*Plant Archives* Vol. 19 No. 2, 2019 pp. 3207-3210 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

# CHANGES IN SOIL QUALITY IN DRY TROPICS: IMPACT OF RECLAMATION OF USAR SOIL

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## Abstract

Among the several problems that limit the economical utilization of land resource in India, the problem of usar soil is of great concern. Usar soil is characterized by impermeability, enormous hardness and irregular presence of unwanted salts that makes the soil unproductive. Application of gypsum followed by thorough irrigation is most common approach used for the reclamation of the usar soil. Present study was undertaken with the objective to analyze the impact of reclamation of usar soil by addition of gypsum on major physical and chemical properties *viz.,* pH, electrical conductivity, water holding capacity, soil organic carbon content and total nitrogen content of the soil collected from usar land, amended usar land and nearby crop land. Level of soil organic carbon and total nitrogen and water holding capacity were found to be highest in crop land followed in decreasing order by amended usar soil and lowest in usar soil that is highest in usar soil and lowest in crop land in dry tropics. Reclamation of usar soil resulted in significant improvement in major physical and chemical properties of soil yet the soil quality was not comparable to that of crop land.

## Introduction

Land is a valuable natural resource that decides the prosperity of the country as all agricultural, animal and forestry products depend on the productivity of land. Land resource is limited due to fixed geographical area. India shares 16.9% of world population with only 2.4% of the world geographical area and it is predicted that by 2050, India will be the most populous country on the earth with about 17.2 % population living here (Chandramouli and General, 2011). Thus every part of land is very important for our country. Among the several problems that limit the economical utilization of land resource in India, the problem of usar soil is of great concern.

Usar soil are mainly found in different states of India like Uttar-Pradesh, West Bengal, Punjab, Bihar, Orissa, Maharashtra, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Gujarat, Delhi and Rajasthan. About 35 % of usar soil are sodic and found in part of Indo-Gangetic plains (Redhu, 2016). Usar soil is characterized by impermeability, enormous hardness and irregular presence of unwanted salts that makes the soil unproductive (Anand *et al.,* 2015).

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Reclamation of vast usar soil may help in achieving improved soil quality which in turn will facilitate in maintaining ecological and economical sustainability of the region. Measures which can reduce the pH, electrical conductivity (EC), exchangeable sodium and hydraulic conductivity of soil will help in improving the quality of usar soil (Subhashini and Kausik, 1981). Physical, biological and chemical approaches are used for reclamation of usar soil. Physical approach involves thorough and continuous irrigation (Pandey *et al.,* 2005), which are quite expensive and hence not commonly used. Chemical approach includes treatments of soil through certain chemicals e.g. gypsum, sulfur etc followed by thorough irrigation. Use of blue green algae is one of the most common biological strategy to reclaim usar soil (Singh, 1950). However this approach is not commonly practiced. The main objective of reclamation of usar soil by any approach is to improve the soil quality.

Soil quality is one of the major determinants of soil fertility and productivity. The most common reclamation strategy of usar soils is application of gypsum for removing exchangeable sodium or its replacement with calcium, so as to leach out exchanged sodium from the root zone (Jaiswal *et al.,* 2010). Limited information is available related to changes in soil quality after the gypsum treatment in dry tropics. Present work was undertaken with the objective to study the long term impact of gypsum treatment on the soil quality in terms of major physical and chemical properties *viz.,* pH, electrical conductivity, water holding capacity, soil organic carbon content and total soil nitrogen content of the soil collected from three different land use patterns *viz.,* usar land, amended usar land and nearby crop land.

## Materials and Methods

### Experimental site

The present study was conducted in the district Azamgarh involving three different land use patterns *i.e.*, usar land ($25^0$ 57' 59" N and $83^0$ 15' 10" E, 81 m above the mean sea level), amended usar land ($25^0$ 58' 08" N and $83^0$15' 14" E 81 m above the mean sea level) and crop land land ($26^0$ 01'47" N and $83^0$ 09'20" E, 81 m above the mean sea level). Usar land and amended usar land were situated within 0.5 km while crop land was 15 km away. Usar land has been barren for more than five decades. A part of this usar was amended by adding gypsum and thorough irrigation approximately 25 years ago and since then it has been regularly cultivated with rice, wheat and leguminous crops. Crop land, the fertile land has been cultivated for many decades with vegetables and forage crops. Soil amendments in the form of farm yard manure and recommended dose of chemical fertilizer were regularly added to this irrigated cropland. The sites are situated in dry tropical region of India marked by distinct seasonal variation including wet and warm rainy season (July to September), cool and dry winter (November to February) and hot and dry summer (April to June) with October and March as transition months between the seasons. About 80% rainfalls is received during rainy season leading to high humidity (70-80%) and high temperature (24-30°C). Average annual rain fall of the area is about 1100 mm. Cool and dry winter season's temperature ranges between $4^0$C to $25^0$C while dry hot summer season's temperature ranges between $30^0$C to $48^0$C.

### Soil Sampling and Analysis

Soil sampling was done during the month of October 2018 from 0-10 cm soil depth. Each experimental site was divided into three sub sites. Five random samples were taken from each sub sites and mixed homogeneously to prepare one composite sample. Collected soil samples were air dried and sieved through a 2 mm mesh screen for the analysis of parameters like soil organic carbon, total soil nitrogen, water holding capacity, pH and electrical conductivity. Soil organic carbon was determined by dichromate titration and oxidation method (Kalembasa and Jenkinson, 1973). Estimation of total nitrogen was done by Kjeldhal method by using a Gerhardt digester and distillation unit (Jackson, 1973). The Analysis of pH and electrical conductivity of soil samples were done by pH meter and electrical conductivity meter. Water holding capacity was determined by Keen-Rackowski box experimental method using perforated circular brass boxes (Piper, 1966).

### Statistical Analysis

SPSS (version 16.0) package was used for the analysis of data. All values were expressed as mean ± standard error (SE). Mean value were compared using least significant difference (LSD) at $P<0.05$.

## Results and Discussion

In the present study among the three land use patterns, usar soil showed highest pH (10.61) and electrical conductivity (0.711 ms/cm) and lowest water holding capacity (36.53%), soil organic carbon (0.30%) and total soil nitrogen (0.0331%). Higher pH and electrical conductivity was probably due to presence of high quantity of undesirable salts and exchangeable sodium in the soil (Jaiswal *et al.,* 2010). Due to this higher pH and electrical conductivity, only few plants can survive there and as a result organic input in the soil through plants was very low. Organic input to the soil is reported to be strongly linked with water holding capacity (Singh and Ghoshal, 2011). Li *et al*., (2007) explained that addition of lower organic matter especially the polysaccharides, which are generally hydrophilic in addition, reduces the adsorbent surface, which in turn, resulted in lowering of water holding capacity. In usar soil the soluble salts of sodium get easily dissolve and move in soil water which in turn decreases moisture availability to the plants by reducing water potential. When such soil become wet the clay particles swell excessively and get dispersed which resulted in weakening of soil aggregates and consequently cause dispersion of soil structure, close of the pores and formation of surface crust (Anand *et al.,* 2015). Thereby severely restricting the water and air movement through soil and also may cause lowering of water holding capacity. Soil with poor physico-chemical properties could not support higher vegetation in turns resulted in lower accumulation of soil organic carbon and total soil nitrogen.

Reclamation of usar soil resulted in significant reduction in pH (8.83) and electrical conductivity (0.063 ms/cm) while considerable increase in water holding capacity (49.22%), soil organic carbon (0.43%) and total

**Table 1:** Variation in soil organic carbon (%), total soil nitrogen (%), water holding capacity (%), pH and electrical conductivity (ms/cm) in the soil of three land use patterns viz. crop land, amended usar and usar. The values are mean ± standard error at 10 cm soil depth. Value of each column having different superscripts are significantly different from each other (P<0.05).

| SiteParameter | Usar soil | Amended usar soil | Crop land soil | LSD |
|---|---|---|---|---|
| Soil Organic Carbon (%) | $0.30^{c} \pm 0.017$ | $0.43^{b} \pm 0.024$ | $0.62^{a} \pm 0.030$ | 0.0837 |
| Total soil Nitrogen (%) | $0.0331^{c} \pm 0.001$ | $0.0748^{b} \pm 0.003$ | $0.0938^{a} \pm 0.003$ | 0.0087 |
| Water Holding Capacity (%) | $36.53^{c} \pm 1.000$ | $49.22^{b} \pm .210$ | $52.20^{a} \pm 0.450$ | 2.2318 |
| pH | $10.613^{a} \pm 0.009$ | $8.836^{b} \pm 0.038$ | $7.563^{c} \pm 0.088$ | 0.1935 |
| Electrical Conductivity (ms/cm) | $0.711^{a} \pm 0.008$ | $0.063^{b} \pm 0.001$ | $0.017^{c} \pm 0.001$ | 0.0170 |

soil nitrogen (0.0748%) relative to usar soil. Amendments of usar soil with gypsum and complimented with thorough irrigation are reported to result in the replacement or removal of sodium and dissolution of calcium compounds, which in turn reduce the soil crusting, prevent the dispersion of clay, and also prevent breaking of soil aggregates thereby improve water infiltration rate, more availability and retention of water in soil (Amezketa *et al.,* 1995). Organic acid produced by the microorganism present in the root exudates play an important role in the reduction of pH (Hamilton *et al.,* 2008; Babu and Reddy, 2011; Koranda *et al.,* 2011). Since various crops have been cultivated in the amended usar soil for more than two decades, which might have helped in reducing the pH of the soil as various studies reported that increase in the number of cropping years resulted in decrease in soil pH (Meng *et al.,* 2000; Zhao *et al.,* 2000). Improvements in soil properties such as pH, electrical conductivity and water holding capacity, supported conducive conditions for better growth of plants which will increase organic inputs to soil through plants (Guo and Gifford, 2002; Doetterl *et al.,* 2015). Plants litter and especially roots play a significant role in enhancing the soil organic carbon and total nitrogen by live root activity and root decomposition (Reeves, 1997). After the harvesting of crops, remaining crop stubbles and roots enhance the soil organic carbon and total soil nitrogen after the decomposition (Wang *et al.,* 2016). The role played by below ground biomass in accumulation of soil organic matter in soil was observed to be more in comparison to the above ground biomass (Puget and Drinkwater, 2001). Continuous addition of soil amendments in the form of organic input and chemical fertilizers might have helped in increasing the carbon and nitrogen contents in the soil of amended usar soil (Cai and Qin, 2006; Zhang *et al.,* 2006, 2009).

Although various physico-chemical properties of usar land has considerably improved after reclamation of usar soil yet water holding capacity, soil organic carbon and total nitrogen were significantly lower( 5.71%, 30.64%,20.25 % respectively) and pH and electrical conductivity were higher ( 14.40%, 73.01 %, respectively) relative to cropland. This study showed that application of gypsum and proper irrigation is an effective measure for reclamation of usar land, however, the process is very slow. To achieve the soil quality comparable to crop land seems to be difficult as it will take very long time and huge expenses. To achieve full potential of amended usar soil, some other management strategies should be explored so as to maintain long term sustainability of these vast usar soils.

**Acknowledgements**

We are thankful to the Head and Coordinator, Centre of Advanced Study in Botany, Department of Botany, Institute of Science, Banaras Hindu University for providing the basic laboratory facilities and the University Grants Commission, New Delhi, India for providing financial support as University Research Fellowship (URF) to Ms P Soni.

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