soil status can be regarded as of moderate quality.Most of the soil samples revealed organic matter near-by or above 3%, which were moderate according to ICAR rating, 1997.The average contents of heavy metals in surface soils (0-15 cm depth)of both organic and conventional systems ranges in the following order; Cd < Ni < Cu < Cr < Zn. However, not a single metal was detected in the control sample. For the fields sampled, it can be concluded that there is little direct benefit on soil physical condition for organic farming practices but equally there is no detrimental effect.

Agricultural sustainability depends on productive soil. The significance of the present study, therefore, lies in scientific assessment of soil quality, which is essential to monitor the sustainability of agricultural systems.

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