Karlova Univerzita v Praze

Přírodovědecká fakulta

Ústav pro životní prostředí

Ochrana životního prostředí a ekologie

Lucie Švorcová

Výskyt metanu v mořských a sladkovodních ekosystémech a jeho vliv na klimatickou změnu

The Occurrence of Methane in Marine and Freshwater Ecosystems and its Impact on Climate Change

Bakalářská práce

Bachelor thesis

Vedoucí práce: Ing. Jaroslava Frouzová, Ph.D.

Praha 2017

The Occurrence of Methane in Marine and Freshwater Ecosystems and its Impact on Climate Change

Abstract

Actual effort to understand the global change encourage scientists to get more datas and expert knowledge about this worldwide problem. As a hydrosphere occupies almost two thirds of the Earth surface, it becomes an important part of current research. Greenhouse gases are slowly leaking from marine and freshwater ecosystems, and so I have decided to completely understand the potentional risk of escaping methane – an efficient greenhouse gas – from aquatic ecosystems.The purpose of such a research is to ascertain how important, hazardous and distant is sudden methane release danger. Whether the ocean reserves threaten our population and if there are other similar methane sources closer to us. This question follows the immense concern and focus on CO_2 emissions. According to the following text, seriousness of methane release situation is equally substantial. Not only, that CH_4 is twenty times more powerfull greenhouse gas than CO_2. It is furthermore an abundant component of our planet´s habitats, hidden in the oceans and freshwater reservoirs. As my research shows, there are two main difficulties brought with methane emissions. First, it is a permanent and increasing leakage of methane gases from freshwater ecosystems. Second, there is a potential peril of a sudden masive release of methane from deeep ocean stores. Each case brings a significant risk on a global scale, besides, both have a positive effect on global warming. While comparing several aquatic habitats, such as oceans, lakes, rivers and streams, I discovered the magnitude and importance of methane emission issues. Nevertheless, despite the global warming theme is becoming more relevant and alarming, there is still a lack of information and scarcity of relevant data from methane release. Every cruical article or scientifical paper point out to this plain gaps and warn against the immense impact that lack of knowledge can bring.

Key words: Methane Hydrate, Methane Emission, Clathrates, Global Warming, Marine ecosystems, Freshwater Ecosystems

DISCUSSION

Methane is the fastest increasing greenhouse gas. Even half of the methane emission sources are anthropogenic, another half is from natural sources. But, are these natural springs of methane unchanged, or do people also convert them?

Aquatic ecosystems, such as oceans, lakes or rivers are rapidly changing thanks to human activities. These actions result big changes in marine and freshwater ecosystems. Anthropogenic damming, land use, fertilizing, contamination and lodging create conditions supporting methanogenesis in water ecosystems. It cause greater income of organic matter, nutrients and also supports anoxic conditions at the water bed. .

Methane emissions make 10 % of the total greenhouse gas emissions. Although carbon dioxide releases 82 % of global emission, methane is 28 times more effective greenhouse gas. The total amount of global methane emissions differ. The most actual measurements state astounding 600 Tg of CH_4 (Ciais et al, 2013). So, how much methane from the whole sum comes from aquatic ecosystems? Thus, are freshwater ecosystems, occupying only 0.3 % of the Earth, a substantial methane source? Or, are oceans holding almost two thirds of the Earth surface the biggest emitter of methane? The results are surprising. After comparing different result, I found out the importance of freshwater ecosystems. The measurements differ from research to research. I had to compare the numbers and find the most relevant ones.

Thus, water reservoirs release 15 %, lakes loosen 7 – 8 %, rivers almost 4 % and marine ecosystems only 1 – 2 % of total methane emissions. These results are surprising. As mentioned before, freshwater ecosystems fill only 0.3 % of earth surface. But on the other hand emit a significant amount of methane. It is essential to believe that freshwater ecosystems, including rivers, streams and lakes are important in question of methane release. However, there is lack of measurements and the imperfection of measuring instruments is an important problem in methane release research. Insufficient quantity and quality of data cause inaccurate results. Fortunately, there are many new and actual studies over last few years, dealing with this issue.

While reshaping freshwater ecosystem, human enhance methane production. It is necessary to reduce anthropogenic activities, so that the amount of loosen methane will not increase. Mainly, this problem should be considered in a question of building new water reservoirs. The

trend of building water reservoirs brings plenty of difficulties and this might be one of them. Also intensive agriculture might be reshaped to smaller and more natural farms, producing plants without using great amount of fertilizers. Furthermore, soil and water contamination must be strictly controlled to prevent methane emissions increase.

Marine ecosystems are not significant in case of global methane emission, with its small amount of released methane. However, the problem is hidden deep in the oceans and seas along the shore. Methane created by methanogenesis in the anoxic conditions deposit as methane hydrate in the depth. Creating great supplies of methane, it builds a potential gas bomb. Any disruption can cause a sudden release. The biggest problem is a fast change in global temperature, caused by human. If people will not stop emitting greenhouse gases and so enhancing global warming, the stable conditions in the oceans might change. An increase in ocean depth temperate over 7°C can cause changes in stability. That will launch rapid methane release from the hydrate supplies and lead to extreme increase of methane in the atmosphere. On the account, greenhouse effect would be amplified.

This potential risk is predicted to happen in next 1000 years. Next 100 years, temperature in ocean depths will not be affected enough. Anyway, the danger of possible massive release is a substantial warning. Anthropogenic activities causing greenhouse gas growth must be reduced. The population must reduce greenhouse gas emissions, besides every other warming boost another warming and eventually can cause a huge and sudden marine methane breakdown.

If the warming will carry on, next few generations might face to a unstoppable hazard, caused by nowadays inconsiderate behaviour.

And after all, there is a fundamental question of future methane mining. Is that a correct step to future? Are methane hydrates another step forward, switching places with oil and creating a new source of energy? While breaking into the inventories, people can disturb the stability of methane hydrate supplies. There might be a risk of sudden inventories breakdown. But on the other hand, this source of energy might bring new opportunity. Later, it might also replace the fossil fuel.

CONCLUSION

This wide topic allowed me to compare two different mechanisms of methane release danger, both in aquatic ecosystems. First is a continuous methane leakage into the atmosphere from the sediments in freshwater ecosystems. Second is a sudden release of methane from the vast methane hydrate supplies in ocean depths.

Actual global methane emissions are determined as 600 Tg CH_4 per year (Ciais et al, 2013). These 600 Tg is only 10 % of total greenhouse gas emissions. One half of methane emissions comes from natural sources, the other comes from anthropogenic sources. But also the natural ecosystems loosening methane are being reshaped by human.

Concerning freshwater ecosystems, water reservoirs loosen approximately 100 Tg CH_4 per year, which equals to 15 % of global methane emissions (Lima et al, 2008). Lakes emit significant amount of methane, ranging from 50 – 70 Tg CH_4 yr^{-1}, causing 7 – 8 % of global methane emissions (Bastviken et al, 2011). Streams and rivers were surprisingly discovered also as important methane source, with its 26,8 Tg CH_4 yr^{-1}. This makes 4 % of total methane emissions. Eventually, this fact showed, that methane fluvial emissions are of the same magnitude such as wildfires, methane hydrates and permafrost (cca 21 Tg CH_4 per year), or equals to the terrestrial methane absorption (cca 28 Tg CH_4 per year) (Kirschke et al, 2013). This new knowledge, distinct from others underrated studies, highlighted the importance and magnitude of streams and rivers methane emissions. (Stanley et al 2016)

Table 2 – Total methane emissions in aquatic ecosystems and its ration in total global methane emissions

Aquatic ecosystem	**Methane emissions (Tg CH_4 per year)**	**Methane emissions ratio in global methane emissions budget (%)**
Water reservoirs	100	15
Lakes	50 – 70	7 – 8
Rivers	26.8	4
Oceans, seas	2 - 9	1 - 3

Eventually, global methane emissions from the ocean are slight compare to all freshwater emissions. Marine waters, covering over 70 % of Earth´s surface, emit into the atmosphere only 2 – 9 Tg CH_4 annually (approximately 3 % of total CH_4 emissions). (Ciais, 2013)

This number is tiny compared to substantial freshwater emissions. However, methane produced in oceans close to the shore deposit in methane hydrate stability zone. The estimates of methane hydrates supplies differ between 1800 – 2300 Gt C (Ruppel, 2017). This number is comparable to fossil fuel supplies. In spite of this fact, oceans bring an immense peril to the question of global warming. As long as ocean store huge amount of global energy (carbon, heat), it creates its own carbon supplies and ocean water temperature is increasing. Methane generated or absorbed by marine waters accumulates in sediments as methane hydrates. As mentioned in this research, increasing temperatures of ocean water may result a huge collapse of these deposited hydrates supplies. Bringing large amount of released methane, further warming and creating submarine slides and slumps. Fortunately, there is no close prospect anticipating such a crisis in next hundred years. But, in next 1000 years, the ocean depth water temperature will be affected enough to change the stability zone.