Risk Assessment for Future Geologic Sequestration Projects: Is the Lake Nyos Disaster a Valid Analogue?

Ian Duncan
Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin
ian.duncan@beg.utexas.edu

Keywords Risk analysis; CO2 transportation;

By far the largest catastrophic event attributed to CO2 occurred in August 21st, 1986 in a large village located by Lake Nyos. There is now a scientific consensus that the gas outburst at Lake Nyos was related to the rapid expulsion of a CO2 dominated gas from a chemically stratified lake. A number of estimates of the amount of CO2 emitted during the eruption are shown in Table One. The consensus of the more robust estimates is that between 1.2 and 1.6 million metric tons of CO2 were released in the event, killing 1,746 people. It has been suggested that the "Lake Nyos incident offers a vivid image of the catastrophic effects of CO2". The Lake Nyos disaster has become the focus for those most vocal groups opposed to implementation of CO2 sequestration in deep brine reservoirs.

The Lake Nyos area is remote with very limited access to medical facilities. As foreign scientists and medical personnel arrived over a week after the incident and all the victims of the event had been buried. As a consequence no proper autopsies were done and limited information is available on the appearance of the corpses or medical nature of the deaths. Although the medical teams reported no definitive evidence of cause of death, they did note that many victims had prominent skin bullae (blister like features) or has succumbed to comas, and that neither of these prominent symptoms. The US medical team concluded that "doubt must remain that all the findings can be attributed to [CO2] alone".

Evaluation of the symptoms documented in medical from the foreign scientific expeditions to Lake Nyos by medical experts on gas poisoning lead to a conclusion that the Lake Nyos victims died from Carbon Monoxide poisoning. Allough these assertions have been dismissed by geologists studying the Lake Nyos event, their reasoning appears flawed. A plausible model for the causative agents for the Nyos disaster was a combination of CO2 (quite possibly at non-lethal concentrations), reduced oxygen, and CO. This interpretation, together with the magnitude and circumstances of the release, has significance for risk considerations regarding CO2 sequestration. Mixed gases are known to be deadly at concentrations at significantly lower than the lethal levels of either component alone. Perhaps the real lesson of the Lake Nyos incident for carbon capture and storage is to draw attention to the inherent danger from mixtures of toxic gases. For example mixtures of H2S with CO2 will increase the toxic effects of H2S. The risk profile for a sequestration project changed a decision is made to inject mixed streams of gas such as CO2 + H2S rather than essentially pure CO2.

Perhaps the most important aspect of the Lake Nyos incident is the exceptionally large quantity of CO2 that was abruptly released in the incident. The exact quantity is uncertain however there is a consensus view that it amounted to between 1.0 and 1.6 million metric tons of CO2. In the context of CO2 sequestration this minimum amount of CO2 corresponds with

approximately four months emissions from a 275 MW FutureGen type IGCC or over a month of CO2 captured from a large, but not atypical, 1000 MW coal fired power plant. This volume of CO2 is also equivalent to weeks or months of gas that would be transported in the largest pipelines contemplated for a future sequestration project.

What is the likelihood that CO2 sequestration brine storage sites will be located in an area that has that could create the physical conditions necessary to have a Lake Nyos type disaster? A review of the limnology literature suggests that deep, stratified lakes similar to Lake Nyos both exceptionally rare and readily identifiable. Most lakes overturn on an annual basis. Overturning disrupts physical (density) layering in the lake and tends to mix the different water chemistries that evolve in stratified lakes.

The only reasonable conclusion from the evidence is that there is essentially no reasonable possibility that sequestered CO2 could accumulate in a lake without equivalent properties to Lake Nyos. This paper will argue that there is no credible mechanism for creating a CO2 release in any way similar to the Lake Nyos other than trapping in a deep, stratified lake. Perhaps a more useful analogy between natural CO2 seepage and the worst-case scenario for leakage from CO2 sequestered in deep brine reservoirs is provided by the volcanic/geothermal terrains in Italy, the Azores, and Africa. In this paper the available information and analysis of the presumed CO2 releases at these sites and the related deaths are reviewed and the implications (if any) for evaluating the risk posed by either slow or rapid leakage from CO2 sequestration are considered.