

Chlorine

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Introduction

- Chlorine is a reactive gas that has been used over two hundred years
- Caustic effects of Chlorine is well known after it's use in Ypres, Belgium in 1915 for chemical warfare

Chemical and Physical Properties of Chlorine

- Chlorine in pure form is greenish-yellow gas
- Odor is very pungent and suffocating
- Highly reactive and can form explosive mixtures with flammable gases and vapors
- When Chlorine is added to water it forms two forms of free chloride
 - Hypochlorous acid (HOCL)
 - Hypochlorite ion (OCL)

Common Source-1

- Largest amount used in commercial industry
 - ↑ Production of vinyl chloride monomer and polyvinyl chloride (PVC) resins
 - ↑ bleach pulp
 - ↑ production of chlorinated solvents and chlorofluocarbons

Common Source-2

- ↑ meat, fruit, vegetable, and fish processing
- ↑ water purification and waste water treatment
- non commercial uses
 - ↑ swimming pool sanitation
 - ↑ common household disinfectant and cleaning products

Common Source-3

- Environmental concerns
 - ◆ reactive nature cause it to mix with substance in environment
 - ☞ formation of chloride salts
 - ☞ formation of chlorinated organic chemicals
 - ◆ Not likely to move into the ground water
 - ◆ Plants and animals do not store chlorine

Routes of Exposure-1

Exposure can occur in various routes

Dermal Contact

- Chlorine is very corrosive
- It may cause sweating and irritation of the skin
- If severe and prolonged exposure, burning and blistering of the skin

Routes of Exposure-2

Ingestion

- Exposure through ingestion not common
- Concentration 50-90 PPM of chlorine had no adverse effects
- At doses >90 PPM, it irritates the membrane of the mouth and throat
- Concentration >25 PPM make the water unpalatable

Routes of Exposure-3

Inhalation

- It is very pungent and irritating to the respiratory tract
- It can be classified as pulmonary irritant
- It is one of the most common toxic inhalant

Toxicokinetics

- Following oral administration of chlorine, it is rapidly absorbed into the blood.
- ↑ The level of chlorine is highest in the plasma followed by bone marrow, kidneys, lung, and liver.

Toxicokinetics-2

- ↑ Chloride is strong oxidizing agent and reacts very readily with biological material and form chlorinated compounds
- ↑ Chlorine is excreted from the body primarily in urine and feces
- Does not remain in the body due to it's reactivity

Health Outcomes

Acute effects

- The effects vary pending on concentration, duration exposure, water content of the tissues involved, and pre-existing medical condition of the patient
- In Chlorine, inhalation is the main route of exposure

Health Outcome-2

- Effects on the mucus membrane and respiratory tract at various doses
 - ↑ 0.014 PPM tickling of the nose
 - ↑ 0.06 PPM, noticeable coughing
 - ↑ 0.35 PPM burning from conjunctiva
 - ↑ 1.0 PPM, shortness of breath, headache, and irritation in the throat

Health Outcome-3

- ↑ 30 PPM, chest pain, vomiting, dyspnea
- ↑ 46 PPM, toxic pneumonitis and pulmonary edema
- ↑ 430 PPM, lethal after 30 minutes
- ↑ 1000ppm, lethal in few minutes

Fatal cases are characterized by hemorrhage, epithelial necrosis and denudation, pulmonary edema, and rapid death

Health Outcome-4

Subchronic and Chronic Effects

- ◆ There is a debate as to if there are any chronic effects. There are conflicting studies in this arena
- ◆ Some studies have indicated long term effects such as
 - ☞ chronic bronchitis, asthma, tuberculosis, and emphysema
- ◆ Other studies have indicated no dose relationship
- ◆ One of the difficulty of performing a good long term study is largely due to difficulty controlling confounding factors.

Health Outcome-5

- Central Nervous System (CNS)
 - ↑ evidence on the effect of chlorine in CNS is controversial
 - ↑ the CNS may have been overlooked because
 - ↑ these symptoms were seen as another illness
 - ↑ the delayed and less dramatic
 - ↑ past clinical tests were not sensitive
 - ↑ the CNS impairment according to some studies are as follows
 - in balance, reaction time, cognition, verbal recall, adverse mood states

Carcinogenicity

- There are no conclusive evidence to prove carcinogenicity of chlorine due to limited information human and animal studies.
- There are conflicting evidence
- Study in Norway, New Jersey, and Massachusetts, showed increase in birth defects due to chlorinated water
- A study in Taiwan showed no relationship

Appropriate Treatment

- Treatment of chlorine exposure primarily systematic
- The most widely accepted treatment is use of beta-2-adrenergic agonist and humidified oxygen
- The use of bicarbonate and corticosteroids are controversial

Regulation

- According to National Institute of Occupational Safety and Health, the recommended exposure to chlorine is 0.5 PPM for 15 minutes (ceiling)
- EPA has not classified chlorine to be carcinogenic