Microbial Biodiversity

Edited by

P. Ponmurugan and J. Senthil Kumar

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CHAPTER TEN

MICROBES IN WATER

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Abstract

Water microbiology deals with microorganisms that live in water, or can be transported from one environment to another by water. Water can sustain the growth of many types of microorganisms. This can be advantageous. However, the presence of other disease-causing microbes in water is harmful and can even be life threatening. Contaminated drinking water can be fatal. The intestinal tract of warm-blooded animals also contains viruses that can contaminate water and cause diseases. Many microorganisms are found naturally in fresh and salt water. Water can also be the best way of transporting microorganisms from one place to another. Drinking water is usually treated to minimize the risk of microbial contamination using chemicals like chlorine. Current methods of treating water include using modernized filters and activated carbon. An important aspect of water microbiology, particularly for drinking water, is testing water to ensure that it is safe to drink.

Keywords: Water microbes, Water treatment, Drinking water, Water microbiology

1. Introduction

Water is essential for life, and the quality of the water we drink has a direct effect on our health. Achieving and maintaining good water quality requires specific types of expertise in the production, distribution, and use of water, as well as cooperation among various operators. The quality of water may deteriorate because of chemical treatments, the fact that it has remained in the water distribution system for a long period of time, or structural/use-related problems in the water system. Research has been undertaken to obtain further information on the prevailing problems related to water quality and to find solutions for these issues.

2. Waterborne outbreaks

Waterborne outbreaks can be caused by microbiological or chemical contamination of drinking water. An outbreak may also be caused by airborne transmission of *Legionella* bacteria, which grows in the water supply systems. Many microorganisms that survive in the atmosphere could settle on the surface of open water source and could turn into a pathogen after a period of time.

2.1 Causes of waterborne outbreaks

Most waterborne outbreaks are caused by microbial contamination of groundwater, and outbreaks have often occurred at groundwater sources. Some waterborne outbreaks have also been caused by the use of unpurified lake or river water as drinking water (Figure 1). Aquifers can be contaminated by surface runoff like floods, heavy rain, poor drainage of household water, and the entry of wastewater into groundwater.

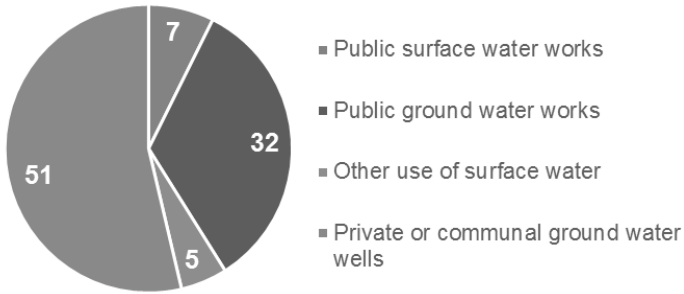

Figure 1: Breakdown of waterborne outbreaks by drinking water production system

2.2 Microbes causing waterborne outbreaks

The majority of waterborne outbreaks are caused by the norovirus and campylobacter (Figure 2). These microbes are fairly persistent, migrate well in soil and water, and have strong pathogenicity (Egli et al., 2002). Other soil microbes that cause outbreaks include clostridium and protozoans.

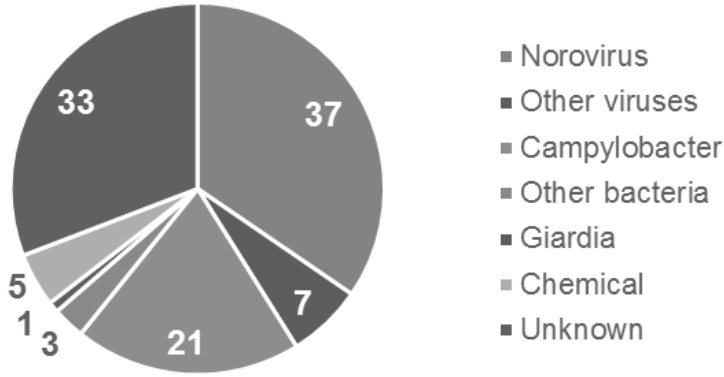

Figure 2: Etiological agents in waterborne outbreaks

3. Drinking water

Waterworks produce drinking water from surface water, groundwater, or artificial groundwater. Their water purification process depends on the quality of the raw water. The raw water collected from the natural source is filtered first to remove any suspended impurities and other floating substances. Disinfection is then carried out before the groundwater is pumped into the distribution system. The disinfection process can be carried out in different ways, including using chemicals, such as chlorine, and effective filtration systems.

3.1 Microbial growth and chemicals causing health risks

Microbes present in drinking water, raw water sources, or by-products of water production can cause health risks. Water leaving waterworks can become stagnant if left in the water distribution system for long periods of time, as this can result in microbial regrowth and changes to the water quality. Drinking water quality will be poor in stagnant water systems and

even become hazardous to health if the conditions are favorable for microbial growth. Health risks include the growth of bacteria in water distribution systems (Miettinen et al., 1997). The quality of the water collected can be checked for odor, color, and taste. If the results of this initial analysis are not satisfactory, water samples can be taken for further microbial and dissolved solids analysis, which will be able to decide if the water is potable or not.

3.2 Microbes in the water distribution system

Microbes multiply both in the water and on the biofilms on the pipes' surfaces under favorable conditions. These biofilms and pipeline deposits hold harmful microbes, which then enter the water distribution system. Microbes, such as viruses, can live on the system's surfaces for long periods of time, and cleaning the contaminated system requires either disinfection or mechanical cleaning. Unfavorable odors and tastes in drinking water can be detected easily and are caused by microbial growth in the water distribution system. One of the reasons for such organoleptic problems can be the growth of molds or actinomycetes in the water distribution system.

4. Well water

In sparsely populated areas, drinking water is usually acquired from a well. Well water results from groundwater that has infiltrated the soil and does not usually require any treatment before use (Sobsey and Water, 2002). But due to land pollution and industrial waste that seeps into the groundwater, well water also becomes contaminated and can allow pathogenic organisms to grow.

4.1 Contamination of well water

The quality of the well water largely depends on the quality of the groundwater, which can have considerable variation depending on the environment and habitat. Many waterborne outbreaks can be caused by the use of contaminated well water as drinking water. Many pathogenic organisms, such as *E. coli*, have been found in well water contaminated by fecal material. Causes of contaminated well water include,

- Leaking from drainage systems
- Fecal matter from small animals residing in the well

- The storage and treatment of sludge
- Composting of waste material
- Surface water (rainwater, flood water)

A contaminated well can be salvaged through maintenance and cleaning measures. Such measures will be of no use if the soil surrounding the well has been contaminated. Usually, in such situations, the only effective solution is to dig a new well on clean soil far enough away from any source of pollution.

5. Waterborne Diseases

Hazardous drinking water can contain several water-borne diseases, which can be fatal (Borts, 1949). Some commonly encountered waterborne diseases are listed below.

5.1 Cholera

The gram-negative bacterium, *Vibro cholera*, causes this disease (Figure 3). It is transmitted by water and food that has been contaminated with fecal matter. This bacterium invades the layer of cells that lines the intestines and produces a potent protein toxin that is responsible for the disease (WHO, 2014). This toxin reverses the flow of liquids from the intestine into the bloodstream, thereby producing massive and explosive diarrhea of up to 20 liters per day. This, in turn, causes nausea, vomiting, and abdominal pain. The loss of body fluids, along with the electrolyte salts in the blood causes dehydration and shock. The blood becomes thick and the heart overworks itself to pump it through the body. The combination of these effects often leads to death within 24 to 36 hours after the onset of symptoms. There is currently no vaccine for cholera.

Figure 3: *Vibrio cholerae*

5.2 Salmonellosis

This disease is caused by members of the *Salmonella* genus (Figure 4). This is a gram-negative rod of the Enterobacteriaceae family. These bacteria live in the intestines of animals, including birds, mammals, reptiles, and amphibians. It induces gastroenteritis, diarrhea, abdominal cramps, fever, and vomiting. The disease is transmitted by food or water contaminated with fecal matter. Generally, they invade the cells lining the colon, the lower small intestine, and the underlying tissues. Their virulence mechanisms are not totally understood.

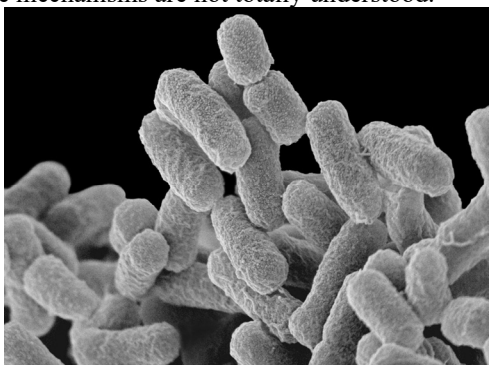

Figure 4: *Salmonella*

5.3 Shigellosis

Shigella is another gram-negative bacterial intestinal pathogen that is transmitted in fecal contaminated water and food (Figure 5). Its main host is human and it is a major cause of infant mortality (Pandey et al., 2014). This organism is able to invade and destroy the colon's epithelial cells. It produces diarrhea, often with bloody stools and abdominal cramps. Its virulence is due to the powerful protein toxin it produces during infection.

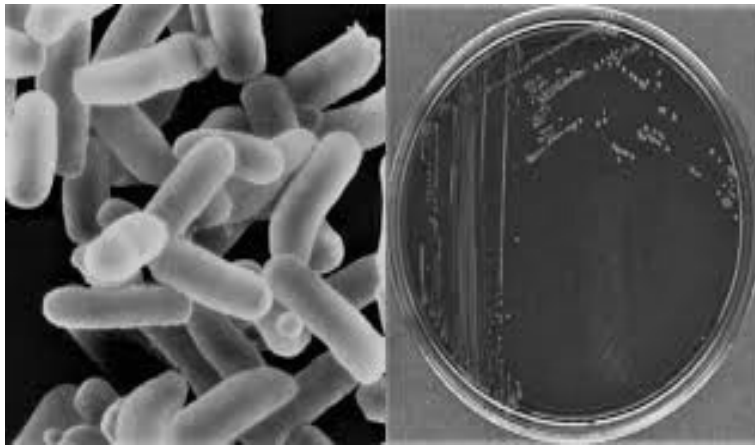

Figure 5: *Shigella*

5.4 *Helicobacter pylori*

This spiral shaped bacterium (Figure 6) is found in almost all stomach ulcer patients. It is now known that 95% of peptic ulcers and 100% of chronic gastritis is caused by *H. pylori*. This organism is the major cause of stomach cancer because it produces a persistent immune response that damages the stomach lining. It grows in the mucous lining that protects the stomach cells from the strong acid. *H. pylori* is highly mobile and is able to propel through thick mucus due to its vigorous corkscrew motility. Further, they are protected from the stomach's acid by the production of the urease enzyme, which breaks down urea into ammonia; this then neutralizes the stomach acid in the area affected by *H. pylori*. Its transmission may be via water and person-to-person contact, but this has not yet been proven.

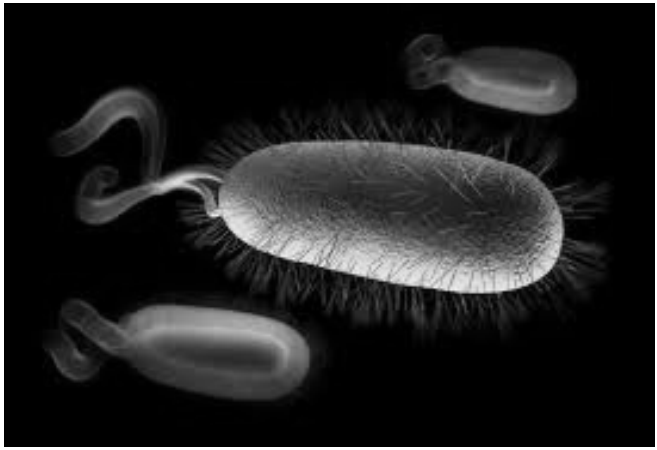

Figure 6: *H. pylori*

5.5 Hepatitis A

Hepatitis A (Figure 7) is a water-borne disease caused by a virus that can be transmitted via the fecal-oral route. It produces fatigue, jaundice, fever, and diarrhea. It has a long incubation period before symptoms develop and it is infectious during much of this period. The virus survives in water contaminated with human waste and it is easily spread through poor handling of food. There is no treatment for this disease because it is caused by a virus (Ramírez-Castillo et al., 2015).

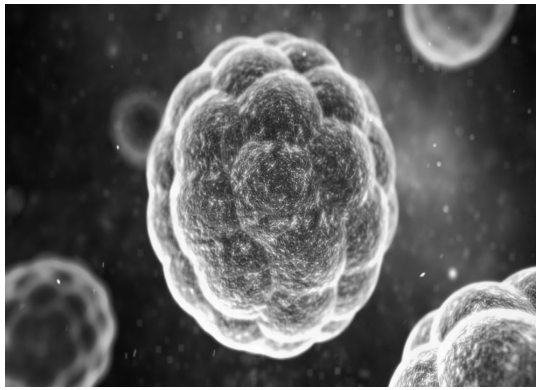

Figure 7: Hepatitis A virus

5.6 Amoebiasis

Amoebiasis is a disease caused by the protozoa, *Entamoeba histolytica* (Figure 8). It is endemic worldwide and is mostly found in crowded, unsanitary conditions. Its etiological agent is an amoeba that is capable of forming a chitin-covered cyst to resist adverse environmental conditions (Efstratiou et al., 2017). It causes amoebic dysentery, which is characterized by diarrhea, abdominal pain, and blood in the feces. It is rarely fatal, but it is a chronic infection and it is primarily transmitted by water contaminated with feces. This organism can invade other tissues and can cause severe liver damage and early death. Anti-protozoan drugs can treat it, but once it leaves the intestine it is often impossible to cure.

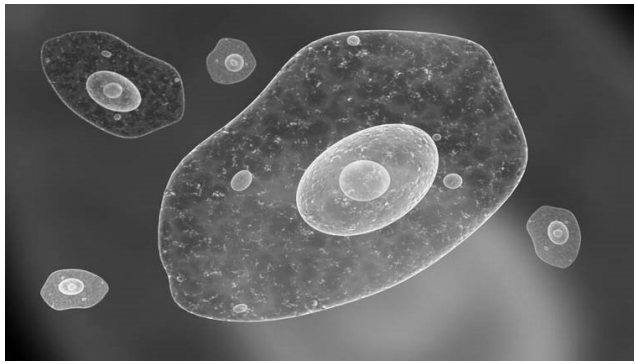

Figure 8: *Entmoeba histolytica*

5.7 *Campylobacter jejuni*

Campylobacteriosis is an infection caused by *Campylobacter jejuni* (Figure 9). Symptoms of this illness include cramps, diarrhea, fever, and pain. These bacteria may be present in water, as well as in unpasteurized milk or chicken. Symptoms of infection appear two to ten days after exposure.

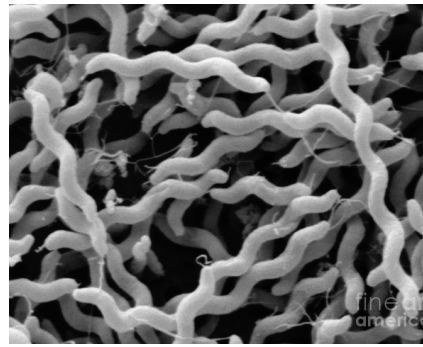

Figure 9: *Campylobacter jejuni*

5.8 *Escherichia coli*

Infections with *E. coli* bacteria cause fever, vomiting, nausea, abdominal pain, and diarrhea (Figure 10). If a person drinks water contaminated with *E. coli*, symptoms will typically appear within one to eight days.

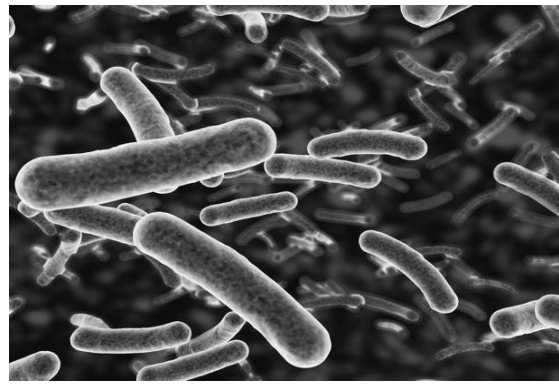

Figure 10: *E. coli*

6. Managing Waterborne Pathogens

Water from public supplies must be treated effectively in order to remove microbial pathogens because they can grow into large colonies when favorable conditions are present (Ericksen and Dufour, 2018). In addition to treating the water, the infrastructure of the supply system must be clean

and free of biofilms. These biofilms grow on any surface through which the water flows and facilitates the growth of microbes; they eventually become part of the community. Biofilms, as a microbial community, collaborate to protect themselves from disinfection, so any presence of biofilm is a risk. Furthermore, according to the World Health Organization, the minimum standards used to treat and distribute drinking water to the general public are not stringent enough for the treatment and management of water utilized in healthcare settings.

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