

Microbes in desalinated drinking water

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Abstract

“Water water every where, not a drop to drink”. In fact, only 3% of earth’s total water is fresh water while the remaining 97% is oceanic saline water. Hence, from time immemorial, there has been a reasonable approach to make fresh water from sea water.

At present technologies involved in desalting sea water belong to two major groups viz. thermal and membrane desalting processes. Under certain circumstances, some pathogenic micro-organisms are able to persist in source water and finished desalinated water for long period. Therefore, it is important to know the source of microbial contaminants in sea and assess the risk factors posed by pathogenic micro-organisms in desalinated water. In Island conditions, where there is hardly any alternative to use of desalinated water, the desalination process should provide adequate protection of public health through controlling pathogens in order to prevent water borne diseases.

The present paper discusses major groups of micro-organisms found in sea water and hyper saline water. It also mentions some popular desalination processes and reviews the risk of occurrence of certain potentially pathogenic micro-organisms in desalted sea water. Finally, certain safety measures have been proposed for using desalinated water as drinking water.

Introduction

Sea water abounds with microbes like viruses, bacteria and algae. It is one of the major reservoirs of micro-organisms. Many such organisms grow in slime layers on the substratum while others remain dispersed in sea water or float in the surface. The bacterial flora in water may come from anthropogenic sources. Further, some naturally occurring bacteria and cyanobacteria of sea

water and toxin generating algae cause health hazards. Temperature, salinity and nutrient sources play important role on the occurrence of micro-organisms (Jiang & Fu, 2001)

Even away from the influence of coastal human habitation, huge number of micro-organisms is present. Phytoplankton which are the producers in oceanic ecosystem form the basis of food chain. Some microbes are pathogenic. If they survive desalination process and remain in the finished water used for drinking, they may cause health risk.

Major groups of micro-organisms in sea

The major group of microbes occurring in saline water of sea and oceans include the following:

Viruses: Viruses are tiny particles made up of a protein coat and DNA or RNA - one of the two nucleic acids. Phytoplankton are attacked and killed by marine viruses -algae by algal viruses, fungi by fungal viruses and bacteria by bacteriophages. The dead plankton becomes source of carbon to other sea life. It is estimated that about 25% of all carbon in the living organisms of ocean is made available through the action of viruses. In the oceans viruses infect all living organisms from bacteria to whales. Human pathogenic viruses in marine environment include enteroviruses, hepatitis A viruses, Norwalk viruses, reoviruses, rotaviruses, adenoviruses etc

Bacteria: These are prokaryotic micro-organisms. Most bacteria in sea water are free living while others are parasitic or symbiotic. For example the deep sea fishes use bacterial bioluminescence to signal other members of their species Cyanobacteria, which are relatives of bacteria not algae, are also abundant. Some bacteria are present even in the bottom of the oceans. Gram negative marine bacteria are *Aeromonas hydrophila*, *E.coli*, *Vibrio salmonicida* etc. while Gram positive bacteria includes moderate halophiles viz. *Bacillus*, *Halobacillus*, *Marinococcus*, *Salinococcus* etc.

Actinomyetes from saline soil include *Actinopolyspora halophila* which grow best in moderate NaCl concentration.

Archaea : Archaea are bacteria like microbes which can live in extreme environment. Recently, scientists have discovered that archaea are also found in open sea. It has been estimated that these microbes form about fifty percent of the mass of life in oceans.

Algae: There are many photosynthetic organisms in the ocean. It is generally known that 95% of the Earth's total photosynthetic product is formed in water. Algae are the most abundant among photosynthetic organisms. Diatoms, a group of unicellular algae form another important group of micro-organisms. Algal species sometimes form blooms by population explosion. Such bloom causing algae may produce biotoxins. These toxins bioaccumulate in oceanic food chains and kill higher organisms. Examples of marine algae are *Gambierdiscus*, *Karenia* etc.

Protozoa: There are number of protozoan in sea water. Some are free swimming; some remain attached to substratum, while still others are found in organic debris. Examples of marine protozoa are *Litonotus*, *Entosiphon*, *Euplote* etc.

Fungi: It is known that there are large group of marine fungi. They represent considerable amount of biomass in marine habitat. Common marine fungi are *Aspergillus sydowii*, *Lagenidium callinectes*, *Lindra thalassiae*, *Dendriphiella salina*, *Ceriosporopsis halima* etc.

Desalination technologies:

Most desalination processes use sea water as their sources. This non typical source of drinking water exhibit severe microbial contaminations. Thus some basic questions are faced by this operation are as follows:

1. Extent of microbial contamination.

2. Performance of specific technology for microbial control.
3. Disinfection and its by products.
4. Bacterial regrowth during distribution.
5. Whether microbes unique to saline water are removed by desalination process and post disinfection.
6. Whether bacteriophages like MS2 which is smaller than membrane pores can be removed.

The principal desalination technologies include:

Reverse osmosis (RO) :- It reverses the natural process of osmosis and as a result of outside pressure the solvent from higher concentration is migrated through membrane pore leaving the solute. It is suitable for water with low potential for membrane fouling. The reverse osmosis membranes are permeable to water but not to solutes. It has been found that in absence of antimicrobial treatment desalinated water obtained by RO contain microbial contaminants.

Distillation technologies: - Principal distillation (Vaporization--condensation) system includes multistage flash (MSF) distillation, multiple effect distillation (MED), Vapor compression distillation (VCD).

In distillation process water is vaporized and the condensed vapor is collected while concentrated brine is produced as a residual. During MSF, heat of vaporization is recovered by condensing vapor on to the surfaces that are in contact with water. In MED, steam is condensed on one side of a tube causing evaporation of saline water on the other side. The VCD system works by compressing water vapor causing condensation on a heat transfer surface that allows heat of condensation to be transported to brine on the other side of the surface resulting in the vaporization of water.

Membranes: Common membranes are polymeric materials such as cellulose triacetate. The actual mechanism of the membranes is different in different systems but they share three common characteristics as under :

- (a) Energy is required.

(b) Membranes are sensitive to metals, microbes, chlorine and suspended solids.

(c) Post disinfection necessary.

Electrodialysis: In electrodialysis salts are drawn through membranes leaving desalted water behind. The basic part includes cation permeable membrane, demineralised feed water stream, anion permeable membrane and concentrate flow stream. When an electric current pass through electrodes, anions are drawn through anion permeable membranes by their attraction towards cathode but cannot pass through cation permeable membrane and vice versa for cations.

The water desalinated by electrodialysis requires post disinfection because in this process only solutes are withdrawn. The micro-organisms including pathogenic ones are to be eliminated before domestic use.

Disinfection strategies

(1) During disinfection process chlorine is generally applied to decrease biofouling and membrane degradation. It reduces health risks.

(2) The membranes often possess the ability to stop the passage of microbes.

(3) In case of ultrafiltration with pores (-0.001 to 0.1 microns) the viruses and protozoa are eliminated considerably.

(4) The Giardia cysts (4-14 microns) are generally removed by intact ultrafiltration membranes.

(5) Distillation at high temperatures would completely destroy the pathogenic microbes. But when reduced pressure is used to lower the energy demand, the spores may survive. Generally at 60-80°C most of the pathogenic organisms are destroyed with in a few minutes.

(6) Pre-disinfection processes produce byproducts which are removed by the desalination process.

(7) New chlorine resistant membranes are needed to be developed.

(8) Chlorination at present is perhaps unavoidable.

(9) There are some alternative disinfection techniques like ozone, chloramines, peroxone, CuSO_4 salts, UV irradiations, Quaternary ammonium chloride

compounds etc and some of them no doubt have shown merits in their area of applications but they are yet to replace chlorination.

(10) Some heavy metals like Cu, Ag etc have also been used as disinfectants..

Discussion

Marine micro-organisms are difficult to study because they are small and not easily culturable.. There are a billion of microbes living in each liter of sea water. They constitute 98% of the biomass of the oceans and supply more than half of the world's oxygen. Some microbes have shown promises of new drug discovery. It is known that 5 ml of sea water contain 50 million viruses. Naturally, while some are useful many of them may be pathogenic and it is very essential to remain safe microbiologically.

The US Virginia Island is the first state to establish many desalination plants. In that Island about 80% of the total water supplied for domestic and human use comes from desalination plants (Buros, 1984). At present reverse osmosis is the most suitable treatment technology which gives higher benefit in lower costs. It drastically reduced operating pressure, energy requirement and fuel requirement. But the operating efficiency of RO gets deteriorated due to fouling of membrane by bacteria and other microbes. It requires both pre treatment and post treatment to make water free of microbial interference. In case of electro dialysis also pretreatment is necessary. While suspended solid may be removed by filtration, a disinfectant (chlorine or its alternative like ozone, UV, etc) may be applied to make it microbes free. Microbes also can be removed by membranes as long as they are intact. However, some bacteria can always grow through the membranes.

It has been stated that ultra filtration membrane which having pores 0.001 to 0.1 micrometer can reduce micro-organisms to a great extent *eg* Giardia and Cryptosporidia cysts. Even MS2 bacteriophages of size 0.027 micrometer are substantially removed although membrane pores are 0.035 micrometer (PHE, 2007). It has been observed that during storage and distribution micro organisms show regrowth . Actually after long standing the disinfectant used may also disaspitate.It may be experimented whether use of two different disinfectant during post and pre treatment lower microbial risks and also byproduct of disinfection.

References

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