METHANE EMISSIONS FROM RICE FIELD AND PEAT SOIL AND CONTRIBUTION OF INDONESIA TO GLOBAL WARMING

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SOURCES OF METHANE

Rice fields are considered to be among the highest sources of atmospheric methane, an important source of global warming. In order to meet the projected rice needs of the increasing world population, it is estimated that the annual world's rough rice production must increase to 760 million tons (a 65% increase) in the next 30 years. This will increase methane emissions from rice fields if current technologies are kept (Minami and Neue, 1993).

Indonesia, a country of which rice is one of its staple foods, produces 43.2 M tons of rice per year (Indonesia's Central Bureau of Statistics, 1992). It is produced from wetland paddy of 9.2 M ha and 1.2 M ha dry land paddy.

Total global and individual source emission estimates for methane remain essentially as presented in the IPCC First Assessment Report (1990), but with some individual changes. There has been a re-evaluation of some sources, particularly rice, and the additional sources such as animal and domestic wastes. A large portion of these emission comes from liquid waste handling systems. Uncertainties in global and regional emissions remain significant. A detailed analysis of new information on rice suggests annual emissions in the lower end of the 20 - 150 Tg/year range (Heinloth and Karimanzira, 1993).

Different numbers of amount of methane emission could be met due to uncertainties and variation of measurement methods. According to Jarvis and Pain (1992), there are major problems in obtaining reliable, reproducible measurements of the rates and extent of processes responsible for emission of CH_4 and N_2O gases. This is, firstly, because of the difficulty in measuring the relatively small change in background atmospheric concentrations of gases that result from fluxes from agriculture; secondly, because of the major spatial and temporal variability that exists; and, thirdly, because of interactive effects between the various components of the soil-plant-animal-atmosphere continuum.

Level of CH_4 produced as a result of human activities are three to four times greater than those from natural sources. Of these, current estimates of the amounts of CH_4 released from rice paddies are the greatest and are still being revised upwards as more Chinese information becomes available (Wellburn, 1994).

One of the sources of atmospheric methane is wetlands. Thurman (1990)

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divides two types of wetlands, i.e. salt marshes and mangrove swamps. Both are intermittently submerged by ocean water and are characterised by oxygen-poor mud and peat deposits. Marshes, characteristically inhabited by a variety of grasses are known to occur from the equator to latitudes as high as 65°. Mangrove trees are restricted to latitude below 30°.

Table 1. Estimates of global turnover of CH_4, adapted from various sources (Wellburn, 1994)

Natural SOURCES	Mta^{-1}	Homogenic Sources	Mta^{-1}
Wetlands	120 - 200	Landfill	30 - 70
Termites	5 - 150	Biomass burning	30 - 100
Oceans	7 - 13	Rice paddies	70 - 170
Ruminants (wild)	2 - 6	Ruminants (domestic)	70 - 80
Lakes	2 - 6	GasVenting, Pipeline leaks and flaring	25 - 50
Tundra	1 - 5	Coal mining	10 - 35
Others, e.g. volcanoes	0 - 80	Sewage operations	5 - 70
SINKS			
Tropospheric •OH oxidations	375 - 475		
Stratospheric Decomposition	35 - 50		
Soil absorption	10 - 30		

Indonesia is the fourth largest country with peat deposits after Canada, Russia, and USA. Distribution of world's peat is depicted in the Table 2.

Considering Table 1 and 2 depicted above and area of Indonesia's wetland paddy and peat deposits, Indonesia's land could be a significant contributor of methane emission.

Table 2. Areas of peat deposits in the world (Olenin, 1988 *in* Sri Hastuti, 1995)

Country	Area (M ha)
Canada	170
Russia	150
USA (Alaska)	30
Indonesia	26
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Netherlands	0.25
Belgium	0.018
...	...

METHANOGENESIS IN SOIL AND METHANE EMISSIONS FROM RICE PADDIES

Anaerobic fermentation produces an array of organic substances, many of them are not found in well aerated soils. Various hydrocarbon, alcohols, carbonyls, volatile fatty acids, non volatile fatty acids, phenolic acids and volatile S compounds are found in flooded soils. The main gaseous end products are H_2, H_2S, N_2, CH_4, and CO_2. The last three gases usually comprise the largest portion of the gas phase in flooded soils (Minami and Neue, 1993).

Most emission of CH_4 arise from methanogenic bacteria in anaerobic environment but a small proportions is from abiogenic origin from deeper inside the Earth's crust. All methanogens require very low level of O_2 to form CH_4 but they grow well over a wide range of temperature and pH levels (Wellburn, 1994).

The mechanism in all, however, is very similar. The substrate (e.g. CO_2) binds to a five-membered carbon ring structure (a furan) and is then progressively reduced through formyl (HCO-), methenyl (CH=), methylene (CH_2), and methyl (CH_3) stages, finally releasing CH_4 (Wellburn, 1994).

According to Minami and Neue (1993), there are five processes (diffusion, oxidation, mass flow into ground water, ebullition, and plant mediated transport) governing the release of CH_4 produced in the soil to the atmosphere.

METHANE AS A GREENHOUSE GAS AND THE GLOBAL WARMING

Methane plays an important role in the photochemical of the troposphere and the stratosphere and a change in its concentration exerts a strong influence on the atmospheric chemistry (Thompson and Cicerone, 1986 *in* Minami and Neue, 1993).

Like CO_2, CFCs, and Nitrous Oxide (N_2O), methane (CH_4) is also an important greenhouse gas that traps part of the thermal radiation from earth's surface. (Wang *et al*, 1976 *in* Minami and Neue, 1993).

Methane significantly contributes to global warming. The increasing concentration of CH_4 accounts for almost 20% of the radiative force added to the atmosphere (Watson *et al*, 1990 *in* Minami and Neue, 1993).

The predominant CO_2 contributes about 50% to overall warming but the others are important because all of them are more efficient absorber of IR than CO_2 (Wellburn, 1994).

Methane levels in the atmosphere are arising as a result of various human activities. Currently, atmospheric concentration is around 1.75 $ml.l^{-1}$.

FURTHER CONSIDERATIONS

IPCC (Intergovernmental Panel on Climate Change) report reveals that if no measures are taken major climate changes could occur in the 21st century. The available evidence compiled by the IPCC also shows that the projected climate changes would be global in extent and affect all people. In other words, no nation and no community, developed or developing, will be unaffected (Olindo, 1992).

In the absence of mitigation measures, methane emission are likely to continue to increase from each source. This is because increased production from livestock and rice are required to feed the expanding world population. Current emissions for animal, rice, and animal wastes could grow by about 40-60%, 50-60% and 30-40% respectively by 2025.

Referring to the phenomenon of global warming, a temperature increase of the magnitude of 0.3 - 0.6 ^oC has occurred over the past century and a rate of global warming 0.5 - 1.0 ^oC per decade could be through the next few decades (IPCC report).

The anticipated rise in global average temperature of about 2 to 3 ^oC over the next century will most likely lead to severe impacts on agriculture and forestry such as Heinloth and Karimanzira, 1993):

- A shift of the climatic zone by several hundred kilometres towards the poles, thus enlarging the arid zones in the tropical and subtropical regions, and reducing the land available for agriculture.
- A rise in sea level of about 0.3 m, inundating valuable land in coastal areas, especially in tropical and subtropical zones.
- A gradual breakdown of many ecosystems like the forests in temperate and boreal regions, leading to additional CO_2 emissions and thus to further greenhouse warming.
- Uncertain effects of CO_2 fertilisation and climate change on cycles of pests and weeds.

With the inevitable increase in human population, the quantity of methane in the atmosphere will increase. Unfortunately, in the most parts of the world, biogas has not yet been harnessed to convert methane into a major energy resource. Instead, it is freely discharged into the atmosphere and increase the concentration of the greenhouse gases. There is a need to devise ways of extracting some of these gases from the atmosphere by conventional means for commercial purposes (Olindo, 1992).

Methane emissions from rice cultivation may potentially be reduced whiles maintaining or enhancing productivity. Mitigative practices may include modifying water depth and timing of irrigation, the type, rate, and application method of fertiliser, alternative cultivation technology, and cultivar selection. Much research is still required in order to realise these opportunities, and therefore a short-term reduction of methane emissions from rice growing cannot be expected. However, over a number of decades, although rice production may be doubled, an integrated management approach may succeed in reducing methane releases by 20-40 % (Heinloth and Karimanzira, 1993).

There are some efforts being done by Indonesia in accordance with methane emission reduction, i.e.:

1. Intensification of paddy cultivation.
2. Developments of dryland paddy cultivation.
3. Diversification of staple foods in order to reduce rice consumption.
4. Research on utilisation of peat as a household energy resource.

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Table 3. Past, present, and future details of important greenhouse gases excluding water vapour molecules, adapted from IPCC and Deutscher Bundestag data (Wellburn, 1994)

Parameter	**CO_2**	**CH_4**	**N_2O**	**O_3**	**CFCs**
Concentration (1993)	362 $\mu l.l^{-1}$	1.75 $\mu l.l^{-1}$	3.13 $nl.l^{-1}$	20 $nl.l^{-1}$	0.6 $nl.l^{-1}$
Concentration (1765)	280 $\mu l.l^{-1}$	0.8 $\mu l.l^{-1}$	288 $nl.l^{-1}$	15 $nl.l^{-1}$	-
Current % yearly increase	0.45	0.95	0.25	0.5	5
Lifetime (y)	100	10	150	0.1	100
Past radiative forcing ($W.m^{-2}$) for the period 1765-1993	1.5	1.56[a]	0.1	0.05	0.2
Warming potential per molecule (= numbers of CO_2 molecules)	1	32	150	2 000	15 500
Current % contribution to global warming[b]	50	19	4	8	17

[a] Radiative forcing is the difference between total incoming solar radiation (240 $W.m^{-2}$) reaching the surface of the Earth and radiation emitted back out into space. This is the amount of actual global warming. In the case of CH_4, an extra 0.14 $W.m^{-2}$ has been added so as to account for additional water vapour arising from the atmospheric oxidation of CH_4.

[b] These percentages exclude water vapour molecules which, being the greatest contributors to the greenhouse effect, currently add an additional 65% to total warming.

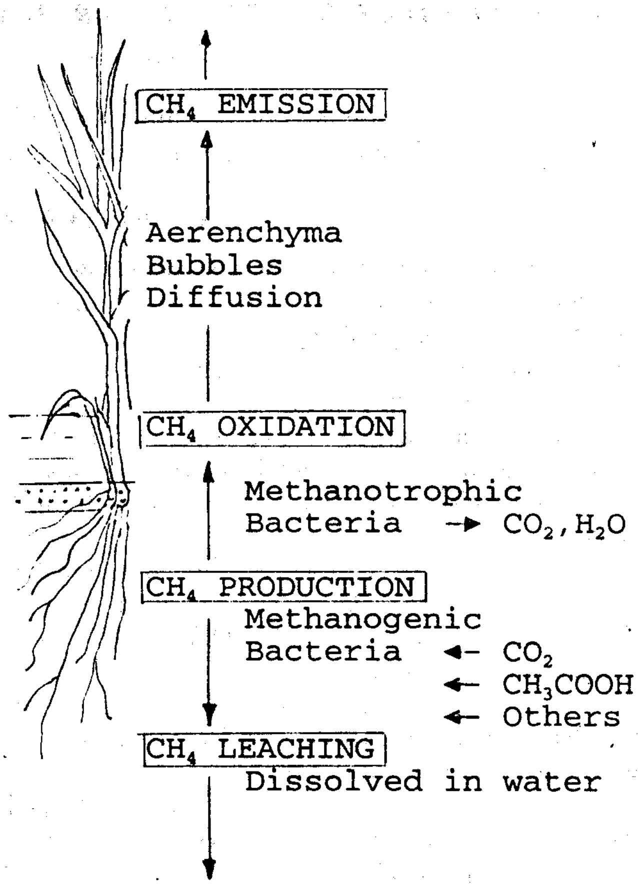

Fig. 1. Methane production, oxidation, emission, and leaching (Minami and Neue, 1993).