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A Crucial Review of Soil Quality Status of Rajasthan (India) for the Period of 1963-2022

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Abstract

Soil is one of the most precise tools for regulating the environmental sustainability, agricultural economy, food quality, water quality, and health of living organisms. Therefore, we can say that the contribution of soil to the global system is significant. Consequently, soil quality management becomes one of the important tasks to improve agriculture production, environmental health, food-water quality, etc. The purpose of the present paper is to provide a critical review of the soil fertility status of Rajasthan for the period 1963 to the present. The present paper is able to provide past information on soil conditions that will help guide farmers, scientists, researchers, etc., for long-term soil fertility management and the information needed to formulate future agricultural research strategies on soils.

Keywords:*Agricultural economy; formulate; Rajasthan; farmers*

1. Introduction

Several large existential environmental challenges (ecosystem service, food security, water security) have been found in the way of sustainable human and environmental health development. They are complex and difficult to resolve because they are interrelated. Also, improving agriculture production is essential because agriculture is the prime food source for a rapidly growing population (Sihag and Prakash 2019). In all challenges, soil is a common factor and is used to investigate these global challenges (Herrick 2000; Bouma and McBratney 2013; McBratney et al. 2014). A lot of studies have insisted that soil is one of the important components of the global environmental policy agenda. Roosevelt famously said, “The nation that destroys its soil destroys itself” (Griffioen 2016).

Soil is crucial and able to solve global environmental challenges such as water security, food security, and biodiversity protection because soil lies at the center of solving the significant issues of food security, biodiversity, climate change, and fresh-water regulation (Hartemink and McBratney 2008; Arrouays 2017). Also, this agricultural production is directly influenced by the management and maintenance of soil because the soil is a supplier of the required nutrients to plants for proper growth (Power and Prasad 1997). The fertilization status or quality of the soil is comprehensive (Bautista-Cruz 2007); therefore, it can not be assessed only by certain parameters. To evaluate soil fertility, it is necessary to estimate physical, chemical, and biological attributes. Soil texture, soil content (sand, silt, and clay) percentile, water holding capacity, particle density, and bulk density are included in physical parameters. Whereas chemical parameters include soil pH, electrical conductivity, organic carbon, nitrogen concentration, phosphorus concentration, potassium concentration, sulphur concentration, zinc concentration, iron concentration, copper concentration, manganese concentration, and heavy metal concentration, and biological parameters include microbial quantity, biochemical test, microbial biomass and enzyme activity (Marinari et al. 2006; Karlen et al. 1997; Vasconcellos et al. 2013; Vasconcellos et al. 2016). These parameters are capable of characterizing soil fertility.

Soil quality can sustain plant production, support human health, manage ecosystem boundaries, and maintain air and water quality (Karlen et al. 1997; Baruah et al. 2013). Knowledge of the distribution concentration of major and trace elements in the soil is important and helps in environmental and agricultural management at a large scale (Towett et al. 2014). Since the location selected for analysis of soil fertility is Rajasthan, therefore I have studied and reviewed previous works relating to soil fertility of Rajasthan (*Table 1*), wherein the assessment of the soil of different parts of Rajasthan has been done on various parameters of soil fertility. The papers have also dealt with the status of soil fertility. We have tried here to briefly summarize the previous studies done in the field of soil fertility in various parts of Rajasthan and have provided the results obtained in these studies.

2. Historical review of soil data of Rajasthan

I have tried to summarize below various studies conducted with respect to the analysis of soil fertility status of different study areas of Rajasthan. Therefore, the information revealed in the present paper is described in the Table below.

Table 1. Review of soil status of Rajasthan

Study Area	Year	Brief Description
Pali, Jodhpur, Jalore, Nagaur, Barmer, Jaisalmer, Bikaner, Churu, and Jhunjhunu	1963 (Seth and Metha 1963)	For the arid region of Rajasthan, soil samples were analyzed for pH, EC, and essential nutrients (N, P, and K). Soil pH in Jaisalmer and Jhunjhunu district were found in the normal range. While 3.7, 2.8, 5.5,12, 12.5, 1.5, and 3.5 percent soil of Pali, Jodhpur, Jalor, Nagaur, Barmer, Bikaner, and Churu were found to be alkaline in nature. The data revealed that mostly the study area came in low nitrogen status. In the case of P and K nutrients, medium-range was more pronounced for Jaisalmer, Bikaner, and Churu districts. While a

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		medium to high range of K was assessed for Jalore and Barmer.
Indian Desert	1983 (Rao and Venkateswarlu 1983)	The assessment of soil physico-chemical properties and microbial analysis studied the microbial ecology of Indian desert soil. In the majority of areas, 80% of the fungal population belonged to the *Aspergillus* and *Penicillium* genera. Microbial populations were higher for Pali, Jaitpura, and Jodhpur as compared to Barmer and Jaisalmer. In desert soil, microbial activity was lower due to low organic matter and poor moisture. Positive correlations were found between organic matter and micro-organisms (Bacetria, fungi, *Azotobacter, Actinomycetes, and Nitrosomonas*).
Alluvial fan region of Gaggar River	1993 (Giri et al. 1993)	The soil of the alluvial fan region of the Gaggar River was investigated by Giri et al. (1993). Overall, nutrients were marginal. Moderately calcareous, non-saline, alkaline nature and fine loamy to fine soils were found. Also, nitrogen, organic matter, and iron deficiency are found. In the study area, sufficient availability of copper was found.
Khabra Kalan village of Jodhpur	1997 (Tsunekawa et al. 1997)	Different soil profiles were investigated under three (A: most productive, B: productive in the past, and C: oran land) sites. In which soil texture, bulk density, OC, N, EC, and pH were examined. Sandy loam for A, loamy sand for B, and sand for C were observed. The mean pH value of surface soil was 8.75 (B), 8.72 (A), and 8.68 (C). Poor availability of organic carbon, nitrogen was observed. However, surface OC concentration was highest at site A (0.14) than at site B (0.10) and C (0.09%).
Arid soils of Western Rajasthan	2004 (Chaudhary and Shukla, 2004)	In irrigated and rainfed soil of Western Rajasthan, boron status and correlation of different soil characteristics on available B were observed. In irrigated soil, the boron concentration varied between 0.26 (Petrogypsid) to 7.10 mg kg-1 (Haplosalid).

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		While in rainfed soil, the boron range varied between 0.22 (Petrogypsid & Petrocalcid) to 1.15 mg kg^{-1} (Haplocambid). The boron concentration was observed in low, medium, and sufficient ranges for 17%, 36%, and 47% of irrigated soil, respectively.
Pali	2004 (Krishna and Govil, 2004)	Levels of the metals in soils around the industrial area were found to be significantly higher than their normal distribution in soil. The highest concentration of Cu (298 mg/kg), Zn (1,364 mg/kg), Pb (293 mg/kg), Cr (240 mg/kg), and Sr (2,694 mg/kg) was observed. High concentration of these toxic elements in the soil is responsible for the development of toxicity in agriculture products, which in turn affects human life.
Arid Region of Rajasthan	2006 (Joshi et al. 2006)	Three fields (Narwa, Sathin I, and II) of the arid region were studied to characterize the spatial variability in soil salinity. Soil texture was categorized as loamy sand and clay loam for Narwa, Sathin I, and II, respectively. Mean EC values for Narwa, Sathin I, and II were 0.55, 1.62, and 1.17 mS cm^{-1}, respectively.
Uniara Panchayat Samiti of Tonk	2006 (Meena et al. 2006)	Soil pH was measured from a moderate to alkaline nature. For 95% of the soil, normal electrical conductivity was assessed. Organic carbon content, potassium, and nitrogen were available for the studied area in the low to medium range. The textural class varied from loamy sand to clay. Potassium concentration in 56.5% of soils was observed in the medium range. Available organic carbon was positively correlated with nitrogen, potassium, and phosphorus.
Barmer, Jaisalmer, Jodhpur, Hanumangarh and Pali	2006 (Aseri and Tarafdar 2006)	Soils were categorized as sandy to clay loam. The soils were non-saline and alkaline in nature. Maximum organic carbon, 0.38 mg $kg^{-1,}$ was observed in Mathania (Jodhpur) and Roopse (Jaisalmer). The highest available nitrogen, 56 mg $kg^{-1,}$ was observed at Tiwari (Jodhpur), while the lowest was 15 mg kg^{-1}

		(Dhakha). At Bilara, the highest biomass carbon, acid and alkaline enzyme activities were assessed.
Churu	2009 (Kumar et al. 2009)	The soils of Churu were characterized and classified. For Molasar, Modasar, and Dune complex, loamy sand to fine sand, moderately alkaline and classified as *torripsamments*. Soils of the Dune complex were very low in organic carbon, nitrogen, and potassium. Micronutrients (except zinc) were adequate. While potassium and organic carbon content were found in the medium to high range and low range for Molasar, Chirai, Masitawali, and Saroopdesar series. Medium phosphorus range was observed for Masitawali and Saroopdesar series, while for Molasar and Chirai, a low to the medium range was observed.
Bikaner	2011 (Ritu and Prerna 2011)	Investigated the soil samples of Bikaner for electrical conductivity, organic carbon, pH, and boron concentration. According to the data, the soil nature was non-saline. A slight to moderate pH range was assessed. Soil organic carbon varied between 0.13 to 0.25 percent, indicating that OC and nitrogen are available in deficiency. A deficiency of available boron content was also found in investigated soil.
Churu	2011 (Kumar et al. 2011)	Due to the high pH value, alkaline soil was found. With the low electrical conductivity was observed. The availability of organic carbon was measured in deficiency. $CaCO_3$ varied between 0.10 to 9%.
Jhunjhunu	2011 (Mahesh et al. 2011)	The surface soil samples of agriculture (irrigated and rainfed), sand dunes, and grazing lands of Jhunjhunu were collected for observation of soil fertilization. Soils of the district were observed to be adequate in copper, iron, and manganese. About 25% of soil samples of the district were assessed for potassium deficiency, mostly present in agricultural systems. Poor organic carbon was found in the studied district but was more pronounced in dune soils.

Jhunjhunu	2011 (Kumar and Babel 2011)	The texture classes of soils were categorized as loamy sand, sandy and sandy loam. The study area soils were non-saline, moderately calcareous, and moderately alkaline. Micronutrient iron and zinc availability were deficient for 90 and 70 percent area, respectively. While the remaining micronutrient, copper, and manganese, were found to be sufficient for 95.72% and 100% area, respectively. According to data, low organic carbon and a high amount of calcium carbonate were more pronounced in the study area. The micronutrient availability was observed to be positively correlated with clay, silt, organic carbon, and CEC, while negatively correlated with soil pH, $CaCO_{3,}$ and sand content.
Chittorgarh	2011 (Panwar et al. 2011)	The analyzed salt-affected soils were found to be deficient in nitrogen. The phosphorus (6.8 to 25 kg/ha) and potassium (kg/ha) values indicated that soils were found to be medium in phosphorus and medium to high in potassium ranges. Iron was found deficient. While copper and manganese are shown to be sufficient, and their values range between 0.27 to 1.04 and 2.76 to 7.79 mg kg^{-1}, respectively.
Western Rajasthan	2011 (Yadav 2011)	Alkaline and non-saline soils were observed in western Rajasthan. Low to medium availability of organic carbon was observed. Iron, Cu, Zn, and Mn deficiency was observed for 45, 30, 40, and 20% of soil samples. All examined micronutrients showed a positive correlation with soil OC.
Western Rajasthan	2012 (Tamboli and Vyas 2012)	The estimation of soil parameters like pH, EC, OC, and soil texture observed the presence of mycorrhizae in soil. Sandy gravel, coarse loam, and sand gravel soil texture were observed for Pali, Jodhpur, and Barmer districts. Mean pH values for Pali, Jodhpur, and Barmer were 5.10, 5.25, and 6.10, respectively. The soils were slightly acidic in nature due to the presence of heavy metals. Low organic carbon content was

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		assessed in the soil of all sites.
Jodhpur	2012 (Verma and Kumar 2012)	In three different (AFP, IP, and AP) plantations, the value of pH, EC, and OM were observed. Mean pH values of 8.08, 8.29, and 8.32 were observed for AFP, IP, and AP, respectively. For AFP, IP, and AP, soil EC varied between 0.38 to 0.82, 0.28 to 0.55, and 0.10 to 0.50 mS/m, respectively. Soil OM was available from 0.54 to 1.02, 0.67 to 0.86, and 0.25 to 0.66 percent in AFP, IP, and AP, respectively. The higher organic matter was available in AFP > IP > AP order. The highest growth of *Azadirachta indica* was observed in AFP than in IP and AP in terms of height and dbh. At AFP, *Azadirachta indica* helped in maintaining soil pH and fertility.
Western Rajasthan	2012 (Vyas and Vyas 2012)	Sandy gravel, sandy loam, and sandy and loamy sand were the more dominating textures observed in Barmer, Bikaner, Jaisalmer, and Jodhpur, respectively. Soil pH data indicated the alkaline nature of the soil. Phosphorus and organic carbon were found in low status.
Sri Ganganagar	2013 (Singh et al. 2013)	This study investigated the effect of irrigation and cropping sequences on soil physico-chemical properties. The SOC, potassium, water holding capacity, silt, and clay content increased in high canal irrigation treatment compared to irrigated and non-irrigated conditions. Although bulk density, sand content, and soil temperature were reduced in irrigation. Biomass carbon and phosphorus were 2.2 to 3 and 1.82 to 2.1 times higher than low–irrigated conditions.
Bikanaer, Churu and Jaisalmer	2014 (Devra et al. 2014)	The distribution of phosphorus was studied in the soil of the western plain of Rajasthan. Majorly sandy soils were present in the study area. Although soil texture varied between sandy to loam. Data demonstrated that the phosphorus concentration in 33.77, 44.16, and

		22.07 percent soil samples of Bikaner was observed in the low, medium, and high ranges, respectively. Whole Churu and 53.06% Jaisalmer soil were assessed in low phosphorus. While the remaining 38.78 and 8.16 percent areas of Jaisalmer were found in the medium and high P range, respectively.
Raisinghnagar of Sri Ganganagar	2015 (Ramana et al. 2015)	Soil macronutrient status and their relationship with physico-chemical properties were assessed. Organic carbon was observed in the low range for 89 percent of soil. About 97% of areas were found in the medium range for nitrogen nutrients. Potassium and phosphorus were observed in a high range for 63% soil. Sufficient availability of Ca and Mg was observed in 93% and 85% soil, respectively. Natural to moderately alkaline and non-saline soil was found.
Western Rajasthan	2015 (Santra et al. 2015)	Soil orders were divided into *Aridisol* and *Entisol* for 38 and 61 percent area of western Rajasthan, respectively. Soil organic carbon content was found to be very low for most of the study area. The pH and EC varied between 7.02 to 8.73 and 6 to 805 mSm^{-1}. Organic carbon content was positively correlated with EC and clay content.
Agriculture sites of Sri Ganganagar	2015 (Singh et al. 2015)	Concentrations of heavy metals were studied in soil, water, and some crops, and in agricultural soil, zinc, lead, and chromium metal varied between 0.1 to 0.2 ppb. The average values of Cu, Cd, Fe, Ni, and Co were assessed at 0.025, 0.003, 12.70, 0.050, and 0.020 ppb, respectively.
Industrial areas of Jaipur and Kota districts	2016 (Sharma and Kumar 2016)	According to the results, toxic concentrations of heavy metal Cd, Cu, Ni, Cr, Pb, and Zn were observed in Sitapura, Jhotwara, RIICO, Viswakarma industrial areas of Jaipur and Indraprastha, Chambal, RIICO, Paryavaran, large scale industrial area of Kota.
Wasteland of Bhilwara	2016 (Sharma et al. 2016)	Soil electrical conductivity and pH were analyzed from 0.10 to 0.89 dSm^{-1} and 7.52 to 8.80, respectively, for

		wasteland soil samples, organic carbon and calcium carbonate were found from 0.27 to 0.82% and zero to 9.96 percent, respectively.
Jaisalmer district of western Rajasthan	2017 (Dinesh et al. 2017)	With respect to essential nutrients, 57.60 and 44.80 percent of samples were observed to be low in P_2O_5 and sulphur, respectively. About 99.2, 94.40, 66.40, and 46.40% of samples were observed to be deficient for Cu, Mn, Zn, and Fe, respectively. While 36, 87.20, and 54.40 percent samples were found in medium-range for available P_2O_5, K, and S, respectively. The availability of N and OC was found in low for all samples. Highly alkaline soil was present in Jaisalmer.
Chittorgarh	2017 (Vyas et al. 2017)	The study was done on soil physical parameters like soil content, particle density, bulk density, water holding capacity, specific gravity, and water retaining capacity. Different types of soil textures like clay loam, sandy loam, loam, and sandy clay were found in the study area. The bulk density varied between 1.05 to 1.30 g/cm^3. According to physical parameters results, the examined sites' soil was found to be in good condition for different tropical and subtropical crop cultivation.
Gharsana of Sri Ganganagar	2017 (Kumar et al. 2017)	This study analyzed soils based on the pH, EC, OM, CEC, calcium carbonate, micronutrients, and available essential nutrients. In 95% study area, loamy sand texture was examined. This strong alkalinity was found to be calcareous in nature in 86.25% and 50% of study areas, respectively. The deficiency of nitrogen, organic carbon, zinc, and iron was more pronounced in the whole area. Similarly, a low concentration of phosphorus and copper was measured in 45% and 97.5% areas, respectively. On the basis of these parameters, soil fertility was low in the study area.
Gharsana of Sri Ganganagar	2017 (Kumar et al. 2017)	For whole studied sites, loamy sand soil textures were observed. The nature of the soils was highly alkaline

		and calcareous. Whole areas were observed with deficiencies in soil organic carbon and nitrogen. This observation observed potassium concentrations in the medium and high range for 80% and 20% area, respectively. The low and medium availability of phosphorus was observed in 45% and 55% of the studied area, respectively. Consequently, the soil fertility of Gharsana was poor.
Raisinghnagar and Sri Vijayanagar of Sri Ganganagar	2017 (Kaur et al. 2017)	For the studied area, sandy and sandy loam soil textures were observed. The data revealed that bulk density varied between 1.08 to 1.23 g/cc. While particle density was observed from 2.40 to 2.66 g/cc. Good soil physical conditions were observed for sub-tropical and tropical crops.
Ghatol of Banswara	2017 (Meena and Mathur 2017)	Soils were categorized as clay loam, sandy clay loam, and clay. Neutral to moderately alkaline soil was measured. The EC values indicated that soils were less saline. Soil organic carbon and calcium carbonate varied between 3.74 to 9.91 g kg^{-1} and 9.91 g kg^{-1}, respectively. Micronutrient zinc, iron, manganese, and copper varied between 0.42 to 1.95, 2.26 to 28.4, 2.10 to 21.85, and 0.37 to 4.15 mg kg^{-1}, respectively. Clay content and organic carbon were positively correlated with Zn, Cu, Fe, and Mn, while $CaCO_3$, sand, and pH were negatively correlated.
Bikanaer, Churu and Jaisalmer	2017 (Kumar et al. 2017)	Potassium nutrient concentrations were observed in the western plain of Rajasthan. The pH data indicated that soils were neutral to slightly alkaline, but the majority of soil samples were alkaline. Soil texture varied between loam to loamy sand with a light texture. Soil organic carbon and calcium carbonate varied between 0.01 to 0.25% and 0.05 to 26.80%, respectively. The distributions of organic carbon were low for the whole of the western plain. Medium potassium availability was observed in most areas.

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Mandal Block in Bhilwara	2017 (Gurjar et al. 2017)	It was observed that 16.37, 77.77, and 5.84 percent cultivated soil samples of Bhilwara were found to be neutral, slightly alkaline, and strongly alkaline, respectively, in reaction. Low to medium availability of organic carbon and phosphorus was observed in most of the soil. Most of the analyzed soil samples were found to be deficient in nitrogen. While all samples are shown to be high potassium range.
Ajmer	2017 (Jat et al. 2017)	Sand, silt, and clay were found at 67, 38, and 14%, respectively, for cultivated soil samples of Ajmer. Results showed a sandy loam texture. Medium status of organic carbon, nitrogen, and potassium was observed at 0.67%, 181.21 kg $ha^{-1,}$ and 257.37 kg ha^{-1}, respectively. Alkaline soil nature was observed for farmland soil. Phosphorus nutrient was assessed as 16 kg ha^{-1}.
Jobner, Jaipur	2017 (Aechra et al. 2017)	For the soil of Jobner, loamy sand soil texture was analyzed. Before any treatment, soil pH values were indicated to be alkaline in nature. A deficiency of nitrogen and organic carbon was found. While potassium and phosphorus nutrients were observed in the medium range. Dehydrogenase and alkaline phosphatase enzyme activity was observed as 5.53 pKat g^{-1} and 8.59 µg PNP g^{-1} h^{-1}.
Ajmer	2017 (Lomror et al. 2017)	For the soil of Ajmer, medium status was observed for nitrogen (181.21 kg/ha), potassium (257.37 kg/ha), and organic carbon (0.67%). While the mean value of phosphorus was found as 16.4 kg/ha (deficient). Soil pH (7.5) values indicated that soils were found to be alkaline in nature. The sand, silt, and clay percentage was assessed as 67, 38, and 14, respectively. These soils were categorized as sandy loam.
Ajmer	2017 (Solankiand Parihar 2017)	The soil parameters were analyzed to assess the effect of cement kiln dust on the soil. Soil pH (7 to 9) values indicated that soils were alkaline in nature. However,

		soil pH decreased with the increased distance to the cement factory. Different soil organic carbon ranges were assessed at 1.15 to 1.9, 1.04 to 1.21, 0.97 to 1.50, 0.99 to 1.30, and 0.75 to 1.12 percent at near, 0.5, 1, 2, and 3 km distance of factory, respectively. The highest concentration of Zn (156 ppm), Ni (39 ppm), Pb (110 ppm), and Cr (131 ppm) in soil was obtained on the upper surface near the cement factory.
Tabiji, Ajmer	2017 (Harisha et al. 2017)	Micronutrient zinc, iron, copper, and manganese concentration was assessed as 0.62, 6.29, 1.07, and 4.54 mg/kg, respectively, for sandy loam soil of Tabiji (Ajmer) before any micronutrient treatment.
Agricultural site of Bhilwara	2018 (Khajanchi and Sharma 2018)	Low to medium availability of organic carbon was assessed for most of the soil. While medium to high phosphorus status was analyzed in agricultural soil. Soil electrical conductivity was shown to be normal in status.
Agricultural field of Sawai Madhopur	2018 (Iram and Khan, 2018)	Soil pH (7.04 to 8.3) indicated that soils were slightly alkaline in nature. Nitrogen, phosphorus, and potassium nutrient ranges ranged between 13.8 to 218.6 kg/ha, 54.72 to 298.4 kg/ha, and 138.5 to 641 kg/ha, respectively. While the organic matter of agricultural soil was observed from 0.188 to 3.14 percent.
Jhunjhunu	2019 (Jeph and Khan 2019)	This study analyzed soils based on pH, EC, P, N, and WHC. The nature of soils was alkaline and within the safer limits of electrical conductivity. The distributions of organic carbon and nitrogen were low. Low to medium availability P was observed in the soil. Most of the soil samples were also low range in water holding capacity.
Sri Ganganagar	2019 (Meena et al. 2019)	Moderately alkaline (8.25 pH) to strongly alkaline (9.56 pH) soil was observed. Organic carbon and nitrogen were found in low status. Non saline to strongly saline nature of the soil was found. Low to

		medium ranges of potassium and phosphorus were found. Analyzed soil samples were found to be deficient in Mn and Fe. While high availability of Zn and Cu were observed.
IB-INW zone of Rajasthan	2019 (Sihag and Prakash 2019)	For the soil fertility status of the IB-INW (irrigated northwestern) zone, soil samples were collected from different soil groups like *torrifluvents* (TFS), *torripsamments* (TPS), *and calciorthids* (COS). Soils were categorized as clay loam (TFS), sandy loam (TPS), and loamy sand (COS). Noncalcareous soil was found in all TPS and COS. Mean water holding capacity was observed as 18, 10.57, and 7% for TFS, TPS, and COS, respectively. The organic carbon was observed in the low range for 55.26 and 94.74 TFS and TPS soil samples, respectively.
IB-INW and IC-HAPI zone of Rajasthan	2019 (Sihag et al. 2019)	Soil physicochemical parameters like sand, silt, clay, calcium carbonate, CEC, pH, EC, OC, N, P, K, Zn, Fe, Cu, and Mn of IB-INW were compared with that of the IC-HAPI zone. Nitrogen was the most deficient nutrient in both zones. Similarly, the phosphorus nutrient in 21.05% farmland area of the IB-INW zone and 40% of the IC-HAPI zone were measured in the deficient range.
Ajmer	2019 (Sihag et al. 2019)	Low nitrogen, OC, and potassium range were analyzed for 23, 22, and 25% FLS, respectively. A sufficient range of Zn, Cu, and Mn was observed in farmland soil. Enzyme activity of dehydrogenase, acid, and alkaline phosphatase was observed at 9.351 $pKatg^{-1}$, 4.721 $nKatg^{-1,}$ and 2.048 $nKatg^{-1}$, respectively, for the farmland soil of Ajmer.
Nagaur	2020 (Singh et al. 2020)	Some chemical parameters (pH and EC) were observed to characterize and map salt-affected soils of the Nagaur district. Soil pH value was observed to be 8.20 (Nagaur), 8.44 (Jayal), 8.55 (Didwana), 8.47 (Ladnu) and 8.47 (Nawa), respectively whereas electrical

		conductivity was 1.25 dSm^{-1} (Nagaur), 1.35 dSm^{-1} (Jayal), 1.38 dSm^{-1} (Didwana), 1.29 dSm^{-1} (Ladnu) and 1.34 dSm^{-1} (Nawa), respectively.
ICAR-Central Arid Zone Research Institute, Jaisalmer, Rajasthan (Chandan Farm)	2020 (Kumar et al. 2020)	In this study, the effect of different land use systems, viz., agroforestry, pastures of sewan (Lasiurus sindicus) grass, horti-pasture, horticultural and silviculture systems on soil physico-chemical properties and fertility was studied. The soil organic matter ranges from 0.71-1.21 g kg^{-1}. Soils of the entire area showed higher values for pH. The mean OC content in different land uses was rated as in the category of low to very low. Soil nitrogen ranged between 24.7-47.1 kg ha^{-1}, significantly correlated with SOC content. Soils under horti-pasture, horticulture, and arable crops were comparatively higher in phosphorus than the other soils. The mean values of iron, manganese, copper, and zinc in soils vary from 4.5-18.5, 7.2-30.8, 0.22-2.8, and 0.30-1.6 mg kg^{-1}, respectively, in all the land use systems. The Zn, Fe, Mn, and Cu showed a positive correlation with SOC content. Fe, Mn, and Zn exhibited a negative correlation with pH and EC.
IC-HAPI zone of Rajasthan	2020 (Sihag et al. 2020)	For the soil of the IC-HAPI zone of Rajasthan, soil fertilization was analyzed. According to the results, IC-HAPI found low OC and nitrogen status. A low zinc concentration was observed for 71% soil of the studied zone. Overall low fertilization status was examined for the whole IC-HAPI zone.
IA-AW zone of Rajasthan	2020 (Sihag et al. 2020)	Soil physical, chemical parameters and enzyme activities were assessed in the IA-AW (Arid western) zone of Rajasthan. Two types of soil samples, farmland, and wasteland, were collected. High sulphur status was examined in 70% FLS and 64% WLS soil. The data revealed that 90% FLS and 95% WLS come in low nitrogen status. The deficiency of zinc, phosphorus, and organic matter was observed in 49,

		50, and 90 percent wasteland soil, respectively.
Sanganer	2021 (Sharma et al. 2021)	Soil fertility was examined for the soil of Sanganer block of Jaipur. According to the results, the soil was neutral to alkaline in pH (6.2 to 8.9), low in organic carbon (0.3 to 1.92%) and sulphur (0.97 to 11.47 mg/kg). The nitrogen (150.32 to 350.3 kg/ha), zinc (0.21 to 0.64 mg/kg), iron (1.2 to 4.83 mg/kg), and manganese (0.14 to 1.02 mg/kg) were found to be low. Furthermore, potassium (123.2 to 504 kg/ha) was moderate, and phosphorus (14.68 to 36.13 kg/ha) and copper (1.19 to 4.68 mg/kg) were found to be high.
Hot arid regions of Thar Desert, Rajasthan	2021 (Kumar et al. 2021)	For soil fertility assessment and mapping, 5655 soil samples were collected covering 12 districts of hot arid Rajasthan. Soil samples were analyzed for pH, electrical conductivity, organic carbon, phosphorus, potassium, iron, zinc, copper, and manganese. About 49, 11, 56, and 41 percent of samples of the hot arid regions were observed to be deficient for phosphorus, potassium, zinc, and iron, respectively. Results of the soil analysis revealed that OC is low throughout the region, while available P was low to medium but generally medium to high in available K. Among the micronutrients, Cu and Mn were adequately supplied in most areas, but Zn and Fe were inadequate in large parts.
Phagi tehsil, Jaipur	2022 (Jajoria et al., 2022)	Soils were categorized as loamy sand. Sand, silt, and clay content were analyzed from 81.5 to 90.10, 6.20 to 12.10, and 3.20 to 7.30%, respectively. The data revealed that bulk density varied between 1.47 to 1.54 mg/m^3. Soil calcium carbonate value indicated that soils were found to be non-calcareous in nature. The soil samples were low in cation exchange capacity, which ranged between 5.21 to 9.22 Cmol (p^+)/kg with a mean value of 6.71 Cmol ($p^{+)}$/kg.

Sri Ganganagar	2022 (Shekhawat et al. 2022)	The soil of the kinnow orchard was investigated for nutrient status. A deficiency of OC and nitrogen were observed. In the study area, medium availability of phosphorus was found. Soil potassium varied from 149.33-457.2 kg ha^{-1}. The availability of potassium in soil is medium to high.
IIA-IDD zone of Rajasthan	2022 (Sihag and Prakash 2022)	The non-calcareous soil nature was found in all soil samples of the IIA-IDD zone of Rajasthan. No toxicity of lead and chromium has been found in any of the soil samples of the IIA-IDD zone. Similarly, normal cadmium concentration (no toxicity) was observed in IIA-IDD (FLS and WLS). The acid phosphatase enzyme activity was maximum in farmland soil of the IIA-IDD zone. According to data, the most deficiency of nitrogen, phosphorus, potassium, organic carbon, zinc, iron, and copper was analyzed in farmland and wasteland soil of the IIA-IDD zone.
Sub-humid southern plains of Rajasthan	2022(Yadav et al. 2022)	Soils of the sub-humid southern plains of Rajasthan were studied using geospatial techniques to understand the soil quality and spatial variability of soil properties. In which organic carbon, nitrogen, phosphorus, potassium, Zn, Fe, Cu, Mn, pH, and electrical conductivity were examined. Rashmi tehsil had the highest (0.674) soil quality index (SQI) among the different tehsils. Soil pH ranged from 5.70 to 8.50. Moderately saline to highly saline soils were found in 2-5% of the studied area. The spatial variability maps of soil properties indicated that OC was deficient in 47% area, whereas nitrogen, phosphorus, and potassium were low in 14.8, 7.56, and 26.5% area, respectively. Micronutrients Zn and Mn were found low in 16-20% area, while iron was low in 47.7% area. The OC had a significant and positive correlation with K, Fe, and Cu, while it had a significant negative correlation with soil pH.

3. Conclusion

In the present scenario, high agrarian production is essential to accomplish the demands of the rapidly and regularly growing population of Rajasthan. As well as the reclamation and conservation of product quality are necessary to maintain the health of present and future generations. In the context of this study, it can be concluded that regular soil monitoring for soil nutrients is necessary because of the varying amounts of nutrients in the soil.

From the above studies on soil analysis, it can be conclusively said that only certain parameters of soil fertility have been analyzed in these studies. However, as discussed in the introduction, soil fertility cannot be determined through limited parameters only; a detailed analysis of different physico-chemical and biological parameters is essential for determining soil fertility status. Further, any corrective measures suggested only on the basis of analysis of limited parameters would fall short of achieving effective and efficient management of soil fertility.

For economic development and sustainable agriculture, it is essential to analyze chemically, physically, and biologically the wasteland and arable soil that will help to understand the present challenges of soil and the problem of soil fertility degradation in Rajasthan. The present paper can provide past information on soil conditions, which will help scientists, researchers, etc., to conduct further studies in this area in the future. It will also help in making effective strategies to detect soil defects and maintain and manage soil fertility in Rajasthan.

Conflict of Interest

On behalf of all authors, the corresponding authors state that there is no conflict of interest.

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