Investigation the Impact of Municipal Solid Waste on Sub Surface Environment

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Abstract— The purpose of this work is to study the impact of Municipal Solid Waste on sub surface environment. Municipal solid waste landfill represents significant threat to ground water and sub-surface soil. The leachate percolating through soil up to ground water table through voids between sub soils and significantly contaminates it. To study and analyze the possible impact of leachate percolation on soil properties and ground water quality. Soil samples and Ground water samples are collected from various areas of nashik landfill sites, where large concentrations of municipal solid waste are dumped. The physical parameters of these collected samples such as, specific gravity, Maximum dry density (MDD), Optimum moisture content (OMC), Permeability and Consistency limits for soil sample and pH, Total dissolve solid (TDS), Hardness, Total solid (TS), and Alkalinity for ground water samples are studied. It has been found that most of the parameters of soil and water are affected because of municipal solid waste and leachate. Here based upon experimental values suggested the some preventive measure to minimize the pollution of sub soil and ground water.

Key words: Environmental Impact, Ground Water, Landfill, Municipal Solid Waste, Soil Properties

I. Introduction

Nashik is the one of the metro city of Maharashtra after the Mumbai and Pune. It is Pilli gram city as well as it is industrial and institutional Centre of North Maharashtra. Due to the rapid growth of urbanization, the population of city going on increase day by day and due to the increase in population the production of solid waste is increased. Nashik city does not have the proper municipal solid waste system as per the guidance of Ministry of Environmental, India. Due to this improper solid waste management system, the environmental effect of the solid waste is occurred near the area of landfill site which is situated near the Pandavleni [1]. Ground water contamination and sub soil contamination is one of the major problem in now day. When the rain water is coming contact with the solid waste landfill or when the solid waste loses its moisture leachate is generated. This leachate is main responsible source of polluting soil as well as ground water [1].

Solid waste is the solid or semisolid, non-soluble material (including gases and liquids) such as agricultural refuse, demolition waste, industrial waste, mining residues, municipal garbage and sewage sludge. It may also be defined as total wastes in the form of papers, garbage's, vegetables, plastic and other forms generated in the houses, factories, commercial Centers and other places that is eventually transported to the municipal solid waste landfill [1]. The increase in population and urbanization was also largely responsible for the increase in solid waste. Since the beginning, humankind has been generating waste, be it the bones and other parts of animals they slaughter for their food or the wood they cut to make their carts and with the progress of civilization, the waste generated became of a more complex nature. At the end of the 19th century the industrial revolution saw the rise of the world of consumers. Not only did the air get more and more polluted but the earth itself became more polluted with the generation of non-biodegradable solid waste [1].

A. Type of Solid Waste

1) Based upon their Origin

- Domestic
- Commercial
- Industrial
- Hospital
- Institutional
- Municipal
- Street Sweeping
- Animals
- Constructional & Demolition

2) Based upon their Nature

- Dry waste
- Wet waste

3) Based upon their Constituents

- Hazardous
- Non-Hazardous

B. Landfill

A landfill is defined as a system that is designed and constructed to dispose of discarded waste by burial in land to minimize the release of contaminants to the environment. The landfills are broadly classified in the following types: [19].

1) Sanitary Landfill

In this landfill waste is isolated from the environment until it is safe. It is considered safe when it has completely degraded biologically, chemically and physically. Sanitary landfills use technology to contain the waste and prevent the leaching out of potentially hazardous substances. There are two main methods used in sanitary landfills the trench method and area method.

2) Municipal Solid Waste Landfill

This type of landfill collects household garbage and is regulated by state and local governments. Some materials may be banned from disposal in municipal solid waste (MSW) landfills. Items such as paints, chemicals, motor oil, batteries and pesticides are some of the common items that are municipal solid wastes landfill are not allowed to dispose [19].

3) Construction and demolition waste landfills

These types of landfills used debris generated during construction, renovation, demolition of buildings and bridges. The types of debris include concrete, wood, asphalt, gypsum, metal, bricks, glass, plastic, rock and building components like plumbing fixtures.

4) Industrial waste landfill

Industrial hazardous waste consisting of non-hazardous waste associated with manufacturing and other industrial activities [19].

C. Leachate

Leachate is a polluted liquid emanating from the base of the landfill, which contains innumerable organic and inorganic compounds. Leachate is the liquid that has percolated through solid waste in a landfill and has extracted soluble dissolved or suspended materials in the process. Ground water quality is significantly affected due to leachate. Leachate is the contaminated liquid that has percolated through solid waste in a landfill and has extracted soluble dissolved or suspended materials in the process.

II. EFFECT MSW ENVIRONMENTAL COMPONENTS

Solid waste disposal in landfills remains the most economic form of disposal in the vast majority of cases [6]. Therefore; landfills will continue to be the most attractive disposal route for solid waste. Indeed, depending on location, up to 95% of solid waste generated worldwide is currently disposed of in landfills. Resorting to landfills is not limited to the disposal of municipal solid waste, but it includes most other industrial wastes [7]. For instance, nearly 70% of hazardous wastes generated in the India are dumped in landfills. Therefore it exert very large burden on environment. Following are the effect of MSW landfill on environment:

A. Effect on Water

Rain water in the rainy season reacts with MSW and percolate it from dumping ground reaches ground water table pollutes the ground water. The study has revealed that the ground water quality does not conform to the drinking water quality standards as per Bureau of Indian Standards. The effects of dumping activity on ground water appeared most clearly as high concentrations of total dissolved solids, electrical conductivity, total hardness, chlorides, chemical oxygen demand, nitrates and sulphates. The study clearly indicates that landfills in densely populated cities should have the groundwater monitored on regular basis. Furthermore, ground water in and around the landfill sites shall not be used for drinking purposes unless it meets specific standards. Indiscriminate dumping of wastes in developed areas without proper solid waste management practices should be stopped.

B. Effect on Land

When these MSW are deposited or dumped on dumping yard cause land pollution, because it will decrease fertility of land. MSW when dumped on ground it will react with soil and alters its properties. MSW affects the permeability, porosity, density, consistency limit like plastic limit, liquid limit etc. As large area cover by the dumping ground and landfill hence pollution scale will be large.

C. Effect on Air

MSW on dumping ground also pollute the air because of generating various toxic or non-toxic gasses in the surrounding air which will cause unhygienic environment human. These gasses contain CO_2, NO_2, SO_2, Methane etc. which having very bad odder.

D. Effect on Human and Animals

Arsenic is a toxic chemical that is naturally found in the solid waste and is a proven carcinogen for humans when exposed thru oral, dermal and inhalation pathways. Typically, arsenic exposure occurs as a result of natural and anthropogenic sources where oral and dermal routes are the most significant intake mechanisms. Arsenic-containing groundwater is the primary medium of exposure in many areas of the world influencing large populations.

Hazardous waste is waste that poses substantial or potential threats to public health or the environment and which is flammable, reactive, corrosive and toxic. In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining and rubber goods industries [6].

III. INVESTIGATION ON MSW IMPACT AT NASHIK LANDFILL SITE

Nashik is 16th fastest developing city in the world and spread over 264.23 sq.km at latitude 20°01′N 73°30′E and longitude 20.02°N 73.50°E located at an altitude 561m above mean sea level. In the entire area of Nashik solid waste treatment plant is 33.18 Ha and about 421 MT of solid waste is generated per day. Unlike other Indian cities, this garbage is collected by vehicles titled 'Ghantagadi'; a system which has resulted into a garbage dump free city. A plant has been set by the Nashik Municipal Corporation near Pandav Leni (Pandavleni Caves) to process the garbage and convert into compost. The waste normally contains domestic wastes (household waste, street litter, municipal park sweeping waste, garden waste, commercial waste from shops etc.). Further wastes from poultry and fish markets, slaughterhouses, dairy farms, and non-infectious hospital waste are also dumped without proper segregation.

Solid waste is characterized as shown in fig 3.1; which shows the actual scenario of municipal solid waste (MSW) and its characteristics.

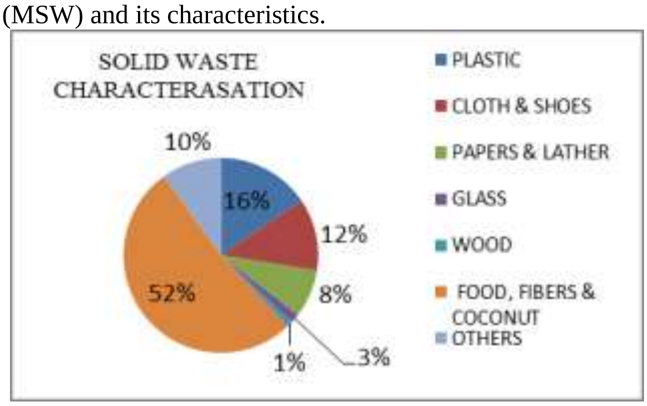

Fig. 1: Characteristics of Nashik Municipal solid waste

A. Soil Consistency

Soil consistency shows the degree of cohesion and adhesion between the soil particles which causes the resistance of the soil to deform or rupture. Cohesion is the attraction of soil molecule to another due to hydrogen bonding, whereas adhesion involves the attraction of a soil molecule to a non-soil molecule. These consistency limits are mostly used for fine grained soil and are based on water content.

Consistency specifies the degree of firmness of soil which may be classified as soft, firm, stiff or hard. When water is added to fine grained soil, a plastic paste is formed which can be moulded into different shapes under stresses. Addition of water causes reduction in cohesion of soil, hence it becomes easier to mould. Further addition of water causes reduction in cohesion until the soil mass not able to retain its shape under its own weight and flows as a liquid [4]. Addition of more water causes the soil particles to get dispersed in a suspension. Now, if water is evaporated from such a suspension, the soil passes through various stages of consistency. These stages are:

- Liquid state
- Plastic state
- Semi-solid state
- Solid state

Atterberg divided these stages by arbitrary limits on basis of water content which are called Atterberg limits. These limits are expressed as percent water content [4].

B. Consistency Limit

Albert Mauritz Atterberg was an agriculturist and a chemist. He started focusing his efforts on the classification and plasticity of soils, for which he is most remembered. He laid down seven "limits of consistency" also known as Atterberg's Limits, to classify fine-grained soils. These were later modified by Arthur Casagrande. In current engineering practice only two of these limits, the liquid limit and plastic limit, are generally used. A third limit, called the shrinkage limit, is also used occasionally. The Plasticity characteristics are used as an essential constituent of many engineering classification systems to characterize the fine grained fraction of the soil. The Liquid limit, Plastic limit and Plasticity Index of soils are also used in a widespread way, either singly or together with other soil properties to correlate with geo-technical behavior such as shear strength, compressibility, compatibility, shrinkage, swelling and permeability [4].

IV. EXPERIMENTAL WORK

A. Study Area

Pandavleni is located at latitude 20°01′N 73°30′E and longitude 20.02°N 73.50°E located at an altitude 561m above mean sea level. The Pandavleni land filling dumpsite is on National Highway passing through the city Mumbai-Agra National Highway No.-3. Pandavleni Land filling dumpsite is surrounded by residential areas in which they are heavily affected by both soil and water pollution through the leach out of hazards from the solid waste. The soil and water collected from the nearer to the solid waste dumpsite.

B. Sampling and Methodology

The Preliminary survey on the quality of ground water, soil and solid waste samples was conducted in the month of January 2015, because the ground water and soil get polluted due to solid waste dumping nearer to the location.

C. Ground Water sample

Sample Collection, preservation and analysis were done as per the standard methods. Water samples were taken at each well point at different locations at Pandavleni. The polyethylene sample containers cleaned by nitric acid and left it for 2 days followed by thorough rinsing of distilled water. Two litres of samples were collected for the analysis. The generally suitable techniques for the preservation of samples followed as per Indian standard methods. Total suspended solids, Nitrate, phosphate and sulphate were analyzed as soon as possible.

D. Soil Sample

The representative soil samples collection, preservation and analysis were done as per the standard methods. The sampling of soil was done using hand augur. The augur was used to bore a hold to the desired depth and then withdrawn. The sampling area first to be cleaned and first six inches of surface soil was removed with the radius of 6 inches around the drilling location. Begin auguring, periodically removed and deposited accumulated soil onto the plastic sheet. After reaching the desired depth slowly and carefully removed the augur from the hole and the samples were directly from the augur. The composite samples collected and they were kept in the suitable labeled container. The collected soil samples were protected from sunlight to sunlight to minimize any potential reaction. The dry soil samples for various tests were prepared as per the Indian Standard method. The received soil samples dried in sun or air and the pulverization was done.

E. Solid Waste Samples

500 g of representative solid waste samples were collected in the different places of Pandavleni Landfill site on 15th January 2015. The solid waste samples were collected as per the standard procedure.

V. RESULTS AND DISCUSSION

To investigate the effect of municipal solid waste landfill on the ground water environment, we collected 1 leachate and 11 ground water samples from the surrounding area of the Pandavleni landfill site of Nashik. After the analysis and laboratory testing of given sample, we got results which are tabulated in following tables.

Sr. No.	Sample	LE	GW1	GW2	GW3
	Parameters				
1	pH	6.12	6.49	7.30	7.27
2	TA (mg/l)	308	240	296	216
3	TS (mg/l)	440	680	1020	2300
4	TDS (mg/l)	520	2360	540	9140
5	TVS (mg/l)	720	960	1420	1300
6	EC (µS/cm)	53800	41100	22600	41300
7	Chlorides (mg/l)	1651.8	1248.1	620.04	1240.4
8	TH (mg/l)	2270.93	1933.3	845.5	1713.7
9	COD (mg/l)	12848	3828	2246	5882
10	BOD_3 (mg/l)	6860	1230	912	2459
11	Na (mg/l)	100.27	38.07	26.29	100.2
12	K (mg/l)	47.37	2.22	2.22	1.48

Table 1: Test Result of Analysis of Well Sample from GW1 to GW3

Sr. No.	Sample Parameters	GW4	GW5	GW6	GW7
1	pH	7.04	7.22	7.27	7.44
2	TA (mg/l)	220	128	208	96
3	TS (mg/l)	200	3550	1960	3520
4	TDS (mg/l)	680	2000	400	340
5	TVS (mg/l)	1300	5340	3080	2120
6	EC (µS/cm)	22600	1581	1740	5860
7	Chlorides (mg/l)	556.4	254.4	524.7	182.3
8	TH (mg/l)	845.9	472.4	549.3	450.4
9	COD (mg/l)	9072	585	570	760
10	BOD_3 (mg/l)	4672	350	126	375
11	Na (mg/l)	41.05	22.15	14.35	18.40
12	K (mg/l)	1.21	3.30	2.87	1.28

Table 2: Test Result of Analysis of Well Sample from GW4 to GW7

Sr. No.	Sample Parameters	GW8	GW9	GW10	GW11
1	pH	7.06	8.75	8.18	7.48
2	TA (mg/l)	148	220	240	202
3	TS (mg/l)	4630	3560	4420	4570
4	TDS (mg/l)	5200	1020	1250	520
5	TVS (mg/l)	2170	1540	1870	980
6	EC (µS/cm)	1840	2536	2430	2600
7	Chlorides (mg/l)	688.6	115.4	99.1	636.9
8	TH (mg/l)	801.9	804.3	805.6	900.3
9	COD (mg/l)	612	816	749	759
10	BOD_3 (mg/l)	254	328	426	350
11	Na (mg/l)	14.91	23.20	18.6	20.3
12	K (mg/l)	1.77	3.84	3.45	2.24

Table 3: Test Result of Analysis of Well Sample from GW8 to GW11

To investigate the effect of municipal solid waste landfill on the sub surface environment, we collected one normal soil sample far away from source of pollution and five samples around the landfill area of the Pandavleni landfill site of Nashik. After the analysis and laboratory testing of given sample, we got results which are tabulated in following tables.

Sr. No.	Soil parameter	Normal Sample	Sample 1	Sample 2
1	Bulk density (ρ_b) g/cm^3	1.82	1.65	1.69
2	Water content (w)	15.7 %	14.0%	14.5%
3	Dry density (ρ_d) g/cm^3	1.587	1.44	1.47
4	Specific gravity (G)	2.62	2.38	2.23
5	Liquid limit (W_L)	65.48	40.75	42.60
6	Plastic limit (P_L)	44.50	25.90	26.43
7	Shrinkage limit (S_L)	20.53	10.45	13.65
8	MDD (ρ_d)	1.76	1.19	1.39
9	OMC	19.20%	21.0%	14.50%
10	Coefficient of permeability (k) cm/sec	2.89×10^{-4}	1.21×10^{-4}	1.28×10^{-4}

Table 4: Test Result of Analysis of Soil Sample around Landfill of NMC

Sr. No.	Soil parameter	Sample 3	Sample 4	Sample 5
1	Bulk density (ρ_b) g/cm^3	1.76	1.70	1.73
2	Water content (w)	13.5%	17.3%	14.7%
3	Dry density (ρ_d) g/cm^3	1.55	1.505	1.521
4	Specific gravity (G)	2.26	2.35	2.38
5	Liquid limit (W_L)	47.35	57.40	61.78
6	Plastic limit (P_L)	28.72	33.33	36..90
7	Shrinkage limit (S_L)	14.20	18.36	19.21
8	MDD (ρ_d)	1.44	1.73	1.84
9	OMC	19.35%	18.5%	23.60%
10	Coefficient of permeability (k) cm/sec	1.35×10^{-4}	1.69×10^{-4}	2.75×10^{-4}

Table 5: Test Result of Analysis of Soil Sample around Landfill of NMC

VI. CONCLUSION

The leachate derived from the Nashik MSW dumping site demonstrates exceedingly high values for almost all physico-chemical parameters. Erratic rainfall patterns, high permeability of local black cotton soil and induced fracturing in the country rocks have accelerated the contaminant movement and infiltration. As there is no other natural and artificial source of pollution in given locality therefore reason of high concentration of these pollutants, it can be concluded that leachate and solid waste has significant impact on groundwater and sub soil quality near the area of landfill site. The groundwater and soil samples quality improves with the increase according to distance from the pollution source. To reduce this ground water contamination and sub-soil pollution a suitable liner system along with piping for leachate removal should need to be provided. The leachate treatment plant should be provided at the landfill site. The existing SWM system in the city is inadequate to collect and handle the MSW, it is necessary to implement efficient MSW management plan to reduce the subsequent environmental impact.

As in locality lot of brick manufacturing plant are present and also large portion of land is cover by agricultural land. Because of this contaminant there productivity is affecting. As soil comes with contact of MSW various properties of soil are largely affected and it became unsuitable for construction purposes. Shear strength and bearing capacity also reduces because the, presence of various organic and inorganic substances in soil which induces due to MSW. The 3-E's can be incorporated in the process which are 'Education' about MSW generation and handling, 'Engineering' measures to minimize contamination at landfill site and 'Enforcement' of rules and regulation by various authorities to control the environmental pollution.

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