Pattern of methane emission from a garbage dump

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Municipalities in rural areas collect garbage from houses and dump it in a low-lying marshy ground. After several years when this ground is completely filled up, garbage dumping is stopped. Then this ground is used for public purposes. With the passage of time, garbage starts decomposing and starts releasing methane. Methane is an important greenhouse gas which is non-toxic, but highly flammable. It is an asphyxiant and can be fatal. Dhapa in Kolkata is a ground where garbage was dumped till 1991. Methane emission measurements from this garbage field were made from May 1995 onwards for a couple of years. The results are presented in this communication. It was found that the methane values from the garbage dump are 3–4 times higher than those from the surrounding paddy field.

Keywords: Atmospheric methane, garbage dump, emission measurements, paddy field.

METHANE is a trace gas in the atmosphere. It is non-toxic, but highly flammable. It has potential health effects. It is an asphyxiant and can displace oxygen in an enclosed space. Methane is also known as one of the important greenhouse gases in the earth's atmosphere. It has about 15–30 times greater infrared absorbing capacity[1,2] compared to CO_2. Thus it has great impact on global warming and climate change. Its concentration in the atmosphere has been increasing at the rate of about 1% per year up to 1999, but has slowed down and approached a steady state[3] at 1.751 ppmbv (parts per million by volume). According to the NOAA website (http://noaa, 2010, http://www.epa.gov/methane/science/html), methane concentration in the atmosphere was at 1.775 ppmbv in 2005 and is still increasing at a rate less than 0.5% per year. If the current rate of increase is maintained, in the next 50 years, it is estimated to contribute an additional 0.5 W m^{-2} in radiative heating[3]. The main sources of methane are natural wetland, marshy land, paddy field, ruminants, termites, biomass, coal, enteric (buffalo, goats), etc. Another important source is the garbage dump. Statistics show that in India about 120,000 metric tonnes of solid waste are generated per day. This garbage is picked up from houses, piled into municipal trucks and then dumped in low-lying, marshy ground. After several years when this ground is completely filled up and the level is also reasonably higher than the surrounding, the authorities allot it for public purposes like commercial complex. But with sunshine and rain, the garbage starts decomposing and starts releasing poisonous gases. These gases are mainly methane, hydrogen sulphide and other sulphurous compounds. If not properly handled, these gases may cause explosion and fire. The Central Government's Municipal Solid Waste Rule (2000) states that there should be no human settlement on a landfill for at least 15 years after its closure. But this rule is hardly followed. At Malad in Mumbai, a dazzling commercial complex has come up overnight on a 19 ha municipal dumping ground, where dumping was stopped in 2002. Within five years there were reports of malfunctioning of various types of equipment as well as stinking smell. Another garbage dump at Gorai in Mumbai was full and shut down in December 2007. The authorities might be considering to open it for public utility. But, before that, proper monitoring of gas emission from this garbage dump is necessary. Dhapa in Kolkata is one such ground where garbage was dumped till 1991. After a couple of years, the Calcutta Municipal Corporation gave about 25 acres to set up the multi-crore Science City. The large Science City Complex was built up on this ground within years. Later, residents of this complex had filed a writ petition before the Green Bench of Calcutta High Court that methane was trapped in the underground subsoil, which if not gotten rid of, might cause accidents and even blow up the Science City Complex. The Green Bench of Calcutta High Court then passed a judgement to monitor the underground methane concentration and assess the potential of its danger to the public. After this judgement, a detailed survey was undertaken by us. Some results of our measurements are presented here. Though these results are quite old, and no untoward incident has happened so far, they may serve as an index of the safe level of methane emission from the garbage dump site before it is allotted for public utility. Also, the data from a garbage dump, which are sparse, may be an additional input for the estimation of methane loading in the atmosphere.

Dhapa is situated on the outskirts of north Kolkata. It is a scantily populated, marshy lowland. The Science City Complex was built on this ground more than a decade ago. Methane emission from below and from the open space surrounding this complex was measured. Static chamber technique was used for the measurement[4,5]. Air samples were collected in 100 ml stainless-steel cylinders with battery-operated oil-free pumps. Observations were taken at 2 h interval from 0800 to 1800 IST for two days in a week. In each set, five samples were collected at an interval of 5 min for 20 min (e.g. 1000, 1005, 1010, 1015 and 1020 h IST). The analysis was completed by the next day using NUCON-5765 gas chromatograph (GC) equipped with FID and a 5A molecular sieve column

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maintained at 120°C. Nitrogen was used as a carrier gas and flushed at a rate of 30 ml/min. Both the injector and the detector were kept at a temperature of 150°C. Calibration was done using 1.94 ppmbv methane standard in air, and 4.4 and 10.9 ppmbv methane standards in nitrogen (procured from M/s Matheson Gas Products, USA). About 100–200 μl of gas was taken from the sample collected in the 100 ml cylinder and injected in GC. From the same cylinder, five samples, each of volume 100–200 μl, were injected successively into GC to get five values of methane concentration. The mean of these five values was taken as the methane concentration of the sample in the given cylinder. For one day there will be six values. The mean of these six values was taken as the concentration of methane for that day. Details of instrumentation and methodology are given elsewhere[4,5].

Measurements were made during different times from 1995 to 1999. This period covers a dry season and a wet season (part of monsoon season when methane emission was expected to be on the higher side).

For spot measurements, vein pipes of 6.5 cm diameter were planted below the complex at several locations. The samples were collected from an enclosed space covering the mouth of these pipes. Typical results of spot measurements, made on 19 September 1996 at three locations, viz. near the office of the complex, in front of the auditorium and below the auditorium are as follows: (1) At an open space (1.5 m above the ground) near the office of the complex: 2.7 ppmbv. (2) At an open space (1.5 m above the ground) in front of the auditorium: 2.0 ppmbv. (3) At the mouth of a vein pipe planted below the auditorium to allow the trapped methane in the subsoil material to escape: (i) 30 cm above the vein pipe (1.5 m above the ground): 5.9 ppmbv, (ii) 30 cm above the vein pipe, but 1.5 m away: 5.2 ppmbv, (iii) 30 cm above the vein pipe, but 3 m away: 3.4 ppm.

Figure 1 shows mixing ratio values measured during a dry season (May–June 1995) at an open space 1.5 m above the ground near the office of the complex. The corresponding ambient values and the range of the lowest and highest values are also shown in the figure. One can see that while the ambient value remains almost constant at 6.3 ppmbv level throughout the day, the vein pipe value, starting from 0915 IST, starts decreasing from the ambient value, becomes steady around 1100 IST, remains so up to about 1500 IST, decreases till sunset and then attains the ambient level during night-time. The average dry season value is ~4 ppmbv. Methane emission value decreased from 4 ppmbv (in May–June 1995) to 2.7 ppmbv (mentioned above for 19 September 1996) during one year. This comparison may not be exact, because May–June is a dry period with higher temperature compared to September, when temperature was lower and the atmosphere was also wetter than May–June period.

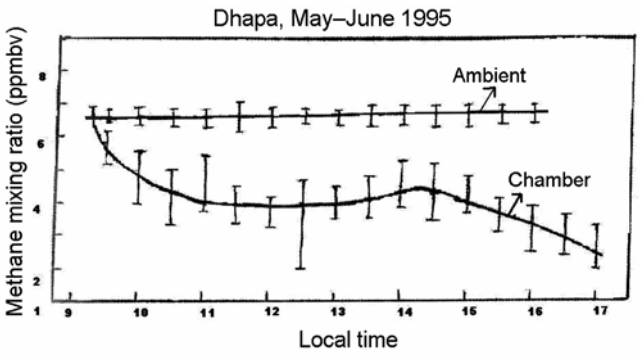

Figure 1. Methane emission values expressed in terms of mixing ratio at different times of the day during a dry season. Corresponding ambient values are also shown.

Now let us consider diurnal variation. The absolute value of emission rate of methane, F, has been calculated using the equation

$$F(\text{mg m}^{-2}\text{ h}^{-1}) = [\{\phi_f \times (V_{stp})_f - \phi_i \times (V_{stp})_i\} \times M \times 60]/(22.4 \times A \times t), \quad (1)$$

where ϕ_f and ϕ_i are the final and initial concentrations (in ppmbv) of samples collected at an interval t (min), $(V_{stp})_f$ and $(V_{stp})_i$ are the final and initial volumes of the chamber at STP, A the area of the base of the chamber (in m^2) and M the molecular weight of methane. As mentioned above, at one time, for the observation period of 20 min, there are five values of methane concentration (e.g. at 1000, 1005, 1010, 1015 and 1020 IST). Substitution of methane values of 1000 and 1005 IST in eq. (1), gives one value of emission rate, F, for the period 1000–1005 IST. For an observation period of 20 min (e.g. from 1000 to 1020 IST) with an interval of 5 min, there would be four values of F. The mean of these four values is taken as the emission rate of methane for that particular time (e.g. from 1000 to 1020 IST). In one day there will be six observations (0800–1800 IST) at an interval of 2 h. The average diurnal variation of methane emission rate calculated in this way for the August 1998 is shown in Figure 2 *a*. The corresponding soil temperature is shown in Figure 2 *b*. One can see from Figure 2 *a* and *b* that the emission rate becomes maximum after the local noon and it follows the variation in soil temperature. For comparison, the emission rate and soil temperature measured at a nearby paddy field (Gabaria) are also shown in Figure 2. It can be seen that the emission rate for Dhapa is ~3 times higher than that of Gabaria, and soil temperature is also higher by ~4°C. Also, the diurnal behaviour of methane emission and soil temperature for the paddy field is identical to that of the garbage dump. A study done by us earlier on methane emission from a paddy field has shown that it depends more on temperature than water content in the soil[5].

Measurements made on different days during the wet period show that the diurnal variation of methane emis-

sion rate was not always monotonic. A typical example is shown in Figure 3, which shows that in addition to the normal process, emission in the form of ebullition also occurs during high emission (wet) period. Similar behaviour has been found in the case of rice crop in the nearby field[5] as well as in other places[6]. Figure 3 also shows the emission rate during the dry period, which is almost negligible. It can be inferred from Figures 2 and 3 that emission rate depends on the soil temperature during the wet period only and not during the dry period.

As mentioned earlier, the average of six values in a day was taken as the methane emission rate for that particular day. Figure 4 *a* shows the values of methane emission rate for waterlogged garbage dump from 20 August 1998 to 10 January 1999. It can be seen from the figure that the rate of methane emission after the monsoon is more than 60 mg m^{-2} h^{-1}; it decreases as the days pass and stabilizes at around 40 mg m^{-2} h^{-1}. For comparison, methane emission rate from the nearby paddy field is also shown in the figure. Measurement of emission from the paddy field started 35 days after transplantation (corresponding to 20 August 1998). It is evident from Figure 4 *a* that methane emission values from the garbage dump are 2–3 times higher than those from the paddy field.

Figure 4 *b* shows the seasonal variation (20 August 1998–10 January 1999) of soil temperature for Dhapa in a waterlogged condition. It appears that the methane emission from the garbage dump follows the soil temperature. The corresponding Gabaria rice field values at a depth of 5 cm are also shown in Figure 4 *b*. The temperature variation at the garbage dump is identical to that in the rice field, and the difference between the two temperatures is 2–4°C.

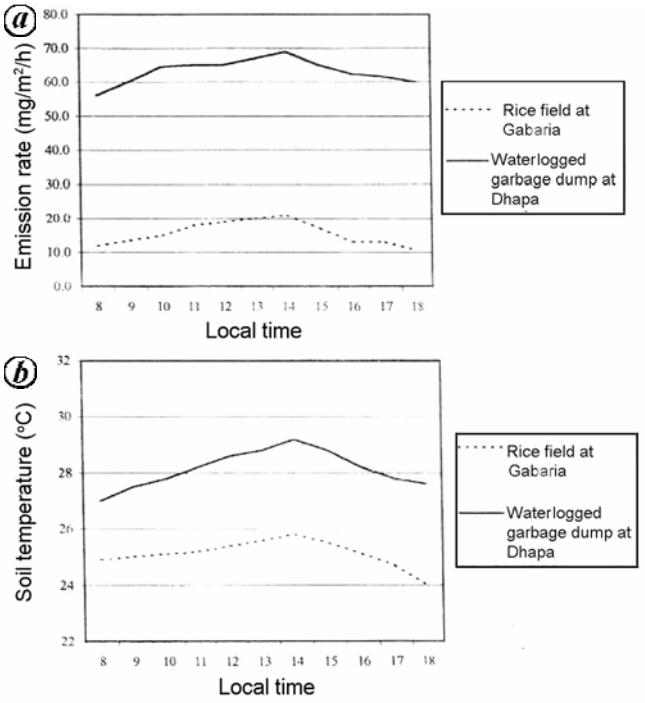

Figure 2. ***a***, Diurnal variation of emission rate for Dhapa and a nearby paddy field, Gabaria, during the wet season. ***b***, The corresponding soil temperature values.

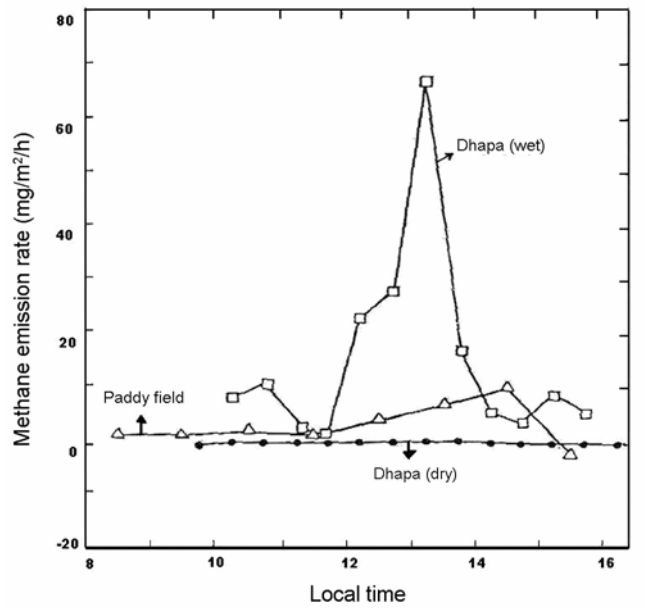

Figure 3. Typical methane emission rates for Dhapa for both dry and wet seasons and for the paddy field.

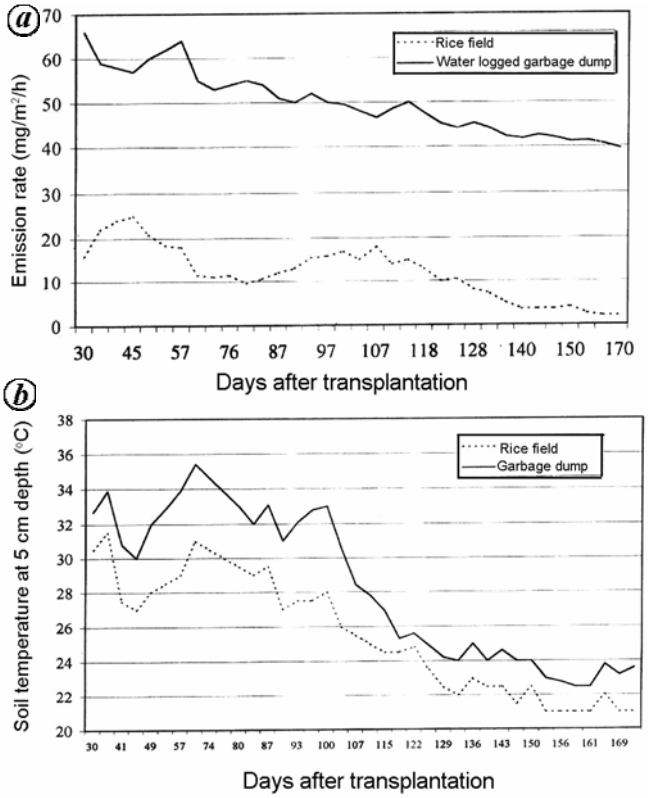

Figure 4. Seasonal variation of emission rate for Dhapa and Gabaria during the wet season. ***b***, The corresponding soil temperature values.

Garbage dumping is usually practised by municipalities in low-lying marshy ground. Methane emission measurements from the garbage field at Dhapa were made from May 1995 onwards for a couple of years. These may serve as safe-level reference values for the authorities to open garbage fills for human settlements in the future. However, the safe limit may be even higher. When structures are built on or near landfills, methane and other gases can penetrate the interior of the buildings and expose the occupants to a significant level of these gases. Methane has potential health effects because it is an asphyxiant. Some buildings have a specially engineered recovery system below the basement to capture these gases and vent them away from the buildings. An example of this type of system is in the Dakin Building in Brisbane and California. In the absence of such a system, vein pipes could be planted below the buildings made on garbage dumps with their outlets in the open area so that methane can dissipate. Another important point which has emerged from this study is that methane emission level from the garbage dump is about 3–4 times higher than that from a paddy field. About 20% of total methane emission in the atmosphere comes from the paddy field. Hence emission from the garbage dump should also be considered as an important source of methane loading in the atmosphere.

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Nitrous oxide emission from tea (*Camellia sinensis* (L.) O. kuntze)-planted soils of North East India and soil parameters associated with the emission

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Dynamics of nitrous oxide (N_2O) emission and the relationship of soil properties with N_2O emission were studied from the tea ecosystem of North East India situated at north bank plain agroclimatic zone at Tezpur, Assam. The gas samples were collected from the tea bush at weekly intervals from 30 August 2008. Our results shows that N_2O fluxes from the tea garden planted with varieties Hilika and TV-23 ranged from 7.51 to 63.30 μg N_2O-N m^{-2} h^{-1}. Seasonal N_2O emission from Hilika and TV-23 was 46.13 and 55.17 mg N_2O-N m^{-2} respectively. N_2O emission showed a relationship with soil moisture, soil temperature and soil NO_3^--N of the experimental field. Soil moisture and soil temperature were found to be the main variables influencing N_2O emission from the tea ecosystem.

Keywords: Nitrous oxide flux, soil moisture, soil temperature, tea ecosystem.

NITROUS OXIDE (N_2O) is an important atmospheric trace gas accounting for approximately 6% of the total greenhouse effect[1]. It is also involved in the destruction of stratospheric ozone[2]. Its concentration in the troposphere is currently increasing at a rate of 2% per year. Soils have been identified to be the dominant source of N_2O, contributing about 57% (9 Tg yr^{-1}) of the total annual global emissions, of which about 27% (2.4 Tg yr^{-1}) originates from agricultural soils[1]. Emissions of N_2O from agricultural soils are due to microbial processes of nitrification and denitrification. Nitrification is a predominant process for production of N_2O in aerobic soils, whereas denitrification is a predominant process under anaerobic conditions[3]. The extent to which these two processes contribute to N_2O emission will vary with climate, soil conditions and soil management. N_2O production, transport and emission in soil depend on environmental factors such as aeration, temperature, moisture, supplies of available organic carbon, fertilization, pH, texture, etc. Temperature and moisture content in humid tropical soils are optimal for biological processes most of the year, resulting in generally large production of gaseous N-oxides. Soil moisture is essential

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