Microbial update

water

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Attempting to write an article on the microbiology of water is one of the most difficult things for a microbiologist to do. Water is, by weight, the most important constituent of any living cell and is an absolute requirement for life. Water has been and indeed is still a most important vector of illness in both developing and advanced countries around the world. To start to consider the importance of water microbiology, we must look at how water is used and how it comes into contact with our bodies.

When considering water, it is easy to confine discussions to drinking water, but water is used in many other places with our food industry, and can come into contact with foods in many ways.

Potable water

Potable water is a term used widely and simply means water that is fit to drink. Legislation and regulation in different countries throughout the world will give different definitions of potable water, but essentially it must be free from human pathogens and hazardous chemicals.

Water sources that are used as a supply of potable water have to be picked carefully, there must be a year round supply, protection from pollution and an ability to be suitably treated. Surface waters (reservoirs, lakes, rivers) offer a good supply, but can be at risk from contamination. Ground waters potentially offer a better quality supply, as they are more protected from external factors. These are often used without any form of treatment, over those used to reduce hardness.

Water can contain a wide variety of innocuous micro-organisms such as acinetobacter, chromobacterium, flavobacterium, moraxella, and pseudomonas. However, contamination of waters with animal or human faecal material can introduce large numbers of pathogenic micro-organisms, many of which have a low infective dose. Pathogenic bacteria linked to waterborne outbreaks include, Campylobacter spp., Escherichia coli, Salmonella spp., Shigella spp., Vibrio cholera, Yersinia enterocolitica, and Aeromonas hydrophila. Distribution of these in drinking water can result in large outbreaks.

Additionally viruses such as enterovirus, adenovirus, hepatitis A, rotavirus and norovirus may be found in sewage contaminated water, whilst the protozoan parasites entamoeba, giardia, cryptosporidium and cyclospora may be found in some raw waters. Water that is a threat to heath, may be contaminated before treatment, and the infective agent then not effectively eliminated; or contamination can occur after effectively treated water has been distributed. Whichever the case such water has been the cause of large outbreaks of illness.

Processing of raw water

Raw waters will usually receive a pre-treatment to clear large debris, and then be stored in storage tanks or ponds. Ponds can increase water quality by allowing sedimentation, and antimicrobial action due to the effects of sunlight. Sedimentation can be improved by use of various metal salts or clays, these can cause a flocculation of suspended solids. It has been reported that up to 99% of the pathogens present in raw water can be eliminated at this stage.

Filtration can be used to further reduce microbial levels, this is often through natural or man made sand beds and can be efficient enough to effect a 1,000 to 10,000 fold microbial reduction, as well as a removal of some chemical contaminants. Other types of filtration, for example carbon filters, micro, ultra or nano-filtration can also be used.

As a final phase of water treatment, a disinfection step is often employed. This step is aimed at microbial inactivation, and is often required to maintain a bactericidal effect for some time throughout distribution.

The most commonly used disinfecting agent is chlorine, but others can be used (for example bromine, ozone, UV light).

Following treatment, water is distributed to its point of use. The distribution system must protect the clean water supply from recontamination, as well as preventing growth of injured organisms present in treated waters. Complex, very long or old distributions systems give the highest risk of microbial contamination or development, and it is at this stage that concerns over pathogens such as legionella, aeromonas and mycobacterium arise.

Overall, the water supply systems in developed countries, treat and supply very large amounts of water to large populations and it is done very safely and effectively. A great deal of care goes into this as by its very nature a minor contamination issue at a treatment works can supply poor quality water to large numbers of people, and has caused large outbreaks of illness. This is, however, a rare occurrence.

Bottled waters

There has been a trend in recent years, toward the consumption of bottled water rather than 'potable tap water'. This has been accelerated by health alerts that we

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should drink larger volumes and stay hydrated, together with concerns over consumption of drinks containing large amounts of caffeine or sugar. Bottled waters come in many forms and they are highly regulated.

Bottled water or 'table water' is any water placed in a sealed container and sold for drinking, such water can be treated to remove micro-organisms.

Spring water is bottled water derived from an approved underground source. Spring water can be treated to remove microbiological contaminants. Natural mineral water is bottled water obtained from an approved underground source, and may not be treated to remove micro-organisms.

Bottled waters are usually available in either carbonated or non-carbonated forms. The addition of carbon dioxide can reduce microbial levels in bottles, as it is an antimicrobial and additionally reduces the pH of the water.

The effects of storage on the bacterial levels in bottled water can be varied. The natural flora in water will tend to remain at a low level whilst the water is in its natural environment. This can, however, change once the water is bottled. Storage of bottled waters at room temperature is reported on occasion to allow multiplication of a bacterial flora to levels of $>10^4$/ml. The reason for this increase in numbers may include an increase in oxygen level during the bottling process, trace amounts of nutrients in the bottle and an increase in temperature of the bottled water over the source water.

As the organisms in the bottle grow and subsequently die and lyse, this may provide a second source of nutrients for other species, including human pathogens, if they were present. There has been considerable work done on the survival of various human pathogens in bottled waters, and results suggest that salmonella could survive for over one year and E. coli O157 for over 300 days. This shows the importance of ensuring the absence of human pathogens from bottled waters.

It is important for users to understand that bottled waters are not sterile, they will contain a varied microflora of generally innocuous organisms, but this should be kept in mind when handling bottled waters. They should not be stored continuously at elevated temperatures, once opened they should be consumed relatively quickly, and there should be good stock rotation to minimise storage of old bottles.

Food preparation

Besides the drinking of water, humans come into contact with water in many ways. One of these is in foods. Food production uses water, and this can become incorporated into food products.

Dried materials may require hydration before use, in the production of drinks, water is the main raw material, all food processing equipment requires regular washing, food production staff need to wash their hands, and in some type of food (fresh salad production) large quantities of water are used to help to clean the food itself.

All of these actions require the use of water of good microbiological quality. This will usually mean potable mains water, although spring and borehole ground waters are used by some organisations if they are available.

Food production

Agriculture is a major water user. In most parts of the world, at some point in the growing season, crops will require irrigation and the microbiological quality of irrigation water, as well as the type of irrigation used require some consideration. Crops can be divided into two types depending on risks to the consumer. Firstly there are those that have to be cooked before they are eaten, for example potatoes. These pose little risk, as the cooking process applied by the consumer will be sufficient to eliminate high microbiological loadings from the crop.

Secondly, there are a wide range of salad crops that will be, or could be eaten in a raw state, for example lettuce, tomato, strawberry, carrot and pepper. In these cases there will not or may not be a cooking process applied before consumption. Thus microbiological contamination could be an issue.

It is important to consider the quality of irrigation water with all crops, but particularly those that could be eaten in a raw state. Waters that could contain animal or human sewage should be avoided. The use of drip irrigation, where water is provided at soil level rather than sprayed on the edible parts of plants, can help to reduce the chance of organisms in the water attaching to the plant leaves or fruit.

There have been a number of large outbreaks of food poisoning around the world linked to the consumption of vegetables, and whilst some have been traced to animals contaminating field crops, a number have been linked to crop contamination from irrigation water, or indeed local waters used to make up pesticides, that have been sprayed onto crops.

Flooding

Over recent years, there have been a number of well publicised issues of widespread flooding in many countries. Flooding provides an uncontrolled, widespread coverage of homes, factories, restaurants and crop growing areas with potentially highly contaminated water. Flood water must be considered to be highly contaminated and will probably contain both human and animal waste and thus be a source of human pathogens.

Any food production areas (restaurants, factories or domestic kitchens) that have been flooded must be considered to be highly contaminated with micro-organisms. They require thorough cleaning to remove all waste and debris, followed by decontamination using disinfectants/sanitisers. In commercial situations, the cleaning/decontamination process should be verified by swabbing and testing for microbiological pathogens.

Flooded crops require careful consideration as their edible parts could potentially be contaminated with human pathogens. Generally any crops that have been subject to flooding should not be eaten in a raw state, but should be cooked thoroughly before consumption is considered.

Conclusions

Water is used everywhere. It is consumed either from normal supply or as a bottled drink, it is used as a raw material in food and drink production, it is used as the base cleaning material in all food production units, it is used to clean raw food materials, and to irrigate ready to eat crops.

Considering its widespread and varied use it is satisfying that so few large health issues are traced to water, however this should never lead to complacency. Wherever water is used either for direct drinking or within food production, risks associated with it should be considered and minimised, before it is used. ■

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