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Methane emission from open drain

N N Purkait[1] & D K Chakrabarty[2,$,*]

[1]SK Mitra Centre for Research in Space Environment, Institute of Radio Physics and Electronics, University of Calcutta, Kolkata 700 009, India

[2]Centre for Environment Survey, Vidya Nagar Society 29/251, Ahmedabad 380 015, India

[$]E-mail: dkchakrabarty@rediffmail.com

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Solid waste that comes along with the wastewater from household gets deposited at the bottom of the drain. With passage of time, this solid waste starts decomposing and starts releasing methane. Methane is an important greenhouse gas, which is non-toxic but highly flammable. It is also an asphyxiant and can be fatal. Every year several people die for this reason while cleaning solid sewage of choked drains. Methane emission measurements from three drains of Kolkata were made during 2009-2010. The results are presented in this communication. It is found that methane emission from drains is ~4-100 times greater than that from paddy field. Data obtained in this work will be a valuable input for making reliable prediction of methane loading in the atmosphere and alert workers of the danger in order to take adequate safety measure before cleaning sewage sediments.

Keywords: Atmospheric methane, Methane emission, Emission measurement

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1 Introduction

Methane is an odorless and colorless gas in its pure form but when it mixes with other gases, the mixture provides an odor. For example, places of high concentration of methane smells like rotten egg. Methane is non-toxic but highly flammable and hazardous. Methane hazards are primarily of poisoning, explosion and asphyxiation. On its own, methane is not poisonous but is poisonous when it mixes with other gases. It is highly explosive; even small spark can cause a big explosion in methane-rich enclosed places like drain or commercial natural gas (CNG) stores. Methane displaces oxygen and cause death by asphyxiation. Air has to have at least 18% oxygen for survival. But in methane mixed air, oxygen level can go down to as low as 5%. It is also called a sewer gas. Sewer gas is a complex mixture of toxic and non-toxic gases produced and collected in sewage system by decomposition of organic household or industrial wastes. Methane is also an important greenhouse gas in the earth's atmosphere whose contribution to the greenhouse effect is ~1.7 Wm^{-2}. It has about 15-30 times greater infrared absorbing capacity[1] compared to CO_2 and about 20 times the global warming potential of CO_2 although CO_2 is far more abundant in the atmosphere[2]. Due to human activities, its concentration has been increasing at the rate of ~1% per year but has been decreasing for the past two decades and reached near zero around 2006 (Ref. 3). After being stable for almost a decade before 2006, it began increasing again and its increase is continuing[4-6]. If the current rate of increase is maintained, it is estimated to contribute an additional 0.5 Wm^{-2} in radiative heating in the next 50 years[7]. According to a new assessment report[7] by the Intergovernmental Panel on Climate Change (IPCC), "warming of the earth's climate is unequivocal and since 1950s many of the observed changes are unprecedented over decades to millennial and it is extremely likely that human influence has been the dominant cause of the observed warming since the mid 20th century". Methane emission control is an effective way of simultaneously meeting air quality standards and abating global warming[8]. Hence, there is global concern and steps are being taken by all the countries to reduce its emission in the atmosphere from all sources. Methane emission in the atmosphere comes from paddy field, natural wetlands, marshy lands, ruminants, termites, biomass burning, coal, enteric (cattle, sheep), garbage dumps, drains, etc. There are thousands of kilometer long open drains in villages and towns. In megacities, there are, also, drains as big as canals from which foul smell comes 24 hours due to methane emission. Drains often get choked due to solid waste which has to be cleaned manually. Many times municipality workers go inside the closed drains without safety precaution and get asphyxiated and die. To our knowledge, till date, no study has reported the values of methane emission from drains. In their earlier works[9-11], the authors have reported results of methane emission measurements from paddy field and garbage dump (landfill). During 2009-10, methane emission is measured from three different types of drain in Kolkata. The results of these measurements are presented in this paper.

2 Measurement technique and Methodology

Air samples were collected in 100 ml stainless steel cylinders with battery operated oil free pumps by opening their mouths over the drain. Cylinders were properly cleaned and dried before use. The analysis of the sample was completed by the next day using NUCON 5765 Gas Chromatograph (GC) equipped with Flame Ionization Detector (FID) and 5Å molecular sieve column maintained at 120°C. Nitrogen was used as a carrier gas and flushed at a rate of 30 ml per min. Both the injector and detector were kept at 150°C. A standard source of methane concentration having two parts per million by volume (ppmv) in nitrogen, procured from M/s Chemtron Scientific Laboratory, Mumbai, was compared with the concentration of methane in the collected samples. Calibration was done using 1.94 ppmv methane standard in air and 4.4 ppmv and 10.9 ppmv methane standards in nitrogen obtained from M/s Mathesons 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.

3 Results and Discussion

Figure 1 shows the results from an open drain situated at Baguihati in the north of Kolkata. The drain receives solid waste materials and wastewater from the surrounding densely populated area. The air samples were collected from about 2 cm above the drain during a week in November 2009. The average of five days values measured from 0900 to 1900 hrs LT is shown in Fig. 1. It is seen in this figure that methane emission starts increasing from morning hours (6.3 ppmv at 0900 hrs LT) becomes maximum around noon time (14.3 ppmv at 1300 hrs LT) and then decreases in the afternoon hours. At 1700 hrs LT, its value is 2.35 ppmv. It again shoots up and becomes 63.98 ppmv at 1900 hrs LT. During morning hours, the water level of the drain is ~ 30 cm and the increasing trend of methane emission during morning hours is due to the effect of increase in temperature on sediments. This emitted methane is partly absorbed by the superincumbent waste water and the rest goes in the open air. In the afternoon hours, the water level decreases significantly due to the reduction in household activities. At this time, the drain sediments start getting exposed to the open air and foul smell starts coming. Also due to the decrease in temperature during afternoon hours, production as well as emission to the atmosphere decreases. At 1900 hrs LT, when the sediment is fully exposed to the open air, the generated methane escapes to the atmosphere in the form of ebullition showing very high value (~64 ppmv).

Figure 2 shows results of another open drain called Adiganga situated in the south of Kolkata. Adiganga is a tributary of the river Ganges but due to the accumulation of the sediments, the tributary has become a big drain like a narrow canal. During high tide, water enters in this drain from the Ganges and its level reaches ~100 cm but during low tide when water recedes, only a narrow stream remains in the middle of the drain exposing its sides to the atmosphere. The clayey sediment is full of decomposed organic matter and emits methane. The air samples were collected from about 2 cm above the drain during a week in November 2009 and the average values of five days are shown in Fig. 2. It can be seen from this figure

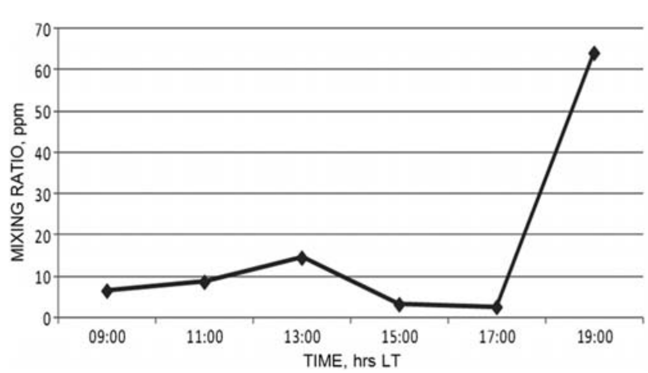

Fig. 1 — Methane emission values expressed in terms of mixing ratio at different times of the day for Baguihati drain

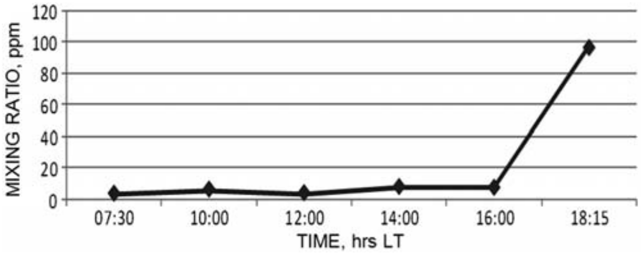

Fig. 2 — Methane emission values expressed in terms of mixing ratio at different times of the day for Adiganga drain

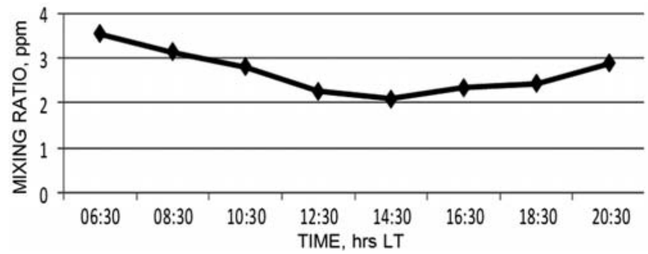

Fig. 3 — Diurnal variation of methane emission values expressed in terms of mixing ratio for a paddy field

that methane concentration in the morning is low (3.14 ppmv at 0730 hrs LT), increases to a value of 5.79 ppmv at 1000 hrs LT, then decreases to 3.49 ppmv at 1200 hrs LT, again increases to 7.43 ppmv at 1400 hrs LT and then decreases to 6.94 ppmv at 1600 hrs LT. In the evening again, it shoots up and reaches 96.45 ppmv at 1815 hrs LT, when methane emission is from ebullition. Decrease after 1000 hrs LT and low value at 1200 hrs LT is due to the occurrence of high tide at that time. During other time of the day, when there is enough current in the drain water, the variation of methane concentration is due to the muddling in the drain water.

A third sample was collected from the mouth of a closed drain in Garia. In front of the mouth, there is collection of stagnated water round the year. The sediment of the drain is degradable solid waste. Measurements were made at 1200 hrs LT during a week in December 2009. The average value of the samples of five days was found to be 297± 6 ppmv.

For the sake of comparison of methane values emitted from drain with those from paddy field, samples were collected during February 2010 from a paddy field in a village Madhavpur. Madhavpur is situated about 100 km from Kolkata. At this time of the year, paddy plants were fully grown and submerged in water. The results are shown in Fig. 3. It can be seen from this figure that methane concentration is low during noon time and high during forenoon and afternoon hours. The noon time value of methane from the paddy field is 2.10 ppmv compared to 297 ppmv of Garia drain, 7.43 ppmv of Adiganga drain and 14.30 ppmv of Baguihati drain. The evening time methane value of the paddy field is 2.45 ppmv as compared to 96.45 ppmv of Adiganga drain and 63.98 ppmv of Baguihati drain. It is to be noted that in paddy field methane emission is low during noon time whereas in drain methane emission is high during noon time. This difference is due to the different mechanism of methane production from drain and paddy field.

All the present measurements are for daytime condition. It may be of interest to know how daytime methane emission compares with the nighttime values. Some measurements (not shown here) were done at night and methane concentration is found to be low compared to day time. This is explainable because methane production is dependent very much on temperature which is low during nighttime. But methane concentration is also dependent on photolysis of O_3 and concentration of H_2O, which is clear from the following reactions:

$$O_3 + h\nu \rightarrow O^1D + O_2$$

$$O^1D + H_2O \rightarrow OH + OH$$

$$OH + CH_4 \rightarrow H_2O + CH_3$$

At night there is no photolysis, as a result [OH] is low and hence, the loss rate of CH_4 is low during nighttime. This may lead to build up of CH_4 at night.

Wind is another parameter, which may affect the methane concentration. The direction from which wind comes, methane concentration in that side is found to be low. And the direction in which wind goes, methane concentration is found high in that side. But since the present measurements are very close to the source, the effect of wind is not very significant.

4 Conclusion

Methane is one of the major gases emitted from drains. Drains are regularly cleaned by municipal workers when they are choked by sediments. In doing so, many times workers die because methane is an asphyxiant. Methane emission measurements from three types of drains were made during 2009-2010. These may serve as a safe level alert for workers who are employed for cleaning drains. However, the safe limit may vary depending on the magnitude of methane in the drain. It is, therefore, advisiable to carry portable, hand-held gas monitor and measure the methane concentration of the drain before undertaking its cleaning operation. Another important point which has emerged from this study is that methane emission level from drain is about 4-100 times higher than that from the paddy field. About 20% of total methane emission in the atmosphere comes from the paddy field. Hence, emission from drains should also be considered as an important source of methane loading in the atmosphere.

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