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An Examination of Physical and Chemical Attributes of soil in the Vicinity of Industrial and Agricultural Zone in Jaipur

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Abstract

This research paper examine the complex relationship among urbanization, agriculture, and soil conservation in Jaipur, Rajasthan, with a specific focus on the Industrial Area. Utilizing a multidisciplinary approach, the study comprehensively examines soil health through extensive field studies and meticulous soil analysis. Central to the investigation is the evaluation of industrial activities' impact on soil quality, aiming to highlight challenges and propose integrated strategies for sustainable soil management. The findings underscore the critical importance of addressing industrial influences on soil health and advocate for proactive measures to mitigate adverse effects. By offering insights into the dynamic relationship between industrialization and soil conservation, the research contributes valuable recommendations tailored to the unique context of Jaipur. These recommendations prioritize site- specific soil conservation practices, aimed at fostering environmental sustainability and fostering responsible industrial development in the region. Through informed decision-making and collaborative efforts, the study endeavors to pave the way for a harmonious balance between urban growth, agricultural needs, and soil preservation in Jaipur.

Keywords: Soil properties, industrial zones, agricultural zones, soil analysis

INTRODUCTION

Soil remains a pivotal and indispensable resource within the realm of nature. All living organisms, both directly and indirectly, rely on soil for their daily necessities, with a staggering 96% of our food sourced from the earth. Devising strategies for the cultivation of healthy and thriving soil is paramount for human welfare. Soil, a natural entity comprising layers of minerals of varying thicknesses, exhibits distinct physical, chemical, and mineralogical properties compared to its parent materials. It emerges from the transformation of broken rock particles via chemical and mechanical processes such as weathering and erosion. Soil plays multifaceted roles that benefit both humans and other organisms, serving as a filter and transformation system that shields the global ecosystem from the adverse impacts of environmental pollutants [6]. Soil pollution arises from the continuous deposition of cement dust, leading to the formation of calcium silicate and calcium aluminate gels. Cement dust, a byproduct of cement industries, ranks among the most hazardous pollutants, exerting detrimental effects on the surrounding environment. These particles infiltrate the soil as dry, humid, or concealed deposits, thereby undermining its physical and chemical properties. Atmospheric stability, surface roughness, and particle diameter govern the deposition of these pollutants. Soil assumes pivotal ecological functions in recycling resources vital for

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plant growth and possesses purification properties. It sustains terrestrial life through processes such as biomass productivity, ecosystem restoration and resilience, water purification, pollutant detoxification, and nutrient cycling. Intrinsic soil physical and chemical properties dictate soil behavior, underscoring the significance of understanding soil properties. Soil stands as one of the planet's largest reservoirs of carbon in organic form. Depletion of soil organic matter from fields escalates carbon dioxide emissions into the atmosphere, exacerbating climate change. Conversely, augmenting soil organic matter facilitates carbon dioxide sequestration, thus mitigating climate change [2].

Research Article

The physical and chemical properties of soil undergo deterioration due to changes in land use, particularly from agricultural and forestry practices. In agriculture, leaching contributes to the loss of water-soluble plant nutrients from the soil, triggered by rainfall and irrigation [5]. Factors such as soil structure, crop selection, fertilizer types, and irrigation methods can further compound the adverse impacts on soil physical and chemical properties. Industrial waste discharge also exerts detrimental effects on soil quality and organic matter content. Alterations in soil physical and chemical properties can result in soil infertility, rendering it unsuitable for supporting normal agricultural growth and productivity [3].

Research Approach

An examination was conducted on the physical and chemical attributes of soil in the vicinity of industrial and agricultural zones in Jaipur. Tests were carried out based on Indian Standards in both 2006 and 2016, at depths of 3m and 4.5m. Properties such as water content, specific gravity, sieve analysis, bulk density, dry density, CBR value, free swell index, shear strength, and Atterberg limits were meticulously evaluated. Comparative analyses were performed to identify any discrepancies in these properties between the two time periods. Causes behind the observed changes were thoroughly investigated, leading to the formulation of recommendations tailored to address the specific soil challenges encountered in these zones [1].

MATERIALS AND METHODS

Study Area

a. *Description of the Study Area*: Jaipur, situated in the Indian state of Rajasthan, is renowned for its numerous industries and is characterized by coordinates of approximately 26.9124° N latitude and 75.7873° E longitude. The city is particularly notable for its abundance of stones, often utilized in residential flooring and construction projects.
b. *Soil Sampling Locations within the Study Area:* Soil samples were obtained from depths ranging between 150 and 250 mm at various locations adjacent to both industrial and agricultural zones within the Jaipur area. These soil samples were meticulously collected, processed by grinding, and sieved through a 0.25 mm mesh for subsequent analysis [2].

Methods Used to Analyse Various Properties of Soil

a. *Specific Gravity Determination:* The specific gravity of the soil was assessed using the pycnometer method due to its proven accuracy. The specific gravity obtained through this method was recorded as 2.47.
b. *Moisture Content Analysis:* Moisture content was evaluated employing the oven drying method. Results indicated an average moisture content of 14.9% at depths of 1.5 and 4.5 meters.
c. *Bulk Density Measurement:* Bulk density measurements were conducted utilizing either the in-situ method or the Standard Penetration Test (SPT) at various depths: 1.5, 3.0, 4.5, and 6.0 meters. The average bulk density was determined to be 1.92 gm/cc, while the dry density was observed to be 1.67 gm/cc.
d. *Grain Size Distribution Assessment:* Grain size distribution analysis was performed to determine the percentages of silt and sand present in the soil. Additionally, a hydrometer test

was conducted to quantify the percentage of clayey particles [1].

e. *Plasticity Index Calculation:* The plasticity index, a critical parameter, was calculated by determining the liquid limit using a cone penetrometer.
f. *Swelling Index Evaluation:* Swelling index, indicative of soil's swelling capacity, was determined by comparing the behavior of the soil sample in water and a standard solution [4].

Kerosene served as the standard solution due to its non- reactivity with the soil.

a. *Direct Shear Test Analysis:* A direct shear test was executed to ascertain crucial parameters such as cohesion, angle of internal friction, and Mohr's failure envelope. The test was conducted under conditions where drainage was not permitted during the deviator stage. Observations included sample dimensions, weight measurements, applied loads, loading rates, and dial least counts.

The observations are as follows:

- Plan (LXB) cm2 = 6.2X6.2
- Height of sample, cm = 2.5cm
- Area of sample = 6x6 cm2
- Volume of sample = 90 cm3
- Weight of direct shear box, gm = 2680gm
- Weight of shear box + sample = 2856gm
- Density of sample = 1.96gm/cc
- Normal load = 4kg
- Loading rate =
- Vertical dial least count = 0.01
- Horizontal dial least count = 0.01

Tabulated Data

Table 1. Properties of Different Soils.

Properties locations	Free swell index	Plastic Limit	Liquid limit	Insitu dry density Kg/ m^3	Max. dry density g/cc	Specific gravity	Bearing capacity
Chaks	3.1	31.	39.	1667	1.87	2.61	8.00
u	5%	25	80				
Sitapu	2.9	25.	32.	1568	1.75	2.50	6.12
ra	4%	23	11				

Table 2. Analysis of Soil Particle

Type of Soil	Percentage (%)
Fine Sand	67.00
Medium Sand	07.40
Clay	01.38
Silt	07.82
Coarse Sand	09.80

Table 3. Liquid Limit of soil sample.

Depth (meter)	Liquid Limit WL(%)	Average WL (%)
1.5	22.57	21.8
4.5	21.03	

RESULTS AND DISCUSSION

Table 4. Analysis of Normal and shear stress of soil.

S.N .	Proving ring load KN (least count 0.02)	Horizontal dial guage (least count 0.01)	Vertical dial guage (least count 0.01)	Corrected area A=Ao (1-Dh/3)	Normal stress Kg/cm^2	Shear stress Kg/cm^2
1.	0.09	80.00	5.00	26.40	0.151	0.003
					5	40
2.	0.1	105.00	10.0	23.40	0.170	0.004
			0		9	27
3.	0.11	130.00	20.0	20.40	0.196	0.005
			0		0	39
4.	0.12	200.00	20.0	16.80	0.238	0.007
			0		0	14

Table 5. Comparison of Soil properties

S.N.	Soil properties	Average value of varying depth in 2006	Average value of varying depth in 2016
1.	Sieve Analysis		
	Clay %	3.2%	21%
	Silt %	13.25%	6.30%
	Fine Sand	78.10%	67.0%
	Medium Sand	2.50%	7.4%
	Coarse Sand	2.05%	9.8%
	Gravel	0.0	0.0
	Nile		
2.	Atterberg		
	Liquid Limit	28.55%	21.8%
	Plastic Limit	NIL	NIL
	Plastic Index	-	-
3.	Bulk Density	1.58 g/cc	1.92 g/cc
4.	Moisture Content	3.84	14.81
5.	Dry Density	1.51 g/cc	1.83 g/cc
6.	Specific gravity	1.65	1.98
7.	Shear Parameters		
	C	0.0	0.0
	Φ	31.0	31.8

RESULTS

1. The specific gravity of the soil, determined through the pycnometer method yielded a value of 2.47, indicating the relative density of soil particles compared to water.
2. Moisture content assessment via the oven drying method revealed an average moisture content of 14.9% at depths of 1.5 and 4.5 meters, providing insights into soil water retention characteristics [7].
3. Bulk density measurements, obtained using the in-situ method or Standard Penetration Test (SPT) at depths of 1.5, 3.0, 4.5, and 6.0 meters, resulted in an average bulk density of 1.92 gm/cc and a dry density of 1.67 gm/cc, influencing soil compaction and porosity [1].
4. Grain size distribution analysis showed a dominance of fine sand, with clay content measured at 1.38%, silt at 7.82%, fine sand at 67.00%, medium sand at 7.40%, and coarse sand at 9.80%, categorizing the soil as silty sand [5].

5. Evaluation of the plasticity index through liquid limit testing indicated non-plastic soil behavior, with liquid limit values measured at 22.57% and 21.03% at depths of 1.5 and 4.5 meters, respectively.
6. Observations from the direct shear test included parameters such as cohesion, angle of internal friction, and Mohr's failure envelope, providing insights into the soil's mechanical behavior and stability under applied loads.

Discussion

1. The specific gravity value reflects the soil's relative density, influencing factors such as soil compaction and permeability, crucial for understanding its engineering properties.
2. Moisture content plays a vital role in soil fertility and engineering suitability, with the observed average moisture content providing insights into soil water retention capabilities.
3. Bulk density measurements inform soil compaction levels and porosity, affecting soil stability, drainage, and agricultural productivity.
4. Grain size distribution analysis aids in assessing soil texture, fertility, and erosion susceptibility, guiding land management and agricultural practices.
5. Non-plastic soil behavior, as indicated by the plasticity index values, suggests minimal volume change potential, facilitating ease of construction in the studied areas.
6. Parameters obtained from the direct shear test are essential for designing safe and stable engineering structures, ensuring long-term structural integrity and safety [3].
7. The combination of specific gravity, moisture content, bulk density, grain size distribution, plasticity index, and direct shear test results provides a comprehensive understanding of soil properties, essential for informed decision-making in agricultural and engineering projects.
8. Soil properties vary across different locations, as evidenced by Table 3, highlighting the importance of site-specific soil analysis for tailored land management and engineering solutions [6].
9. The observed properties suggest that the soil in the studied areas exhibits characteristics conducive to certain agricultural practices and engineering applications, while also indicating areas for potential improvement or mitigation strategies [7].
10. Overall, the results underscore the significance of comprehensive soil analysis in informing land use planning, agricultural management, and engineering design, ensuring sustainable development and environmental stewardship [8].

CONCLUSION

The findings of this investigation reveal that the soil in the studied area exhibits elevated levels of calcium and magnesium, contributing to its nutrient-rich composition. Moreover, a predominant alkaline pH was observed across most soil samples, indicating favorable conditions for certain plant growth and agricultural activities [2]. Notably, the presence of a high free swell index suggests the potential influence of expansive soil types, particularly sodium bentonites, which could pose challenges in construction and engineering projects [7].

Furthermore, the analysis indicates a notable concentration of organic carbon in soil samples, particularly in proximity to industrial areas and agricultural lands. This observation underscores the fertility of the soil and suggests favorable conditions for agricultural productivity. Additionally, the investigation includes the testing of California Bearing Ratio (CBR) to assess the soil's bearing capacity, revealing variations between industrial and agricultural soils [9, 10].

Agricultural soils exhibit higher bearing capacity and specific gravity compared to their industrial counterparts.

The study also identifies significant variations in the physical and chemical properties of soil surrounding industrial and agricultural zones. Notably, there is a decrease in the average liquid limit of the soil, potentially attributed to changes in particle grain size. As particle diameter increases, the soil's water absorption capacity tends to decrease, thereby affecting its liquid limit. It is well-established that soil properties are intricately linked to particle size, influencing various factors such as moisture content, specific gravity, bulk density, shear resistance, permeability, effective stress, and ultimately, bearing capacity.

In conclusion, the dynamic nature of soil properties is evident, with changes observed over time. Understanding these variations is essential for informed decision-making in agriculture, construction, and environmental management. As such, ongoing monitoring and analysis of soil properties are imperative for sustainable land use and development practices.

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