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Impact of Landfill Proximity on Soil Quality: A Comparative Study of Dumping and Non-Dumping Sites Near Srinagar, Garhwal, Uttarakhand

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ABSTRACT

The present study aims to analyze changes in the physicochemical parameters of the soil in the vicinity of a small municipal solid waste landfill site. The research results were analyzed based on general physicochemical properties, which include pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), and potassium (K) by using standard methods. The results show that the soil from the dump sites contained higher amounts of soil properties (EC, SOC, N, P, K) than the non-dumping sites. Pearson correlation shows that pH exhibits a robust negative correlation with all other parameters while the remaining other parameters had a positive correlation with each other. Also, PCA analysis shows dumping sites mostly depict positive values in PC1, whereas the non-dumping sites indicate negative values. The final interpretation indicates that the soil in the dump site was found suitable for plant growth. However, due to improper solid waste management, this nutrient-rich soil could be mixed up with several other contaminants, such as soluble salts, plastics, heavy metals, and so on. This could make the soil unhealthy or unsuitable for plant growth. The study also suggests proper segregation, recovery, treatment, and safe disposal of solid waste and formulates an integrated municipal solid waste management plan for this particular dumping site.

INTRODUCTION

Solid waste management is one of the important obligatory functions of the municipal authorities. Except for a few large cities, local bodies of medium and smaller towns have not undertaken regular exercises on the quantification, characterization, and disposal of municipal solid wastes. The waste characterization showed that municipal solid wastes typically contain about 50% organic waste, 17% recyclables, 11% hazardous, and 21% inert. However, some amount of all MSW is not collected at all and hence lies littered in the city/town and finds its way to nearby open areas /drains and water bodies, causing clogging of water percolation, choking of drains, and pollution of surface water. Unsegregated waste collection and transportation lead to dumping in the open, which generates leachate and gaseous emissions besides causing nuisance in the surrounding environment. Leachate contaminates the groundwater as well as surface water in the vicinity (Municipal Solid Waste (Management & Handling) Rules, 2000).

The rapid population growth in developing countries like India accelerates industrialization and urbanization which results in the generation of solid waste exponentially. Solid waste has become a major environmental issue in India. The country generates a total of 160038.9 TPD (tonnes per day) of solid waste, out of which 152749.5 TPD is collected with an efficiency rate of 95.4%. 79956.3 metric tonnes per day (50%) of trash undergoes treatment, while 29427.2 metric tonnes per day (18.4%) are disposed of in landfills. 50655.4 TPD, representing 31.7% of the total garbage created, is unaccounted for. India's per capita solid waste generation in the year 2020-21 was 119.07 grams per day, according to the Central Pollution Control Board (CPCB, 2020-21).

The total amount of solid waste generated in Uttarakhand is approximately 1458.46 Tonnes Per Day (TPD). Out of this, 1378.99 TPD is collected, and 779.85 TPD undergoes treatment, according to the Central Pollution Control Board (CPCB) report for the year 2020-21. The garbage can be either incinerated or illegally deposited on vacant ground within the urban local bodies of the state, resulting in substantial environmental harm and posing a concern to human health. The creation of municipal garbage in Uttarakhand is projected to increase, resulting in an estimated total of 9.0 million tonnes of rubbish being produced between 2014 and 2041, according to the Draft Urban Municipal Garbage Management Action Plan for Uttarakhand state in 2015.

A significant amount of solid waste produced in and around Srinagar town was dumped at a dump site at Srinagar Garhwal. This municipal solid waste was an inevitable byproduct of human and constructional activities, which was disposed of through dumping. This open dump was unsightly, unsanitary, and smelly and attracted scavenging animals, rats, insects, pigs, pests, etc.

Spreading over an area of 9 sq. km, the Srinagar Municipality is divided into 9 municipal wards for undertaking solid waste management. The municipality is involved in door-to-door collection, street sweeping, drain desilting, collection, and transportation of waste from all 9 wards of the town. As per the current estimates of the Srinagar Municipality, about 7.07 tons of solid waste is generated daily in Srinagar. The physical composition of the MSW produced in Srinagar town as: Organic waste (58%), plastic (20.85%), paper (11.16%), glass (7%), rubber & textile (6.23%), and metal (1.37%) (City Sanitation Plan, Srinagar Municipality 2017).

MSW compost contains large amounts of organic matter, and macronutrients play a key role in improving soil properties such as water retention capacity, fertility, and productivity. There are various studies revealed that these valuable nutrients get mixed with toxic chemicals and spread over the surrounding soil with time damaging the upper layer of the soil, distorting soil fertility, and affecting plant life. When rainwater comes into contact with dumping yards, it produces a liquid called leachate. This leachate then seeps through the layers of soil and, over time, contaminates the groundwater and soil in the surrounding area (Deshmukh & Aher 2017). This contamination can be harmful to plants when they absorb it through their roots. Consuming plants and animals that have been exposed to contaminated soils can have adverse effects on human health. Oyebode et al. (2023) proposed that effective remediation methods should be applied to prevent continued contamination of groundwater and soil by leachates released from landfills and waste sites.

Therefore, the focus of the present study is to determine the nutrient status (N, P, K) and their monthly variation in and around the municipal solid waste dumping site so that we can assess the impact of solid waste on soil quality nearer to the solid waste landfill site.

MATERIALS AND METHODS

Study Area

The study was carried out in Srinagar town of Garhwal Himalaya in District Pauri Garhwal, Uttarakhand (Fig. 1, Table 1). Srinagar is a municipality in the district of Pauri Garhwal, Uttarakhand. The Srinagar city is divided into 9 wards. The selected study area in and around the MSW dumping yard is located in the Srinagar town of Uttarakhand, India (Fig. 1). This area is located on the left bank of the Alaknanda River. The dumping site is situated at an altitude of 534.4 masl. It lies between latitude 30° 13' 33.707" N and longitude 78° 47' 8.101" E. It covers an area of 1537.31 m^2 and is situated near to Nagar Palika Road.

Demography and Literacy

The population of the Srinagar Garhwal municipality is 20,115, with 10,751 being males and 9,364 being females. The population of children aged 0-6 in Srinagar Garhwal is 2142, accounting for 10.65% of the total population. The female sex ratio in the Srinagar Garhwal Nagar municipality is 871, which is lower than the state average of 963. Furthermore, the child sex ratio in Srinagar Garhwal is approximately 864, which is lower than the average child sex ratio of 890 in the state of Uttarakhand. The literacy rate in Srinagar Garhwal city is 92.03%, which is higher than the state average of 78.82%. The male literacy rate in Srinagar Garhwal is approximately 94.22%, while the female literacy rate is around 89.51% (Census India 2011).

Climate

The climate of Srinagar Garhwal is sub-tropical monsoon type (mild winter, hot summer). The town is situated on the bank of Alaknanda, so in winter, temperature & humidity affect the weather very much. Due to the river bank, dense fog is often seen in mild winter, but at noon, it is clear shiny weather. Opposite to this in summer, there is very humid weather; temperature and humidity are at its top level. Maximum temperature is 40ºC whereas the minimum temperature is 0.3ºC and the mean annual rainfall is 1210 mm.

Wards: The Srinagar town is divided into nine wards by the municipal council. There are nine wards with different populations in the town (Table 2).

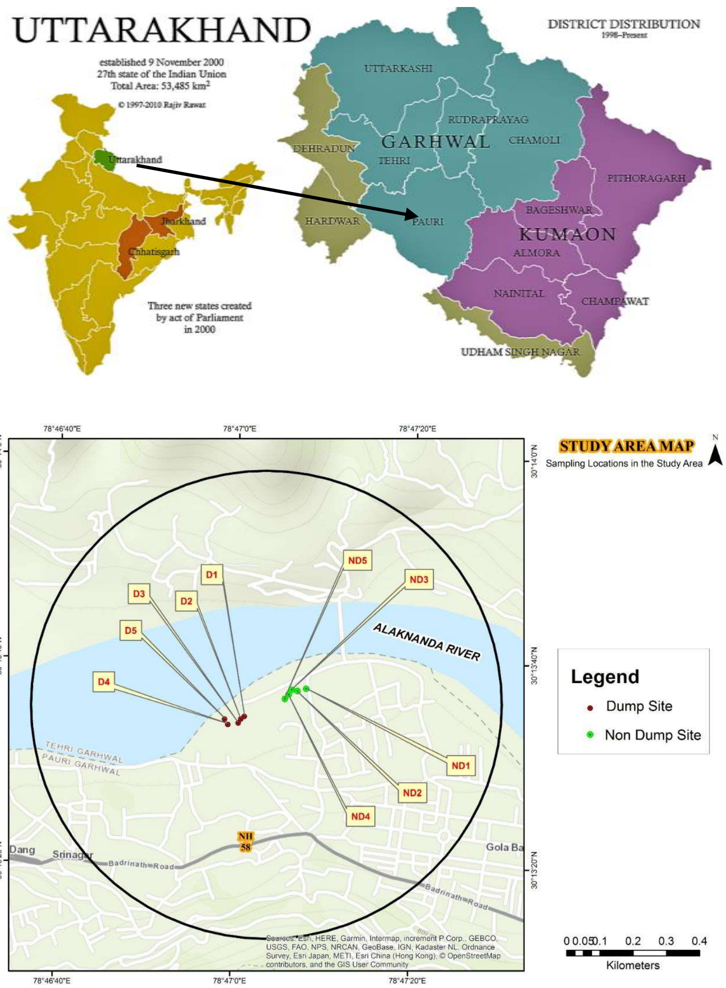

Fig. 1: Mapping of study area and demarcation of studied site.

Table 1: Location of sampling area.

Land Use	Site	Altitude (masl)	Latitude	Longitude
Municipal solid waste Dumpsite	D1	534.3	30° 13’ 34.540” N	78° 47’ 1.201” E
	D2	532.4	30° 13’ 34.278” N	78° 47’ 0.812” E
	D3	528.3	30° 13’ 33.889” N	78° 47’ 0.528” E
	D4	535.1	30° 13’ 33.707” N	78° 46’ 59.361” E
	D5	534.4	30° 13’ 34.237” N	78° 46’ 58.992” E
Municipal solid waste non-dump site	ND1	525.8	30° 13’ 37.346” N	78° 47’ 8.101” E
	ND2	531.1	30° 13’ 37.118” N	78° 47’ 7.139” E
	ND3	527.2	30° 13’ 37.227” N	78° 47’ 6.489” E
	ND4	525	30° 13’ 36.750” N	78° 47’ 6.148” E
	ND5	529.2	30° 13’ 36.320” N	78° 47’ 5.731” E

Table 2: Profile of wards, Srinagar NPP (City Sanitation Plan, 2017).

Ward No.	Name	Area (Ha.)	Families	Population	Total Solid waste production (T/day)
1.	Agency Mohalla	140	727	3946	1.246
2.	Upper Bazar	75	323	1640	0.517
3.	Ganesh Bazar	115	1029	5006	1.580
4.	Mochi Tamta Mohlla	42	328	1761	0.556
5.	Niranjani Marg	77	437	1980	0.625
6.	Mishtri Mohlla	87	313	1663	0.525
7.	Kamleshwar Bagwan	112	740	3361	1.061
8.	S.S.B.	87	145	667	0.210
9.	Shitla Mata Temple	165	372	2376	0.750
	Total	900	4414	22400	7.07

Methodology

The Investigation to evaluate the soil properties in and around the open dumping site in Srinagar Garhwal of Uttarakhand state, soil samples were collected from two land use types i.e., open dumping site and non-dumping site. Thus, from two land uses soil samples were collected to determine soil physio-chemical properties (Texture, pH, EC, OC, N, P, K).

Soil Sample Collection and Analysis

The soil samples were collected in and around the municipal solid waste dumping and non-dumping sites of Srinagar Garhwal. The topsoil was cleaned by removing waste and samples were collected by digging 0-15 cm depth. Soil samples were collected in fresh polythene bags and labeled properly then samples were analyzed in a laboratory for physio-chemical analysis. The samples were air-dried by spreading them on a tray. The sample was sieved using a 2 mm sieve for further chemical and nutrient analysis, i.e., pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), and potassium (K) by using standard methods (Table 3).

Table 3: Methods used for the analysis of soil.

Parameter	Method	Reference
Texture	Sieve method	Bouyoucos (1962)
pH (1:2 soil: water)	Potentiometry	Jackson (1973)
EC (1:2 soil: water)	Conductometry	Jackson (1973)
Organic carbon (%)	Wet oxidation method	Walkley and Black (1934)
Available Nitrogen [$kg.ha^{-1}$]	Micro distillation method	Subbiah and Asija (1956)
Available Phosphorus [$kg.ha^{-1}$]	Spectrophotometry	Jackson (1973)
Available Potassium [$kg.ha^{-1}$]	Flame photometry	Jackson (1973)

RESULTS AND DISCUSSION

Analysis of Physical Parameter of Soil

Analysis of soil samples indicated that the texture proportions in the study area were in order of sand>silt>clay. Sand ranged from 55.42% to 68.85% with a mean value of 63.54%, silt ranged from 10.7% to 21.82% with a mean value15.06%, and clay was ranged from 18.86 % to 24.60% with a mean value of 21.55% in the open dumping site which depicts that the soil belongs to sandy clay loam in texture whereas in non-dumping site sand is ranged from 53.42%-59.16% with mean value 56.03%, silt is ranged from 18.15%-25.51% with mean value 21.13% and clay is ranged from 20.24%-25.13% with mean value 22.87% which depicts that the soil belongs to sandy clay loam in texture (Table 4).

The higher proportion of sand followed by silt and clay could be because of the Alaknanda River bank area, where usually soil finer particles flow away, leaving coarse particles of sand. A similar kind of texture was found by Loughry (1973), who opined that the dumpsites, which dominantly contain high sand fractions and low clay content, allow water and leachates to percolate through the soil, degrade its quality and cause water pollution.

The two sites in consideration also have comparable soil textures with sandy clay loam texture classification due to the dominance of sand. However, the dump site appears to have greater fluctuations in the amount of sand and silt, which indicates that there are external factors such as dumping activities. As there is higher sand content in the dump sites, which suggests elevated permeability, this can also result in the downward migration of contaminants further down the soil and water table. This is congruent with Loughry (1973) and underscores the threat of uncontrolled dumping, for whatever reason, near river banks. The similar texture classification of sandy clay loam in both sites indicates the

Table 4: Soil texture around MSW dump sites and non-dump sites.

Site	Soil sample	Texture %			Texture class
		Sand	Silt	Clay	
Dumpsite	D1	55.73	21.82	23.38	Sandy clay loam
	D2	68.58	10.7	20.71	Sandy clay loam
	D3	68.85	12.28	18.86	Sandy clay loam
	D4	63	16.69	20.23	Sandy clay loam
	D5	61.55	13.83	24.60	Sandy clay loam
	Mean	**63.54±5.45**	**15.06±4.37**	**21.55±2.36**	**Sandy clay loam**
Non-dump site	ND1.	53.42	21.44	25.13	Sandy clay loam
	ND2	59.16	18.15	22.16	Sandy clay loam
	ND3	57.77	18.73	23.48	Sandy clay loam
	ND4	55.73	21.82	23.38	Sandy clay loam
	ND5	54.07	25.51	20.24	Sandy clay loam
	Mean	**56.03±2.42**	**21.13±2.93**	**22.87±1.81**	**Sandy clay loam**

effect of the river Alaknanda caused sedimentation and also the factors like waste disposal contributed to the soil texture. Although in the non-dump site, it is expected to be moisture-retentive silt clay soil as well, the fact that this is only slightly the case suggests that, yes, more water is available for plants in this area than in the dump site. The high level of sand in both sites means that the soil is well-drained but has little moisture and nutrient retention (especially at the dump site). According to this, too, clay content is low, which means sand is easily eroded by each swept contaminant in the waste, deteriorating soil profile as well as groundwater. The higher amount of silt in the non-dump sites means that more moisture and nutrients could be retained, suggesting fairly good quality of soil. However, it can also be concluded that the presence of sandy clay loam at the dump site increases the risk of environmental pollution by enhancing leachate movement in the soil.

Analysis of Chemical Parameter of Soil

The present study compares the soil quality index (SQI) of two distinct sites, Dumping (D) and Non- Dumping (ND), which includes pH, Electrical Conductivity (EC), Soil Organic Carbon (SOC), Nitrogen (N), Phosphorus (P), and Potassium (K) (Fig. 2).

Dumping sites had a mean pH of 6.524, which indicates slightly acidic soil conditions, whereas non-dumping sites had a mean pH of 7.224, which indicates neutral to slightly alkaline soil (Table 5). This difference in pH may occur due to nutrient availability and may also be affected by microbial activities in both sites. The results depict the acidic nature of the soil at the dump site and the basic nature of the non-dump site. The presence of a lower value of pH at the dumping site suggested that the soil samples were contaminated by municipal solid waste having organics, which might have decreased the pH (Kanmani & Gandhimathi 2013). The more acidic pH level identified in the dumping sites suggests waste breakdown and leachate concentration have contributed to soil acidification, which can have adverse effects on nutrient availability, microbial activities, and plant growth. There was no such geochemical alteration as in the case of the neutral pH in non-dumping sites, which is more favorable for soil and supports better vegetation growth and nutrient cycling. Under the existing dump conditions, the slightly acidic conditions in the dump sites are quite alarming as they are likely to cause soil and environmental degradation. It, therefore, calls for waste management practices and remediation measures.

Electrical Conductivity (EC), which measures soil salinity, is higher at the Dumping site (mean of 0.7136 $dS.m^{-1}$) compared to the non-dumping site (mean of 0.4296 $dS.m^{-1}$), indicating that the Dumping site has a higher salt concentration (Table 5). The values of EC fall under the normal rating charts. The highest EC was recorded in the soil samples collected from dump sites and the lowest from non-dump sites. High EC in the samples close to the dump yard may be due to the presence of large amounts of ionic substances and soluble salts released from the MSW dump as compared to the natural soil samples (Deshmukh 2012). Soil Organic Carbon (SOC) is much higher at dumping sites (1.0224%) compared to non-duping sites (0.6272%), which indicates high organic matter at dumping sites (Table 5). Munoz et al. (1994) reported that biodegradable municipal solid wastes were the major contributor to increased organic matter in soil.

Nitrogen (N) levels are also higher at the Dumping site (mean of 332.5624 $kg.ha^{-1}$) than at the non-dumping

Table 5: Comparative data analysis of different soil chemical parameters at dumping and non-dumping sites.

Sites	Samples	pH	EC	SOC	N	P	K
Dumping Sites	D1	6.56	0.566	0.862	332.778	27.962	303.95
	D2	6.22	0.876	1.196	342.998	29.852	309.874
	D3	6.9	0.642	0.99	333.054	27.924	297.474
	D4	6.72	0.546	0.91	319.218	26.334	297.528
	D5	6.22	0.938	1.154	334.764	29.704	306.466
	Mean	6.524 ± 0.302	0.713 ± 0.181	1.022 ± 0.147	332.562 ± 8.545	28.355 ± 1.456	303.058 ± 5.491
Non-dumping Sites	ND1	7.26	0.376	0.522	252.916	20.652	227.98
	ND2	7.04	0.392	0.568	263.246	17.998	241.298
	ND3	7.36	0.44	0.676	247.156	18.924	237.33
	ND4	7.34	0.462	0.682	254.21	20.522	227.488
	ND5	7.12	0.478	0.688	256.504	20.146	222.374
	Mean	7.224 ± 0.139	0.429 ± 0.044	0.627 ± 0.076	254.806 ± 5.843	19.648 ± 1.147	231.294 ±7.770

site (mean of 254.8064 $kg.ha^{-1}$), which could lead to more vigorous plant growth at the Dumping site (Table 5). These values reflect that the nitrogen is found in the medium range at the dump site while it is found in the low to medium range at non-dump sites. Nitrogen content in the dumping site's soil was recorded as higher than in the non-dump site's soil. Higher nitrogen content at the dumping sites might be due to higher organic matter content of the soil contributing to higher available nitrogen in the soil (Ouled et al. 2014).

Dumping sites had mean values of Phosphorus (P) and Potassium (K) 28.3552 $mg.kg^{-1}$ and 303.0584 $mg.kg^{-1}$, respectively, compared to 19.6484 $mg.kg^{-1}$ of P and 231.294 $mg.kg^{-1}$ of K at the non-dumping site (Table 5). These differences suggest that Dumping sites were more fertile and might support higher crop yields, provided the slightly acidic pH was managed appropriately. The phosphorus availability was recorded as higher in dump sites whereas lowest in non-dump sites due to high organic matter in the dumpsite soil as a result, which in turn increased the proportion of soil phosphorus (Ouled et al. 2014). The above results reflect that the potassium found maximum in dump sites than in non-dump sites due to high organic matter at the dumpsite soil as a result which in turn increased the proportion of soil potassium present as exchangeable potassium (Ouled et al. 2014).

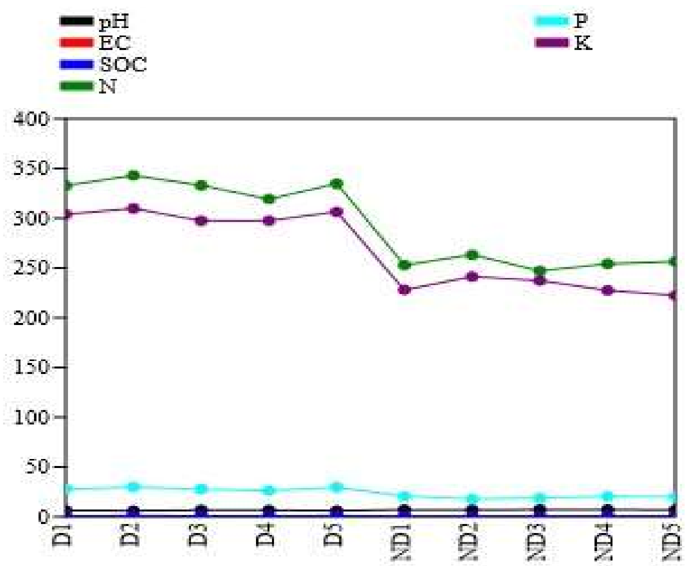

Fig. 2: Plotting of different chemical parameters of analyzed soil.

In conclusion, the dumping sites are more enriched in nitrogen, phosphorus, potassium, and SOC due to waste decomposition phenomena. It should be noted, however, that the mildly acidic pH and greater EC at the dump sites may eventually negatively affect the plant's nutrition, health, and microbiological activity. They may lead to some additional soil salinity and contamination as, a phenomenon which deteriorates the soil even further. Non-dumping sites characterized by neutral pH, lower EC, and more appropriate nutrient distribution are more favorable for soil conditions on a long-term basis. Therefore, nutrient recycling in these sites is effective and promotes sustained agronomical practice and plant development whilst lowering the risks of pollution. The present study shows that non-dumping had lower nutrient levels (particularly SOC, N, P, and K), which suggests that soil amendments are required to achieve optimal crop production. Also, the neutral to slightly alkaline pH of non-dumping sites might be more suitable for particular crops, but it could act as a limiting factor in crop growth without proper soil management.

Statistical Analysis of SQI

Table 6 depicts the Pearson correlation in studied soil quality parameters. pH exhibits a robust inverse relationship with all other factors. This indicates that as the pH level rises, the levels of EC, SOC, N, P, and K fall. In this common situation, elevated pH levels (indicating more alkaline soil) can diminish the accessibility of vital nutrients such as nitrogen, phosphate, and potassium, as well as organic carbon.

The EC shows a strong positive correlation with SOC, N, P, and K, which indicates that EC was increased with increasing SOC, N, P, and K. It could imply more soil fertility or more decomposition of organic matter in the soil. The SOC shows a very strong positive correlation with EC, N, P, and K. Nitrogen shows a very strong positive correlation with P and K. This indicates that soils with high nitrogen content also have high levels of phosphorus and potassium, both of which are important for plant growth. The significant correlation could be attributed to the interdependence of these nutrients on organic matter. Phosphorus shows a very strong positive correlation with N and K, suggesting that these elements mostly coexist in the soil. This phenomenon could be due to shared origins, such as the use of identical fertilizers or their response to comparable soil conditions.

PCA is a very useful multivariate statistical tool, particularly in this study, to examine the interactions of pH, EC, SOC, N, P, and K in regard to various soil quality measures and to resolve any difficulties regarding the measurement of complex datasets. Here's how it works in this study: PC1 (the first principal component) shows the greatest amount of variance and the clearest separation between such sites as dumping and non-dumping. PC1 in this study is said to be strongly influenced by SOC, nitrogen (N), phosphorus (P), and potassium (K), meaning that these factors are serviceable in giving out the functionality of soil

Table 6: The correlation table represents the Pearson correlation coefficients between different soil quality parameters.

	pH	EC	SOC	N	P	K
pH		-0.89397	-0.88651	-0.90181	-0.88953	-0.89147
EC	-0.89397		0.95845	0.81477	0.8656	0.79356
SOC	-0.88651	0.95845		0.90397	0.92939	0.89021
N	-0.90181	0.81477	0.90397		0.97203	0.98518
P	-0.88953	0.8656	0.92939	0.97203		0.94988
K	-0.89147	0.79356	0.89021	0.98518	0.94988	

Table 7: PCA data represent the relation of PC 1 to PC 6 with different dumping and non-dumping sites.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
D1	1.4759	0.88473	-0.26899	-0.1473	0.021069	-0.022407
D2	3.3371	-0.47804	-0.096794	0.047777	-0.10556	-0.041698
D3	1.4645	0.47049	0.66004	0.027893	-0.014499	0.15644
D4	1.0233	0.6548	0.0087711	0.14795	-0.05987	-0.13733
D5	3.258	-0.76821	-0.16491	-0.063858	0.15636	0.029423
ND1	-2.4044	0.16652	-0.10331	-0.36408	0.10575	-0.021681
ND2	-2.0723	0.1388	-0.60717	0.26804	-0.0005679	0.13385
ND3	-2.2084	-0.24797	0.27854	0.29725	0.12755	-0.092568
ND4	-2.0295	-0.31974	0.36671	-0.087519	-0.023654	-0.0062389

quality imbued with dumping and without digging. PC2 to PC6 are said to account the relatively less variance and explain primary variations. Although they offer increased understanding, they do not separate the two types slightly enough as PC1 does. PCA also assists in simplifying the data of the soil, especially in establishing the critical attributes that differentiate the soil's quality between gelatinous and non-gelatinous sites. In this way, it contributes to informing about the possible waste and its effect on soils and recommends some management parameters for soils.

The PCA analysis shows a clear segregation between the Dumping sites (D1 to D5) and non-dumping sites (ND1 to ND4), with PC1 showing a particularly pronounced split (Table 7). The Dumping sites mostly depict positive values in PC1, whereas the non-dumping sites indicate negative values. This analysis implies that PC1 may be capturing a noteworthy characteristic that differentiates these two groups. PC2 to PC6 shows a greater diversity within each study site, but the distinction between Dumping sites and non-dumping sites was not as pronounced (Table 7). This analysis indicates that the PC1 is highly influential in explaining the variability in the dataset, and it clearly distinguishes between the Dumping sites and non-dumping sites. PC2 to PC6 represent a lower amount of variance compared to the previous components (Table 7). Although they offer a further understanding of the data structure, their contributions are less impactful.

PC1 is the dominating component, majorly driven by P, N, and SOC shows a strong correlation among these soil quality parameters (Table 8). Whereas pH contrasts sharply and contributes negatively. PC2 shows secondary variability, and EC shows a strong negative correlation, which means it acts differently from other soil quality parameters. PC3 to PC6 shows regular less variance (Table 8). This PCA analysis helps in understanding the primary and secondary factors that influence soil health and fertility in the studied area.

Table 6 illustrates a prevailing pattern in which the majority of parameters exhibit either positive or negative correlations with one another. More precisely, there is a negative relationship between pH and other soil quality indices, suggesting that soils with higher acidity or alkalinity tend to have lower nutrient levels. The parameters EC, SOC, N, P, and K have a positive correlation, suggesting that these elements collectively influence soil fertility and are likely to vary in the same direction. The correlation matrix offers useful insights into the interrelationships among different soil properties. The presence of strong positive relationships among EC, SOC, N, P, and K indicates that these parameters are interconnected and jointly impact soil fertility. Conversely, the negative associations with pH emphasize the significance of regulating soil acidity/alkalinity to uphold nutrient accessibility. Gaining insight into these relationships can provide valuable guidance for implementing more effective soil management strategies, especially in regions impacted by the disposal of solid waste, where the quality of the soil may be impaired.

CONCLUSION

A total of seven parameters (soil texture, pH, EC, OC, N, P, K) were analyzed during the study period. Results of particle size analysis of soil samples indicated that soils in and around the MSW open dumping sites belong to sandy clay loam. The soil properties indicated that the dumping site is acidic, and the non-dumping site is alkaline in nature. The values of organic carbon and macronutrients (N, P, K) were found to be higher in the dump site than in the non-dump site. As per the soil fertility rating (FAO/WHO, 2001), the mean values of organic carbon and macronutrients (N, P, K) were found in the low category at the non-dump site, whereas the mean values were found in the medium category at the dump site.

From the above results, it is clear that the soil from the dump sites contained higher amounts of soil properties (pH, EC, OC, N, P, K) than the soil away from the dump sites. So as per the soil properties and the soil fertility rating, the soil in the dump site was found to be suitable for plant growth. But, due to improper solid waste management, this nutrient-rich soil could mix up with several other contaminants, such as soluble salts, plastics, heavy metals, and so on. This makes the soil unhealthy or unsuitable for plant growth. Proper segregation, recovery, treatment, and safe disposal, either

Table 8: PCA data represent the relation of PC 1 to PC 6 with different studied soil quality parameters.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
pH	-0.94982	0.067246	0.30366	0.014462	0.023003	0.01936
EC	0.92537	-0.37257	0.027386	-0.012711	0.052074	0.035394
SOC	0.96824	-0.17054	0.14933	0.082506	-0.057967	-0.030901
N	0.97088	0.22634	0.015862	-0.0020035	-0.040355	0.06541
P	0.97564	0.11125	0.10631	-0.153	0.0087144	-0.030886
K	0.95916	0.25592	-0.00065631	0.10096	0.06304	-0.018574

composting or sanitary landfill, will provide nutrient-rich organic soil for cultivating crops and for plantation purposes.

As a result, there is a need for integrated municipal solid waste management of the Srinagar dumping site to segregate the organic waste and utilize it as compost. Thus, the present study can be used in future monitoring and management of MSW in and around the dump site.

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