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Physico-Chemical properties of Soil: A Case Study of Village Ecosystems of Hisar District, India

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Abstract

Agricultural practices are the mainstay of people of Haryana, and a large section of population depends on agriculture based activities for their livelihood. Soil quality represents an integral value of the compositional structure and natural functions of agroecosystem. Soil physical and chemical properties are indicators of soil quality and health. Soil nutrient measurement has been particularly useful tool to evaluate land fertility and increasing production of various crops. Changes in socioeconomic status of village due to availability of irrigation, fertilizer and adopting various crops which are economically more beneficial are one of major cause for a rapid decline in traditional agriculture which has been clearly depicted from the replacement of traditional crops with cash crops and hybrid seed varieties. Hence, present study is focus on the socioeconomic and physico-chemical parameters of soil in Hisar, Haryana.

Keywords: Agroecosystem; biodiversity; Soil nutrients; Socioeconomic

Introduction

Agro-ecosystems vary widely in the amount of biodiversity in terms of cultivars or varieties within species and within cultivars. Management practices modify climate-vegetation-soil interactions operating in the native ecosystem (Hu *et al*., 1997; Katterer and Andren, 1999; Jackson *et al*., 2007). In natural ecosystem the vegetative cover of forest or grassland prevents soil erosion, replenishes ground water and controls flooding by enhancing infiltration and reducing water runoff (Perry, 1994). In agricultural systems, biodiversity performs ecosystem services besides production of food, fiber and fuel. Examples include recycling of nutrients, control of local microclimate, regulation of local hydrological process, regulation of the abundance of undesirable organisms and detoxification of noxious chemicals that usually involve in assemblages of spaces and guilds, each with a complex set of function and interaction (Pearce and Moran, 1994; MEA, 2005; Pascual and Perrings, 2007). These renewal processes and ecosystem services are largely biological, therefore their persistence depends upon maintenance of biodiversity (Altieri, 1994) i.e., the capacity to recover from disruption of functions and mitigation of risks caused by disturbance (Holling, 1996; Swift *et al*., 2004; Jackson *et al*., 2007).

A large section population of Haryana depends on agriculture based activities for their livelihood. Agriculture in the region is closely interlinked with traditional crop cultivation, animal husbandry and all activities to form an integrated production system for sustainable livelihoods. The traditional agricultural system is characterized by dependence on local resources and locally developed technologies. Physico-chemical properties are important edaphic factors because they influence the fertility of soil, ability of soil to support plant growth, water holding capacity and the biodiversity. During recent years due to stress conditions caused by adverse anthropogenic effects such as dissemination of chemical pollutants and over cultivation, the fertility of the soil is severely affected. Soil quality represents an integral value of the compositional structure and natural functions of agro-ecosystem. Soil physical and chemical measurements are indicators of soil quality and health. Soil nutrient measurement is a useful tool to evaluate land fertility which increases the production of various crops and adopting various crops depending upon their nutritional quality present in present soil. However, in recent years a rapid decline in traditional agriculture has been observed due to replacement with cash crops and hybrid seed varieties.

Extensive studies have been carried on changes in agro-ecosystems and ecological implications of such changes in Himalayan region and Southern India (Mitchell, 1979; Ramakrishnan 1992; Rao and Saxena, 1994, 1996; Maikhuri *et al*., 1996; Singh and Saxena 1997; Chandra *et al.,* 2009; 2010). Physico-chemical characteristics of soil were carried out by several workers Ahmed *et al.* (1996), Baruah and Das (1992, 1997), Achrajee *et al*. (1999), Anand and Sharma, (2000) and Bhuyan and Sharma, (2006). Mishra, (2001) carried out the physico-chemical studies of soil of intensive agriculture zone in Rohad village in Rohtak district of Haryana to analyze the structure functions of agro-ecosystem to strengthen the knowledge required for environmentally sound agricultural development. The main objective of the present study is focus on the assessment of socioeconomic and physico-chemical parameters of soil.

MATERIALS AND METHODS

Study area

The study was carried out in the Depal village of Hisar district, Haryana, India which is situated in eastern region of Hisar of central Haryana (Figure 1). Irrigation is done by canal along with tube-wells. Two crops are grown in a year; one in winter i.e. rabi crop and followed by summer crop i.e. kharif crop. The main rabi crops of this area are wheat (*Triticum aestivum*), barley (*Hasreum vulgare*), oat (*Avena sativa*), berseem (*Trifolium sp.*), and mustard (*Brassica compestris*). The karif crops are cotton (*Gossypium sp.*), paddy (*Oryza sativa*), millet (*Pennisetum typheires*). The main source of livelihood is agriculture and animal husbandry. Other occupations include allied activities, unskilled and semi skilled labor and government service. People of villages are educated, access to education and other public service. Even today, every aspect of economy and day to day lives of the majority of the population are governed by agriculture sector. The stability and sustainability of agriculture is therefore of great significance.

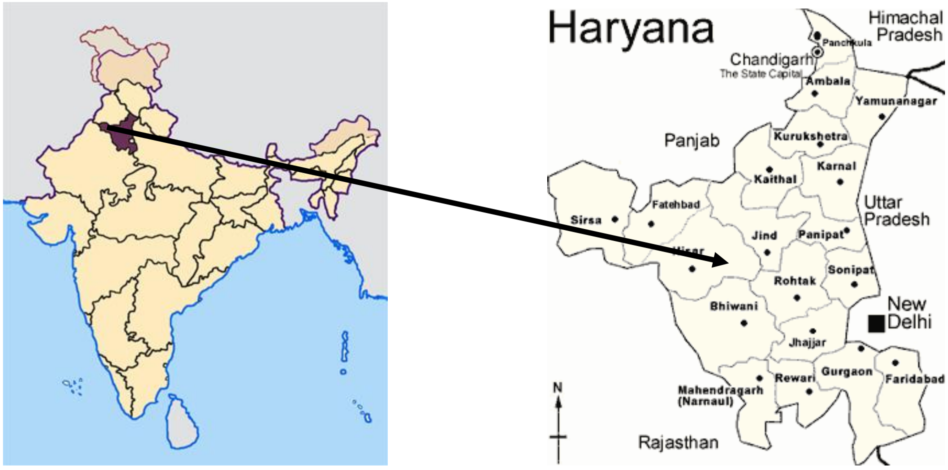

Figure 1 Study area for analysis of village ecosystem

Soil Sampling and Analysis

Soil sampling was carried out at depth of 0-15 cm and 15-30 cm in the months of January/February. Soil was sampled from five random locations in each of the three replicate plots for all cropland. Samples from each plot were mixed thoroughly to obtain one composite sample per plot. Soil pH and EC was measured according to Jackson (2005). Soil organic carbon content was determined using the method of Walkley and Black (1934). Organic carbon free soil samples were used to determine total N, P, K, Ca, and Mg. The digestions were carried out using Kjeldhal apparatus (Anderson and Ingram, 1989). Total N was estimated by micro- Kjeldhal method (Allen, 1974). Organic phosphorous was measured at 880 nm wavelength using a spectrophotometer (Systronics 160). Calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) were estimated with same the filtrate using atomic absorption spectrophotometer (AA 6300 Shimadzu, Japan).

Results and Discussions:

Socio-economic conditions:

Out of total population, more than 75% are engaged either in agriculture or in horticulture. Crop farming is mostly traditional and over all cropping pattern of this plain region of Haryana of an under developed agriculture economy. Here, nearly 90% of the total cropped area is devoted to subsistence food crops. Livestock support the livelihood of the village people and on an average a household maintains 4 animals, mainly buffalo, bullock are in dominance, constituting 80% and others 20% including, goats, sheep and Cows. Demographic profile of the study villages is given in the Table 1.

Table 1: Demographic profile of the studied villages

Particular	Number
No of house hold	271
Total population	1281
Male	468
Female	390
Children (<20)	423
Average Family size	6
Total animal population Buffalo Bullock Goat Sheep Cow	 828 218 135 98 15
Sex Ratio (female per1000 males)	915
Literacy	74%
Total Geographical Area	940 (acre)
Total Agriculture Area	788 (acre)

2. Physico-Chemical properties of soil

Physico-chemical properties like pH, EC (electrical conductivity) and Total organic carbon (TOC) of different soil samples were estimated and found that pH of all soils with standing different crops are almost neutral and did not differ significantly between 0-15 cm and 15-30 cm soil horizons within a given land use type (Table 3). The electrical conductivity of wheat (0-15 cm horizon) is highest among all other crop horizons. Moura *et al*. (2009) carried out a study to evaluate chemical and physical quality indicators for a structurally fragile tropical soil and observed that simultaneous surface application of low and high quality plant residues affect variables that maintain the productivity of fragile soils in the humid tropics and also observed that best indicators of soil quality under the experimental conditions are water stress days and penetration strength.

TOC does not differ significantly among all the horizons of different croplands and present in an average quantity. TOC content was highest in berseem cropland compared to mustard and wheat cropland while the quantity of TOC in lower horizons of mustard and wheat cropland is lowest compared to all other horizons of all other cropland. The TOC among different crops is more in upper horizons as compared to lower soil horizons. Carbon stock was found in medium range in all croplands. Soil organic matter (OM) is perhaps the most important determinant of soil quality and is most commonly estimated by determining the soil organic carbon (C) content. Soil organic carbon is a key property given its importance to soil fertility and erosion resistance. (Jankauskas *et al.,* 2006). Critical levels of soil carbon are difficult to establish because they vary with soil texture and climatic regime. Soil carbon may be less than 1% in some stable soils, whereas other soils would face structural collapse at such level (Christensen and Johnston 1997). Soil carbon respond only gradually to change in agroecosystem management such as crop rotation, fertilizer input manure application or tillage. Most of soil carbon changes require at least 20 years to be detectable by present analytical methods because of the small yearly inputs of carbon into a much larger matrix, a substantial portion of which is relatively inert.

Nitrogen is mainly found in the form of nitrate in soil. Nitrogen content was higher in upper horizon as compared to lower horizon. Soil nitrogen contents were highest in upper horizon of barley and mustard croplands. Soil area under wheat crops (15-30 cm) contains lowest quantity of nitrogen. Phosphorus contents are mainly found in the form of P_2O_5 in soil. Phosphate content was in medium range in all croplands except upper layer of mustard cropland which was found in high range and lowest in berseem cropland.

The main exchangeable cations present in soil are potassium, sodium, magnesium and calcium. Potassium was present higher in upper horizon of berseem and oat croplands, lower in lower horizon of barley. The trend in exchangeable cations Ca>Mg>K observed in all croplands.

Table 2 Pearson correlation between soil physicochemical

	pH	EC	C	N	P	K	Ca	Mg
pH	1	0.62*	0.11	-0.36	0.17	0.70**	-0.36	-0.12
EC		1	0.27	-0.85	0.24	0.80**	-0.57	0.36
C			1	0.05	-0.26	0.38	-0.36	0.34
N				1	-0.20	-0.47	0.56*	-0.24
P					1	-0.09	0.33	0.10
K						1	-0.45	0.28
Ca							1	0.11
Mg								1

Significant level *- P<0.05; ** - P<0.01.

Physical properties like pH, EC and TOC of different soil samples from different winter crops like wheat *Triticum aestivum*), mustard (*Brassica compestris*), barley (*Hordeum vulgare*), oat (*Avena sativa*), berseem (*Trifolium sp.*) were estimated and found that pH of all soils under different crops is almost alkaline and did not differ significantly between 0-15 cm and 15-30 cm soil horizons within a given land use type. Cropland under wheat has highest pH followed by croplands under mustard and berseem. EC differs significantly between upper and lower horizons of each land use type. EC in upper horizon of berseem cropland is highest followed by lower horizon of wheat cropland, lower horizon of mustard cropland, upper horizon of wheat cropland and lower horizon of berseem cropland. Thus, there is a large difference between EC of upper and lower horizons of berseem cropland (Table 3).

Nitrogen except for lower horizon (15-30 cm), wheat cropland soil nitrogen content is medium to high in all other soil horizons each cropland. Soil nitrogen content is highest in case of upper horizon of mustard cropland while soil nitrogen content is lowest in case of lower horizon of wheat cropland. Soil nitrogen content is lower in wheat and berseem croplands as compared to mustard cropland which is much higher than all other soils under different crops. It indicates that leguminous plants are able to fix atmospheric nitrogen in soil.

Available phosphorous (kg/ha) in soils is highest in mustard cropland than all other croplands. Phosphorous content is in medium range in berseem cropland i.e. between 11-15 kg/ha. Phosphorous content in upper horizon of wheat cropland is high while in lower horizon it is in medium range (Table 3).

Table 2 Physico-chemical properties in the soil of village-Depal

CROP SOIL HORIZONS	**pH**	**EC(mS)**	**TOC (%)**	**N (Kg/ha)**	**P (kg/ha)**	**K (asK2O in kg/ha)**	**Ca (%)**	**Mg (%)**
Wheat(0-15cm)	**7.8**	**13.67**	**0.57**	**280**	**20**	**175.03**	**0. 09**	**0. 07**
(15-30cm)	**7.7**	**13.43**	**0.55**	**224**	**18**	**158.99**	**0.07**	**0.07**
Mustard (0-15cm)	**7.6**	**11.46**	**0.56**	**520**	**22**	**121.10**	**0.13**	**0.07**
(15-30cm)	**7.5**	**11.23**	**0.51**	**492**	**18**	**112.58**	**0. 11**	**0. 06**
Barley(0-15cm)	**7.3**	**11.16**	**0.58**	**540**	**16**	**116.37**	**0.08**	**0. 06**
(15-30cm)	**7.3**	**11.09**	**0.56**	**448**	**11**	**111.64**	**0.11**	**0. 07**
Oat (0-15cm)	**7.6**	**14.28**	**0.57**	**280**	**20**	**306.54**	**0.10**	**0.07**
(15-30cm)	**7.7**	**13.62**	**0.54**	**236**	**16**	**294.24**	**0.08**	**0.07**
Berseem(0-15cm)	**7.8**	**13.43**	**0.59**	**448**	**16**	**317.89**	**0.09**	**0.08**
(15-30cm)	**7.6**	**13.15**	**0.57**	**392**	**14**	**311.27**	**0.07**	**0.06**

Potassium content of soil falls in the category of high range of potassium in berseem cropland while in mustard cropland its quantity falls in the category of low quantity of potassium. In case of wheat cropland quantity of potassium in soils falls in the category of medium range of potassium. In lower horizons (15-30 cm) the quantity of potassium in soils is lower as compared to quantities of potassium in soils of upper horizons (0-15 cm) of each cropland. The concentration of calcium was highest in mustard cropland, medium in wheat cropland and lowest in berseem cropland. The concentration of magnesium was higher in mustard cropland, medium in wheat cropland and lower in berseem cropland. The concentration of calcium was highest in mustard cropland, medium in wheat cropland and lowest in berseem cropland. Similarly, the concentration of magnesium was highest in mustard cropland, medium in wheat cropland and lowest in berseem cropland.

Deka *et al*. (2008) reported the significant variations in physico-chemical parameters like soil texture, pH, organic carbon, available phosphorus and potassium, while evaluating the physico-chemical characteristics of soil of Kapla beel, a freshwater wetland in Barpeta District, Assam. In contrast to biological or chemical fertility indicators, there are few examples of physical indicators related to plant production, although the effects of physical soil properties on plant diversity growth and health have been investigated.(Jayawardne and Chan, 1994; Wong and Asseng, 2007).

Conclusion

The present study is directed towards the evaluation or assessment of the physico-chemical properties of land used under the cultivation of different crops like winter crops (wheat, mustard, barley, oat and berseem) in the selected village ecosystem which indicates that pH of land used under different crops is slightly alkaline which favours a good crop yield. High range of electrical conductivity exhibits high concentration of exchangeable ions in the soil. Organic carbon contents in each type of crop land are medium and not much depleted due to cultivation of different crops. Nitrogen contents were present in medium range in several croplands except mustard cropland, in which high quantity of nitrogen is present. Phosphorus contents of almost all croplands were medium. Calcium and magnesium ions concentration was present in optimum ratio.

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