

## 1. PUBLIC HEALTH STATEMENT

This public health statement tells you about chlorine and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Chlorine gas is too reactive to be detected in environmental media at hazardous waste sites. Any chlorine gas released at these sites would be quickly converted to other substances whose primary source may or may not have been chlorine.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact. Since chlorine is highly reactive, you are unlikely to be exposed directly to it unless there has been a large scale accidental release in the nearby vicinity.

If you are exposed to chlorine, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

The subject of this profile is molecular chlorine ( $\text{Cl}_2$ ), which exists as a gas under normal environmental conditions or as a liquid when stored under pressure. Although molecular chlorine is used in some water disinfection processes, the resulting solution, commonly referred to as chlorinated water, does not actually contain molecular chlorine. Therefore, water disinfection and the chemicals present in chlorinated water, such as hypochlorite, are not the main focus of this document and are only discussed where relevant.

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## 1.1 WHAT IS CHLORINE?

<b>Chlorine is a gas with a very irritating odor</b>	It is very unstable and quickly reacts with many substances to form other chemicals.
<b>Used in manufacturing and water disinfection</b>	Chlorine is an extremely important industrial chemical that is used in the production of thousands of products.  It is also used for water disinfection, although the chlorine itself is quickly transformed into other chemicals at the beginning of the process.
<b>Chlorine gas is not present in chlorinated water</b>	A common misconception is that molecular chlorine (Cl <sub>2</sub> ) is present in chlorinated water. During water chlorination, molecular chlorine gas may be added to the water at first; however, the chlorine is quickly transformed into other chemicals, which actually disinfect the water. Hypochlorous acid and hypochlorite anion are two of these chemicals that disinfect the water.  The terms “free chlorine” and “aqueous chlorine” in drinking water usually refer to the amount of hypochlorous acid and hypochlorite in the water. It is important to recognize that these compounds are different from molecular chlorine.
<b>Bleach is not chlorine</b>	One of the important products that chlorine is used to make is bleach, and people sometimes confuse chlorine with bleach. Bleach contains a compound called sodium hypochlorite. If you mix acidic chemicals with bleach, chlorine can be formed and given off as a gas.

For more information on the sources, properties, and uses of chlorine, see Chapters 4 and 5.

## 1.2 WHAT HAPPENS TO CHLORINE WHEN IT ENTERS THE ENVIRONMENT?

<b>Chlorine is very unstable in the environment</b>	Chlorine is very unstable, and reacts with a variety of chemicals and water when it is released into the environment.
<b>Rapidly broken down</b> • Air  • Water	Chlorine is broken down by sunlight within a matter of several minutes.  Chlorine dissolves in water and is converted into chloride and hypochlorous acid.
<b>Chlorine can travel from its source</b>	If chlorine is spilled into water or onto soil or if it is released from a tank into the air, the chlorine will evaporate very quickly forming a greenish-yellow cloud that can be carried by the wind from the source.

For more information on chlorine in the environment, see Chapter 6.

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## 1.3 HOW MIGHT I BE EXPOSED TO CHLORINE?

<b>Most people are not expected to be exposed to chlorine</b>	Because chlorine is so reactive, it is not normally detected in the environment except for very low levels in the air above seawater.
<b>Accidental exposure to chlorine</b>	<p>You may be exposed through breathing, skin contact, and eye contact if an accident involving chlorine takes place nearby, such as a liquid chlorine spill, a leak from a chlorine tank, or a leak from a facility that produces or uses chlorine.</p> <p>You may also be exposed to chlorine if you mix household chemicals such as toilet cleaner with bleach.</p> <p>Hypochlorous acid is used to treat swimming pool water. You may be exposed to chlorine gas through the improper use of swimming pool chemicals.</p>
<b>Workplace air</b>	<p>People who work in places where chlorine is made or used may be exposed to low levels over a period of time.</p> <p>People may be exposed to high levels if a large amount of chlorine is released during an accident.</p>

For more information on human exposure to chlorine, see Chapter 6.

## 1.4 HOW CAN CHLORINE ENTER AND LEAVE MY BODY?

<b>Chlorine gas enters your body only when you breathe it in.</b>	<p>Chlorine gas can enter your body through your nose or your mouth.</p> <p>At low concentrations (less than 10 ppm), almost all of the chlorine is removed from the air in the upper part of the respiratory airways and only a very small amount may reach your lungs.</p> <p>If you drink hypochlorite solution, it may react with the acids in your stomach and possibly form chlorine gas.</p>
<b>Immediately reacts with other chemicals</b>	<p>Chlorine gas reacts with the water in the cells located in the surface of the respiratory airways and forms other compounds that produce irritation of the airways.</p> <p>Most of these compounds eventually are transformed into chloride ions, which are normal components of the body.</p>

For more information on how chlorine enters and leaves the body, see Chapter 3.

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**1.5 HOW CAN CHLORINE AFFECT MY HEALTH?**

This section looks at studies concerning potential health effects in animal and human studies.

The effect of chlorine on human health depends on how much chlorine is present, how you are exposed to it, and the length of exposure.

<b>Short-term exposure to chlorine in air</b>	<p>The following effects have been observed in humans briefly exposed to chlorine:</p> <ul style="list-style-type: none"> <li>• mild nose irritation at 1–3 ppm</li> <li>• eye irritation at 5 ppm</li> <li>• throat irritation at 5–15 ppm</li> <li>• immediate chest pain, vomiting, changes in breathing rate, and cough at 30 ppm</li> <li>• lung injury (toxic pneumonitis) and pulmonary edema (fluid in the lungs) at 40–60 ppm</li> <li>• death after 30 minute exposure to 430 ppm</li> <li>• death after a few minute exposure to 1,000 ppm</li> </ul> <p>The concentrations listed above are approximate; the effects will depend also on exposure duration. In general, people who suffer from respiratory conditions such as allergies or hay fever, or who are heavy smokers, tend to experience more severe effects than healthy subjects or nonsmokers.</p>
<b>Long-term exposure to chlorine in air</b>	<p>No significant harmful health effects were observed in workers exposed for years to relatively low concentrations of chlorine (around 1 ppm).</p> <p>The tissues inside the nose were principally affected in animals exposed to chlorine for longer durations.</p>
<b>Short-term exposure to hypochlorite solution by ingestion</b>	<p>Drinking small amounts of hypochlorite solution (less than a cup) can produce irritation of the esophagus. Drinking concentrated hypochlorite solution can produce severe damage to the upper digestive tract and even death. These effects are most likely caused by the caustic nature of the hypochlorite solution and not from exposure to molecular chlorine.</p>
<b>Long-term exposure to hypochlorite solution by ingestion</b>	<p>There is no information on long-term ingestion of hypochlorite solution in humans. Animals that drank hypochlorite solution in water for up to 2 years did not show any significant health effects. The amount of hypochlorite solution in the water that the animals drank was much smaller than what is found in household bleach.</p>
<b>Skin exposure to hypochlorite solution</b>	<p>Spilling hypochlorite solution on the skin can produce irritation. The severity of the effects depends on the concentration of sodium hypochlorite in the bleach.</p>

Further information on the health effects of chlorine in humans and animals can be found in Chapters 2 and 3.

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**1.6 HOW CAN CHLORINE AFFECT CHILDREN?**

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

<b>Children are likely to have similar effects as adults, but may be more sensitive than adults</b>	Short-term exposures (minutes) to high concentrations of chlorine affect children in the same manner they affect adults (i.e., mucous membrane and respiratory tract irritation). We do not know what the effects could be in children following longer-term (weeks or longer), low-level exposure to chlorine gas, but this type of exposure occurs only in workers and is not relevant to children. We also do not know what the effects could be in children following longer-term, low-level exposure to hypochlorite solution.
<b>Birth defects</b>	<p>We do not know whether exposure to chlorine gas during pregnancy can result in damage to unborn babies because there are no studies of pregnant women or pregnant animals exposed to chlorine gas.</p> <p>One study of rats exposed to hypochlorite solution during pregnancy found no evidence of birth defects or any other developmental alteration in the baby rats. The amount of chlorine that the rats consumed was many times higher than what people are normally exposed to through drinking water.</p>

**1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO CHLORINE?**

<b>Do not mix bleach with household cleaners</b>	Chlorine gas can be released to the air when bleach is mixed with other cleaning solutions that contain an acid like some toilet cleaners. Mixing bleach with ammonia also produces very hazardous gases, such as chloramines.
<b>Store household chemicals out of reach of young children</b>	Always store household chemicals in their original labeled containers out of reach of young children to prevent accidental poisonings. Never store household chemicals in containers children would find attractive to eat or drink from, such as old soda bottles.
<b>Follow instructions for swimming pool disinfection</b>	Chlorine gas can also be released to the air when chemicals used to chlorinate swimming pools are mishandled. If you have a swimming pool at home, read the labels of the chlorination products carefully and do not let children play with these products.

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**1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CHLORINE?**

<b>There are no medical tests available for chlorine</b>	<p>There are no medical tests to determine whether you have been exposed specifically to chlorine.</p> <p>Chlorine is transformed in the body into chloride ions, which are normal components of the body. An enormous amount of chlorine has to be inhaled or ingested in order to detect a significant increase in chloride ions in the blood. This has occurred in a few cases of ingestion of large amounts of hypochlorite solution and one of them was a fatal case.</p>
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**1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?**

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as “not-to-exceed” levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it.

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Some regulations and recommendations for chlorine include the following:

<b>Levels in air set by EPA</b>	EPA established an environmental air limit of 0.5 ppm. Exposure to higher levels could result in discomfort and irritation. Dependent on the concentration, these effects may be reversible when exposure ends.
<b>Levels in workplace air set by OSHA</b>	OSHA set a legal limit of 1 ppm chlorine in air as a ceiling limit. At no time should a worker's exposure exceed this limit.
<b>Levels in drinking water set by EPA</b>	EPA established a maximum contaminant level (MCL) and maximum residual disinfectant level (MRDL) of 4 mg/L for free chlorine in drinking water.

**1.10 WHERE CAN I GET MORE INFORMATION?**

If you have any more questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are also available on-line at [www.atsdr.cdc.gov](http://www.atsdr.cdc.gov) and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636), by e-mail at [cdcinfo@cdc.gov](mailto:cdcinfo@cdc.gov), or by writing to:

Agency for Toxic Substances and Disease Registry  
 Division of Toxicology and Environmental Medicine  
 1600 Clifton Road NE  
 Mailstop F-62  
 Atlanta, GA 30333  
 Fax: 1-770-488-4178

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Organizations for-profit may request copies of final Toxicological Profiles from the following:

National Technical Information Service (NTIS)  
5285 Port Royal Road  
Springfield, VA 22161  
Phone: 1-800-553-6847 or 1-703-605-6000  
Web site: <http://www.ntis.gov/>