Health Aspects of Virological Water Quality: An Overview Review

Redwan, N.A.; Al-Fassi, F.A. and Ali, M.A.

Microbiology Division, Department of Biological Sciences, Faculty of Science, King Abdulaziz University, Jeddah, KSA.
Environmental Virology and Water Pollution Research Department, National Research Center, Cairo, Egypt.

Abstract: The wide variety of waterborne diseases is the most important concern about water quality. It is known that enteric viruses are not normal flora in the human intestine but transmitting through contamination of water and foods. Detection of enteric viruses in water resources is not available for all countries so, the WHO water quality standards ignored virological quality of water but with alarm that drinking water must be virus free. In the present article we discuss the health impact of contamination of drinking water with enteric viruses and the drinking water quality guidelines in the world.

Key words: Health aspects, virological water quality, review

INTRODUCTION

Contamination of water sources with viruses is a worldwide problem not only for underdeveloped countries, but also for developed one. The wide variety of waterborne diseases is the most important concern about water quality, and their public health impact has far-reaching implications. The pathogens concerned include many types of viruses, bacteria, protozoa and helmiths, which differ widely in size, structure and composition. In developed countries the mortality due to waterborne diseases is low, but the socio-economic impact is phenomenal.[18]

Waterborne diseases are typically caused by enteric pathogens, which belong to the group of organisms basically transmitted by the faecal-oral route. In other words, they are mainly excreted in faeces by infected individuals, and ingested by others in the form of faecally contaminated water or food.

Viruses feature prominently among the wide variety of waterborne pathogens. Examples include the 1991 outbreak with 70,000 cases of hepatitis E caused by polluted drinking water in Kanpur, India.[11] Reasons for the high incidence of waterborne viral infections include excretion in exceptionally high numbers by infected individuals, relatively high resistance to unfavorable environmental conditions including water treatment and disinfection processes, and a minimal infectious dose which may be as low as a single viable viral particle[18]. Epidemiological studies on waterborne viral infections are complicated by the absence of clinical symptoms in many individuals, particularly children, while all infected individuals excrete viruses at similar rates. Factors which affect the occurrence of pathogens include changes in population densities, socio-economic situations, standard of living, education, vaccination, climate, geography, urbanization, migration and traveling, and public health policies. The role of microbiological analysis is very important in a strategy for the control of waterborne diseases based on appropriate treatment systems, appropriate operation of the treatment systems, and appropriate quality monitoring.

The quality of water, whether it is used for drinking, irrigation or recreational purposes, is significant for health in both developing and developed countries worldwide. Water quality can have a major impact on health, both through outbreaks of waterborne disease and by contributing to the background rates of disease. Accordingly, countries develop water quality standards to protect public health. Recognizing this, the World Health Organization (WHO) has developed a series of normative "guidelines" that present an authoritative assessment of the health risks associated with exposure to health hazards through water and of the effectiveness of approaches to their control. The three principal guidelines are intended to assist countries in establishing effective national or regional strategies and standards.[33]

Waterborne Viruses and Health Hazards: Infectious diseases caused by pathogenic viruses are the most common and widespread health risk associated with drinking water. The pathogens that may be transmitted
through contaminated drinking water are diverse. While many of the pathogens are known it is unlikely that all water-borne pathogens have yet been recognized. For pathogens transmitted by the faecal-oral route, drinking water is only one vehicle of transmission. Contamination of food, hands, utensils and clothing can also play a role, particularly when domestic sanitation and hygiene is poor. Due to this multiplicity of transmission routes, improvements in the quality and availability of water, in excreta disposal and in general hygiene education are all important factors in achieving reductions in morbidity and mortality rates of faecal origin\[1\].

Some of the pathogens that are known to be transmitted through contaminated drinking water lead to severe and sometimes life-threatening disease. Examples include infectious hepatitis caused by hepatitis A virus (HAV) or hepatitis E virus (HEV). Others are typically associated with less severe outcomes, such as self-limiting diarrheal disease (examples rotavirus). Whilst the latter are of limited importance to healthy adults, diarrheal disease is associated with significant infant morbidity and mortality in some regions and amongst immunocompromised. More widely it contributes to malnutrition and thereby to developmental problems. The impact of an episode of diarrhea on a child in a developing country is typically greater than the impact on a child in a more developed country because of this. Other health outcomes may be more significant amongst other age groups\[21\].

The effects of exposure to pathogens are not the same for all individuals and as a consequence not for all populations. Repeated exposure to pathogens may be associated with a smaller probability or severity of illness because of the effects of acquired immunity. For some pathogens, immunity is life long (e.g. HAV) whereas for others the protective effects may be restricted to a few months to years. On the other hand, sensitive subgroups (such groups as the young, the elderly, pregnant women and the immunocompromised) in the population may have a greater probability of illness or the illness may be more severe including mortality. Not all pathogens have greater effects in all sensitive subgroups\[6\].

Not all infected individuals will develop symptomatic disease. The ratio of a symptomatic carriers differs for pathogens, and also depends on population characteristics such as prevalence of immunity. Symptomatic and a symptomatic carriers may both contribute to secondary spread of pathogens, thereby boosting the effects of primary exposure to pathogens in water.

Waterborne Viruses and Related Diseases: Over than 140 types of pathogenic viruses can be transmitted to humans from the aquatic environment. These viruses are all enteric viruses eliminated in the stools of the infected person (Table-1).

Infective Dose and Infectivity: Waterborne transmission of the pathogens listed in table-1 has been confirmed by epidemiological studies and case histories. Part of the demonstration of pathogenicity involves reproducing the disease in suitable hosts. Experimental studies of ‘infective dose’ provide relative information, as shown in Table-2, but it is doubtful whether the infective doses obtained are relevant to natural infections.

Reported data show that for a range of viruses of human origin, including the enteroviruses, doses as low as a single infectious particle is capable of inducing infection in man\[36\].

Individuals vary widely in immunity, whether acquired by contact with a pathogen or influenced by such factors as age, sex, state of health, and living conditions. Viruses are likely to be widely dispersed and diluted in drinking water, and a large number of people will be exposed to relatively small numbers. Hence, the minimal infective doses and the attack rates are likely to be lower than in experimental studies. If a susceptible person becomes infected by water, subsequently infecting others by person-to-person contact, the initial involvement of water may be unsuspected. Hence, improvements in water supply, sanitation, and hygiene are closely linked in control of disease in a community\[36\].

The multi-factorial natures of infection and immunity mean that experimental data from infectivity studies and epidemiology cannot be used to predict infectivity or risk precisely. However, probabilistic modeling has been used to predict the effects of water treatment in reducing attack rates from very low doses of viruses and thereby to confirm water treatment criteria.

Not all infected individuals will develop symptomatic disease. The ratio of asymptomatic carriers differs for viruses, and also depends on population characteristics such as prevalence of immunity. Symptomatic and asymptomatic carriers may both contribute to secondary spread of viruses, thereby boosting the effects of primary exposure to viruses in water.

Disease Surveillance and Waterborne Outbreaks: Disease Surveillance System: There is no national surveillance system in place for waterborne disease outbreaks. Surveillance system is designed to detect
Table 1: Human Pathogenic Viruses Found in Aquatic Environment[36].

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Serotype</th>
<th>Disease Caused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picornaviridae</td>
<td>Entovirus</td>
<td>Poliovirus</td>
<td>1-3</td>
<td>Paralysis, Meningitis, Poliomyelitis, Meningitis, Respiratory infection,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coxsackievirus group B</td>
<td>1-6</td>
<td>Myocarditis, Rash, Fever, Meningitis, Respiratory Infection, Pleurodynia, Paralysis, Hepatitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Echovirus</td>
<td>1-33</td>
<td>Diarrhea, Paralysis, Exanthema, Hepatic disturbance, Pericarditis and myocarditis, Pneumonia and bronchitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enteroviruses 68 to 71</td>
<td>4</td>
<td>Acute Haemorrhagic conjunctivitis (type 70) Paralysis and Meningoencephalitis (type 70, 71) Hand-foot-and-mouth disease (type 71)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hepatovirus</td>
<td>Hepatitis A virus</td>
<td>1</td>
</tr>
<tr>
<td>Reoiviridae</td>
<td>Reovirus</td>
<td>Human reoviruses</td>
<td>3</td>
<td>Respiratory and Gastrointestinal illnesses</td>
</tr>
<tr>
<td></td>
<td>Rotavirus</td>
<td>Human rotaviruses</td>
<td>6</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Caliciviridae</td>
<td>Norwalk like viruses</td>
<td>Norwalk viruses</td>
<td>9</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td>Sapporo-like viruses</td>
<td>Sapporoviruses</td>
<td>4</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td>Hepatitis E virus</td>
<td>Hepatitis E virus</td>
<td>1</td>
<td>Infectious hepatitis</td>
</tr>
<tr>
<td>Astroviridae</td>
<td>Astrovirus</td>
<td>Human astroviruses</td>
<td>8</td>
<td>Gastro-enteritis</td>
</tr>
<tr>
<td>Coronaviridae</td>
<td>Coronavirus</td>
<td>Human Coronaviruses</td>
<td>2</td>
<td>Enterocolitis</td>
</tr>
<tr>
<td>Adenoviridae</td>
<td>Mastadenovirus</td>
<td>Human enteric adenoviruses</td>
<td>2</td>
<td>Respiratory Infection, conjunctivitis and Gastroenteritis</td>
</tr>
<tr>
<td>Circoviridae</td>
<td>Circovirus</td>
<td>Post-transfusion hepatitis (TTV)</td>
<td>1</td>
<td>Chronic liver disease and fulminent hepatic failure</td>
</tr>
</tbody>
</table>

* Virus classification was updated according to the International Committee for Taxonomy of Viruses.

Table 2: Orally transmitted waterborne pathogens and their significance in water supplies[33].

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Health significance</th>
<th>Persistence in water supplies</th>
<th>Relative infective dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenoviruses</td>
<td>High</td>
<td>NK</td>
<td>Low</td>
</tr>
<tr>
<td>Enteroviruses</td>
<td>High</td>
<td>Long</td>
<td>Low</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>High</td>
<td>NK</td>
<td>Low</td>
</tr>
<tr>
<td>Hepatitis E</td>
<td>High</td>
<td>NK</td>
<td>Low</td>
</tr>
<tr>
<td>Norwalk virus</td>
<td>High</td>
<td>NK</td>
<td>Low</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>High</td>
<td>NK</td>
<td>Medium</td>
</tr>
<tr>
<td>Small round viruses</td>
<td>Moderate</td>
<td>NK</td>
<td>NK</td>
</tr>
</tbody>
</table>

Dose required to cause infection in 50% of healthy adult volunteers; may be as little as one infective unit for some viruses.
NK Not known or uncertain.

Continual monitoring of quality on a routine basis to ascertain that water sources, treatment and distribution comply with the given objectives and regulations.

Control and avoiding contaminating water supplies.
Communication can play a vital role in the detection, and prevention, of outbreaks.

Determine of disease agents, their occurrence and the severity of the disease.
Local doctors are responsible for any

waterborne disease outbreaks, and examines the actions taken upon suspecting an outbreak. It also examines some of the outbreaks that have occurred, principally from drinking water[33].

Regulations for surveillance system are based on:

- Determine of disease agents, their occurrence and the severity of the disease.
- Local doctors are responsible for any epidemiological relating to a patient and also for giving hygiene advice to people who have contracted communicable diseases.
- Continual monitoring of quality on a routine basis to ascertain that water sources, treatment and distribution comply with the given objectives and regulations.
- Control and avoiding contaminating water supplies.
- Communication can play a vital role in the detection, and prevention, of outbreaks.
Outbreaks are both a demonstration of a breakdown or failure in the system and, by acting as a ‘natural experiment’, present an opportunity to provide new insights into disease transmission and, perhaps, improvements to the system.

An outbreak or epidemic normally means that more cases are clustered than the anticipated, endemic, background level. The World Health Organization definition of a food- or waterborne outbreak is when two or more persons experience a similar illness after ingestion of the same type of food or water from the same source and when the epidemiological evidence implicates the food or the water as the source of the illness\textsuperscript{[22]}. The probability of detecting an outbreak depends on both knowledge and resources (both microbiological and personnel). Rapid recognition of the possibility of an outbreak and a timely start to the investigation greatly increase the likelihood of determining cause. Two criteria must be met for an event to be defined as Waterborne Disease Outbreaks (WBDO):

- Two or more people must have experienced a similar illness after either ingestion of drinking water or exposure to water used for recreational purposes.
- Epidemiological evidence must implicate water as the probable source of the illness.

Some Reported Waterborne Outbreaks:

U.S. Waterborne Disease Statistics 1991-2000: In the United States, the Centers for Disease Control and Prevention (CDC) and the U. S. Environmental Protection Agency (EPA) collaborate to track waterborne disease outbreaks of both microbial and chemical origins. The CDC released U.S. waterborne disease outbreak surveillance data for the time period 1999-2000. The Chlorine Chemistry Council aggregated these data with similar CDC data for previous reporting periods. The number of drinking water outbreaks between 1991 and 2000 were 155 and 431,846 cases of illness in public and individual U.S. water systems. Not all drinking water outbreaks are of viral origin but viruses represent 6% of the total number of outbreaks, bacteria represent 18%, parasitic protozoa 21% chemical 16% and 39% undetermined agents\textsuperscript{[23]}. Most of the outbreaks causative agents were Hepatitis A virus and noroviruses.

European Waterborne Disease Outbreaks: The great majority of European viral outbreaks could be attributed to Norovirus. In Denmark, England and Wales, Finland, France, and Sweden, >95% of nonbacterial outbreaks were attributed to noroviruses as were 84% of outbreaks in the Netherlands. The relative number of infections from noroviruses was lower in Slovenia (43%) and Spain (57%), although these estimates are based on a small number of outbreaks (n=14 for both). These figures are consistent with previous reports that Norovirus could be detected in 91% of all nonbacterial infectious intestinal disease outbreaks in the Netherlands\textsuperscript{[24]} and 89% of such outbreaks in Sweden\textsuperscript{[13]}. Similarly, Fankhauser et al. found Norovirus responsible for 96% of nonbacterial outbreaks in the United States\textsuperscript{[9]}. Foods were implicated as the vehicle of transmission in 16 (94%) of 17 outbreaks in Denmark and 28 (100%) of 28 outbreaks in France because surveillance systems in these countries were designed to detect foodborne disease. In countries with more general outbreak data, estimates of foodborne transmission were lower: 7 (17%) of 41 in the Netherlands, 14 (24%) of 58 in Finland, and 20 (7%) of 290 in England and Wales, although laboratory and statistical evidence of association with food or water was scant\textsuperscript{[21]}.

The settings of outbreaks also reflected the proportion of reported outbreaks that were ascertained to be foodborne. For example, in Denmark, 75% of all reported outbreaks were set in food outlets. In Spain, the Netherlands, and England and Wales, most reported outbreaks occurred in residential homes and hospitals, with only a small fraction occurring in food outlets. In Finland, the National Public Health Laboratory is the only facility in the country testing for Norovirus and, therefore, is aware of all such investigations. Most other surveillance systems receive data on outbreaks from a number of sources including local public health authorities, other diagnostic laboratories, and physicians. Surveillance in Denmark is anomalous in that only outbreaks from the national food inspection service are reported, which, in conjunction with the special mention of shellfish in the definition of an outbreak, explains the preponderance of food-related outbreaks in Danish surveillance. Such diversity in data sources and definitions may also explain the differences in estimates among other countries, including those external to the Foodborne Viruses in Europe network. Based on data from 90 outbreaks, Fankhauser et al. estimated that 47% of Norovirus outbreaks in the United States were spread by food\textsuperscript{[7]}. This estimate, derived from local and state health department reports, may be affected by reporting bias or may truly reflect different epidemiologic patterns of viral gastroenteritis outbreaks compared to those seen in European countries. Factors that might affect the relative amount of foodborne transmission of Norovirus are the virologic quality of food, food-handling guidelines, and infection control practice in health-care settings\textsuperscript{[17]}. 

Egyptian Waterborne Disease Outbreaks: Different disease outbreaks were observed in Egypt but the data were not available. The cooperation between the Ministry of Health and Population and the environmental research centers is not recognized but only one waterborne virus outbreak was observed in 1989. The disease was acute hemorrhagic conjunctivitis and the etiologic agent was Enterovirus type 70\[17\]. The number of cases was not recorded.

Saudi Waterborne Disease Outbreaks: Water pollution, the result of inadequate water and waste disposal systems and indiscriminate dumping of refuse, is a serious health problem in inhabited areas. Although modern sanitation systems are being installed in some of the larger cities, dumping of raw sewage into coastal waters, wadis (dried river beds), and vacant land areas is common. Wadis, polluted with waste materials, may flood with water during heavy downpours and contaminate local wells. Water supplied by municipal water systems, although chlorinated, may become contaminated due to faulty or improperly maintained distribution lines. Food- and waterborne diseases are the major sources of morbidity for non-indigenous personnel in Saudi Arabia. Inadequate sanitation contributes to the incidence of acute diarrheal diseases, hepatitis A, enteric protozoal diseases, typhoid and paratyphoid fevers, and brucellosis. Sandfly fever, cutaneous leishmaniasis, and falciparum malaria are the primary vector-borne disease risks; other arboviral fevers are present. No available data about the number of viral disease outbreaks and the number of cases.

African Waterborne Disease Outbreaks: The World Health Organization recognized an outbreak of paralysis among children living in Angola, Central Africa, caused by polioviruses. Almost all cases that have been found are children under five; most are aged between one and two years. They are living in overcrowded municipalities in the capital Luanda.

The National Institute for Virology in South Africa confirmed that wild poliovirus type 3 had been isolated from 11 of the 22 stool samples taken from paralysed children in Angola. Ninety percent of the paralysed children are either unvaccinated or partially vaccinated and therefore unprotected from the virus\[32\].

Common Causes of Waterborne Disease Outbreaks: From community systems supplied with surface water the following occurrences were highlighted\[24\]:

- Wastewater contamination of raw water source in combination with disinfection deficiencies or no disinfection.
- Cross-connections.
- Concerning groundwater, source water contamination through wastewater infiltration.
- Safety area for source not established.
- Risk due to wastewater pipes close to source.
- Pollution risk at groundwater source.
- Pollution risk at low reservoir from drain gutter.
- Pollution risk at low reservoir from overflow pipe.
- Unsatisfactory water treatment (other than disinfection).
- Unsatisfactory control programme for distribution system.

Outbreak Management: Once a possible outbreak is observed, three stages must be preceded.

First Stage:

- Confirmation of the outbreak: Formation of outbreak control team.
- Case definition: Case definitions may include a range of possible onset dates, clinical symptoms, geographical locations and microbiological results.
- Develop a hypothesis as to the cause of the outbreak.
- Start to control the outbreak for both cases and the source.

Second Stage:

- Outbreak description. Data will include name, address, age, sex, date of onset, the results of microbiological examination and sufficient clinical information to prove that the individual satisfies the case definition.
- Develop a hypothesis as to the cause of the outbreak.
- Start to control the outbreak for both cases and the source.

Third Stage: The dissemination of lessons learnt.

Strategies for Prevention and Control of Viral Contamination: Strategies for prevention and control of viral contamination are summarized in the following flow chart (Fig. 1):

Fate of Viruses During Water Treatment Technologies: The life span of viruses in water depends on a certain number of parameters, which are difficult to separate one from the other, as they are all interrelated. The situation is particularly complex in an aquatic environment since enteric viruses are rarely free and isolated, but tend to be in aggregate form or linked with organic matter or suspended solids. They therefore form a specific structure, which called "hydrovirus"\[9\].
Fig. 1: Schematic diagram of strategies for prevention and control of viral contamination.

**Natural Inactivation:** In a natural environment viruses are well protected when linked with organic matter or suspended particles. On the other hand, temperature, sunlight, pH and organic or inorganic ions are considered to be the most important inactivating factors in an aquatic environment.

**Temperature:** In sterile, pH7 water, the type 1 poliovirus can survive for 296 days at a temperature of between +18°C and +23°C, whereas at +4°C the inactivation process is considerably slower, it would take 10 to 15 years for all the infectious particles in the water to disappear\[23\]. The concentration of type 1 poliovirus and hepatitis A virus in mineral water can no longer be traced after 300 days, while the hepatitis A virus takes 360 days to disappear when kept at laboratory temperature\[5\].

**Sunlight:** Sunlight has an inactivating effect on viruses but this inactivation is less efficient when the water contains suspended solids, since the latter both protects the adsorbed viral particles and hinders the diffusion of ultraviolet rays\[14\].

**pH:** Viruses are inactivated in alkaline solutions (3,11) when water undergoes lime treatment\[12\]. In the same way, ammonia inactivates enteroviruses because it raises the pH and has a direct toxic effect by fragmenting the nucleic acids\[30\]. On the other hand, caliciviruses are inactivated between pH 3 and pH 5 and rotaviruses are inactivated in an acid solution at pH 3.5.

**Organic or Inorganic Ions:** The di- and trivalent ions protect RNA naked viruses indirectly by encouraging viral adsorption on clays\[29\]. Organic pollution is thought to encourage the survival of viruses,\[15\]. Ionic detergents can affect the stability of the capsidal proteins of naked viruses\[31\].

**Treatment:** Virological studies have shown that drinking water treatment can considerably reduce the levels of viruses but may not eliminate them completely from very large volumes of water. The following table (Table 3) showed the percentage of virus reduction at various stages of drinking water treatment processes.

**Viruses and Water Quality Guidelines and Standards:** The quality of drinking water is significant for health. Accordingly, countries develop water quality standards to protect public health. The incidence and behaviour of human viruses in water environments and treatment processes may differ extensively from that of faecal indicators for reasons such as:

- Viruses are excreted only by infected individuals, and coliform bacteria by almost all people and warm-blooded animals. Numbers of viruses in water environments are, therefore, generally lower than those of indicators such as faecal coliforms by several orders of magnitude.
- Viruses are excreted for relatively short periods in numbers of up to 1012/g of faeces, while coliform bacteria are excreted fairly consistently in numbers of about 109/g of faeces.
Table 3: Percentage of virus reduction at various stages of water treatment processes.

<table>
<thead>
<tr>
<th>Treatment step</th>
<th>Test virus</th>
<th>% of virus reduction</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulation-flocculation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alum</td>
<td>Poliovirus type 1</td>
<td>86</td>
<td>Bitton, 1994</td>
</tr>
<tr>
<td>Ferric sulfate</td>
<td>Poliovirus type 1</td>
<td>99.8</td>
<td></td>
</tr>
<tr>
<td>Ferric chloride</td>
<td>Poliovirus type 1</td>
<td>96.3</td>
<td></td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Poliovirus type 1</td>
<td>98</td>
<td>Rao et al. (1988)</td>
</tr>
<tr>
<td></td>
<td>Rhinovirus</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hepatitis A virus</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Softening</td>
<td>Poliovirus type 1</td>
<td>96</td>
<td>Rao et al. (1988)</td>
</tr>
<tr>
<td></td>
<td>Rhinovirus</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hepatitis A virus</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Slow sand filtration</td>
<td>Poliovirus type 1</td>
<td>99.9</td>
<td>Poynter and Slade, 1977</td>
</tr>
<tr>
<td>Rapid sand filtration</td>
<td>Poliovirus type 1</td>
<td>99.9</td>
<td>Poynter and Slade, 1977</td>
</tr>
<tr>
<td>coagulation with alum + Sand filtration</td>
<td>Without settling</td>
<td>90-99</td>
<td>Bitton, 1994</td>
</tr>
<tr>
<td>With settling</td>
<td></td>
<td>&gt;99.7</td>
<td></td>
</tr>
</tbody>
</table>

The structure, composition, morphology and size of viruses differ fundamentally from that of bacteria, which implies that behaviour and survival in water differ.

In view of the above differences it is not surprising that bacterial indicators such as coliform bacteria have shortcomings as indicators for viruses. These shortcomings have been confirmed in epidemiological studies and research on the incidence of indicators and viruses in water supplies. Ideally water quality surveillance should, therefore, include tests for viruses.[21]

Unfortunately, viruses are not rigour included in the standards for the following reasons:

- Virological investigation of water needs high-equipped laboratory.
- Virus concentration procedures are not of high recovery rate.
- Culturable viruses needs tissue culture laboratory.
- Non-culturable viruses need molecular biology methods for detection and more complex methods for virus enumeration.
- Viruses are found in very low concentration in water.
- Virological analysis requires well-trained workers.
- Virological analysis is costly.
- Viruses are not propagated in water and not stable much in environmental conditions.
- Lengthy nature of virological analysis and the fact that they cannot detect the most relevant viruses.

Scope on Guidelines and Standards: The quality of water, whether it is used for drinking, irrigation or recreational purposes, is significant for health in both developing and developed countries worldwide. Water quality can have a major impact on health, both through outbreaks of waterborne disease and by contributing to the background rates of disease.

The origin of WHO Guidelines for Drinking-Water Quality (GDWQ) goes back to the 1950s. at that time the requirements for safe and potable water supplies became particularly pertinent with the great increase in travel, especially global air travel. It became apparent that the traveler must be provided with potable drinking water. In 1953, WHO distributed a questionnaire to all member states to assess the status of water treatment plants and their production of acceptable water quality. The replies to the questionnaire clearly indicated the magnitude of the problem and the need for WHO to establish drinking water standards.[42]. Following a series of expert consultations culminating in a meeting in 1956 in Geneva the International Standards for Drinking Water were published in 1958. In this instance the term "standards" was used to be applied to the suggested criteria of water quality.[42]. In addition to being cited in the International Sanitary Regulations for deciding what constitutes pure and acceptable water supply at ports and airports, the 1958 International Standards became to be widely used as a reference in the development of local national standards and as a basis for improved water treatment practices.

Some countries adopted the International Standards as the official and legal standards of water quality while other countries developed national standards based in part or in whole on the International Standards. Increasing knowledge of the nature and effect of various contaminants, and improved techniques for identifying and determining their concentrations, have led to a demand for further
In 1963 and 1971[42,41,39]. The International Standards for Drinking-Water were revised to supersede the WHO Guidelines for Drinking-Water Quality (GDWQ) in 1984. While it was recognized that it might not be possible by a number of member states to attain all of the recommended guideline levels, it was anticipated that member states would develop water quality standards as close as possible to these guidelines in the endeavour to protect public health. The change from Standards to Guidelines meant that the guidelines were intended for use by member states as a basis for the development of national standards which, if properly implemented, would ensure the safety of drinking water supplies both in the urban and rural settings. The philosophy and content of the WHO Guidelines constituted a drastic departure from the previous International Standards. The revised guidelines were published in three volumes including criteria monographs prepared for each substance or contaminant listed in the guidelines[38,37]. The second edition of the GDWQ Volume 1 was published in 1993 followed by Volume 2 in 1996 and Volume 3 in 1997. The work involved numerous institutions, over 200 experts from nearly 40 different developing and developed countries and 18 meetings of the various coordination and review groups. The International Programme on Chemical Safety (IPCS) provided major input to the health risk assessments of chemicals in drinking water. In establishing WHO guideline values for chemicals in drinking-water, guideline values were calculated using a tolerable daily intake (TDI) for chemicals showing a threshold for toxic effects. For carcinogens, for which there is convincing evidence to suggest a nongenotoxic mechanism, guideline values were calculated using a TDI approach. In the case of compounds considered to be genotoxic and carcinogenic, the International Agency for.

A continuing process of updating guideline values was established with a number of chemical substances and microbiological agents subject to periodic evaluation. Addenda containing these evaluations were issued in 1998 for Volumes 1 and 2 and will be issued as necessary until the third edition of the GDWQ is published approximately 10 years after the second edition[34].

**WHO International Standards for Drinking Water:**
The World Health Organization (WHO) has developed a series of normative "guidelines" and standards that present an authoritative assessment of the health risks associated with exposure to health hazards through water and of the effectiveness of approaches to their control.

In 1975 the WHO scientific group recommended that where Virological facilities can be provided, it is desirable to monitor raw water sources and drinking water for the presence of viruses. This will provide baseline data to evaluate the health risk faced by the population.

The World Health Organization Has Been Recommended That:

- Drinking water must essentially be free of human enteroviruses (Enteric) to ensure negligible risk of transmitting viral infection. Any drinking water supply subject to faecal contamination presents a risk of viral disease to consumers[36,33].
- Groundwater obtained from a protected source and documented to be free from faecal contamination from its zone of influence, the well, pumps, and delivery system can be assumed to be virus-free. However, when such water is distributed, it is desirable that it is disinfected, and that a residual level of disinfectant is maintained in the distribution system to guard against contamination.

Recent epidemiological data associate substantial levels of enteric infections with drinking-water supplies which meet specifications for treatment, disinfection and counts of indicator organisms. A WHO Scientific Group has concluded that the presence of even a few enteric viruses in a large volume of drinking water poses a threat to public health (WHO, 2003).

**US Environmental Protection Agency (US EPA):** It is intended to protect against exposure to viruses as well as many other pathogens. The rule requires all systems that use surface or ground water to reduce the level of viruses by 99, 99% (4 log reduction). Under this rule all surface water systems must disinfect[27,26]. In EPA, July 20, 2003 stated the enteric viruses must be zero before human consumption for both drinking and ground water and recommend disinfection.

**European Drinking Water Standards (EDWS):** The European standards for drinking water, 1970 did not mention the virological examination in their microbiological parameters but, recommended that:

- If not even one plaque-forming unit (PFU) of virus can be found in 1 litre of water it can reasonably be assumed that the water is safe to drink.
- It would, however, be necessary to examine a sample of the order of 10 litres to obtain a proper estimation of the PFUs at this level. Such examinations cannot be made in ordinary control
laboratories, but there should be at least one laboratory in each country capable of carrying out virus examinations and also of pursuing further research in this field.

- It would not be practicable for examination for viruses to be carried out as frequently as bacteriological examination but in large communities, which use surface water or ground water, which requires treatment, examination for viruses should be carried out at intervals, which would depend on local circumstances\[20\].

In 1991 the rule sets non-enforceable health goals and maximum contaminant level goals (MCLGs) for viruses at zero because any amount of exposure to these contaminants represents some health risk\[16\].

**Canadian Guidelines and Standards:** Numerical guidelines for human enteric viruses are not proposed at this time. There are more than 120 types of human enteric viruses, many of which are non-culturable. Testing is complicated, expensive, not available for all viruses, and beyond the capabilities of most laboratories involved in routine water quality monitoring. The best means of safeguarding against the presence of human enteric viruses are based upon the application of adequate treatment and the absence of faecal indicator organisms, such as \textit{Escherichia coli}\[10\].

**Egyptian Guidelines and Standards:** In Egypt, environmental policy for water resources had been evolved since 1960s by a group of Egyptian experts representing governmental and non-governmental institutions and researcher. All water specifications ignored the Virological quality of water. The main reason was the lack of environmental virology laboratories. In 1985, the environmental virology laboratory had been developed in the water pollution research department of the National Research Centre and Virological monitoring of water was one of its targets.

Till now, water quality guidelines and standards in Egypt lack viruses’ parameter, which represent health hazards for Egyptians.

**KSA Guidelines and Standards:** In Saudi Arabia virological water quality does not included but it is mentioned that production of virus-free drinking water is preferable.

**Conclusions:**

- Waterborne diseases have a major public health and socio-economic impact, and are the most important concern of water quality.

- Strategies for the control of waterborne diseases must be based on the selection of appropriate water sources and treatment systems, and reliable microbiological quality monitoring.

- Safe drinking water, as defined by the Guidelines is such that it does not represent any significant risk to health over a lifetime of consumption.

- It is recommended that where virological facilities can be provided, it is desirable to monitor raw water sources and drinking water for the presence of viruses. This will provide baseline data to evaluate the health risk faced by the population.

- Waterborne disease outbreak surveillance system is an urgent need for both developing and developed countries.

- Researches must be continuing to find alternative water disinfectant other than chlorine, which produce hazardous by-products.

- Virus analysis of water must be taken in our concern for Egyptian guidelines of water quality.

- Waterborne diseases are not local-specific and for this reason it must fit within one international guidelines and standards.

**REFERENCES**


