Investigative Study of Hydraulic Conductivity at Deonar Dumping Yard

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Abstract— The city of Mumbai is located in western India and is the capital of the State of Maharashtra. Mumbai and its neighboring suburbs, together constituting the Greater Mumbai Metropolitan area, inhabits more than 20.7 million people on an area total of 437.71 square kilometers. Due to growth in population, industrialization & urbanization, the generation of solid waste has increased frighteningly. In these research paper analytical study of hydraulic conductivity of Deonar dumping, yard has been carried out with the help of falling head method and using Darcy's equation. The hydraulic conductivity of municipal solid waste ranged from 4.73×10^{-4} to 5.12×10^{-4}cm/s in Deonar dumping yard.

Keywords: Deonar Dumping Yard, Solid Waste Management, Hydraulic Conductivity

I. INTRODUCTION

Waste management is worldwide phenomenon, rising population, industrialization & urbanization are accountable to produce tremendous amount of waste. Today's daily waste generation rate is about 760,000 tons. By 2025, this rate will be increased to about 1.8 million tons per day. These estimates are conservative; the real values are probably double of this amount. [1]

Local governments in Asia at present spend about US $25 billion per year on waste management of urban area. This amount is used to collect more than 90 percent of the waste in high income countries & it is about 50 to 80 percent in middle income countries, and only 30 to 60 percent for low income countries in 2025, Asian governments should look forward to spend at least double this amount on solid waste management activities. [1]

Due to change in habitats of people some researcher's forecasted that between 2020 and 2025 the waste composition of Indian garbage will undergo drastic change. It has been seen that the consumption of inorganic waste is increasing day by day and still we don't have permanent, effective and green solutions over these problems.

Mumbai is a peninsular city separated from the mainland by the Thane creek and Harbor bay in the east, facing the Arabian Sea to the west and south. The city initially originated as a group of seven islands that were connected by massive land reclamation projects. Hence, the city is low lying with an above sea level height of hardly 10-15 meters, at some places just above sea level. [2]

Due to rapid urbanization and economic growth, the city has over the last decades faced great challenges of providing basic services like adequate housing and infrastructure. Population density in some areas exceeds 100000 people per square kilometer. Furthermore, many people live in slum areas with inadequate sanitation facilities and poorly maintained waste management. This causes serious public health problems and environmental risks that affect the entire population of Mumbai. To understand the Municipal Solid Waste (MSW) management, it is vital to understand the hydraulic conductivity. [3]

A. Necessity of Solid Waste Management

- Due to growth in population, industrialization & urbanization, the generation of solid waste has increased threateningly.
- Solid waste has many severe influences over the development of a city or village.
- Diseases, odor pollution, unhygienic surrounding are the major fears arise due to solid waste.
- Major cities in India are producing more than 1000 tonnes per day of solid waste. A major part of this waste is discarded to land dumping which has its own impacts over land, society, and environment.
- Proper SWM provides competence of collection, segregation, transportation, & treatment of waste suitably.
- This reduces odor pollution & risk of diseases, also good management improves the aesthetics of the city.
- If not managed appropriately then the concept of a smart city can worsen the situation of the current SWM scenario.
- Though SWM is complex to execute but with appropriate analysis & study, disciplinary work, and modern eco-friendly techniques. It is possible to achieve needful.

B. Study Objective

"The ultimate aim of this work is, to study the hydraulic conductivity of solid waste at Deonar dumping yard by conducting the analytical study by the falling head method and investigated by Darcy's law"

II. LITERATURE REVIEW

A literature review of scholarly articles, books, dissertations, conference proceedings and other resources which are relevant to the study and understanding the characteristics of municipal solid waste and its methodologies is carried out to set the background on what has been explored on the topic so far. An extensive literature review provides background information on current knowledge related to the research topic. On the bases of learning from the literature review, the methodology will be secure and study will be carried out. The hydraulic conductivity derived from various research papers is formulated in tabular form below

Tittle of Research Paper	Year of Publish	Hydraulic Conductivity (mm/s)	Method of Test
Hydrogeological and Geotechnical properties of refuse using Large compression cell by Beaven R. & W. Powrie	1995	1.7×10^{-4} to 2.0×10^{-4}	Constant Head Test

Hydraulic conductivity of compacted municipal solid waste by Chen Ten Hong & David P. Chynoweth	1995	$4.7x10^{-7}$ to $9.6x10^{-4}$	Constant Head Test
Permeability and compression characteristics of Municipal solid waste samples by Durmusoglu E. & Sanchez T. M	2006	$4.7x10^{-6}$ to $1.2x10^{-4}$	Falling Head Test
Hydro – mechanical behaviour of MSW subject to leachate recirculation in a large-scale compression reactor cell by Olivier F & Gourve J. P	2010	$1.0x10^{-6}$ to $1.0x10^{-4}$	Falling Head Test
Geotechnical properties of fresh Municipal Solid Waste at Orchord hills landfill, USA by Reddy K. R., Hethiarchchin H, Parakalla N. S., Gargathulasi J., Bogner J. E	2016	$1.0x10^{-8}$ to $1.0x10^{-4}$	Constant Head Test
Porosity and Hydraulic conductivity of MSW using laboratory scale tests by M. Staub, B. Galietti, Oxarango, M.V. Khire & J. R. Gourc [7]	2016	$4.6x10^{-6}$ to $7.4x10^{-5}$	Falling Head Test
Experimental Investigation of Hydraulic conductivity of municipal solid waste by Varsha S. Gawhare & et al.	2017	$3.94x10^{-7}$ to $1.96x10^{-6}$	Constant Head Test

Table 1: Hydraulic Conductivity Values from Various Research Paper

III. Material and Method

A. *Method*

The municipal solid waste samples are collected at various depths as specified in methodology and examined for the study of hydraulic conductivity. In our study, the hydraulic conductivity is calculated by the falling head method and investigated by Darcy's law and typically has the same units as that for velocity and expressed in units of cm/s or m/s. Darcy's equation was used to examine hydraulic conductivity which states that

$$K = \frac{a \times L}{At} \ln \frac{h1}{h2}$$

Where,
'a' is cross sectional area of Inlet pipe (cm^2)
'L' is Length of solid waste sample column (cm)
'A' is cross sectional area of solid waste sample column (cm^2)
't' is time required for head drop from h1 to h2 (sec)
'h1' is total head before test (cm)
'h2' is total head after test (cm)

B. *Experimental Set up*

The study is accomplished in a custom built setup called "Hydraulic Conductivity Chamber". The use of large particles in a small setup allows the development of large voids where the particles touch the borderline of setup. An important concern in conducting hydraulic conductivity test is the selection of appropriate setup size as per the average particle size. The ratio of setup size to the size of the largest solid waste particle should be close to greater than 15 times was prerequisite. [10]

In the collected sample, the minimum and maximum pragmatic size of particle is about 3mm and 25mm respectively. Since built setup chamber is a rigid square box with width 40cm x breadth 40cm x height 63cm fabricated of plywood with water resistant finish with adequate number of small opening at top and bottom face for leakage free fixing of inlet and exit pipe(with the help of M–seal) as shown in Figure 5. The chamber is used to saturate, drain and run falling head tests on waste samples. To study the samples closely to the real conditions, the collected samples from the designed sampler are double packed in plastic bags and transferred towards the laboratory for further examination without much of disturbance and the height of Hydraulic Conductivity Chamber is kept equal to the 2 feet. Waste is placed in the chamber with uniformly compacted to ensure even density throughout the chamber. Porous stones are used to consent even distribution of water.

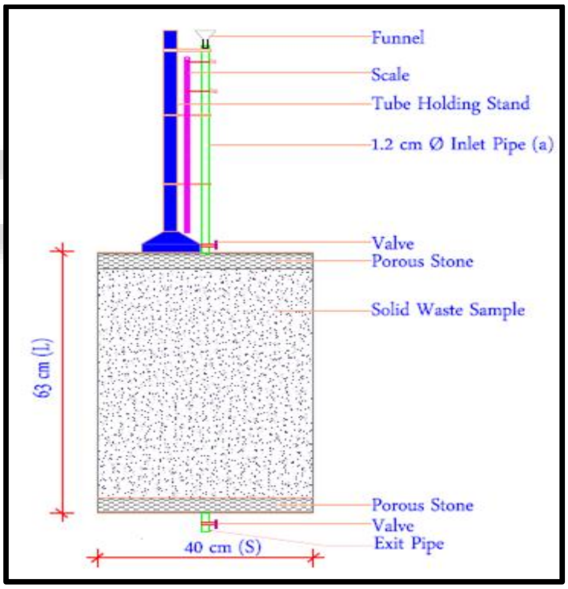

Fig. 1: Sketch of Custom Built Setup "Hydraulic Conductivity Chamber"

IV. Data Collection and Analysis

A. *Sampling Details*

- Methodology of Sampling: Manual Sampling, Random sampling from the recently dumped garbage.
- Quantity of sampling: 10 Numbers of samples
- Device used: Sampler Collector, custom built - Hydraulic Conductivity Chamber
- Precautionary measures: Hand gloves

B. *Procedure*

- Wash and dry Hydraulic Conductivity Chamber.

- Place the porous stone at the base of Hydraulic Conductivity Chamber.
- Weight the sample and put into the Hydraulic Conductivity Chamber uniformly.
- Level the solid waste sample and place second porous stone at top.
- Connect the inlet pipe at the top and exit pipe at the bottom of Hydraulic Conductivity Chamber.
- Start pouring the water in inlet pipe with the help of funnel and allow water to be out from the exit pipe.
- Allow all air to be flushed out by keeping the flow of water for some time.
- Open the valve to be a measurable reading (h1), record the time (in sec) it take to reach the second reading (h2) in cm.
- Repeat the test for all samples.

1) Result Discussion

Hydraulic conductivity was studied by taking average of three samples from every depth of (0-2), (2-4) and (4-6) feet for examination. All readings were taken by checking average values of the series of two trials, to safeguard consistency of result. The analysis of samples is shown in tabular and graphical representation in below section. The value of average density data is obtained from dumping site collection office.

In our study, the hydraulic conductivity is calculated by the falling head method and investigated by Darcy's law and typically has the same units as that for velocity and expressed in units of cm/s or m/s. Darcy's equation was used to examine hydraulic conductivity which already stated in previous section.

Depth	Average Density (Kg/m3)	Average Hydraulic Conductivity (cm/s)
0 - 2 feet	382	5.12 E-04
2 - 4 feet	421	5.04 E-04
4 - 6 feet	457	4.73 E-04

Table 2: Hydraulic Conductivity at various depths

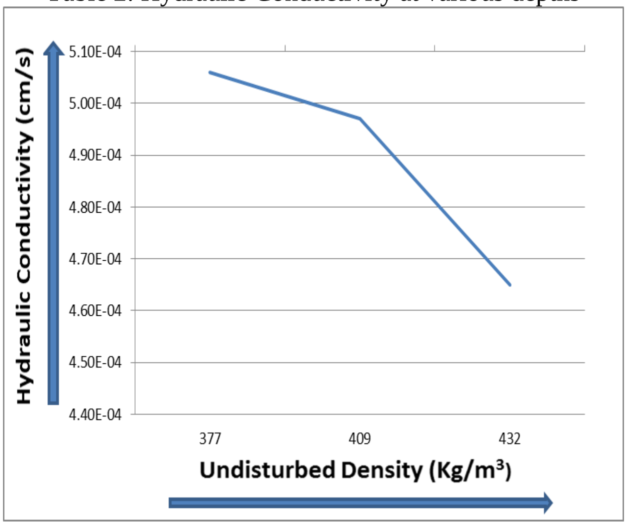

Fig. 2: Hydraulic conductivity v/s undisturbed density

V. Conclusion

Solid waste management is one of the challenging threats in front of world, the change in habitats of people, rapid development are responsible for large generation of waste, in Mumbai are generating more than 7500 MT of waste per day. This waste is creating problems to public health, drainage, aesthetics, of the cities, Proper collection, storage, processing, transport & disposal of waste will lead to minimization of waste impacts, Deonar dumping yard receives 50 - 60 percent of the total waste generated in Mumbai as this is the largest of all the three dumping sites with an area of 111 hectare. Presently the study of Deonar landfill facility for disposal of waste which is not efficiently working.

The hydraulic conductivity of municipal solid waste ranged from 4.73 x 10 -4 to 5.12 x 10 -4cm/s when compacted to densities of 382 to 457 kg m -3. Ina large system of Deonar dumping yard, the hydraulic conductivity is probable to be higher due to channeling.

It can be clearly observed that the hydraulic conductivity is decreasing with the increase in depth due to the change in density, reduction in pore between particle of solid waste and change in geometry with respect to depth.

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