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IMPACT OF MSD ON CHEMICAL AND PHYSICAL PROPERTIES OF SOIL

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ABSTRACT

Municipal solid waste has a huge impact on soil where it is disposed and change the whole character of soil including chemical properties and geotechnical properties of soil. Chemical properties which are effected are change in proportion of macronutrient, macronutrient and heavy metals. Also properties like pH, Electrical conductivity, Organic carbon and soil salinity has changes. Geotechnical properties like particle size, shear parameter, liquid limit, specific gravity, bulk density, water retention capacity.

I. INTRODUCTION

Municipal solid waste effect on soil is very large and special care should be taken for its dumping. Before dumping quality of waste should be checked. All the toxic present should be removed because it will totally change the charater of soil. Special dumping site should be selected so we can dump waste for longer time and its effect on chemical, geotecnical properties and agriculture is minimum. Municipal Solid Waste (MSW) is complex refuse consisting of various materials with different properties. Some of the components are stable while others degrade as a result of biological and chemical processes. 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 contamination of both soil and groundwater.

While the developed countries of the world, such as USA, have in place effective systems for MSW management, in many developing countries, such as India, management of MSW is a major concern, even in major cities of the country. The increasing level of solid waste is a serious problem in the urban areas like Delhi. This is compounded by the high rate of population growth and increasing per-capita income, which results in the generation of enormous solid waste posing serious threats to quality of soil and water. These threats are even more in the developing countries where large quantities of solid waste are dumped haphazardly

II.OBJECTIVE

Objective is to find the effect on soil due to landfilling and our main consideration is to find the effect on agriculture. We can find whether its effect on agriculture is positive or negative because due to addition of municipal solid waste various properties of soil is changing like PH, electrical conductivity, macronutrients, micronutrients, heavy metals. We also consider effect of toxic waste on soil and up to what extent it can harm the soil. We also saw how various geotechnical properties like particle size, shear parameter, liquid limit, specific gravity, bulk density, water retention capacity. Finally we found that how it will affect the growth of plant and productivity of crop in agriculture. We can say our main consideration is to find the effect on chemical properties of soil.

III.SCOPE OF WORK

Land filling has a big impact on soil and the extent of impact depends on the type of municipal solid waste, proportion of organic waste and waste from industries. If municipal soild waste contain toxic waste then it causes negative effect on soil properties. Firstly, we found out the effect of municipal solid waste on geotechnical properties of soil and then our main consideration is to find the effect of municipal solid waste in land filling on agricultural soil. In agriculture effect, we study change in PH, electrical conductivity of soil, proportion of macro-nutrients, proportion of micro-nutrients, proportion of heavy metals, organic content, etc. Apart from that we can go more deep inside the effect of MSD on soil by finding out the
various methods of reclamation of soil effected properties. We
can also concentrate on weather landfilling area can be used
for construction purpose and how we can use it for the benefit of mankind. Today as the population is increasing and more and more municipal solid waste is increasing, and place for
dumping is decreasing. We have to find out new method to decrease waste and use it properly at various places. In future we have to concentrate on this topic and find out a process so that we can decrease the negative effect of soild waste on soil as much as possible. This problem arises in those countries where very population is very high and municipal waste generated is very large. So, we can say in future scope of this particular topic is very huge.

IV. REVIEW OF LITERATURE

1. The paper presents results of laboratory investigation of the effects of municipal solid waste on the chemical and geotechnical properties of soils. Soil samples taken from three trial pits at depths of 0.5, 1.0 and 1.5 m, were used for the investigation. Two of the trial pits were located around the studied dump site to serve as control points or uncontaminated soil, while the third trial pit was located within the dump site to serve as contaminated soil. Soil samples collected were subjected to pH, electrical conductivity,change in proportion of nitrogen, potassium, and varous other macronutrients, micronutrients, heavy metsals, carbon content and together with geotechnical properties like specific gravity, natural moisture content, particle size analysis, consistency, compaction, permeability, tri-axial and consolidation tests. Results of the investigation show that Municipal Solid Waste (MSW) increases the all the nutrients in soil, increase the electrical conductivity of soil and deceases the pH of soil, also lowers the specific gravity, increases the natural moisture content, increases the fine particles content, lowers the maximum dry density with higher optimum moisture content, lowers both the cohesion and the angle of internal friction, increases the coefficient of permeability, coefficient of consolidation and coefficient of volume compressibility of the soil. These effects reduced with depth. A comprehensive large-scale laboratory testing program using direct shear (DS), tri-axial (TX), and simple shear tests was performed on municipal solid waste MSW retrieved from a landfill in the San Francisco Bay area to develop insights about and a framework for interpretation of the shear strength of MSW. Stability analyses of MSW landfills require characterization of the shear strength of MSW. Although MSW is variable and a difficult material to test, its shear strength can be evaluated rationally to develop reasonable estimates. The effects of waste composition, fibrous particle orientation, confining stress, rate of loading, stress path, stress strain compatibility, and unit weight on the shear strength of MSW were evaluated in the testing program described herein.

The results of this testing program indicate that the DS test is appropriate to evaluate the shear strength of MSW along its weakest orientation i.e., on a plane parallel to the preferred
orientation of the larger fibrous particles within MSW. These laboratory results and the results of more than 100 large-scale laboratory tests from other studies indicate that the DS static shear strength of SW is best characterized by a cohesion of 15 kPa and a friction angle of 36° at normal stress of 1 atm with the friction angle decreasing by 5° for every log cycle increase in normal stress. These recommendations are based on tests of MSW with a moisture content below its field capacity; therefore, cyclic degradation due to pore pressure generation has not been considered in its development.

MSW used to dump nearby on low laying lands. This investigation aims to characterizing MSW and assessing geotechnical properties of contaminated soils at dumping sites in Chickballapur city of Karnataka. Representative solid wastes from selected wards of the city were collected and analysed. Substantial release of leachate form the dump yards occurred during past few years and the soil at the dump site experience extensive contamination. The test results of contaminated and uncontaminated soil show increase in Optimum Moisture Content and decrease in Maximum Dry Density. The unconfined compressive strength decreased considerably for soil samples obtained at 0.0 m, 0.5 m and 1.0 m depths below waste dump. At depths greater than 1.5m compaction characteristics and UCC strength closely matches with the uncontaminated soil. Little variation in pH value, which makes soil slightly alkaline, was observed. From the study, it is inferred that, this investigation is very significant, as the foundation normally at these depths may be affected by this contamination.The objectives of this research was to determine the effects on, and the role of the soil in the transport of hazardous wastes in and around landfills. Certain aspects of the research represented technology transfer; whereas, other aspects of the research focused on defining the physical characteristics of type soils and the effects of hazardous wastes on their permeability, strength and plasticity. Dumping also effect the agriculture on near by soil.

The immediate goals (Phase I) included: Task A - Assessment of the present state of the art with respect to the effects of hazardous waste material on the engineering behaviour of soil. Task B - The geotechnical engineering laboratory characterization of selected clay minerals which have been subjected to hazardous waste chemicals.

The long range goal (Phase II) is to apply the knowledge gained through the research effort to study soil behaviour at specific hazardous waste disposal sites, either in operation or in the process of applying for permit, within the state of Oklahoma.

A literature search of the Oklahoma State University library was made using the disposal of hazardous wastes as a general topic. Some of the main topics included industrial waste disposal, solid waste disposal, sanitary 2 landfill leachate, and soil pollution articles selected for inclusion in the literature review contained information on the interaction of hazardous wastes with soils, groundwater quality near a landfill, mechanism of transport of a waste within a soil, and effects of the waste on soil properties.

V. EXPERIMENTAL INVESTIGATION

Now we will give various experiments to know about the effect of municipal solid waste on nearby soil.

PH and Electrical Conductivuty:- First of all we will take the sample of soil and dilute it to make a solution and we that solution in beaker. Then we will take electrode and dip it in the beaker and reading and PHmeter is noted. Generally PH of a soil is decreases due to acidic nature of the municipal solid waste. PH of soil has huge impact on soil properties because solubility of various nutrients increases with decrease in PH of soil. So due to high solubility, availability of nutrients increases to plant and plant growth increases with application of waste upto limited extent. Electrical conductivity of soil increases due to dumping of soil.

Organic Content:- Municipal solid waste generally contain organic waste due to this organic carbon increases. It can be find out by the oxidising soil solution by potassium dichromate & sulphuric acid and then titrating with ferrous ammonium sulphate. If waste does not contain organic waste then organic content of soil remain constant.

Nitrogen:- Nitrogen content of the soil increases with municipal solid waste landfilling. Because MSD contain large amount of nitrogen content than the soil nitrogen content. Free ammonia can be calculated simply by boiling and sum total of ammonical nitrogen and organic nitrogen is called kjeldahl's ammonia. Chemical like borax buffer, boric acid+ indicator, hydrochloric acid, etc. are used to find the nitrogen content of soil.

Phosphate:- It increases with municipal solid waste application on soil because waste contain more amount of phosphate than soil.

Iron Content:- It is also increases with increase municipal solid waste application on soil. This is because waste contain large amount of iron containing compound than soil so it's content increases with its application.

Apart from above chemical content , elements like Mn, Zn, Cu, Cd, Pb, Ni also increases in amount with application of municipal solid waste. Together with above elements some new elements like Cl, Ca, bicarbonate is also added to the soil.

Table no1 Properties of soil away from MSD Site

s. no.	Property	Values
1.	PH	7.4
2.	EC dS/m	1.51
3.	OC mg/kg	0.16
4.	N	0.06
5.	P	25
6.	K	227
7.	Fe	2.39
8.	Mn	2.45
9.	Zn	1.07

Table no2Properties of soil away from MSD Site

s. no.	Property	values

1.	PH	6.2
2.	EC dS/m	14.2
3.	OC mg/kg	0.65
4.	N	0.22
5.	P	85
6.	K	1895
7.	Fe	287.4
8.	Mn	35.6
9.	Zn	4.88

Together with the chemical properties geotechnical properties are also effected due municipal waste dumping. Various geotechnical properties changes are finer content, shear parameter, specific gravity, water holding capacity, consistency limit, optimum moisture content, dry density, shear strength parameter, coefficient of permeability, etc.

1. SPECIFIC GRAVITY (G)

The specific gravity of soil solids is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water.

$$G = \frac{(M_2 - M_1)}{((M_2 - M_1) - (M_3 - M_4))}$$

where, M_1 - Weight of empty pycnometer bottle

M_2 - Weight of pycnometer bottle + soil sample

M_3 - Weight of pycnometer bottle + soil sample + water

M_4 - Weight of pycnometer bottle + water (fully filled)

Table no3 uncontaminated soil from TP1

	SAMPLE 1	SAMPLE 2	SAMPLE 3
M_1 (g)	695.24	694.67	693.84
M_2 (g)	896.11	897.34	894.32
M_3 (g)	1678.52	1683.98	1680.53
M_4 (g)	1564.12	1565.07	1564.71
G	2.33	2.41	2.368

The value of the specific gravity of the soil tested is taken as average value of the three samples i.e. **G = 2.37**

Table no 4 contaminated soil from TP2

	SAMPLE 1	SAMPLE 2	SAMPLE 3
M_1 (g)	694.42	698.41	697.33

M_2 (g)	893.37	899.12	898.41
M_3 (g)	1671.14	1670.24	1671.04
M_4 (g)	1564.47	1566.81	1565.82
G	2.15	2.06	2.09

The value of the specific gravity of the soil tested is taken as average value of the three samples i.e. **G = 2.1**

2. DIRECT SHEAR TEST

The direct shear test was conducted on the soil sample to obtain the friction angle of the soil (ϕ) and the cohesion (c) using the direct shear apparatus with mould of size 60mm * 60mm. The test was conducted for three different normal loadings of 50kN/m^2, 100kN/m^2 and 150kN/m^2. The horizontal displacement corresponding to different shear force is noted and curves are plotted for different normal loadings.

The shear stress corresponding to normal load is obtained by dividing the maximum shear force with the initial area of the mold i.e.

$$shear\_stress(KN/m^2) = \frac{shear\_force(N) \times 1000}{60 \times 60}$$

For uncontaminated soil

The value of apparent cohesion, c and angle of internal friction ϕ are obtained from the plot of maximum shear stress corresponding to respective normal loadings, where c is the intercept and ϕ is the slope of the failure line.

Thus, c=4.9 KN/m^2 and

$\phi = \tan^{-1}(0.63) = 32.21^o$

Table no5 Result Obtained from Direct Shear Test

Normal load(KN/m^2)	Shear Stress (KN/m^2)
50	37.11
100	69.32
150	97.21

For contaminated soil

The value of apparent cohesion, c and angle of internal friction ϕ are obtained from the plot of maximum shear stress corresponding to respective normal loadings, where c is the intercept and ϕ is the slope of the failure line.

Thus, c=19 KN/m^2 and

$\phi = \tan^{-1}(0.234) = 13.17^{o}$

Table no6

Normal load(KN/m^2)	**Shear Stress (KN/m^2)**
50	29.16
100	44.05
150	59.7

3. DRY SIEVE ANALYSIS TEST

The dry sieve analysis of the soil sample was carried out to find the particle size distribution. The sieves of different size were arranged in decreasing size from top to bottom and the mass retained on each sieve was noted. The table below shows the calculation of percentage finer particles for each sieve.

Table no7 For uncontaminated soil sieve analysis

(1)	**(2)**	**(3)**	**(4)**	**(5)**
Sieve size	**Mass retained (g)**	**%Mass retained**	**Cumulative % retained**	**% Finer (N)**
4.75 mm	261.32	26.132	26.132	73.868
2.36 mm	198.42	19.842	45.974	54.026
1.018 mm	224.75	22.475	68.449	31.551
0.6 mm	138.64	13.864	82.313	17.687
0.425 mm	123.04	12.304	94.617	5.383
0.300 mm	38.98	3.898	98.515	1.485
0.150 mm	4.20	0.420	98.935	1.065
0.075 mm	3.22	0.322	99.257	0.743
Pan	7.41	0.741	99.998	0

Contaminated soil sieve analysis

$$C_C = \frac{D_{30}^2}{D_{10} \times D_{60}} = \frac{1.2^2}{0.5 \times 3} = 0.96$$

(1)	(2)	(3)	(4)	(5)
Sieve size	**Mass retained (g)**	**%Mass retained**	**Cumulative % retained**	**% Finer (N)**
4.75 mm	199.55	19.955	19.955	80.045
2.36 mm	95.10	9.510	29.465	70.535
1.018 mm	161.56	16.156	45.621	54.379
0.6 mm	253.30	25.330	70.951	29.049
0.425 mm	40.89	4.089	75.04	24.96
0.300 mm	55.56	5.556	80.596	19.404
0.150 mm	35.45	3.545	82.141	17.859
0.075 mm	20.36	2.036	86.177	13.823
Pan	138.20	13.820	99.997	0

$$C_C = \frac{D_{30}^2}{D_{10} \times D_{60}} = \frac{0.68^2}{0.1 \times 1.55} = 2.98$$

4. LIQUID LIMIT TEST

Liquid limit test was performed on the soil by using casagrande's apparatus to determine liquid limit of contaminated and uncontaminated soil. The test was performed on soil with different water content and no. of blows were determine and on that basis water content corresponding to 25 no. of blow gives the liquid limit

For uncontaminated soil,

Liquid limit = 20.72

For contaminated soil,

Liquid limit = 26.67

5. COFFICIENT OF PERMEABILITY

Laboratory constant head method was used in the determination of the coefficient of permeability of the soils. From the results, the contaminated soil has lower values of coefficient of permeability than the uncontaminated soils. These results shows fact that the contaminated soil has more fine soil particles, which would have ordinarily reduced the pore space in the soil. This anomaly may be due to particles' flocculation as a result of contamination with MSW. The flocculation process may have altered the behaviours of the fine particles from sand-like to silt-like and consequently, making the soil less permeable. This also confirms to the results of the consistency limits.

Table no8: Results obtained from constant head permeability test

SOIL SAMPLE	TRAIL PIT	COEFFICIENT OF PERMEABILITY
Uncontaminated	TP1	18×10^{-4} m/s
Contaminated	TP2	7.4×10^{-4} m/s

VI. RESULT AND DISCUSSIONS

- **Macronutrients of soil:** macronutrients contents of the soil increases because waste contain large amount of nutrients which increases its content in soil.
- **Micronutrient of soil:** its content also increase.
- **Heavy metals:** Its value also enhances in soil
- **pH:** pH of a soil decreases due to the production of acids.
- **Electrical conductivity:** its value decreases.
- **Salts :** Its value decreases.
- **moisture content:** Natural moisture content of soil increases because soil the soil below the MSW does not comes in contact with sunlight and atmosphere and due higher percentage of organic content water retention property of soil gets increased.
- **Specific gravity:** specific gravity of soil decreases due to MSW because due to MSW and leachate percentage of fine organic particles increases which have lower specific gravity of range (1.1-1.8)
- **Sieve analysis:** Results of sieve analysis shows earlier soil was poorly graded had low amount of fine particles but due to contamination fine particles got increased which can be observed by graph.
- **Direct shear test:** From direct shear test we observed that soil is sand with low content of fines (silt) due to with shear parameters were **c=4.9** & **Ø=32.21**, due to contamination finer particles increased resulted increase in cohesion **c=19** and decrease in angle of internal friction **Ø=13.12.**
- **Liquid limit test:** Test result shows that liquid limit of soil increases due contamination because amount of organic content increases.
- **Permeability:** permeability test results shows that the sandy soil have higher permeability value but due to MSW, finer particle content increases which fills the pores and decreases the permeability of soil.
- These findings will help in guiding geotechnical engineers when designing and constructing foundations for buildings and other related structures on these types of soils.

VII. CONCLUSIONS

Based on the results of the study, the following conclusions can be drawn:

1. Nutrients in the soil increases.

2. pH of soil decreases due to decomposition of soil.

3. Electrical conductivity decreases.

4. Salts and ions increases.

5. The Natural (uncontaminated) soil within and around the dump site is relatively homogeneous.

6.The contaminated soil has lower specific gravity, contains more fine particles, lower MDD with higher OMC, both lower cohesion and angle of internal friction,

7. The contaminated soil has higher NMC, higher coefficient of permeability and both coefficient of consolidation and coefficient of volume compressibility are higher than the uncontaminated soil.

8. The difference in the geotechnical properties exhibited by the contaminated soil, as depicted by the test results was impacted by the dumped MSW.

These effects reduce with depth.

•These findings will help in guiding geotechnical engineers when designing and constructing foundations for buildings and other related structures on these types of soils.

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