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Microbiological Safety of Drinking Water and Health Risks

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Abstract: ***Safe and clean drinking water is basic requirement for human life. Contamination of water due to microbiological hazards which include lack of clean water supply, sanitation and unhygienic practices are major causes for many waterborne diseases in a community causing water - related health problems such as cholera, diarrhoea, dysentery, hepatitis A, typhoid, polio etc. The aim of this brief review is to highlight the microbial contamination of drinking water. Pathogenic microorganisms includiing Burkholderia, Campylobacter, Legionella, Leptospira, Shigella, Vibrio, Yersinia, Cryptosporidium, Cyclospora, Entamoeba, Giardia, Microsporidium, Naegleria, Toxoplasma, Salmonella spp, Listeria monocytogenes, Pseudomonas aeruginosa, Campylobacter jejuni, Escherichia coli, Enterococcus faecalis, Adenovirus, Astrovirus, Calicivirus, Coronovirus, Enterovirus, Poliovirus etc. contaminate drinking water and transmit diseases. In adults, symptoms include myocarditis, diabetes, reactive arthritis, cancers etc. Pathogens in contaminated drinking water include helminths, Entamoeba histolytica, Giardia lamblia hepatitis A and E, Enteroviruses, C. jejuni and H. pylori. Water borne diseases are spread by bathing, washing, or by eating food exposed to contaminated water. Developing countries in rural areas are facing maximum problems of water contamination in potable water. Diarrhoea and vomiting are the most commonly reported symptoms due to waterborne illness. Improved water supply and sanitation treatments as well as better management of water resources contribute to human health and poverty reduction.***

Keywords: Drinking water, Water contamination, Pathogen, Diseases

1. Introduction

Globally about 1.7 billion people use a drinking water source contaminated with faeces. Microbial contamination of drinking water poses a great risk to drinking water safety and human health. Drinking water is an important source for human existence and microbial contamination poses a serious health problem. India's water demand by 2030 is projected to be double the amount available as reiterated by the Interconnected Disaster Risks report in October 2023. The net amount of water that can be used in India in a year is estimated at 1, 121 billion cubic meters (Bm^3). Yale University's 2022 unsafe drinking water index ranked India at 141 out of 180 countries. Nearly 70% of India's water is contaminated. The business - as - usual scenario projects the total water demand to increase by 22% and 32% by 2025 and 2050, respectively, from the present level of 680 Bm^3.

Contaminants

The contaminants are of four different types. The organic contaminants are pesticides, domestic waste, industrial wastes, etc. These results in cancers, hormonal disruptions and nervous system disorders. Biological contaminants are due to the presence of living organisms such as algae, bacteria, protozoan and viruses. Radiological contaminants are caused by radioactive elements. These increase the risk of cancers. These are available in groundwater than surface water. Pesticides are also a source of contaminant under organic contaminants. Dyes are of great concern under environmental type. Besides pharmaceuticals are of great concern for pollution which come from hospital effluents.

2. Brief Review

Ramirez - Castillo et al. (2015) reported water borne outbreaks globally. They found that drinking water quality is deteriorated by contaminants of toxic chemicals and microbes in storages, poor handling and transport. Bitton. (2005) found 2 billion people utilizing contaminated drinking water with excreta under such circumstances. More people died each year by consuming contaminated drinking water as reported by WHO 2022. Hu et al. (2011), Patel et al. (2016) and Praveena et al. (2018) reported that quality of tap water in high - income countries is stringently regulated and monitored. The demand for bottled and dispensed water has been on increase worldwide. The consumption of bottled water has been increasing by at least 10% every year since 2008. The fastest growth of consumption has been observed in Asia and South America which was reported by Gleick et al. (2012). Use of different drinking water sources from different machines for human consumption has been increasing as reported by Girolamini et al. (2019). They found new sources of drinking water which are self - standing microfiltered water vending machines and drinking water from soda fountains which are commonly preferred alternatives to bottled water and appeared to be environmentally friendly thus overcoming bottled water disposal and pollution hazards. These sources are typically equipped with reverse osmosis or activated carbon filters that can remove chlorine taste, odors, and organic and inorganic contaminants. Ramirez - Castillo et al. (2015) found that soda fountains are commonly used to dispense beverages in most fast - food restaurants where consumers either dispense their own beverages in a purchased cup, or employees use soda fountain to dispense purchased beverages for customers. Soda fountain machines dispense carbonated soft drinks and drinking water. The global soda water dispenser market was valued at $1.0 billion in 2018 and is expected to grow at a compound annual growth rate of 5.4% from 2019 to 2025. The majority of reports of water contamination from Soda fountains come from mass media sources as reported by Cox (2010) and Park et al. (2010). Disease causing microorganisms which are transmitted via drinking water are usually infected with faecal material and are a cause of serious enteric infection (Ashbolt et al., 2001

and Hunter et al., 2002). Apart from *E. coli*, there are certain parasitic protozoa such as oocysts of *Cryptosporidium parvum* and various enteric viruses as given by Hambidge (2001) and Li et al., (2002). This paper provides a brief review of waterborne pathogens in drinking water with a focus on remedial measures to get safe and clean drinking water.

Saunders and Warford (1976) described in his finding how Greeks during 6000 years ago used different techniques to purify water. These people adopted charcoal filters, boiling, straining and exposure to sunlight to improve the aesthetic quality of drinking water (WHO, 2003b). The outbreak of cholera in Germany took place during1892 which point out to understand the reason of waterborne pathogens in drinking water. Residents of Hamburg suffered high mortality due to this reason. The use of water treatment by slow - sand filtration was found fruitful in escaping the problem of disease outbreak. The German microbiologist, Robert Koch escape the worst ravages of the outbreak by isolation of the causative agent, which he named *Vibrio comma* later renamed to *Vibrio cholerae*. This lead to a technique of sand filtration. During late nineteenth century innovations resulted in the largest reduction in global disease burden. Similar improvements have been sought in various developing countries of the world which have been reported by Saunders Warford (1976). WHOa estimates that about 1.1 billion people globally drink unsafe water. Kindhauser (2003) described Global defence against the infectious disease threat and the vast majority of diarrhoeal disease in the world (88%) is attributable to unsafe and contaminated water. WHO (2003a) revealed it by quantifying selected major risks to health due to contaminated water. According to finding of Payment et al., (1997) in North America many cases of gastrointestinal disease come from water borne infection that was further supported by Tauxe, 2002. Guidelines given by WHO indicate high level of *E. coli* in developing countries. Major cause of concern by WHO in raising agricultural crops is by the practice of irrigating them with faecal contaminated water.

Infectious agents of diseases are spread by the faecal oral route, poor hygiene etc. In 2001, infectious diseases account an estimated 26% of deaths worldwide as recorded by Kindhauser (2003). Social and environmental changes continue to result in waterborne pathogen issues and climate change was estimated to be responsible during the year 2000 for approximately 2.4% of world - wide deaths due to diarrhoea, 6% of malaria in some developing countries and 7% to dengue fever in some industrialised countries. *Salmonella typhi* is the cause of Typhoid fever, *Salmonella paratyphi* cause Paratyphoid fever. *Salmonella* is the cause of Salmonellosis. *Shigella* spp. is the cause of Bacillary dysentery while *Vibrio cholera* cause of cholera. Enteropathogenic *E. coli* causes gastroenteritis. *Legionella pneumophila* and related bacteria cause acute respiratory illness. Polio viruses cause Poliomyelitie. Coxsackie viruses A cause aseptic meningitis. Coxsackie viruses B cause aseptic meningitis. WHO (2002) found that cholera was the most frequent with acute diarrhoea and typhoid, paratyphoid fever caused by *Salmonella typhi* and *S. paratyphi*, respectively resulted in an annual incidence of about 17 million cases worldwide. Both typhoid pathogens are passed in the faeces and urine and people become infected after eating food or drinking beverages that have been handled in poor way by people. Most water is contaminated by sewage water. Once the bacteria enter the human body, it multiplies and spread from the intestine into the bloodstream. Even after recovery from typhoid or paratyphoid, a small number of individuals called carriers continue to carry the bacteria. Other parasitic protozoa include *Entamoeba histolytica*, *Giardia lamblia*, *E. coli* and *Cyclospora cayetanensis*. Trabulsi et al., (2002) described typical and atypical enteropathogenic *Escherichia coli* as the only reservoir to cause infection in humans. These bacterial pathogens are spread due to poor handling of human excreta that hampers water quality and thus became a major problem in causing human diseases. Several aquatic species of bacteria are also opportunistic pathogens of humans as reported by (Ashbolt, 2003). Examples of *Legionella* that cause legionnaires disease and Pontiac fever were described by Atlas (1999).

Several species of *Legionella* are transported in drinking water, however, it is the growth of certain serogroups and subtypes in warm waters/biofilms that result in high number necessary to be aerosolised and inhaled into the human lungs where the target phagocyte cells reside. Environmental pathogens that may well be transmitted directly by drinking water in developing regions are fast - growing atypical mycobacteria, *Burkholderi pseudomallei* and *Helicobacter pylori*. In tropical regions, *Mycobacterium ulcerans* is found in aquatic environments and *M. avium* complex and *M. intracellulare* bacteria appear to grow in piped and chlorinated water biofilms and are a major concern to immuno - suppressed individuals which was reported (Falkinhamet et. al., 2001). Ascariasis is an infection caused by *Ascaris lumbricoides* which is a a large round worm. The eggs of the worm are found in soil and are transmitted by contaminants of human faeces or in uncooked food (Ashbolt, 2003). Ascariasis occurs with higher frequency in tropical and subtropical regions which is a major cause of morbidity and mortality in children. This is a disease of people who are exposed to untreated wastewater or food grown on it (Blumenthal and Peasey, 2002). They highlighted the importance of diseases due to agricultural activity. There are a range of Helminths diseases potentially transmitted by water and are easily removed from drinking water by filtration. Hence, Helminths are generally less of a problem via drinking water than the smaller microbial pathogens. Black (1993) reported waterborne and foodborne parasitic protozoa which include *Cryptosporidium parvum*, *Giardia lamblia* and *Toxoplasma gondii*, *Cyclospora cayetanensis* and *Sarcocystis* spp. All these parasitic protozoa are the cause of diarrhoea.

Water purification can reduce the concentration of particulate matter including suspended particles, parasites, bacteria, algae, viruses, and fungi as well as reduce the concentration of a range of dissolved and particulate matter. The first step in purifying surface water is to remove large debris such as sticks, leaves, rubbish and other large particles which may interfere with subsequent purification steps. Water from rivers may also be stored in bankside reservoirs for periods between a few days and many months to allow natural biological purification to take place. This is especially important if treatment is by slow sand filters.

Storage reservoirs also provide a buffer against short periods of drought or to allow water supply to be maintained during transitory pollution incidents in the source river. In many plants, the incoming water is chlorinated to minimise the growth of fouling organisms on the pipe - work and tanks. The most common type of filter is a rapid sand filter. Water moves vertically through sand which often has a layer of activated carbon or anthracite coal above the sand. The top layer removes organic compounds, which contribute to taste and odour. The space between sand particles is larger than the smallest suspended particles. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles. Effective filtration extends into the depth of the filter. This property of the filter is a key to its operation if the top layer of sand were to block all the particles. Disinfection is a method to control parasitic and viral pathogens. Use of bacteriophages i. e., viruses that infect faecal indicator bacteria is another method of treatment. Bioremediation is of great importance in purification of water. Monitoring water is a prerequisite for one or more indicator microorganisms to assess the health risk associated with the consumption of water. Total coliform bacteria have been used to assess the microbiological quality of the drinking water. Safe disposal of human and animal excreta *in situ* is also a safely managed sanitation service in developing countries.

3. Conclusion

Quality drinking water is the first fundamental requirement for life and survival on earth. Contaminated drinking water results in many health problems due to waterborne diseases for which prevention is one of the foremost requirements and is a challenging task. There is a need to find out a rapid, inexpensive and accurate way to assess the microbiological quality of water. It is also found that there is a need to work out the pathogens from agricultural water to fresh produce for food safety and human health. The problem associated with developing countries is related to unsafe water, poor sanitation and inappropriate hygiene. There are numerous emerging waterborne microorganisms and issues. At some other places there is scarcity of water supply due to which people go to nearby water bodies. Though these water bodies are affected by faecal contaminates due to which a chain of cycle is transmitted to human beings and thus becoming a source of diarrhoea. Perhaps the greatest threat to safe drinking water is also through close association with animals.

4. Future Thrust

Government should take measures to abolish slum areas so that people adopt good personal hygiene conditions and transmission of diarrhoea thus avoided by faecal contaminates. Water bodies should be saved from dumping out of waste material. Best way to keep healthy is to use the process of filtration and chlorination besides distillation which will be a remedial measure for use of drinking water in sewage affected areas. There is a need for comprehensive data base in public domain and study on assessment of the impact of climate change on different water resources.

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