



Research/Technical Note

# Monitoring of CO<sub>2</sub> in the Nyiragongo Volcano Cracks on Bugarura and Munigi Sites from January 2019 to January 2020

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**Abstract:** In the area north of Lake Kivu, in the western part of the African Rift, deep fractures allow the uptake of gas, especially carbon dioxide. The Nyiragongo territory is located in the western part of the African Rift Valley. The deep fractures allow gases, especially carbon dioxide (CO<sub>2</sub>), to rise. CO<sub>2</sub> is a heavier-than-air gas, asphyxiating, irritating to the eyes, nose and throat, and deadly at concentrations above 15%. The variation of CO<sub>2</sub> in the different stations allows us to study the behaviour of the Nyiragongo volcano although in our stations we have not reached the lethal concentration of CO<sub>2</sub>. The volcanic activity of Nyiragongo is therefore closely monitored by the inhabitants, and any news of increased activity agitates the inhabitants of the region, especially those living in the Nyiragongo territory. Here we report a short carbon dioxide monitoring time series for five stations (BUGARURA I, II, III, IV and MUNIGI stations). The various variations in CO<sub>2</sub> give us information about the activity of the Nyiragongo Volcano in the crater. The active volcanoes of the Virunga chain expose the Nyiragongo region to numerous natural hazards such as lava flows, gas plumes, dissolved gases in Lake Kivu and risks related to epidemiological diseases and armed conflicts.

**Keywords:** Monitoring, Carbon Dioxide, Crack, Volcano

## 1. Introduction

The Nyiragongo volcano is threatening the inhabitants of Nyiragongo territory and ~ 1.5 million people in the cities of Goma (DR Congo) and Gisenyi (Rwanda). In 2002, the volcano produced lava flows that invaded almost the entire territory of Nyiragongo, the city of Goma, destroying the city's economic district, forcing a massive exodus of the population and causing the loss of several lives. Nyiragongo's volcanic activity is closely monitored by the inhabitants, and any news of increased activity agitates the inhabitants of the region, especially those living in the Nyiragongo territory and those of Goma. Here we report a short time series of carbon dioxide

release for five stations. The Nyiragongo Volcano is a beautiful and active volcano, a large stratovolcano near Lake Kivu on the eastern border of DR Congo with Rwanda in the Virunga National Park. The Nyiragongo Volcano is sadly famous for its extremely fluid lava that flows like water when the lava lake is flowing. On 17 January 2002, the city centre of Goma, the capital of the eastern Virunga province, was destroyed by voluminous lava flows [3, 4].

The active volcanoes of the Virunga range expose the Nyiragongo region to numerous natural hazards such as lava flows and gas plumes, in addition to risks related to epidemiological diseases and armed conflict. Of these risks, volcanic gases are the most permanent threat to the Nyiragongo population because gases are emitted by volcanoes not only

during the eruptive period but also during calm periods [6, 9]. Among the gases emitted are direct emanations from the ground in volcanic regions to the atmosphere. For example, the Virunga Volcanic Province (PVV) is full of several of these gas emanation zones, where carbon dioxide ( $\text{CO}_2$ ) accumulates by gravity, making the air toxic and even lethal.  $\text{CO}_2$  is a heavier-than-air gas, toxic at high concentrations and asphyxiating, it irritates the eyes, nose and throat and is lethal at a concentration of 15% [1, 4, 5, 7, 10-12].

The concentration of  $\text{CO}_2$  in the air is mainly due to local degassing of the soil, while the contribution of the crater gas emission is negligible at the breathing height for humans and always remains well below the lowest indoor  $\text{CO}_2$  concentration threshold [8]. In addition to the volcano, which the population of Nyiragongo inherited, there is also the growing insecurity.

## 2. Description of the Study Environment

The Nyiragongo Territory is a deconcentrated administrative entity in the east of the North Kivu province in the Democratic Republic of Congo. It has only one chiefdom led by the Mwami and is divided into 7 groups of 58 villages. Its chief town is Kibumba. With an estimated population of some 145,748 inhabitants by 2016 [13] and an area of 163  $\text{km}^2$ .

It is limited:

- In the North: The chiefdom of BWISHA in the territory of Rutshuru;
- In the South: The commune of Karisimbi in the city of Goma;
- In the East: The Rwandan Republic;
- To the West: The free zone of the Virunga National Park which separates it from the chiefdom of Bahunde in Masisi territory.

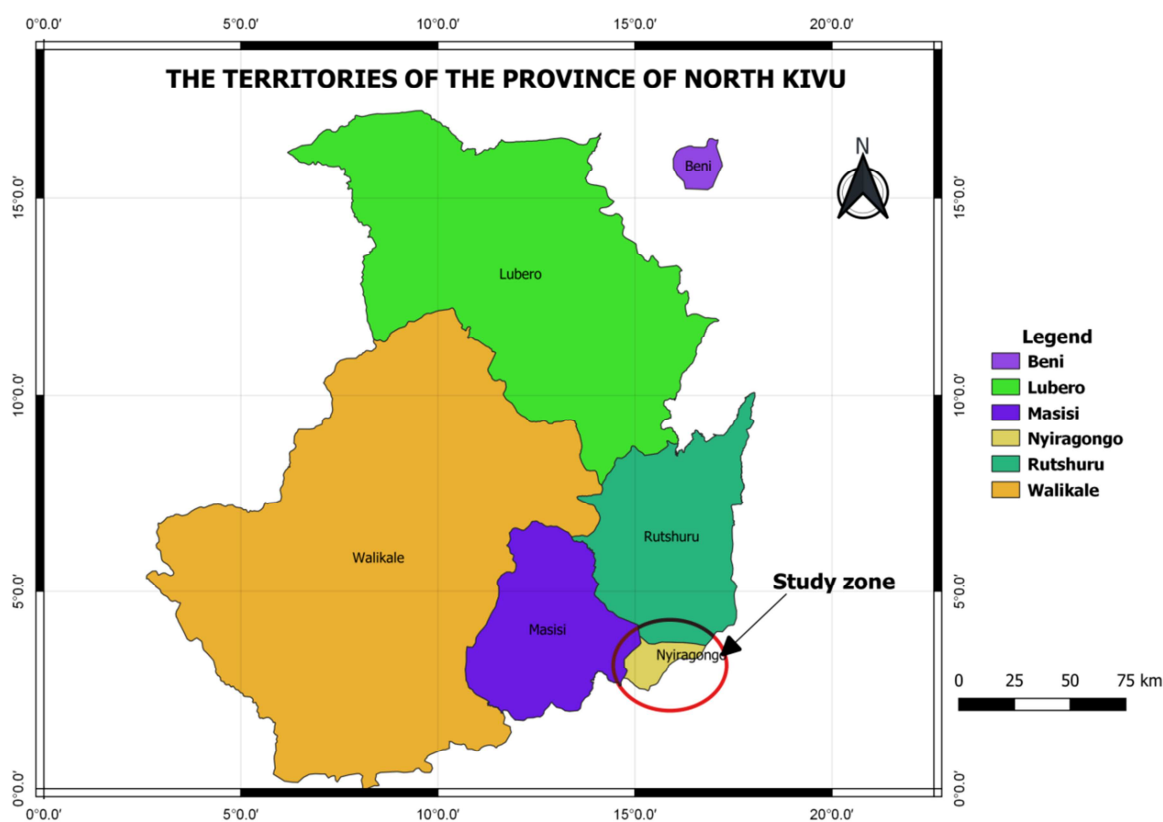


Figure 1. Study zone.

## 3. Materials and Methods

For the measurement of the  $\text{CO}_2$  concentration in the Bugarura and Munigi stations we used a portable gas analyser GA5000 (Geotechnical Instruments, UK) which gives the concentration in percent with typical accuracy.

$\text{CO}_2$  is measured with a wavelength infrared detector (WIRD) with a reference channel. The GA5000 is equipped with a pump and a gas inlet connected to a plastic pipe. The end of the pipe is placed at the precise location where the concentration is to be measured. The pumped gases first pass

through a 0.45  $\mu\text{m}$  polysulphone filter and are then led to an IR analyser. The results are displayed on the instrument screen [2, 15]. Carbon dioxide was measured at ground level in the Bugarura and Monigi stations on a one-off basis and once a week.

## 4. Results and Discussion

Carbon dioxide measurements carried out at the Bugarura and Munigi stations from January 2019 to January 2020 show that  $\text{CO}_2$  is still at concentrations well below the lethal threshold of 15%.

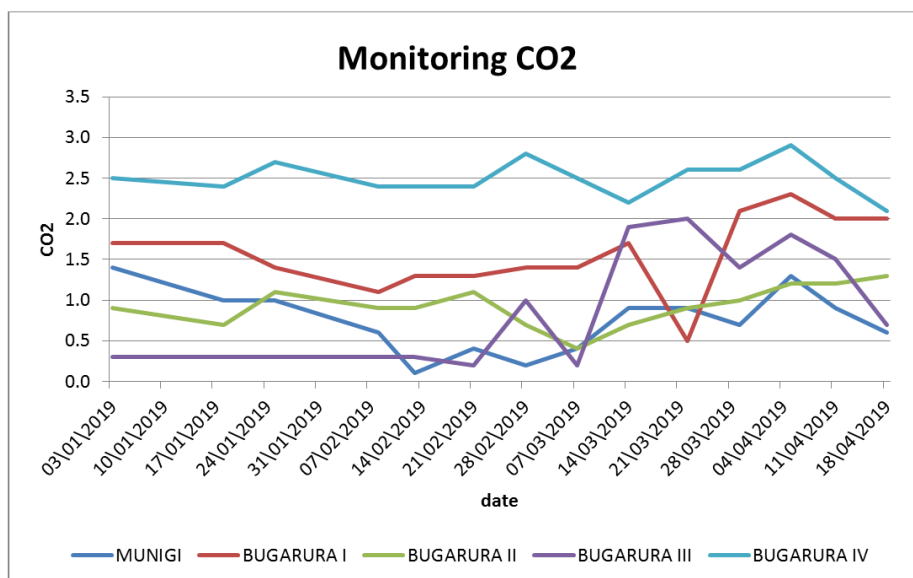


Figure 2. Legend Monitoring of CO<sub>2</sub> January to April 2019.

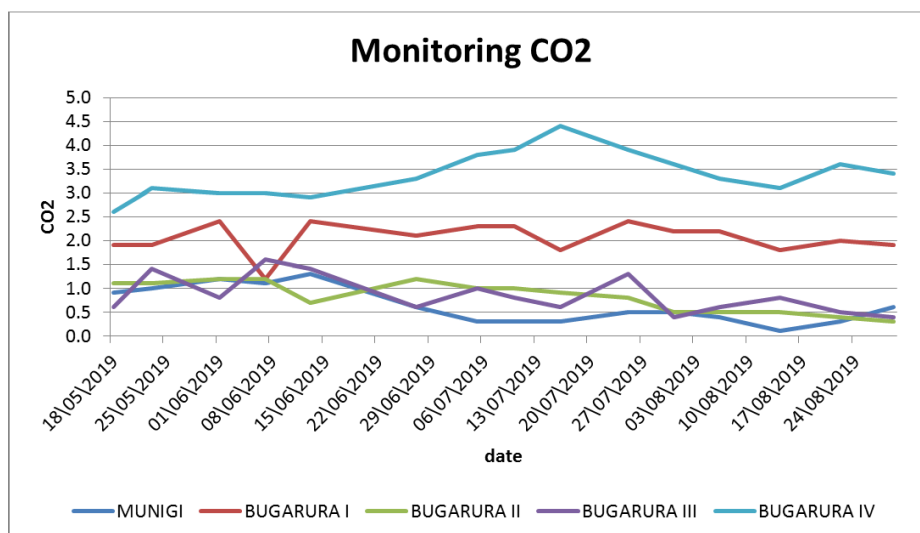


Figure 3. Legend Monitoring of CO<sub>2</sub> May to August 2019.

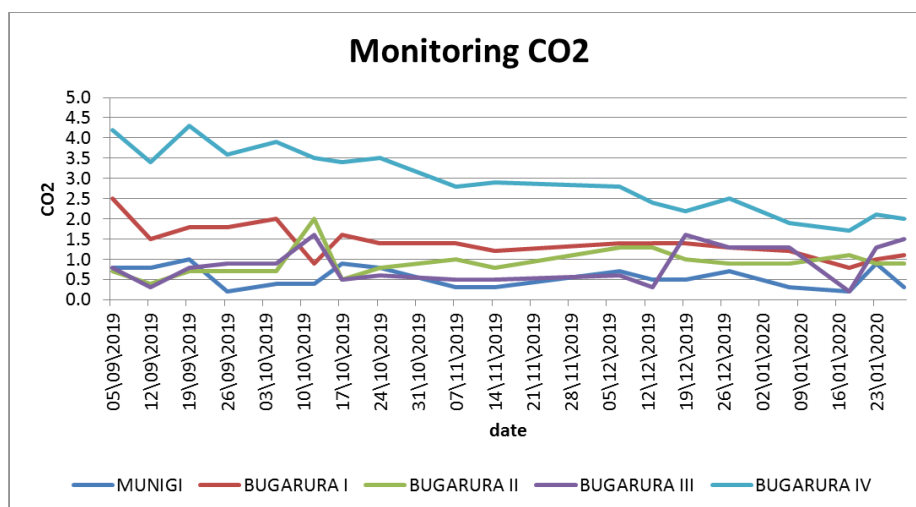


Figure 4. Legend Monitoring of CO<sub>2</sub> September to January 2020.

We note that during the entire monitoring period from January 2019 to January 2020 the carbon dioxide concentration is high in the Bugarura IV site compared to the other four sites (Bugarura I, II, III and Munigi). Although the percentage of CO<sub>2</sub> in the atmosphere is 0.04 [14]; in our five stations the carbon dioxide concentration has never decreased to 0.04.

## 5. Conclusion

CO<sub>2</sub> concentration is still present in Nyiragongo territory, mainly in the chiefdom of Bukumu. Measurements show that 18 years after the devastating eruption of the Nyiragongo volcano in 2002, the CO<sub>2</sub> concentration in these five sites, which was already present before this event, is still present. As the CO<sub>2</sub> concentration has not diminished or disappeared in this region, the variation of CO<sub>2</sub> in this environment leads us to believe that an eruption will occur in the coming years. It is up to the political and administrative authorities of the Democratic Republic of Congo, in particular those of the North Kivu Province, to seriously consider the risk posed by the carbon dioxide emitted by the Nyiragongo Volcano and to secure this area.

Information and awareness-raising campaigns on the risks associated with carbon dioxide are also recommended.

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