

Comparative Study of Physicochemical Parameters of Soil Affected by Different Land Use in Nagpur Region

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Abstract—Soil quality is a critical factor in environmental sustainability, influencing agriculture, biodiversity, and water cycles. Different land-use types, including industrial, urban, agricultural, and natural ecosystems, affect soil properties such as pH, organic carbon, electrical conductivity (EC), and heavy metal contamination. This study examines soil samples from six locations in Nagpur, analyzing key physicochemical parameters. The results show that industrial and urban soils have higher contamination levels, while agricultural soils face nutrient imbalances. The study highlights the need for sustainable soil management policies to maintain soil health.

Keywords: Soil quality, Land use, Physicochemical properties, Heavy metals, Urbanization

I. INTRODUCTION

1. Importance of Soil

Soil, often referred to as the "skin of the Earth," is a fundamental component of terrestrial ecosystems. It is a complex and dynamic mixture of minerals, organic matter, water, air, and living organisms that supports plant life and various biological processes. Soil plays a crucial role in maintaining ecological balance by facilitating water retention, nutrient cycling, and habitat formation for microorganisms. It is also essential for food security, sustainable agriculture, and environmental health. However, increasing urbanization, industrialization, and unsustainable agricultural practices have significantly impacted soil quality worldwide.

Understanding the physicochemical characteristics of soil is necessary for effective land management, environmental conservation, and agricultural productivity. The study of soil properties, including pH, organic matter content, nutrient availability, and heavy metal concentrations, helps in assessing soil health and its suitability for different land uses.

2. Soil Formation and Classification

The formation of soil, known as pedogenesis, is a slow and complex process influenced by parent material, climate, topography, biological activity, and time. Weathering of rocks, decomposition of organic matter, and interactions between physical, chemical, and biological processes contribute to soil development over thousands of years.

2.1 Soil Formation (Pedogenesis)

Soil formation, also known as pedogenesis, is a slow and complex process influenced by multiple environmental factors over thousands to millions of years. It occurs due to the interaction of geological, climatic, biological, and topographical elements. The main processes involved in soil formation include:

1. Weathering of Parent Material

Rocks and minerals break down into smaller particles through physical, chemical, and biological weathering.

Physical weathering (e.g., temperature changes, wind, water, and ice) causes fragmentation of rocks. Chemical weathering (e.g., oxidation, hydrolysis, carbonation) alters mineral composition.

Biological weathering (e.g., microbial activity, plant roots) further disintegrates rocks into finer soil particles.

2. Addition of Organic Matter

Plants and microorganisms contribute organic matter as they grow and decay.

Decomposition of dead plants, animals, and microbes enriches soil with essential nutrients, forming humus (dark organic material that improves soil fertility).

3. Leaching and Translocation

Water movement through soil layers transports dissolved minerals and nutrients.

Leaching removes soluble substances from upper layers, leading to nutrient redistribution in the soil profile.

4. Soil Horizon Development

Over time, distinct layers or horizons form within the soil profile:

O Horizon – Organic-rich top layer (humus).

A Horizon (Topsoil) – Rich in organic matter and nutrients.

B Horizon (Subsoil) – Accumulates minerals from upper layers.

C Horizon (Parent Material) – Weathered rock fragments.

R Horizon (Bedrock) – Unweathered parent rock beneath the soil.

5. Influence of Climate and Topography

Climate affects soil development through temperature, rainfall, and moisture availability.

Topography (elevation, slope, drainage) influences soil erosion, water retention, and nutrient availability.

Soils are classified based on their composition, texture, structure, and nutrient availability. In India, the Indian Council for Agricultural Research (ICAR) has categorized soils into eight major groups, including alluvial, black, red, laterite, desert, mountain, saline-alkaline, and peaty soils. Each type has distinct physical and chemical characteristics, influencing its fertility and agricultural potential.

3. Soil Types in the Nagpur Region

Nagpur, located in central India, has diverse soil types due to its varied geological and climatic conditions. The primary soil types found in the Nagpur region include:

Black Soil (Regur Soil): Formed from basaltic lava, rich in clay content, moisture-retentive, and ideal for cotton cultivation.

Red Soil: Found in high rainfall areas, iron-rich, but low in organic matter and nutrients like phosphorus and potassium.

Alluvial Soil: Found along riverbanks, rich in organic matter, with good moisture retention, supporting diverse crops.

Laterite Soil: Present in hilly regions, iron and aluminum-rich but deficient in essential nutrients, making it less suitable for intensive agriculture.

Within Nagpur, six distinct soil types—Kali, Morand, Khardi, Bardi, Kachchar, and Wardi soils—vary in texture, moisture retention, and fertility, influencing land use patterns in the region.

II. RESEARCH PLAN

The research follows a systematic approach:

1. Site Selection: Identifying sampling locations, including industrial, agricultural, and urban areas.
2. Sample Collection: Collecting soil samples from different land use zones.
3. Physicochemical Analysis: Measuring pH, electrical conductivity, moisture content, organic matter, and heavy metal concentrations using standard laboratory techniques.
4. Data Interpretation: Comparing results across different land use categories to determine the extent of soil quality degradation.
5. Conclusion: Identifying Soil Characteristics leads to Soil Pollution to control and mitigate soil pollution.

III. MATERIALS AND METHODOLOGY

1. Materials

The study involved soil sample collection and laboratory analysis using various instruments and reagents.

Glassware and Chemicals

- Glassware: Borosilicate beakers, conical flasks, test tubes, measuring cylinders, and pipettes.
- Reagents: Analytical-grade chemicals (A.R. Grade) used for pH determination, nutrient analysis, and heavy metal estimation.

Instruments and Equipment

Instrument	Purpose
Digital pH Meter	To measure soil pH
Conductivity Meter	For electrical conductivity (EC) measurement
Spectrophotometer	To analyze chemical concentrations
Flame Photometer	To determine potassium content

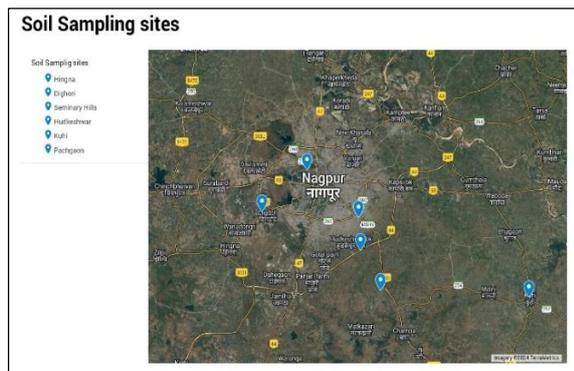
Kjeldahl Apparatus	For nitrogen estimation
Weighing Balance	For precise measurement of soil and reagents
Hot Air Oven	To dry soil samples

2. Methodology

Sampling and Site Selection

Soil samples were collected from six different locations in the Nagpur region, representing different land use types.

Sample No.	Land Use Type	Location
Soil Sample I	Industrial Site	Hingna
Soil Sample II	Construction Site	Dighori
Soil Sample III	Botanical Garden Site	Seminary Hills
Soil Sample IV	Outer Ring Road Site	Hudkeshwar
Soil Sample V	Village Site	Kuhi
Soil Sample VI	Agricultural Site	Pachgaon



Sample Collection and Preparation

- Depth of Sampling: 20 cm using a soil auger.
- Processing: Samples were air-dried, sieved (2 mm mesh), and stored in clean, labeled containers to prevent contamination.



Different Soil Samples

Physico-Chemical Analysis

Soil samples were analyzed for various physicochemical properties using standard laboratory methods.

The physico-chemical analysis of soil samples was conducted using the following standard methods:

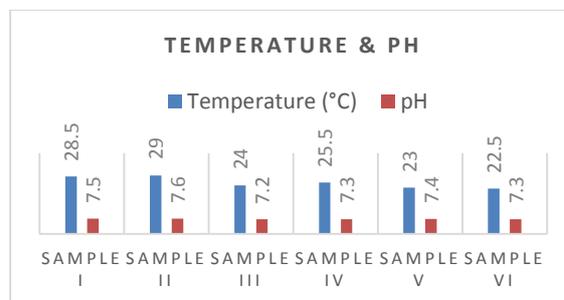
- pH Measurement: Digital pH meter method
- Electrical Conductivity (EC): Conductivity meter method
- Moisture Content: Oven drying method
- Organic Matter & Organic Carbon: Walkley-Black method
- Nitrogen (N): Kjeldahl's method
- Phosphorus (P): Spectrophotometric analysis
- Potassium (K): Flame photometry
- Heavy Metal Analysis (Fe, Ni, Zn, Cu, Pb): Atomic Absorption Spectrophotometry (AAS)

IV. RESULT AND DISCUSSION

1. Physicochemical Properties of Soil

1.1 Temperature and pH

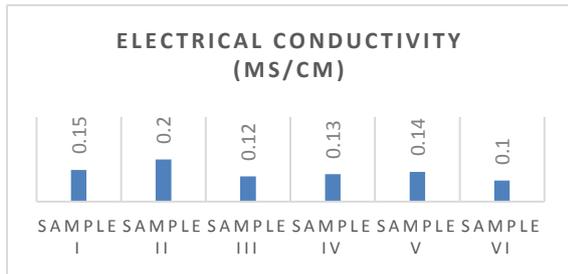
Soil temperature varied between 22.5°C (agricultural site) and 29.0°C (construction site), indicating the impact of land exposure and surrounding activities. The pH values ranged from 7.2 (botanical garden) to 7.6 (construction site), suggesting a generally neutral to slightly alkaline nature of the soils. This neutrality is favorable for plant growth but may influence nutrient availability in certain locations.



1.2 Electrical Conductivity (EC)

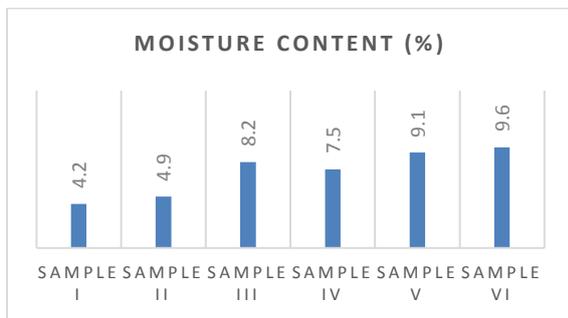
The highest EC was observed at the construction site (0.20 mS/cm), likely due to the presence of construction materials and debris affecting soil salinity. The lowest EC was recorded at the

agricultural site (0.10 mS/cm), indicating minimal salt accumulation, which is beneficial for plant growth.



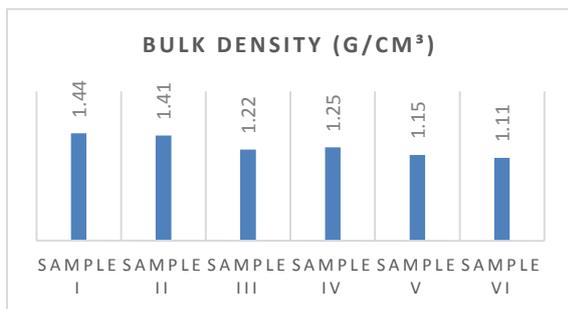
1.3 Moisture Content

Moisture content was highest in the agricultural site (9.6%), followed by the village site (9.1%), both of which are subjected to irrigation and organic matter enrichment. The lowest moisture content was observed at the industrial site (4.2%), possibly due to compaction and heat absorption from industrial activities.



1.4 Bulk Density

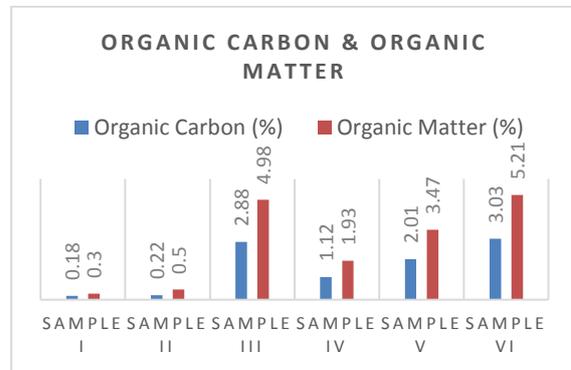
Bulk density was highest at the industrial site (1.44 g/cm³) and lowest at the agricultural site (1.11 g/cm³). Higher bulk density at the industrial and construction sites indicates soil compaction, which can negatively impact root penetration and water movement.



2. Organic Matter and Nutrient Content

2.1 Organic Carbon and Organic Matter

The highest organic carbon and organic matter were recorded at the agricultural site (3.03% and 5.21%, respectively), indicating the accumulation of plant residues and microbial activity. In contrast, the industrial and construction sites had the lowest values, suggesting degradation due to urban activities.

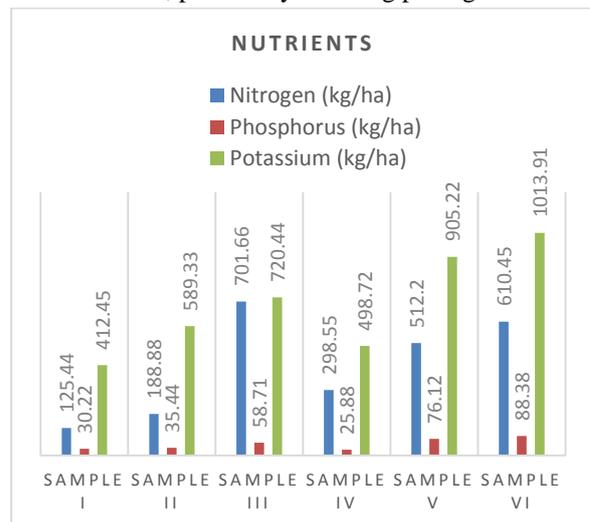


2.2 Nitrogen, Phosphorus, and Potassium (NPK)

Nitrogen: The highest nitrogen content was observed in the botanical garden (701.66 kg/ha), likely due to organic decomposition. The lowest was at the industrial site (125.44 kg/ha), possibly due to the absence of vegetative cover.

Phosphorus: The agricultural site (88.38 kg/ha) had the highest phosphorus, crucial for plant root development, while the outer ring road site (25.88 kg/ha) had the lowest.

Potassium: The agricultural site (1013.91 kg/ha) showed the highest potassium content, beneficial for crop yield, whereas the industrial site (412.45 kg/ha) had the lowest, potentially affecting plant growth.



3. Heavy Metal Contamination

3.1 Iron (Fe), Zinc (Zn), Lead (Pb), Nickel (Ni), and Copper (Cu)

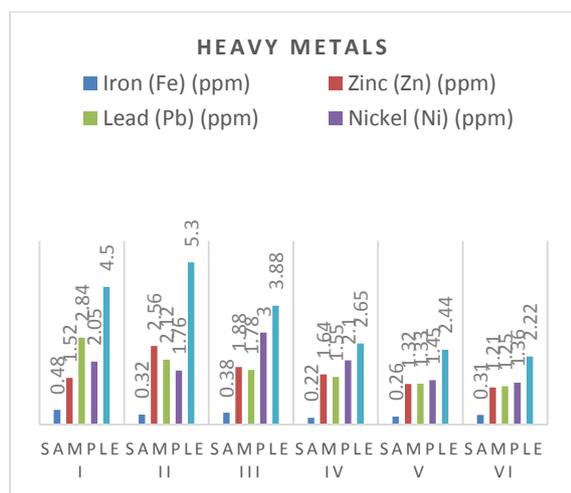
Iron levels ranged from 0.22 ppm (outer ring road) to 0.48 ppm (industrial site), with higher concentrations in industrial areas likely due to metallic waste deposition.

Zinc was highest at the construction site (2.56 ppm), indicating possible contamination from construction materials.

Lead concentrations were highest at the industrial site (2.84 ppm), which could be due to vehicular emissions and industrial waste disposal.

Nickel was most prevalent in the botanical garden (3.00 ppm), possibly from natural sources and fertilizers.

Copper was found in the highest concentration at the construction site (5.30 ppm), likely due to metal-based materials.



4. Land Use and Its Impact on Soil Quality

Industrial and Construction Sites: These areas showed low organic matter, high bulk density, and heavy metal contamination, indicating soil degradation and reduced fertility.

Botanical Garden: The soil was rich in organic carbon and nitrogen, suggesting active microbial activity and decomposition.

Agricultural and Village Sites: These areas exhibited high organic content and nutrient

availability, making them suitable for sustainable farming.

VI. CONCLUSION

The study confirms that soil properties significantly vary with land use. Industrial and urban areas show signs of soil degradation, while agricultural and green spaces maintain better soil health. Effective land management strategies, such as organic amendments, pollution control, and soil conservation practices, are essential to maintaining soil quality and fertility in urban and rural areas.

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