TerranearPMC Safety Share

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Week of September 30, 2019 – Carbon Dioxide

Carbon dioxide is classified as a simple asphyxiant. That is, it is non-toxic and unlike other materials such as hydrogen sulfide, hydrogen cyanide and its closely molecularly-related substance, carbon monoxide – all classified as chemical asphyxiants - it will not chemically interact with our respiratory system, causing our body's inability to absorb oxygen into our blood stream or prohibit its use on a cellular level: all resulting in an almost instantaneous death by suffocation. Nevertheless, as a simple asphyxiant, CO_2 can displace air, causing the same serious suffocating effects.

So, practically speaking, CO_2 really doesn't warrant much of a S&H concern; agreed? Well, not quite. Let's say you have a few CO_2 cylinders in a control room where instrumentation is actuated through pressure supplied by the cylinders. Or, we just have CO_2 cylinders stored in a small room – let's say a room with dimensions of 10' x 10' x 8'…. That's 800 cubic feet (ft^3). A typical compressed gas "K-bottle" contains its gaseous material that when released, will occupy a volume of over 200 ft^3. So, four bottles would effectively fill the entire 800 ft^3 room. And therefore, should a leak occur in the valve that controls the gas flow, the room would have CO_2 displacing the rooms' air. Thus, an unsuspecting person entering the room would – upon first breath – succumb to the environment's lack of oxygen. The National Institute for Occupational Safety and Health (NIOSH), has established an "Immediately Dangerous to Life and Health (IDLH)" for CO_2 at 40,000 ppm or 4%. So, a complete displacement of air would certainly be potentially dangerous. This was the concern during the now-famous Apollo 13 space voyage to the moon (made famous by the movie of the same name that stars Tom Hanks) where CO_2 was building up in the space craft due to the astronaut's exhalation.

These are feasible scenarios, and, as a result, many facilities that have compressed gas cylinders, have O_2 monitors to warn personnel when there is a possible displacement of breathing air.

One of the most devastating events involving CO_2 build-up occurred not that long along and is presented below.

It was on August 21, 1986, when a mysterious event occurred. It was in the village of Lower Nyros in the African nation of Cameroon. The day was rather typical with people spending their time at the market place where a variety of food and goods were being bought and sold. That evening the villagers went to sleep and in the morning over 1700 people and approximately 3500 domestic animals were discovered lying on the ground, dead.

Lake Nyos is located along the Cameroon Volcanic Line (CVL), a 950-mile long chain of volcanoes and volcanic crater lakes extending from the Gulf of Guinea into Cameroon and Nigeria. The origin of the CVL is still not completely understood. It is possible that during the breakup of Africa from South America some 150 million years ago, a third rift started to develop, but failed to become an oceanic basin like the Atlantic Ocean. Today, the only active volcano of the CVL is Mount Cameroon. However, there is still a large magma chamber found at a depth of 50 miles under the CVL. From this magma chamber, large quantities of gases are continuously released. Following the fault lines, gases flow into the crater lakes or maar lakes, as collapsed volcanic craters are filled by water.

Volcanic gases, in this case, CO_2, originating from the ground, beneath the lake became more and more concentrated. Just prior to the devastating event, the level of the lake dropped by about a meter and trees near the lake were knocked down. Geologists are still not sure why the cap of warm water, holding the gases on the bottom of the lake, dissipated that night. Perhaps an earthquake or volcanic eruption on the bottom of the lake disrupted the water stratification. This may explain what some residents described as they heard a rumbling noise from the vicinity of Lake Nyos just before the catastrophe. Another theory for the disruption of the lakes' stratification involved cool rainwater possibly falling on one side of the lake that, in turn, triggered a landslide that resulted in large amounts of mud falling into the lake. Whatever initiated the gas-rich water from the bottom of the lake to reach the surface, the result was an estimated 1.6 million tons of CO_2 emanated from the waters, forming a 160 feet thick layer of the gas above the lake. The cloud – having a density greater than air - traveled as far as 15 miles from the lake into the surrounding valleys. At a concentration of 6 to 8 percent CO_2, there existed a scenario of causing immediate unconsciousness and death to those in the community. Some survivors later reported a strange smell (most likely from sulfur gases; also associated with volcanic activity) along with seeing what they described as a white-translucent cloud approaching while family members who suddenly and without apparent cause collapsed. The strange smell could have been sulfur dioxide or hydrogen sulfide – both extremely toxic. However, CO_2 was the only gas detected in samples of lake water, suggesting that this was the predominant gas released and as such, the main cause of the incident

Scientists concluded from the evidence that a 330-foot column of water and foam formed at the surface of the lake, spawning a wave of at least 82 feet that swept the shore on one side.

Carbon dioxide has a density of 1.98 milligrams per cubic centimeter (mg/cm^3) while air's density is 1.23 mg/cm^3. This means CO_2 is 1.67 times dense, thus causing the cloud to remain close to the ground, displacing breathing air which hovered above the layer of CO_2. This means the local population had no air to breath. The cloud mass was about 160 feet thick, and travelled downward at 12–31 mph. For roughly 14 miles, the gas cloud was concentrated enough to suffocate many people in their sleep in the villages of Nyos, Kam, Cha, and Subum. About 4,000 inhabitants fled the area, and many of these developed respiratory problems, lesions, and paralysis as a result of the gas cloud.

Carbon dioxide is part of the Earth's environment, consisting of a concentration of 0.04%: that's equal to 400 ppm. Therefore, it is a natural substance that is part of our normal lives. Yet, like many other "naturally occurring materials" – such as radon gas, asbestos, and beryllium, when encountered in high concentrations or allowed to be present without any assessment to determine how these materials may affect us, unforeseen and quite possibly unfortunate consequences may happen.

Liberty cannot be preserved without general knowledge among the people - John Adams