Environmental Impacts of Ghazipur Landfill on its Surroundings

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Abstract - *Conventionally running landfill areas are the main contributors of air, water and soil pollution around the landfill site. Along with those pollutions greenhouse gas (GHG) emitted from the landfill is a big concern to the global warming. In the present study the effect of landfill on air, water and soil around the nearby areas have been studied. This site is one of the biggest and oldest landfill of Delhi. All the nearby municipal solid waste are being disposed here for around 30 years due to which it looks like a huge mountain. The process of recovering valuable recyclable materials which have been previously landfilled is known as Landfill Mining. Ghazipur landfill site has been selected for converting the waste into energy in which the garbage are mined from the landfill for converting them into RDF (Refuse Derive Fuel) which is further used for the generation of energy and around the ten acre of landfill area has been given to GAI (Gas Authority of India) for mining methane and other gases to be used as fuel. The field experiment has also been done in many studies in which the estimate of methane and nitrous oxide emission from landfill areas of Ghazipur and the range of methane emission flux was noted to be 18 mg/m^2/h lowest in winter sample and highest 264 mg/m^2/h in summer sample. The range of nitrous oxide emission was estimated as 230-1730 μg/m^2/h, if the extraction rate and calorific value of emitted gas is large enough then it could be utilized to generate electricity. In the present study the effect of landfill to nearby underground water has been experimentally studied and conclusion made for the same. Effect of landfill on the soil of nearby area was also studied.*

Key Words: Greenhouse Gas, Landfill, Methane, Municipal Solid waste, Refuse Derived Fuel

1. Introduction

The Ghazipur landfill area is selected for present study, this landfill area is one of the oldest and largest landfill areas of Delhi, which is receiving solid waste since approximately last thirty years. As almost all operational landfill areas is Delhi is overflowing with garbage and became garbage mountain thus for its sustainable management it is essential to reclaim it. Landfill mining and reclamation (LFMR) is one of the recently used process for excavating and processing of landfill resources. on-methane organic compounds (NMOCs)

Landfill , covers an area of about 70 acres, is surrounded by Fish, Egg and Poultry markets on the northern side, Hindon Canal on the eastern side, habitation on southern side and Ghazipur Dairy Farm on the western side with the approximate GPS coordinates of 28°37′28.45′′ N & 77°19′39.05′′E. The site was started in 1984 for disposal of MSW with bottom level being at about 3 m below the general ground level land had no liner at the bottom. At present about 2600Metric Tons of waste is being received daily on this site from different zones of the city. Tipping over method of disposal is being practiced at this site also as in the case of other waste disposal sites in Delhi (generally in developing countries). Compaction of dumped waste is carried out through a leveling dozer during tipping of MSW over slopes and by tipping vehicles. The total height of the landfill, at present, is about 44 m from the ground level of the adjacent Dairy Farm (Western side)and about 42 m from the road level at poultry market(Northern side). From the topographical survey of the site slopes of the landfill were observed to be varying from about 38° for tall raisings (9 to13 m) to about 70° with horizontal for shorter raisings (2 to5 m).

2. Literature Review

Solid waste management is an integral part of urban and environmental management, like most of other infrastructural services has come under great stress, consider low priority areas, solid waste management was never taken up seriously either by public or by concerned agency or authorities and now the piled up waste is threatening our heath, environment and well-being (Chouhan and Reddy 1996, Mazumdar 1994 & Yadav et al. 2009).The study done by Singhal and Pandey, (2001) showed that methane emission will increase from 6 Tg to 40 Tg in 2047 . Delhi has three operational landfill areas at present i.e., in Okhla, Ghazipur and Bhalswa . These landfill areas are situated at South of Delhi, East Delhi and North Delhi respectively. These landfills are receiving MSW from various parts of Delhi.In the absence of leachate collection systems in the non-engineered landfill sites, leachate is a potential source of ground water pollution, rendering the ground water unusable for domestic and other purposes (Bakare et al. 2000).Therefore, leachate is recognized as an important environmental problem, and its risk assessment and management is thereby considered essential. The composition of leachate varies considerably among landfills depending on various factors such as hydrogeology, amount of rainfall, age of the landfill, as well as waste composition and degradation stage of waste (Kjeldsen et al. 2002).

For general purpose, pollutant load of leachate can be divided into four major groups, such as dissolved organic matter, inorganic salts, metals, and xenobiotic organic compounds(Christensen et al. 1994). Previous studies have reported presence of hazardous organic compounds like aromatics, chlorinated aliphatics, phenols, phthalates, and pesticides in leachate (Baun et al. 2004; Schwarzbauer et al. 2002). Different heavy metals including lead, chromium, copper, and iron have also been reported by different studies as reviewed by Baunand Christensen (2004). Apart from these major groups of contaminants, a huge number of other chemicals may also present in leachate in trace amounts (Kalcikova et al. 2011).

A limitation of using chemical analyses alone is that the compounds present in low concentrations below the detection limit of the instrument remain unidentified, and hence their potential biological effects are underestimated. Therefore, eco toxicological and toxicological risk assessment methodologies are gaining importance as knowledge of the chemical composition along with the toxic potential of the leachate is necessary not only to assess the risk but also to make projections on its long-term impact and possible adverse effects on human and ecosystem health (Tsarpali and Dailianis2012)

3. MATERIALS AND METHODS

3.1 Materials

With an increase in the population of Delhi city, quantity of waste material also increases every day. The sampling locations are selected in such a way, that it truly represents length and breadth and the nature of dumping taking place in different parts to get the homogeneous picture of study area. The sampling locations had been selected in order to get maximum representation of the probable variations in groundwater quality and land use pattern with due consideration to its hydro-geological setup.

3.2 Sampling

3.2.1 Water collection

To obtain the concentration of parameters sampling is done. The samples of underground water are collected at different radius around the landfill site. There are three samples were collected at 50m,200m and 500m radius respectively.

3.2.2 Leachate collection

Leachate samples were collected from Ghazipur landfill-site and its adjacent area to study the possible impact of leachate percolation on groundwater quality.

3.2.3 Methane Collection

The 108 ppm methane standard, EDT, London, UK, was used for the analysis of methane in the collected samples. Methane gas was collected in Perspex chamber by technique of "Camera Closed". Gas is collected, stored, and transported in a series of jars and sealed immediately after collection. Three copies were taken from each sampling location. Temperatures and atmospheric temperatures at a depth of 5 cm were also monitored continuously. Samples were collected every hour from 10 a.m. to 4 p.m.

3.2.4 Nitrous Oxide Collection

Nitrous oxide is collected in the similar manner as given above but in brown colour vials to avoid its decomposition. The Merck standard of nitrous oxide standard was used for analysis. The methane flux is measured using GC- FID, and Nitrous oxide is measured by GC using ECD detector. Emission flux and rate was calculated by method of Verma et al, (1999).

3.3 Methodology

3.3.1 Preparation of Sample For Analysis

The underground water samples were tested in the environment lab and the results obtained are given in the table. For each borehole, 5 litres of the groundwater samples were collected in 600 mL sterilized polyethylene bottles, stored at 28 C and analyzed. The analyses covered physical, chemical and bacteriological parameters of water samples from each borehole. The physical parameters tested for included: odour, taste, colour, turbidity and temperature. Chemical parameters analyzed were pH, Dissolved oxygen (DO), total dissolved solids (TDS), Total Hardness, Total Iron, Nitrate, Nitrite, Chloride, Calcium and heavy metals such as Copper, Zinc and Lead..Ph test was done using Ph meter.
Similarly the samples of methane and nitrous oxide are also prepared and the testing is done in the specified laboratory.

4. RESULTS AND DISCUSSION

4.1 Methane And Nitrous Oxide Emission

The flow of nitrogen oxides and methane emissions from the Gazipur landfill in Delhi was studied. Very little research has been reported from India on the field measurement of methane and nitrogen oxide emissions from landfill sites in India. Most of the studies were conducted using the first-order decomposition model or the modified triangular method (MTM). In the current research work, field studies have been conducted to measure the share of greenhouse gas in the landfill area of India and to analyze the benefits of waste mining.

4.1.1 Methane flux from Ghazipur landfill area

The methane emission reported by Borjesson and Svensson, (1997) for landfill areas of Sweden was as 0.54-320 mg/m^2/h, whereas Chen et al. (2008) had quantified methane emission from the closed landfill site as 8.8- 163 mg/m^2/h. Jha et al, (2008) had estimated methane emission flux from two landfill areas of Chennai, India as 1-433mg/m^2/h. Rawat et al, (2008) had also reported the maximum methane emission flux from three operational landfill areas of Delhi as 300 mg/m^2/h at Ghazipur landfill area due to presence of large quantity of organic waste from slaughter house. The emission flux of methane was highest at 3-4 pm in afternoon, as emission depends on temperature.

4.1.2. Nitrous Oxide flux from Ghazipur landfill area

The range of N_2O emission flux found in summer samples was ranged as 826-1730 µg/m^2/h and winter season had the range of 230-973 µg/m^2/h. The emission flux of nitrous oxide reported by Jha et al, (2008) was 3-1200 µg/m^2/h for the landfill areas of Chennai. The concentration of nitrous oxide emitted from Ghazipur landfill area is higher than the flux reported from Chennai landfills by Jha et al, (2008). This could be expected as the quantity of MSW is more in Delhi landfill area and also organic matter is higher in Ghazipur landfill areas due to waste from slaughter houses. Similarly, Zhang et al, (2009) has estimated the annual average N2O flux from three landfill areas of China as 176-566 µg/m^2/h. The nitrous oxide gas has various industrial, bio-medical applications and used as a propellant gas in the food industry.

4.2 Impacts on Air Quality

The saturated Ghazipur landfill in East Delhi is one of the biggest contributors to the alarming level of air pollution in the region.While civic authorities built a waste-to-energy plant on the site to remove waste and control pollution, the plant is far from operational.The landfill is located very close to AnandVihar, one of the most polluted places in the world. Harmful gases from landfills that mainly comprise methane and carbon dioxide have added to air pollution in the region, environmentalists said.

Health experts say that short-term exposure to high levels of landfill gas can cause coughing, irritation of the eyes, nose and throat, headache, nausea and shortness of breath. Anumita Roy Chowdhury, executive director of the Center for Science and the Environment, told Mail Today that she agreed with the harmful effects of landfill gas: “With instructions from the Supreme Court to focus on waste management, the Corporation should convert waste into energy Functional plant without much delay. "When the technology to reuse and recycle garbage is available, the corporation must focus on putting it to use. However, the civic body must ensure that the emissions control system is in place."

The MCD official in the East Delhi Municipal Corporation of engineering department said that the corporation is awaiting consent to operate and that it will be given after site inspection by the three-member committee appointed by the National Green Court.

The MCD expects to receive the consent certificate next week.The 12 MW capacity waste-to-power plant will use 1,300 metric tons of municipal solid waste every day to generate electricity. Authorities said that once operational, the plant will fulfill the dual purpose of generating electricity and consuming waste deposited in the landfill.

4.3 Leachate Characterisation

4.3.1 Leachate

Physico-chemical characteristics of the leachate depend primarily upon the waste composition and water content in total waste. The characteristics of the leachate samples that were collected from the Gazipur landfill site has been presented in Table 1. From the experiment the pH value was found to be 6.7. The higher values of EC (23500 µScm-1) and TDS (26826 mg l-1) indicated the chance of presence of inorganic material in the samples. The existence of great BOD (18200 mg l-1) and COD (25400 mg l-1) signposts the high organic strength. Amid the nitrogenous compound, ammonia nitrogen (2675 mg l-1) was existing in greatamount, this is perhaps due to the deamination of amino acids during the decomposition of organic compounds (Crawford and Smith, 1985; Tatsiand Zouboulis, 2002). Higher concentrations of NO_3- (370 mg l-1) and Si (336 mg l-1) were also observed in the leachate samples.

Table 1: Physical- chemical characteristics of the leachate

Parameter	Concentrations*
Cu (mg l^{-})	0.87
Fe (mg l^{-1})	68.25
EC (µS cm^{-1})	225400
TDVS (mg l^{-1})	14742
FDS (mg l^{-1})	12645
COD (mg l^{-1})	25400
K+ (mg l^{-1})	1520
pH (µS cm^{-1})	6.7
Pb (mg l^{-1})	1.45
BOD (mg l^{-1})	18200
NO2- (mg l^{-1})	Nil
NO3- (mg l^{-1})	340
Si (mg l^{-1})	342
Phenol (mg l^{-1})	0.03
TDS (mg l^{-1})	26826
Ni (mg l^{-1})	0.34
Cr (mg l^{-1})	0.24
Zn (mg l^{-1})	2.26
Cd (mg l^{-1})	0.04
Na+ (mg l^{-1})	457

4.4 Underground Water

The underground water of the studied area is used for domestic and other purposes. As the quality of underground water assessed by in terms of physical and chemical parameters.

The concentration of various parameters like pH, temperature, turbidity, alkalinity, hardness, BOD, COD, total suspended solid, total dissolved solid present in subsurface water sample are measured.

Table 2 shows the desirable and maximum permissible limit recommended by Bureau of Indian Standard (BIS, 1991) and World Health Organization (WHO, 1997)

Table 2: Desirable and maximum permissible limit by BIS

Parameters	BIS standards		WHO standards
	Desirable	Max. Permissible	
Colour	5	25	-
Odour	Unobjectionable	Unobjectionable	-
Taste	Agreeable	Agreeable	-
pH	6.5-8.5	6.5-8.5	6.5-9.2
TH	300	600	300
TA	200	600	
TDS	300	1500	500
Cl^{-}	250	1000	250
SO_4^{2-}	250	400	200
$NO3^{-}$	45	45	50
F^{-}	1.0	1.5	0.5

$Ca^{2}+$	75	200	100
$Mg^{2}+$	30	100	150
K+	-	-	200
Na+	-	-	200
NH_4+	-	-	1.5
Phenol	-	-	0.0
B	-	-	0.3
Fe	-	-	0.3

**Except pH and colour all unit are in mg l^{-1}

4.5 Sampling And Testing

To obtain the concentration of parameters sampling is done. The samples of underground water are collected at different radius around the landfill site.

There three samples were collected at 50m, 200m and 500m radius respectively. The underground water samples were tested in the environment lab and the results obtained are given in the table.

Table 3: different tests and result achieved for different sample

Name of tests	Sample 1 (at 50m)	Sample 2 (at 200m)	Sample 3 (at 500m)
Total Hardness (ppm)	560	567	412
Temperature (celcius)	24.8	25	25.3
Alkalinity as CaCO3 (mg/l)	164	112	98
Total suspended solids (mg/l)	810	750	630
Total dissolved solids (mg/l)	760	720	615
Turbidity (NTU)	1.5	1.2	1.3
D.O.	5.1	5.3	5.2
BOD	30	25	20
pH	7.6	7.8	7

4.5.1 Result on soil

- There are various impacts of landfill on the surrounding soil, some of them are
- Non-dumpsite soils.
- The proposed site is characterized by highly variable stratified soils.
- The result shows that the moisture retention capacity of the soil is 46 %, which is good.
- Soil of the area is slightly basic with a pH of 7.82
- The CEC (Cation exchange capacity) analysis of the soil sample is 12.14 meq /100 gm, which is low and it, can be concluded that the soil is sandy.

4.5.2 Soil density relationship

Moisture content and dry density values were plotted in separate graphs obtained for dumpsite and non-dumpsite soils. Graph of Moisture Quantity - Lumps of Dumpsite Soil - Density Relationship Shows the length of curve for non-dumpsite soils which suggests clay content in controlled soils, hence its effect, non-dumpsite as compared to dumpsite soils There was more in the mud. Dumpsite and non-dumpsite clay ltd. The optimum moisture content (OMC) was 10 and 14.25 percent respectively, while the maximum dry density (MDD) for both soils was 2.66 and 2.02 g / c^3, respectively. Dumpsite soils will require more compaction to deflect air temperatures and to stabilize the material for the foundation than non-dumpsite soils..

4.5.3 Atterberg limits

Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) are valuable limits for identifying and classifying soils. The LL is the higher limit establishing the state of consistency (degree of firmness) for fine-grained soils, and it divides the liquid state from the plastic state of the soil. The plot of number of blows against groove-closing moisture content of the sample in the water limit device for dumpsite and non-dumpsite soils is shown on the graph respectively. The dumpsite soil showed low variability with the best fit line having R2 = 0.888 while the non-dumpsite soil showed high variability with the best curve having R2 = 0.319.

The specific gravity of the samples, being between 2.0 and 2.80, indicates that the soil at that depth is not organic soil although they cannot be classified as inorganic clay either, but their properties agree with the properties required for soil as foundation soil. This is very significant since many dumpsite soils have the composting problem that may render them as organic soils, but, the degrading effect is highly diminished even at the foundation depth as such a dumpsite soil is rehabilitated.

4.5.4 Plasticity index

This is the range of moisture content between two liquid states – the LL and the PL, and was 2.55% and 20.45% for dumpsite and non-dumpsite soils respectively. The wide range of PI for the control soil accounts for the wide difference between the Atterberg limits and may show that the coarser soil is higher in the control soil than in the dumpsite soil, since PI tends to increase in numerical value as grain size decreases. Relationship curve between compaction or number of blows and soil moisture content from where OMC was obtained at the 25 blows along the log-normal abscissa.

The precision of the estimates of PI was accepted as the difference (2.1%) of the results (21.9 and 19.2%) of the replicate tests for dumpsite soil compared to 2.6% which is the acceptable range of difference for the plastic limit tests on one-point method. For the dumpsite soil, the difference was 0.9 (i.e. 37.3 – 36.6%) and 0.9 < 2.6

4.5.5 Compaction and future settlement

The Liquid Limit (LL) is the soil water content at which the shear strength of the soil becomes so small that the soil "flows". The insignificant difference between the LL of the dumpsite and non-dumpsite soil samples confirm that both soil samples have nearly equal high shear strength.
Also maximum dry density (MDD) is used by designers to specify where shear strength is increased maximally by compaction, or to decrease future soil settlement or to achieve the lowest hydraulic conductivity. This is significant for dumpsite soil to indicate shear strength in the event of any undetected residual effect of biodegradation existing. The lowest hydraulic conductivity will be achieved normally when the soil is compacted slightly above the OMC. Thus, if dumpsite soil becomes a foundation soil for a structure in future, compacting the soil slightly above the OMC or 10% will achieved decrease in settlement and increase in shear strength. The values of K indicate that the control soil had a lower value of K compared to the dumpsite value; hence the dumpsite soil was not completely compacted. Therefore, soil compaction level did not recover completely from MSW leachate contamination effect. More time is needed to devoid the pores of air in the foundation soil.
Compression index, Cc for determining the expected consolidated settlements of load on clays is given as:
Cc = 0.009 (LL-10)

5. Conclusions and Recommendations

(A)Better Source Separation

The benefits of better source separation are netter safety condition for worker (less handling of potentially hazardous materials such as chemicals dust and diapers etc),improve efficiency (lees effort in sorting),and better recycling rates.
Therefore a better management system should be developed to keep the waste separated at all the stages.

(B)Training And Education

Education activities for waste haulers and general public should be conducted.
The kit should be provided to the rag pickers and also, they should be well trained so that they do not get diseased.

(C) Lining of Landfill

Proper lining of landfill site should be done to reduce the amount of leachate percolating through solid waste mass to the ground water.
(D) Waste to Energy Conversions

The waste should be handled in such a way that it can be recycled and used as a energy resource.
Methane can be taped in control manner to generate electricity.
Presently GAIL has set up power generation plant which produces only 10MW, like such plant many more plant should be set up so that the waste can be easily used and recycled.

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