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Correlation studies between chemical properties of degraded soil and plant available nutrients in Ballia district of Uttar Pradesh, India

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Abstract

Various factors, including salinity, alkalinity, erosion, and others, contribute to land degradation, which is a serious problem for agricultural output. For identifying, analysing, mapping, and keeping track of land degradation, remote sensing and geographic information systems (GIS) are important tools. A study was undertaken in the Ballia district of Uttar Pradesh to map the spatial variation in physico-chemical properties of soil and correlate land degradation with climatological and anthropological factors. The study was conducted on soil assessment under special monitor and mapping of degraded soil of Ballia district, UP reference to GIS and Remote sensing conducted during the year 2018-2020 at Department of Soil Science and Agricultural chemistry, with an objective to assess and monitor land degradation dynamics using geo-spatial technology in Ballia District of Uttar Pradesh. Using the Global Positioning System, 77 soil samples were taken from Ballia district of Uttar Pradesh. Correlation studies to study the relationship between two dependent variables. The statistical software IBM SPSS (version-20), was used to analyse the association between the chemical characteristics of the soil and the amount of plant nutrients that are present in the soil. With "r" values of -.604 and - .522 respectively, the correlation coefficient (r) of pH demonstrated a substantial negative association with the amount of accessible P and Na. The EC demonstrated a substantial negative association with available P and Na, with r values of -.497** and -.232* and respectively and positive relation with available K with "r" values of .618**. Organic carbon having a negative relation with available S ("r" value -.316**).

Keywords: Land degradation, geo-spatial technology, geographic information systems (GIS), remote sensing, correlation

Introduction

Land is crucial since it includes both geographical lands and all naturally occurring resources. The ability of the soil to naturally provide nutrients for plants and their growth is known as soil fertility. Deterioration is brought on by a number of soil issues, including salinity, alkalinity, and erosion. Numerous anthropogenic and natural activities can reduce soil quality, altering the physical, chemical, and biological characteristics of the soil. Decreases in soil's organic matter content, which also impacts their structural integrity, can cause soil to degrade. The soil's potential for usage in the future may be diminished by cropping due to a variety of detrimental changes in different soil qualities that make the soil unsuitable for continued cultivation. Decision-making processes and soil management strategies should be chosen by assessing the regional variability of soil characteristics and chemical properties (Carbardella *et al.*, 2017) [1]. The primary geographic characteristics of soil that affect its composition and quality are pH (H+ activity), EC (electrical conductivity), soil organic carbon, and organic matter. However, land degradation mapping takes into account a variety of anthropological elements, including those related to land use management (Khaledian *et al.*, 2017; Cerda *et al.*, 2016) [9, 2]. Along with pH, EC, and organic carbon, many other soil physiochemical characteristics are assessed to determine the extent of land degradation. These include spatial variability in alkalinity ($CO3_{2}$-, HCO_{3}-), soil-Na+/K+, soil-Ca2+/Mg2+, soil-S, available soil-N, soil-P, and soil-K, cation exchange capacity (CEC), structural characteristics, and soil textural class. The study are demonstrated a correlation between the chemical characteristics of degraded alkaline soils and the available plant nutrients. Studying the relationships between soil pH, EC, organic carbon and the amount of accessible nitrogen, phosphorus, potassium, sodium and sulpher allowed researchers to calculate correlation coefficients and report the "r" value. For understanding the reasons of deficiency of available nutrients in soils, correlation of chemical properties with available macro and micronutrients was needed.

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Materials and Methods

Study Area

Between the Great Himalayas in the north and the peninsular plateau in the south, the easternmost region of Uttar Pradesh (UP), known as the Ballia district, is located in the central Ganges basin. The district's boundaries are 25°23 to 26°11 North latitude and 83°38 to 84°39 East longitudes, covering a total area of 2981 square kilometres (298100 hectares).

Soil Chemical Parameters Analysis

Soil pH

With the aid of a hand pH metre, the pH of a soil-water suspension (10 g of soil and 25 mL of distilled water) was determined (Chopra and Kanwar, 1982).

Electrical conductivity

The electrical conductivity of the soil was estimated using the soil water suspension that had been created for pH measurement. Until the supernatant became clear, the soil suspension was allowed to settle. Using a hand EC metre, electrical conductivity was measured and expressed as dS m-1.

Organic carbon

Using the Walkley and Black method, the soil's organic carbon content was measured (Walkley and Black, 1934). A 500 ml conical flask was filled with one gramme of soil. The addition and mixing of ten ml of 1 N $K_2Cr_2O_7$ solution. The flask was then filled with 20 ml of concentrated H_2SO_4, swirled 2-3 times, and left to stand for 30 minutes in the dark. 200 cc of distilled water were used to dilute the suspension. Ten millilitres of 85% H_3PO_4 and one millilitre of a ferrous ammonium sulphate solution were added, and the mixture was titrated against it until the colour changed from violet to bright green. There was also a blank titration performed.

$$\text{Organic carbon in soil (\%)} = \frac{\text{(B-T)x.003}}{\text{2xWT. of Soil}} \text{x } 100$$

Where,
B = Volume of 0.5 N FAS solution used for blank titration
T = Volume of 0.5 N FAS solution used for sample titration

Available Nitrogen

Weighed and placed in the distillation flask were 20 g of the soil sample. Fix the distillation assembly after moistening the sample with distilled water (approximately 20 ml). To minimise frothing and bumping during boiling, 100 ml of a 0.32% $KMnO_4$ solution and 100 ml of a 2.5% NaOH solution were added, along with 1 ml of liquid paraffin and a few glass beads, respectively. In a distillation assembly, the ingredients are distilled steadily, and the liberated ammonia is collected in a conical flask or (250 ml) include 20 ml of boric acid solution with mixed indicator (4 drops)—dip the delivery tube's tip into the solution to see how the pinkish colour changes to green as ammonia is absorbed.. In around 30 minutes, 100–150 ml of distillate must be collected, after which the tubes must be detached. A standard sulphuric acid is used to back-titrate the boric acid. The blue colour simply vanishes at the finish line after one extra drop makes the solution pink. Run the blank repair as directed by the aforementioned process without adding dirt.

$$\text{Available N (\%)} = \frac{\text{Z x 0.00014 x 100}}{\text{W - (20 g)}}$$

Weight of soil sample = W (20 g)
0.01 N H_2SO_4 used during the back titration = (Z) = Y – X ml

Available Phosphorus

The Olsen's approach was used to determine the soil's available phosphorus concentration (Olsen, 1954). First, ammonium molybdate, antimony potassium tartrate, and H_2SO_4 were used to make reagent A. Reagent A was then used to prepare reagent B. A 150 ml conical flask containing two grammes of soil was filled with 40 ml of Olsen's reagent (0.5 M $NaHCO_3$) and 40 ml of Darco G-60. The suspension was then filtered through Whatman No. 1 filter paper after being shaken for 30 minutes on a mechanical shaker. Five millilitres of filtrate were put into a 25 millilitre volumetric flask, acidified with 2.5 M H_2SO_4 to a pH of 5, and then 4 millilitres of reagent B were added. The intensity of the blue colour was measured on a spectrophotometer at 882 nm after waiting for 10 minutes. Additionally, a blank was ran concurrently. Following the initial standard reading, a sample reading was taken in 1954. First, ammonium nitrate was used to prepare reagent A.

Available Phosphorus (kg ha^{-1}) = Concentration of Phosphorus (mg kg-1) x 2.24

Available Potassium

Using a flame photometer and the process of extracting 1 N ammonium acetate, the soil's available potassium level was assessed (Hanway and Heidal, 1952). 25 ml of a 1 N ammonium acetate solution and 5 grammes of dirt were put into a 100 ml conical flask and shaken vigorously for 5 minutes. Following a Whatman No. 1 filter paper filter, the suspension was then tested for potassium concentration using a flame photometer. Following the sample reading, the first standard reading was taken.

Calculation

Dilution factor = 25 / 5 = 5 times
Reading of the flame photometer for the test sample = R
Available K (kg ha-1) = R x 5 x 2.24

Available Sodium

A 500 ml conical flask containing 10 g of air-dried soil was also filled with 200 ml of 1N neutral ammonium acetate solution. After that, let it stand for 18 hours while stirring now and then. After that, samples were removed and the suspension was centrifuged. After that, pour 5 ml of the liquid supernatant into a 50 ml volumetric flask and dilute it with 1N neutral ammonium acetate until the desired volume is reached. 2, 3, and 4 ppm were prepared after the 5 ppm standard. The flame photometer was initially run with a blank solution and set to zero, then with a 5 ppm solution and set to 100. After that, a calibration graph was constructed using the sample reading. Utilizing the calibration curve, determine the sodium content.

Available Sulphur

Turbidity technique was used to determine the amount of available sulphur in the soil (Chesin and Yein, 1950) [3]. 25 ml of 0.15% $CaCl_2$ solution and 5 g of dirt were added to a 100 ml conical flask. The suspension was then filtered through

Whatman No. 42 filter paper after being shaken for 30 minutes on a shaker. A 25 ml volumetric flask was then filled with 10 ml of the aliquot, 1 g of the sieved BaC12 crystals, and agitated for a minute. After adding one ml of 0.25% gum acacia solution, the volume was adjusted to the proper level. Following a minute of shaking, the turbidity was determined using a spectrophotometer and a blue filter with a 420 nm wavelength. A blank was also carried at the same time using the same method. Following the sample reading, the first standard reading was taken.

Results and Discussion

The available N, Na and P have a negative, non-significant association with the pH of the research area's soils, while the available K, and S have a positive, non- significant correlation. It showed negatively non significant correlation with available N and significant correlation with Na and P with the 'r' values of -.024, -.522** and -.604** (Table: 1) and this could be as a result of the high rate of denitrification at lower nitrogen availability levels and higher pH (Tisdale *et al.* 1997) [15]. According to Rousk *et al.* (2010) [3], pH was favourably correlated with the relative variety and abundance of bacteria. The mineralization process is impacted by this action, resulting in increased Nmin content in soils with higher pH. Similar correlations were also discovered in Sapek and Kaliska's (2004) [8] and Sapek's (2007) [14] research. Higher pH affect calcium availability whereas calcium precipitates with P as Ca- phosphate and reduce P availability (Tisdale *et al.* 1997) [15]. Alkalinity and salinity may both be present at the same time. This happens when Na and NaCO3 build up and hydrolyze, releasing OH ions that raise the pH over 8.5 and cause minerals like phosphorus, calcium, magnesium, and sulpher to precipitate and become less accessible to plants (Choudhari and Kharche, 2018; Wahba *et al.*, 2019) [5, 16].

The available P, Na and S had a negative, but not statistically significant, association with the research area's EC. however, a strong association with available N and K that is not significant. EC demonstrated a substantial negative connection with the amounts of accessible P, Na and S, with r values of -.497**, -.232* and -.135 respectively and positive correlation with available N and K with r values of .053 and .618** (Table: 1). A significant correlation was observed among EC and different levels of nitrogen as well as different levels of moisture (Mirzakhani, 2017) [10]. The soil's electrical conductivity (ECe) revealed a substantial positive association with the soil's sodium, magnesium, chloride, sulphate, potassium, calcium, and water's electrical conductivity (EC), as well as a significant negative correlation with the soil's pH (Mirzakhaninafchi, 2017) [11].

The available Na showed a non-significant and S showed a significant negative association with organic carbon with the 'r' values of -.093 and -.316** respectively but the available N showed a significant and P and K showed a non- significant positive correlation with the 'r' values of .773**, .006 and .012 respectively (Table: 1). Significantly positive association between soil phosphorus and soil organic matter was found. Significantly favourable connections between soil sodium and soil magnesium, chloride, sulphate, potassium, calcium, electrical conductivity (EC), nitrate, sodium, and potassium were also observed (Mirzakhaninafchi, 2017) [11]. According to Indulkar *et al.* (2007) [7], the available N exhibited a substantial positive connection with organic carbon. The availability of P, S, Mo, Fe, Mn, Zn, and Cu were positively and non-significantly correlated with organic carbon.

Table 1: Pearson correlation matrix for soil physico-chemical properties and plant available nutrient of Ballia district of Uttar Pradesh (Degraded soil)

	pH	EC	OC
N	-.024	.053	.773**
P	-.604**	-.497**	.006
K	.203	.618**	.012
Na	-.522**	-.232*	-.093
S	.164	-.135	-.316**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Conclusion

In degraded soil, the presence of an excess amount of soluble salt has the greatest impact on the link between the chemical characteristics of the soil and the available plant nutrients. With rising pH, available N, P and Na decreased and available K and S increased. With rising EC, available P, Na and S dropped while available N and K increased. Available N, P and K increased with incensement of organic carbon and available Na and S decreased.

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