Inadmissible planktons in potable water: a potential risk for human health

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Water pollution is a major concern influencing human lives in many ways. It affects not only the nature of potable water, but also the health of those who consume it. Hazardous water pollutants are broadly categorized into soluble toxicants and toxic planktons. The presence of planktons in potable water causes a negative impact on the human body. The inadmissible planktons of potable water such as copepods, protozoans, helminths, anilids, blue-green algae, dinoflagellates, and diatoms can lead to severe dysfunction in the normal physiology of humans. Complications of the gastrointestinal tract, hepatobiliary system and brain result from drinking polluted water. Toxins such as cyanobacterial toxin, saxitoxin, neosaxitoxin and domoic acid are by-products of the inadmissible planktons which cause adverse effects on the human organ systems. They also derange the percentage of dissolved oxygen in the water bodies. The health-related consequences of the planktons range from cell damage to mortality.

Keywords: Human health, planktons, soluble toxicants, water pollution.

THE earth has viable climate with requisite environmental factors. Excessive insertion of noxious components can cause acute defilement in our ecosystem. About 4.2 million premature deaths per year in both urban and rural area are due to the polluted environment[1]. Pollution is the coalescence of offensive contaminants into innate environment. The quality of the environment significantly affects human lives. Living in a pollution-free environment can enhance the quality of life[2]. Pollution is an unfortunate hassle of this planet which is drastically disturbing entire biomes[3]. The audacious ethos of human being is the key factor for this growing hag[4]. The increasing levels not only affect our climate, but also human health[5]. Ingested or inhaled pollutants are affecting our health every day. Inhaled contaminants are remarkably disturbing the human physiology while aquatic defilements have also some deleterious effects. Planktons are the most common aquatic components of potable water[6,7]. Aquatic lagoons are usually filled by many kinds of planktons in accordance with their ecological niche[8]. They grow there naturally in order to balance the ecosystem. However, a few planktons are also reported in potable water tanks because of their poor conditions[9,10]. This may have deleterious effects on human health. The presence of faecal coliform bacteria confirms contamination of the aquatic environment with faecal material of human or other animals[11]. Hence, monitoring planktons in potable water is important to prevent the potential risks to human health[12,13]. In India, drinking water is regulated for a single microbiological parameter, i.e. faecal coliform bacteria[14], whereas other hazardous planktons, such as amoebiasis, giardiasis and cyanobacterial toxicosis have also been reported, which have several deleterious effects on human health[15–17]. The presence of planktons in potable water is inadmissible, and have numerous negative impacts on the recipients[18]. Planktons are classified under two types – zooplanktons and phytoplanktons (Figure 1)[19]. Zooplanktons are organisms that live in water bodies. They play a key role in the aquatic ecosystem but some of them are inadmissible in drinking water[20]. These include copepods, protozoa, helminths and annelids[21,22]. Phytoplanktons are autotrophic components of water bodies. Most phytoplanktons are tiny in size and cannot be seen with naked eyes. However, when present in enough numbers, they are easily visible.

Although planktons are indispensible components of the aquatic ecosystem, many of them are undesirable for potable water and water tanks. A few species such as dinoflagellates and diatoms can produce toxins in potable water. They may cause severe effects like diarrhoea, dysentery, dizziness, memory loss and even paralysis. This article deals with the hazardous effects of planktons which are generally present in spotted water tanks and municipal water supply.

Health hazards of inadmissible plankton

Safe potable water is indispensable for good health. Presence of noxious flora and fauna in potable water and its

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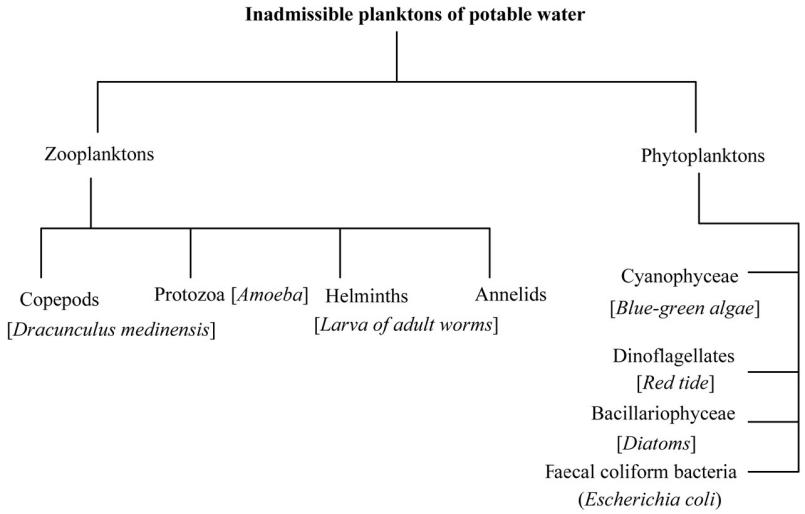

Figure 1. Inadmissible planktons in potable water.

consumption can lead to acute or chronic dysfunction in humans. Though planktons are part of the marine ecosystem, they are not desirable in drinking water.

Zooplanktons

Zooplanktons are floating organisms that may enter potable water from surface-water sources such as reservoir tanks, rivers and lakes[23]. Few important zooplanktons are copepods, protozoa, helminths and annelids.

Copepods: Freshwater copepods of genus *Cyclops* are the intermediate host of *Dracunculus medinensis* and guinea worm, which cause dracunculiasis. This disease can be diagnosed by observing wounds on the lower limbs of the recipient of polluted water. The emerging worms can be confirmed on the lesions and the larvae by microscopic examination. The lesions are generally found on the legs of infected individuals[24].

Protozoa: These are single-celled eukaryotes often present as contaminants in potable water. They are the source of many diseases such as amoebiasis, giardiasis, acanthamoeba keratitis, toxoplasmosis and cryptosporidiosis[25]. Amoebiasis is an infection of the gastrointestinal tract caused by *Entamoeba histolytica*, which is present in contaminated water. People affected by amoebiasis suffer from intense abdominal cramps and diarrhoea. Invasion of *Entamoeba histolytica* in the intestinal lining can result in blood dysentery. If the pathogen reaches the liver via the blood stream, it can cause amoebic liver abscess. This can occur without any dysenteric symptoms[26]. Giardiasis is caused by *Giardia lamlia* which is a well-known contaminant of polluted water. The symptoms include diarrhoea, abdominal pain and vomiting. Its persistency can cause acute blood loss in stool[27]. Acanthamoeba keratitis is caused due to the invading action of amoeba on the cornea of the human eye. It leads to visual impairment[28]. Toxoplasmosis is a protozoal disease caused by *Toxoplasma gondii* through contaminated water and poorly cooked food that contains cysts of the parasite. This illness is often asymptomatic; however, after a long exposure it manifests some influenza-like symptoms such as headache, swollen lymph nodes, fever, fatigue or muscle ache that last for a month or more[29]. Cryptosporidiosis is a waterborne protozoal disease. The parasite affects distal part of the small intestine. It is transmitted through faecal–oral route. Generally, it is an asymptomatic infection, but in case of persistent exposure, it causes moderate to severe diarrhoea and low-grade fever[30].

Helminths: These are the contaminants and large macroparasites of potable water. They include two classes of platyhelmintheses (flatworms), namely Cestodes and Trematodes, and many species of Nematodes as well. Among these, Trematodes (blood flukes) linked parasitic disease is the second-most socio-economically ruinous parasitic disease after malaria[31].

Annelids: Although annelids are helpful in increasing soil fertility, their presence in potable water causes illness. They increase the unpalatable organic content and disturb the quality of drinking water[32]. Polychaeta class of annelids are found in the coastal ecosystem. They are a source of many other pathogens and can cause gastrointestinal disorder when present in drinking water.

Phytoplanktons

Phytoplanktons are tiny florae that drift in watery environment. Some of them are bacteria, some are protists (algal blooms) and unicellular plants.

Cyanophyceae: Cyanophyceae are photosynthetic bacteria known for fixing atmospheric nitrogen in soil. Among these, blue-green algae are frequently seen in freshwater. Despite their substantial benefit in agronomy, blue-green algae are unacceptable in drinking water[33]. They contain numerous endotoxins, neurotoxins, cytotoxins and hepatotoxins such as domoic acid, aplysiatoxin, cyanopeptolin, cylindrospermopsin, nodularin R, saxitoxin and neosaxitoxin.

Dinoflagellates: The algal bloom of dinoflagellates in the aquatic ecosystem is known as red tide. They are flagellated eukaryotes and mostly found in the marine ecosystem, but a few are also seen in freshwater. They exhibit concentration-dependant toxicity and produce toxins known as dinotoxins. If the concentration of dinoflagellates is more than a million cells per millilitre in potable water, they can produce a toxic effect[34].

Bacillariophyceae: Diatoms (Bacillariophyceae) are microalgae found in grimy water tanks[35]. Although they are an essential component of the aquatic ecosystem, their presence in potable water tanks is undesirable. In pond and lakes, they have the capacity to reduce harmful blue-green algae and filamentous algae. Diatoms also increase dissolved oxygen in water. But there are few toxic diatoms. The long skinny diatoms (family Pseudonitzschia) produce toxins (domoic acid) that are harmful to human beings[36].

Faecal coliform bacteria: Although faecal coliform bacteria live in large numbers in the intestine of many cold and warm-blooded animals, their presence in drinking water is undesirable. The presence of coliform bacteria (especially *Escherichia coli*) in potable water usually indicates some faecal contaminants and a risk of pathogens[37].

Regardless of the above-mentioned facets, there are some virus and bacteria whose presence is undesirable in potable water. Diseases like hepatitis, cholera and typhoid are caused by poor quality of drinking water. These biotic factors of water pollution can spawn many toxins and chemicals[38]. There are many toxins and chemicals which can cause serious health hazards when their levels increase beyond the permissible limits (Table 1).

Since most of the contaminants of drinking water have many deleterious effects on humans, the water should be purified using certain techniques (Table 2). The methods of water purification are based on certain physical, chemical and radiation techniques, such as filtration, flocculation, chlorination, sedimentation and use of electromagnetic radiations (ultraviolet light). These are the rudimentary methods from which many advanced techniques have been derived and being practised in the developed countries. Methods like fluoridation and pH correction are also being adopted in the developed countries. Fluoridation improves the quality of community water supply and adjusts the concentration of fluoride ion to an adequate level so that dental cavitations can be reduced. Excess fluoride in drinking water leads to a serious health hazard and can damage the parathyroid gland. Hence, its adequate monitoring is necessary. Correction in the pH level of community water helps prevent several health hazards. Adequate pH level strengthens our physiology and intercepts a recipient from acid–base imbalance.

Approaches followed in the developed countries

High-quality freshwater is limited in quantity and the impact of water pollution is worsening each day[39]. According to the need (such as domestic, industrial and agricultural purposes), there are various units for the control and supervision of undesirable matter in surface water in the developed countries. As far as the standard of drinking water is concerned, it varies from country to country. There is no single explicit or universally accepted standard for all countries[40]. In Europe, the European Drinking Water Directive has set the standards, while in United States, the Environmental Protection Agency (EPA) has established standards for drinking water. These standards exhibit slight variation. Moreover, the approaches used to regulate planktons in potable water are based on parameters such as identification of hazards, dose–response assessment, exposure assessment and risk characterization[41–43].

(i) Identification of hazards: The identification of extrinsic agents is carried out in order to evaluate the adverse effects on human physiology.

(ii) Dose–response assessment: It is a biological method used to explore the quantitative relationship between dose and the extent of adverse effects on human beings.

Table 1. Admissible limits of chemicals in drinking water according to the World Health Organization

Parameters	Limits (mg/l)
Total hardness	500
Iron	0.1
Chlorides	200
Calcium	75
Magnesium	50
Copper	1.0
Fluoride	1.5
Mercury	0.001
Cadmium	0.005
Selenium	0.01
Arsenic	0.05
Lead	0.05
Zinc	5.0
Total dissolved solid (TDS)	500 (500–1000, High TDS)
pH	6.5–8.5

Table 2. Commonly used water-treatment techniques

Primary techniques	• Coagulation • Precipitation • Chemical oxidation • Chemical reduction	• Ozonation • Media filtration • Ultrafiltration • Boiling and filtration
Secondary techniques	• Activated sludge • High rate activated sludge • Extended aeration	• Trickling filters • Aerated lagoons
Advanced techniques	• Reverse osmosis • Powdered activated carbon • Granular activated carbon	• Ion exchange • Electrodialysis

(iii) Exposure assessment: In this stage, the population or individuals are exposed to toxic pollutants for a certain time period and exposure assessments are carried out.

(iv) Risk characterization: This deals with the estimation of incidence and severity of the detrimental effects in a population due to predicted or actual exposure.

It has been reported that despite traditional methods of drinking water treatment, certain new techniques such as pressure-actuated membrane processes (ultra filtration, microfiltration, nanofiltration and reverse osmosis) are also being adopted in USA and Europe[44,45]. These techniques are good alternatives to the conventional purification method for removal of planktons from potable water. The membranes of microfiltration have pores in the range 0.1–10 μm with highest permeability, which can encounter planktons of potable water. Ultrafiltration membranes and nanofiltration membranes have smaller pores of 0.002–0.1 μm and 0.001 μm respectively. Reverse osmosis is a dynamic technique utilized for the purification of drinking water[46].

Discussion

The issue of undesirable planktons in potable water is aggravating in rapidly urbanizing countries. The people of urban region obtain potable water from the community water supplies (after purification from different water bodies) and, in the course of wastewater management the impact of the discharge of secondary treated effluent on water bodies sufficiently affect the quality of potable water[47,48]. If human and animal waste products get into the water bodies, they can cause diseases. The presence of coliform bacteria in surface water indicates contaminants of faecal matter. Addition of sewage, domestic and industrial waste has a major impact on dissolved oxygen and biological oxygen demand of surface water[49]. Though planktons are an essential part of the ecosystem, a few are not desirable in drinking water. *Asellus* (freshwater shrimps) and chironomids (midge fly larvae) are organisms that can be seen with naked eye. They are harmless and do not cause any risk to human health. However, there are many other organisms which are undesirable in potable water and can cause serious health issues. The presence of cyanobacterial bloom (blue-green algae) in potable water has several adverse effects on human health. Many of them produce various cyanotoxins (neurotoxins, hepatotoxins, cytotoxins and endotoxins)[50]. Integrated water and wastewater management approach may be useful in reducing the potential risks of water pollution by these planktons[51]. It is an effective process that encourages management of water and related resources in order to maximize economic and social well-being without any odious settlement with the facets of ecosystem[52]. Guinea worm disease is transmitted by drinking contaminated water[53]. There is no vaccine available to treat or prevent this illness. Metronidazole and thiabendazole are the drugs which may help in this disease, but the local application of these drugs can lead to migration of the worm to other parts of body[54]. Another example is giardiasis. Giardia are flagellated protozoans which can cause a variety of gastrointestinal disorders. According to the guidelines of the World Health Organization, the medicines used to treat giardiasis are nitroimidazole compounds such as metronidazole, tinidazole, ornidazole or secnidazole[55]. Amoebiasis can be prevented by avoiding contaminated water. However, at the tissue level amoebiasis can be treated by nitroimidazole compounds while luminal infections by luminal cysticidal agents such as iodoquinol and diloxanide furoate[56]. Acanthamoeba keratitis is generally associated with the perfusion of contaminated water to the human eye, after which the amoeba invades the cornea. In case of contact lens contamination, the associated pathogen remains alive in the space between the lens and the eye[57]. Toxoplasmosis is generally transmitted through oral route when *Toxoplasma gondii* cysts are ingested through drinking water or contaminants. The preferred drug for the treatment is sulphamethoxazole with trimethoprim[58].

Consumption of drugs or antibiotics for water-borne diseases is not the solution to the problem. After recurrent exposure they can produce certain adverse effects. The organism may exhibit resistance also. In order to address the problem of undesirable planktons in potable water, a safe and well-planned approach is required.

Conclusion

Introduction of toxic chemicals in the biomes has become a serious issue in the present era. Environmental pollutants affect almost all organ-systems. Planktons are microscopic organisms that live in aquatic environments, both salty and fresh. They are an essential part of the aquatic ecosystem, but their excessive limits in potable water are undesirable. Zooplanktons and phytoplanktons in potable water can cause severe impairment in the physiology of recipients. Many species of cyanobacteria, dinoflagellates, bacillariophyceae, copepods and protozoans have been reported as being capable of producing toxins. They can cause dermatotoxicity, neurotoxicity, hepatotoxicity or gastrointestinal disorders. Potable water and municipal water tanks must be free from undesirable planktons.

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