Microbiological parameters of drinking water

I Production of drinking water and problems related to it.

Clean and safe drinking water is essential for healthy, thriving communities. The availability of drinking water is one of the most important basic conditions for human existence [1;2].

Rivers, lakes and underground aquifers are all potential sources of potable water [2]. In order to ensure the availability of clean drinking water to the population, its treatment is carried out. The treatment most often includes physical purification, chemical purification (sedimentation, coagulation, filtration) and disinfection (primary and secondary disinfection).

Chlorination is the most common method of primary disinfection after which, the now potable (drinking) water is pumped to storage tanks. Ultraviolet radiation also is used to treat secondarily treated effluent from water plants. UV radiation has several advantages over chemical disinfection procedures like chlorination. Firstly, UV irradiation is a physical process that introduces no chemicals into the water. Secondly, UV radiation-generating equipment can be used in existing flow systems. Thirdly, no disinfection by-products are formed with UV disinfection.

Potable water flows through distribution system of storage tanks and supply lines to consumers (*Figure 1*). The production of drinking water not only ensures the disposal of potential microbiological pathogens, but also eliminates taste and odour, reduces nuisance chemicals and decreases turbidity, which is a measure of suspended solids [2;3].

Biological stability of drinking water refers to the concept of providing consumers with drinking water of same microbial quality at the tap as produced at the water treatment facility [1]. Once drinking water leaves the treatment facility, the water often travels through many miles of municipal and premise distribution pipes from the facility to the consumer [3]. The presence of dissolved organic compounds in this water can cause problems, such as taste and odour, enhanced chlorine demand, and bacterial colonization of water distribution systems [4].

Bacterial growth and interactions are regulated by factors, such as 1) availability, type and concentration of different nutrients; 2) type and concentration of residual disinfectant; 3) presence of natural predators (most often protozoa), 4) environmental conditions (water temperature), 5) spatial location of microorganisms (bulk water, sediment, or biofilm) [1].

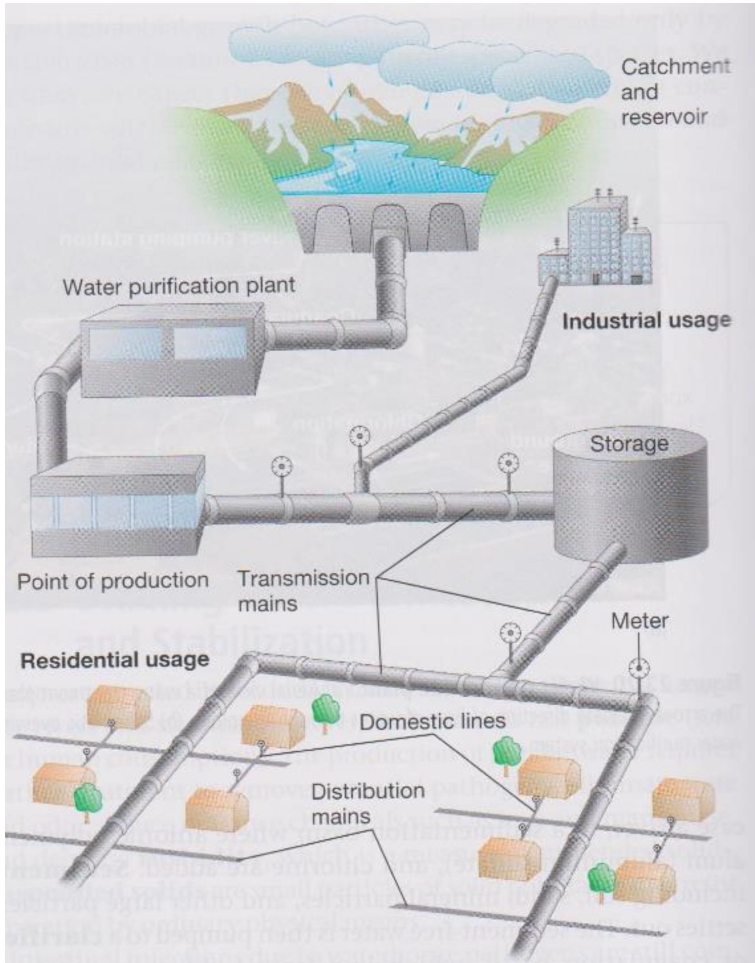

Figure 1. Drinking water distribution system [3].

Growth of bacteria is unavoidable because of reduction in chlorine concentration with increasing distance from the point of production together with the tendency of microorganisms to form biofilms on the pipe walls. Biofilms are clusters of microorganisms that adhere to biological or non-biological surfaces. We can also define biofilm as a surface association of microorganisms that are strongly attached through the production of an extracellular polymer matrix [3,5]. Biofilm development occurs through microbial attachment to a solid surface in a several stages: 1) reversible attachment (a transitory physicochemical attraction) and 2) irreversible attachment (a biologically mediated stabilization reaction) [2;6;7].

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Biofilm formation includes several actions shown in *Figure 2*. At the beginning dissolved organic molecules accumulate at the solid surface - water interface and form a conditioning film. Bacteria can approach the solid surface because of water flow and/or active motility provided by flagellum. Various attractive or repulsive physicochemical forces leaking to passive, reversible surface attachment, control the initial adhesion (phase I). A chemical bridge to the solid surface (phase II) is formed by the proliferation of bacterial exopolymers; a biological, time-dependant process related to this proliferation is an irreversible attachment. The mature biofilm is formed by means of combining colonization and bacterial growth [2;3].

Several advantages have been described as to why it is beneficial for microorganisms to form biofilms. Firstly, biofilms resist physical forces that could otherwise remove cells loosely attached to a surface. Biofilms also resist phagocytosis by protozoa and immune system cells and retard the penetration of toxic molecules, such as antibiotics. Secondly, biofilm formation allows cells to remain in a favourable niche. Biofilms attached to nutrient-rich surfaces, or to surfaces in flowing systems, fix bacterial cells in locations abundant with nutrients or are constantly being replenished. Thirdly, biofilms form because they allow bacterial cells to live in close proximity to each other. This facilitates cell-to-cell communication, offers more opportunities for nutrient and genetic exchange, and in general increases chances for survival [3].

Microorganisms in biofilms are more resistant to disinfection, and significant microbial accumulation is found in all distribution systems. Experimental results showed that *Escherichia coli* is 2400 times more resistant to chlorine when attached to surfaces compared to free cells in the water, leading to high survival rates within the distribution system [8].

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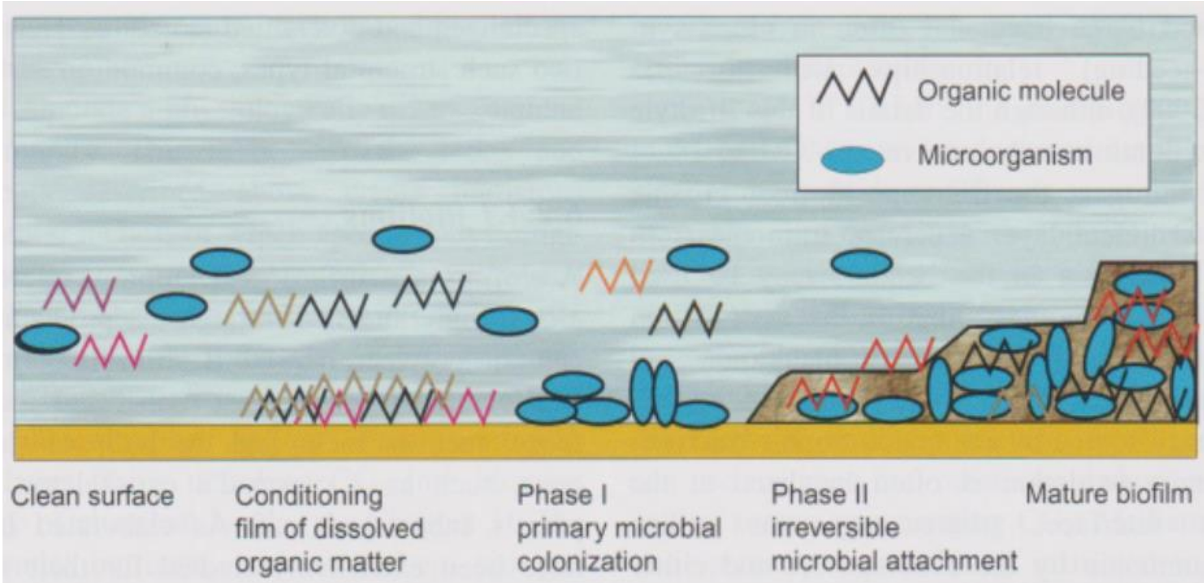

Figure 2. Representation of biofilm formation [2].

Contaminated drinking water in the distribution system can result from inadequate treatment, or from leaks or breaks in the distribution pipes. Traditionally, utilities have utilized indicator tests for fecal pollution to monitor the potential presence of pathogens. However, such culture assays can take up to 48 hours to complete, during which time contaminated water could be delivered to consumers [2,3].

Recently, utilities have been evaluating new online monitoring systems to augment traditional monitoring. Specifically, the goal has been to integrate software for data management with new real-time sensor technologies to provide an early warning monitoring program via a supervisory control and data acquisition system (SCADA), installed at critical points within the distribution system. Use of such real-time technologies allows for a rapid response to contamination that safeguards the public from consuming contaminated water [2].

Self-control questions.

1. What general procedures are used to reduce microbial numbers in water supplies?
2. What are the advantages of UV disinfection versus, or as a complement to chlorionation?
3. Why might biofilm be a good habitat for bacterial cells living in a flowing system?
4. Define and describe the main stages of biofilm formation.
5. Give an example of a biofilm which forms in all healthy humans organism.

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