Impact Assessment of Lake Nyos Eruption on Nigeria: "Prevention and Control" – An Overview

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Abstract: In this work, impact assessment of lake Nyos eruption was considered at 100km radius of the eruption dominantly Nigeria away from Lake Nyos. Also prevention and control measures were proffered to minimize possible hazards from future eruption and to avert danger of possible collapse of the natural dam formed from accumulation of water in the vent or crater left behind in previous eruption. To allay fears of the possible threat Lake Nyos posses to its neighbourhood, Northern Cameroon and Nigeria, this study becomes extremely important by ensuring appropriate mitigating and future disaster averting plans.
[Adetoyinbo A.Adedeji ,Adewole O.Olukorede. **Impact Assessment of Lake Nyos Eruption on Nigeria: "Prevention and Control" – An Overview.** World Rural Observations 2010;2(4):13-18]; ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural.

Keywords: Impact assessment, Eruption, Stratification, TLD, Asphyxia, Degassing.

1. INTRODUCTION

Lake Nyos is a crater lake located in the North West province of Cameroon adjacent to Nigeria, 100km away in West Africa. It lies on longitude 6.44^0N and latitude 10.30^0E and elevation 10, 486 (3,035m), Fig. 1.

Nyos is a deep lake high on the flank of an inactive volcano near Mount Oku at the Northern part of boundary of Cameroon volcanic line, a zone of weakness and volcanism that extends to the Southwest through the Mount Cameroon stratovolcano.

Lake Nyos fills a roughly circular mear in the Oku volcanic field, an explosion crater when a lava flow interacted violently with ground water. The mear is believed to have been formed in an eruption about 400years ago. The area has been volcanically active for millions of years after South America and Africa were split apart by a plate tectonics about 100million years ago.

West Africa also experienced rising although to a lesser degree, which is prominent in the MBERE Rift Valley. Crustal extension has allowed magma to reach the surface along alien extending through Cameroon, Mount Cameroon lies on the fault line. Lake Nyos is surrounded by Old lava flow and pyroclasic deposits.

A sublacustrine source introduces warm, salty and CO_2 enriched water into the deepest part of the water column (Nojiri *et al,* 1989,1993,Evans *et al,*1993,Kusakabe, *Tanyileke,1*994, 2000) which leads to a chemocline in the deep water.

One prominent characteristic of Lake Nyos is the permanent stratification of the water column. The source water (hypolimnion) is heavier than the hypolimniotic.

A prominent characteristic of Lake Nyos due to the sublacustrine is the permanent stratification of the water column in the hypolimnion which is not affected by seasonal convection unlike the upper section, eplimnion which is convectively mixed every year in the dry season.

The contribution of CO_2 to the stratification is much larger than that of TDS (total dissolved solids including carbonates and other salts as well as silica but not CO_2). Such stratification, with a stabilizing and destabilizing effect can lead to convective layers by double-diffusion (Turner,1973,2004), if the effect of the stabilizing component is not more than 10 times as large the destabilizing effect of temperature (Kelly *et al*, 2000).

Water holds 15 times its own volume of CO_2 at a depth of 200m. Estimation indicates that every litre of water in the lower part of the Lake have between 1 to 5 litres of CO_2.

Several other processes assumed as the trigger of the eruption include, local supersaturation of CO_2 caused by a barachinic uplift of the water column triggered a self-amplifying plume within the water column (Evans *et al,* 1994). Others comprises a landslide (Kling *et al*, 1987), convection due to heavy rainfalls (Galbriath, 2002) and a bubble plume rising from the Lake bottom (Treath and Kay, 1987) have been suggested as the possible cause of the uplift.

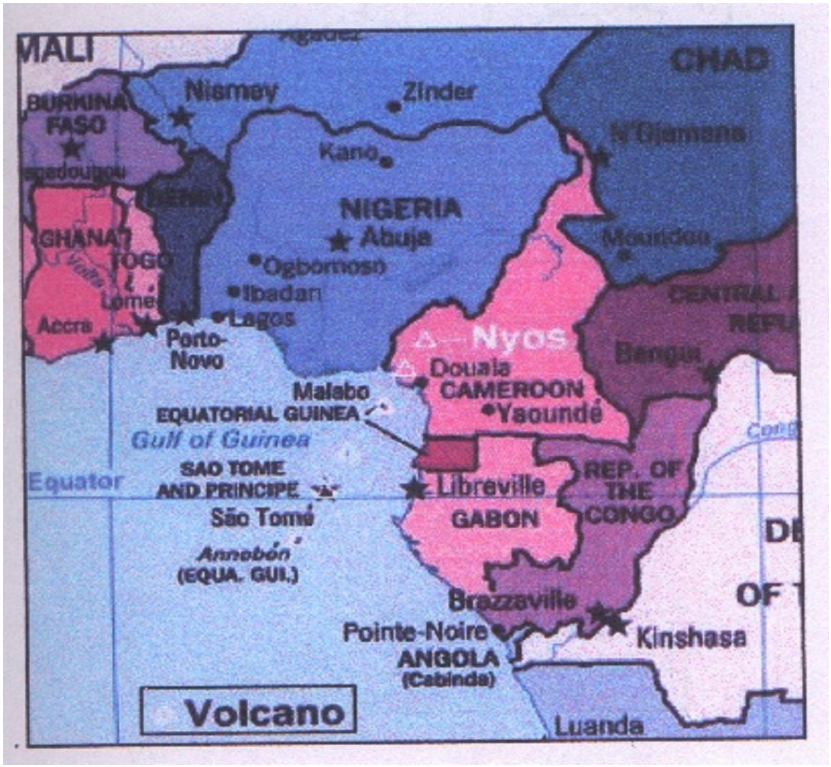

Figure 1

2. MATERIALS AND METHODS

The impact assessment of Lake Nyos eruption on Nigeria situated in Cameroon in the North Province has been examined. Nigeria lies 100km radius of the Lake Nyos eruption, thus necessitated this study on the impact assessment of the terrifying volcanic eruption and expulsion of gases especially CO_2 from Lake Nyos coupled with the anticipated collapse of the Natural dam formed by the crater left behind by previous eruption.

Mainly, data available on the Lake Nyos eruption have been gathered and analyzed, principally delineating the effect of the eruption and discharged gases on the animal population, infant, adult and livestock with vegetation and indicating the death and health related problems within different distances from the event zones.

Having come this far, this study will go a long way to increase consciousness allay of teeming Nigerians on the impact of Lake Nyos on the environs. Future work and investigations could be fostered towards averting where necessary, and minimizing any potential catastrophe Lake Nyos eruption and its natural dam might cause by unveiling appropriate mitigating and precautionary plans as ways of allaying fears.

3. RESULTS AND DISCUSSION

The hazards resulting from volcanic eruption are due to the materials ejected during the eruption and on the volcano type, Lava type, climate, topography and population density. The hazard causing materials of volcano eruption comprised the following; Lava flows Tephra falls, Nuees Ardentes, Lahars, Poisonous gases (Lake Nyos), even radiation energy.

The most abundant gas release during volcanic eruption is water vapour followed by carbon-dioxide, and the estimate of volcanic gases released is shown in Table 1 below (from Symonds, *et al*, 1994).

Table 1: The estimate of volcanic gases

Volcano Tectonic Style	Kilauca summit Hot Plate	Erata' Ale Convergent Plate	Momotombo Divergent Plate
Temperature	1170^0C	1130^0C	820^0C
H_2O	37.1	77.2	97.1
CO_2	48.9	11.3	1.44
SO_2	11.8	8.34	0.50
H_2	0.49	1.39	0.70
CO	1.51	0.44	0.01
H_2S	0.04	0.68	0.23
HCl	0.08	0.42	2.89
Hf	-	-	0.26

Volcanic gases are hazardous, rarely beyond 30km but have equally been noticed to reach 100km. some of the hazards associated with volcano eruption include *Asphyxia;* respiratory or heart problems, burns and paralysis due to the gases. Other hazards imminent comprise population displacement, burial of farmlands, animal and human population, roads, etc.

Volcano eruptions can also alter the climate of the earth for short and long periods of time. The eruption of Mount Pinatab in 1991, resulted to average global temperature drop by about a Fahrenheit for two years and the cold temperature caused crop failures and farming in North America and Europe for two years following the eruption of Tambora in 1815.

There is increasing evidence of global climate change (Watson, 1996). Over long period of time (thousands of millions of years) multiple eruptions of giant volcanoes, such as the flood is a salt volcanoes can raise carbondioxide levels enough to cause significant global warming. Although the long range consequences are hard to predict, more severe cyclonic storms, an increase in both flooding and drought, and a trend towards desertification cannot be ruled out. The secondary consequences of global climatic change could well result in new hazards, wild fires and mudslides, may become more frequent with increased drought and flooding. Also, stratospheric ozone depletions, a global climate change has caused increase in heat-wave related illness and death. New diseases may be produced, for instance alga blooms are now appraising frequently on coastal waters and have been found to harbor fibroid cholera, causative organism of cholera. Due to resulting rise in sea levels, health problems associated with deteriorating water supply and sanitation, loss of agricultural land and fishing grounds, and flooding.

Lake Nyos eruption is predominantly gases more especially carbondioxide. Gaseous hazards are not beyond 25km though notice beyond till 100km radius. Originally, the two states of Nigeria Taraba and Benue proximal to Cameroon were not vulnerably to any hazard or risk of Lake Nyos outbursts. The major cause of alarm in Nigeria is the natural dam of Lake Nyos which is anticipated may collapse as the dam do not satisfy engineering norms. The upper 40m of lake Nyos is bounded on the north by a narrow dam of poorly constructed pyroclastic rocks, emplaced during during the eruptive formation of the lake Nyos maar a few hundred years ago. The 50m wide dam is structurally week and is being eroded at an uncertain, but geologically alarming rate. The eventual failure of the dam could cause a major flood, estimated peak discharge, 17,000 cubic meter per second, Lockwood et al, 1988. The collapse of the natural dam could lead to devastating flood up to 50 million cubic metres of water affecting downstream as far as Nigerian states of Taraba and Benue, homes to more than 10, 000 people.

Table 2. Carbon dioxide concentration variation effect

Distance from Event Zone	CO_2 Conc.	Effect on Animal Death and health Problems			Effect on Vegetation
		Infant	Adult	Livestock	
0km – 5km	90%	630	220	1, 100	Heavily 95%
6km – 10km	83.5%	370	190	980	Heavily 87%
10km – 15km	78.3%	68	202	160	Heavily 68%
16km – 20km	50%	13	57	600	Mild 48%
21km – 25km	22.7%	6- death 27-health	27 death 400 health	280	Mild 30%
26km – 30km	40%	Health Problem 51	7 death 259 health	380	Mild 15%
31km – 35km	0.65%	9	99	-	No effect
36km – 40km	0.60%	-	-	-	No effect

The table clearly indicates that effects of volcanic eruption are greater at distances close to the volcanic event zone compared to those noticed at larger distances often beyond 25Km radius of the event zone. The carbondioxide (CO_2) is optimum within 5Km of the event zone specifically 90% but decreases almost with a linear trend beyond event zone of 5Km and almost zero at 40Km event zone.

Lake Nyos and Mammoth Mountain in California are two well known underground release of carbondioxide (CO_2) in nature. The release carbondioxide is volcanic in origin (magmatic origin). Wide volcanoes release 130 million tons of CO_2 into the earth's atmosphere. Though water vapour is the primary volcanic gas, but CO_2 can accumulate for nearly half the entrained gas in certain formations. The expansion of the entrained gases force the magma to move faster in aspirating effect, the expanded gases give volcanoes most of their power.

Obviously from this discussion, and schematics with vivid evidences illustrated, Nigeria is not prone to hazards of volcanic gaseous eruption. However, due to proximity of the two Nigerian states; Taraba and Benue with Nigeria within 100km radius to the Cameroon province, the natural dam due to lake Nyos should be investigated and certified safe in the nearest future. The main fear is the volume of water that may eventually cause flooding in this region. Katsina Ala, a town in Nigeria is prone to sudden flood surge down (Freeth et al, 2000).

Considering the impact of Lake Nyos, apart from the gaseous and volcanic eruption, it is anticipated that an event zone within 100km like Nigeria and neighbouring towns of Cameroon could be prone to serious flooding disaster in the nearest future. To avoid possible catastrophe, Lake Nyos has to be visited having identified possible disasters, presently gaseous build up from previous eruption and possible eruption with dam collapse.

Peradventure, man is often ready to take risks to occupy areas or regions previously affected by natural or physical disaster for reasons dominantly economic. The complete prevention of disasters is only feasible by complete elimination of people susceptible and vulnerable to hazard by evacuating hazard zones, providing complete protection from hazards or preventing the physical hazard altogether. This seems practically unrealistic and rarely achieved.

Mitigation hazards are often aimed at reducing the impact of future hazard events and reduction of vulnerability and susceptibility to high-risk group, but not eliminating completely. The best often achieved is reducing the potential impact of emergencies and disasters.

Mitigation actions/plans include diversion of lava flow by construction of barriers, explosives, cooling lava fronts with water. For lahars, the only prevention and mitigation mechanism is the evacuation of people and property.

4. CONCLUSION

At present, there is no absolute means of preventing an eruption thus the best that could be done practically is to install effective mitigation actions/plans. Computer modeling is also used to predict eruptions and can even be used to estimate the primary products of a volcano. In the catastrophic event of Lake Nyos, Cameroon, West Africa, other mitigating process proffered are; Degassing, Dam reinforcement, Gas sequestrations etc, this is to avert future re-occurrence of such event in Cameroon and its neighbouring countries particularly Nigeria.

Although it has been ascertained that hazards of volcanic eruption do not go beyond 25Km even though gaseous eruption are noticed 100Km radius of the event zone. Thus to allay the fear of Nigeria being a vulnerable and danger prone zone, certain mitigating and disaster averting precautions should be ensured.

The following solutions are proffered to alleviating and minimizing disasters possible due to Lake Nyos eruption and the natural dam; to reduce the gas level to tolerable level, more pipes should be installed. Four more pipes could reduce the carbondioxide concentration to 99% by 2010. Further more, the dam should be reinforced to avert future catastrophe within 100km especially neighbouring countries; Nigeria which is prone largely to threat of erosion or flooding; of the lake downhill and direct intrusion.

The project is finance intensive. It is expected that Nigeria should join and intensify the vanguard for reinforcement of the dam to avoid imminent threat posed.

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11/28/2010