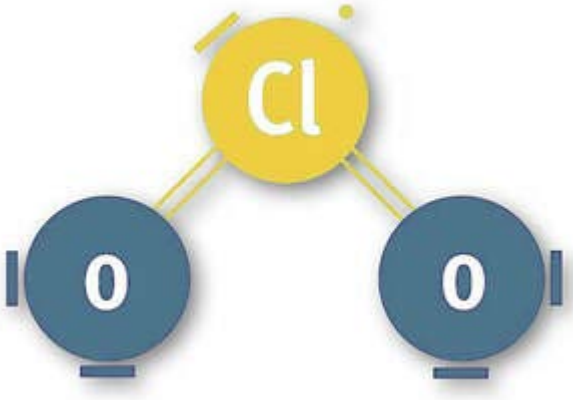
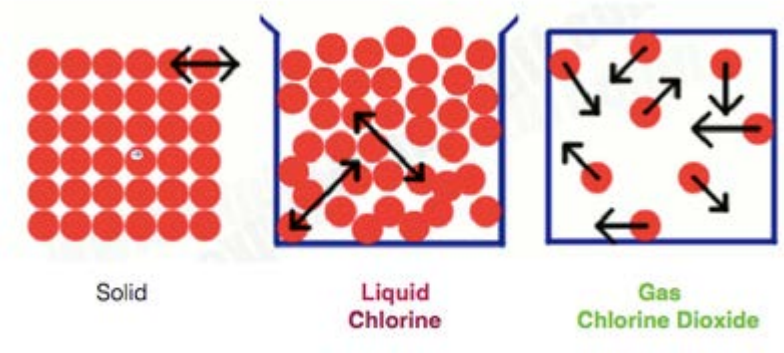
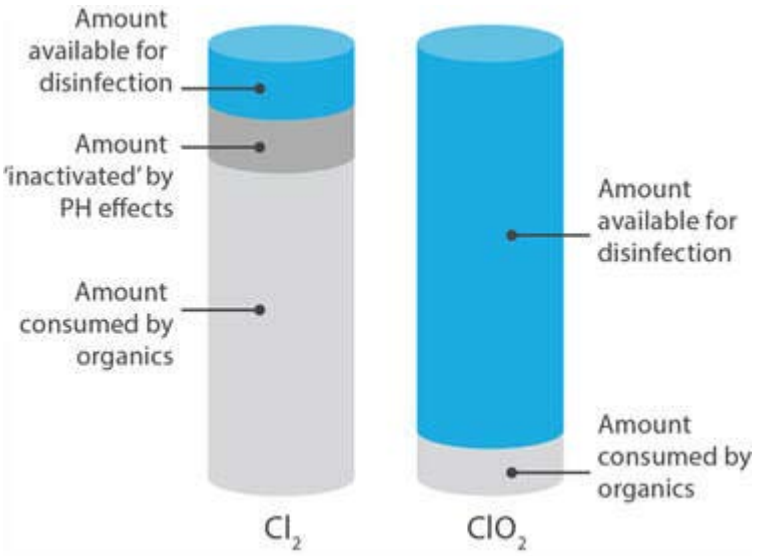
What is Chlorine Dioxide?

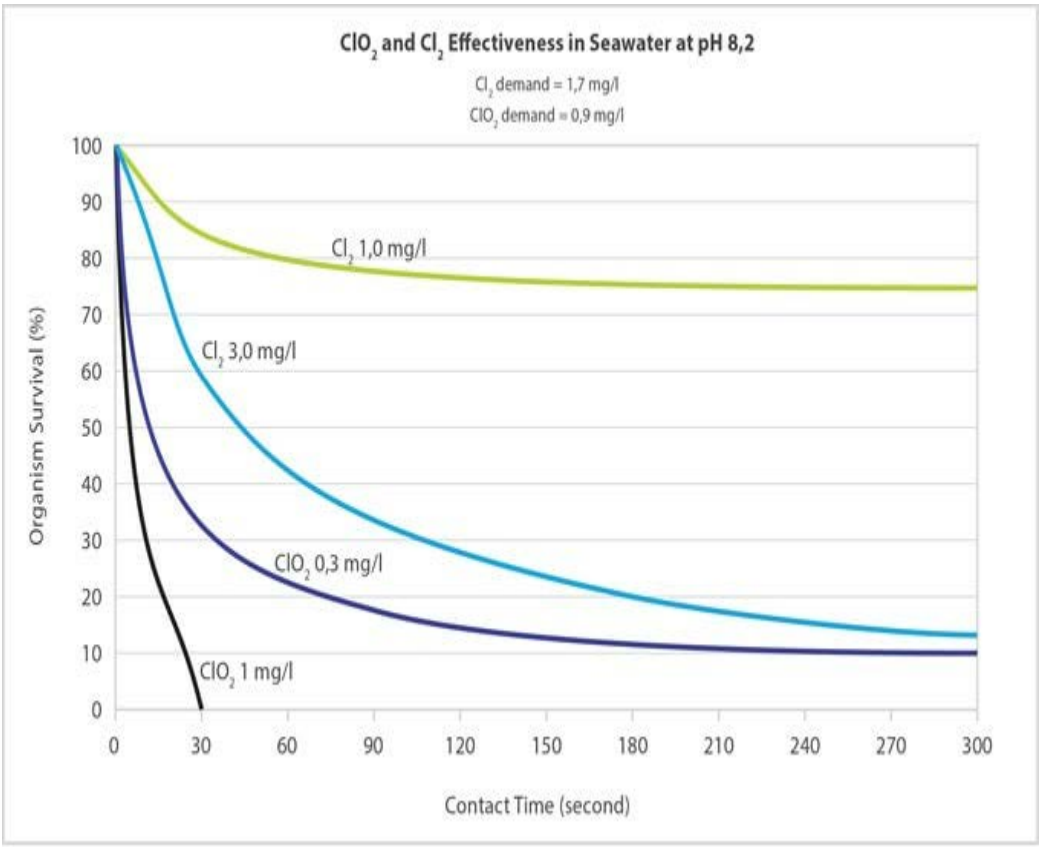
A gas which is highly soluble in water, Chlorine dioxide (ClO_2) is a synthetic, green-yellowish gas with a chlorine-like, irritating odor. Chlorine dioxide is a neutral chlorine compound. When chlorine dioxide is photo-oxidized by sunlight, it falls apart. The end-products of chlorine dioxide reactions are chloride (Cl^-), chlorite (ClO^-) and chlorate (ClO_3^-). One of the most important qualities of chlorine dioxide is its high water solubility, especially in cold water. Chlorine dioxide does not hydrolyze when it enters water; it remains a dissolved gas in solution. Chlorine dioxide is approximately 10 times more soluble in water than chlorine. Chlorine dioxide can be removed by aeration or carbon dioxide. The best way to store chlorine dioxide is as a liquid at 4 °C.





By comparing the oxidation strength and oxidation capacity of different disinfectants, one can conclude that chlorine dioxide is effective at low concentrations. Chlorine dioxide is not as reactive as ozone or chlorine and it only reacts with sulphuric substances, amines and some other reactive organic substances. In comparison to chlorine and ozone, less chlorine dioxide is required to obtain an active residual disinfectant. It can also be used when a large amount of organic matter is present.





- The oxidation strength describes how strongly an oxidizer reacts with an oxidizable substance. Ozone has the highest oxidation strength and reacts with every substance that can be oxidized. Chlorine dioxide is weak, it has a lower potential than hypochlorous acid or hypobromous acid.
- The oxidation capacity shows how many electrons are transferred at an oxidation or reduction reaction. The chlorine atom in chlorine dioxide has an oxidation number of +4. For this reason chlorine dioxide accepts 5 electrons when it is reduced to chloride. When we look at the molecular weight, chlorine dioxide contains 263 % 'available chlorine'; this is more than 2,5 times the oxidation capacity of chlorine

Oxidant	oxidation strength	oxidation capacity
ozone (O_3)	2,07	2 e-
hydrogen peroxide (H_2O_2)	1,78	2 e-
hypochlorous acid (HOCl)	1,49	2 e-
hypobromous acid (HOBr)	1,33	2 e-
chlorine dioxide (ClO_2)	0,95	5 e-

Chlorine dioxide disinfects through oxidation.

- As an oxidizer chlorine dioxide is very selective. It has this ability due to unique one-electron exchange mechanisms. Chlorine dioxide attacks the electron-rich centers of organic molecules. One electron is transferred and chlorine dioxide is reduced to chlorite (ClO2-).
- It is the only biocide that is a molecular free radical. It has 19 electrons and has a preference for substances that give off or take up an electron. Chlorine dioxide only reacts with substances that give off an electron. Chlorine, oppositely, adds a chlorine atom to or substitutes a chlorine atom from the substance it reacts with.
- Substances of organic nature in bacterial cells react with chlorine dioxide, causing several cellular processes to be interrupted. Chlorine dioxide reacts directly with amino acids and the RNA in the cell. It is not clear whether chlorine dioxide attacks the cell structure or the acids inside the cell. The production of proteins is prevented. Chlorine dioxide affects the cell membrane by changing membrane proteins and fats and by prevention of inhalation. When bacteria are eliminated, the cell wall is penetrated by chlorine dioxide. Viruses are eliminated in a different way; chlorine dioxide reacts with peptone, a water-soluble substance that originates from hydrolysis of proteins to amino acids. Chlorine dioxide kills viruses by prevention of protein formation. Chlorine dioxide is more effective against viruses than chlorine or ozone.
- Chlorine dioxide as a disinfectant has the advantage that it directly reacts with the cell wall of microorganisms. This reaction is not dependent on reaction time or concentration. In contrast to non-oxidizing disinfectants, chlorine dioxide kills microorganisms even when they are

inactive. Therefore the chlorine dioxide concentration needed to effectively kill microorganisms is lower than non-oxidizing disinfectant concentrations. Microorganisms cannot build up any resistance against chlorine dioxide.