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Research Paper

Organic toxicants in drinking water and its mitigation

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Abstract: Chemical toxicity has been recognized as a major public health risk, particularly in developing countries. This paper is an attempt to clarify concerns about the toxicity in drinking water due to organic toxicants in India. The toxicants present in water disturb the spontaneity of the mechanism and result in long/short-term diseases. The types of toxicity and their possible treatment are discussed in the present review. Continued research efforts result in some processes/technologies to remove the toxicants from water. The review includes concepts and potentialities of the technologies in a comprehensible form.

Keywords: Chemical toxicity, Organic Toxicants, Treatment, Technologies.

Introduction:

Study on Organic Toxicants done under Chemical toxicology refers to the science that deals with the nature & reactions of toxic substances involving Chemical aspects of their origin, exposure and disposal. Toxic substances include any substance whose physiological Action is harmful to health. 'Toxic' is a relative term which depends upon several factors such as the dose, route of Entry, susceptibility of the individual etc.

Organic Toxicants in water can be prevented by taking measures even at the household level. Water contamination is a common problem to all over the world. These may be geological or anthropogenic (man-made)). Higher levels of contaminants in drinking water are seldom to cause acute health effects. Of course it depends on individual susceptibility and mode of contact with the body.

Generally many Organic Toxicants are man-made by-products of industry, and agriculture, including heavy metals like mercury, copper, chromium, lead, and hazardous, chemicals, dyes and compounds like insecticides and fertilizers. Improper storing or disposing of household chemicals such as paints, synthetic detergents, solvents, oils, medicines, disinfectants, pool chemicals, pesticides, batteries, gasoline and diesel fuel can lead to ground water contamination.

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Types of toxicants:
The toxics and toxicants are four types associated with water pollution-
Inorganic Toxicants
Organic Toxicants
Biological Toxicants
Radiological Toxicants

Organic Toxicants:
The major anthropogenic sources of Organic Toxicants are pesticides, domestic waste, and industrial wastes, etc. Contamination through organic materials can cause serious health problems like cancers, hormonal disruptions, and nervous system disorder. Trihalomethanes (THMs) are formed when chlorine in the treated drinking water combines with naturally occurring organic matter.

Pesticides:

Pesticides contaminate through agricultural as well as public hygienic sources;. The adverse environmental effects of pesticides used in agriculture and public health are due to an improper handling and application procedure (WHO 2010). Pesticides are designed to interact with various chemical processes in the pest's living body chemistry. Unfortunately, doing this, all pesticides may interact with the metabolism of non-targeted living organism. Mostly, pesticides damage the liver and nervous system. Tumour formation in the liver has also been reported. Environmental agencies have fixed their MCL's. Some of the pesticides with their MCLs are as follows;

Pesticides	Nature	Maximum contamination level (MCL), µg/L
Carbofuran	Nematocide	40
Endothall	Algaecides	100
lyphosate	Herbicide	700
Oxamyl	Insecticide	200
Picloram	Herbicide	500

Corbofuran: Carbofuran, an anticholinesterase carbonates, which is commonly used as an insecticide and Nematocide in agricultural practice throughout the world. Due to its widespread use in agriculture, contamination of food, water, and air has become imminent, and consequently adverse health effects are inevitable in humans, animals, wildlife, and fish.

Endothall: human consumption is prohibited when concentrations of the active ingredient (Endothall) are greater than 0.1 ppm in the treated water. The US EPA has set this level of protection based on the best available science to prevent potential health problems. Some people who drink water containing Endothall well in excess of the MCL for many years could experience problems with the stomach or intestines.

Glyphosate: glyphosate caused developmental effects, including reduced infant body weight and skeletal changes. Long-term ingestion of glyphosate also caused some minor gastrointestinal effects, including changes to the salivary gland in rodents.

Oxamyl: Oxamyl can be acutely toxic because of its effect on blood and brain cholinesterase activity .Toxic decreases in cholinesterase activity were not observed in any animals after the first day or in low-dose males and females at any time.

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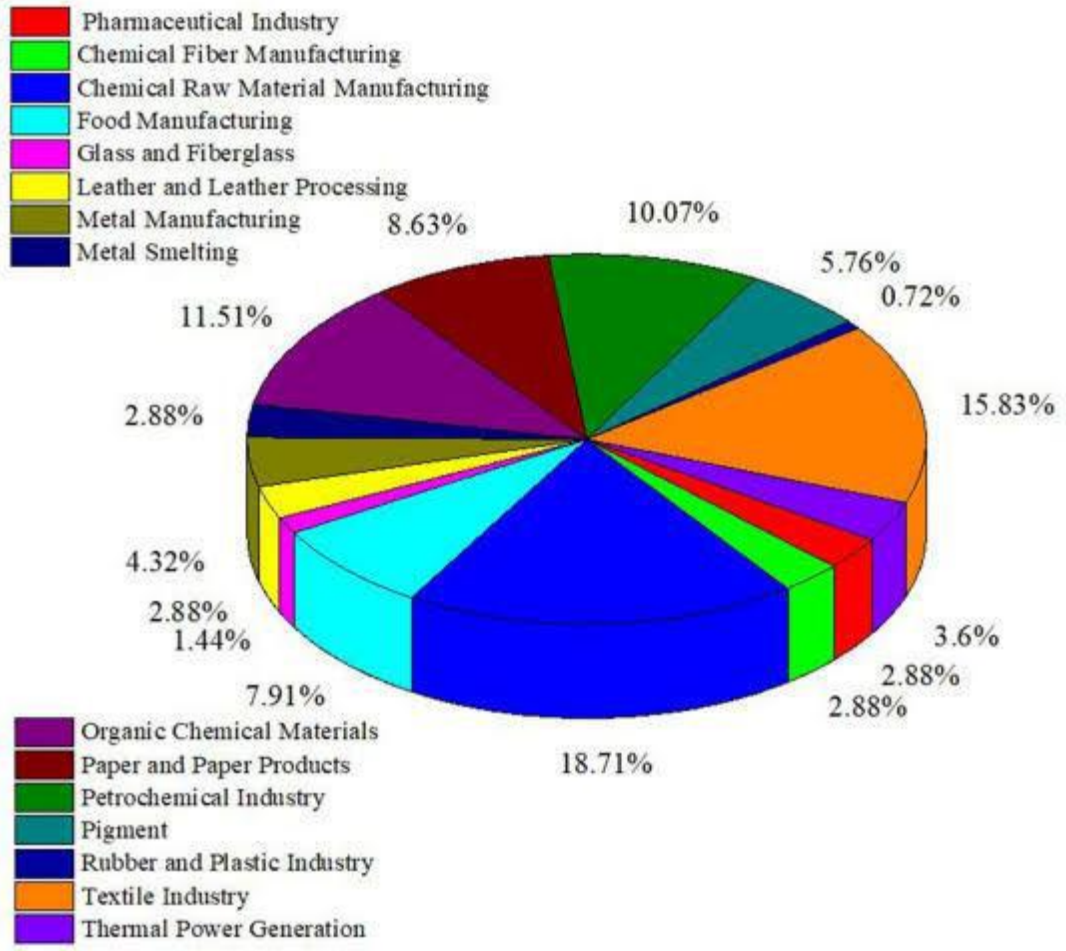
Picloram: Picloram is a potential health hazard. Continued exposure to drinking water that has levels of Picloram above its MCL can cause adverse health effects such as Weakness, Diarrhoea, Weight loss, Liver damage and Damage to central nervous system.



VOLATILE ORGANIC COMPOUNDS

Volatile Organic Chemicals (VOCs) are a class of chemicals that are carbon-containing and evaporate, or vaporize, easily into air at normal air temperatures. VOCs are found in a variety of commercial, industrial, and residential products, including gasoline, solvents, cleaners and degreasers, paints, inks and dyes, and pesticides. The U.S. Environmental Protection Agency (EPA) estimates that VOCs are present in one-fifth of the nation's water supplies. They can enter drinking water supplies from a variety of sources. For example benzene, may enter groundwater from gasoline or oil spills on the ground surface or from leaking underground fuel tanks. Other examples of commonly detected VOCs are dichloromethane (methylene chloride), an industrial solvent; trichloroethylene, used in septic system cleaners. VOCs evaporate, or vaporize easily, into air at normal air temperatures and when in contact with water may dissolve in and be transported by water. In addition, dissolved organic chemicals in water may vaporize out of water into the air.

Effects on humans: Volatile organic compounds can have a variety of harmful health effects. The risk to human health is a function of the exposure route, level of exposure, and length of the exposure. In general, exposure to low levels of certain

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VOCs over long periods of time may lead to impaired immune system function, may damage the liver or increase the risk of cancer. At high levels of exposure, many VOCs can cause central nervous system depression (drowsiness, stupor). For short-term exposure, it is possible that the organics can irritate the skin or to the mucous membranes if inhaled.

PREVENTIONS & MITIGATION METHODS

Pure Water is the World's First and Foremost Medicine. – Slovakian The need of science-based solutions for uncontaminated water provisioning results in several water treatment methods to counter the problem. Of course, the suitable technology is based on raw water characteristics, infrastructure (i.e., power, manpower, availability of chemicals), affordability/cost as well as acceptability. Some of the common water purification methods are sedimentation or settling, boiling/distillation, chemical treatment (precipitation/coagulation) and Bioremediation.

The processes and techniques in mitigating the Organic Toxicants are as follows. Precipitation and coagulation

Precipitation is a technique of removing one or more substances from a solution by adding reagents so that insoluble solids appear. The 'solubility' rules the technique, that is when the product of ion concentrations (in simple) in the solution over the solubility product of the respective solid, the precipitation occurs. It is one of the simple methods to purify water. The chemicals are added to form particles which settle and remove contaminants from water. The treated water is reused whereas the settled portion is dewatered and disposed of. The technique is used in softening of water as well as to remove impurities like phosphorus, fluoride, arsenic, ferrocyanide and heavy metals, etc.

Softening of water

The presence of Ca/Mg in terms of carbonate, bicarbonate, chloride and sulphate results in hardness of water. Addition of proper chemical forms precipitation and makes it soft. Addition of $Ca(OH)_2$ forms precipitation with bicarbonate and sulphate in water.

$Ca(HCO3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$,

$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaSO_4$.$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaSO_4$.

Addition of Na-aluminate forms precipitation of hydroxide with sulphate and chloride in water. Actually, Na-aluminate forms sodium hydroxide with water, and with sulphate /chloride it forms hydroxide.

$MgSO_4/CCl + Na_2Al_2O_4 + 4H_2O \rightarrow Mg(OH)_2\downarrow + Na_2SO_4/NaCl + 2Al(OH)_3\downarrow$

Formation of aluminium hydroxide aids in flock formation, sludge blanket conditioning and silica reduction.

Removal of dyes

Dyes are non-biodegradable, and precipitation with CaCO3 can be one of the approaches to remove them from the water.

Benefits:

- Simple process,
- Effective for the removal of As, Cd, Ba, Cd, Cr, Pb, Hg, Se, Ag, etc.,
- It is also applicable to remove natural organic matter (NOM) or dissolved organic carbon (DOC).

Limitations:

- Requires continuous supply of huge chemicals,
- Handling of by-products,
- Disposal of coagulation/precipitation sludge is a concern.

Reverse osmosis

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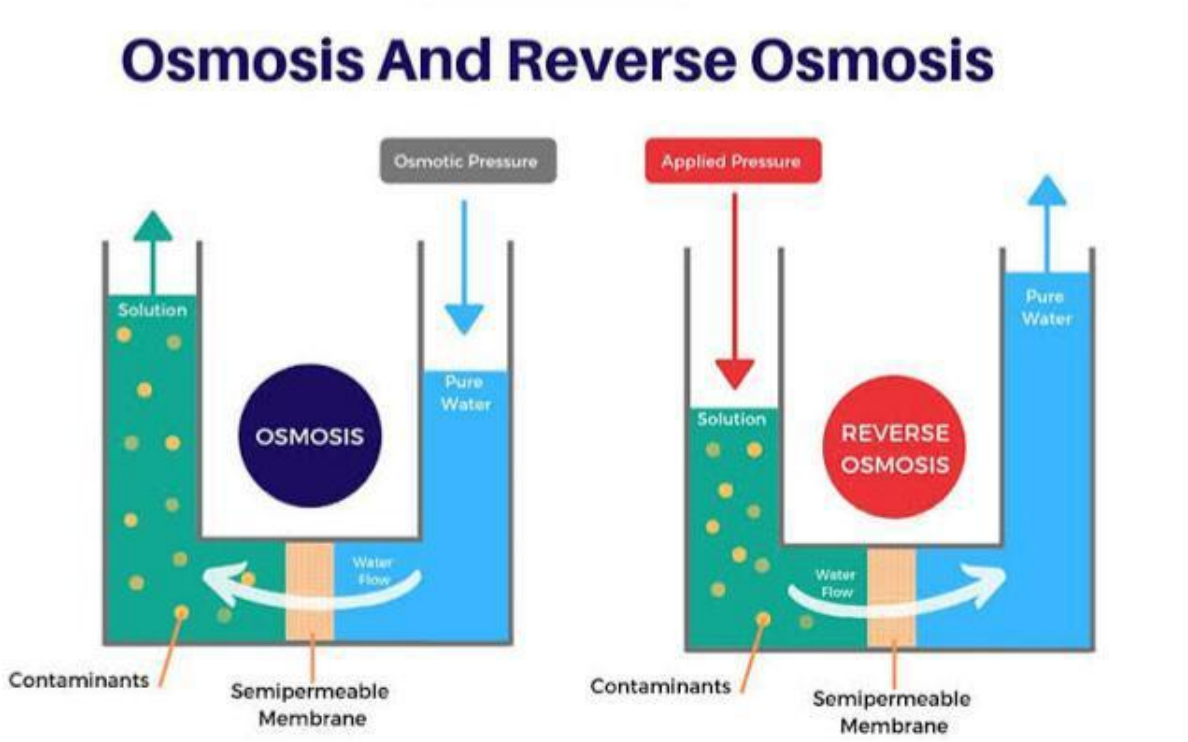

The two processes (viz. osmosis and reverse osmosis) are the regulator of life. Though they are termed as concentration and pressure driven simultaneously, both are controlled by thermodynamic function, i.e., 'chemical potential' of the systems. It is essentially a driving force expressed as a change in the free energy of the system as a result of the change in the composition of the system. Under isothermal operating condition, the tendency for material transport is always in the direction of lower chemical potential for both the processes. In osmosis, the flow is occurring solvent to solution side through a semipermeable membrane, whereas in reverse osmosis the flow is a solution for solvent. In both cases, only solvent molecules migrate from one side to another. The schematic diagram of osmosis and reverse osmosis :

Benefits:

- No phase changes and thus requirement of low energy,
- Eco-friendly as they do not produce or use any harmful chemicals; compactness and space requirements are less compared to distillation, and can be designed according to the requirement,
- Ability to remove almost all kinds of contaminates like Cl−, NO3−, F−, SO4--, Pb2+, Na+, K+, Mg2+ , organics as well as microorganisms.
- No alteration in the taste and smell of water and effective removal of microbes and toxins.

Limitations:

- The purified water obtained after reverse osmosis treatment is devoid of useful minerals,
- Membrane may become clogged after prolonged use and, hence, requires periodical replacement of the membrane.

Phytoremediation

It signifies the removal of pollutants from the environment by the use of plants. The technology involves different mechanisms, phytoextraction, rhizofiltration, phytostabilization,phytotransformation/phytodegradation. Phytoextraction involves metal accumulation into the harvestable

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parts of the roots and the above ground shoot. Rhizofiltration indicates the absorption, precipitation and concentration of toxic metals from polluted effluents. Phytostabilization is a process in which mobility of heavy metals is reduced through the use of tolerant plants, whereas phytotransformation/phytodegradation is the process in which contaminants can be eliminated via phytodegradation or phytotransformation by plant enzymes or enzyme co-factors. Macrophytes water hyacinth (Eichhorniacrassipes); pennywort (Hydrocotyle umbellate L); duckweeds (Lemna minor L.) and water velvet are considered the biological filters and play the important role in the maintenance of the aquatic ecosystem. The floating plants Lemna minor , Eichhorniacrassipes show good potential in accumulating the metals directly from industrial effluents.

Benefits:

- Cost effective,
- Eco-friendly.

Limitations:

- Seasonal growth of the plants,
- Biomass disposal.

ADVANCE TECHNOLOGIES

The torch of the scientific quest along with the traditional technologies has now been handed over to the nanotechnologists of the twenty-first century, to whom a major challenge is to transform this into the field. Ultraviolet (UV) irradiation technology is primarily used in the water and wastewater treatment industry as a disinfection process that capitalizes on the germicidal effect of UV light in the wavelength range of 250 to 270 nm . The process is commonly designed such that water flows in a narrow region around a series of UV lamps. The microorganisms in the water are inactivated through exposure to the UV light. The process is compact since the time of exposure (which translates into hydraulic retention time) is commonly measured in seconds. The process works on the principle that UV energy disrupts the DNA of the microorganisms and prevents it from reproducing.

Ozone, O3 is an unstable form of oxygen and protective layer of UV-radiation. But in drinking water, it makes an effective disinfectant. It readily gives up oxygen and thus a powerful oxidizing agent. Ozone is made by passing oxygen through UV-light or a ‘cold’ electrical discharge. The very high oxidation potential of ozone is easy enough to insert oxygen into the bonds of organic compounds to form aldehydes and ketones. It is effective for killing the biological contaminants (Pathogens) than that of chemical disinfection method like chlorination.

Nanotechnology refers to technologies involving particles on the approximate size scale of a few to hundreds of nanometres in diameter. IN terms of applicability, three approaches are there, viz. Individual nanoparticles, binding the nanoparticles to a powder/granule form and nanoparticles onto membranes/polymers. The Nanoscopic materials such as carbon nanotubes and alumina fibres embedded in zeolite filtration membranes, carbon nanotubes, wrapped around a carbon block filter structure have the capacity to remove the impurities from water. Nano reactive membranes are able to decompose pollutants such as 4-nitrophenol and bind metal ions in water solution. Super chlorination is another advanced technique to get clean and disinfected water. It signifies that extra dose of chlorine oxidize organics kill and remove algae and pathogens from the water within the short-contact time. HOCl is the active chemical that provides sanitation as well as shows reactivity towards organic pollutants. When there is sufficient HOCl, the pollutants are easily oxidized.

Conclusion:

The world is facing turbulent water future. With the growing economy and rising

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population, the theme of all nations is 'Save water'. Quantity and quality of water should be given equal importance. Awareness related to 'water conservation' and 'safe drinking water' is extremely important, and should be given a good thought to the people. The technological solution depends on raw water characteristics, affordability and acceptability and level of application. Of course, sustainability depends on an awareness of the related issues. Since there are limitations in every individual treatment technologies but hybrid technologies are always beneficial. Availability, selection, optimization, etc are important for the best performances of the system. Lastly, it must be mentioned through the gambling of research that the future of the water treatment technology is highly prosperous and hope one day we will fulfil the demand 'fresh water for everyone'.

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