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Global Change Essay

The role of methane and methane clathrates as a cause of global warming

Climate change is not only a pressing issue in recent years, but also a very complicated one. The earth is a very complex system, and has had a very erratic history of global temperatures. Although it will probably be many decades before we are able to conclude whether mankind will have a meaningful impact on natural climate change cycles, there is definite evidence that anthropogenic factors can play a crucial role in artificially increasing global temperatures. This paper will investigate only one of the dozens of factors effecting climate change; methane in its gaseous and crystalline forms with special emphasis on man made sources.

Methane is a greenhouse gas, defined by Moss as gases that "allow the ready penetration of solar energy to the earth's surface, but at the same time... retard the return upward flow of infra-red radiation" (Moss 1993, p7) thus leading to a heating effect in the atmosphere. These gases include ozone, nitrous oxide, methane, carbon dioxide, carbon monoxide, water vapor, CFCs and PFCs (Bryant 1997, p119). With the exception of the last two groups of chemicals, all the greenhouse gases occur naturally in the environment in small concentrations. However agriculture and industry significantly increases the amount of these gases in the atmosphere, which has a effect of increasing global temperatures. Methane is the most potent greenhouse gas, although CO_2 produces the greatest potential for global warming; 63.8% of the effect as opposed to 19.2% for methane, when considered over a twenty year period, one molecule of methane has fifty six times the greenhouse effect of a single CO_2 molecule (Bryant 1997, p120).

Methane is produced almost entirely by bacteria called methanogens as a part of their anoxic respiration process, largely in digesting decomposing biological matter (Khalil 2000, p42). They are especially present in wetland and flooded environments such as marshes and also in the digestive systems of animals. This accounts for the two major anthropogenicly induced sources of methane production, in flooded rice paddies, and from grazing cattle, especially sheep and cattle. It is also important to note that many insect species also produce large quantities of methane (Hackstein and Stumm 1994, p5441) especially cockroaches, and that modern urban living provides a very good habitat for cockroaches, perhaps therefore increasing methane production. Other important man-made sources are sewage treatment facilities, landfill sites, and the extraction of coal and natural gas as fuel sources. On the positive note, the drainage of large areas of wetland and marsh over the last century to create suitable agricultural land would have a small impact in reducing methane emissions by removing much of a significant source.

Rice paddies account for approximately 20% of total methane emissions (Khalil 2000, p170) which is produced by bacteria in the soil. More than 50% of this methane is not released from the paddy fields due to the effects of methane consuming bacteria called methanotrophs (Khalil, p173), but the net emission is still very significant. The increasing amount of land being given over to rice production, especially in economically less developed countries (ELDCs) has lead to paddies being an increasingly important source of methane released into the atmosphere. The intensification of rice paddies also creates a much greater elevation in methane production when planting density is increased. The change in practice from using dryland rice culture to wetland where soil is puddled to retain moisture through the year is the real cause of methane production in modern agriculture, as dryland rice practices

produces practically no methane at the cost of much smaller yields (Khalil 2000, p174).

Another agricultural source of methane production is from livestock and grazing animals, accounting for 15% of global methane production, and as high as 37% of the total methane emission from the UK (Lockyer 1997, p11). Studies have shown that cattle are probably the largest sources of methane on the farm, producing approximately five times more than grazing sheep (Lockyer 1997, p12), and when one considers how cattle numbers are increasing globally, especially in ELDCs such as Brazil for the fast food market, this must be an ever more important source. The disposal of silage from livestock on the farm also generates methane (Khalil 2000, p253) a factor not measured in Lockyer's study of emissions by sheep and cattle while grazing.

However this production of methane is not very beneficial to either the livestock or farmer. The bacteria present in the digestive system of these animals feed off food being digested in the gut, reducing the amount of nutrient that would otherwise be absorbed by the animal. By changing the size and type of feed in an artificial farming environment and by also adding chemicals to increase fermentation in the stomach, conditions for these bacteria can be made unfavorable, not only making sheep and cattle feeding more efficient, but reducing methane production as well (Moss 1993, p73).

When combustion occurs incompletely in the presence of insufficient oxygen, methane may be produced. This is an important process because the burning of biomass, chiefly in the clearing of tropical moist forests for farmland and in savanna ecosystems as a natural and artificially induced fertilizing process is a common practice, and can contribute significant quantities of methane, as much as 15% of total global methane emissions (Khalil 2000, p190). The burning of coal and wood for fuel also releases large amounts of methane, practices that are growing in ELDC's. While this can have important climate change potential from the methane released, it should also be realized that biomass burning releases much more significant amounts of CO_2 .

One of the most frightening potential sources of greenhouse gas comes from special concentrated compounds of methane called clathrates. They are found in frozen tundra regions in the permafrost layer, but mostly on the ocean seabed. Although it is very difficult to estimate global quantities of methane clathrates, it is estimated that there are more than 24,000 gigatones of carbon stored in the oceans alone (Harvey and Huang 1995, p2905). These are stable at low temperatures, however with the prospect of global warming it is possible that there might be a positive feedback mechanism, whereby rising temperatures lead to the melting of clathrates and the subsequent release of methane, thereby increasing temperatures further. This could theoretically lead to exponential temperature increase with very dramatic global consequences. It has been suggested that this has happened before in the earth's climate history, but a detailed study into the stability of the extensive seabed sources of methane clathrates by Harvey and Huang has discounted this to a large extent. They recognize the potential of methane clathrates as being a significant temperature change factor, but state that as most of the methane sediment areas are in waters over 2km deep, and it would require a 10°C increase in temperature to release them; much higher than current global warming projections (Harvey and Huang 1995 p2911). It should also be noted that bubbles of methane dissolve as they rise through water, and can be oxidized, decreasing the actual amount of methane that reaches the atmosphere.

When considering the effects of methane being released into the atmosphere, it is crucial to consider natural absorption processes that actually remove 90% of methane produced annually from the air (Khalil 2000, p86). 90% of this methane is removed from the air by reactions with OH radicals in the lower atmosphere, with small amounts also removed in soil processes and in the stratosphere. However this methane eventually gets converted into CO_2 by natural processes in the atmosphere, creating another

greenhouse gas with a longer residence time (Khalil 2000, p309).

Trends of methane concentrations in the atmosphere over the last few centuries have shown there has been more than a doubling of methane levels in the atmosphere, closely matching increases in population and the more intensive agriculture that this entails (Moss 1993, p10). Over the last decades there has been a marked decline in the rate that methane concentrations are rising, although not an actual fall in methane levels (Khalil 2000, p7). The cause of this apparent reversal of a 500 year trend is unknown; it is not considered that global efforts to control methane levels are having such an immediate and pronounced effect. It may simply require another decade of sampling to determine whether this trend is a glitch, or to conclude that the methane problem is actually receding. Nevertheless, methane is still contributing CO_2 to the global system, and with the loss of sinks such as tropical moist forests, methane is a very important factor in the earth warming process.

Bibliography

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