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Covid Pandemic & Its Impact on Water Treatment Plant & Distribution System

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Abstract

Safe water is most essential for hygiene and sanitation. Indiscriminate disposal of untreated & treated sewage or effluent has grossly contaminated rivers & added spectrum of manmade soluble & insoluble solids. Sewage discharge to the water body adds large numbers of microorganisms along with Pathogens. Therefore, river water contains a varying number of organisms present naturally & contributed from the sewage. Polluted water sources are a major source of illness and death throughout the world, particularly in developing countries. Viruses may survive for a longer time & can cause diseases. Removal or destruction of such viruses is required to ensure safe drinking water supply. The conventional treatment process consists of pumping, aeration, sedimentation, filtration and disinfection. The performance for removal of Microorganisms and Viruses of unit processes of Conventional Water treatment plants is discussed. Unpredicted & unusual Pandemic situations have shown the bottleneck and drawback in the Water Treatment & Distribution system. Some of the issues & required studies for Virus free safe water are discussed. Policy makers, planners Designers & Professional, Manufacturers & Contractors working in the water sector must take the lesson to rethink conventional water management and add new dimensions to it.

Keywords: *Pollution of Water source; Solids in Water; Unit Process; Virus removal; Lesson from Kovid Pandemic*

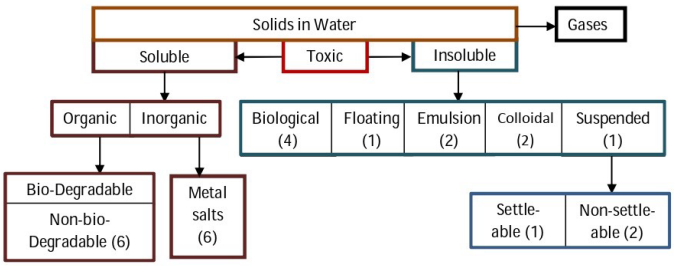
Introduction

Water is a unique material on earth which is available in three phases as water (liquid), vapour (gas) & ice (solid). These three phases play an important role in the hydrological cycle. All forms are used by the human being for various activities & applications. Water is used for drinking, cooking, washing & industries etc. Vapour (steam) has wide applications in industries & domestically. Ice is being used in ice-cream, chilling & cooling etc. Surface & underground water are main sources for water. Earlier water is used as such or after sedimentation/Filtration. In India still the well water is used as such for drinking. In past by default, storage of water in the copper vessel used to disinfect water. There are water treatment plants installed before independence. After independence most of the small & large municipal committees & corporations installed water supply & water treatment plants. This is further extended to rural areas. At many places water is pumped, stored & supplied as such or after disinfectant with bleaching powder.

Concentrated growth of human population in urban areas & increasing industrialization resulted in discharge of waste water into the receiving water bodies. The waste water is also disposed of on land. Sewage is getting more contaminated due to increasing use

of man-made chemicals & their ultimate disposal into sewage. This has resulted in pollution of surface water & underground water.

The quality & treatment of water is defined by the solids present in water. The natural solids present in water & surface water are contributed by unpolluted catchment areas. The solids in underground water are determined by geochemistry of soil strata. Indiscriminate disposal of untreated & treated sewage or effluent has grossly contaminated rivers & added spectrum of manmade soluble & insoluble solids. Many rivers in India are flowing through cities carrying the more sewage rather than river water. Pollution of rivers has increased solids in river water. Now many solids are different from that of natural solids in unpolluted rivers. Figure 1 shows different types of solids present in water. Number below the solids (1 – 6) indicates difficulty in its removal from water.



1. Simple – size & gravity separation (screen & grit chamber, floatation etc.)
2. Chemical (neutralization, coagulation, de-emulsification)
3. Biological treatment (activated sludge, trickling filter, anaerobic)
4. Disinfection (chlorination, ozonation)
5. Advance methods (softening, ion exchange, ultra filtration, RO, electro dialysis)
6. Difficult - incineration

Figure 1: *Different Types of Solids Present in Water.*

Conventional water treatment for surface water is based on the principle of removal of insoluble solids & disinfection. All unit operations are designed to remove the insoluble solids from water. The provision is not made to remove the natural and manmade soluble solids from water. It is amazing that all over India water treatment plant follows the flow chart as shown in Figure - 2

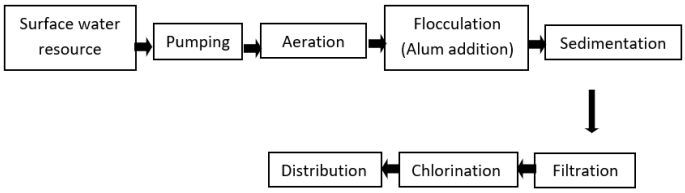


Figure 2: *Conventional Water Treatment Process.*

At most of the places underground water is pumped, stored & directly used at individual level. For larger water supply it is disinfected with bleaching powder & supplied. Almost all towns are expanding their geographical boundaries, encroaching on agricultural land & surrounding villages. Villages are also getting changed from traditional houses with thatched roofs to concrete structures. Population is migrating from villages to growing townships. Rise in population of urbanized areas is not due to multiplication of population, but migration of people in search of livelihood. Rise of population is increasing stress on the available water supply system. It is becoming a difficult task to provide potable water to expanding areas. Residential complexes at the outskirts of town have to find their own water source. Water treatment plant is to be installed to have desired water quality as per BIS 10500. The design & selection of proper water treatment is now becoming a state of art technology.

Biological solids in Water

There is a whole range of organisms that live in water. These organisms are the flora and fauna found in water. Major planktons present in water are Phyto, Zoo, Protozoa, Heterotrophic Bacteria and Virus. Besides, Periphytons are also present in water. Sewage discharge to water body adds large numbers of microorganisms along with Pathogens. Therefore, river water contains a varying number of organisms present naturally & contributed from the sewage. Fresh water is now become the host to numerous microorganisms that affect human health directly. Polluted water source is a major source of illness and death throughout the world, particularly in developing countries.

Coliform bacteria are often referred to as "indicator organisms" because they indicate the potential presence of disease-causing bacteria in water. The presence of coliform bacteria in water indicates that drinking the water may cause an illness. Rather, their presence indicates that a contamination pathway exists between a source of bacteria (surface water, septic system, animal waste, etc.) and the water supply. Disease-causing bacteria may use this pathway

to enter the water supply. For many years the accepted criterion of water quality has been the coliform index, which is most helpful for evaluating the efficiency of treatment processes for public water supplies and is the basis for bacteriological water quality standards. Recently it is suggested that the coliform index applies only to intestinal pathogens of bacterial nature and may not be indicative of the presence or absence of viral pathogens [1].

Viruses in Water

Viruses may survive for a longer time & can cause diseases such as gastroenteritis, poliomyelitis and infectious hepatitis. Removal or destruction of such virus is required to ensure safe drinking water supply. Extreme dilution of viruses in the environment reduces their count per unit volume, but does not eliminate the probability of infection of individuals in an exposed population. The effect of viral pollution of surface waters is a low-grade seeding of the population, resulting in low-level transmission of infection in the community.

Commonly bacteria are considered as major cause of diarrhea which is transmitted through unsafe drinking water. However, Viruses that can cause diarrhea include Norwalk virus (also known as norovirus), enteric adenoviruses, astrovirus, cytomegalovirus and viral hepatitis. Rotavirus is a common cause of acute childhood diarrhea. The virus that causes coronavirus disease 2019 (COVID-19) has also been associated with gastrointestinal symptoms, including nausea, vomiting and diarrhea. World Health Organization (WHO) has done classification of water-transmitted viral pathogens as having a moderate to high health significance that include adenovirus, astrovirus, hepatitis A and E viruses, rotavirus, norovirus and other caliciviruses, and enteroviruses, including coxsackieviruses and polioviruses [2]. Also, viruses that are excreted through urine like polyomaviruses [2] and cytomegalovirus [3] can potentially be spread through water. Other viruses, such as influenza and coronaviruses, have been suggested as organisms that can be transmitted through drinking water, but evidence is inconclusive [2]. Most of the above viruses are most commonly associated with gastroenteritis, which can cause diarrhea as well as other symptoms including abdominal cramping, vomiting, and fever. It should be noted that some of these same viruses could also cause more severe illnesses including encephalitis, meningitis, myocarditis (enteroviruses), cancer (polyomavirus), and hepatitis (hepatitis A and E viruses) [2]. Waterborne virus-based diseases may be higher in developing countries, where there is widespread malnutrition and large populations of HIV-positive people. Waterborne viruses differ in terms of their genome content and capsid proteins. These viruses share several properties that make them of particular concern regarding the risk of disease outbreak associated with drinking water contamination. Several of these viruses have extremely low infectious doses; the probability of infection from exposure to one rotavirus particle is 31% [4]. Viruses are shed with feces in very high numbers even there are no symptoms of disease. For example, up to 1011 norovirus particles can be present per gram of stool [5]. In addition, non-enveloped viruses can persist in water for long periods of time [6]. When considering these characteristics, inadequate disinfection of fecally contaminated drinking water could easily cause outbreaks of viral gastroenteritis from ingestion. Besides water can also transmit viruses via inhalation (e.g., showering) or contact with skin and eyes (e.g., swimming) causing respiratory and ocular infections.

Removal of Microorganisms & Viruses in Units of Water Treatment

Biological solids are mainly micro-organisms in the water. Sometimes worms, nematodes & their eggs are also present in the water. Worms because of the larger size get removed in sedimentation & filtration. E-Coli are considered as an indicator organism for contamination due to sewage & presence of pathogens. However, in order to properly assess and manage the risk of infection by enteric viruses in tap water, virus removal efficiency should be evaluated quantitatively for individual unit process in drinking water treatment plants. There are only a few studies due to technical difficulties in quantifying low virus concentration in water samples [7].

All viruses are coated with proteins and contain genetic material which can either be DNA or RNA. Since both nucleic acids have phosphodiester bonds, the genetic material provides a partial negative charge to the virus. The viral nucleic acid genomes are wrapped in proteins that can be neutral, negative, or positive in charge. Therefore, the net charge of a virus depends upon the cumulative charges of the genetic material and the protein. [8]. However, viruses in drinking water sources and their impact on human health is not yet considered seriously.

Corona Pandemic compelled the water professional to rethink about the Virus removal from water and waste water.

The units in Conventional Water Treatment Plant, Function, Removal of Microorganism, Removal of Viruses and waste water generation and microbial load is given in Table – 1

Name	Function	Removal of Microorganism	Removal of Virus	Waste Water Generated & Microbial load
Aeration	Drive away the soluble gases & increase the dissolved Oxygen in the water	No	Aerosol form during aeration can cause airborne contamination	
Flocculation	Non-settle-able solids are negatively charged & get flocculated with the help of flocculating agents like alum	Microorganisms are negatively charged so may get flocculated with other suspended solids.	Virus having negative charge gets flocculated by positively charge alum. Also, they may get trapped in the Floc	
Sedimentation	Settle-able solids settle downs by gravity due to higher density & larger size	Microorganisms trapped in floc settle down	Viruses trapped in floc settles down	Sludge drain from the Clarifier contains large amounts of Microorganism dead and live.
Slow Sand Filtration	It removes particulate matter from water by forcing the water to pass through biological film on top & porous media below at slow speed	It removes bacteria, protozoa and viruses	100% removal is not possible	Scraped biological film at top contains large amounts of Microorganisms and Viruses.
Rapid Sand Filtration	It is a physical process that removes suspended solids from the water when it passes through porous media.	It effectively removes pathogenic microorganisms. Giardia lamblia is a major concern in drinking water supplies, as it forms cysts that cannot be killed by traditional chlorination.	Scouring with air during backwashing forms aerosol that can cause airborne contamination Viruses may pass through the filtering media	Backwash water contains large amounts of Microorganisms and Viruses.

Table 1: *Unit Operation, Function, Removal of Microorganisms, Removal of Viruses & Waste water generation & Microbial load.*

Sludge from Primary Clarifiers and Back wash water are potential sources of Viruses. However, these are simply drained out to the sewer system or natural stream that finally joins the water body. Therefore, treatment and safe disposal of this waste are to be included in water Treatment Plant. The operator shall wear the protective devices when he works at the Aeration and Filtration unit.

Disinfection

Sedimentation & filtration remove the microorganism to a certain extent however most of microorganism remains in filter water. Therefore, disinfection is a must before water distribution.

Boiling water for 20 minutes at the household ensures 100% disinfection of water. However, this cannot be implemented on a large scale. To kill/remove microorganism disinfection with Chlorine, Ozone & Ultraviolet light is done. Table-3 gives comparisons of 3 different disinfectant agents.

In Water treatment plants in India Chlorine is used as a disinfecting agent. The added advantage is that it provides residual chlorine in the distribution system to counteract the post contamination during distribution. For highly contaminate water pre-chlorination is a better option to kill a spectrum of microorganisms.

Corona Virus & its removal in Water Treatment Plant

Most coronavirus types which attack humans (possible for SARS-CoV-2) are often inactivated rapidly in water (i.e., the survival of human coronavirus 229E in water being 7 days at 23°C). However, the survival period of coronavirus in water environments strongly depends on temperature, property of water, concentration of suspended solids and organic matter, solution pH, and dose of disinfectant used. The World Health Organization has stated that the current disinfection process of drinking water could effectively inactivate most of the bacterial and viral communities present in water, especially SARS-CoV-2 (more sensitive to disinfectants like free chlorine). However, Water, Wastewater and sewage workers should follow the procedures for safety precautions against SARS-CoV-2 exposure. [9]

Details	Chlorine	Ozone	U. V. light
Available as	Chlorine gas from Chlorine cylinder, Calcium hypochlorite as bleaching powder. Sodium hypochlorite as liquid chlorine.	Ozone from ozone generator.	From U.V. lamp fitted in the Pyrex glass tube.
Disinfection	Kill almost all pathogens, microorganisms. Viruses & spores escape chlorination.	100 % kill of all pathogens & micro-organism including viruses & spores. Ozone oxidizes organic matter of cell.	100 % kill of all pathogens & micro-organism including viruses & spores.
Dozing	Preparation of chlorine gas solution for dozing. Preparation of Calcium hypochlorite solution by adding bleaching powder into water. Dozing as liquid. Sodium hypochlorite is directly dozed as such or after dilution	Ozone solution with water is dozed into the pipeline	Water passing through U. V. housing where U.V. light is on.
Dozing rate	1 -2 mg /l	0.05 – 0.1 mg /l	Maximum 100 mm water depth.
Residual Effect	Residual chlorine remains in water to counteract post contamination during distribution.	No residual effect. Water is to be consumed immediately	No residual effect. Water is to be consumed immediately
Drawback	Gaseous Chlorine is hazardous. 10 -15% losses of chlorine along with sludge form during preparation of bleaching powder solution. It adds Calcium to water. Sodium Hypochlorite adds sodium to water & increases pH & alkalinity. Dead microorganisms remain in water.	Required energy to generate ozone.	Required energy to generate U. V. light. The mutation of micro-organism due to inadequate ultraviolet sources cannot be ruled out. Dead microorganism remains in water
Cost	Low	High	Medium

Table 1: *Comparison of disinfecting agents.*

Lesson from Pandemic for Water Supply Management

Unpredicted & unusual Pandemic situations have shown the bottleneck and drawback in the Water Treatment & Distribution system. Some of the issues & required studies are listed below.

- Lack of water quality monitoring at source. It can be linked with endemicity that results in the increase of pathogen load through the sewage discharge in water bodies.
- Increase in Domestic Water demand for better sanitation and health
- Though there is reduction in effluent discharge from the industry there is rise in discharge of untreated sewage due to increase in water consumption.
- Lack of complete Microbial analysis especially for detection of viruses in raw water and output of each unit operation. Most of the water treatment plant consider Ortho toluidine test to ensure safe during water supply
- Monitoring of airborne contamination due to unit operations
- Collection, Treatment & Safe Disposal of Microbiologically hazardous sludge and back wash water.
- Decrease in Manpower to operate the plant. Some of the operations like pumping, chemical addition, drain out of sludge & back washing are manual and need manpower.
- Lack of advanced technologies such as remote sensing, the internet of things, and artificial intelligence to improve the management capabilities toward a comprehensive monitoring and modelling system.
- Distribution system at many places is done by Valve operators. During pandemic the restrictions on movement and fear in mind are the prohibitive factor for smooth distribution.
- Water Safety plan from water resource to tap is must to face such conditions in future.
- Needs frequent water sampling along with satellite-based water quality monitoring that complements the ground-based monitoring system). A strengthened monitoring system and its high-resolution data (e.g., daily or weekly) at the national scale will help toward detailed analyses on the water quality status due to anthropogenic activities. This will also serve the warning for endemic situation.
- Need of conducting detailed modelling studies at multiple scales across the nation from minor to major water bodies.
- Further the data measurements and estimations during the lockdown period may serve as reference data for the baseline scenario in water sectors, including water consumption, wastewater discharge, treatment facilities, and groundwater

withdrawals, to estimate the future anthropogenic effects in these sectors.

- Eliminating post contamination of water in distribution system due to leakages in water distribution and sewerage system.
- Availability of funds to implement the required modifications and up-gradation.
- Public awareness and involvement to create trust in quality of water supplied by Water treatment & distribution system.
- Integration of water quality with the Pandemic data to correlate water quality with spread or control of disease.

Conclusion

Current evidence indicates that the COVID-19 virus is transmitted through respiratory droplets or contact. Contact transmission occurs when contaminated hands touch the mucosa of the mouth, nose, or eyes; the virus can also be transferred from one surface to another by contaminated hands, which facilitates indirect contact transmission. Consequently, hand hygiene is extremely important to prevent the spread of the COVID-19 virus. It shows there is no evidence on the occurrence of the virus in the drinking water resources. Besides, not a single case of Corona virus infection caused due to drinking of water is reported in India and elsewhere. This will lead to interprets drinking water is not causing infection of. It does not mean that it allows relaxing and continuing with the same Water Treatment & Supply management. There is need to work on the issues faced during Pandemic. If required current process of water treatment can be upgraded or modifies to suit to pandemic if occurred in future. For example, disinfection by Ozone to ensure complete removal of viruses followed by chlorination to counteract the post contamination in Distribution system. Policy makers, planners Designers & Professional, Manufacturers & Contractors working in the water sector must take the lesson to rethink about the conventional water management and add new dimensions to it.

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Conflict of Interest

Author has no conflicts of interest to disclose

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