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COMPARISON OF QUALITATIVE AND QUANTITATIVE APPROACHES TO SOIL QUALITY ASSESSMENT FOR AGRICULTURAL PURPOSES IN JAIPUR DISTRICT, RAJASTHAN

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ABSTRACT: The nutritional quality of soil plays a key role in the growth of plants as soil minerals act as a source and sink for providing the essential nutrients to plants. The fertility of the soil and nutritional management are the two important factors that directly influence plants' productivity and quality. Soil management is an important tool for agriculture to provide nutritious food. Soil management is essential for maintaining the quality of soil and soil life support system. Soil quality includes soil structure, fertility, conservation, and organic matter. The soil management practices are generally implemented to enhance the productivity of soil. Soil testing is the first step of managing the fertility of soil. The soil testing provides valuable information about the nutritional levels (micronutrients, macronutrients, organic carbon content (OC), electrical conductance (EC), pH *etc*.) of soil. This article shows the influence of the environment on the fertility and nutritional quality of soil that has been collected from different areas of Rajasthan. The soil test report is helpful in the recommendation of fertilizers on the bases of the crop grown. The variability in soil data showed the impact of the environment on the soil in that area.

INTRODUCTION: The sixteen essential nutrients are required to grow and reproduce plants [1-2]. Except for carbon, hydrogen, oxygen and nitrogen, rest of the nutrients are derived from the soil [3]. These soil nutrients may be classified into two types, micronutrients and macronutrients [4-5]. The macronutrients like potassium and phosphorus *etc* are essential for the basic biological functions of plants, whereas micronutrients such as copper, zinc, manganese, iron, sulphur, *etc*., are responsible for the proper growth of plants [6].

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More inorganic fertilizers lead to the deficiency of micronutrients in soil [7-8]. The productivity of soil and nutritional quality are interrelated to each other [9]. The deficiency of any nutrient in the soil leads reduction in the yield and growth of the plants grown in that soil [10-11]. Thus, nutritional deficiency in the soil directly affects soil fertility [12]. The soil fertility is the combination of three components, *i.e.*, chemical, structural, and biological fertility [13-14].

These three components strongly interact and work together to maintain the nutritional value of soil and frame soil ecosystem [15]. Several environmental factors influence the soil properties, nutritional quality, and fertility of soil [16-17]. Thus, by minimizing these environmental impacts, we can enhance the soil fertility and quality to improve soil health and increase productivity [18]. The soil-related

problems affect the productivity and fertility of soil. Nowadays, soil health analysis has become a thrust area of research for agricultural growth and maintaining a sustainable environment. Soil health or soil quality is essential to sustain the productivity of plants and animals [19-20]. Soil enzymes play an important role in maintaining soil ecology and soil health. The soil health indicators evaluate the overall health of soil [21]. Soil quality indicators are valuable tools required for assessing and monitoring the ecosystem. The indicators may be categorized into physical, chemical, and biological [22]. In the present communication, we use biological indicators (organic carbon content) and chemical indicators (micronutrients, macronutrients, EC, pH) to detect the value of soil quality [23]. pH is an important chemical indicator of soil health as inadequate pH negatively impacts plant growth and varies microbial communities in soil [24].

The amount of salts present in soil can be measured by electrical conductivity (EC), which indicates the suitability of the crop, availability of nutrients, and activity of microorganisms in soil [25]. The organic carbon content indicates the quality, health and productivity of soil as it plays a key role in improving the soil's chemical, physical and biological properties [26]. The carbon component present in soil forms organic carbon derived from soil organic matter [27]. The detection of soil organic matter indicates the index of nitrogen available in soil. The organisms present in soil and biotic parameters are also serving as indicators of soil [28].

In the present communication, we measure different soil properties like pH, EC, organic carbon content and analyze micronutrients and macronutrients of the soil samples collected from different areas of Rajasthan. This study aims to provide a comparative assessment of soil parameters or indicators of soil collected from different areas of Rajasthan to show the effects of the environment on soil health which implies fertility and nutritional quality of the soil. Apart from these indicators, microorganisms are also considered indicators of soil health, as microorganisms actively affect the nutritional cycle and physical and chemical properties of soil [29-30]. It is very easy to evaluate soil health with the help of microorganisms as microbial population and activity respond very quickly to the change in soil environment [31]. Soil enzymes show the earliest indication of the change in the soil as these enzymes are closely associated with organic matters, physical properties, and soil microbial activities [32]. The activity of enzymes can be used to measure microbial activities, inhibitory effects of pollutants, and soil productivity [33]. Analyzing soil health with the help of indicators by soil testing is a viable practice essential for soil management. The soil testing is quite helpful in recommendations of fertilizers to increase soil fertility and crop selection according to the nature of soil [34].

Study Area: Jaipur district falls in agro-climatic zone 3-A semi-arid eastern plain zone. The major area is sandy loam in texture except for Tehsil Dudu & Phagi and part of Chaksu & Kotputli, Viratnagar, which have heavy soils. These soils are deficit in nitrogen but more or less normal in phosphorus & potash. The major kharif crops are Groundnut, Bajra, Kharif Pulses, Rabi, Wheat, Mustard, Barley & Gram. The major vegetables viz. Tomato, Pea, Chilli, Brinjal, Cabbage, Cauliflower, etc., are cultivated. Ber, Aonla, Bael, Guava, Lemon, etc., are important fruit crops of the district. There is good potential for horticulture development. Jaipur district of Rajasthan has been selected for the study, which covers a total geographical area of 11.1 ×1000 km2 and spreading between N 26° 25’ - 27° 51’ and E 74° 55’ -76° 15’.

The Jaipur district gets average annual precipitation in the form of rainfall of 527 mm (1901-71) while average yearly precipitation for (1977-2006) is 565 mm. Annual average precipitation for the period (2001 to 2010) has been recorded as 527 mm **Table 1**. The majority of precipitation, over 85%, is received from July to August. Overall yearly potential evapotranspiration (PET) for the Jaipur district is 1744.7 mm [26]. The coefficient of variation in precipitation is reasonable at32.6%, indicating a slightly unpredictable arrangement of precipitation. Although Jaipur is the capital of Rajasthan and often called as the pink city has experienced vast floods in 1981, even though the Jaipur district is susceptible to famine as perceived in the year (1984-1989) and (1999-2002). The soils are suitable for cultivation but for low rainfall and high evaporation. Kharif crops are rainfed, and

Rabi crops are grown through well irrigation. In the Kharif crops Bajra, Jowar, pulses are grown, and wheat, mustard & vegetables are grown in Rabi crops. The Jaipur district is drained by small seasonal streams such as Sota, Dhund, Bandi, Mashi, and Sabi and with their small branches.

The district is further categorized by extensive backgrounds, including hills, rising and falling plains, dune turfs, *etc*. The main mounts of the districts include Jaigarh, Nahargarh, Manoharpura, and Bichum, whose elevation varies between (599m – 747 m amsl). The soils found in the district are sand and sandy clay loam, and in minor portion of River sand.

Soil Type	Characteristics
Clay Loam Soil	Medium Organic Matter, Medium NPK
Loamy Soil	Medium Organic Matter, Medium NPK
Sandy Loam	Low Organic Matter, Low in NPK, Zn, S
Problematic Soil	Saline & Alkaline, Low organic matter, zinc deficient

Methodology Followed:

- Collection and sampling of soil which is taken from different areas of Rajasthan near Jaipur city.
- Evaluation of the nutritional value of soil by soil testing of different soil samples.
- Comparison of soil parameters of different soil samples.
- Analysis of the influence of environment on soil taken from different areas of Rajasthan.
- Investigation of soil samples on the basis of critical limit of nutrients in soil.

EXPERIMENTAL: The whole experimental work is carried out very carefully in a well-equipped soil lab. Wensar Electronic Balance PGB 200/301 is used for the weighing purpose in soil testing. The Systronic Digital Ph-meter 335 is used for pH measurement of samples, whereas Labtronics conductivity meter LT-16 is used for the determination of electrical conductance [35]. Systronics Double Beam Spectrophotometer 2203 (wavelength ranges from 200 to 1100 nm) is used for the analysis of available phosphorus and sulphur in soil samples [36]. Available potassium is detected by Systronics Flame Photometer 128. Thermo Fisher Scientific India Pvt. Ltd. Atomic Absorption Spectrometer (AAS) ICE 3300 is used to evaluate zinc, iron, copper, and manganese concentrations in the samples [37].

MATERIALS AND METHODS:

Collection of Soil Sample: Nine soil samples were collected from nine villages of Rajasthan from 25 cm depth. The soil sample was collected in labelled sterile polyethylene bags and taken in ice-packed cooler to the laboratory for Physico-chemical analysis [38-39].

Preparation of Soil Sample for Analysis: Each sample meant for physic-chemical analysis was air dried for five days and then sieved to ensure homogeneity using a 2mm size sieve [40].

Metal Analysis: Analytical grade reagents were used for the preparation of reagents. Glassware's used was washed thoroughly with detergent and then with deionized water. Heavy metals were extracted by using one gram of each air-dried soil sample digested in 10 ml 1:1 concentrated HNO_3 [41].

The mixture was evaporated to near dryness and then cooled. The procedure was repeated with a 15 ml solution of 1:1 concentrated Hall. The extract was filtered with man filter paper and then made up to 100 ml with 2% HNO_3. The solution of the samples was analyzed by using atomic absorption spectrophotometer using water as a blank [42].

- **pH Measurement:** The saturated paste method is used to evaluate the nature of the soil, which may be acidic or alkaline.
- **Electrical Conductivity (EC):** It provides the concentration of soluble salts present in the soil at a particular temperature. The clear extract after pH measurement is used for detecting electrical conductivity. The conductivity of samples was determined with the help of a conductivity meter.
- **Organic Carbon (OC):** The titration method (Walkley and Black method) is used for the determination of the organic carbon content present in soil samples.

- **Macronutrients:** The presence of macronutrients is required in relatively more in amount for plants.
- **Available Phosphorus:** Phosphorus exists in the form of orthophosphates in the soil. The major fraction of Ca-P is found in neutral and alkaline soil. Available Phosphorus content in soil mainly comprises of Ca, Al and Fe-P. In the soil samples, the value of available Phosphorus is investigated by the reported Olsen method by spectrophotometer.
- **Available Potassium:** The ammonium acetate method reported by Hanway and Heidel is used for the determination of available potassium by flame photometer.
- Sulphur content in the form of sulphate easily estimated by spectrophotometer from the extract of soil samples.
- **Micronutrients:** The extremely small quantity of micronutrients required by plants and deficiency of these nutrients is very rare.
- Atomic Absorption Spectrometer evaluates zinc, iron, copper and manganese concentrations in the soil samples by using DTPA (diethlene-triaminepenta acetic acid) method of Lindsay and Norvell [43].

Available sulphur is generally found in the form of sulphate ions in soil as shown in **Table 1.**

TABLE 1: VARIOUS PARAMETERS FOLLOWED FOR SOIL TESTING

S. no.	Particulars	Method Used
1	pH	pH-merry
2	Conductance	Conductometry
3	Nitrogen	Alkaline permanganate method
4	Phosphorous	Olsen`s Method
5	Potassium	Flame photometric method
6	Magnesium	Titration
7	Calcium	Titration
8	Zn, Fe, Cu. Mn	Atomic absorption Spectrophotometric method
9	Organic carbon	Titration
10	Alkalinity	Titration

RESULTS AND DISCUSSION: The soil samples collected from different villages near Jaipur belong to Rajasthan districts as shown in **Fig. 1**. After soil collection and sampling, the evaluation of different soil indicators was performed by soil testing in a well-equipped laboratory. The variation in pH of various soil samples was collected from different villages of Rajasthan. It is found that all villages of different districts possess alkaline soil may be due to over-liming acidic soils [44]. Danaukhurd in Sanganer and Booj in Jamwa Ramgarhexhibits highly alkaline soil. Many factories are located in Sanganer and farmers use toxic drain water for farming, which may be responsible for increased pH values. Slightly less alkaline soil is found in Bhadwa & Sitopsinghpura (pH 7.6), as shown in **Fig. 2**. It is observed that increased pH values may be a factor leading to a reduction in the quantity of micronutrients (Zn, Fe, Cu & Mn).

FIG. 1: COLLECTION OF SOIL SAMPLES FROM DIFFERENT VILLAGES OF RAJASTHAN NEAR JAIPUR

The electrical conductivity values of soil provide a measurement of soil salinity [45]. The presence of excess salt in soil affects the soil-water balance and hinders the growth of plant. The electrical conductivity provides a correlation with concentrations of nitrates, sodium, potassium, sulphate, chloride and ammonia. In non-saline soil the electrical conductivity provides a convenient and economical way to detect the amount of available nitrogen for plant [46-47].

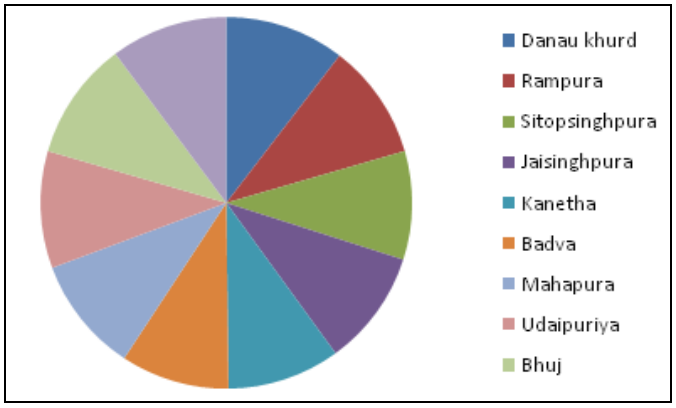

FIG. 2: THE GRAPHICAL REPRESENTATION SHOWING VARIATION IN SOIL pH VALUES OF VARIOUS VILLAGES BELONGS TO DIFFERENT DISTRICTS OF RAJASTHAN

The least value of electrical conductivity is 0.25 dS/m in Mahapura village, while highest value 0.69 dS/m found in Kanetha village of Sanganer as shown in **Fig. 3**.

The organic carbon content affects water relation, workability and aeration of soil48. It plays an important role in providing colour, nutrient holding capacity and stability of nutrients in soil and climatic change [49].

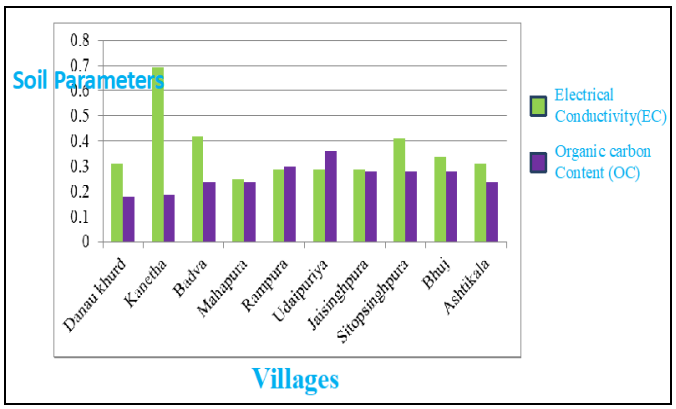

FIG. 3: THE GRAPHICAL REPRESENTATION SHOWING VARIATION IN SOIL PARAMETERS (ELECTRICAL CONDUCTIVITY AND ORGANIC CARBON CONTENT) OF SOIL

The lowest organic carbon content in Danau Khurd village (0.18% of C) of Sanganer and its highest value is in Udaipuriya village (0. 36% of C) of Jhotwara. The electrical conductivity and organic carbon contents comparative variations in different soil samples taken from various villages of Rajasthan. Among the six macronutrients essentially found in soil, only three important macronutrients, phosphorus, potassium and sulphur are studied in this article. Phosphorus and potassium are primary macronutrients, whereas sulphur belongs to secondary macronutrient category [50]. The soil's phosphorus is essential for plants' growth and reproductive processes [51-52]. The least value of Phosphorus is found in Asti Kalan (33 Kg/ha) of Chomu and highest value of Phosphorus is (56 Kg/ha) in Mahapura of Sanganer. Potassium activates the enzymes important for the synthesis of adenosine triphosphate (ATP). It is essential for osmo-regulation and regulates stomata opening and closing [53].

The lowest rate of potassium among all the soil samples is found in Booj village (194 Kg/ha) of Jamwa Ramgarh and its highest rate in Bhadwa village (578 Kg/ha) of Sanganer. The crucial role of sulphur is found in the formation of enzymes, protein, vitamins and chlorophyll of plants [54]. It also assists the photosynthesis process in plants. The highest value of sulphur is observed in the soil samples of DanauKhurd village (108 Kg/ha) of Sanganer and its lowest value is in the soil samples of Rampura village (61.1 Kg/ha) of Jhotwara as shown in **Fig. 4.**

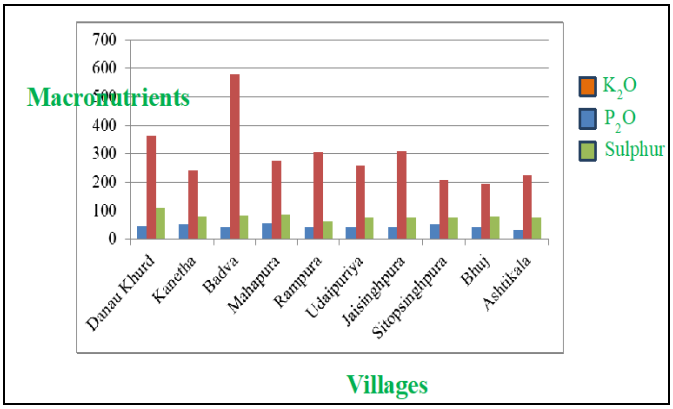

FIG. 4: THE GRAPHICAL REPRESENTATION SHOWING VARIATION IN MACRONUTRIENTS PRESENTED IN DIFFERENT SOIL SAMPLES

The productivity of plants decreases in the absence of micronutrients in the soil as it plays a key role in plant development and growth. The variation of only four micronutrients (Zn, Fe, Cu & Mn) was discussed in this article. The zinc deficiency in soil leads to reduced carbohydrate, chlorophyll and protein formation in plants [55]. The presence of zinc is essential for synthesizing enzymes responsible for driving the plant's metabolic reactions. The lowest zinc concentration is present in the soil sample of Asti Kalan village (0.07ppm) of Chomuand its highest concentration is found in Sitopsinghpura village (2.46ppm) of Shahpura. Another micronutrient iron plays a key role in chlorophyll synthesis. Iron is also important for the maintenance of normal structure and functioning of chloroplast. The highest concentration of iron is found for the Bhadwa village (5.35ppm) of Sanganer and its lowest concentration 0.64 ppm is in Danau Khurd village of Sanganer.

As a micronutrient, copper is essential for the activation of enzymes used in lignin synthesis. Copper also plays an important role in the metabolism of proteins and carbohydrates. The least concentration of copper is observed in Kanetha village (0.19ppm), and its highest concentration is found in Danau Khurd village (0.74 ppm) of Sanganer. Micronutrient manganese helps grow pollen tubes, pollen germination and elongation of root cells *etc*. It also contributes in photosynthesis, nitrogen assimilation, and respiration-like processes. The highest manganese concentration is found in Kanetha village (9.54ppm) of Sanganerand its lowest concentration is observed in Asti Kalan village (2.65ppm) of Chomu as shown in **Fig. 5.**

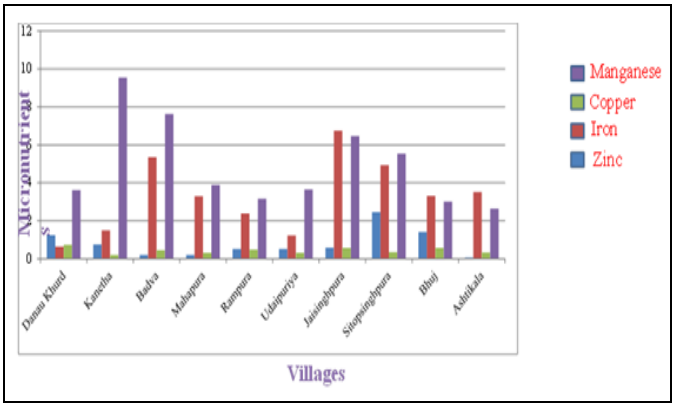

FIG. 5: THE GRAPHICAL REPRESENTATION SHOWING VARIATION IN MICRONUTRIENTS PRESENT IN VARIOUS SOIL SAMPLES

Apart from all these indicators, certain plants are used as toxicity indicators, and some indicate a deficiency of nutrients. The soil testing analysis provides the critical limit for the required nutrients. The critical limit of nutrients is a factor by which we can evaluate the requirement of fertilizers in the soil. The value of the critical limit of nutrients depends on the crop to crop. Based on the critical limit, the soil is divided into three categories-low, medium, and high nutrient soil. Thus, based on the critical limit, all soil samples have been assessed and shown in **Table 2**.

TABLE 2: THE VARIATION IN SOIL PARAMETERS OF VARIOUS VILLAGES NEAR JAIPUR BELONGS TO DIFFERENT AREAS OF RAJASTHAN

S. no.	Tehsil	Village	PH	EC (dS/m)	OC (% of C)	Macronutrients (in Kg/ha)			Micronutrients (in ppm)			
						P_2O_5	K_2O	S	Zn	Fe	Cu	Mn
1.	Sanganer	DanauKhurd	8.4	0.31	0.18	46	364	108.0	1.24	0.64	0.74	3.62
2.	Sanganer	Kanetha	7.9	0.69	0.19	55	244	81.0	0.75	1.50	0.19	9.54
3.	Sanganer	Bhadwa	7.6	0.42	0.24	45	578	82.5	0.20	5.35	0.46	7.63
4.	Sanganer	Mahapura	8.1	0.25	0.24	56	275	87.0	0.20	3.29	0.32	3.88
5.	Jhotwara	Rampura	8.1	0.29	0.30	45	305	61.1	0.52	2.39	0.48	3.16
6.	Jhotwara	Udaipuriya	8.2	0.29	0.36	43	259	76.1	0.52	1.23	0.32	3.65
7.	Sanganer	Jaisinghpura	8.1	0.29	0.28	42	309	75.3	0.58	6.75	0.56	6.47
8.	Shahpura	Sitopsinghpura	7.6	0.41	0.28	55	208	75.7	2.46	4.94	0.34	5.54
9.	JamwaRamgarh	Booj	8.3	0.34	0.28	42	194	80.6	1.41	3.32	0.57	3.01
10.	Chomu	Asti Kalan	8.2	0.31	0.24	33	225	76.1	0.07	3.51	0.33	2.65

Note: Electrical Conductivity (EC): Organic carbon content (OC)

CONCLUSION: In the present article, efforts have been made to compare the soil parameters/ indicators of different soil samples taken from villages of Rajasthan. Some villages are located near industrial areas, showing the environmental impact on soil quality. The comparative study of

soil indicators of these soil samples help in the evaluation of the nutritional quality of soil by soil testing as shown in **Table 3**. Further, this study supports the investigation of soil's nutritional level, which helps increase soil's productivity. The recommendation of the type of fertilizers and other treatments for enhancing the yield can also be done by knowing the nutritional value of soil.

TABLE 3: EVALUATION OF CATEGORY OF SOIL ON THE BASIS OF CRITICAL LIMIT OF SOIL INDICATORS PRESENT IN SOIL SAMPLES

S. no.	Soil indicators	Critical Limit	Low	Medium	High
1.	P_2O_5	33-56 kg/ha	-	All samples (S1-S10)	-
2.	K_2O	194-280 kg/ha	-	S2, S4, S6, S8-S10	S1, S3, S5, S7,
3.	S	20 kg/ha	-	-	(S1-S10)
4.	Zn	0.5 -1.0 ppm	-	S2 - S7,S10	S1, S8, S9
5.	Fe	5-10 ppm	S1, S2, S4-S6, S9, S10	S3, S7, S8	-
6.	Cu	0.2-0.4 ppm	-	S2 - S6, S8,S10	S1, S7, S9
7.	Mn	5-10 ppm	S9,S10, S4- S6, S1	S2, S3, S7, S8	-

Danau Khurd (S1), Kanetha (S2), Bhadwa (S3), Mahapura (S4), Rampura (S5), Udaipuriya (S6), Jaisinghpura (S7), Sitopsinghpura (S8), Booj (S9), Asti Kalan (S10).

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