



Assessment Of Soil Degradation And Fertility Loss Due To Chemical Contaminants From Agricultural, Industrial, And Waste Sources in Jabalpur, India

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Abstract

A study was conducted to assess the impact of soil degradation and fertility loss caused by chemical contaminants from agricultural, industrial, and waste sources. The five major locations operate from Jabalpur, (M.P). Although the negative effects of air pollution on human health are widely recognized, the effects of soil contamination remain poorly understood. This paper aims to demonstrate how hazardous materials endanger sustainable agriculture while silently deteriorating the land. Using standard techniques, soil samples were examined for physicochemical parameters such as pH, phosphorus, moisture content, particle density, water-holding capacity, electrical conductivity, and organic matter. (S2) agriculture soil had higher fertility levels as compared to (S1) garbage factory soil and (S5) mine soil, which showed more signs of degradation, particularly nutrient depletion, acidity, and salinity. These results emphasize the urgent need for sustainable land management, degraded land rehabilitation, and integrated soil conservation strategies. To put it simply, protecting soil resources is essential for long-term agricultural productivity, ecological stability, and food security in addition to being an environmental priority.

Key Words: Soil degradation, Soil fertility, Heavy metals, physicochemical properties

Introduction

Soil degradation includes physical, chemical and biological deterioration, which is the reduction in soil quality brought on by improper use. It is impacted by human and anthropogenic activities in addition to natural elements like topography, climate, and soil characteristics. Previous research frequently linked the composition of land cover to sediment yield and erosion. The combined effects of several land use changes on soil degradation were examined in fewer studies (1). The term “soil degradation” refers to a decline in the quality of the soil, which prevents crops and other organisms from producing goods and benefiting from the soil ecosystem. Due to the lack of freshwater, waste water is reused for agriculture irrigation. This waste water contains metals and other harmful substances that come from various sources, including industrial waste, municipal sewage, fertilizer, mining, smelting, vehicle emissions, industrial activities. Industries such as tannery, textiles, paper and cycle that produce extreme waste water, that contains toxic inorganic and organic substances. This is a major concern because it affects crop production, air, water, and human and animal health. Since this type of wastewater is used on agricultural land, heavy metals will disrupt the fertility of the soil and may alter key characteristics like organic carbon, pH, electrical conductivity, and cation exchange capacity (CEC) (2).

Although the detrimental effects of air pollution on human health are widely known, the effects of soil contamination are still poorly understood. Nonetheless, a number of studies have demonstrated that an increase in soil contaminants can change the chemical characteristics of the soil, impact microbial activity, and have a detrimental effect on the health of plants and animals that live in or on the soil (3). Human activities, especially consumer activities and industries are increasing soil contamination and these includes transportation, municipal waste and energy production particularly in urban areas (4). Toxic elements and heavy metals in soil can originate from point sources, human activity, or natural sources like parent material. Certain contamination occurs in small or localized areas, making it comparatively identifiable. Heavy metal contamination of agricultural soil is a serious environmental concern due to the ongoing use of fertilizers, agrochemical lines, atmospheric deposition, sewage, and waste water. Pesticides, fertilizers, sewage sludge, waste water, and surface runoff are the main sources of heavy metals in agricultural soil. The biggest worry is that heavy metals can build up from soil to crops, then through the food chain to human health, posing a serious risk to human health (5). The study's main objective is to investigate how soil health is affected by chemical and heavy metal pollution. Following the collection of soil samples from five distinct environments—agricultural land, mining areas, lake surroundings, garbage disposal sites and industrial regions—eight key parameters were used to evaluate the samples. The objective is to show how hazardous materials are endangering sustainable agriculture and silently deteriorating the land. Mining, tailings, lead, fuel, chemicals, fertilizer, animal waste, sewage sludge, and pesticides can all cause heavy metal contamination. Petroleum spills, industrial emissions, and residues from burning coal. These pollutants endanger the health of the environment and sustainable agriculture by causing extensive soil contamination and degradation.

Study Area

Jabalpur is a city on the banks of river Narmada in the State of Madhya Pradesh in central India. Jabalpur is the third-largest urban centre in Madhya Pradesh and 38th largest in India. It is the administrative headquarters of Jabalpur district in Jabalpur division based in the Narmada basin.

Jabalpur has a humid subtropical climate zone like the rest of north-central India. The summers are from late March to June, with temperatures averaging over 40 °C, reaching up to 48 °C peak in May. The monsoon arrives in mid-July and ends in early October, with an average of 889 mm rainfall, with an annual average of 1,386 mm rainfall. The winters start from late November and end in early March, with the average temperature in January touching 15 °C.

The alluvial tracts of the Narmada are highly suitable for cultivation. It is a rich farming tract of MP, comprising of crops like millet, wheat, rice, sorghum, etc. The commercial crops include pulse, oilseeds, cotton, sugarcane, and medicinal plants. In addition, Madhya Pradesh has emerged as a leading producer of soybean in the country.

Thus, in the present scenario, Jabalpur is suitable for studying the impact of different contaminants on the soil. For the same, soil samples have been collected from agricultural land, industrial areas, waste dumping yards and the lake beds to examine the influence of agricultural practices, industrial effluents, urban waste on the fertility of the soil.

1) Sontalai (Agricultural and Lake Site)

Soil samples were collected from Sontalai village of Patan Tehsil on 23rd March, 2019. The village is located at a distance of 13 kms from Jabalpur district headquarters. The samples of the lake bed soil were foul-smelling and full of organic matter, whereas the agricultural land soil was comparatively dry with a mixture of sand and clay. The farmland was good with a variety of crops in the field. However, the lake had a poor smell with the presence of a large amount of organic matter.

2) Richhai Industrial Area (Industrial Sites)

Soil samples were collected on 24th March, 2019 from the Richhai Industrial Area which is a sub-locality of Ruchia in Jabalpur district, Madhya Pradesh. The sample site was located near the Industrial Solution Hospital Linens manufacturing surgical accessories with an observation that the industry was releasing chemical effluents on the soil. The soil of this area is exposed to extreme contamination from chemical effluents, as a result, the fertility of the soil is affected with the inability of supporting plant growth.

3) Bhudagar Mine area

The soil samples were collected on 29th March, 2019 from the mining area of Budhagar which is in Jabalpur district, Madhya Pradesh. The mining area had laterite soil which consists of Aluminium(Al) and Iron oxides(FeO). It is a poor soil for cultivation as it lacks potash, phosphate, and lime. This soil may affect the fertility in the nearby areas when mixed with the regular soil.

4) Kathonda Plant (Garbage Dumping Site)

Soil samples were collected on 15th May 2019 from the Kathonda Garbage processing plant situated at Kathonda village on the outskirts of Jabalpur city in the Jabalpur municipal corporation. The plant was processing garbage for the city but it was observed that while burning the waste, the ashes and dust were released in the open. This affects the soil when mixing with it, by changing the acidity of the soil and destroying the useful bacteria needed for fertility.

The dumpsite with garbage mixed with ashes poses a threat to human life. The waste material when mixed with the soil makes it unfit for cultivation because of the presence of some poisonous elements in it. If not properly disposed of the garbage poses a threat to the groundwater and air by pollution. Inhalation of air pollutants can be dangerous to the human respiratory tract, and if any cultivation is made in the nearby area, it will cause danger to humans feeding on those crops.

Table 1. Physicochemical Characteristics of Soil

Parameters	S1	S2	S3	S4	S5
Moisture content	23.80	24.10	23.90	24.00	23.70
Particle density (g/cm ³)	2.208	2.30	3.06	0.88	0.76
Water holding capacity	52%	64%	64%	52%	52%
Soil reaction (pH)	4.85 & 3.73	3.58 & 1.47	10.55 & 3.94	3.03 & 3.11	0.26 & 5.22
Soil Salinity (EC) (mS/cm)	9.28	1.43	0.66	8.12	5.29

Total Nitrogen(g/kg)	0.151	0.35	0.201	0.274	0.151
Total Phosphorous (g/kg)	0.4	18.0	7.0	12.0	3.0
Organic Carbon(g/kg)	0.9	0.9	0.9	0.6	0.6

Materials and Methods

Soil samples were collected from the top soil at a depth of 4-16cm. They were collected cross-section ally using an auger from five major location (agricultural, lake, industrial, mine and garbage factory sites). The study was conducted for period of six months (March, 2019 to August, 2019). Five major sites, representing a range of environmental influences, were sampled. Soil samples were collected from Sontalai (~13km from Jabalpur) representing industrially influenced soil, Bhudagar mine area representing lateritic, mining – affected soil rich in Al and Fe oxides, and kathonda, Garbage Power Plant representing waste – affected soil containing ash, dust, and semi-burnt waste residues. The samples were analyzed for selected physicochemical characteristics and fertility status of the soil. In each case the soil samples of totaling five location were subjected to pretreatment which included air, dried, cleaned, crushed and passed through 2mm wash sieves and analysed in laboratory (1:2 soil water extract).The physicochemical and nutrient parameters of soil were determined including moisture content, particle density, water- holding capacity (WHC), pH, electrical conductivity (EC), total nitrogen, available phosphorus an organic carbon. Moisture content was determined by drying air dried soil in an oven at 105°C for 24 hour and calculating the loss in mass before and after drying. Particle density was determined using oven dried soil sieved to 2mm and distilled water by the pycnometer (Rd bottle) method. The water holding capacity (WHC) was determined by saturation from the soil and measuring the amount of water retained by soil. The soil reaction (pH) was measured in the soil suspension after treatment with hydrogen peroxide using a calibrated glass electrode pH meter. Electrical conductivity (EC) was determined using an EC metre after mixing 10 g of air dried soil with 50ml distilled water and shaking for 1h. The EC metre was calibrated with standard KCL solution, and readings were recorded after stabilization. Total nitrogen (TN) was estimated by the micro- Kjeldahl method, involving acid digestion of 5g soil, followed by ammonia distillation into boric acid and titration with standard acid. The results were expressed as EC (ms/ cm) and nitrogen, respectively. The available phosphorus was determined using the Olsen sodium bicarbonate extraction method. The phosphorus content was measured calorimetrically at 88 nm using the ascorbic acid method after 2.5 g of air- dried soil was extracted with 50mL of 0.5 M NaHCO₃ (pH 8.5) shaken for 30 minutes and filtered. The Walkley-Black wet oxidation method was used to estimate soil organic carbon. This involved oxidizing the carbon with potassium dichromate and concentrated H₂SO₄, then titrating the excess dichromate with ferrous ammonium sulphate. The findings were present as available phosphorus and organic carbon content respectively.

Analysis and Discussion

The physicochemical and fertility parameters of the soil samples taken from five different locations varied significantly, indicating variations in land use and human impact. Agricultural soil (S2) demonstrated relatively better water retention, with moisture content ranging from 23.70 to 24.10% and water-holding capacity ranging from 52 to 64%. Particle density varied from 0.76 to 3.06 g/cm³, with industrial soil (S3) having the highest value, suggesting contamination or compaction. Soil pH ranged widely from 3.03 to 8.47. Garbage-factory soil (S1) and mine soil (S5) were relatively acidic, while agricultural soil (S2) was slightly alkaline. Electrical conductivity ranged from 0.66 to 9.28 mS/cm, with garbage-factory soil (S1) having the highest value, indicating more soluble salt accumulation. Total nitrogen concentrations ranged between 0.151 and 0.274 g/kg, with lake soil

(S4) having the highest concentration, while S1 and S5 had lower nitrogen levels. Total phosphorus levels ranged from 0.4 to 18.0 g/kg, with agricultural soil (S2) having the highest concentration, possibly due to fertilizer application. Organic carbon concentrations ranged from 0.6 to 0.9 g/kg, with higher values in S1, S2, and S3. Overall, S2 (agricultural soil) had better fertility conditions than S1 (garbage-factory soil) and S5 (mine soil), which showed more signs of degradation, particularly in terms of nutrient depletion, acidity, and salinity.

Conclusion

The present study emphasizes the significant effects of various environmental factors and human activity on soil fertility and quality. Key physicochemical parameters, such as pH, electrical conductivity, nutrient content, organic carbon, and moisture retention, showed significant variation across agricultural, industrial, mining, lake, and waste-affected sites. While sites affected by industrial discharge, waste accumulation, and mining operations showed evidence of significant degradation, soils from agriculturally managed areas displayed relatively balanced fertility indicators. The negative consequences of unsustainable land use practices are confirmed by decreases in the content of nitrogen, phosphorus, and organic matter, as well as by increased salinity and disturbed pH levels. In order to restore and maintain soil health, these findings highlight the critical need for integrated soil conservation strategies, rehabilitation of degraded lands, and promotion of sustainable land management. To put it simply, safeguarding soil resources is not only an environmental priority but also a fundamental requirement for long-term agricultural productivity, ecological stability, and food security.

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