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Landfill Site Design for Municipal Solid Waste of Sindkhed Raja, India

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Abstract: Municipal Solid Waste (MSW) is one of the major environmental problem of the urban and sub-urban areas. Rapid Industrialization and population explosion in India has led to generation of thousands of tons of Municipal Solid waste daily. It has become a global issue and is of a major concern, due to various environmental problems, such as pollution of air, soil and water. The problem of ineffective municipal solid waste management (MSWM) is also prevailing in the Sinkhed Raja. Therefore the present study was undertaken to find out the current status and designing a sanitary landfill site for Sinkhed Raja town. Currently mainly open dumping is done for municipal solid waste in Sinkhed Raja. It was found that negative environmental effects can be reduced, if engineered sanitary landfill is used in place of open dumping. Land filling is the most appropriate management option for mixed type of waste where segregation of waste is not done at source or at transfer station.
Keywords: Municipal Solid Waste, Sanitary Landfill, Solid Waste Management, Water Quality, Soil Quality.

I. INTRODUCTION

The rising accumulation of waste in the environment becomes more imminent in recent decades, necessitating the need to take actions towards a more sustainable society. An estimated 12.6 million people died as a result of living or working in an unhealthy environment in 2012 – nearly 1 in 4 of total global deaths, according to new estimates from World Health Organization. Environmental risk factors, such as air, water and soil pollution, chemical exposures, climate change, and ultraviolet radiation, contribute to several diseases and injuries. Unless properly managed, solid wastes have potential of serious impacts on environment. It can lead to surface and ground water contamination, land pollution and air quality deterioration. Solid waste disposal sites are found on the outskirts of the urban areas, turning into the major sources of contamination due to the incubation and proliferation of flies, mosquitoes, and rodents; that, in turn, are disease transmitters that affect population's health, which has its organic defences in a formative and creative state. The per capita solid waste generation rate is around 300 g/capita/day[1] in developing countries but consumerism and "throw away" culture increases the amount of solid waste generation.

Municipal solid waste management involves waste collection, transportation, treatment and disposal. Land disposal is the commonly adopted method for mixed waste. In developing countries waste is disposed of in open dumps, which lead to severe environmental impact and also loss of natural resources [2].These are various adverse environmental impacts due to unscientific management of waste disposal leads to ground and surface water pollution, air pollution due bad odor, green house gas emission, harmful effects of rat, stray animals and insects etc [3].However, the municipal governments of developing nations lack the ability to provide even this basic function (Medina 2002).Domestic solid waste includes all solid wastes generated in the community and generally includes food scraps, containers and packaging, discarded durable and non-durable goods, yard trimmings, miscellaneous inorganic debris, including household hazardous wastes (for instance insecticides, pesticides, batteries, left over paints etc., and often, construction and demolition debris.

A landfill is a large area of land or an excavated site that is specifically designed and built to receive wastes. In many regions of the world, landfills have long been seen as a final way to store waste at minimum cost (Krook et al., 2012). This dependence on landfilling has created a chain of long-term economic, social and environmental impacts

II. STUDY AREA

The name Sindkhed is derived from the name of king Sindhurama, who is said to have established this city in ancient time. While other believes that this area was known as 'Siddha Kshetra' (holy land of seers), which over a period of time got abbreviated to Sindkhed.

Sindkhed Raja is located 77 KM towards South from District head quarters Buldhana. It is a Taluka head quarter. Tuljapur (5 KM), Shivani Taka (6 KM), Asola Jahagir (6 KM), Pimpalkhuta (7 KM), Waghora (7 KM) are the nearby Villages to Sindkhedraja.

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Sindkhedraja is surrounded by Sindkhedraja Taluka towards East, Jalna Taluka towards west, Jafrabad Taluka towards North, Mantha Taluka towards East. Jalna, Partur, Lonar, Mehkar are the nearby Cities to Sindkhedraja.

Table 1: Population Growth Trend of Sindkhed Raja

Year	Population	Decadal Growth Rate (in %)	Average Annual Growth Rate (in %)
1971	7450	NA	NA
1981	9500	27.52	2.75
1991	11591	22.01	2.2
2001	13941	20.27	2.03
2011	16434	17.88	1.79

Source: Census of India

A total of about 23 Samples (More than 0.13% of the Total Population As per CPHHEO Manual) Samples (62% From Slum/ LIG, 15% From MIG/ HIG, 15% From Commercial establishments which includes institutional generators; hospitals and health care establishments; small and medium-sized enterprises; hotels; function halls; vegetable markets; sports complexes or facilities; places of worship (temples, mosques, etc.); &**8%** At Dumpsite) were collected to determine the Waste Generation, Waste Composition, Physical-Chemical Characteristics of MSW. The sampling exercises were done in accordance with the standard procedure mentioned in the CPHHEO Manual.

Table 2: Average Waste Composition at Source and at Dumpsite

Type			Average at Source	At Dumpsite
Biodegradable	Green Waste and Kitchen Waste	%	36.94	22.14
Recyclable	Plastic, Polythene, Tetra Packs Etc	%	7.99	5.35
	Paper and Card Board	%	8.03	2.95
	Metal	%	0.10	0.18
	Glass	%	0.30	0.26
Non Biodegradable	Textiles	%	4.42	1.48
	Horticulture Waste & Wooden Piece	%	5.51	10.33
	Leather, Rubber Etc	%	0.14	0.11
Inert	Inert (Silt, Debris, Construction and Demolition Waste Etc)	%	36.56	57.20

III.MUNICIPAL SANITARY LANDFILL

A. Conceptual Design of Landfill

Simple Landfill design involves development of concept, adoption of suitable procedure for disposal component and safety considerations. A landfill is a typical combination of different component and each of these components has to be designed separately. Before generating a complete design of sanitary landfill, a design concept has been developed. For this process standard design procedure by CPHEEO Manual on municipal solid waste management, United States Environmental Protection Agency's Manual on Solid Waste Management (Subpart –D- Design Criteria) and Municipal Solid Waste (Management & Handling) Rules have been adopted. A design concept for the following components has been developed.

1) *Design Life:* The life of a sanitary landfill comprises of an active period and a closure and post-closure period. The active period may typically range from 20 to 25 years depending on the availability of land area. The closure and post-closure period, for which a sanitary landfill will be monitored and maintained, will be 15 years and more after the active period is completed. For the project design life of the landfill are for ULB has been considered as 5 years as specified in Terms of Reference. The design period is 2018-2022.
2) *Landfill Volume and Area Required:* A capacity needs assessment was conducted as the first step of the site selection process. An in-depth capacity calculation will be the first step in the design process, taking into account the municipal solid waste management (MSWM) plan and computed waste amounts for the active period of the sanitary landfill. The area required for

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landfill development for the ULB is assessed based on the method suggested in CPHEEO manual. The following is the area requirements for Disposal of waste calculated for 30 Years.

Table 3: Area Required for Disposal of Waste

Assume, waste to be disposed off of daily generated waste =	20	% of total waste
Assume, density of compacted waste =	0.85	T/m^3
Provide daily cover/layer of inert materials/Soil =	15	% of disposed waste

S. No.	Year	Population	Total House hold	Total Waste generated (TPD)	Amount of waste to be Disposed (TPD)	Total Disposable Waste (Tonne per Annum)	Annual Volume (m3 per Annum)	Volume required for cover material (in m^3 Per Annum)	Total Volume (in m^3 per Annum)	Cumulative Volume of Total Disposable Waste (in m^3)
PHASE- 1 (2018-2022)										
1	2018	18050	3706	5.42	1.084	395.66	465.48	69.82	535.30	535.30
2	2019	18284	3754	5.49	1.098	400.77	471.49	70.72	542.21	1077.51
3	2020	18518	3802	5.56	1.112	406.99	478.81	71.82	550.63	1628.14
4	2021	18754	3851	5.63	1.126	410.99	483.52	72.53	556.05	2184.19
5	2022	18991	3900	5.70	1.140	416.10	489.53	73.43	562.96	2747.15
PHASE- 2 (2022-2027)										
6	2023	19227	3948	5.77	1.154	421.21	495.54	74.33	569.87	569.87
7	2024	19465	3997	5.84	1.168	427.49	502.93	75.44	578.37	1148.24
8	2025	19702	4046	5.91	1.182	431.43	507.56	76.13	583.69	1731.93
9	2026	19942	4095	5.98	1.196	436.54	513.58	77.04	590.62	2322.55
10	2027	20182	4144	6.05	1.210	441.65	519.59	77.94	597.53	2920.08
PHASE- 3 (2027-2032)										
11	2028	20422	4193	6.13	1.226	448.72	527.91	79.19	607.10	607.10
12	2029	20663	4243	6.20	1.240	452.60	532.47	79.87	612.34	1219.44
13	2030	20905	4293	6.27	1.254	457.71	538.48	80.77	619.25	1838.69
14	2031	21148	4343	6.34	1.268	462.82	544.49	81.67	626.16	2464.85
15	2032	21392	4393	6.42	1.284	469.94	552.87	82.93	635.80	3100.65
PHASE- 4 (2032-2037)										
16	2033	21635	4443	6.49	1.298	473.77	557.38	83.61	640.99	640.99
17	2034	21880	4493	6.56	1.312	478.88	563.39	84.51	647.90	1288.89
18	2035	22125	4543	6.64	1.328	484.72	570.26	85.54	655.80	1944.69
19	2036	22372	4594	6.71	1.342	491.17	577.85	86.68	664.53	2609.22
20	2037	22620	4645	6.79	1.358	495.67	583.14	87.47	670.61	3279.83
PHASE- 5 (2037-2042)										
21	2038	22867	4695	6.86	1.372	500.78	589.15	88.37	677.52	677.52
22	2039	23116	4747	6.93	1.386	505.89	595.16	89.27	684.43	1361.95
23	2040	23365	4798	7.01	1.402	513.13	603.68	90.55	694.23	2056.18
24	2041	23615	4849	7.08	1.416	516.84	608.05	91.21	699.26	2755.44
25	2042	23866	4901	7.16	1.432	522.68	614.92	92.24	707.16	3462.60
PHASE- 6 (2042-2047)										
26	2043	24117	4952	7.24	1.448	528.52	621.79	93.27	715.06	715.06
27	2044	24370	5004	7.31	1.462	535.09	629.52	94.43	723.95	1439.01

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28	2045	24623	5056	7.39	1.478	539.47	634.67	95.2	729.87	2168.88
29	2046	24877	5108	7.46	1.492	544.58	640.68	96.1	736.78	2905.66
30	2047	25132	5161	7.54	1.508	550.42	647.55	97.13	744.68	3650.34

As the site is found to accomplish the square landfill and easy of construction of a square type landfill over other type it is more feasible to provide a square type of landfill in Sindkhed raja.More cost-effective landfill management strategies take advantage of the natural hydro geological characteristics and attenuation properties of the subsurface. The 'dilute and disperse' strategy employs the natural sorption and ion exchange properties of clay minerals, and it has been shown that in appropriate situations it is effective in attenuating landfill leach ate and preventing pollution of water resources. Waste volume for landfill computed for the "active" period of the landfill by the current generation of waste per annum and the anticipated increase in rate of waste generation due to population growth rate. Study involves Designing of landfill site for Sindkhed raja. Poor waste disposal adversely affect the environment and also uses precious land resources in large amount. It does not require any infrastructure or equipment. Landfill design can be applied to proposed new landfill. The following is the design of proposed simple landfill site.

Table 4: Design and Area Requirements for Simple Landfill Site								
NO	PARAMETER	PHASE- 1 (2017-2022)	PHASE- 2 (2022-2027)	PHASE- 3 (2027-2032)	PHASE- 4 (2032-2037)	PHASE- 5 (2037-2042)	PHASE- 6 (2042-2047)	UNIT
		QTY	QTY	QTY	QTY	QTY	QTY	
1	Total required volume	2747.15	2920.08	3100.65	3279.83	3462.60	3650.34	CUM
2	Provide depth from center	3	3	3	3	3	3	M
3	Provide height from center	2.71	2.63	2.56	2.71	2.63	2.55	M
4	Volume below center	1587.95	1687.91	1792.28	1895.86	2001.5	2110.02	CUM
5	Volume above center	1159.20	1232.17	1308.37	1383.97	1461.10	1540.32	CUM
6	provide side slope below center V : H	1:2	1:2	1:2	1:2	1:2	1:2	
7	provide side slope above center V : H	1:3	1:3	1:3	1:3	1:3	1:3	
8	Now, Length at bottom	16.75	17.47	18.2	18.9	19.6	20.3	M
	Say	17	18	19	19	20	21	M
9	Width at bottom	17	18	19	19	20	21	M
10	Length at center	29	30	31	31	32	33	M
11	Width at Top	11	12	13	13	14	15	M
12	Now, Volume provided below center	1623	1764	1911	1911	2064	2223	CUM
13	Volume provided above center	1157	1231	1308	1385	1462	1538	CUM

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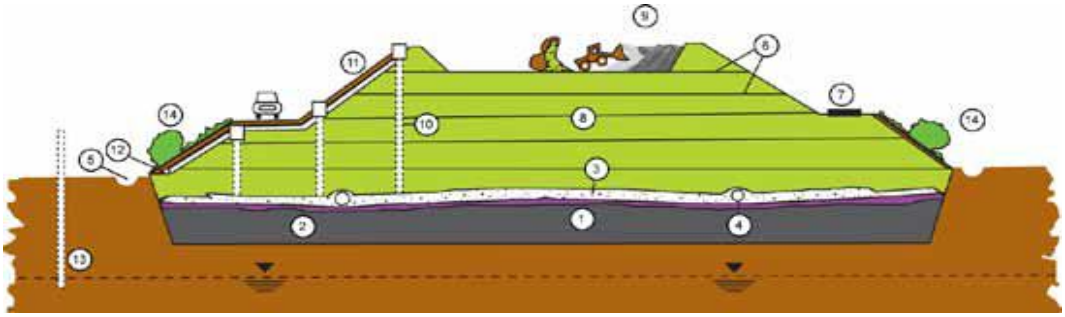
Table 4: Design and Area Requirements for Simple Landfill Site

NO	PARAMETER	PHASE- 1 (2017-2022)	PHASE- 2 (2022-2027)	PHASE- 3 (2027-2032)	PHASE- 4 (2032-2037)	PHASE- 5 (2037-2042)	PHASE- 6 (2042-2047)	UNIT
		QTY	QTY	QTY	QTY	QTY	QTY	
14	Total Volume Provided	2780	2995	3219	3296	3526	3761	CUM
		Safe	Safe	Safe	Safe	Safe	Safe	
15	Area required	841	900	961	961	1024	1089	SQ M

3) *Evaluation of Concept Development Plan*-Foot Print of Land Fill Site: sanitary landfill focuses on optimised leachate management, as leachate is a main source of potential environmental pollution. It is important to minimise leachate generation and to avoid leachate being retained for a long time in the landfill body. A landfill can be both above ground or partially below ground, based on the local hydro-geological situation and the availability of land. Where abandoned quarries are to be used as potential sanitary landfill sites, the landfill could be below ground, depending on the site situation. Based on the topography and shape of the site identified for landfill development a broad concept for development of landfill was evaluated. The final shape and phase- wise development plan and internal cell arrangement was finalized after estimating the volume required for the land-filling of waste from 5 years (design life).

4) *Design of Final Cover System:* A final landfill cover is usually composed of several layers, each with a specific function. The surface system must enhance surface drainage, minimize infiltration, support vegetation and control the release of Landfill gases. The landfill cover to be adopted will depend on the gas management system. As recommended by the MoEF and CPHEEO the final cover system must consist of a vegetative layer supported by a drainage layer over barrier layer and gas vent layer. It should be able to minimise infiltration of storm water in the landfill body and to allow storm water runoff, a surface sealing system has to be installed after the final completion of each landfill part. The main purposes of the final cover system are to:

a) Control the amount of storm water filtration into the waste to reduce leachate quantities
b) Prevent erosion
c) To minimise the migration of greenhouse gases (GHG) into the atmosphere
d) Protect the base sealing (impermeable) layer
e) To minimise other emissions causing negative impacts on the environment.



f) Geological barrier
g) Impermeable base liner
h) Drainage layer
i) Leachate collection syste
j) Storm - water drain ditc
k) Bordering dam
l) Circulation road
m) Landfill bod
n) Filling and compacting in layers
o) Gas venting syste

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p) Protective cover syste
q) Gas collector
r) Groundwater control
s) Re-planting

IV. CONCLUSIONS

The need of the hour is to save water and reduse soil contamination from being polluted by moving away the municipal solid waste dumpsite from the area and design a properly managed landfill site.

The design area of landfill site is 841 Sq. M. which can be easily manage in Sindkhed raja. Leachate control within a landfill prevent migration of leachate from landfill sides and landfill base to the subsoil by a suitable liner system; and drainage of leachate collected at the base of a landfill to the sides of the landfill and removal of the leachate from within the landfill. Energy must be recovered from the collected landfill gas.

Finally represent this paper as environmentally friendly proposal.

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