

[Research]

## Methane in Kano-Nigeria atmosphere

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### ABSTRACT

Methane concentrations in Kano municipality have been attributed to the burning of solid and fossil fuels and industrial processes. Using an automatic gas sampling system, methane in the Kano atmosphere was determined. Its distribution in the municipality was skewed towards high frequency of low concentration with a mean and standard deviation of  $0.61 \pm 0.39 \mu\text{g}/\text{m}^3$ . Similarly the distribution in Sabon gari, Bata, Nassarawa and Hotoro were  $0.41 \pm 0.28$ ;  $0.58 \pm 0.29$ ;  $0.46 \pm 0.31$  and  $0.71 \pm 0.49 \mu\text{g}/\text{m}^3$  respectively while BUK, City Brigade, Kurna-Asabe and other residential areas were ( $0.54 \pm 0.45$ ,  $0.74 \pm 0.46$ ;  $0.61 \pm 0.34$ ;  $0.78 \pm 0.40 \mu\text{g}/\text{m}^3$ ) respectively. The industrial areas did not show significant variations from each other as in the residential areas.

**Keywords:** Concentration, Kano atmospheres, Methane.

### INTRODUCTION

Methane is a greenhouse gas that remains in the atmosphere for a considerable length of time (EPA, 1986; EPA, 2005). Methane is more effective in trapping heat in the atmosphere than carbon dioxide and is emitted from a variety of natural and human influenced sources such as landfills, natural gas and petroleum systems, agricultural activities, coal mining stationary and mobile combustion, waste water treatment and certain industrial processes. It is a primary constituent of natural gas and an important energy source (Elsom, 1987; McDonald, 1975; Hall, 1977; Neue and Sass, 1998; Sass *et al.*, 1999; Wang and Shangguan, 1996; Ding and Wang, 1996; Fung *et al.*, 1991; Hein *et al.*, 1997; Cao *et al.*, 1998).

Methane's chemical characteristics and interactions in the atmosphere contribute to its significance as a greenhouse gas. Methane ( $\text{CH}_4$ ) is a principal component of natural gas. It is formed and released to the atmosphere by biological processes occurring in anaerobic environments. Once in the atmosphere, methane absorbs terrestrial infrared radiation that would otherwise

escape to space. This property can contribute to the warming of the atmosphere, which is why methane is a greenhouse gas (Houghton *et al.*, 1992).

Methane's chemical lifetime in the atmosphere is approximately 12 years. Methane's relatively short atmospheric lifetime, coupled with its potency as a greenhouse gas, makes it a candidate for mitigating global warming. Once emitted, methane is removed from the atmosphere by a variety of processes. The balance between its emissions and removal processes ultimately determines its atmospheric concentrations, and how long methane emissions remain in the atmosphere. The dominant sink is oxidation by chemical reaction with hydroxyl radicals (OH). Methane reacts with OH to produce  $\text{CH}_3$  and water in the tropospheric layer of the atmosphere. Stratospheric oxidation plays a minor role in removing methane from the atmosphere. Similar to tropospheric oxidation, minor amounts of methane are destroyed by reacting with OH in the stratosphere. These two OH reactions account for 90% of methane removals. In addition to methane

reaction with OH, there are two other known sinks: microbial uptake of methane in soils and methane's reaction with chlorine (Cl) atoms in the marine boundary layer. It is estimated that these sinks contribute 7% and less than 2% of total methane removal, respectively.

Natural background levels of methane in the atmosphere range from 784 to 980  $\mu\text{g}/\text{m}^3$  (1.2 to 1.5 ppm) on a worldwide basis (National Air Pollution Control Administration (NAPCA), 1970). Methane is the only hydrocarbon found naturally with a background concentration in the atmosphere of 1.3 to 1.4 ppm (Ehhalt and Schmidt, 1978; Heidt and Ehhalt, 1980; Graedel and McRae, 1980; Rasmussen and Khalil, 1981, 1983; Blake *et al.*, 1982). Other hydrocarbons in air are derived from a variety of sources, such as oil and petroleum refineries and storage depots (Leggett *et al.*, 1972). Methane is the principal component of natural gas, which does not contain sufficient evidence in itself from which to deduce its origin on earth. It is found in locations where biogenic origin is improbable or where biological deposits seem inadequate; in ocean rifts in the absence of any substantial sediment, in fissures, in

igneous and metamorphic rock, even at greater depth; in active volcanic region, even where there are massive amounts of methane hydrate in permafrost and ocean deposits, where it is doubtful that an adequate quantity and distribution of biological source material is present (Thomas, 1993; Petit *et al.*, 1999; Brook *et al.*, 2000).

Many workers have employed different methods to determine the concentration of methane in air. Burgett and Green (1976) utilized an automatic gas chromatographic system in measuring CO, CH<sub>4</sub> and non-methane hydrocarbons in a sample. Cooper *et al.*, (1974) determined methane in air by separating it from other hydrocarbons using a cryogenic trap. This paper reports level of methane in different parts of Kano Municipal environment using automatic gas sensors.

## MATERIALS AND METHODS

Samples of methane were measured from different locations in the municipality shown in Fig 1. A total of four hundred and fifty samples were taken between October, 2004 and March 2005 on a continuous basis through the sampling period. The sampling sites are as shown in Fig 1.

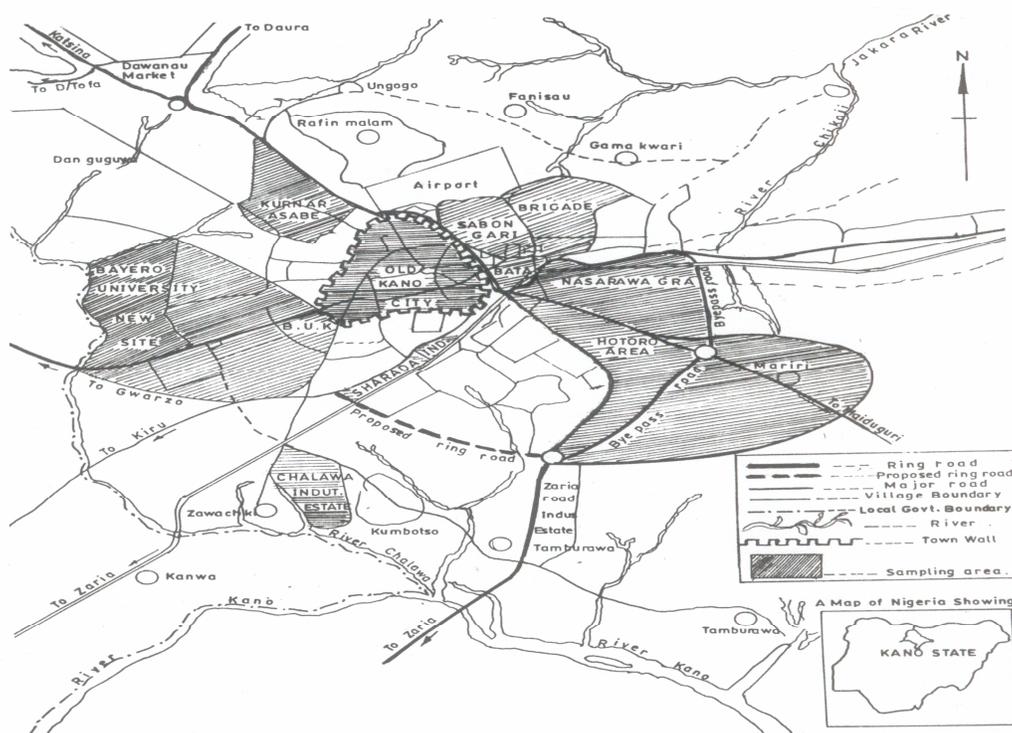


Fig 1. Kano metropolis showing the locations of sampling area.

## Instrumentation

The Crowcon - Gasman "FL" and "TO" Detection Instruments were used (Fig2).

The Gasman "FL" is designed to monitor for the presence of flammable gases, and is certified to ex ia IIC T3/T4 while the Gasman "TO" is designed to monitor for the presence of specific toxic gases, and is certified to EEx ia IIC T3/ T4. Temperature classification T3 applies if the unit is fitted with the Crowcon rechargeable battery pack, with the T4 applies if the unit is fitted with disposable batteries. To adjust the span of the "TO" and "FL" versions gas of known concentration and reliable delivery systems to the sensor are required. The calibration gas test kits, comprising gas mixtures, either in disposable cylinders, regulator, and tube and calibration adaptors were used. The calibration adaptor was fitted into the top of the sensor housing and the gas cylinder valve was opened. The gas flow rate was set to sensor 0.5l/min and the reading on the display was allowed to stabilize. The CAL preset was adjusted so that the display indicated the concentration shown on the cylinder.

With the unit now placed in normal air, the switch was turned to the GAS position. The green LED and the sounder (if factory set) operated once a second. The LCD display showed 000 for "TO" and "FL" versions. If not removed the black cover below the display was adjusted to ZERO preset until the display was 000. (for "TO" or "FL" versions). It was ensured that the cover was placed after adjustments were made.

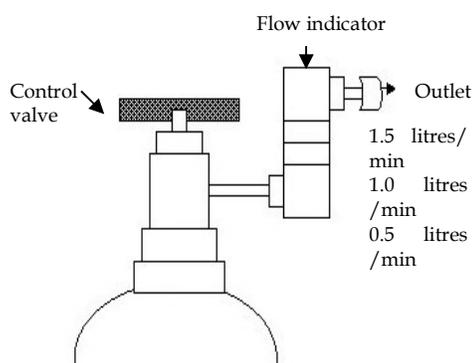


Fig 2. Schematic Diagram of the Automatic Sampler.

## RESULTS AND DISCUSSION

The means, standard deviations and coefficient of variation for methane gas is as shown in Table 1. The frequency distribution

pattern for methane concentration in the Municipality is as shown in Fig 3a.

The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.61 \pm 0.39 \mu\text{g}/\text{m}^3$ . This observed pattern may be as a result of decaying vegetation as well as from industrial and domestic sources (Alan, 1988). The frequency distribution pattern for  $\text{CH}_4$  concentration at Sabon Gari is as shown in Fig 3b. The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.41 \pm 0.28 \mu\text{g}/\text{m}^3$ . This pattern may be due to burning of coal and natural gas (Morrison and Boyd, 2001). The frequency distribution pattern for  $\text{CH}_4$  concentration at Bata is as shown in Fig 3c. The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.58 \pm 0.29 \mu\text{g}/\text{m}^3$ . This observed concentration may be due to transportation, incomplete combustion from stationary sources and car engines (Howard *et al.*, 1985). The frequency distribution pattern for  $\text{CH}_4$  concentration at Nassarawa is as shown in Fig 3d. The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.46 \pm 0.31 \mu\text{g}/\text{m}^3$ .

This may be due to incomplete combustion from stationary sources and car engines. The frequency distribution pattern for  $\text{CH}_4$  concentration at Hotoro is as shown in Fig 3e. The distribution is bimodal and is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.71 \pm 0.49 \mu\text{g}/\text{m}^3$ . This observed deviation is due to the presence of a petroleum depot in the vicinity.

The frequency distribution pattern for  $\text{CH}_4$  concentration at Kurna Asabe is as shown in Fig 3f. The distribution is skewed toward high frequency of low concentration with a mean and standard deviation of  $0.78 \pm 0.40 \mu\text{g}/\text{m}^3$ . This distribution pattern may be due to the anaerobic decay of plants and the burning of coal. The frequency distribution pattern for  $\text{CH}_4$  concentration at Sharada is as shown in Fig 3g. The distribution is skewed toward high frequency of low concentration with a mean and standard deviation of  $0.64 \pm 0.34 \mu\text{g}/\text{m}^3$ . This distribution pattern may be due to burning of coal, and incomplete combustion from car engines and stationary sources.

The frequency distribution pattern for CH<sub>4</sub> concentration in the City is as shown in Fig 3h. The distribution is skewed toward high frequency of low concentration with a mean and standard deviation of  $0.74 \pm 0.46 \mu\text{g}/\text{m}^3$ . This observed pattern may be due to anaerobic decay of plants and burning of coal. The frequency distribution pattern for CH<sub>4</sub> concentration at Challawa is as shown in Fig 3i. The distribution is skewed toward low frequency of high concentration with a mean and standard deviation of  $0.64 \pm 0.32 \mu\text{g}/\text{m}^3$ . This observed concentration pattern may be attributed to the burning of coal, and incomplete combustion from stationary sources, and car engines.

The frequency distribution pattern for CH<sub>4</sub> concentration at Brigade is as shown in Fig 3j. The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.61 \pm 0.34 \mu\text{g}/\text{m}^3$ . The observed distribution pattern may be attributed to the anaerobic decay of plants and burning of coal.

The frequency distribution pattern for CH<sub>4</sub> concentration at BUK is as shown in Fig 3k. The distribution is skewed towards high frequency of low concentration with a mean and standard deviation of  $0.54 \pm 0.45 \mu\text{g}/\text{m}^3$ . This observed distribution pattern may be due to incomplete combustion from car engines, and stationary sources.

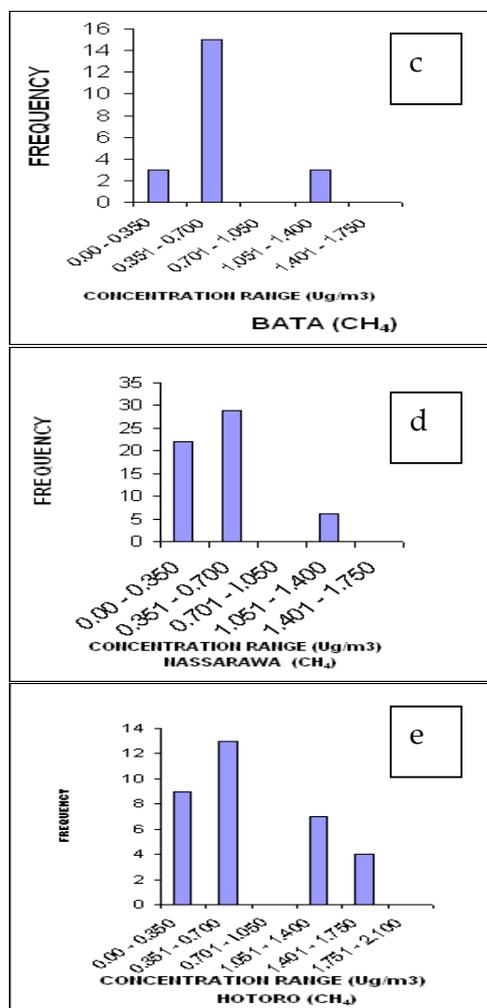
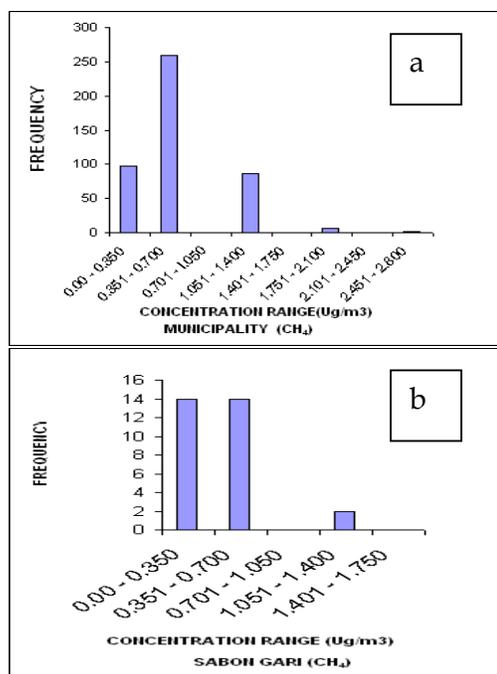


Fig 3. Frequency Distribution Pattern for Methane gas (a)Municipality, (b) Sabon-gari, (c)Bata, (d)Nassarawa (e) Hotoro.

Table 1. Methane Concentration ( $\mu\text{g}/\text{m}^3$ ) in Kano Municipality, Nigeria

LOCATION	x	S	CV%
Municipality	0.61	0.39	63.7
Sabon - Gari	0.41	0.28	67.5
Bata	0.58	0.29	50.7
Nassarawa	0.46	0.31	66.4
Hotoro	0.71	0.49	69.2
Kurna Asabe	0.78	0.40	51.6
Sharada	0.64	0.34	53.0
City	0.74	0.46	62.0
Challawa	0.64	0.32	50.0
Brigade	0.61	0.34	56.2
BUK	0.54	0.45	83.3

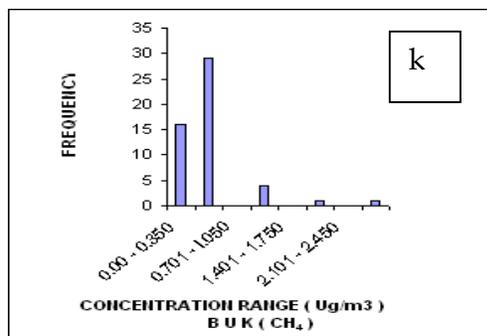
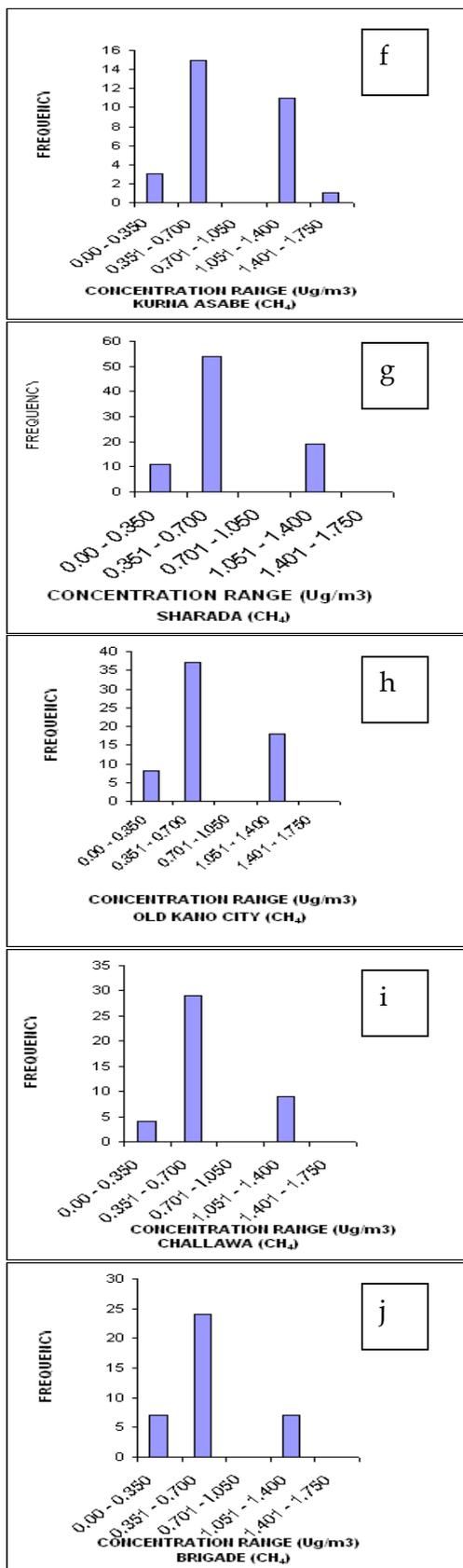


Fig 3. Frequency Distribution Pattern for Methane gas (f) Kurna Asabe (g) Sharada (h) City (i) Challawa (j) Brigade (k) BUK

We cannot escape air pollution, not even in our own home since toxic chemicals are found in the air of every home are at times more likely to cause some type of cancer than outdoor air pollutants (EPA, 1985; Miller, 1990). The pollutant methane gas is dispersed throughout the metropolis' atmosphere in a concentration not high enough to cause serious health problems, (Miller, 1990). Information on the spatial distribution of this pollutant may be useful for the improvement of environmental quality, for example, planning reduction of industrial pollution emission, direction for future development of industry, reduction of pollution in urban area and creation of pollution free zone (Ayodele and Ahmed, 2001). The high concentration of methane at Sharada and Challawa were high because of the several industrial processes like tannery, glue and fur-dressing, pulp-paper industries, water plants and chemicals. These and other activities make the area prone to pollution. Methane concentration is high at Kurna Asabe and Sabon Gari, and these may be attributed to the decay of organic matter in gutters, heaps of refuse, sewers, plants and animal waste by microbial activities (Ayodele and Bernard, 2006).

Methane concentration was high at Sharada, Challawa and Bata and this may be attributed to combustion in stationary sources (Howard *et al.*, 1985). It was observed during sampling that almost every industry, factory as well as business centres had to provide an alternative source of power supply from private power generators with several of them smoking profusely showing signs of inadequate maintenance and source of pollution. Nassarawa and BUK areas recorded low concentration of pollutants.

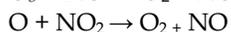
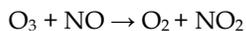
This may be attributed to the cleanliness of the areas characterized by good drainage systems, and low traffic flow. The result of this study indicated that the concentrations of these pollutants do not pose threat to the environment of the metropolis. However, the pollutants were high in Challawa as well as Sharada industrial areas, which if not checked can pose a serious threat to lives and properties in the nearest future. It is necessary to ascertain the concentration of pollutants in the atmosphere so that policies on safety regulations could be made to checkmate further pollution activities and treatments that can improve the air quality can be proposed for implementation. Further studies in the field are carried out on the concentration of these pollutants in indoor of premises in the metropolis to give a better understanding of the source and concentration of methane.

Methane varies in a pattern that suggest it is being driven by an external factor viz the pattern of warming and cooling triggered by the earths orbital variations and amplified by the changes in the bio geo-chemical cycling of the gas.

Methane is produced by many natural processes and increased animal populations on the worlds farms are one source, but it also comes from the decay of vegetation, from the release of gas as frozen arctic soils thaw and from leaks in gas pipelines (Houghton *et al.*, 1990 Houghton, 1991).

Thus the gas being produced in increasing quantity as the human population of the world increases and makes ever-greater use of farm animals, motorcars and natural gas (Fung *et al.*, 1991; Houghton *et al.*, 1992; Hein *et al.*, 1997; Lelieveld *et al.*, 1998; Mosier *et al.*, 1998; Olivier *et al.*, 1999) As is well known, ozone is a molecular form of oxygen compound of three atoms created by fusing energy of sunlight.

These ozone molecules are in turn destroyed by the catalytic activities of some minute gas (Warr, 1991) These gases can in turn 'steal' an oxygen atom to destroy ozone in what may be described as atomic quadruple. One such gas is nitric oxide (NO); its reaction with ozone



Methane does a similar job as follows (Logan *et al.*, 1981).

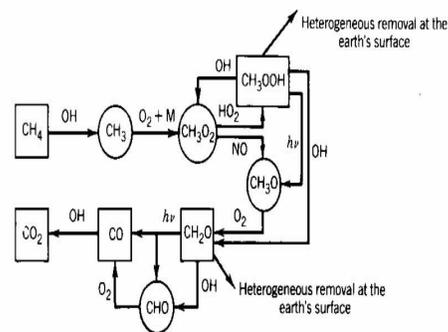


Fig 4: The atmospheric oxidation of Methane (Logan *et al.*, 1981).

Thus methane plays a part in an ozone destroyer and these, two are on the increase (Ehhalt and Schmidt, 1978; Logan *et al.*, 1981; Crutzen and Schmailzl, 1983; Ehhalt, 1998; Ehhalt, 1999) Methane is emitted from a variety of both human-related (anthropogenic) and natural sources. Human-related activities include fossil fuel production, animal husbandry (enteric fermentation in livestock and manure management), rice cultivation, biomass burning, and waste management (Fung *et al.*, 1991; Hein *et al.*, 1997; Lelieveld *et al.*, 1998; Houweling *et al.*, 1999; Moisie *et al.*, 1998; Olivier *et al.*, 1999). These activities release significant quantities of methane to the atmosphere. It is estimated that 60% of global methane emissions are related to human-related activities (Intergovernmental panel on Climate Change (IPCC), 2001).

Natural sources of methane include wetlands, gas hydrates, permafrost, termites, oceans, freshwater bodies, non-wetland soils, and other sources such as wildfires. Methane emission levels from a source can vary significantly from one country or region to another, depending on many factors such as climate, industrial and agricultural production characteristics, energy types and usage, and waste management practices. For example, temperature and moisture have a significant effect on the anaerobic digestion process, which is one of the key biological processes that cause methane emissions in both human-related and natural sources. Also, the implementation of technologies to capture and utilize methane from sources such as landfills, coal mines, and manure management systems affects the emission levels from these sources. The principal human-related sources of methane are:

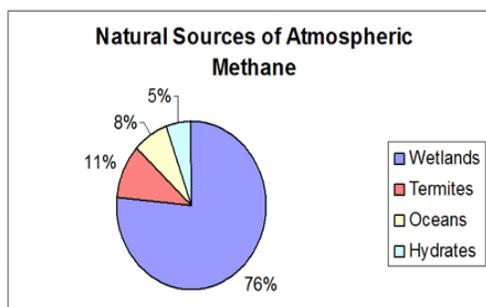


Fig5: Natural Sources of Atmospheric Methane (IPCC,2001).

Methane is the single naturally produced organic present in the largest concentration in ambient air through out the world (Finlayson-Pitts and Pitts, 1986). It is produced by anaerobic bacterial fermentation processes in water which contains substantial organic matter (Ehhalt and Schmidt, 1978), such as swamps, marshes, rice fields and lakes (Finlayson-Pitts and Pitts, 1986).

In addition it is produced by enteric fermentation in mammals as well as by other species. Smaller amounts are emitted into the air via seepage of natural gas from the earth. Forest fires some of which are due to natural causes, also produce some methane.

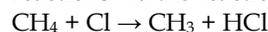
The major sources appear to be enteric fermentation in cattle and an anaerobic process in rice fields, wetlands, and termites (Zimmerman *et al.*, 1982; Rasmussen and Khalil, 1983).

The recent increase in atmospheric methane concentrations is not clear but one obvious potential explanation is an increase in emissions from one or more sources. As the human population increases, the number of cattle and the amount of land devoted to rice fields are also increasing, and hence more CH<sub>4</sub> is produced from these sources. Hence the rise is caused by human activities.

An increase in atmospheric CH<sub>4</sub> could be due to a decrease in its sinks, rather than an increase in its sources. The major atmospheric sinks are in the reaction of CH<sub>4</sub> + OH → CH<sub>3</sub> + H<sub>2</sub>O.

A decrease in the rate of removal of CH<sub>4</sub> by the reaction leads to an increase in the atmospheric CH<sub>4</sub> concentrations if the OH concentration were decreasing. One of the major species controlling the OH concentration in remote areas is CO, since it reacts with OH as well (Chameides *et al.*, 1977).

Increase in CH<sub>4</sub> could have effects both on atmospheric chemistry and on the earth's radiation balance since it plays some roles in global tropospheric chemistry. Additionally, it affects the radiation balance of the earth (Logan *et al.*, 1981) as it absorbs infrared radiation and converts it to heat. Therefore increased CH<sub>4</sub> should thus lead to increased surface temperatures (Wang *et al.*, 1976; Marland and Rotty, 1985; Ramanathan *et al.*, 1985). CH<sub>4</sub> also diffuses upward to the stratosphere, where it can react with OH (Ehhalt and Schmidt, 1987; Crutzen and Schmailzl, 1998; Wang *et al.*, 1998). An additional role of CH<sub>4</sub> in stratospheric chemistry is as a terminator for chlorine atom reactions via the reaction



while HCl remaining in the stratosphere eventually reforms Cl, some of the HCl reaches the troposphere and is rained out thus removing Cl from the stratosphere (Herman and McQuillan, 1985).

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