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**Abstract**

Water must be made safe to drink, and an important step in ensuring water safety is disinfection. Disinfectants are added to water to kill disease-causing microorganisms. Ground water sources can be disinfected by “The Water Treatment Rule,” which requires public water systems for disinfection. Chlorination, ozone, ultraviolet light, and chloramines are primary methods for disinfection. However, potassium permanganate, photocatalytic disinfection, nanofiltration, and chlorine dioxide can also be used. Organic material is naturally present in water. Certain forms of chlorine can react with these organic materials and result in the formation of harmful by-products; the U.S. Environmental Protection Agency has anticipated maximum levels for these contaminants.

**Keywords:** chlorination, chloramines, ozone, ultraviolet light, photocatalytic disinfection

**1. Introduction**

Killing, removal, or deactivation of harmful microorganisms can be referred to as disinfection. Destruction or deactivation of pathogenic microorganisms results in stopping their reproduction and growth. People may fall ill by consuming the contaminated water containing the pathogenic microorganisms. Disinfection and sterilization are interrelated processes, but sterilization kills all the harmful and harmless microorganisms. Hence, disinfection is a more appropriate process.
2. Methods of disinfections

2.1. Chlorine Gas

Chlorine is a greenish-yellow gas. By providing high pressure, the gas becomes liquid. It is toxic. Chlorine gas is mostly used as a water disinfectant. Introducing chlorine to water plays a very effective role for removing almost all pathogenic microorganisms. It can be used both as a primary and a secondary disinfectant. The gas is not applicable to be used in household system as it is very dangerous. It is lethal at concentrations as low as 0.1% air by volume [1].

2.1.1. Advantages

• Chlorination is a cheaper source than UV or ozone disinfection methods used to treat water.
• It is very effective against a wide range of pathogenic microorganisms.
• Dosing rates are controlled easily as they are flexible.
• The chlorine residuals left in the wastewater effluent can make the disinfection process longer even after initial treatment. They can be further used to evaluate the effectiveness [2].

2.1.2. Limitations

Although chlorine gas is used in large-scale water distribution treatment plants and networks as a best method for treating water, still it have various limitations. These limitations might affect the applicability to a point of use (POU) treatment system. Objections against chlorination are because of the esthetic, logistic, and health-related concerns.

Regarding esthetic level, chlorination might be rejected as it imparts bad tastes and odors to the water. The developed countries might teach their people about the good impacts of chlorination; however, less-developed countries lack this ability.

Limitations in using chlorine gas in a household context might include the distribution, procurement/manufacturing, dosing of chlorine, and accurate handling. The health hazards caused by chlorine are not only confined to its volatile nature. A great concern might be the byproducts and incompletely oxidized compounds present in chlorinated water that increases its toxicity. The most notorious byproducts of chlorination are chloro-organics and trihalomethane (THMs). Humic and fulvic acids are present in the water. When chlorine reacts with these acids, trihalomethane are formed. It has been identified in many studies that some of these chloro-organics are mutagens, toxins, or carcinogens. The well-known THM chloroform is an animal carcinogen. Some guidelines have been set by USEPA (United States Environmental Protection Agency) that THMs should not be greater than 0.10 mg/l. The high concentrations of THMs will lead to health complications [1].
3. Conclusions

Water can be affected by environmental factors. Both human and environmental risks are taken into account, which may be tangible and/or intangible. Chlorination can lead to the formation of by-products or toxic chemicals that are hazardous to aquatic life. High chlorine residues may range from avoidance to death of aquatic organisms. The threshold tolerance limit of some aquatic species to chlorine is 0.002 mg/l in freshwater and 0.01 mg/l in saline water. The by-products can also accumulate in the aquatic environment. The toxicity of the chlorinated residues can be eliminated by dechlorination.

In summary, the beneficial use of aquatic ecosystem protection may be compromised when chlorinated wastewater is discharged to receiving surface waters.

Chlorination might not be a risk to the environment if the treated wastewater is reused beneficially rather than discharging into receiving surface waters. An acceptable method for disinfecting wastewater reuse is chlorination. Chlorination is the best method for reuse applications when a residual is required for microbial re-growth. However, there is a limitation of 1 mg/l of chlorine at the point of application of reclaimed water. These limits mostly do not harm the plant life. However, some sensitive crops may be damaged at a level of chlorine lower than 1 mg/l and users should consider the sensitivity of any crops that may be irrigated with chlorine disinfected reclaimed water. However, little environmental risks are associated with the direct use of chlorine. However, the manufacture, storage, and transportation of chlorine products still pose a risk to the environment.

Toxic by-products are formed by the oxidation of ozone. Ozone gas might harm the environment because of its corrosive nature.

Microfiltration only poses a risk to the environment if there is a spill of cleaning agents or the contaminated backwash waste is disposed of incorrectly. UV light poses less risk as compared to other disinfection methods, but it may pose a risk regarding photo-reactivation and mutation of the microbial population present in the discharge. No reuse option is available for UV lamps. Controlling the natural systems like detention lagoons is difficult.

A major environmental risk associated with lagoon-based disinfection is the excessive growth of undesirable organisms, such as blue-green algae. Humans are at high risk as blue-green algal blooms produces toxins. Environment is also at risk as the levels of SS and BOD increases. In terms of potential environmental cost, it would appear that UV, lagoons, and microfiltration have the least potential to impact adversely upon the environment, followed by ozonation and then chlorination. This ranking is based on the formation of by-products and the level of toxicity of the discharge to the receiving environment.

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