Mathematical modelling of methane gases extraction from Lake Kivu

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Lake Kivu

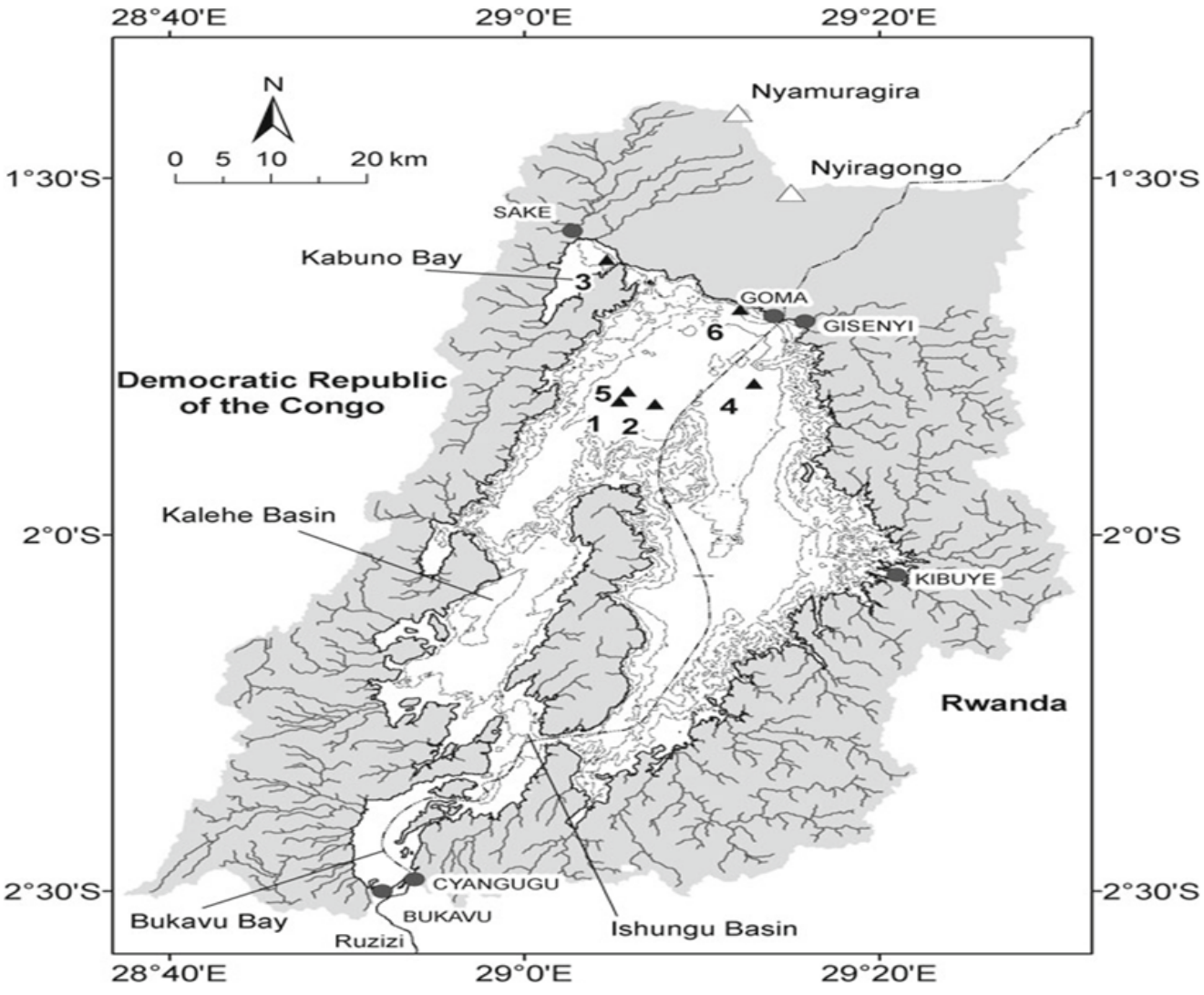

Figure : Lake Kivu location

Introduction from Report of Lukas Jarc, Martin Schmid and Alfred Wuest

- Lake Kivu, located on the border of Rwanda and the Democratic Republic of Congo is one of the world's most unique lakes, and at the same time, potentially one of the most dangerous.
- The uniqueness and the danger of Lake Kivu arise from the carbon dioxide (CO_2) and methane (CH_4) gases dissolved in the deep waters of the lake.
- The best approach to eliminate any risk for a gas eruption would be to completely remove all the gases from Lake Kivu immediately.
- The downside of the gases in Lake Kivu is the danger it exposes to all oxygen-depending life in the lake region: A gas eruption in the lake water could lead to an unimaginable disaster of apocalyptic dimension.

Gas concentration

- Most of the methane is stored in the deep part of the lake, indicated as the Resource Zone in the length of 500 m.
- These gases are a natural hazard, as they could potentially lead to a gas eruption from the lake if their concentrations increase further.
- Currently, the dissolved CH_4 is being extracted from Lake and used for power production.

Gas concentration

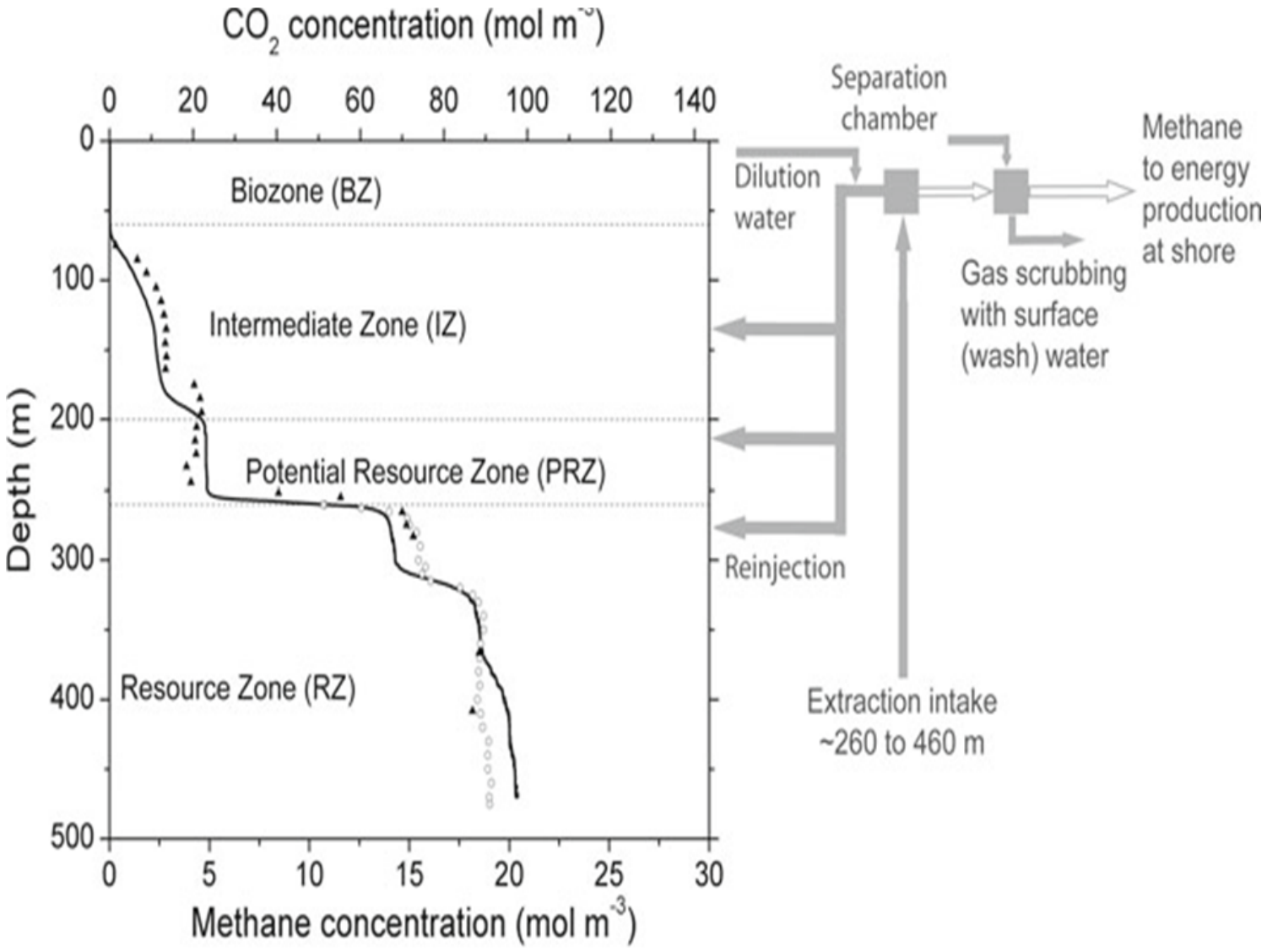

Figure : Gas concentration.

Methane extraction

- extract a quantity of water from lake through a tube at 320 m in the lake down into the Resource Zone (extraction)
- on the platform, extracted gas and water are separated (separation)
- bubbles are formed and their buoyancy drives the upward flow in the tube in a continuous and self-sustaining mode (self-siphoning).
- After washing the extracted raw gases (mainly retaining H_2S and CO_2 in the lake water), water without gas is returned to lake at depth of -90 m (re-injection)
- from the gas the power is produced (production)
- not all the methane extracted ends up in the methane gas produced
- 84 % of the methane extracted ends up in the produced gas
- 15 % is vented to the atmosphere
- 1 % is returned to the upper part of the lake (below the biozone or surface layer)

Methane extraction diagram

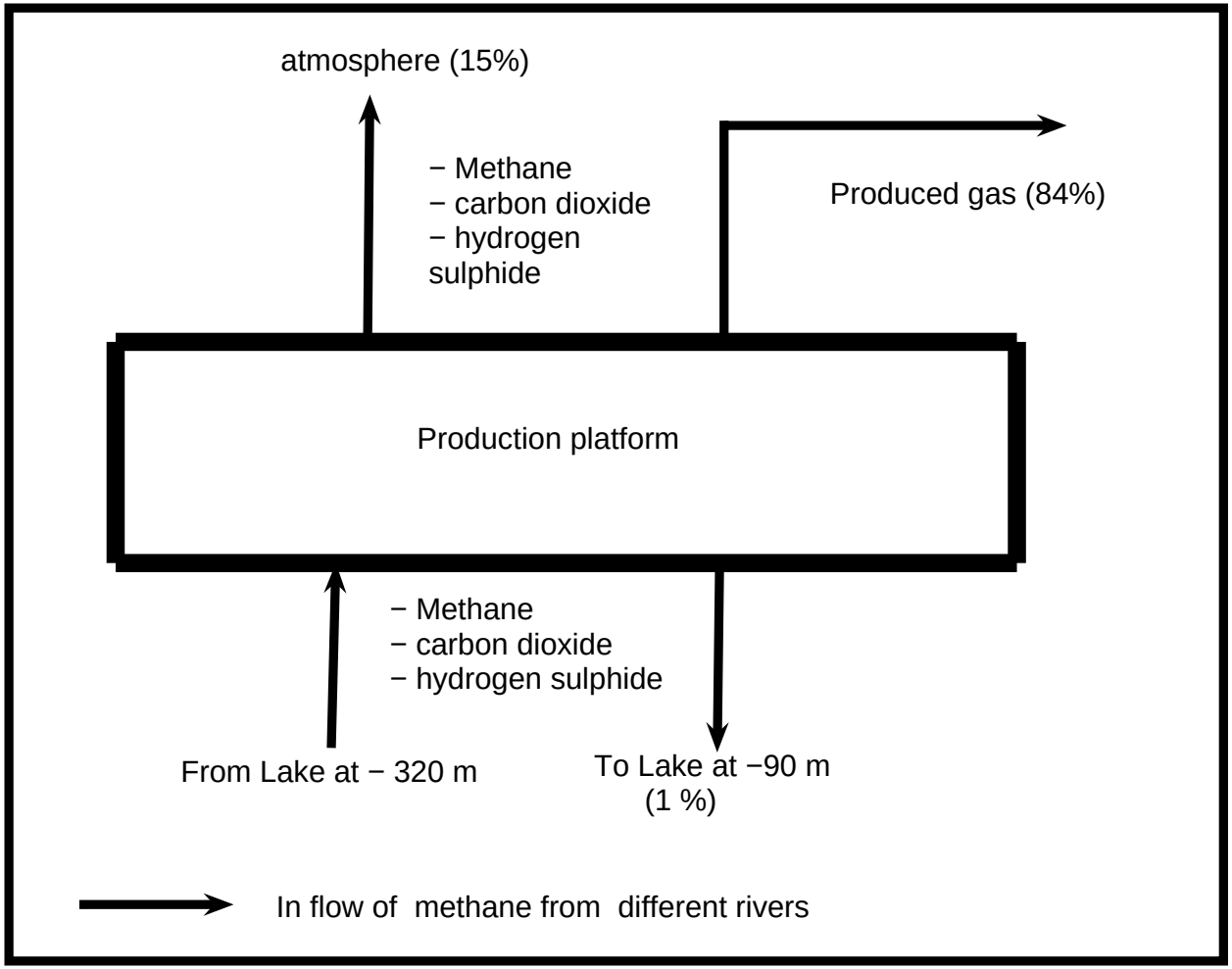

Figure : Gas extraction concept.

Suggestion Methodology

- In order to support environmental scientists in finding sustainable solution, we will develop an adequate model of the gas extraction process.
- The model will provide the development of all variables relevant for the study, i.e. the gas content (CO_2 and CH_4), the temperature and the nutrient fluxes (PO_4andNH_4).
- Once the model is found, we will perform simulations using different models, we will assess the identifiably and estimate the values of model parameters (using measured data), and estimate prediction uncertainty.
- We will also study the stability analysis of the system since by removing the methane; the extraction will reduce the potential risk of gas eruption in the lake and maximize the energy gain.
- On the other hand, maintain permanent stratification and avoid nutrients increase in the biozone.

Suggestion Methodology

The found model should at the same time respond to the following requirements

- ensure the safety of the population and the environment
- maximize the harvestable methane while minimizing the methane losses to the atmosphere and within the lake

THANK YOU