

Lake Pleasant Carbon Monoxide and Watercraft

Potential health effects of carbon monoxide exposure

Carbon monoxide is an invisible, odorless, and tasteless gas that results from incomplete combustion of carbon compounds (e.g. gasoline). People have no perceivable way to know that they are in danger of carbon monoxide poisoning. The hemoglobin in our blood prefers carbon monoxide (240 times greater) to oxygen. The best prevention is simply to minimize exposure to engine exhaust. Table 1 shows the expected health effects associated with amounts of carbon monoxide in the blood (COHb).

% COHb	Symptoms
< 5%	None
5-10%	Slight headache, decreased exercise tolerance
10-20%	Shortness of breath on exertion, headache
20-30%	Throbbing headache, mild nausea, some impaired judgment
30-40%	Severe headache, nausea and vomiting, impaired judgment
40-50%	Confusion and brief loss of consciousness
50-60%	Fainting, coma, seizures
60-70%	Coma, seizures, cardio respiratory depression, death
>70%	Failing hemodynamic status, death

The above chart identifies symptoms for the average person, and not the more sensitive members of our population which would include; those with respiratory or cardiac disease, those on medications that affect the functioning of the heart or lungs, heavy smokers, children who are normally more physically active (increased respiratory rate) and have less body mass (than adults), and finally pregnant women. Those who can identify with these *more sensitive* groups need to exercise greater diligence in keeping their distance from engine exhaust.

Background

Until recently carbon monoxide poisonings were thought to occur in enclosed, poorly ventilated areas. However, open-air cases of poisoning have recently been reported including exposures from exhaust from various kinds of watercraft including houseboats, cabin cruisers and ski boats. Unlike automobiles, boat engines do not have mechanisms such as catalytic converters, to reduce carbon monoxide emissions.

Previous studies at Lake Havasu and Lake Powell, combined with other national data indicate that carbon monoxide poisoning from recreational watercraft can create a significant health hazard. The United States Coast Guard has issued warnings to all boat

owners concerning the potential for carbon monoxide exposure and the risk of severe injury and death.

During the summer months, especially weekends and holidays, Lake Pleasant draws large numbers of boaters. Humbug Cove, at the north end of the lake, is a popular location for boaters to meet. The density of watercraft and the large numbers of people gathering at Humbug Cove creates an environment for individuals to become exposed to excessive carbon monoxide emissions.

In 2003, the Arizona Department of Health Services (ADHS) assessed the health risk from carbon monoxide poisoning at Lake Pleasant and based on the data collected, concluded that there was *No Apparent Public Health Hazard*. The study found that human exposure to carbon monoxide may be presumed, however the levels of exposure were not expected to cause adverse health effects (based on observed levels of carboxyhemoglobin). In 2003, investigators, who were accompanied by Peoria Police officers, invited boaters around Lake Pleasant to participate in the study. Most of the volunteers were found at the 10 lane boat ramp, the 4 lane boat ramp, or other wide open, flat areas of the lake. When boaters in Humbug Cove were invited to participate, most declined, because they were uneasy about ADHS' intentions. Many had been consuming alcohol, and they were suspicious that the breath test for CO poisoning was actually testing for alcohol.

The current study was designed not to repeat the 2003 study. Instead, it was designed to explore the potential health effects of carbon monoxide under the conditions of Humbug Cove. Humbug Cove is known for congregating idling boats, higher frequency of alcohol consumption, and being a location that was secluded and sheltered from breezes or wind.

Methods

The ADHS returned to Lake Pleasant, during the 2006 Fourth of July holiday weekend, to conduct additional investigations. Unlike the investigation done in 2003, this most recent study was performed at Humbug Cove. Humbug Cove is more protected from wind and natural ventilation. It is located at the far north end of the lake. This cove is a popular place for boats to gather, according to the park police. The shoreline along Humbug Cove is rugged and provides little opportunity for boaters to come ashore. Boaters typically socialize by congregating in large groups, often with engines running. Many of these watercraft are equipped with electric appliances (refrigerators, blenders, stereo systems, etc.), so idling of engines to produce electricity is relatively common.

The ADHS and the Peoria Fire Department teamed up to complete this study. The study involved setting up ambient air monitors, identifying participants, having the participants complete questionnaires, and lastly take a measurement of the participants' carboxyhemoglobin levels (the amount of carbon monoxide in the blood).

Air Monitoring

A Scott/Bacharach Carbon Monoxide Sniffer (see appendix) was used to monitor the carbon monoxide levels in the air. The instrument was set up on the bow (front) of the boat. Whenever the investigator noticed elevated levels of CO (> 8 ppm), the time and concentration was recorded. If CO levels in the air exceeded 20 ppm, an alarm would sound, and the air concentration of CO was also recorded.

Questionnaires

An Arizona Department of Health Services investigator and two firemen from Peoria Fire Department (Station 199 located on Lake Pleasant) administered a short questionnaire while carboxyhemoglobin samples were collected and analyzed in the field. Participants were asked; whether they smoke, in what kinds of recreation activities they had been participating, and how many hours they had been recreating in the area. The investigator did not collect personal identifiers. A total of 15 individuals participated in this study at Humbug Cove.

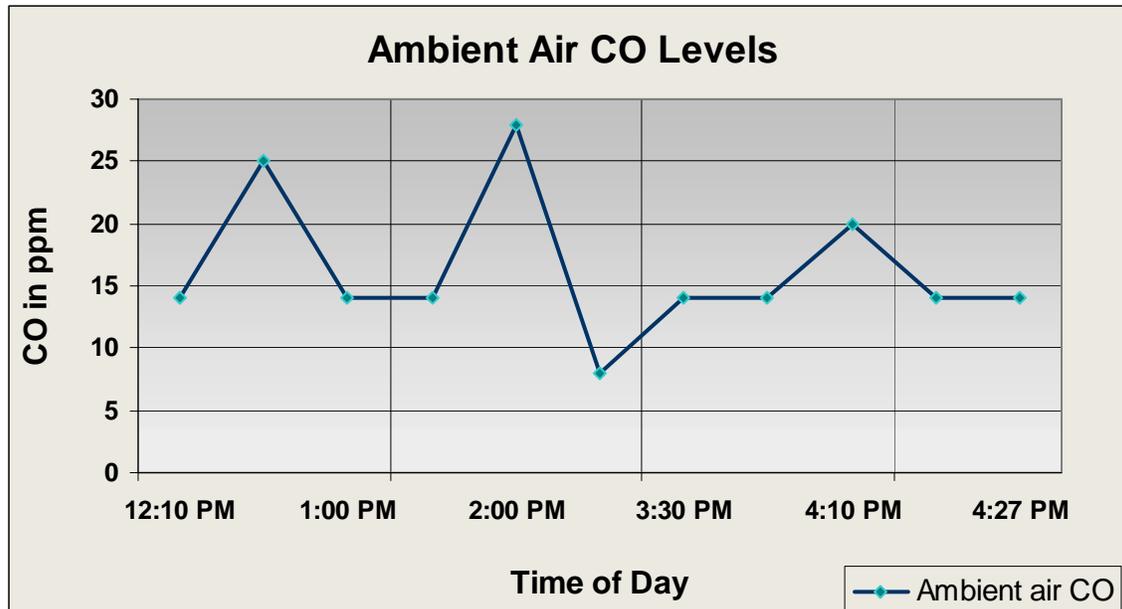
Carboxyhemoglobin Levels

The concentration of carbon monoxide in the blood (also called carboxyhemoglobin levels) was examined using two different methods. The Pulse CO-oximeter (Rad-57) (see appendix) was used by holding a probe against a person's finger. The instrument read the carboxyhemoglobin levels in that person's blood without actually drawing any blood or pricking the finger. A second method used to determine carboxyhemoglobin levels was with an instrument called Bedfont ToxCO. This instrument is administered much like a breathalyzer and is able to measure the carboxyhemoglobin levels by analyzing the person's exhaled breath. The module included an internal mechanism to ensure that ethanol did not interfere with the analytical results.

Results

Air/weather

The high temperatures on the July 4th holiday weekend ranged from 103 to 108°F, and no rain or wind was noted. The air monitor's alarm sounded eleven times. The levels of carbon monoxide recorded ranged from 8 to 28 ppm. The Environmental Protection Agency (EPA) has adapted the National Ambient Air Quality Standards (NAAQS) for carbon monoxide for both an 8-hour average (9 ppm) and a 1-hour average (35 ppm). These standards are intended to be protective of sensitive populations such as asthmatics, children and the elderly. The graph below shows eleven point measurements of CO in the air. They are not a time-weighted average, so caution must be used when comparing the CO levels measured at the lake with the NAAQS. Also, NAAQS are designed to be protective of long-term / chronic (months to years) exposures and associated potential health effects. Exposure at the lake is typically very short term (most people surveyed had only been at the lake 2 hours). However, it should be noted that the ambient air CO levels never exceeded the 1-hour NAAQS for carbon monoxide (the highest level of CO measured in the ambient air was 28 ppm).



Carboxyhemoglobin Levels

With just 14 subjects participating in this study, caution must be used when drawing conclusions. Four (4) of the fourteen (14) subjects had carboxyhemoglobin levels high enough to potentially elicit minor health effects (slight headaches and decreased exercise tolerance). None of the participants' carboxyhemoglobin (COHb) levels were elevated to a point to where medical attention would be recommended (see Table 2).

Table 2: Carboxyhemoglobin levels vs. time spent at the lake

Hours spent at lake	1	2	3	4	5
Range of COHb	1% (N=2)	1-10% (N = 6)	1-7% (N = 3)	1% (N =2)	1% (N =1*)

* The one individual that was at the lake for 5 hours had been camping at the lake for four days, and the carboxyhemoglobin test was administered at 10:30 in the morning.

Conclusions

The combination of drinking alcoholic beverages, smoking, and breathing carbon monoxide will significantly impair one's judgment and increase the risk of unintentional injury to the individual and those around him/her. Add exposure to the sun and heat to the mix, and the risk of injury and adverse health effects increases even more.

Boating in a confined area such as Humbug Cove increases the chance for carbon monoxide intake and therefore, increases the danger for adverse health effects due to carbon monoxide. This study has shown that spending even as little as 2 hours in protected areas of the lake can contribute to carboxyhemoglobin levels in the blood elevated enough to cause noticeable health effects.

Studies previously performed by the ADHS and the US Coast Guard have adequately demonstrated the dangers of carbon monoxide exposures at other Arizona lakes (Lake

Havasu and Lake Powel). The ADHS continues to encourage individuals to limit their exposure to carbon monoxide while swimming, boating, or otherwise recreating at lakes.

The local fire departments and county health departments have also been spreading the word to help prevent any further injuries due to carbon monoxide exposure. ADHS will continue to perform periodic monitoring of carbon monoxide levels in both the ambient air and blood samples from volunteers visiting Lake Pleasant.

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Appendix

Rad-57™
Pulse CO-Oximeter™



Bedfont ToxCO monitor:

