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Characterization of Municipal Solid Waste and Evaluation of Subsurface Water Quality In The Vicinity of Dumping Sites

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Abstract: The physical characterization of municipal solid waste is done in order to measure the quantity of the recoverable and to study the effect of the physical composition on the strength and stability characteristics of the MSW. Municipal Solid Waste (MSW) is composite refuse consisting of various materials with different properties. The characteristics of municipal solid waste play a key role in many aspects of waste disposal facilities and landfills. Proper management of growing quantities of municipal solid wastes (MSW) has been a major concern of environmental professionals. Leachate resulting from this is hazardous pollutant to the soil and ground water underlying. Leaching of this leachate and heavy metals into the soil leads to the pollution of both soil and subsurface water. Municipal solid waste disposal on land has become one of the challenges in landfill engineering design. The stability of landfill is governed by the physical properties and strength parameters of MSW. In this paper results of laboratory investigation of the physical properties of MSW and impact of municipal solid waste dumping on subsurface water quality.
Keywords: Municipal Solid waste (MSW), Leachate, Characterization, Landfill, Water

I. INTRODUCTION

In India the most preferred method of waste disposal is landfill. Most of landfills areas in India are open dumping areas. The characteristics of municipal solid waste (MSW) play a key role in many aspects of waste disposal facilities and landfills. Because most of a landfill is made up of MSW, the overall stability of the landfill slopes is governed by the strength parameters and physical properties of the MSW. On the other hand, the composition of the waste, which affects the geotechnical behavior of the MSW, is dependent on a variety of factors such as climate, disposal technology, the culture and habits of the local community.
It is therefore essential that the design and stability evaluations of landfills in each region be performed based on the local conditions and the geotechnical characteristic of the MSW [1-4]. Design and implementation of new landfills or expansion of existing landfills is necessary to accommodate this ever increasing volume of MSW. Geotechnical engineering properties of MSW such as compressibility and shear strength are of prime importance in design and maintenance of these landfills [8]. Wastes placed in dumping yards/landfills are subject to either groundwater underflow or infiltration from precipitation and as water percolates through the waste, it picks up a variety of inorganic and organic compounds, flowing out of the wastes to accumulate at the bottom of the landfill. The resulting contaminated water is termed 'leachate' and can percolate through the soil [22]. Leachate resulted from municipal solid waste, is most hazardous pollutant for the soil underlying and subsequently ground water. Leaching of nutrients and heavy metals into the soil which leads to soil and groundwater contamination [28]. Fortunately no lethal failures have occurred in India to date, despite uncontrolled loose dumping. However from the view of enormous increase in the solid waste generation, escalating of grades of the existing landfills and proposals for the upcoming engineered landfills, it is imperative to undertake extensive investigation of the engineering behavior of MSW under static and dynamic conditions so as to avoid such disastrous failures in India and other developing countries in future [12]. This paper attempts to explore the physical and geotechnical characteristics of municipal solid waste such as composition, water content, specific gravity, Atterberg's limits, and compressibility characteristics of municipal solid waste of selected site samples and assessment of subsurface water quality in and around the municipal solid waste dump sites of study area.

II. MATERIALS AND METHODS

A. Sampling and Laboratory Testing of Municipal Solid Waste

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The Municipal solid waste samples were collected randomly from the selected dumping sites. Samples were collected into the separate bags and some relatively small portion of the collected samples were placed in air tight polythene bags for the purpose of measuring natural moisture content. Random sampling was adopted for fair representation of municipal solid waste bottom sediments. The collected samples were subsequently transported to the Geotechnical laboratory for testing. Different geotechnical tests were conducted on these collected samples in accordance with the Indian Standard (I.S.) as well as American Society of Testing and Materials (ASTM).

B. Field Sampling and Laboratory Analysis of Subsurface Water

Subsurface water samples were collected from near the municipal solid waste dumping sites, sampling locations consisting of bore wells and hand pumps were selected in the study area. Sampling was done in accordance with grab sampling methods in 1litre plastic containers and prior to collection all the bottles were washed with non-ionic detergent and rinsed with de-ionized water prior to usage. Before the final water sampling was done, the bottles were rinsed three times with well water at the point of collection. During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly. Each bottle was labeled according to sampling location while all the samples were preserved at 4ºC and transported to the laboratory.

III. CHARACTERIZATION OF MUNICIPAL SOLID WASTE

The physical characterization of municipal solid waste is done in order to measure the quantity of the recoverable and to study the effect of the physical composition on the strength and compressibility characteristics of the municipal solid waste.

A. Waste Composition

The waste is segregated by hand sorting into paper, plastics, inert (rubber, leather), glass, stones and the organic fraction of the waste. The physical characterization of the waste passing through 100 mm sieve was done by hand sorting and on the weight basis. The MSW samples used for all the experiments were those passing through the 20 mm sieve and retained by the 4.75 mm sieve. Therefore the composition analysis of the 4.75 mm sieve retained waste was done and results are summarized in Figure -1.

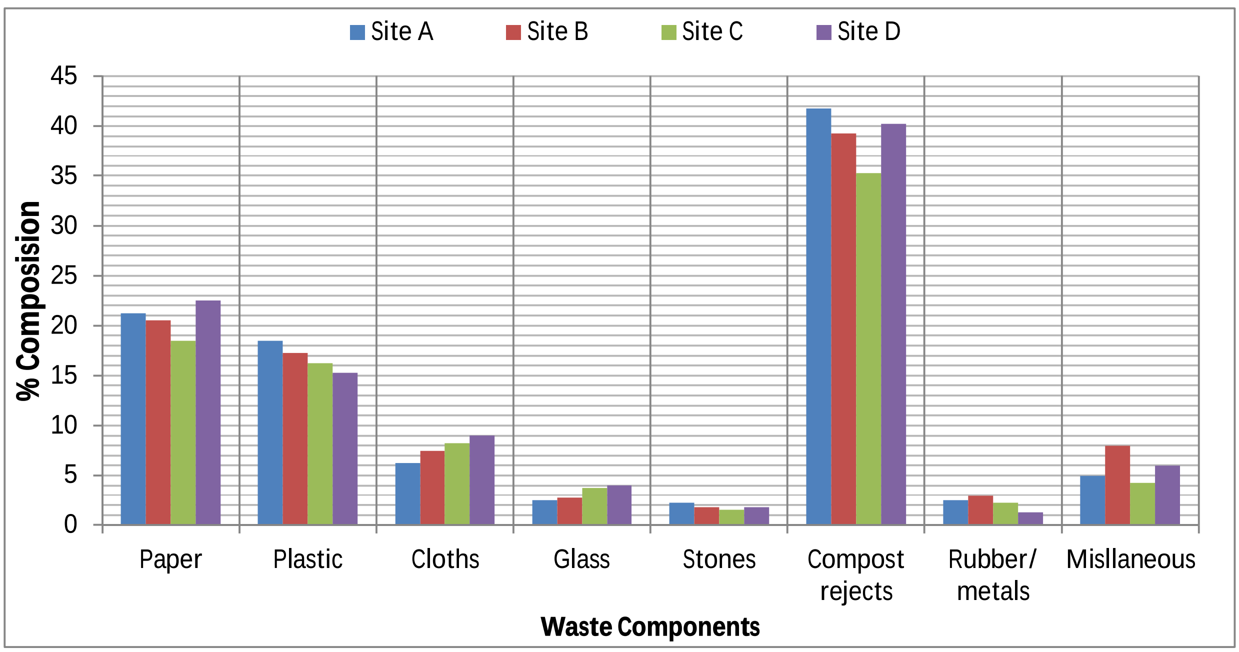

Figure-1 Composition of municipal Solid waste at different dumping sites

B. Moisture content

Moisture content of the waste smaller than 10 mm material was calculated as the ratio of the weight loss to the weight that remained after heating at a temperature of 70°C until the specimen has dried to a constant mass. The observation of the moisture contents are summarized in Table- 1.

Table -1 Moisture content of municipal solid waste samples

Serial No.	Sample site	Moisture content on dry weight basis
1.	Station A	23.27 % to 27.33%
2.	Station B	30.60 % to 34.01 %
3.	Station C	14.95 % to 18.05 %
4.	Station D	16.94 % to 19.75%

Moisture contents measured were ranged from 14.95% to 34.01 % on dry weight basis, for different municipal solid waste dumping sites. The Minimum water content was found in Station C sample site and maximum water content was found in Station B sample.

C. Specific Gravity

Pycnometer method was employed to determine specific gravity for municipal solid waste in laboratory. Specific gravity of for municipal solid waste samples is summarized in Figure-2.The specific gravity of municipal solid waste samples are found to be 1.87 to 1.98. The lower value of specific gravity can be attributed to the presence of decomposed organic matter.

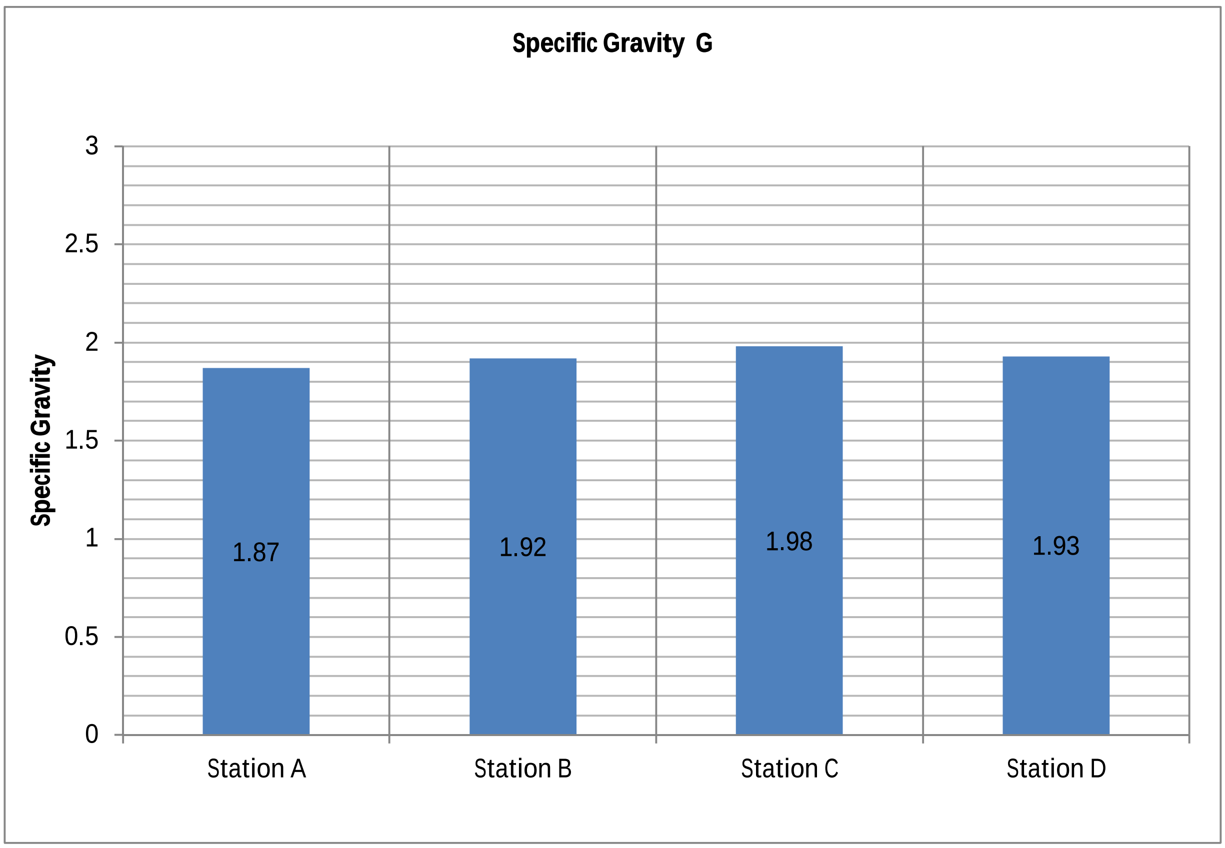

Figure 2 Specific gravity values of samples collected from dumping sites

D. Atterberg's limits

The Atterberg limits are the basic measure of the critical water contents of a fine-grained soil. The moisture contents at which the consistency changes from one state to the other state are called Atterberg limits. The Atterberg limits are the liquid limit (w_L), plastic limit (w_P), shrinkage limit (w_S) and plasticity index. The result of Atterbeg limits (liquid limit, plastic limit and plasticity index) are summarized in Figure 3.

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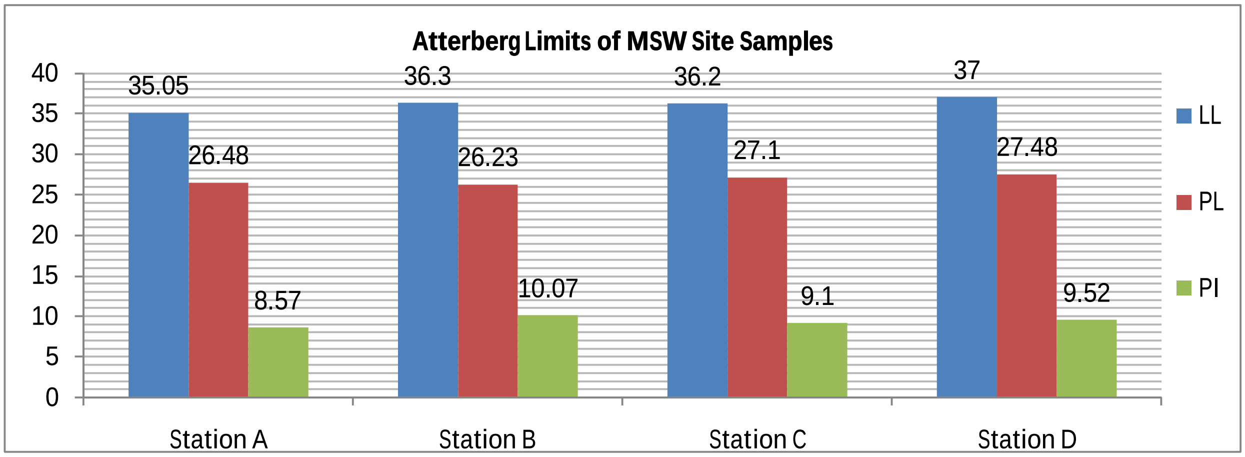

Figure: 3 Atterberg limits of MSW site samples

E. Compressibility TeS

Compressibility of municipal solid waste was tested in general accordance with ASTM D2435. The compression index (C_c) can also be estimated more quickly and easily without a consolidation test, and on the knowledge of liquid limit, as the two empirically related by Terzaghi as:

For undisturbed soil of normal sensitivity

$C_c = 0.009$ [L.L- 10] ……………….. (a)

For remoulded soil

$C_c = 0.007$ [L.L- 10] ……………….. (b)

Where L.L = Liquid limit moisture content in percentage.

In present study of compressibility, compression index (C_c) is calculated by the use of empirical relation given by the Terzaghi for remoulded soil sample. The result of compressibility test is summarized in Table 2

Table 2 Compressibility characteristic of municipal solid waste

Sl. No.	Station Name	Liquid Limit (L.L)	Compression Index (C_c)
1	Station - A	35.05%	0.17
2	Station - B	36.30%	0.18
3	Station - C	36.2%	0.18
4	Station - D	37.0%	0.19

IV. PHYSICO CHEMICAL ANALYSIS OF SUBSURFACE WATER

Eleven locations of the MSW dumps were selected from the study area for physico-chemical analysis of sub surface water. In the areas surrounding to these MSW dumps, three types of water sources were found to be in use and thus these three kinds of water

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sources were selected, for taking water samples, namely- open wells (all depth less than 20 m), tube wells and hand pumps. Results of the physico-chemical analysis of subsurface water are summarized in Table-3.

Table- 3 Physico-Chemical parameters of the subsurface water samples near MSW dump sites

Sl. No.	Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
1	Temperature (^{0}C)	24.8	28.9	28.5	29.2	27.8	25.5	27.8	25.5	24.5	28.1	28.4
2	pH	7.20	6.82	7.92	7.89	6.70	7.85	7.54	6.67	6.73	7.80	7.35
3	Turbidity (NTU)	1.5	2.9	1.5	1.5	2.0	1.7	1.5	2.0	1.9	2.8	2.5
4	Electrical Conductivity (µS/cm)	728	822	714	845	802	671	812	794	819	802	703
5	TDS (mg/l)	760	886	780	837	880	646	774	756	807	751	769
6	TSS (mg/l)	79	72	46	54	35	40	59	45	67	56	45
7	Total Solids (mg/l)	839	958	826	891	915	686	833	801	874	807	814
8	Total Alkalinity (mg/l)	164	170	159	153	140	148	156	145	167	138	164
9	Total Hardness (mg/l)	396	398	386	359	365	359	320	345	312	332	329
10	Calcium Hardness (mg/l)	268	256	258	247	248	267	232	243	214	228	227
11	Magnesium Hardness (mg/l)	128	142	128	112	117	92	88	102	98	104	102
12	Dissolved Oxygen (mg/l)	5.1	4.6	5.1	4.2	5.0	4.3	4.2	5.2	5.2	6.4	5.7
13	COD (mg/l)	6.8	8.8	9.3	8.0	6.3	8.4	7.6	5.8	6.3	8.0	6.3
14	BOD (mg/l)	3.0	3.5	3.1	3.3	2.8	3.2	3.0	3.2	3.4	3.0	2.8
15	Chlorides (mg/l)	245	55	76	85	33	76	79	53	67	70	47
16	Fluorides (mg/l)	0.80	0.70	0.40	0.50	0.90	0.70	0.60	0.50	0.30	0.10	0.40
17	Nitrate (mg/l)	2.60	3.50	4.12	1.78	4.65	0.10	0.01	0.60	0.35	3.45	5.80
18	Nitrite (mg/l)	0.15	1.25	0.20	5.25	5.22	3.67	5.50	0.30	2.20	5.10	0.30
19	Sulphate (mg/l)	64.0	3.33	3.45	2.40	0.68	3.17	3.80	2.79	1.21	1.08	4.59
20	Iron as Fe (mg/l)	0.05	0.12	0.21	0.42	0.30	0.39	0.35	0.31	0.20	0.03	0.38
21	Lead as Pb (mg/l)	ND	ND	ND	0.01	ND	ND	ND	ND	0.01	ND	ND
22	Zink as Zn (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

V. SUMMARY AND CONCLUSION

The characterization include the physical composition, water content, specific gravity, Atterberg's limits and compressibility properties were measured. The obtained geotechnical properties were compared to data reported in the literature. Study of physico-chemical analysis of subsurface water in the vicinity of municipal solid waste dumping sites was done. The obtained results were compared with the BIS and WHO standards of drinking water.

Based on the laboratory investigation and results of present study of municipal solid waste samples, the composition of municipal solid waste representing organic content about 40%, paper 20%, plastic15%, cloths 7% and other components. Moisture contents measured were ranged from 14.95% to 34.01 % on dry weight basis, for different municipal solid waste dumping sites. Specific gravity of municipal solid waste in the present study was found to be 1.87 to 1.98. The lower value of specific gravity can be recognized to the presence of organic matter.

Atterberg's limits test results shows that the selected municipal solid waste stations are similar in nature. Plasticity index results shows that the municipal solid waste samples are fine sand and silt type group and having intermediate plastic properties. For present work the compression index calculated by using Terzaghi empirical equations for the remoulded sample are found to be 0.17 to 0.19. These values falls in the range of values reported in the published literature.

The results of physico-chemical analysis of the subsurface water samples are presented in the Table 3. These results were compared with BIS and WHO standards of drinking water. From study of physico-chemical analysis of subsurface water in the vicinity of municipal solid waste dumping sites, it is found that most of the parameters like pH, Turbidity, Alkalinity, Dissolved Oxygen, COD, BOD, Chlorides, Fluorides, Nitrates, Metals, etc. are under the permissible limits of Indian Standard for drinking water (BIS) and WHO. Some of the parameters like Electrical Conductivity, Total Dissolved Solid (TDS), Total Hardness (TH), Calcium and Magnesium concentration are above the limits of Indian Standard for drinking water (BIS) and WHO.

Hence it is concluded that at present the municipal solid waste has minimal impact on the subsurface water quality. Although the water quality is just good but it needs to be maintained from being polluted due to municipal solid waste dumping sites for the future.

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