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Original Article

Investigation of methane emission potential for municipal solid waste landfill sites in Iran and declining approaches2008

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ABSTRACT:

Objective: The objective of this study was to investigation of methane emission potential for municipal solid waste landfill sites in Iran and declining approaches.

Methods: In this study methane emission rate from MSW landfill sites in Iran was estimated by IPCC (2000) method. Also emitted methane amounts from three different scenarios of MSW land filling and recycling have been surveyed in Iran.

Results: The results showed that methane emission rate from unsanitary MSW landfill site in existence situation of (first scenario) was 1.682 million ton per year which would be equal with 162.7 kilo gram of methane per ton of buried MSW. In this scenario, methane emission portion from MSW landfill sites on Iran in comparison to global rate was 4.67 percent.

Conclusion: Based on the results, in first scenario if MSW land fill sites became sanitized and methane recovery from these sites carried out (second scenario) methane emission would be reduced to rate of 0.7 million ton per year. Also appropriate recycling of MSW in Iran up to 80 percent and land filling of residual solid waste with recovering of generated methane (third scenario) was reduced methane emission to rate of 0.158 million ton per year. So, it has been recommended intensively that sanitary land filling processes and appropriate MSW recycling would be considered as two significantly important actions for methane emission decreasing on Iran MSW landfill sites.

Keywords: Emission potential; Iran; Methane gas

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1. INTRODUCTION

Excessive growth of population, deforestation, soil erosion, city dwelling, rapid industrialization and extensive changing in consuming patterns altogether are the factors that disturb climatological and ecological balance in many part of the earth (1, 2, 3, and 4). Observations have shown that since 1970 the earth has got between 0.8 to 1 degree Celsius warmer (5). This global warming is caused by the emission of the greenhouse gases such as CO2, CH4, NO2 and etc in atmosphere (6). This emission already has significant impact on climate and caused destructive phenomenon such as global warming, polar ice melting, heavy floods, strong storms and successive droughts (7, 8, 9, 10, 11, and 12).

Global warming and environmental crisis caused by it has led to special consideration in minimization and emission control of greenhouse gases so specific circumstances for formation of international environmental convention such as Rio and Kyoto has been provided.(13,14,15). United state and Russia) agreed to reduce their collective greenhouse gases (GHG) emissions by 5.2% from the level in 1990, ration of this reduction range from 8% for European union, 7% for united states, 6% for Japan and 0% for Russia(16,17). Land filling is one of them process that led to production of greenhouse gases, investigation have shown that 50% of generated gases from MSW landfill sites allocated to methane gas. This gas comprises 3-19%of total greenhouse gases in different part of the world (18). Although methane concentration in atmosphere is much lowers than carbon dioxide its global warming potential (GWP) is 21 times that of carbon dioxide (7, 19, and 20).

Table 1. Some of the models that have been used for methane emission estimation from MSW landfill sites (25)

	Moel formula	Symbol index
German EPER model	Q=(M)(DOC)(DOC_f)(F)(D)	Q=methane production (kt/yr) M=waste generation (Mt/yr) DOC=degradable organic carbon(kg/tone ne) DOC_f= fraction assimilated DOC F=fraction of methane in landfill gas D= collection efficiency factor
TNO model	Q=(DOC)(1.87)(M)(DOC)(k)$e^{-(Kt)}$	Q= methane production (kt/yr) DOC_f= fraction of assimilated DOC M=waste generation (Mt/yr) DOC=degradeble organic carbon(kg/ton ne) k=decay rate(yr^{-1}) t= time of waste disposal(yr)
Belgium model	Q=(M)(DOC)(k)(DOC_f) $exp^{-(kt)}$	Q= methane production (kt/yr) M= waste generation (Mt/yr) DOC=degradable organic carbon(kg/ton ne) K= decay rate(yr^{-1}) DOC_f= fraction Assimilated DOC t= time of waste disposal (yr)
Scholl Canyon	Q=(M)(k)(Lo)$exp^{-(kr)}$	Q= methane production (kt/yr) M=waste generation (Mt/yr) K= decay rate(yr^{-1}) Lo= methane generation potential(kg/ton ne) T= time of waste disposal(yr)
LandGEm Version 2.01	Q= (M/100)(k)(Lo)$exp^{-(kt)}$	Q=methane production (kt/yr) M=waste generation (Mt/yr) K= decay rate (yr^{-1}) Lo= methane generation potential (yr) t= time of waste disposal (yr)
Modified model	Q= (M/100)(k)(Lo) $exp^{-(kt)}$	Q=methane production (kt/yr) M=waste generation (Mt/yr) K= decay rate (yr^{-1}) Lo= methane generation potential (kg/ton ne) X= divisor of waste between 1 and 10 t= time of waste disposal (yr)

In spite of the CH4 emission from MSW landfill sites is ranked only with the third in anthropogenic CH4 emission sources, comparing with that from paddy fields and ruminants, so the control of emission from landfill sites is the most feasible and effective measure to minimize the growth of total CH4 amount (19). In landfill sites anaerobic biodegradation of solid wastes by methanogens is responsible for about 19% of the anthropogenic CH4 introduced into the atmosphere each year (21).

Average per capita MSW production rate of 640 gr per day was estimated in Iran. Therefore with account of 44251893 people living in urban area of Iran, total generated MSW 28321.211 tons per day. Investigation of municipal solid waste plan in Iran has conveyed that around 84% MSW in Iran has being buried in landfill (22). MSW disposal in landfills would led to anaerobic fermentations of organic material and methane gas emission. several factors are involved in methane production in landfill sites which most important of them are waste chemical compound, putricibility of material, moisture content, age of buried material, ph and temperature (23,24).

Research shows that global amount of CH4 emission from MSW decomposing in landfill sites is around 22-36 Mt per year. CH4 emission from landfills is about 2.2 Mt per year in Britain, accounting for about 20% of its total CH4 emissions. In the United States annual emission from landfill is 11.6 Mt accounting for 37% of its total CH4 emissions the emission contribution rate is 21.8-34.4% in 1995 in Japan (19). Table one shows physical analysis in Iran and plot (1) shows the contributions of biodegradable components. By the way seen from plot (1), 72.04 percent of average weight of MSW is comprised by organic material with high biodegradability (22). In consideration to such a high ration of organic material in MSW, production and emission of methane in extensive scale would be expected in Iran landfill sites, so the objective of this study would be Investigation of methane emission potential for municipal solid waste landfill sites in Iran and declining approaches. There are many methods to calculate methane emission from landfills, including theoretic gas generation method, IPCC default method and one order dynamic method etc which have considerable differences not only in their assumption but also in their complexity and input data required (19). Table two shows the list of method for estimation of methane gas emission from MSW landfill sites (25).

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2. MATERIAL AND METHODS

Among models that have been used for methane decomposition until now, first degree decomposition model have the most usage, this model have been proposed by both US.EPA (2) and IPCC for methane emission estimation from MSW landfill sites (9). The differences between US.EPA models L0 parameter relied on K, methane production rat constant (yr-1) meanwhile in IPCC models L0 relied on decomposable and degradable organic carbon (26). Gas emission parameters can be acquired from theoretical prediction methods, experimental experiences and gas recovery analytical simulation in real landfill, theoretical prediction estimated base on chemical combination of MSW and give the maximum net potential of emitted methane but in actually this potential is not accessible any more(27,28,29). First degree decomposition model have been used successfully in china (19), Israel (16), Europe union, United States, Canada (6) and Pakistan (23) for CH4 emission estimation from landfill sites.

F: Methane proportion in landfill gas (50)
MSWT: Total produced MSW
R: Recycled methane factor
OX: Oxidation factor
Lo: Methane production potential
DDOC: Decomposable and degradable organic carbon
DOC: Methane correction factor
DOCF: Biodegradable organic carbon proportion

Table 2. methane proposed correction factor

Type of Site	MCF default values
Managed-anaerobic	1.0
Managed-semi-aerobic	0.5
Unmanaged-deep (>5m waste) and/or water table	0.8
Unmanaged-shallow (>5m waste)	0.4
Uncategorized landfill	0.6

Table 3. Degradable carbon fraction and DOC_f for different waste material

Waste category	Proportion of total carbon	(DOC_f) (%)
Paper and cardboard	100	35
Food waste	100	75
Garden waste	100	50
Textiles	50	30
Misc. combustible	75	30
Fines	65	60

R value (recycled methane) for standard landfill in England regarded equal to 80% and OX value (oxidation factor are regarded equal to 25% in landfill sites. USEPA determined r and ox values equal to 75% and 10% respectively (10). In study that had been carried out in Thailand OX was estimated to 15% (29). In this study in consideration to lack of methane recovery system in existence situation on landfill sites R and OX values are justified to 75 and 20 percent respectively, also with this assumptions, in this study F (methane percent) was justified to 50 percent and MCF (methane correction factor)for different scenario was regarded according to table(3).

In scenario 1 r values regarded as to be zero because in Iran landfill sites gas recovery had not been carried out anymore.

In this study methane emission potential MSW was investigated in three different scenario inconsideration to type of land filling operations and material recovery extends of:

1. In existence situation of unsanitary landfill sites and material recovery of MSW according to plot(2) (at present in Iran recovery rats for readily and slowly biodegradable material are 10 and 6 percent respectively in contrast the equal portion of material that disposed directly in landfill sites equal to percent)
2. with existence recovery rate and this assumption that MSW disposal met the environmental health standard guidelines.

Table 4. Physical analysis of Iran MSW

structure / locate	**Organic material**	**Paper & cardboard**	**Plastic**	**Metals**	**Rubber**	**Textile**	**Glass**	**Wood**	**Other**	**Total**
Fars	64.14	6.35	12.96	2.27	1.32	2.00	0.23	0.00	7.73	100
southeast	62.55	8.30	12.15	30.05	1.90	2.25	2.25	0.90	6.65	100
South beach	78.98	4.94	7.41	2.40	0.40	1.62	1.89	0.00	2.36	100
Tehran	74.56	5.04	6.25	2.48	1.11	3.29	2.03	1.89	3.42	100
Esfahan	76.30	4.38	5.26	2.90	0.97	3.72	1.71	0.00	4.76	100
Khorasan	70.96	6.93	6.87	2.36	0.74	2.93	2.27	0.00	6.94	100
Khazar	77.72	8.43	7.61	0.89	0.47	1.24	0.91	0.96	1.77	100
Azarbayjan	67.34	8.67	11.85	2.25	0.00	2.87	1.81	2.39	2.82	100
Zagros	78.24	7.21	7.28	1.71	0.52	1.4	1.94	0.6	1.10	100
Khoozestan	60.92	8.26	8.38	4.42	3.24	4.06	4.11	1.10	5.50	100
Scale average of all the country	72.04	6.43	7.77	2.52	1.14	2.86	2.03	1.10	4.11	100
Standard deviation	8.8	2.3	3.2	1.4	1.0	1.1	1.0	0.9	2.7	0.0

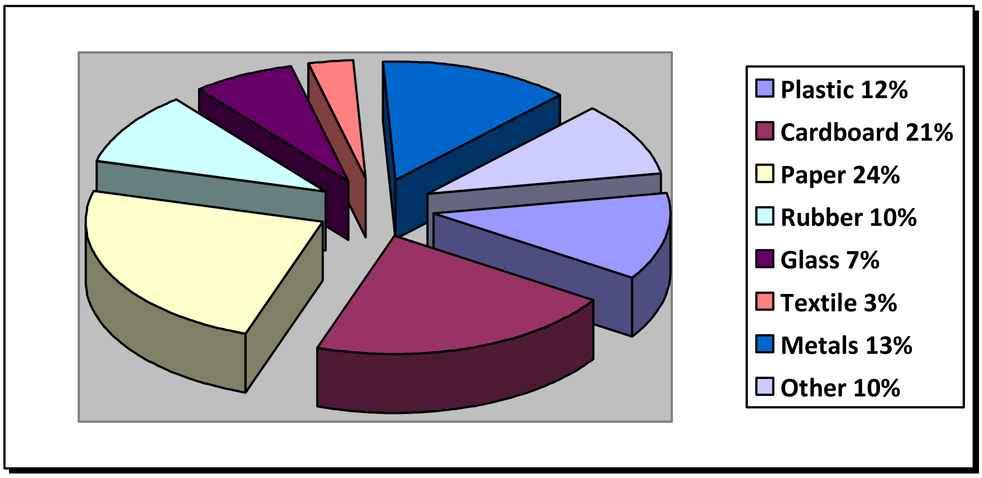

Diagram 1. Extend of recycling for MSW constituents in Iran (22)

3. RESULTS

At present landfill is the most common method for MSW disposal in Iran. The results that reflected in table (5) shows that major portion of MSW in Iran comprised with organic material. Based on data that reflected in table (5), MSW amounts which disposed in landfill sites in first and second scenario are equal to 7.49 million ton per year but in third scenario with assumption rate of 80% MSW portion which disposed in landfill sites would be decreased to 1.71 million ton per year.

According to result that have been shown in table(6) methane emission potential of organic material in comparison to the components of MSW have highest rank (in first scenario L0 is equal to 0.3 but in second and third scenario L0 is equal to 0.5) meanwhile methane emission in textile has lowest rank (in first scenario L0 is equal to 0.06 but in second and third scenario is equal to 0.1)

Emitted methane content in different scenario is presented in table (6). Base on information that aforementioned in this table, methane emission potential related to first, second and third scenario was equal to 1.682, 0.7 and 0.158 million ton per year respectively.

Table 5. Buried MSW content in different scenario (million ton per year)

MSW constituents	Buried MSW content in 1th and 2nd scenario	Buried MSW content in 3th scenario
Organic material	6.724	1.494
Paper and cardboard	0.367	0.133
textiles	0.288	0.059
Wood and garden waste	0.114	0.023
total	7.493	1.709

Table 6. Emitted methane content in different scenario in according to different constituents of MSW in Iran (million ton per year)

MSW constituents	Methane production potential (L_0) in 1th scenario	Methane production potential (L_0) in 2nd and 3th scenario	Emitted methane in 1th scenario	Emitted methane in 2nd scenario	Emitted methane in 3th scenario
Organic material	0.3	0.5	1.61	0.672	0.15
Paper and cardboard	0.14	0.23	0.041	0.016	0.006
textiles	0.06	0.1	0.013	0.005	0.001
Wood and garden waste	0.2	0.33	0.018	0.007	0.001

4. DISCUSSIONS

Diabetes mellitus is a major public health problem and a leading cause of morbidity and mortality worldwide. Its prevalence is on the rise in many areas of the developing world, especially in India, in response to increasing prosperity and sedentary lifestyles. To the best of our knowledge, no similar study has been conducted in Ahmedabad, Western India.

Nonetheless, literature regarding the prevalence of diabetes is available from South and North India (18-21). This study presents observational data from large numbers of subjects with diabetes attending Department of Diabetology, All India Institute of Diabetes and Research, and Yash Diabetes Specialties Centre (Swasthya), Ahmedabad. Based on etiologic classification of diabetes mellitus (Type 1 and Type 2), our study found that Type 2 DM is a major burden in Western India. This complements findings by D. Simon . (22). Achieving optimal glycemic control in diabetic subjects has proven to be a real challenge to healthcare providers. In this study, only 9 percent of the subjects had achieved good glycemic status, which is different from various studies such as a Swedish survey found that 34 percent of Type 2 diabetics had good glycemic control (23). A study by F. Al-Maskari, et al. found that 38 percent of Type 2 DM subjects had good glycemic control (24) and study by J. Al-Kaabi, et al., reported 31 percent of subjects had good glycemic control (17). The reason for the discrepancy may be that this study includes both Type 1 and Type 2 DM patients. Also, the sample was drawn from tertiary care hospital and these subjects may have had diabetes for many years as was evident from complications like renal dysfunction and vision impairment.

The limitations of our study were: i) This is a cross-sectional evaluation of diabetic subjects and we are aware of its limitations, but it does give a clear snapshot of the current situation and may help improve outcomes for subjects and develop a hypothesis that can be tested through analytical studies; ii) Our study population is drawn from hospitals. Nonetheless the area is very wide but of course it is not a population-based study, so we are unable to generalize the results to all of Western India; and iii) We haven't collected data on the duration of diabetes, so we are unable to report the duration of the disease in our subjects.

5. CONCLUSION

This program by the way of presenting specified timetable divided period of plan performance in to several operational phase and determined that purpose of every phase accomplishment is decreasing a portion of released methane. Its clear that methane emission monitoring along with program performance would be project progress and goals achieving indicator of plan. Estimation pattern had been used for methane gas emission in MSW landfill sites could be regarded as a base for methane gas management plan in Iran.

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