Age Variation in Geotechnical Properties of Contaminated Kalamassery Municipality Soil

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***Abstract* — Waste disposal is a hectic problem for all developing countries including India. The faster rate of pollution generation is due to the rapid population growth. In-efficient waste management leads to pollution and severe health problems. The unlined waste disposal areas are often the dumping zones of these heterogeneous waste materials. These decomposable solid waste undergoes precipitation to form Leachate will cause the pollution of surrounding soil and ground water. The project deals with identification of pollutants in the waste of Kalamassery municipality landfill. The two governing factors determining the intensity of pollution in soil and surrounding water bodies are the quantity and transport depth of leachate. From the study it is found that the geotechnical properties of soil vary with age. Amended clay liners using natural geomaterials are the best and economic option to reduce the penetration of leachate into deeper strata.**

Keywords —landfill; leachate; chemical analysis

I. INTRODUCTION

Land filling is the common disposal technique adopted worldwide for disposal of municipal solid waste. In every country, millions of tons of waste are produced annually and it has become one of the toughest jobs to dispose it. Waste disposal in India, simply involves summing up the waste from different parts and dumping everything in a landfill. India is currently facing a municipal solid waste mess, for which all elements of the society are responsible. The public awareness about its ill-effects is comparatively low. There is no system of segregation of organic, inorganic and recyclable wastes at household level. Proper assessment of the municipal solid waste has become an extremely important in the light of the pollution caused by them. Once a landfill is completely occupied, new landfills are discovered at different places. The landfill method creates land pollution and in some cases, ground water contamination also. Lots of environmental drawbacks including smell and wastage of valuable land remain un-resolved.

The characteristics of municipal solid waste play a key role in many aspects of waste disposal facilities and landfills. The waste is not subjected to recycling, composting, or any other form of environmental treatment. Hazardous toxic wastes and organic wastes in the landfill are dumped together thus creating environmental pollution and health problems. Increased concern in the environment protection during the last decades, led to an increase in the importance of design and maintenance of landfills for waste disposal. Municipal Solid Waste (MSW) is commonly referred as household wastes and commercial wastes. There is a misconception that MSW is relatively safe and would not adversely affect the environment and human beings. The municipal solid waste leachate gets transported through the surrounding soil and may give chance for the pollution of the soil and serious health problems to the living organisms.

Landfill of MSW is the simplest, cheapest and most cost effective method of disposing of waste in both developed and developing nations if protection measures like covers, barriers and liners are provided.

II. MATERIALS & METHODOLOGY

A. General

The site selected for the study is a typical unlined MSW landfill area which is situated at Kalamassery municipality, Cochin, Kerala, Ernakulam district. The district has a moderate climate. It sprawls over 27km^2. It is also a part of the Kochi metropolitan area and the new Kochi metro passes through this area. According to the 2011 census Ernakulam district has a population of 3,282,388. The soil consists mainly of sediments like Alluvium, Teri's, Brown sand. Red coloured sticky soil also found in these areas. The average yearly rainfall in the district is 3432 mm. This site is spread over an area of about 4 x 10^4 m^2 and situated near National Highway 47. The height of the waste dumped is about 10-15 m. The base of landfill is not lined, which may result in continuous groundwater and soil contamination. This site has not been designed systematically before being used for disposal of waste. Furthermore no environmental impact assessment had been carried out prior to selection of this site.

B. Collection of soil sample

The soil sample was collected from two different points of Kalamassery Municipality. Two sets of soil samples were collected. Sample 1 (collected from previous dumping area) was 5m away from pile number 222 of Cochin metro, which was taken as the permanent boundary. The second sample (collected from present dumping area) was at a distance of 15m from the boundary. The samples were taken from a depth of 1.5m. For the purpose of sample collection a borehole was drilled with the help of labours. Red coloured sticky soil obtained from the area indicated it is a lateritic soil sample. Sample one was moderate red colour while sample two was blackish nature with stingy smelling.

Fig.1 Overview of Kalamassery Municipality

Fig.2 Soil Sample 1

Fig.3 Soil Sample 2

III. MATERIAL PROPERTIES

Initial properties of the collected soil samples were determined by conducting various tests according to IS classification.

TABLE I INITIAL PROPERTIES

Properties	Sample 1	Sample 2
Initial moisture content (%)	27	48.33
Liquid limit (%)	46	52
Plastic limit (%)	36.36	37.86
Shrinkage limit (%)	9.64	14.14
Specific gravity, G	1.65	1.76
Max.dry density γd (g/ cm^3)	1.49	1.42
OMC (%)	17	14.3
D10	0.2	0.1
Cu	7.5	8
Cc	0.675	0.78
% sand	7.52	15
%silt	34.4	4.6
% clay	58.08	80.4
Soil classification	OI	OH

IV. RESULTS & DISCUSSIONS

Various tests like Atterberg's limit, compaction, particle size distribution, unconfined compressive strength tests were carried out on the materials collected and following results were obtained.

A. Natural moisture content(NMC)

NMC is greater for contaminated soil. This trend could be due to moist condition as the natural ground level is covered by the MSW, thereby preventing direct evaporation of moisture from the soil below. The presence of large amount of fine particles in contaminated soil increases the moisture, since fine soil particles have more affinity for water. The change in natural moisture content decreases with age.

B. Atterberg's limits

Atterberg's limits of soil samples were performed by cone penetrometer (IS: 2720 Part 4). The plasticity values obtained lies within the range of 7-17 which indicates the soil is silty and is cohesive in nature. The soil sample lies in a range between medium-high plastic. Based on the plasticity chart the soil sample is obtained as intermediate organic or silty soil and soil sample 2 is obtained as highly organic or silty soil. Water content corresponding to 20mm penetration was obtained as liquid limit.

The result of chemical analysis conducted at NCESS, Akkulam, proved the sample 1 is having more chemical constituents than that of sample 2. The chemical content which increases with age is responsible for the low Atterberg's limits, as Atterberg's limits decreases with increase in chemical content.

C. Specific Gravity

Specific gravity of contaminated soil is less. This is because the amount of fines is more in contaminated soil which results in low specific gravity.

D. Compaction

Maximum dry density (MDD) and optimum moisture content were obtained by performing Standard Proctor test IS 2720(Part 7). The optimum moisture content (OMC) and maximum dry density of contaminated soil sample 1 is obtained as 17% and 1.49 g/cc while that of soil sample 2 is obtained as 14.3% and 1.42 g/cc respectively.

MDD of contaminated soil is less. This result conforms with the results of the particle size distribution, which indicates higher percentages of fine fractions in the contaminated Soil. Since fine particles within soil have more affinity for water, the higher the OMC, the lower the MDD.

E. Permeability

Permeability was obtained by conducting Falling head permeameter IS 2720 (Part 36). According to the IS classification sample 1 is classified as silty sand and contaminated sample 2 as silt.

TABLE 2. VALUES OF PERMEABILITY

Permeability	Value
Sample 1 (m/s)	3.6*10^-4
Sample 2 (m/s)	6.8*10^-4

Contaminated soils have high permeability. This is contradict to the fact that the contaminated soil has more fine soil particles, and that would have reduced the pore space in the soil. This may be due to the flocculation of particles as a result of contamination with MSW. The flocculation process has altered the behaviour of the fine particles from clay to silt-like making the soil more permeable.

F. Consolidation

Consolidation was performed according to IS 2720 (part 15).

TABLE 3. RESULTS OF CONSOLIDATION

Consolidation	Value
Sample 1 (cm^2/s)	0.016
Sample 2 (cm^2/s)	5.25*10^-3

G. SEIVE ANALYSIS

Sieve analysis was performed according to IS 2720(part 4). The $c_c$values of the contaminated soil samples lies within the range between 1 and 3 but the $c_u$value obtained is greater than 4.so the soil samples are classified as poorly graded. The c_c value lies in the range between 1 and 3 and cu is greater than 6 so it can be classified as poorly graded sand.

Contaminated soil contains more fines content than uncontaminated. This result conforms to the results of the particle size distribution, which indicates higher percentages of fine fractions in the contaminated soil.

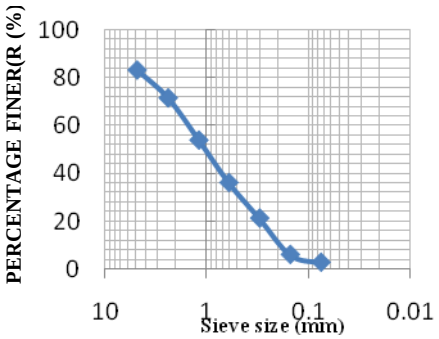

Fig.4 Grain size distribution of Soil Sample 1

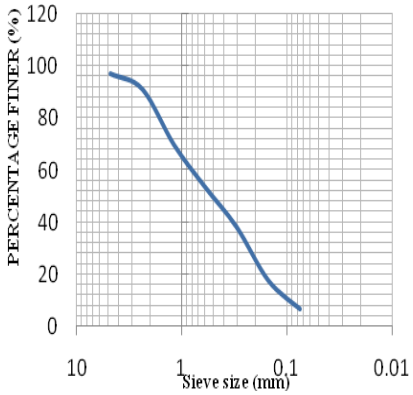

Fig. 5 Grain size distribution of Soil Sample 2

H. UNCONFINED COMPRESSION TEST

Compressive strength of the soil was obtained by conducting unconfined compressive strength test. It was conducted according to IS 2720(Part10).the UCC Values of soil sample 1 and 2 are obtained as 2.497 and 1.929 Kg/cm^2 respectively. From this it can be seen that sample 1 belongs to very stiff type of soil and sample 2 belongs to stiff category.

As chemical content increases, UCC& shear strength increases. This is because the presence of chemicals provides an additional strength to the soil particles.

I. PARTICLE SIZE DISTRIBUTION

Particle size distribution of the soil was obtained by performing hydrometer analysis (IS:2720 Part 4). Percentage of sand, silt and clay present in soil was determined. The results of the particle size distribution, indicates higher percentages of fine fractions in the contaminated soil.

TABLE 4.GRAIN SIZE DISTRIBUTION

Elements	Sample 1	Sample 2
% sand	7.52	15
% silt	34.4	4.6
% clay	58.08	80.4

An experimental setup is conducted in which 3 day and 21 day variation in geotechnical properties is studied. The liquid limit of 3 days is obtained as 47% while that of 21 days it increased to 59% .increase trend in plastic limit is also seen as the value increases from 37.22 to 47.4 % for 3 days and 21 days respectively.UCC strength also shows significant changes due to the presence of various chemicals present in it. The unconfined compressive strength values for 3 days and 21 days are 0.167 and $0.369Kg/cm^2$ respectively. From this it is clear that the geotechnical properties of the soil samples vary continuously with age.

The trend observed was that the atterberg limit decreases and the ucc strength increases.

V. CONCLUSIONS

The concentration of various constituents in landfill varies from time to time depending on various factors like variation in rainfall, temperature, humidity, living habits, encroachment of new buildings etc.

As chemical content increases, atterberg limit decreases and UCC& shear strength increases. These changes may be due the accumulation of particles and increase in void space due to the effect of chemicals and varies with age. Contaminated soil contains more fines and is responsible for the high natural moisture content. Low specific gravity for contaminated soil is due to increased percent of fines. MDD of contaminated soil is less as fine particles within soil have more affinity towards water, the higher the OMC, the lower the MDD.

The change in natural moisture content decreases with age. NMC is greater for contaminated soil. Contaminated soils have high permeability value. This is contradict the fact that the contaminated soil has more fine soil particles. Thus it is clear that as age increases, the properties of the soil varies continously which inturn effect the geotechnical properties of the soil. Hence a detailed investigation has to be carried out before construction on these areas because the chances of settlement is more in these areas.

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