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Variability in soil properties under heavy metal contamination in diverse temperate locations in the Kashmir Valley

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Abstract
The study was conducted in the ecologically diverse Kashmir Valley, nestled in the northernmost part of the Indian subcontinent. The choice of study locations, encompassing Khrew, Pampore, Lassipora, Srinagar and Budgam, was meticulously guided by the identification of potential heavy metal hotspots, meticulously considering the unique geological, environmental, and anthropogenic characteristics inherent to each area. The research findings revealed a broad range of pH values spanning from 5.91 to 8.27. Location 5 (Budgam) exhibited the lowest mean pH, whereas location 3 (Lassipora) showcased the highest. Electrical conductivity exhibited a similar pattern, fluctuating between 0.04 $dSm^{-1}$and 0.40 dSm^{-1}, with location 3 (Lassipora) displaying the lowest mean and location 5 (Budgam) the highest. Organic carbon content exhibited substantial variability, with the lowest mean of 0.75 percent recorded at location 3 (Lassipora) and the highest, at 1.62 percent, observed at location 5 (Budgam).These research findings provide invaluable insights into the intricate tapestry of soil chemical properties and the presence of heavy metal hotspots within the Kashmir Valley and hold significant implications for devising sustainable environmental health and management strategies in this region renowned for its ecological diversity.

Keywords: Soil, chemical, properties, Kashmir, environment

Introduction

Soil plays a pivotal role within the intricate Earth ecosystem, wielding significant influence over the intricate dance of biogeochemical cycles. Beyond its fundamental ecological role, soil serves as a wellspring of essential goods, services, and resources indispensable to humanity's existence (Smith *et al*., 2001; Brevik *et al*., 2015) [16, 2]. The soil's composition, however, can exhibit variances induced by the presence of various chemical constituents and heavy metals, resulting in soil contamination. The issue of heavy and trace elements in the soil ecosystem has burgeoned into a global concern, transcending both private and governmental spheres of interest. This heightened attention arises from the realization that soil constitutes an integral component of rural and urban landscapes alike. Furthermore, the presence of heavy metals introduces grave health concerns, encompassing carcinogenic and non-carcinogenic effects stemming from direct dermal contact, inhalation, and ingestion (Sieghardt *et al*., 2005) [15].

The Kashmir Valley, situated in the northernmost region of the Indian subcontinent, is renowned for its breathtaking landscapes, rich cultural heritage, and ecological diversity (Pandit and Bhardwaj 2017) [14]. The selection of this unique and captivating region as the focal point of present study is motivated by the need to better understand and assess environmental conditions in an area with distinct characteristics and challenges (Nazir *et al*., 2015) [12]. The Kashmir Valley's diverse topography, ranging from verdant meadows to towering peaks, presents a mosaic of land uses, each with its own implications for soil quality and health (Chowdhury *et al*., 2021) [3]. Furthermore, the presence of industrial centers, like Lassipora, juxtaposed with historically and culturally significant locales like Khrew, introduces complexities that demand in-depth investigation (Najeeb *et al*., 2019) [11].

The concept of "heavy metal hotspots" underscores the environmental challenge facing this region. Heavy metals, including cadmium, lead, and chromium, can accumulate in soils due to various sources such as industrial emissions, agricultural practices, and atmospheric deposition (Khan *et al*., 2018) [10].

These pollutants can exert adverse effects on soil quality, plant health, and ultimately, human well-being through the food chain (Pandey *et al*., 2020) [13]. Recognizing the potential environmental and health hazards associated with heavy metals, the present study endeavours to identify and characterize such hotspots within the Kashmir Valley. The findings of present study will contribute to our understanding of the intricate interplay between geological, environmental, and anthropogenic factors in shaping soil properties in the Kashmir Valley. Additionally, it serves as a valuable resource for future research endeavours and environmental management strategies in this ecologically diverse and significant region.

Materials and Methods

Study area

The present study was conducted within the captivating and ecologically diverse Kashmir Valley, which is situated in the northernmost region of the Indian subcontinent. The selection of the study area was guided by the identification of possible heavy metal hotspots, taking into account the region's distinct geological, environmental, and anthropogenic characteristics. The study locations included Khrew, Pampore, Lassipora, Srinagar, and Budgam, each carefully chosen due to their unique attributes. Khrew is renowned for its historical and cultural significance, Pampore is famously known as the "Saffron Town of Kashmir," Lassipora serves as a prominent industrial center, Srinagar functions as the capital city, and Budgam occupies a central position within the region. These diverse locations represented a wide spectrum of land uses and potential sources of pollutants.

Collection of soil samples

To ensure a comprehensive data collection process, a purposive random sampling approach was employed, resulting in the acquisition of 10 soil samples from each location at a depth of 0-20 cm. Precise geographical coordinates, encompassing latitude and longitude, were diligently documented for every sample site, significantly enhancing the study's capacity to evaluate soil chemical parameters and their potential environmental ramifications across this multifaceted geographical expanse.The description of the locations is presented in Table 1.

Table 1: Description of the Hotspot locations

Location number	Location Name
Location 1	Lassipora
Location 2	Pampore
Location 3	Khrew
Location 4	Srinagar – Dal adjoining
Location 5	Budgam – Rangreth adjoining

Soil Sample Preparation and Analysis

The soil samples underwent a systematic preparation process. Initially, they were air-dried and subsequently pulverized using a wooden pestle and mortar. These crushed samples were then filtered through a 2 mm sieve and preserved in plastic containers, earmarked for laboratory analysis. Additionally, a portion of each sample was further sifted through a 0.5 mm sieve and stored separately for the determination of organic carbon content.

Soil pH Measurement

Soil pH levels were assessed in a 1:2.5 soil-to-water suspension, following the methodology outlined by Jackson (1973) [6]. Approximately 20 grams of processed soil samples were taken and transferred to 100 ml beakers. To this, 50 ml of water was added and stirred thoroughly with a glass rod for approximately half an hour. Subsequently, a glass electrode pH meter was employed. Following the warming period of 10-30 minutes, the galvanometer pointer was calibrated to zero. The pH meter was then adjusted using buffer solutions of pH 4, 7, and 9.2, and the pH readings of the soil suspension were recorded after calibration to the desired pH level using an appropriate buffer solution.

Electrical Conductivity Measurement

The electrical conductivity of the soil water extract (1:2.5 ratio) was measured using a conductivity meter, following the procedure outlined by Jackson (1973) [6]. The temperature setting of the conductivity meter was adjusted, and the cell was connected to the meter. The same soil suspension employed for pH determination, after a resting period of more than 12 hours, was used for the conductivity assessment. The conductivity cell was immersed in the test solution, and the conductivity meter was calibrated until the observed shadow was at its widest. The readings on the scale were then duly recorded.

Soil Organic Carbon Analysis

Soil organic carbon content was determined utilizing the Walkley and Black method (1934) [18]. Two grams of soil were oxidized through a mixture of potassium dichromate and concentrated sulphuric acid, capitalizing on the heat generated during sulphuric acid dilution. The remaining potassium dichromate was titrated back with ferrous ammonium sulphate, in the presence of diphenylamine as an indicator.

Results

Soil Reaction

The soil pH at location-1 ranged from 5.91 to 7.23 with a mean value of 6.43 (Table 2). pH observed at Location-2 varied from 6.25 to 6.80 with a mean value of 6.48 (Table 2). The soil samples of the location-3 exhibited the pH values ranging from 6.85 to 8.27 with a mean value of 7.55 (Table 2). In the soils at location-4 pH values ranged from 6.11 to 7.32 with a mean value of 6.70 (Table 2) and at location-5 ranged from 5.91 to 7.23 with a mean value of 6.43 (Table 2). The data pertaining to soil reaction at different pollution hotspots revealed lowest mean pH value at location 5 and highest mean value of pH at location.

Table 2: Descriptive statistics for the chemical parameters of soil at various hotspot locations in the Kashmir region.

Location	Parameters	Mean	Standard Error	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum	CV%
Lassipora	pH	6.43	0.15	0.46	-1.08	0.54	5.91	7.23	7.22
	EC (dSm^{-1})	0.29	0.02	0.07	-1.56	0.24	0.19	0.40	25.60
	OC (%)	1.20	0.06	0.19	-0.43	1.08	1.01	1.55	16.28
Pampore	pH	6.48	0.05	0.15	1.24	0.57	6.25	6.80	2.37
	EC (dSm^{-1})	0.19	0.03	0.09	-0.98	-0.08	0.04	0.32	48.69
	OC (%)	1.62	0.04	0.13	-1.74	0.12	1.45	1.79	7.74
Khrew	pH	7.55	0.30	0.95	6.33	-2.40	5.05	8.27	12.57
	EC (dSm^{-1})	0.20	0.03	0.09	-1.09	0.59	0.10	0.35	45.00
	OC (%)	0.75	0.06	0.18	-0.77	0.28	0.51	1.03	23.74
Srinagar (Dal adjoining)	pH	6.70	0.13	0.42	-1.29	0.26	6.11	7.32	6.31
	EC (dSm^{-1})	0.29	0.03	0.09	0.49	-1.00	0.12	0.40	28.96
	OC (%)	1.30	0.06	0.20	-0.73	0.11	1.01	1.60	15.48
Budgam (Rangreth adjoining)	pH	6.43	0.15	0.46	-1.08	0.54	5.91	7.23	7.22
	EC (dSm^{-1})	0.29	0.02	0.07	-1.56	0.24	0.19	0.40	25.60
	OC (%)	1.62	0.08	0.27	-0.93	-0.63	1.18	1.97	16.35

Electrical conductivity
The soil electrical conductivity ranged from 0.19 dSm^{-1} to 0.40 dSm^{-1} with a mean value of 0.29 dSm-1 at location-1 (Table 2), 0.04dSm^{-1} to 0.32 dSm^{-1} with a mean value of 0.19 dSm^{-1} at location-2 (Table 2), 0.10 dSm^{-1} to 0.35 dSm^{-1} with a mean value of 0.20 dSm^{-1} at location-3 (Table 2), 0.12dSm^{-1} to 0.40 $dSm^{-1}$with a mean value of 0.29 dSm^{-1} at location-4 (Table 2) and at location-5, it varied from 0.19 $dSm^{-1}$to 0.40 $dSm^{-1}$with a mean value of 0.29 dSm^{-1} (Table 2). Location 3 recorded the minimum mean soil electric conductivity value and location 5 the maximum mean value.

Organic Carbon
Soil organic carbon varied considerably among different pollution hotspots with values ranging from 1.01 to 1.55 percent with a mean value of 1.20 percent at location-1, 1.45 to 1.79 percent with a mean value of 1.62 percent at location-2, 0.51 to 1.03 percent with a mean value of 0.75 percent at location-3, 1.01 to 1.60 percent with a mean value of 1.30 percent at location-4 and 1.18 to 1.97 percent with a mean value of 1.62 percent at location-5.Lowest average soil organic carbon content percent was found at location 3 and the highest at location 5 (Table 2).

Discussion
Soil reaction
The pH of the soils of different pollution hotspots ranged from a minimum value of 6.36 to a maximum value of 7.55, Table (1-5). The low pH value noticed in some soils may be ascribed to leaching of soluble salts and higher content of organic matter that lowers down pH by releasing organic acids. Jayashree and Sarma (2012) [19] who studied the soil saround industrial zone Eastern Guwahati Assam, found out the soil pH in the range of [6.5-7.5] for almost all the samples. Similar results in line with the findings of this study were reported by Finzar *et al*. (2008) [4], who found out that pH varied from 6.4 to 7.4 in Mezica valley soils. Bhat (2009) [1] found a pH range of 4.8 to 7.4 in soils of Kashmir under different cropping sequences. The alkaline nature of the soils around cement factories can also be ascribed to presence of calcium carbonate accumulation in the vicinity of cement factories.

Electrical conductivity (EC)
The data presented in table (1-5) revealed electrical conductivity values of 0.19 to 0.40, 0.04 to 0.32, 0.10 to 0.35, 0.12 to 0.40 and 0.19 to 0.40 dSm^{-1} at location-1, location-2, location-3, location-4 and location-5 soils, respectively. Electrical conductivity was within normal limits. Similar results were achieved by Shrivastava and Kumar (2015); Jalali *et al*. (2006) [7] and Inam *et al*. (2000) [5].

Organic carbon
Perusal of data (Table 1-5) showed that organic carbon percent ranged from 1.01 to 1.55%, 1.45 to 1.79%, 0.51 to 1.03%, 1.01 to 1.60% and 1.18 to 1.97% at location-1 location-2, location-3, location-4 and location-5, respectively. The reason for lower organic carbon may be due to the less vegetative cover on the locations, rocky cover of the area, sloppy area and faster degradation of organic matter with little or no addition of organic manures. The reason for higher content may be due to incorporation of organic matter through leaf litter, decayed organic matter from grass and other vegetation. These readings are in consistence with the findings of Khajuria, *et al.* (2010) [9], who found out a variation of soil organic content from 1.25-8.78 g kg^{-1} irrespective of the location. Kaushik (2013) [8] also found out that organic carbon content of soil varied from 2.26-4.18 g kg^{-1} around industrial areas.

Conclusion
The findings of the present study shed light on the soil chemical dynamics within pollution hotspots across the Kashmir Valley. Notably, soil pH, electrical conductivity (EC), and organic carbon (OC) exhibited significant variability across the five locations. The present study provides valuable insights into the soil chemical properties of the Kashmir Valley's diverse pollution hotspots. It underscores the intricate interplay of geological, environmental, and anthropogenic factors in shaping soil characteristics. These findings can serve as a foundational reference for future research and environmental management efforts aimed at preserving and enhancing the quality of soils in this unique and ecologically significant region.

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