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Deciphering the spatial variability of soil texture and bulk density in pollution hotspots across the Kashmir Valley

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Abstract
The present study investigates the physical soil characteristics within pollution hotspots across the picturesque Kashmir Valley. Soil texture and bulk density influencing nutrient availability and heavy metal behaviour, were examined at five distinct locations. The analysis revealed that soil texture ranged from silty clay loam to clay loam, with varying sand, silt, and clay percentages at each site. Notably, location 3 (Khrew) exhibited sandy clay loam texture, while the remaining areas displayed clay loam characteristics. Bulk density, a crucial factor affecting soil properties, exhibited substantial variation among the locations. The values ranged from 1.23 to 1.42 g cm^{-3} at location 1 (Lassipora), from 1.24 g $cm^{-3}$to 1.79 g cm^{-3} at location 2 (Pampore), from 1.27 g cm^{-3} to 1.43 g cm^{-}at location 3 (Khrew), from 1.26 g cm^{-3} to 1.49 g cm^{-3} at location 4 (Srinagar), and from 1.27 g cm^{-3} to 1.37 g cm^{-3} at location 5 (Budgam). These variations could be attributed to differences in soil organic matter content, with areas exhibiting higher organic matter content generally displaying lower bulk density values. The finding of present study provides valuable insights into the soil physical properties of pollution-affected regions in the Kashmir Valley, shedding light on their potential impact on nutrient availability and heavy metal behaviour. Additionally, the present research findings contribute to the understanding of soil dynamics in polluted environments and offers essential information for sustainable land management practices.

Keywords: Soil, texture, bulk density, pollution, Kashmir

Introduction

Analysing soil properties, such as texture and bulk density, is crucial for comprehending soil fertility, nutrient availability, and its capacity to retain or release pollutants. In areas impacted by industrialization, urban development, and pollution, soil quality can undergo significant changes, posing risks to the environment and human health. The disruption of soil's essential functions and the threat of degrading its quality are universal concerns (Golia *et al*., 2019) [6]. Soil acts as a bridge for organic pollutants (Karpouzas *et al*., 2007) [8] and the transfer of heavy metals from cultivated plants to humans (Khum in *et al*., 2020) [9]. The accumulation of these metals in the food chain increases potential health risks (Yang *et al*., 2020) [18].

Heavy metals, being non-biodegradable and resistant to thermal degradation, accumulate in the environment over time, reaching toxic levels in soil due to prolonged exposure to wastewater (Sharma *et al*., 2013) [14]. Many countries have initiated programs to monitor, control, or limit heavy metal release into the soil (Sidhu *et al*., 2017) [15]. Rehabilitating ecosystems affected by heavy metal contamination, caused by rapid industrialization, intensive agriculture, improper mining practices, and waste disposal, has become a significant global challenge (Bhatti *et al*., 2018) [2].

The Kashmir Valley, situated in the northern part of the Indian subcontinent, boasts stunning landscapes and a rich agricultural heritage. However, like many regions worldwide, it is not immune to the consequences of rapid urbanization and industrialization. These processes often lead to alterations in soil composition and structure, which can have far-reaching implications for land use and environmental sustainability. The present study aims to address the gap in our understanding of soil properties in pollution hotspots within the Kashmir Valley. Specifically, we focus on soil texture and bulk density, two critical factors that influence soil functionality and resilience in the face of environmental stress.

Soil texture, determined by the proportions of sand, silt, and clay, impacts water retention, aeration, and nutrient availability (Mantovi *et al*., 2003; Francois *et al*., 2004) [10, 5]. Bulk density reflects soil compaction and organic matter content, influencing root growth, water movement, and overall soil health (Sharma *et al*., 2013; Masrat *et al*., 2017) [14]. Understanding the spatial distribution of soil properties in pollution-affected areas is essential for sustainable land management and environmental conservation. Through an analysis of soil texture and bulk density variations across different pollution hotspots in the Kashmir Valley, the present study aims to offer valuable insights into the challenges and opportunities for sustainable land use in the region.

Materials and Methods

Study Area

The present study was conducted in five pollution hotspots in the Kashmir region of Jammu and Kashmir, India, namely Khrew, Pampore, Lassipora, Srinagar, and Budgam. Khrew, a densely populated urban area known for its industrial activities, served as a representative of soil pollution dynamics. Pampore, on the other hand, is an agricultural hub facing unique challenges due to agricultural runoff and pesticide use. Lassipora, an industrial estate, was selected to investigate the impact of concentrated industrial emissions on soil quality. Srinagar, the capital city of the region, represented the complex dynamics of an urban center, with a mix of industrial, vehicular, and residential pollution sources. Finally, Budgam, a semi-urban area, offered insights into soil pollution patterns in transitional zones between urban and rural environments, providing a comprehensive view of the entire spectrum of pollution-related challenges faced in the Kashmir region. These five diverse pollution hotspots collectively formed a robust study area, allowing for a holistic examination of the effects of heavy metals on the physical properties of the soil.The location of the study area is depicted in Figure 1.

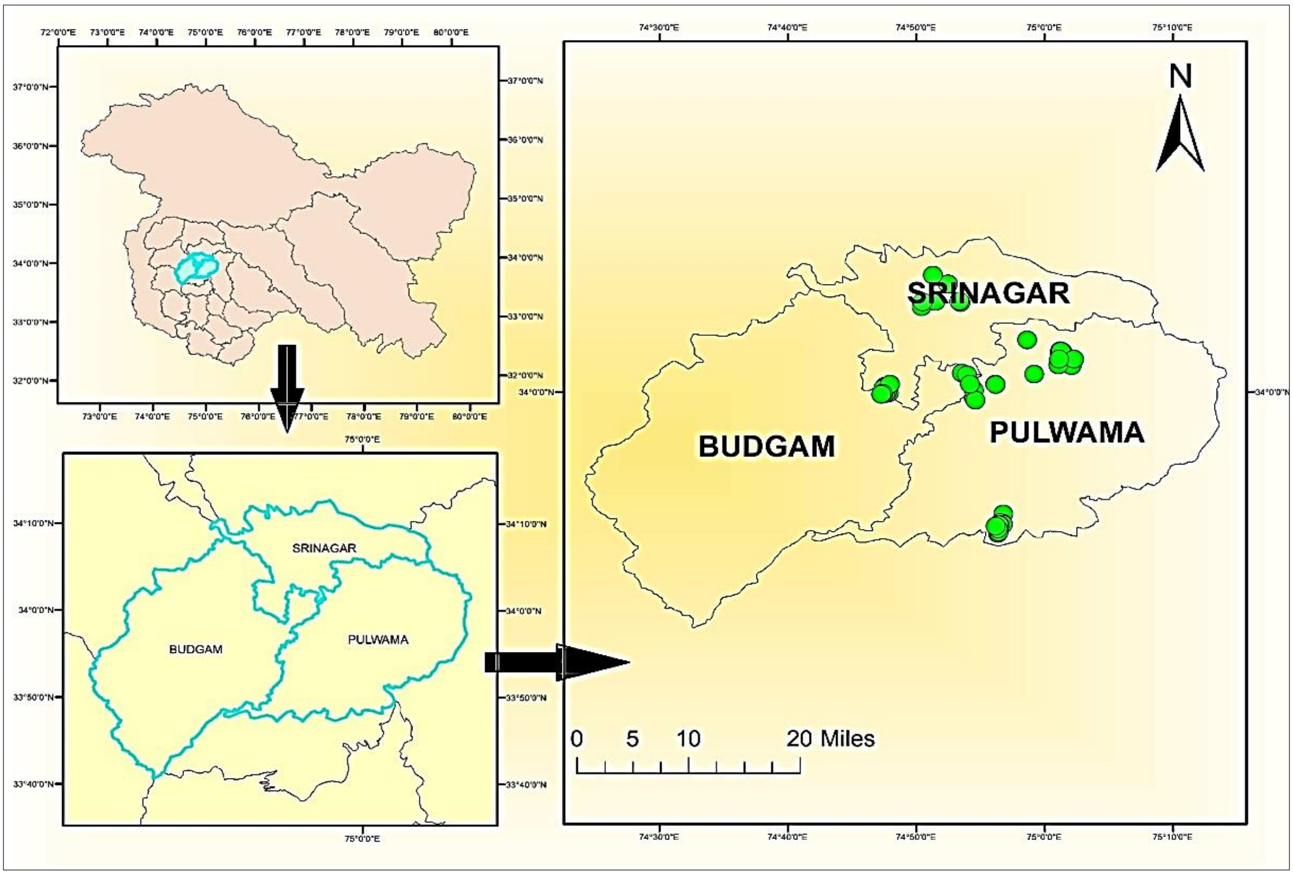

Fig 1: Study Area Map

Experimental design

For performing the research work, purposive random sampling method was followed and the samples were collected accordingly. For each location, 10 samples were collected. Purposive random soil samples were collected up to a depth of 0-20 cm from all the selected sites under different land-use systems as per standard procedure. The samples were stored in cloth bags after necessary processing for analysis of soil physical properties.

Preparation and processing of soil samples

The soil samples were air dried and then crushed with a wooden pestle and mortar. The crushed samples were then sieved through 2 mm sieve and stored in plastic bottles for analysis in laboratory.

Soil sample analysis

Particle size distribution

The particle size analysis was done by Hydrometer method as described by Bouyoucus, 1962 [3]. Through the help of Bouyoucus hydrometer mechanical composition of soil (2mm size) was determined. The percentage composition of clay, sand and silt was obtained with the help of this analysis. With the help of international triangular chart, the different textural classes were determined.

Bulk Density

The bulk density of the soil samples was determined by tapping method (Jalota *et al*. 1998) [7]. Powdered soil sample small enough to pass through a 1.0 mm sieve was taken and allowed to flow freely into the measuring vessel (cylindrical) until it overflowed from it. From the top of vessel, the excess soil was scrapped. The weight of the vessel was determined and accordingly the weight of soil in it was evaluated by subtracting the weight of empty vessel to that of soil laden vessel. The bulk density was then calculated using the formula W_0 /100 and the average of 3 determinations using 3 different samples was obtained.

Results

Particle size distribution

The soil texture under different pollution hot spots varied from silty clay loam to clay loam. Total sand content ranged from 34.69 to 46.01 percent with a mean value of 41.18 at location-1 (Lassipora), from 32.14 to 36.81 percent with a mean value of 34.45 at location- 2 (Pampore), from 64.10 to 71.80 percent with a mean value of 67.38 at location- 3 (Khrew), from 33.52 to 54.16 percent with a mean value of 41.23 at location- 4 (Srinagar) and from 31.67 to 42.23 percent with mean value of 35.38 at location- 5 (Budgam).

The values of silt percent ranged from 24.33 to 32.88 with a mean value of 28.02 at location -1 (Lassipora), from 28.74 to 30.88 percent with a mean value of 29.66 at location- 2 (Pampore), from 7.80 to 19.56 with a mean value of 12.09 at location -3 (Khrew), from 19.54 to 30.55 with a mean value of 26.93 at location- 4 (Srinagar) and from 27.14 to 31.45 with a mean value of 29.39at location- 5 (Budgam).

The **v**alues of clay percent ranged from 26.33 to 35.53 with a mean value of 30.80 at location 1, 34.45 to 36.98 with a mean value of 35.79 at location 2, 15.60 to 27.50 with a mean value of 20.53 at location 3, 26.30 to 35.93 with a mean value of 31.84 at location 4 and 30.63 to 37.96 with a mean value of 35.24 at location 5.The data revealed that the average soil texture at location 1 was clay loam, at location 2 was clay loam, at location 3 was sandy clay loam, at location 4 was clay loam and at location 5 was clay loam.

Bulk density

The soil bulk density showed considerable variation among different pollution hotspots with values ranging from 1.23 to 1.42 g cm^{-3} with a mean value of 1.33 g cm^{-3} at location-1, from1.24 to 1.79 g cm^{-3} with a mean value of 1.44 g cm^{-3} at location-2, from 1.27 to 1.43 g cm^{-3} with a mean value of 1.36 g cm^{-3} at location-3, from 1.26 to 1.49 g cm^{-3} with a mean value of 1.40 g cm^{-3} at location-4, from 1.27 to 1.37 g cm^{-3} with a mean value of 1.33 g cm^{-3}at location-5**.**The soil at location 5 had the minimum mean bulk density and that at location 2 the maximum.

Table 1: Descriptive statistics of physical parameters at location-1 (Lassipora), location-2 (Pampore) and location-3 (Khrew).

Locations	Parameters	Mean	Standard Error	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum	CV%
	BD	1.33	0.02	0.07	-1.52	-0.22	1.23	1.42	5.08
Location-1	Sand (%)	41.18	1.18	3.72	-0.42	-0.57	34.69	46.01	9.02
(Lassipora)	Silt (%)	28.02	0.79	2.49	0.69	0.28	24.33	32.88	8.88
	Clay (%)	30.80	0.86	2.72	0.33	0.52	26.33	35.53	8.82
	BD	1.44	0.05	0.14	4.69	1.64	1.24	1.79	9.98
Location-2	Sand (%)	34.45	0.46	1.46	-0.76	0.09	32.14	36.81	4.25
(Pampore)	Silt (%)	29.66	0.23	0.74	-1.43	0.22	28.74	30.88	2.49
	Clay (%)	35.79	0.25	0.81	-0.87	-0.17	34.45	36.98	2.25
	BD	1.36	0.02	0.05	-0.42	-0.47	1.27	1.43	3.66
Location-3	Sand (%)	67.38	0.75	2.37	-0.08	0.20	64.10	71.80	3.52
(Khrew)	Silt (%)	12.09	1.09	3.43	1.35	1.06	7.80	19.56	28.37
	20.53	1.29	4.08	-0.62	0.55	15.60	27.50	19.86	20.53
	BD	1.40	0.02	0.08	0.08	-0.87	1.26	1.49	5.55
Location-4	Sand (%)	41.23	1.82	5.74	2.67	0.95	33.52	54.16	13.93
(Srinagar-	Silt (%)	26.93	0.97	3.06	3.95	-1.51	19.54	30.55	11.36
Dal)	Clay (%)	31.84	0.91	2.87	0.58	-0.31	26.30	35.93	9.01
	BD	1.33	0.01	0.03	-1.06	-0.35	1.27	1.37	2.61
Location 5	Sand (%)	35.38	1.28	4.04	-0.97	0.96	31.67	42.23	11.41
(Budgam)	Silt (%)	29.39	0.50	1.59	-1.54	-0.36	27.14	31.45	5.41
	Clay (%)	35.24	0.83	2.63	-0.84	-0.90	30.63	37.96	7.47

Discussion

Particle size distribution

It is a basic soil property which affects cation exchange capacity, nutrient supplying power, water holding capacity and aeration of soils, thereby affecting the behaviour of heavy metal ions in soil. (Mantovi *et al*., 2003; Francois *et al*., 2004) [10, 5] suggested that coarseness or fineness of a soil governs the level and availability of plant nutrients including heavy metals. The clay content ranged from 15.60% to 37.96% in different pollution hot spot soils(Table 1). Similar results were found by Finzgar *et al*. (2014) [4] who revealed that clay content varied between 9.3- 35.9% in Mezica valley soils. Wani *et al*. (2014) [17] while studying nutrient status of Kupwara soils recorded clay content varying from 20.8 to 36.5% with a mean value of 33.2%. Similar results were reported by Ramzan *et al*. (2014) [13] on the clay content of the soils of Kashmir Himalayas. The findings are also supported by the research of Wani*et al*. (2010) [16].

Bulk density

Upon the study of data as presented in the (Table 1) showed that the bulk density ranged from 1.23 to 1.42 g cm^{-3}, 1.24 to 1.79 g cm^{-3}, 1.27 to 1.43 g cm^{-3}, 1.26 to 1.49 g cm^{-3} and 1.27 to 1.37 g cm^{-3} at location-1, location-2, location-3, location-4 and location-5, respectively. The higher soil organic matter content may be the reason for lower values of bulk density in these areas. The reason for higher bulk density observed in some locations may due lesser organic matter present, its continuous removal with little or no further addition and compaction of soils under such conditions. Results obtained are in conformity with those observed by Sharma *et al*. (2013) [14], Maqbool *et al*. (2017) [11], Osakwe and Igwe (2013) [12], and Ali *et al*. (2014) [1].

Conclusion

The findings of present study illuminatethe soil dynamics within pollution hotspots across the Kashmir Valley. Notably, soil texture and bulk density exhibited substantial variability across the five locations. Soil texture ranged from silty clay loam to clay loam, with the sandy clay loam texture being a unique feature at location 3 (Khrew). Bulk density ranged widely, influenced by organic matter content, with lower values indicating healthier soils.These findings underscore the importance of site-specific soil management strategies to address local challenges. Sustainable land use practices should consider soil properties to promote environmental sustainability and agricultural productivity. By doing so, this research contributes valuable insights into effective land management in pollution-affected areas.

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