Hidden dangers

Contaminated water diving: the risks divers don't want to acknowledge

Steven M Barsky

Many commercial divers are unaware of the dangers of diving in polluted water. Some bodies of water don't appear polluted, yet have high levels of biological or chemical contamination. In other environments, divers sometimes mistakenly believe that the water itself will dilute the hazard to a low level. In both settings, divers can be dead wrong.

The same hazardous materials that concern haz-mat personnel topside should concern divers underwater. These hazards include biohazards, toxic chemicals, and radiation. However, the situations that divers encounter these hazards in underwater are very different from those on the surface.

The main difference in dealing with a hazardous material underwater is that in many cases, the hazardous material floats in the water around the diver. This means that unless the diver equips himself properly, the material may enter the diver's mouth through the regulator in his helmet. It may also get in his eyes through leaks in a band-mask hood or a helmet's neck dam, and touch his skin through his wet suit. Compare this to a liquid spill topside, where the chemical puddles in the street, and it's easy to appreciate the increased risks.

Toxics that float on top of the water, such as gasoline, also present a serious hazard to the diver. The diver must pass through them to dive or exit the water. Substances that sink in water are those most likely to collect as pockets of pure chemical substance on the bottom. Concentrated chemicals are obviously very hazardous.

Aside from the risks, the biggest problem in contaminated water diving is that many divers don't want to acknowledge the dangers present at the sites where they dive. Conceding that these risks are present means that they must be dealt with intelligently and many divers don't want to make the effort or spend the money to take the proper precautions. Over the short or long term, such disregard can have fatal effects.

Biological pollutants are the most common

Biological pollutants are probably the most common form of hazardous materials encountered by divers. Three main classes of biological contaminants are of concern to divers. Bacteria are single celled creatures that exhibit characteristics common to both plants and animals. Protozoans are single celled animals. Viruses are organisms that take over the chemistry of a host cell in living creatures to reproduce themselves.

Faecal coliforms are a disease-producing bacteria found in human and animal faeces. They are universally present in the water wherever there is raw sewage, or inadequate sewage treatment. The maximum safe level of this organism is considered to be 200 organisms per 100 milliliters of water. Swallowing water that contains faecal coliforms can produce severe, disabling diarrhoea. It might not kill you, but it will result in lost time from work.

Whenever heavy rains fill storm drains and cause waste treatment plants to exceed their capacity, millions of gallons of raw sewage spill into nearby waterways, sometimes closing beaches for several weeks. Such occurrences are common throughout the United States and other countries.

A commercial diver who dives in a waterway that contains high numbers of faecal coliforms should be equipped with the right equipment. Ordinary commercial diving gear is usually not enough. In the United States, even many public safety divers (fire, sheriff, police) now wear vulcanized rubber dry suits and full-face masks or diving helmets for protection from biological contaminants.

If faecal coliforms are present, it's a safe bet there are probably several other forms of biological pollution as well. Other dangerous bacteria include cholera, *Vibrio vulnificus* and *Aeromonas hydrophilla*. Cholera is a good example of a bacteria that can survive in sea water.

Vibrio vulnificus is an extremely potent marine bacteria that can also cause death. It enters the body through the mouth or raw wounds. *Aeromonas hydrophilla* also infects open cuts in the body and is commonly found in harbour waters. *Aeromonas* infections have been fatal if not properly treated.

Like bacteria, many protozoans pose serious threats to divers. For example, eight different species of *Acanthamoeba* occur in polluted waters. This deadly single celled organism causes inflammation of the spinal cord, with death as the end result. *Giardia lamblia*, another protozoan, causes intestinal pain, diarrhoea, and high fever.

Today, there are almost no streams in even remote areas that do not contain *Giardia*. This comes as a result of the high number of campers and backpackers using these areas. It is unsafe to drink water from any lake or stream in these areas unless it is treated. It is equally unsafe to swim or dive in these waters and accidentally swallow any liquid.

One of the most commonly known viruses, Hepatitis type A survives outside the body in both fresh and salt water. In Hepatitis A, the subject's liver will become inflamed. Like other disease producing organisms that spread through contact with raw sewage, hepatitis can be found in faecal matter.

Chemical hazards

When divers think of hazardous materials emergencies, they often think about accidental spills of toxic chemicals. However, in many situations, divers also face serious threats from low level, long term pollution of waterways. Less obvious threats lurk in the form of pesticides and fertilizers that have drained into irrigation ditches or even water traps on golf courses.

A chemical hazard commonly found in all harbours and marinas is the variety of residues from boat bottom paints that have been used over the years. These bottom paints were designed to kill or inhibit the growth of marine life. They have been used on both large and small vessels. The same chemicals that discourage marine growth are hazardous to humans.

One of the primary components of these anti-fouling paints is an organotin compound known as tributyltin, more commonly known as "TBT". There are 20 TBT compounds; 9 are used in boat bottom paints.

TBTs dissolve into fats, giving them the ability to move across the membranes of living cells. This trait is what makes them effective in killing marine organisms, such as barnacles. TBT tends to collect in the silt found on the bottom of harbours.

Almost all the research that has been done on TBTs has concentrated on the effect of these chemicals on marine creatures. However, in a report by the Brookhaven National Laboratory in the US, they note that chemicals in this class have toxic effects on the human central nervous system, blood, liver, kidneys, heart, and skin.

More alarmingly, the scientists noted that while people react to a single acute dose of TBTs, repeated sub-toxic doses also produce negative reactions. This suggests a cumulative effect, where low doses keep adding up in a diver's body after repeated exposures.

Since many commercial dives take place in harbours, TBTs should be of concern to divers and dive supervisors, especially divers working on ship's hulls. A scientist for the US Environmental Protection Agency (EPA) has labelled TBT as the "*most toxic chemical ever deliberately added to the marine environment*". In 1988, the EPA banned the use of TBTs on non-aluminum vessels under 82 feet in US waters. Tributyltin use is restricted in some countries.

Although tributyltin breaks down in clear waters, it persists much longer in murky harbour waters. The by-products of TBT's decay are also harmful. It may be years after TBT is banned worldwide before it no longer can be detected in the marine environment.

PCBs (Polychlorinated biphenyls) also pose serious potential threats to divers. Although PCBs are now banned in many countries, they were widely used in electrical and hydraulic equipment, paints, plastics, and other compounds. PCBs still continue to pollute many sites and numerous divers have been exposed to PCBs.

Divers who work around wooden piers and wharves should also beware of the dangers of creosote. Many wooden pilings are treated with creosote to prevent wood decay. Creosote also discourages marine worms from boring holes in the pilings. Unprotected divers can get chemical burns from brushing against pilings that are coated with creosote.

Certain chemicals are so dangerous that no diver should consider working around them. These chemicals include, but are not limited to, the following:

- Acetic anhydride
- Acrylonitrile
- Carbon tetrachloride
- Chlordane
- Cresol
- Dichloropropane
- Epichlorohydrin
- Ethylbenzene
- Methyl chloride
- Methyl parathion
- Perchloroethylene
- Styrene
- Trichloroethylene
- Xylene

Blood, urine, and stool samples are recommended pre and post dive when divers expose themselves to specific known chemical toxins. In addition, tests of the divers' lung capacity are merited in cases where chemicals are known to affect the divers' breathing ability.

It's only in the last few years that the risks of diving in polluted water have been scientifically correlated with cancer in divers. Dr Elihu Richter, head of the unit of Occupational and Environmental Medicine at Hebrew University School of Public Health and Community Medicine in Jerusalem, was the principal author of a paper which detailed the chemical exposure of 682 Israeli Navy divers working in the Kishon River since 1948. The Kishon River is highly polluted with heavy metals and other contaminants.

Richter and his team found a much higher level of cancer in these divers than in other control populations. Exactly what caused the cancer in so many Israeli Navy divers is unknown, but there was a strong correlation between diving in the Kishon and cancer that cannot be explained by other causes. In the United States we have anecdotal reports of cancer among dive team members in San Diego and Michigan, but there have been no studies undertaken to establish a scientific cause and effect relationship between diving and disease in most parts of the world.

By far, the largest source of pollution in most places is what is termed 'non-point source pollution.' This is a combination of everything that washes into our rivers, streams, and oceans from all 'normal' sources, including tire dust from cars, leaking oil and gasoline, faecal matter from household pets, pesticides and fertilizers used in agriculture as well as personal gardens.

Radioactive hazards

Radioactive substances are most likely to enter the marine environment through industrial accidents. However, the possibility also exists that someday terrorists may dump radioactive material into a drinking water supply or a harbour. Of course, some divers work inside nuclear plants, but they are usually well protected due to stringent monitoring in these environments.

Thermal hazards exist too

Aside from the risks of exposure to hazardous materials, dry suits and helmets also create thermal hazards for the diver. These hazards are exactly the same as haz-mat personnel face topside. They include fluid loss, heat cramps, and heat exhaustion.

During the time the diver dresses in before the dive, and during decontamination, heat stress can be a severe problem. If the diver works in cold water, some of the heat stress will be relieved during the dive. Moving from very warm surface climates into cold water, and back to hot surface temperatures, is stressful in itself.

If the diver works in warm water there is no relief from heat stress. Overheating may be a very real danger. Commercial divers who work in warm waters should carefully evaluate these conditions and plan dives accordingly.

In extended contaminated water diving operations in warm weather the diver's physiology should be monitored. These include heart rate, body temperature, and weight. Measurements of these functions should be taken before and after diving.

Experiments have been conducted at the National Institute of Occupational Health, in Sweden, on the effectiveness of diver cooling using an ice filled vest. The divers in the study wore dry suits similar to those used for contaminated water diving.

Underneath the dry suit they wore a vest fitted with 46 small pockets, each of which was filled with a block of ice in a plastic bag. At water temperatures of 107 degrees F, the divers were able to complete dives that were 15-30 minutes longer when equipped with the ice filled vest. Further tests will need to be performed to determine safe exposure times for using such systems.

Selecting the right equipment for contaminated water diving

One of the basic tenets of contaminated water diving is to never dive unless you know exactly what pollutants are present. In reality, we know that many people do not take the time to find out what risks are present in the water. In certain circumstances, this could be fatal.

In order to protect yourself as fully as possible, the ideal combination of equipment is a vulcanized rubber dry suit with a mating helmet and dry gloves. Keep in mind that even with this gear, there is no one set of equipment that will protect you from all types of chemical hazards. There's also no gear that will protect you from strong sources of radiation.

Free-flow helmets are generally considered very good protection from contaminated water because a positive pressure is maintained inside the helmet. However, demand helmets can also be used successfully, provided the breathing system is equipped with a redundant exhaust system to help prevent a back-flow of contaminants in the breathing system.

The interface between the diving helmet and the dry suit is extremely critical. Ideally, the helmet should mate directly to the suit, quickly and easily. Yet, the connection must be positive and secure. The system should be designed so that few, if any, contaminants are trapped between the helmet and the suit when the two are separated after the dive.

Dry suits for contaminated water diving should be made from a material that has a smooth, non-porous outer surface. The material must not absorb or trap contaminants. For diving in biologically polluted water, vulcanized rubber dry suits are usually considered the best choice.

Dry glove systems consist of a set of cuff rings as well as the gloves (or mittens). The cuff rings come in pairs of inner and outer rings. The inner ring is machined from hard plastic. It goes inside the sleeve of the dry suit where the sleeve attaches to the wrist seal. The outer ring is made from rubber. It slips over the sleeve and compresses the suit over the inner ring. The dry gloves or mittens snap into position over the outer ring.

If you are planning a dive in a chemical environment, it is essential to know the chemical compatibility of your equipment compared to the substances you will encounter. Some manufacturers have produced chemical compatibility tables that will give you the acceptable exposure time, in minutes, for their equipment. 'Permeation time,' which is the time it takes for a particular chemical to make its way through a piece of gear at the molecular level, is an essential issue for you to evaluate.

Evaluating tables like these is the only way to make an intelligent decision whether the risks on a particular dive are acceptable or not. Less scrupulous manufacturers have published results for their products that rate chemical compatibility as ‘good’ or ‘acceptable.’ Information like this is NOT adequate to plan a dive in a chemically contaminated environment. (Note: Chemical compatibility tables are available from some manufacturers as well as in the book, *Diving in High-Risk Environments*.)

Keep in mind that your exposure time is limited by the ‘weakest’ piece of equipment you plan to use. Since helmets and suits are made from many different types of materials, you must evaluate your entire diving ensemble, including suit, regulator diaphragm, exhaust valve, dry suit zipper, umbilical, etc. Making the wrong decision could cost you your life.

It’s also important to remember that the chemical tests conducted by all testing agencies are always conducted on new, unused equipment. Diving equipment that has been previously exposed to other chemicals may fail unexpectedly.

Get the right training

Training for contaminated water diving operations is a complex process. There is no single expert on this topic. Instead, it takes the combined talents of many different people to put together a strong training program. Ideally, the staff for a training course in contaminated water diving would include a biologist, a chemist, a haz-mat specialist, and a commercial diver.

The critical points in the hands-on training for this type of diving include properly dressing and leak testing the diver’s gear, and learning the correct procedures for decontamination following the dive. Since tenders may also need to be protected from fumes or chemicals encountered while tending the diver, they will need to be trained in the proper use of personal protective equipment topside.

Acknowledge the risks

Diving always involves risks and can never be made 100% safe. However, you increase your risks when you refuse to recognize that certain types of dives entail additional risks beyond what’s considered “normal.” Take the time to educate yourself and develop a healthy scepticism so that you’ll be properly prepared the next time someone asks you to dive in a high-risk environment.

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