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Soil characterization and rehabilitation of catchment area around Ghora Katora Lake in Rajgir City, Bihar, India

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Abstract

Monitoring of Land Use Changes (LUCs) of the site named Ghora Katora lake in Rajgir city (Bihar, India at25° 01'01N and 85° 29 51'E) found three types of soils that are Red, light brown and Dark brown soils. All are sandy and highly alkaline with deficient in moisture. Red soil is very much deficient in macronutrient such as phosphorus (0.36%) and total organic carbon (TOC) (0.75%). Light brown and dark brown soils are also deficient in macronutrients contents. Micronutrients like manganese, copper and zinc are present in sufficient quantity in all three types of soils, although red soil has toxic level of manganese and copper. Presence of toxic element like chromium and arsenic are also found in soils. Quantitative assessment of LUCs have drawn picture of degraded quality of soil, so there is immense need for the rehabilitation of damaged soil and hence recommendations are proposed.

Keywords: Land use changes, nitrogen, phosphorus, total organic carbon, micronutrients, rehabilitation.

Introduction

Landscape qualities are described by specific structure, ecological function and disturbance leading to damage along with retrieval[1]. The present study is a quantitative assessment of Land Use Changes (LUCs) showing a picture of degrading soil quality by urbanisation in an agriculture based region[2]. The place Rajgir known as "Rajagriha" was the capital of Great Magadha Empire in 6th century BC. Rajgir city lie in central region of Bihar (Indian state at 85º 42'E longitude and 25º03'N latitude on the Earth) an agriculture based state. This place is also an important Buddhist, Hindu and Jain pilgrimage site.

Rajgir hills are situated near Rajgir city at average height of 300m consists of *five hillocks*: Vipula, Ratna, Udaya, Sharamangiri and Vaibhara with almost similar vegetation. There are temples on the hills which are frequently visited by the pilgrims which put pressure on environmental component and make soil polluted by throwing solid waste both biodegradable and non-biodegradable. Excessive cattle feeding, and use of forest product by local people creat ecological damage. Various types of anthropogenic pressure and climatic changes affected the biodiversity of the region which lead to diminishing soil resources[3]. Human disturbance and various types of land use influenced the composition and geography of landscape elements[4].

Soil degradation are harmful for the wholeness of natural resources and biodiversity. Hence monitoring Land use changes (LUCs) in terms of soil essential and nonessential components have advantage to be available at administrative scales which are easily interpretable by policy makers for the rehabilitation of damaged native soil in order to make the ecological system functional and stable for the better survival of local residents as well as for the promotion of tourism[5].

Methodology

Discription of sampling site: The sampling site Ghora katora lake/Dam is a popular picnic spot in Rajgir, located in Nalanda district of Bihar (Indian state at 85º42'E longitude and 25º03'N latitude on the Earth) (Figure-1). It is surrounded by hills from three sides. In ancient times, this place was a drinkery for large number of the king's army horses.

In 2009 it was developed and declared as destination for tourism with its natural setting, so it is most natural lake surrounded by natural vegetations which is raw, unpolished and least polluted till date. Road is not pitched and for transportation, only horse carts and bicycles are used. For the collection of soil samples in the month of December, 2014, 10 sampling points were randomly selected to cover approximately 10 km of vegetations from the lake. Samples were collected in sterile polyethylene bags and kept in ice. Samples processing done within 24 h of collection. On the basis of colour and texture, soils were divided into three types (Figure-2).

Soil characterisation: Three types of soil were found, first near the lake, second 5km distance from lake and third 10 km distance from lake. Soil texture was determined on the basis of International Society of Soil Science classification. Soil moisture was determined as moisture percentage[6]. pH measured by digital pH meter (Systronic). Soil samples were digested by persulfate digestion[7]. Phosphorus was spectrophotometrically

determined by stannous chloride method at 690nm and total nitrogen was spectrophotometrically determined at 410nm by phenol disulfonic acid method.

The soil organic carbon was estimated by Walkley-Black chromic acid wet oxidation method[8]. Determination of micronutrients (chromium, zinc, manganese, copper) were done by atomic absorption spectroscopy (USEPA 3050B) by outsourcing. Arsenic determination was done by digesting the soil sample by nitric acid method and estimating the arsenic by azure B method with some modifications[9-11].

Results and discussion

Physical characteristics of soil: It is important to note that three types of soil are present within the range of 10 km around the region selected for study i.e. Ghora Katora lake in Rajgir, (Figure-1.) which lie in central region of Indian states of Bihar (at 85º32'E longitude and 25º11'N latitude on the Earth). Different soils were collected on the basis of colour appearance that are Red, Light brown and Dark brown (Figure-2) Soil texture was determined on the basis of International Society of soil Science Classification[5].

Red soil is appeared as gravel sandy, light brown soil is sandy silt (5% clay) and dark brown soil is sandy silt. Different size particle have different properties which decides the texture of soil and is of great significance for plant growth. Sandy soil has larger size particles in greater quantity which creats the loose packing. Water percolates through sand quickly, leaving the soil dry hence resulting lack in moisture content.

Soil moisture is expressed as moisture percentage[6]. All the three types of soil were found deficient in moisture content with only 2.22% moisture in red soil, 4.02% in light brown and 5.38% in dark brown soil Table-1. Plant take their supply of water from soil and rain is the principal source of water for the soil. Soil structure determine the water retention capacity, like water held around the surface of clay and humus but sandy soil is loosely packed and hence water flows down.

All the three types of soils are alkaline having pH 9.4 for red soil, pH 8.4 for light brown soil and pH 8.6 for dark brown soil. Soil pH generally varies from 6 to 8 but here showing some different and unfavourable case. There is an indirect significant effect of pH on plant growth. Actually pH directly effect on the availability of nutrients. Major nutrient like nitrogen and phosphorus are most available at and around neutral pH (6 to 8)[12].

Macronutrients: Elements which are used in quite large amount and essential for growth of plants are called as macronutrients. The minimum concentration of macronutrients required for the plant growth vary species to species. Average requirement of macronutrients for plants are given that are Nitrogen 1.5%, Phosphorus 0.2%[13]. Nitrogen contains major part of all amino acid which are building block of protein hence very important for growth. Significant amount of nitrogen promotes root growth which ultimately leads to better uptake of other nutrients. Deficiency of nitrogen causes stunted growth, thin and weak stem[14]. Amount of nitrogen present in normal type of soil is generally 10-20 ppm.

Red soil is highly deficient in nitrogen as it contains only 0.12%, other two soils are also nitrogen deficient, as light brown soil contains 0.425% and dark brown soil contains only 0.5% of nitrogen.

Phosphorus helps in many fundamental processes of plants like photosynthesis, flowering, fruiting and root growth. Phosphorus uptake by plants is one tenth that of nitrogen. Phosphorus deficiencies is difficult to diagnose in mild case but in severe case yellowing and senescence of leaves occurs[14]. Phosphorus content of all the three types of soils are sufficient. Red soil contains 0.36%, Light brown soil contains 0.78% and Dark brown contains 0.76% of phosphorus which are above than the average 0.2 % to 0.4% phosphorus.

Organic matter only consist of 2-10% of the soil mass but has very important role in functional properties of agricultural soils. Organic matter of soil estimated in the form of carbon content which is termed as total organic carbon (TOC). Organic matter provides better water and nutrient holding capacity to soil. It increases soil aggregation and decreases runoff[15]. Red soil is very much deficient in organic matter as contains only 0.75% of total organic carbon. Light brown soil and dark brown soil are also deficient in organic matter Table-1.

Micronutrients: Micronutrients are the elements required in smaller quantity for the plant's growth. Amount of manganese, copper and zinc are estimated in all the three types of soil. The sufficient concentration in soil for these elements are given in ppm that are Mn= 50, Cu= 6 and Zinc= 20[13]. Deficiency and toxicity level for these elements vary species to species. On the basis of average requirement it is noted that red soil contains toxic level of copper and manganese, light brown soil contains sufficient copper, zinc and manganese and dark brown soil contains lower copper and higher zinc Table-1.

Traces elements chromium and arsenic are also determined in soils which are hazardous to human at more than permissible limit. It is found that red soil contains more than sufficient or toxic level of chromium with negligible arsenic. Light brown and dark brown soil contains sufficient amount of chromium along with 0.6 and 0.8ppm arsenic respectively. Above all monitoring of land use changes (LUCs) are showing altered and degraded quality of agriculture soil.

As the quantity of plant available nutrients diminish which will adversely effect crop productivity and is being a continuous process will also affect the livelihood[16] which is of immediate need to be restored, for the native vegetation and local population.

Table-1: Data of soil samples average n=3 ±mean standard deviations, are showing physiochemical properties of soils.

Physiochemical properties	Red	Light brown	Dark brown
Site	Near lake	5 km away from lake	10 km away from lake
Texture	Gravel sandy	Sandy silt (5% clay)	Sandy silt
% moisture	2.22±0.92	4.02±0.67	5.38±0.59
pH	9.4±0.23	8.4±0.18	8.6±0.13
% Nitrogen	0.12±0.013	0.425±0.021	0.5±0.011
% phosphorus	0.36±0.021	0.78±0.0151	0.76±0.0132
% total organic carbon	0.75±0.031	4.95±0.76	5.25±0.93
Manganese (mg/Kg)	388±6.2	271±4.3	258±8.3
Copper (mg/Kg)	22.3±1.2	18.8±1.94	10.8±0.98
Zinc (mg/Kg)	63.8±2.43	76.8±1.37	93.2±1.98
Chromium (mg/Kg)	42.2±3.47	32.6±5.23	26.8±4.31
Arsenic (mg/Kg)	Nil	0.6±0.021	0.8±0.013

Figure-1: Sampling site (taken on 4th December 2014), Ghora Katora lake in Rajgir (city in Indian states of Bihar at 85º32'E longitude and 25º11'N latitude on the Earth).

Figure-2: Three different soil samples collected from the sampling site.

Recommendations: i. In order to improve the vegetation of Rajgir hills or its eco-restoration there is an immediate need to increase the soil moisture. It can be done by proper irrigation, but all types of soils are very sandy and having less capability to retain good amount of moisture. So it is required to make the soil capable to retain moisture by adding more organic matters (Dead and decayed matter, manure like cow dung, compost etc). The process of mulching, plantation of more tress provides more shade which hinders the sunlight and hence minimize loss of soil moisture via evaporation. ii. The availability of nutrients in the soil is dependent on soil pH. In highly alkaline or acidic soil, many nutrients are not available for the plant uptake. pH 6 to 7.5 is more favourable for the availability of essential nutrients for uptake. If soil pH is more alkaline i.e. above 8.0, some measures can be taken to minimize pH that are as follows[17]. i. Adding more organic matter to the soil will lower the pH. pH of peat or *Sphagnum* peat moss are highly acidic, so amendment of these things in soil will neutralize the alkaline pH to lower level. ii. Addition of elemental sulfur (90 or 99% sulfur material) which slowly form sulphuric acid after oxidation in presence of soil moisture, significantly reduces the soil pH. Sulfur amendment can be done annually at a rate of 6 to 10 pounds per 1000 square feet of area[17]. iii. Regular amendment of acidifying fertilizers in soil such as ammonium sulfate and other products which cause acidic reaction in the soil will lower the soil pH.

In order to increase the nitrogen content of soil, plantation of legumes/ nitrogen fixing tress are very effective and is a good natural approach. Plants such as *Casuarina, Alnus, Leucina, Acacia, Bauhinia, Cassia, Sesbania* have an important advantage over other plants, of being able to obtain nitrogen from the air and make available to plants. This is because, they contain symbiotic bacteria in their roots, which fixes atmospheric nitrogen and convert it to available form of nitrogen for plants. All suggested plants are local species of

Bihar region[18]. Hence these plants are easy to get and grow with favorable conditions.

Above treatments will also help in increasing total organic carbon and phosphorus contents of soil and make it more favorable for vegetation.

To correct Mn, Cu and Zn deficiency foliar application of elements and adjustment of soil pH around neutral can be done. In order to minimize their toxic level pH can be adjusted to more than neutral resulting the unavailability of elements for plant uptake[19].

Conclusion

Ghora katora lake which was developed and declared as destination for tourism with its natural setting. It is most natural lake situated in Rajgir which lie in central region of Indian states of Bihar, surrounded by natural vegetations which is raw, unpolished and least polluted till date. But now days soil quality is degrading due to urbanisation which need to be rehabilitate. The lake surrounded by three types of soils that are Red soil, Light brown soil and Dark brown soil. All the above three soils are very deficient in moisture content with the minimum 2.2% soil moisture in Red soil, 4.04% in Light brown soil and maximum 5.3% soil moisture in Dark brown soil. Textures of all the soils are mostly sandy i.e Red soil: gravel sand, Light brown: Sandy silt (5% clay), Dark Brown soil: Sandy silt. These soils are unable to retain sufficient amount of moisture content due to their sandy nature. All the three soils are alkaline in which red is most alkaline with 9.4 pH, Light brown soil with pH 8.4 and Dark brown soil with pH 8.6. Soils are also deficient in nutrients content like Nitrogen, phosphorus and total organic carbon in which red soil is highly deficient in nitrogen (N=0.12%), Phosphorus (P=0.36%) and total organic carbon (TOC=0.75%) than other two soils. Light brown soil contains 0.42% N, 0.78% P and 4.95% TOC. N, P and TOC content of Dark brown soil is 0.5%, 0.76% and 5.25% respectively. Micronutrients like Mn, Cu, and Zn are present at sufficient levels in light and dark brown soils but red soil contains toxic level of Cu and Mn. Presence of toxic elements like chromium and arsenic are also found in soils. All results have drawn the picture of degraded quality of native soil, hence immediate need for rehabilitation by proposed recommendations.

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