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Assessment of Gases Emission from the Operation of the Semi-Aerobic Landfill Site by Solid Waste of Kathmandu Valley, Nepal

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Abstract: Many landfill sites around the world have been poorly engineered and operated and hence face vociferous public opposition and criticism for their adverse environmental impacts. Because of the concerns arising from poor operation and management, sitting and operation of landfill sites are very sensitive public issues in Nepal. The aim of this study was to assess the environmental impacts due to the faul odour during the operation of the the Sisdol landfill in Okharpauwa VDC, Nuwakot, Nepal. The study focused on identifying the composition of gases from the Kathmandu Valley's solid waste and impacts on local areas air flow moments from the land fill site. LandGEM Ver. 3.02 Model was used for the emission calculation of the landfill gases. Furthermore, the gastec and specified ditector tubes were used for the measurement of H_2S gas at the study area. Among nine sites, the H_2S gas concentration at site (Vent pipe of landfill site) was 1.4 ppm (recorded maximum). The gas was found to be diluted at 208 m downwind location and reached the value near to clean air, i.e., 0.2 ppb. The observed gas concentration was lower than the toxic range though the concentration level was found to have characteristic odor. The significant level of adverse impact was found nearby the landfill site. People working surrounding area of the landfill site were more vulnerable to different impacts.

Key words: Landfill, methane, hydrogen sulfide, air flow, Nepal

INTRODUCTION

Solid wastes are the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted (Cunningham and Cunningham, 2004). Municipal solid waste includes the wastes arising from domestic, commercial, industrial and institutional activities in an urban area (Thapa and Devkota, 1999). According to the Shrestha and Sharma (2003) categories of municipal solid waste include: household garbage and rubbish, yard waste, commercial refuse, institutional refuse and construction. In addition, demolition debris, street cleaning and maintenance refuse, dead animals, bulky wastes, abandoned vehicles and sanitation residues are also parts of solid waste (Bernstein 2004). Solid waste generation rates vary depending upon living standards, livelihood practices and consumption patterns. Owing to increasing industrialization and ever increasing population, the production of paper, leather, rubber, metals, plastics and ceramics has been steeply increasing over the last few decades (Dara, 2004). Sanitary landfilling is one of the methods of final disposal of solid waste (Tuladhar, 2003). Sanitary landfilling is an engineered operation, designed and operated according to acceptable standards (El-Fadel *et al*., 1997). In most landfills, assuming there are some organic wastes, the microbial processes will dominate the stabilization of the waste and hence govern the generation of landfill gas (Paraskaki and Lazaridis, 2005) and the composition of the leachate (Christensen and Kjeldsen, 1989).

MATERIALS AND METHODS

Sisdol landfill site is about 2 ha for landfilling is located in Okharpauwa 4, Nuwakot district which is about 25 km far from capital city Center Kathmandu of Nepal. Since, 2005 Sisdol landfill site was in the operation and

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daily 350 tons day^{-1} of solid waste was dumped. The landfill was developed as a semi aerobic condition (JICA/GON, 2006). Gastec grab sampler (Model ASTM-90) and Digital Anemometer were used for identifying the wind velocity, wind direction and the temperature. LandGEM-Landfill Gas Emissions Model (LGEM), Version 3.02 was used. Default inputs of CAA Conventional were used in inputs. LandGEM-LGEM, 3.02: LandGEM was based on a first-order decomposition rate equation for quantifying emissions from the decomposition of land filled waste in Municipal Solid Waste (MSW) landfills. The methane content of the landfill gas must remain fixed at 50% by volume and gases were dispersed from the landfill site, Gaussian Model was used assuming vent pipes of landfill as point sources. The Eq. 1 is used for the Gaussian Model:

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp\left[-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2} + \frac{(z-H)^2}{\sigma_z^2}\right)\right] \qquad (1)$$

Like wise, Eq. 2 is used for Gaussian equation and the highest concentration is the center of the plume at ground level (y = 0, z = 0, h = 0):

$$\chi = \frac{Q}{2\pi u\sigma_y\sigma_z} \qquad (2)$$

Where:
Q = Emission rate in g sec^{-1}
u = Average wind velocity, δ Values

RESULTS AND DISCUSSION

Total solid waste dumped till June 2010 was about 5,33,551 tons and for the LandGEM, 62% of this waste was used for input considering the total organic wastes dumpedto be so. Though the model evaluates emissions of the 52 gases for a period of 140 years emissions for a period of 50 years as given by the model are shown in Fig. 1. The concentration of the hydrogen sulfide measured up to June 2010 in the nine different sites of the landfill site in Table 1. Wind rose diagram shows the landfill area, wind velocity and direction at different sites of the landfill site (Fig. 2).

Situation analysis: According to field survey 2009, the per-capita household waste generation was found to vary from a minimum value of Kalaiya Municipality 0.12 kg/person/day to a maximum value of Kamalamai Municipality 0.54 kg/person/day. It is remarkable that the households surveyed in some of the municipalities such as Putalibazar, Malangawa, Triyoga, Tikapur were found to reuse most of the wastes generated for their own purpose, e.g., feeding for the pigs and cattle, etc. thus resulting in very low rate of waste generation compared to other municipalities' average. Physical analysis of waste samplings collected from different representative households during the survey on waste generation/collection were carried out to determine the composition of waste (Fig. 3 and 4).

The values for different waste fractions in terms of percentage composition by wet weight obtained from the analysis of waste samples. Average physical composition of household waste of 58 municipalities in four major waste components, i.e., organic waste, recyclable, inert and others (with average values by wet weight %) is represented.

The disposal sites were mainly riverbanks, depressed land/dumps or temporary open piles. Figure 2 shows that eight municipalities have landfill sites. About 23 out of 58 municipalities dumped the solid waste in the river bank and 27 municipalities have no defined disposal sites.

Landfill gas emission: Landfill is emitted various pollutants gases in the environment. Landfills are identified as a hazardous air pollutant source under the Urban Air Toxic Strategy (EPA, 1999). These pollutants include those of concern to human health such as benzene, carbon tetrachloride, methyl ethyl ketone, perchloroethylene, toluene, vinyl chloride and xylene. Landfills have been found to emit <100 Nonmethane Organic Compounds (NMOCs). The majority of the NMOCs is Volatile Organic Compounds (VOCs) and contributes to urban smog. Over thirty of LFG NMOCs are hazardous air pollutants. The human exposure from priority to health risk pollutants emitted from closed municipal landfill at Ano Liosia such as vinyl chloride and benzene by the landfill gas emission using LandGEM 3.02 Software combined with the atmospheric long term dispersion model ISC3-LT (Paraskaki and Lazaridis, 2005). According to Georgia Department of Human Resources, the major impacts of landfill gases are odors, explosion hazard, asphyxiation hazard, toxic chemical hazard, effects on vegetation, etc. In this research, emission rates of toxic gases from Sisdol landfill site were evaluated and highest emission of gases were found to occur at 2008. This may be due to waste in landfill site undergoes methanogenic phase on that year and maximum decomposition of wastes occurs. Landfill gases flow either above or below ground from the landfill. Odors from day to day landfill activities are indicative of

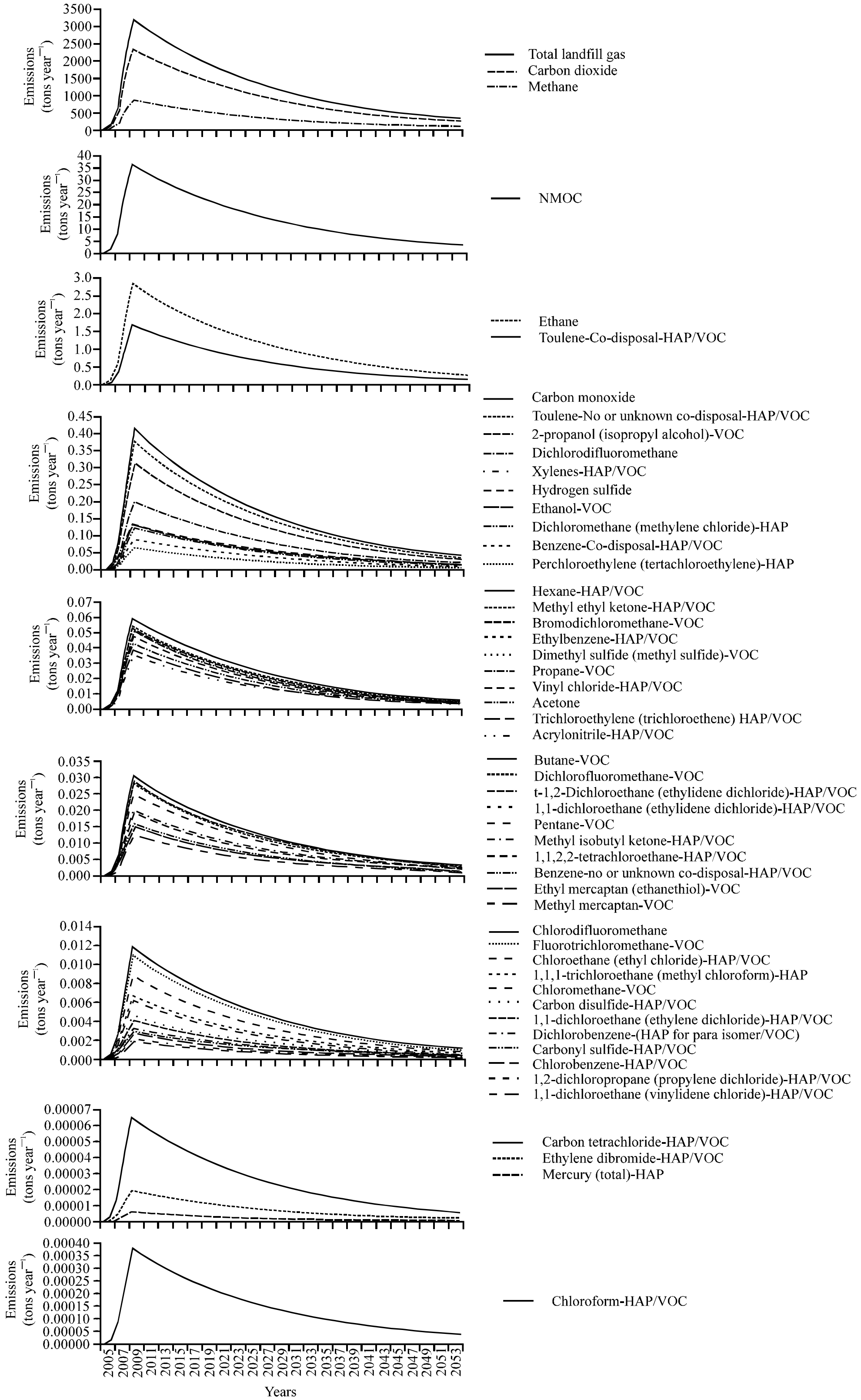

Fig. 1: Different gases emission from Sisdol landfill site (NMOC: Non Methane Organic Carbon)

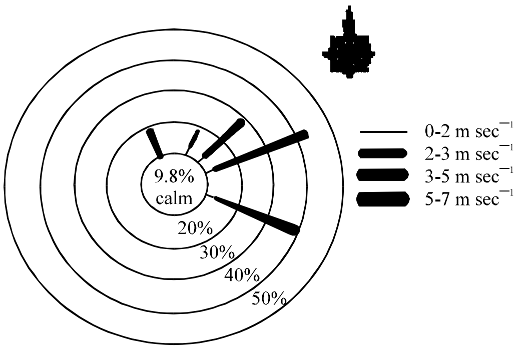

Fig. 2: Wind rose diagram of the Sisdol landfill site

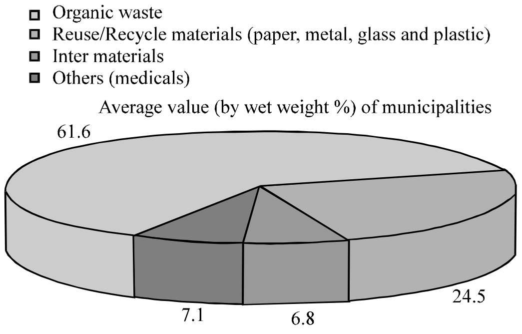

Fig. 3: Physical composition of household waste (Field survey in 2009)

Table 1: Concentration of H_2S in air

Measuring site	Temperature (°C)	Wind velocity (m sec^{-1})	Wind direction (with respect to North)	H_2S (ppm)
S1	27	3.0	64	<0.03
S2	29	2.2	62	<0.03
S3	30	2.0	42	0.03
S4	31	2.2	98	<0.03
S5	31	2.3	98	1.40
S6	30	3.0	358	<0.03
S7	31	3.6	358	<0.03
S8	30	2.2	64	<0.03
S9	30	3.2	98	<0.03

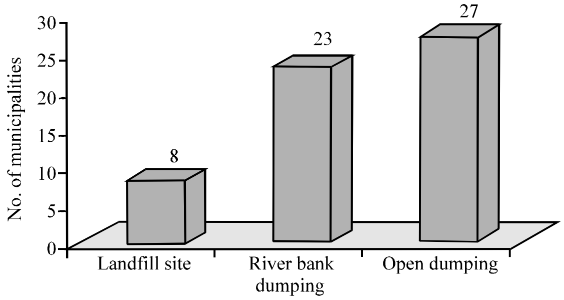

Fig. 4: Existing waste disposal system in Nepal

gases moving above ground. Gases pass through the soil underground and also move surrounding area according to the air velocity and direction. The research found that the foul odors problem from a landfill offensive or unpleasant. Due to the odor many people experienced nausea or headaches problem in the surrounding areas.

Hydrogen sulfide is one of the major gases causing odor problem around the landfill site. The most dangerous aspect of hydrogen sulfide results from olfactory accommodation and olfactory paralysis. Chronic and subchronic exposure to low concentrations of hydrogen sulfide and other organosulfur compounds do cause long-term health problems in humans. The central nervous system symptoms are associated with permanent neurophysiologcal deficits. Injury to the central nervous system includes damage to the basal ganglia and white matter (Thrasher, 2008). The maximum concentration of the H_2S was observed at site at Vent pipe which was 1.4 ppm. Similarly, at site at Leachate pond it was found top be 0.025 ppm, respectively.

Remaining sampling sites found low concentration of H_2S, i.e., <0.025 ppm which was similar with Kevin and Mary result's 1997. The average wind speed at Sisdol landfill site in 2008 was 2.63 and the atmospheric class stability lay. The emission rate of H_2S in 2008 was found to be 0.0837 tons year^{-1}. This emission rate of H_2S emission will be increased in future due to the increasing amount of waste dumped at landfill site.

The odor threshold for H_2S is 0.5-1 µg m^{-3} (ASDR, 2008). The concentration of H_2S in ambient air is generally 0.15 µg m^{-3} (WHO, 1987) whereas rationale and guideline values of H_2S based on sensory effects or annoyance reactions. The detection threshold is 0.2 2.0 µg m^{-3} and recognition threshold is 0.6 6.0 µg m^{-3} and guideline value 7 µg m^{-3} (WHO, 2000). The Illinois Institute in 1974 summarized the literature on human health effects and their observations on the health effects in Illinois ambient air concentrations. The Illinois Institute recommended a standard for gaseous H_2S as 0.015 mg m^{-3} (0.01 ppm) in order to minimize adverse health effects from chronic exposure in urban air. Deterioration of the air quality due to land filling practices could be identified by comparing these values.

The gases generated from the landfill travel to some distances along with air and diffuse in air along with time. Wind velocity and direction determines where the gases are carried away and how they are diffused. Local effects due to topography and heating effect can alter the wind direction. The potential of migration of landfill gas from the site boundaries and nature of damage and found the presence of landfill gas in the root zone caused stress which was visible within the vegetation in the form of chlorosis or dieback (Jones and Elgy, 1994). This can be clearly seen through the windrose diagram. Similarly, the total amount CH_4 of released to the air in 2008 was found to be 779.13 tons. CH_4 is a high with 39,820 kJ m^{-3} calorific fuel gas which is useful for energy production. Only, 50% of the CH_4 produced from the semi aerobic landfill site which can be used or destroyed. Therefore, the total amount of CH_4 is produced from the landfill, 389.70 tons $year^{-1}$ which is equivalent to 8180.865 tons of carbon dioxide. At prevailing market prices, clean development mechanism project gains $42540.50 from the reducing CH_4 gas from the landfill.

CONCLUSION

In this research, the maximum concentration of the H_2S was observed at the Vent pipe of landfill site which was 1.4 ppm. Similarly, at old Leachate pond it was found to be 0.025 ppm, respectively. In other remaining sampling sites the concentration of H2S was found in very minimum amounts i.e., concentration below 0.025 ppm. The emission rate of H_2S was 0.0837 tons $year^{-1}$ and similarly, the total amount CH_4 of released to the air was 779.13 tons $year^{-1}$. This research shows the development of CDM project is also possible from the existing landfill site for reducing release of CH_4 into the atmosphere. The gas was found to be diluted and thus reached the value near to clean air within just 208 m downwind during the study period.

REFERENCES

ASDR, 2008. Landfill gas primer safety and health an overview for environmental health professionals. http://www.atsdr.cdc.gov.

Bernstein, J., 2004. Toolkit, social assessment and public participation in municipal solid waste management. Urban Environment Thematic Group, August 2004.

Christensen, T.H. and P. Kjeldsen, 1989. Sanitary Landfilling: Process, Technology and Environmental Impact. Academic Press, New York, pp: 29-49.

Cunningham, W.P. and M.A. Cunningham, 2004. Principles of Environmental Science, Inquiry and Applications. 2nd Edn., McGraw-Hill Publishing Company Ltd., USA., pages: 303.

Dara, S.S., 2004. Textbook of Environmental Chemistry and Pollution Control. 17th Edn., Chemical Publishing Co., USA., pp: 110-132.

EPA, 1999. Air toxics emissions-EPA's strategy for reducing health risks in urban areas. EPA-453/F-99-002: Office of Air Quality Planning and Standards: Research Triangle Park, NC.

El-Fadel, M., A.N. Findikakis and J.O. Leckie, 1997. Environmental impacts of solid waste landfilling. J. Environ. Manage., 50: 1-25.

JICA/GON, 2006. The study on the solid waste management for the Kathmandu Valley. Nippon Koei Co. Ltd., Yachiyo Engineering Co. Ltd.

Jones, H.K. and J. Elgy, 1994. Remote sensing to assess landfill gas migration waste. Manage. Res., 12: 327-337.

Paraskaki, I. and M. Lazaridis, 2005. Quantification of landfill emission to air: A case study of the Ano Liosia landfill site in the greater Athens area. Waste Manage. Res., 23: 199-208.

Shrestha, S. and A. Sharma, 2003. Study of solid waste of Kathmandu City. Nepal J. Microbiol., 1: 90-106.

Thapa, G.B. and S.R. Devkota, 1999. Managing waste in metro Kathmandu. Asian Institute of Technology, Bangkok.

Thrasher, J.D., 2008. Poison of the month, toxicology of hydrogen sulfide. http://ftp://www.drthrasher.org.

Tuladhar, B., 2003. The search for Kathmandu's new landfill: Science and logic need s to prevail over politics. Himalayan J. Sci., 1: 7-8.

WHO, 2000. WHO regional office for Europe. World Health Organization, Geneva. http://www.who.int/about/regions/euro/en/.

WHO, 1987. Air Quality Guidelines for Europe. World Health Organization, Geneva.