



Gaseous Emissions from MSW Dumpsites in Vijayawada

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Abstract: Assessment of gaseous emissions from two municipal solid waste dumpsites at Vijayawada, Andhra Pradesh in India for the potential health impacts due to the emissions was the prime objective of the present study. A portable multi-gas analyzer of model MODEL_VEP_200 with RS 232 was used to monitor the soil gas and ambient air quality near the two dumpsites of Vijayawada. Specific parameters like CH₄, NH₃, CO, H₂S, H₂, NO₂ and O₂ were monitored for a period of three seasons i.e. winter(November 12 to February 13), summer (March 13 to June 13) and rainy (July 13 to October 13) a complete annual cycle. CH₄ was recorded at both the dumpsites which were presently within the permissible limits. H₂S is resulting in obnoxious odors to the residents near the dumpsites affecting the life of people. NO₂ was within the permissible limits of Indian standards IS 10500. H₂ and NH₃ were below detection levels during the study period in the dumpsites.

Key words: Municipal Solid Waste (MSW), Portable multi-gas analyzer, soil gas, ambient air.

I. Introduction

MSW includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. It consists of household waste, wastes from hotels and restaurants, construction and demolition debris, sanitation residue, and waste from streets. As per estimates more than 55 million tons of MSW is generated in India per year; the yearly increase is estimated to be about 5%. It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0.1 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively. The estimated annual increase in per capita waste generation is about 1.33 % per year. The solid waste generation varies upon the nature of the place, activities and life style of the residents. [1]

In India, the biodegradable portion dominates the bulk of MSW. This is mainly due to food and yard waste. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition has been changing. Unorganized, indiscriminate and unscientific dumping of municipal solid wastes is very common disposal method in many Indian cities which cause adverse impacts to the environment. Over the past few decades, composition of MSW in Indian mega-cities have recorded higher percentages of earth and inert materials (35–52%), varying degradable matter (35–84%) and lowest recyclable material (10–20%). Plastic content in MSW had rapidly increased in past and stabilized thereafter due to growing awareness and recycling practices. [12]

Almost 70–90% of landfills in India are open dumpsites [13]. When solid waste (SW) is disposed in waste dumps and landfills; the organic material will be degraded over a longer or shorter period, ranging in a wide span from less than one year to 100 years or more. The majority of this process will be bio-degradation. Strongly depending on conditions in the site where the SW is disposed, this biodegradation will be aerobic or

anaerobic. The main degradation products are carbon dioxide (CO₂), water and heat for the aerobic process and methane (CH₄) and CO₂ for the anaerobic process ([17], [18]). The CH₄ produced and released to the atmosphere contributes to global warming and the emissions need to be estimated and reported in national greenhouse gas inventories under the United Nations' Framework Convention on Climate Change (UNFCCC). The CO₂ produced originates from biogenic sources (e.g., food, garden, paper and wood waste) and the emissions need therefore not be considered. The estimated global annual emissions from solid waste disposal sites (SWDS) are in the range of 20 - 40 million tonnes of CH₄, of which the most comes from industrialized countries. This contribution is estimated to be approximately 5-20 percent of the global anthropogenic CH₄, which is equal to about 1 to 4 percent of the total anthropogenic greenhouse gas (GHG) emissions. The emissions from developing countries and countries with economies-in-transition will increase in the near future due to increased urban population, increased specific (pro capita) municipal solid waste (MSW) generation due to improved economy and improved SW management practices. From the Annex I countries, the emissions are estimated to remain stable or decline over the next 10 - 20 years. [10]

Compared to the west, the composition of municipal solid waste (MSW) in developing countries has higher (40% - 60%) organic waste. This would have potential to emit higher GHG's from per ton of MSW compared to developed world. The research is scanty on the VOC levels in ambient air from open dump sites ([7], [3], [14]). There are no studies on the gaseous emissions from MSW sites in Indian cities except few studies at landfill sites of Bhandewadi in Nagpur and Amaravathi in Sukhali [1], Chennai city landfills ([12], [21]), Delhi landfill sites ([18], [26]). The present study is first of its kind in Andhra Pradesh. The monitoring of emissions from a dumpsite at Vijayawada has been taken up. This study not only serves as a basis in MSW monitoring in Andhra Pradesh also helps to develop indicators of degradation but also help to develop coordinates for future dynamic models.

II. Study Area

Vijayawada is the second largest city in the state of divided Andhra Pradesh, India, after Visakhapatnam, with an area of 261.88 km² and population of 1,048,240. Vijayawada is surrounded by the Krishna River on the east and west and the Budameru River on the north. The northern, northwestern, and southwestern parts of the city are covered by a low range of hills, while the central, southwestern and northwestern parts are covered by rich and fertile agriculture lands with three major irrigation canals. The topography of Vijayawada is flat, with a few small- to medium-sized hills. The Krishna River runs through the city. These hills are part of the Eastern Ghats cut through by the Krishna River. The city generates solid waste of 650 Tons/Day. Generally low lying areas and outskirts of the city Vijayawada are used for the purpose of open dumping. The management of solid wastes in Indian cities like Vijayawada is largely unscientific and unsatisfactory. The uncontrolled dumping of urban wastes destroys the beauty of country side also there is danger of water pollution when the leachate from a refuse dump enters surface water or ground water resource. In addition uncontrolled release of landfill gas, burning of open dumps can cause air pollution. The main risks of human health arise from the breeding of disease vectors, primary flies and rats thriving in the exposed garbage and refuse dumps [24]. The two MSW dump sites at Pathapadu suburban region of Vijayawada and Ajith Singnagar are been selected for the present study.

III. Materials and Methods:

The two dumpsites of Vijayawada Pathapadu dumpsite (PPD) in the suburban region of Vijayawada and Ajith Singnagar dumpsite (ASN) were selected for the present study. Site descriptions are given below in the table 1.

Table 1

Disposal Characteristics	Pathapadu	Ajith Singnagar
Since when in operation (Years)	5	7
Total site area (Acres)	2	106.6
Disposal quantity(MT/day)	360	225
Waste Disposal method	Land filling	Open dumping

The two dumpsites i.e. Pathapadu dumpsite (PPD) and Ajith Singhnagar dumpsite (ASN) are studied for monthly monitoring of the emissions for specific parameters like CH₄, NH₃, CO, H₂S, H₂, NO₂ and O₂ was done. A portable onsite multi-gas analyzer of model MODEL_VEP_200 with RS 232 was used to estimate emissions from the dump and ambient air quality near the two dumpsites of Vijayawada. The probe of the multi-gas analyzer was inserted in the soil at different depths of the MSW dump for monitoring the soil gas sample. The sampling was done randomly at five identified spots at each dump site and the mean of the five places was taken. Standard deviation (SD) was also calculated for all the five places for the two dumpsites.

IV. Results and Discussion

The samples collected were at the two dumpsites. The sampling was done for complete three seasons of the annual cycle i.e. July 2012 to October 2012 was the monsoon season, November 2012 to February 2013 was winter season and March 2013 to June 2013 was summer season.

People exposed to emissions may be at risk and may face serious chronic health hazard problems since it has been well proven by researchers that there was direct correlation between air pollutants and morbidity and mortality rate ([15], [6], [30], [11]). For example, a case report from North America found increased incidence of cancers of the liver, kidney, pancreas [16]. In contrast, there was no link found between the birth rates or health defects and nearby landfill activities was reported by various authors ([2], [28], [23], [25]).

Methane: The CH₄ concentration was high ie 4.68% at PPD where 4.04% at ASN dumpsites during summer season. The methane concentration reduced in rainy and consecutively in winter seasons at PPD dumpsite. Whereas the methane concentration was constant during rainy and winter seasons at ASN dumpsite. The CH₄ was absent in the ambient air emissions taken from both the dumpsites. The results were in accordance with the earlier studies on landfill emissions ([18], [12]). Similar, findings were reported by [9] for landfill methane emission.

The methane emissions were presently within the Indian standards at both the dumpsites. But in the near future due to the urban sprawl at the dumpsites there is possibility of methane accumulation in the study area. The flammability range for methane in air at atmospheric pressure and ambient temperature is 5 to 15% and the safety concentration limit for confined environments where people live or work is 1% in air (20% of the Lower Explosive Limit) [4]. Methane during migration into atmosphere may be diluted and therefore fall within the flammability range. Reference [18] reported that the people living near landfills expressed the fear of explosion due to accumulated methane gas.

Carbon Monoxide: The CO emissions ranged between 0 and 8% by volume. The CO emissions were high during the summer season in both the dumpsites compared to winter and rainy seasons. The values were exceeding the acceptable levels in both the dumpsites. The CO value was higher in ASN dumpsite than PPD dumpsite in summer season. Higher concentrations of CO are the sign of oxygen-starved burning of the refuse [4]. As the PPD dumpsite is located in the residential area it may contribute to various health problems to the residents. CO causes headaches, dizziness, vomiting and nausea. Exposure to moderate and high levels of CO over long periods of time also been linked with increased risk of heart diseases.

Hydrogen Sulphide: The H₂S emissions ranged between 2.37 and 47.81% at PPD dumpsite whereas 22.43 and 48.93% at ASN dumpsite. The H₂S emissions were found to be very high in both the dumpsites during summer season. The reason is that the dumpsites are active and receives garbage every day. A trend of decrease was recorded during rainy season followed by winter season at both the dumpsites. H₂S even at low levels cause odour problems in the vicinity of the dumpsites. H₂S is causing obnoxious odour to the residents in the study area. H₂S is high in the ambient air samples due to combustion of solid waste at the ASN dumpsite. Hydrogen sulphide is highly toxic and affects the nervous system. It also has a repugnant odour and is highly flammable. Its odour threshold is comprised between 5 and 40 ppm. Above 50 ppm it paralyses the olfactory system, which makes it a particularly pernicious intoxicant. Concentrations above 400 ppm affect the nervous system and above 700 ppm there is risk of death by respiratory failure [4]. Department of health, New York State Agencies have reported health impacts like eye, throat and lung irritations, nausea, headache, nasal blockage, sleeping difficulties, weight loss, chest pain and aggravation of asthma [29].

Nitrogen Dioxide: The NO₂ emissions were high during winter followed by rainy and summer seasons at PPD dumpsite. Whereas, concentrations were higher during rainy and constant during summer and winter seasons at ASN dumpsite. The concentration of NO₂ was higher at ASN compared to PPD dumpsite during rainy season. But the NO₂ emissions were within the permissible limits. Similar findings were reported by [21] during their study where high emissions of NO₂ during monsoon season were recorded due to enhanced waste degradation within fills due to rain water percolation. In dumpsites open burning of the MSW which contains sulfur and nitrogen is most common and expected to emit SO_x and NO_x which may also be the reason of NO₂ emissions in the study area which is also supported by ([19], [20]). Pulmonary tract irritation affecting functioning of lungs is the major symptom associated with NO_x pollution ([27], [5]).

Oxygen: The O₂ monitored was depleting in soil gas samples during summer season in both the dumpsites which is considered as the indicator of anaerobic conditions in the MSW dump. The oxygen levels were high during winter followed by rainy season and decreased during summer at both the dumpsites. Comparatively the oxygen concentrations were very low at ASN than PPD dumpsite. This may be due to more compaction of the solid waste at the ASN dumpsite due to lack of dumping area. The standard oxygen levels of 20.09% by volume were found in the ambient air samples taken from the dumpsites.

Table 2: Gaseous emissions November 2012 to October 2013(Mean ± SD)

Parameter	Stations	Winter	Summer	Rainy
O ₂ (%)	PPD	9.75±1.61	3.66±0.74	3.94±0.19
	ASN	4.63±0.67	0.41±0.11	3.8±0.08
CO (%)	PPD	2.51±0.56	3.67±0.22	3.82±0.59
	ASN	2.51±0.39	4.12±0.38	3.78±0.45
CH ₄ (%)	PPD	2.43±0.8	4.68±1.31	4.37±0.32
	ASN	2.54±0.22	4.04±0.32	2.22±0.54
NO ₂ (ppm)	PPD	1.5±0.45	1.93±0.31	2.75±1.39
	ASN	2.43±0.74	3.93±0.8	2.87±0.85
H ₂ S(ppm)	PPD	2.37±4.75	47.81±30.99	31.18±9.46
	ASN	22.43±9.15	48.93±20.96	33.5±4.41
H ₂ (%)	PPD	BDL	BDL	BDL
	ASN	BDL	BDL	BDL
NH ₃ (%)	PPD	BDL	BDL	BDL
	ASN	BDL	BDL	BDL

Table 3: AMBIENT AIR

Parameter	Stations	Winter	Summer	Rainy
O ₂ (%)	PPD	BDL	BDL	BDL
	ASN	BDL	BDL	BDL
CO (%)	PPD	1.4±0.29	1.6±0.31	1±0.18
	ASN	1.32±0.29	1.55±0.12	1±0.16
CH ₄ (%)	PPD	BDL	3.75±7.5	BDL
	ASN	BDL	BDL	BDL
NO ₂ (ppm)	PPD	BDL	BBDL	BDL
	ASN	BDL	BDL	BDL
H ₂ S(ppm)	PPD	23±4.67	20.82±0.95	20.67±0.45
	ASN	20±0.68	18.95±0.34	20.32±0.31
H ₂ (%)	PPD	BDL	BDL	BDL
	ASN	BDL	BDL	BDL
NH ₃ (%)	PPD	BDL	BDL	BDL
	ASN	BDL	BDL	BDL

The H₂ and NH₃ were below detection levels in both the dumpsites during the study. But the studies by [21] at Chennai recorded the H₂ and NH₃ emissions in the ambient air at the dumpsites.

The ambient air readings were very low or below detection levels for all the gasses except oxygen and carbon monoxide. This may be due to the dispersion of emissions and changing wind directions at the dumpsites.

V. Conclusion

The gaseous emissions at MSW dumpsites in Vijayawada were recorded during the study. The specific parameters like CH₄, NH₄, CO, H₂S, H₂, NO₂ and O₂ were monitored for a complete annual cycle. The parameters like CH₄, CO, H₂S, NO₂ and O₂ were identified at both the dumpsites. The CH₄ and NO₂ were within the permissible limits during the study period. The CO and H₂S emissions were high during the study period. H₂ and NH₄ were below detection levels during the study period at the dumpsites. As both the dumpsites were near to each other i.e. within a distance of 4 Kms, same trend of changes in the emissions were observed during the study period. The research carried out has shown clearly that the gaseous emissions at the dumpsites are affecting the nearby local communities living near the dumpsites. Even though the pollutants are presently within the standard limits, there is possibility of the accumulation of methane in the near future due to urban sprawl. The dumping of MSW if continued in same manner it will slowly result in exceeding of pollution levels above standard limits of residential area. The gaseous emissions were high during the summer season and considerably less during the winter and rainy seasons. Greenhouse effect of methane, CO₂ and other trace gases, result in long-term detrimental effects on human health. People living in surrounding areas complain about fires over the dump site, smoke, smell and unhygienic conditions during monsoon on approach roads and water pool in surrounding low laying areas.

The dumping activities of MSW must be far away from the residential areas to minimize the impacts. Littering of waste at the dumpsites is resulting in high concentrations of H₂S and NO₂ emissions which must be strictly prohibited. A sustainable approach to the MSW in the dumpsites is the present need in every developing country.

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References

- [1] A.B. Akolkar, M.K. Choudhury and P.K. Selvi, Assessment of Methane Emission from Municipal Solid Wastes Disposal sites, Research Journal of Chemistry and Environment, Vol. 12, No. 4, Dec 2008.
- [2] A. Redfearn and D. Roberts, Health effects and landfill sites. In Environmental and Health Impact of Solid Waste Management Activities, R.E. Hester and R.M. Harrison, Eds. Royal Society of Chemistry: Cambridge, UK, 2002.
- [3] A.T. Hodgson, K. Garbesi, R.G. Sextro, J.M. Daisey, Soil-gas contamination and entry of volatile organic compounds into a house near a landfill. JAPCA J. Air Waste Ma., Vol. 42 (3), 1992, pp. 277–283.
- [4] Catherine Fischer, Gas emissions from landfills – An Overview of issues and research needs: A Survey, AFR Report 264, Oct 1999.
- [5] D.L. Mauzerall, B. Sultan, N. Kim, D.F. Bradford, NO_x emissions from large point sources: variability in ozone production, resulting health damages and economic costs. Atmos. Environ., Vol. 39, No. 16, 2005, pp. 2851-2866.
- [6] H.I. Anderson, A. Ponce de Leon, J.M. Bland, J.S. Bower, J. Emberlin, and D.P. Strachan, Air pollution, pollens and daily admissions for asthma in London 1987-92. Thorax, Vol. 53: 1998, pp. 842 – 848.
- [7] H.P. Kgonig, U. Lahl, H. Kock, Determination of organic volatiles in ambient air in the area of a landfill. J. Aerosol Sci., Vol. 18, No. 6, 1987, pp. 837–840.
- [8] INDIAN STANDARDS 10500
- [9] J. Bogner and E. Matthews, Global Methane Emission from Landfills: New Methodology and Annual Estimates 1980-1996, Global Biogeochemical Cycle, Vol. 17, No. 2, 2003, pp. 1065-1082. doi:10.1029/2002GB001913.
- [10] Jens E Froiland Jensen and R. Pipatti, Methane emissions from Solid Waste disposal, Good Practices Guidance and uncertainty management in national greenhouse gas inventories, Background paper pp. 419-439.
- [11] J. Schwartz, F. Ballester, M. Saez, S. Perez-Hoyos, J. Bellido, K. Cambra, F. Arribas, A. Canada, M. Perez-Boillos and J. Sunyer, The concentration response relation between air pollution and daily deaths, Environ. Health Persp., Vol. 109, No. 10, 2001, pp. 1001 – 1006.
- [12] K. Jha, C. Sharma, N. Singh, R. Ramesh, R. Purveja and P. K. Gupta, Greenhouse Gas Emission from Municipal Solid Waste Management in Indian Mega-Cities: A Case Study of Chennai Landfill Sites, Chemosphere, Vol. 71, No. 4, 2008, pp. 750-758. doi:10.1016/j.chemosphere.2007.10.024
- [13] K. Joseph, C. Viswanathan, J. Trakler, B.F.A. Basnayake and G.M. Zhou, Regional networking for sustainable landfill management in Asia. In: Proceedings of the Sustainable Landfill Management Workshop, 3–5 December 2003 Anna University, Chennai, 2003, pp. 39.
- [14] K. Wilkins, Volatile organic compounds from household waste, Chemos., Vol. 29, No. 1, 1994, pp. 47–53.
- [15] M. Bobak, and R.G.A. Feachem, Air pollution and mortality in central and eastern Europe: estimate of the impact, Eur. J. Public. Health, Vol. 5, 1995, pp. 82 – 86.
- [16] M.S. Goldberg, R. DeWar, M. Desy and H. Riberdy, Risk of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada. Arch. Environ. Health, Vol. 54, 1999, pp. 291-296.
- [17] M.A.K. Khalil, Non-CO₂ greenhouse gases in the atmosphere: Annual Review of Energy and the Environment Vol. 24, 1999, pp. 645–661.
- [18] Manju Rawat and A.L. Ramanathan, Assessment of methane flux from Municipal Solid Waste (MSW) Landfill Areas of Delhi, India, Journal of Environmental Protection, Vol. 2, 2011, pp. 399-407.
- [19] N. Watanabe, N. Tanikawa, T. Oikawa, S. Inoue and J. Fukuyama, Improved quartz furnace method for chlorine and sulfur determination in municipal solid waste. J. Mater. Cycles. Waste. Manage., Vol. 5, 2003, pp. 69-76.
- [20] O. Gohlke, T. Weber, P. Seguin and Y. Laborel, A new process for NO_x reduction in combustion systems for the generation of energy from waste. Waste Management, Vol. 30, 2010, pp. 1348 -1354.

- [21] O.P. Karthikeyan, S. Murugesan, K. Joseph, Ligy Philip, Characterization of Particulate matter and volatile organic compounds in the ambient environment of open sites, Universal Journal of Environmental Research and Technology, Vol. 1(2), 2010, pp. 140-150.
- [22] Permissible limits of Ambient Air pollutants, Central Pollution control Board, New Delhi. (<http://cpcb.delhi.nic.in/standard18.hmt>)
- [23] S.E. Morris, O.W. Thomson, L. Jarup, C. de Hoogh, D.J. Briggs, and P. Elliott, No excess risk of adverse birth outcomes in populations living near special waste landfill sites in Scotland, Scottish Med. J., Vol. 48, 2003, pp. 105-107.
- [24] Shaheda Niloufer, A.V.V.S. Swamy and K. Syamala Devi, Impact of Municipal Solid Waste on the Ground Water Quality in Vijayawada City, Andhra Pradesh. Indian Journal of Applied Research, Vol. 3, No. 4, 2013, pp. 62-64.
- [25] S.R. Palmer, F.D.J. Dunstan, H. Fielder, D.L. Fone, G. Higgs and M.L. Senior, (2005): Risk of congenital anomalies after the opening of landfill sites. Environ. Health Persp., 113, 2005, pp. 1362- 1365.
- [26] S. Kumar, A.N. Mondal, S.A. Gaikwad, S. Devotta and R.N. Singh, Qualitative assessment of methane emission inventory from municipal solid waste disposal sites, a case study, Atmospheric Environment Vol. 38, 2004a, pp. 4921–4929.
- [27] S.K. Wahi, A.K. Agnihotri and J.S. Sharma, Environmental management, Willey Eastern Ltd., New Delhi, 1992.
- [28] T.J. Dummer, H.O. Dickinson, and L. Parker, Adverse pregnancy outcomes near landfill sites in Cumbria, northwest England, 1950-1993, Arch. Environ. Health, Vol. 58, No. 11, 2003, pp. 692- 698.
- [29] U.S. Environmental Protection Agency www.epa.gov/methane/ New York State Department of Health www.health.state.ny.us/environmental/emergency/chemical_terrorism/ammonia_tech.htm, Important things to know about landfill gas, April, 2010.
- [30] Y.C. Hong, J.H. Lecem, E.H. Ha and D.C. Christianinc, PM10 exposure, gaseous, pollutants and daily mortality in Inchon, Environ. Health Persp., Vol. 107 (11), 1999, pp. 873 – 878.