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## REVIEW ARTICLE

## METHANE GAS FROM LAKE KIVU IS RESPONSIBLE FOR ANTHROPOGENIC GREENHOUSE EFFECTS: THE CURRENT SITUATION OF GLOBAL WARMING AND CLIMATE CHANGE IN AFRICA.

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## ARTICLE DETAILS

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## ABSTRACT

Lake Kivu is located in Central Africa, between DR Congo and Rwanda. It is a lake that contains a large amount of methane gas and is susceptible to explosion due to the geological conditions (volcano) that exist in this region. This methane gas is toxic, asphyxiating and a greenhouse gas; all these characteristics make this methane gas from Lake Kivu an environmental problem as well as a serious threat to the human health of people living in the region where the lake is located. The greenhouse effect of this methane gas causes global warming. Global warming is now a public health and environmental issue because it promotes the spread of infectious agents and the deterioration of the quality of air, water and food. These factors contribute to an increase in cases of diseases, especially tropical and infectious diseases, as well as malnutrition. The government of the DR Congo should also consider methods of exploiting and using methane gas from Lake Kivu as electrical energy to reduce the risk of explosions and the human, environmental and ecological damage that this lake could cause.

## KEYWORDS

Lake Kivu, Global warming, Climate change, Environmental hazard, Global health, Infectious disease.

## 1. INTRODUCTION

Methane is a fairly abundant chemical compound in the natural environment, it is gaseous under normal conditions and it is one of the main gases responsible for anthropogenic greenhouse effects with a high global warming potential (Badillo, 2021). Lake Kivu is one of the great lakes of Africa and is located in Central Africa, between the Democratic Republic of Congo (DR Congo) and Rwanda. Lake Kivu is the most dangerous of the three meromictic lakes due to the huge amount of toxic and greenhouse gases. As a result, it is a toxic risk to the environment during an event of a natural disaster, such as a volcano, which could create a damaging explosion (Deveaux, 2021). The total volume of the lake is 550 km<sup>3</sup> with a total volume of dissolved carbon dioxide of 300 km<sup>3</sup> and a total volume of dissolved methane of 60 km<sup>3</sup> (Pasche et al., 2011). In addition to the two elements mentioned, in the rainy season, it is common to encounter a zone of accumulation of nitrate and nitrite. This is generally located between 30 and 40 m deep, covering the zone of decreasing dioxide concentrations, and has nitrate concentrations up to 10 micromolar (Llirós et al., 2012).

Methane gas contributes to the greenhouse effect; its concentration in the earth's atmosphere is the cause of climate change, in particular global warming (Lecrenier, 2020).

Climate change is a big threat to human health. High temperate climates are a driving factor in the development of pathogens, the evolution of infectious diseases (Malhi et al., 2020). DR Congo, a country in the tropics,

hence the presence of many tropical and infectious diseases caused by climate change (temperature rise) (Aborode et al., 2022). According to estimates by the World Health Organization (WHO), climate change is the cause of tens of thousands of deaths per year due to the rapid evolution of infectious diseases and the deterioration of air quality, food supply and drinking water. Global warming also poses a threat to national security, affecting food security. It is also estimated that between 2030 and 2050, climate change will result in approximately 250,000 death per year due to malaria, diarrhea, thermal stress and malnutrition. The consequences of global warming therefore have impacts in the natural, social, territorial context and even in the entrepreneurial context.

## 2. MAIN TEXT

## 2.1 Current Situation of Climate Change In Africa

In Africa, where the tropical zone and some low-income countries are located, temperatures are rising and vulnerable populations are becoming more susceptible to diseases such as malaria, dengue and other insect-borne infections (Aborode et al., 2022). Only 10% of the world's population of over 930 million people, or 12% of the total population, spend money on health care and insurance. The low-income population, on the other hand, lacks adequate health insurance coverage, and climate change is only making the situation worse (WHO, 2021). In recent years, more than 75 to 250 million people in Africa have lost access to clean water and face food shortages due to declining agricultural productivity. In addition, the rise in temperatures causes a food shortage and

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exacerbates food insecurity (Calleja-Agius et al., 2021).

Thus, there are documented consequences of climate change in Africa that can result in death and illness from heat waves, as well as increased zoonoses and disease transmission through water supply or vectors. These climate-related health risks disproportionately affect the most vulnerable and disadvantaged people, including women, children, poor communities, migrants, the elderly and people with comorbidities (Mpandeli et al., 2018). Affluent African societies can take advantage of technological advances such as more powerful air conditioners and bioclimatic buildings to protect them against variations in heat. Developing African countries, on the other hand, lack the resources and public health systems needed to prevent these outbreaks (Mpandeli et al., 2018; Chersich et al., 2018). The climate crisis threatens to reverse the progress made in recent years in global health development and poverty reduction. It seriously threatens the achievement of universal health coverage in various ways, including by increasing the existing burden of disease (Wright et al., 2021).

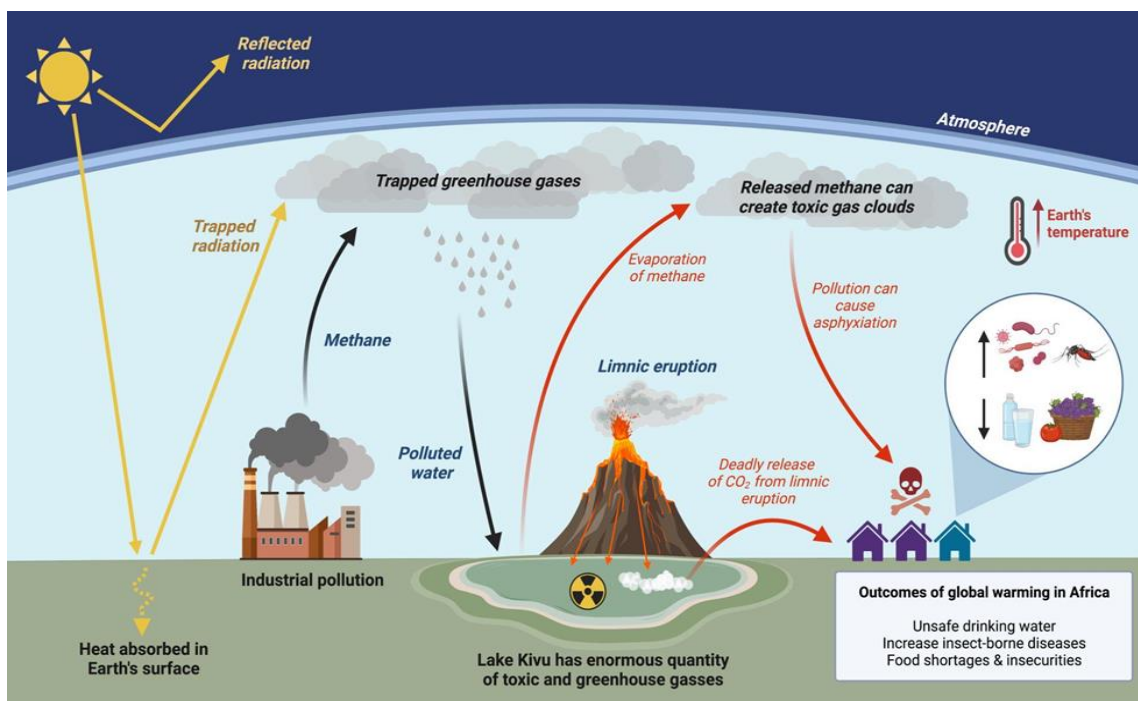
## 2.2 Natural Risks Related To Methane And Health Risks Sensitive To Climate Change

Methane accumulates in stratified and anoxic water masses permanently, its concentration in Lake Kivu does not reach the maximum of 21.8 mol m<sup>-3</sup>. But this concentration gradually increases with depth in Lake Kivu and the oxidation of methane approaches the surface layer containing oxygen (Badillo, 2021). Lake Kivu is located in the East African Rift which is an area of active earthquakes, volcanoes and crustal rupture, which could generate heat waves, contributing to the release of trapped gases and the generation of an explosion. A limnic eruption is one of the deadliest human events due to its asphyxiating power (Deveaux, 2021). In 1984 and 1986, the Monoun and Nyos lakes in Cameroon killed 37 and

1,800 people respectively when CO<sub>2</sub> was released, while the quantity of gas in Lake Kivu is estimated to be hundreds of times greater than that contained in the lake Nyos. The possibility of such a sequence of limnic eruption events increasing the warming of the planet's surface and causing climate change is possible. The results contribute to a seasonal imbalance in which the dry season lasts longer than the rainy season. Population vulnerability and the rate of adaptation will determine the effects of climate change on human health, as will the extent to which transformative actions are taken now to reduce emissions, avoid dangerous temperature thresholds and tipping points. potentially irreversible (Badillo, 2021).

The total oxidation rate is about 35 g C m<sup>-2</sup> y<sup>-1</sup>. The release to the atmosphere is negligible (about 0.2 g C m<sup>-2</sup> year<sup>-1</sup>). This storage rate corresponds to 0.14 km<sup>3</sup> yr<sup>-1</sup>, or 0.2% yr<sup>-1</sup> with respect to the total methane content. Based on the formation of excess methane, one can expect an increase in the methane content of the lake from the current 65 to 72 cubic kilometers over the next 50 years.

The presence of nitrite and nitrate in water has harmful consequences on human consumption as well as the environment. The population of Goma and its surroundings consume water from Lake Kivu after bacteriological treatments and pH adjustment, unfortunately this water does not undergo complete physical and chemical treatment to normalize the quantity of nitrate and nitrite possible, which exposes the population at all possible risks. Lake Kivu is a meromictic lake, which means that its surface and deep waters never mix. In this lake, the release of the methane that is currently dissolved would result in a cloud of gas rising more than 100 meters above the current level of the lake. This cloud would completely obscure the coastal region as well as the important Congolese cities of Goma and Bukavu. As a result, this cloud of toxic and asphyxiating gas would affect at least two million people (Lecrenier, 2020).



**Figure 1:** A simplified schematic demonstrating contributing factors to the greenhouse effect, outcomes of global warming in Africa, and the impact of methane gas polluting Lake Kivu. (Created with biorender.com)

## 2.3 Possible Implications To Global Warming

Global warming is a serious problem in Africa due to the greenhouse effect and may contribute to high death rates in these regions. Higher temperatures in already hot regions can lead to long-term health consequences of food insecurity, unsafe drinking water and an increase in mosquito-borne diseases that disproportionately affect poor communities. Methane is one of the most abundant compounds responsible for anthropogenic greenhouse effects and accumulates in huge quantities in Lake Kivu, one of the largest lakes in Africa. Despite advances in modern technology to ameliorate the effects of global warming, the overwhelming amount of gas trapped in Lake Kivu, surrounded by volcanoes and active earthquakes, could be confronted with a limnic eruption if the temperature of the surface of the earth increases. During the Nyiragongo volcanic eruption in 2021, cracks in the rock were observed in several places in the city of Goma where magma

emerged from the depths, which would cause very major damage if it was an underwater eruption in Lake Kivu. The consequences on human lives are devastating, as clouds of toxic methane could asphyxiate hundreds of people in the community.

## 2.4 Recommendations

Currently, the layer below 260 meters of Lake Kivu is economically viable for the extraction of CH<sub>4</sub> (45 km<sup>3</sup> at 17 mol m<sup>-3</sup>). The layer between 200 and 260 meters deep shows average methane concentrations of 5.4 mol m<sup>-3</sup>. There is a way to transform the risk of Lake Kivu. The same gas that could fuel a deadly natural disaster could also serve as a source of electricity for the Lake Kivu region (Lecrenier, 2020). Methane in Lake Kivu is a boon and a curse, this huge amount of methane provides a unique opportunity to use it to generate electricity with a total commercial value of \$10-40 billion. The possibility of a gas explosion

should be taken seriously. As a result, gas extraction can defuse this ticking time bomb; harnessing such a large amount of methane offers guaranteed profits. This harvesting of gas from Lake Kivu could reduce the risk of a limnic eruption without eliminating it. Nevertheless, for such a dangerous lake, any risk reduction is significant. Goma Volcanic Observatory, which reports high seismic activity and rising temperature, alerts people to volcanic activity, despite lava flow hiding under Lake Kivu and threatening life two million people. The Congolese government should modernize this volcano control center because an eruption of the volcano could lead to the explosion of these gases.

We also recommend that Rwanda, which has launched a pilot program of burning lake methane into natural gas, strengthen and expand its extraction program, and that DR Congo appeal to the actors to launch the same program in order to reduce this amount of gas. A methane extraction program is much more important for people living near Lake Kivu as it could become an important source of energy.

In their efforts to protect populations from the effects of climate change, some countries have begun to prioritize health. However, the failure of other countries to protect health against climate change is particularly detrimental to the poorest population groups. For climate change, we recommend the following actions: prioritize climate change policies that have the greatest impact on health plans, build health system resilience to climate risks by putting in place climate-resilient and environmentally sustainable health facilities, and developing energy systems that protect and improve climate and health.

Some countries have begun to prioritize health in their efforts to protect populations from the effects of climate change. However, the failure of other countries to protect health from climate change is particularly detrimental to poorer population groups. For climate change, we have recommendations to propose the following measures: prioritize climate change policies that have the greatest impact on health plans, strengthen the resilience of health systems to climate risks by implementing building climate-resilient and sustainable healthcare facilities as well as creating energy systems that protect and improve climate and health.

### 3. CONCLUSION

This paper recommends extracting methane gas from Lake Kivu through its existing pilot program, expanding the functionality of the Goma Volcanic Observatory and prioritizing current policies that would build on resilient health facilities to the climate. The recommendations are crucial to reducing the risk of catastrophic environmental catastrophe, and we warrant further research on the risk of limnic eruptions and global warming causing food insecurities to prepare better policies that would improve the quality of life of communities in scarce resources in Africa. In addition, current policies should be adapted to a national approach to reduce the effects of climate change and creating a collaborative environment for improving health care.

### LIST OF ABBREVIATIONS

Democratic Republic of Congo (DR Congo), World Health Organization (WHO),

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