

High CO₂ enrichment in surface waters of MCL lake at Taal volcano, Philippines

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The active Taal volcano complex (the volcano island) lies in the middle of a large (15x22 km) prehistoric caldera filled with Lake Taal. The main crater of the volcanic island contains a volcanic lake termed MCL with a volume of 42 million m³ of slightly warm and acidic waters: pH:2.7-3.0, temperature: 30.5 C. About 6,000 people are living on the volcano island.

Echo-sounder surveys were carried in 2011 and 2012 to evaluate the activity of gas vents at the lake floor by measuring the backscattering strength of sound from ascending gas bubbles in lake waters. These surveys revealed an intense CO₂ degassing by numerous sub-lacustrine fumaroles with about 60% of the lake's floor degassing. The analyses of the echograms show that a majority of the gas bubbles rising to the surface completely dissolve in the lake waters.

A miniaturized NDIR CO₂ gas analyzer used for the first time for volcanic lake monitoring recorded high concentrations of free CO₂ dissolved at the surface (10-20 cm depth) of MCL lake with 32-34 vol.% in January 2011 and 13-15 vol.% in January 2013 and shows that the lake surface waters are highly CO₂ supersaturated with respect to the atmosphere (above mean values correspond respectively to 428mg/l of dissolved CO₂ for 2011 and 181mg/l for 2013). The period of January -June 2011 was characterized by a high seismic activity and elevated CO₂ flux of around 3000 T/day much higher than the background values of 650 T/day. The dissolved CO₂ concentrations measured by the NDIR sensor are almost constant throughout the lake area (1.2 million m²) varying within a narrow range of values contrary to gas fluxes measured with the floating accumulation chamber.

The large temporal variations observed in CO₂ flux and dissolved concentrations suggest that CO₂ is a very sensitive indicator of activity at Taal volcano compared to other lake's parameters that remained almost constant during the period 2011-2013 (i.e. temperature, pH, chemistry). Contrary to sulfates and chlorides (and other solutes) which are largely conservative species in the lake waters; dissolved free CO₂ has a more dynamic behavior in the lake (much like temperature). Its concentration reflects a steady-state balance between CO₂ supplied to the lake by hot springs (in a dissolved form) and by direct degassing and CO₂ lost by diffusion at the air-water interface. So, it is surprising that free CO₂ is almost never determined in acidic volcanic lakes.

A test experiment of continuous monitoring of dissolved CO₂ with the NDIR sensor started in January 2013. This research is made within the framework of a PHIVOLCS-EMSEV cooperation program.