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Review Article

Prospects and Risks Related to Potential Transmission of COVID-19 and Other Viruses and Disinfection in Sewage Effluent

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ABSTRACT

The presence of viruses in treated and untreated sewage water is a serious issue in the agricultural sector as it is highly dependent on recycled water for irrigation purposes due to the shortage of fresh water resources. In this study viruses in untreated and treated wastewater has been reviewed to evaluate the health threats to the people. It has been cited that viruses such as Rotavirus, Norwalk virus, adenovirus, and Hepatitis A virus, are common mediators of the diseases in human beings. Including respiratory disorders, bronchiolitis, digestive tract disorders, pneumonia and conjunctivitis. Additionally, traces of COVID-19 were also found in sewage water sources in some countries like Italy bringing attention towards analysis of sewage water. Based on information from cited literature it is estimated that an individual handling sewage water have approximately 1% chance of becoming infected with virus. Treated sewage effluent and reuse of sewage water for recycle purposes must be considered as it may lead to widespread of COVID 19 in coming decade. Thus, a qualitative risk assessment and disinfection of water supplies based on reported infection rates suggested that viruses in treated and untreated sewage effluents may pose the most risk. This risk assessment and a limited epidemiological evidence suggest that TSE is not harmful for the public places but it cannot be neglected, therefore proper guidelines and policies are required.

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Treated Sewage effluent, Viruses, Sewage water, Urban landscaping, COVID- 19.

INTRODUCTION

The utilization of sewage effluent is not only dedicated to irrigational purposes but also associated with the economy of the country as it is cost-efficient for water scarcity. This utilization is not only for irrigational purposes but also in various other areas such as industry and urban landscaping or as shown in Table I.

Treated sewage wastewater is quite beneficial for crop growth because of the availability of organic nutrients and it is easily available (Jaramillo and Restrepo, 2017). This sort of re-utilization signifies an alternative approach that is being implemented in different parts of the world facing shortage of water and increasing populations with rising water needs for daily purposes (Winpenny *et al*., 2013). Particularly assumed the decrease in groundwater reservoirs occurred due to climate change (CC) and climate variability (CV) in different regions of the world. Almost 805 million of population, 1/9th of the world's population, is affected by hunger explosion because of less availability of domestic crops. There comes a need to facilitate agriculture with cost-effective approaches to manage water scarcity in agriculture purposes for promoting food safety and food security as well as urban landscaping to improve the environment (Corcoran *et al*., 2010). One of the most important reasons for the reuse of sewage water in the agriculture division is the relative reduction in the pressure of water reservoirs to integrate into regular use. Figure 1 illustrates the mapping of countries that are utilizing treated and untreated sewage effluents for their irrigation purposes (Pimentel *et al*., 2007).

On contrary, the occurrence of microorganisms in treated and untreated sewage effluents pretenses a phenomenal threat to public health (Rodrigues and Cunha, 2017). Despite of great developments in aqua treatment plants, waterborne pathogens still cause a danger to the public worldwide. According to an investigation, waterborne microorganisms infect almost 0.25 Billion population per year that results in 10±20 million deaths that which is the biggest rate for any of the causalities (Castillo *et al*., 2015). The types and concentration of dangerous pathogens in the water along with chemical substances may vary from regions to regions as per the socio-economic and sanitary situations imposed by the government nominated rules and regulations (Gerba *et al*., 2017). For instance, the microbial concentration of parasites, and viruses in sewage

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water may exceed by 10–1000X in developing countries as compared to the developed countries where there are proper laws and legislations are maintained for each department operated by ministries (Omarova *et al*., 2018).

Adding to these contamination levels, the occurrence of waterborne sicknesses in the United States of America increased between the years 1971 and 1985 recording more disease outbreaks as compared to any former decade and a half interval since the year 1920 (Craun *et al*., 2006). Department of USEPA and WHO made inventory of viruses as major contaminant and public health threat mediators (Rachmadi *et al*., 2020).

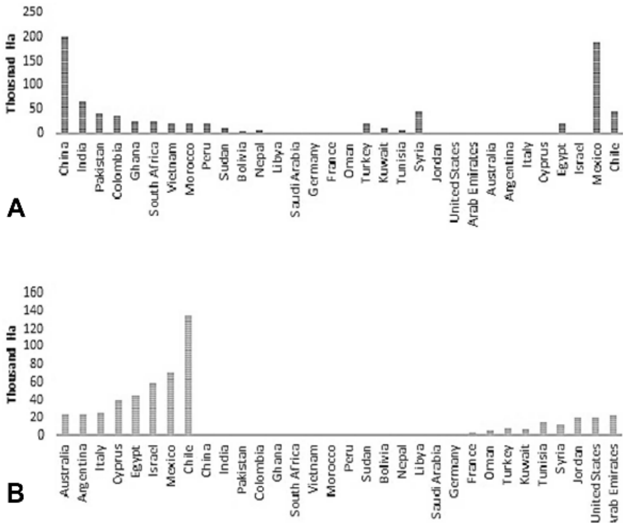

Fig. 1. Areas of the countries irrigated with untreated (A) and treated (B) sewage effluents.

UTILIZATION RATE OF SEWAGE WATER IN MIDDLE EAST

Industrial effluents play a major character in accompanying the water requirement of the Middle East as it has been described only 60% of the produced volume of sewage wastewater up to 10,900 million cubic meters per year was purified in treatment plant (Safwat *et al*., 2011). Out of this volume of treated sewage water, only 1/ 3rd of the quantity is utilized for agricultural and recreational purposes. The following calculations disclose that almost 80% of the total generated sewage water can hypothetically be re-claimed to deal with water scarcity in different regions of the world (Jasim *et al*., 2016).

Whereas, Singapore is presently fulfilling 30% of water requirement by recycling its sewage water and targeting to raise the reclaim rate to 55% by the next 30 years (Bennett, 2015). Similarly, in Israel more than 80% of local household sewage wastewater is cleaned and reused. Many countries in the Middle East have implemented important plans. By the next 20 years, the kingdom of Saudi Arabia is aiming to upsurge in the reclamation rate of water by almost 90% of the total quantity of water generation. The rate of water re-utilization in the KSA agriculture subdivision is likely to grow 1.3X in 2035 as compared to the assumed total of 0.54 Billion cubic meters per year in 2012. The analogous increment is also foreseen in the urban landscaping division in which the recycle quantity in 2035 is estimated at 0.56 Billion cubic meter/ year, respectively. As far as the United Arab Emirates is concerned, it is Environment Vision 2 targets to reclaim 100% of TSE by the year 2030.

WATER-BORNE PATHOGENS

Sewage water purifying plants and generated effluent have been recognized as the reproducing place of resistant microbes (Rizzo *et al*., 2012). The viruses are amongst the significant and possibly perilous of the microorganisms in water reservoirs (Pandey *et al*., 2014). Human viruses are commonly extra resilient to handling procedures, are infective, and entail lesser dosages to cause disease than many other viral pathogens. Table II illustrates a study in Australia reported by Gibbs and Ho (1993), an infectious dose of different viruses to the cause of incidence when sewage water is exposed to the exposed people.

Table I.- Applications of sewage water.

Sector	Application	Reference
Agriculture reuse	Irrigation purposes, industrial crops, seed, processed food, orchards, fodder, commercial nurseries, food crops and livestock	(Jaramillo and Restrepo, 2017; Khan, 2018; Weindl *et al*., 2015)
Urban	Public urban greenery, Football fields, Institutional playgrounds, residential medians, fireguard utilization, highways horticulture, and golf course	(Bizari and Cardoso, 2016; Ma *et al*., 2015)
Environmental reuse	Artificial and natural wetlands, augmenting and sustainable stream and river flows	(De Santis, 2011; Butt *et al*., 2005)
Industrial reuse	Process cooling of broilers and towers	(Xu *et al*., 2019; Sigh *et al*., 2012)

Table II.- Infectious dose of viruses to the cause of the incidence.

Pathogen	Possibility of disease from disclosure to 1 Organism	Dose to cause the incidence of				
		1%	1-25%	26-50%	51-75%	76-100%
Enteroviruses			1-10	10-100	100-1000	10^3-10^4
Poliovirus 3	3.10×10^{-2}	0.32				
Poliovirus 1	1.49×10^{-2}	0.67				
Echovirus 1 2	1.70×10^{-2}	0.59				
Rotavirus	3.10×10^{-1}	0.03				
Norwalk agent			1-10	10-100	100-1000	10^3-10^4
Hepatitis A			1-10	10-100	100-1000	10^3-10^4

These viruses are more problematic to perceive in environment *i.e.,* water and sewage than other microbes such as bacteria and parasites. It is narrated in previous literature that untreated sewage effluent can comprise a wide range of viral pathogens at concentrations of 103± 104 virus particles per liter of water sample (Chahal *et al*., 2016).

The infectious dose of pathogen depends upon the concentration unit of the microbe such as the infectious units required causing an infection in any host organism (Leggett *et al*., 2012). For instance, many parasites and viruses generally involve less than 10 infectious cysts to cause an infection in a targeted organism. Variety and nature of the contaminant in effluent waters can find out the ways of pathogen remediation giving an early caution of health-threatening pathogenic concentrations and estimating the risk at all the possibilities of contact between effluent and people involved in handling and surrounding also permitting inspection for influence in proposed pollution by pathogens in the ecosystem (Derx *et al*., 2016).

Viruses retain at the place wherever the surroundings have been contaminated by sewage or human waste (WHO, 2015). Thus, in natural aquatic habitats, the occurrence of the virus is possibly vulnerable to pollution with exposure or dumping of untreated sewage effluent. Several varieties of human adenovirus have been identified so far, out of which 50 serotypes of viruses are known by the studies (Blyn *et al*., 2008). The human adenovirus known as (HAdV) has been associated with ailments initiating conjunctivitis (respiratory sickness) and gastroenteritis (gut diseases) as well as affecting immunosuppressed people by chronic infections caused by chronic viruses (Kuo *et al*., 2010).

INFECTIOUS DOSE CONCENTRATION

The discovery of viruses in water reservoirs is very essential for public health especially in the prevention of disease and in reaction to epidemics. TSE is commonly utilized in public areas especially for irrigation purposes may cause a drastic impact on the ecosystem around, especially people visiting the places. Even though these pathogens are deliberately crucial but still inadequate statistics are available to estimate the occurrence and dissemination in the TSE used in the surroundings. In the case of viruses particularly human adenoviruses are imperative water-borne microorganisms because of their low infection doses which proves that even exposure of small concentrations of virions has the potential to cause infection in the human body (Boehm *et al*., 2019). Most commonly found human adenoviruses in TSE water samples that have low infection dose are mentioned in Table III.

Table III.- Commonly detected enteroviruses in TSE.

Reference	Species of enterovirus
Fong *et al*. (2010)	Adenovirus 40 41
Murray *et al*. (2013)	Calicivirus
Zhou *et al*. (2014)	Calicivirus (astrovirus)
Tiwari and Dhole (2018)	Coxsackievirus
Bisseux *et al*. (2020)	Echovirus
Baez *et al*. (2017)	Hepatitis E
Zhou *et al*. (2016)	Rotavirus

Barker *et al*. (2013) established the QMRA model for estimating the cause of norovirus infection from untreated sewerage water (UTSE) sprayed lettuce leaves. It is usually done in the Australian agriculture sector but unfortunately, it is not endorsed as per the appropriate guidelines set by the ministry. The assessed annual virus statistics showed in between the range from 2.0×10^{-8} and 5.0×10^{-4} provisional on the sewage water resource and most importantly of how systematically the user rinses the vegetable at home before use. This model forecasted the infection loads of around 4.0×10^{-9} and 3.0×10^{-6} rinsing and cleaning with water correspondingly. Consequently, researchers suggested the rinsing of vegetables before eating that imitated upgraded principles in the Australian region.

Similarly, Mok and Hamillton (2014) led experimentation to define the capacity of collected water post irrigation from Asian leafy vegetable farms by sprinkling method with sewage water, respectively. The possibility of disease was calculated as 7.0 $\times 10^{-4}$ and 4.0 $\times 10^{-3}$ for the utilization of two varieties of Chinese cabbage, and 2.0 $\times 10^{-3}$ recorded for lettuce and Chinese broccoli annually. The mean disease load was in the range of 5.0 $\times 10^{-6}$ DALY and 3×10^{-5} DALY per individual for utilizing Chinese leafy vegetables, correspondingly. This study was the very first demonstration of Asian leafy vegetables in case of water retention measurement also a risk assessment of viral pathogens in leafy vegetables that are irrigated with sewage water in china.

As far as enteric viruses are concerned, limited statistics are available on the presence of human viruses in TSE stated in Table IV.

Table IV.- Concentration of enteric viruses in sewage water.

Authors	No. of organisms/ kg	
	Mean	Range
Llivina *et al*. (2003)	30	0-60
Goyal *et al*. (1984)	550	10-5859
Lydholm and Nielsen (1983)	1900	300-4100
Carrington *et al*. (1991)	200	NS+
Bitton (2005)	810	<0.9- 7500

SEWAGE EFFLUENTS EXPOSURE

The following discussion will concentrate on direct exposure to wastewater as there was not enough published information to quantitatively or qualitatively assess the risks associated with indirect exposure to TSE. It has been proved by various studies proved that the improper biological standard of irrigation water play role in in spreading human viruses. United States Environmental Protection Agency (USEPA) added caliciviruses such as norovirus, adenovirus, enterovirus comprising echovirus, polioviruses, and coxsackievirus and particularly HAV in the list of contaminant candidate (CCL4) since 2016 as common microbial pollutants (USEPA, 2018). Additionally, the World Health Organization (WHO) strategies classified HEV, astrovirus, rotavirus, and sapovirus as main microbes for high health hazards evidently (WHO, 2015). The main purpose to review this agenda is to assess the potential health risks related to the usage of treated sewage effluent from sewage water purification plants. TSE from different purifying plants vary depending on wastewater treatment strategy, but here comes a critical aspect for assessing the risks to the exposed people in treatment plants. The risks can be assessed by looking at the following research questions: (i) which groups of people could be at risk from exposure to TSE? and (ii) what alarming densities of pathogens have been found in wastewater for causing disease?

It also focuses on the major route of infection for most enteric viruses *i.e.,* COVID-19 from person to person contact. However, this does not negate the possibility that exposure to TSE may be another potential route of infection.

Urban water risk assessment of living organisms associated with the handling of sewage effluents numerous studies reported pathogen in urban sewage water comprising viral pathogens HAV, Poliviruses, nepavirus, and rotavirus that may directly or indirect infect the handlers and visitors around (Battistone *et al*., 2014). The individuals at health risk from exposure to wastewater can be distributed into II groups, those who are directly and indirectly exposed to the viruses (Adegoke *et al*., 2018). The direct exposure holders include treatment plant labors and managers, caretakers of the community using the garden that is irrigated with TSE, farmworkers, and landscaping workers (Dickin *et al*., 2016). People directly exposed to TSE could ingest pathogens contaminating their hands or clothes. Children are probably most at risk because they are more likely to directly ingest or eat without washing their hands (Biezen *et al*., 2019). From a literature study conducted in Hevsel Gardens, Turkey was irrigated untreated sewage water which induced the Hepatitis-E infection risk by consuming vegetables and irrigation labors that used untreated sewage effluent were examined out of that around 34.8% were found positive for anti-HEV (Ceylan *et al*., 2003).

COVID-19 IN SEWAGE WATER AND TSE

As the resiliency of environment, the Irrigation Association's staff and leadership have been working behind the scenes, both advocating on behalf of agricultural and turf-landscape irrigation in public urban green areas to make it COVID 19 free for local visitors around. FAO (2020) department of Land and Water supports planning across the rural, peri-urban, and urban agriculture by providing resources and tools to national and city governments and supply chain actors as they work to provide safe water consumption through water and wastewater treatment, composting of waste, and sustainable land and soil management. FAO Land and Water assists in the resilience of virus-free TSE for irrigational purposes.

EVIDENCES AGAINST COVID-19 TRANSMISSION IN SE AND TSE

According to the reports by CDC, traditional water treatment techniques that include the use of disinfection and filtration, mostly in municipal water treatment systems must eliminate or deactivate the COVID-19 strains (CDC, 2020a). From recent studies, it is estimated that COVID-19 has been detected in the excreted waste material of patients suffering from COVID-19 which ultimately gets mixed with sewage water and make its way to irrigation reservoirs.

Presently, the diffusion risk of COVID-19 via appropriately intended and sustained sewerage plants is assumed to be quite low. Whereas, scientists have investigated the existing data which proposes that regular individual and municipal purification systems and sewage water management practices must deactivate the virus eventually. Based on all previously published information regarding SARS and MERS, the experts think that there is a quite low threat of infection between individuals through Sewage as Covid-19 does not endure activation for longer periods after being excluded from the human body (AS English, 2020). The Centre for disease control and prevention is revising evidence on COVID-19 spread as soon as it will be available by advanced studies (CDC, 2020a).

MEANS OF COVID-19 TRANSMISSION FROM UNTREATED SEWAGE WATER AND TSE

Coronavirus has been identified in untreated wastewater but (CDC, 2020b) it is stated that there is no confirmation about coronavirus can be contracted into a human by coming into contact with it. The possibility of becoming infected via the feces of a COVID-19 carrier is also remote - there have been no confirmed reports of this occurring. However, it is added that coronavirus may be transferred via feces to oral consumption. It is confirmed that RNA virus has been identified within the stool of infected patient and eventually researchers observed that few patients who suffered from COVID-19 initially infected by diarrhea instead of any fever and the concluding this incidence as common afterward (WEF, 2020). This indicates the presence of novel coronavirus persistence into the sewage water and can infect patients via feces oral route.

Reuters (2020) published in Al-Arabiya published the detected traces of coronavirus in sewage effluent in Italy during December 2019 which suggests that COVID-19 was previously existing in Italy before Wuhan reported its first coronavirus case. This report was published as a result of the Italian National Institute of Health observed 40 different sewage water samples taken from sewage treatment plants in Italy from October 2019 till February 2020, respectively. Similar studies directed by scientific crews in Australia, Netherlands, and France have identified that coronavirus can be spotted in TSE, and various states are starting to use sewage samples to track the outbreak of the infection. Similarly, it is also considered that the occurrence of the virus in the sewage samples of Italy doesn't indicate inevitably that the key reason for the spreading of the epidemic was initiated from the initial integration of coronavirus in the sewage sample (La Rosa, 2020). The survival of coronaviruses in water prompted labs around the country to begin using sewage monitoring as a means of tracking COVID-19. Although infectious droplets may contaminate water and the virus has been detected in wastewater, experts agree that when it gets into large bodies of water, like lakes, rivers, and oceans, the concentration of the virus would be so diluted that it would be difficult to contract it (Needles, 2020).

Wastewater could prove to be a vital resource if future outbreaks occur (Sims and Kasprzyk-Hordern, 2020). A one-month study in Paris was able to gauge the rise and fall in reported coronavirus cases in the French capital during the lockdown. In Eau de Paris, according to a virologist, Sébastien Wurtzer elucidated at public water service of the city, that "the higher the concentration of virus in wastewater the higher the number of infected people: "This visibility is also going to help us predict the future waves of outbreaks," (Lesserre, 2020).

IDENTIFICATION AND DISINFECTION OF SEWAGE WATER FROM VIRUSES

For the prevention of health issues and corrosion of ecological systems, the sewage water used in the alternate method should satisfy the following quality standards that will examine the physical, chemical, and biological quality of water before utilization (Khalid *et al*., 2018). In this cause, various quality parameters are applied in different regions of the world (Ceylan *et al*., 2003). Some of the quality parameters that must be taken in to account for the utilization of sewage effluent for irrigational purposes are mentioned below in Table V.

Uzen (2017) reported some limitations in the utilization of sewage water for irrigation purposes where there are chances of its direct contact with the people around. As turf irrigation and recreational parks irrigation is now totally mechanical in which water sprinklers and waterjets are accommodated for irrigation purposes

Table V.- Quality standards for the classification of sewage water for irrigation purpose (Uzen, 2017).

Quality parameter	Class of quality (highest to least quality)				
	1st	2nd	3rd	4th	5th
E $C_{25} \times 10^6$	250	250- 750	750- 2000	2000-3000	More than 3000
Exchangeable Na %	Less than 20	20- 40	40- 60	60- 80	More than 80
Adsorption rate of Sodium (SAR)	Less than 10	10- 18	18- 26	Greater than 26	-
Residual (Na_2 CO_3)	<66 meq L^{-1}, mg L^{-1}	66- 133 meq L^{-1}, mg L^{-1}	>133 meq L^{-1}, mg L^{-1}	-	-
Chlorides	0- 142 meq L^{-1}, mg L^{-1}	192-249 meq L^{-1}, mg L^{-1}	249-426 meq L^{-1}, mg L^{-1}	426-710 meq L^{-1}, mg L^{-1}	>710 meq L^{-1}, mg L^{-1}
Sulphates	0-192 meq L^{-1}, mg L^{-1}	192-336 meq L^{-1}, mg L^{-1}	336-575 meq L^{-1}, mg L^{-1}	575-960 meq L^{-1}, mg L^{-1}	>960 meq L^{-1}, mg L^{-1}
Total Solids Dissolved	0-175 mg L^{-1}	175- 525 mg L^{-1}	525- 1400 mg L^{-1}	1400- 2100 mg L^{-1}	>2100 mg L^{-1}
Boron (B)	0-0.5 mg L^{-1}	0.5-1.12 mg L^{-1}	1.12-2.0 mg L^{-1}	More than 2.0 mg L^{-1}	-
Water class	$C_1 S_1$	$C_1 S_2$ $C_2 S_2$ $C_2 S_1$	$C_1 S_3$, $C_3 S_4$, $C_2 S_3$, $C_3 S_3$, $C_3 S_1$	C_4S_3, C_4S_2, C_1S_4, C_2S_4, C_4S_1, C_3S_4, C_4S_4	-
Nitrogen NH_4^+ / NO_3^-	0-5 mg L^{-1}	5-10 mg L^{-1}	10-30 mg L^{-1}	30-50 mg L^{-1}	Greater than 50 mg L^{-1}
Coliform of Feces 1/100ml	0-2ml	1-20ml	20- 100ml	100- 1000ml	>1000ml
BOI_5	0- 25 mg L^{-1}	25- 50 mg L^{-1}	50- 100 mg L^{-1}	100- 200 mg L^{-1}	More than 200 mg L^{-1}
Solids particles (Suspended)	20 mg L^{-1}	30 mg L^{-1}	45 mg L^{-1}	60 mg L^{-1}	More than 100 mg L^{-1}
-log of H (pH)	6.5- 8.5	6.5- 8.5	6.5- 8.5	6.5- 9	<6 and >9
Temp (C)	30 C	30 C	35 C	40 C	More than 40 C

around the roads, parks, and urban landscape areas in homes as well. This is because the agricultural areas and surrounded vegetation are done at a large scale where these technologies supported water sprinklers can reduce the labor and irrigation is done in proper ways. The limitations of sprinkling sewage water for irrigation in public places, gardens, and orchards must follow the following limitations (Table VI).

Identification of viruses in sewage water resources typically includes viral strains concentration out of big volumes of a sample followed by identification techniques such as microbial culture in appropriate host cells, scanning electron microscopic technique and immunological performances. Disinfection as the las barrier in wastewater treatment plays a critical role in removing those enteric viruses (Okoh *et al*., 2010).

Table VI.- Limitations for irrigation with sewage water (Uzen, 2017).

Agricultural species	Limitations
Viti culture and orchards	No irrigation with sprinkler Prohibited consumption of fallen fruit Fecal coliform must not exceed 1000/l00 ml
Seed and Fiber production	sprinkler allowed chlorinated and biologically clean sewage water can be used through a sprinkler No of Fecal coliform must not exceed 1000/l00 ml
Forage and oil crops, floriculture, raw inedible flora	surface irrigation, mechanically treated wastewater

RISK ASSESSMENT MODEL

Pachepsky *et al.* (2011) stated a quantifiable pathogenic risk assessment model to evaluate the threat of infection because of ingestion of generated irrigated pathogens contained water. This model is basically comprised of two phases: a) exposure model and b) infectivity model. Exposure model in 6 stages. First phase estimate whether pathogens are immune enough to pass through all stages and remain active to cause infection if ingested. Second phase in which Infectious dose of pathogen is transmitted form source to the host and chance of infection is evaluated. The major factor to assess in second model is the time and probability of illness to happen. Time is usually about the persistence of microbe throughout the process and its activation towards infection causing whereas probability of disease occurrence is about immunity of the host who is ingesting that microbe in activated form. Figure 2 is illustrating the steps.

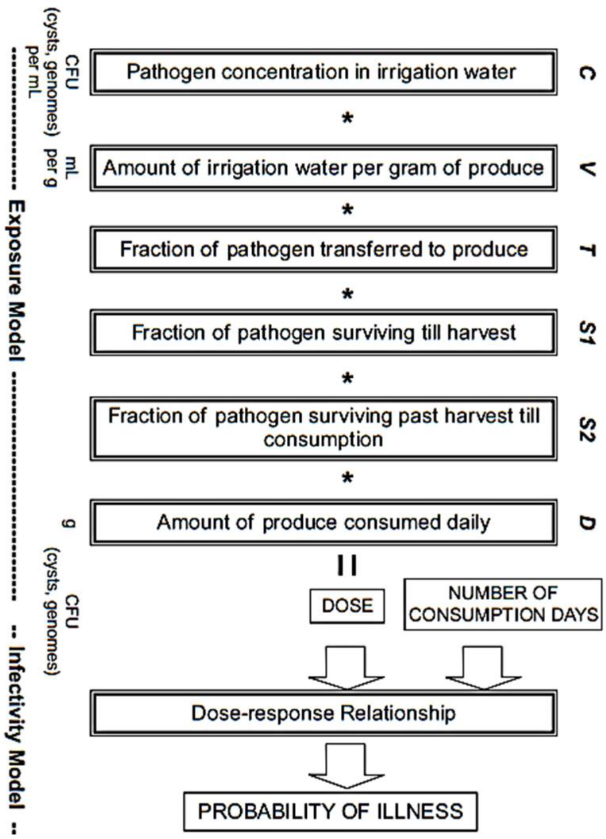

Fig. 2. Quantitative risk assessment model of irrigation water containing microbes (Pachepsky *et al.*, 2011).

Indicator pathogen method

Quality standard for biological water is an indicator microbe that may be not pathogenic but is supposed to correlate with other existing pathogens in the water, therefore enabling assessment of the probability that possible pathogens are present in the sample or not (Korajkic *et al.*, 2018). There are plenty of microbes that have been projected and confirmed as indicators for detection, while only a fewer of these have been implemented in standard procedures.

CT value method

To justify the importance for water sterilization, engineers are applying disinfection strength, which is defined as a CT value product of concentration of disinfectant and time of contact (mg x min/L) treating against viral pathogens in sewage water samples. As per reported by Rachmadi *et al.* (2020) sterilization of water sample was conducted against echovirus and Coxsackie B. Results depicted high CT values which means lesser susceptibility as 4-log10 deactivation as compared to Norovirus and Adenovirus with free chlorine usage. Similarly, adenovirus showed lesser susceptibility towards mono chloramine as compared to that of coxsackie and norovirus, respectively. Virus type, water temperature, pH and water matrices really affect the CT value (Rachmadi *et al.*, 2020). Conversely, according to guidelines of WHO there are multiple barrier system for health hazard managing in sewage water recycling and re utilization for irrigational purposes. There are certain criteria set forward for concetation of viruses in water based on the acceptable loss of disability-adjusted life years known as (DALYs) / individual. Yr, reduction of virus by 2- to 3-log10 to 6- to 7-log10 is compulsory in the recycled water for treated and untreated irrigation resources, correspondingly (Ito *et al.*, 2017). Gerba *et al.* (2017) suggested further 2- to 3-log10 elimination of viral pathogens in water samples to confirm the protection of reclaimed water for irrigational purposes**.** The last barrier in sterilization treatment is typically disinfection procedure. Sodium hypochlorite (NaClO), ozone (O_3), and acetic acid (CH_3COOH) are normally consumed as disinfectants in sewage treatment plants especially in developed regions like West and Europe (Brandão *et al.*, 2013). Amongst existing sterilization agents, the free chlorine and mono chloramine are mostly utilized disinfection agents because of cost effectiveness and efficacy for the eradication of microbes, in spite of having narrow contact surface area in the incident that groups of viruses are made and there are certain scavengers in sample water *i.e.*, organic matter simultaneously (Collivignarelli *et al.*, 2017).

Advance oxidation process (AOP)

Ozone (O_3) based advanced oxidation process (AOP) may suggest an innovative clarification to treat microbes present in sewage effluents (Uslu *et al*., 2015). Numerous researches have emphasized that traditional water cleaning techniques that depend on basic microbial treatments and chlorination are quite unsuccessful in eradicating hazardous pathogens such as viruses. Major drawback of chlorination is formation of chlorinated disinfecting agents as by-products (Wang *et al*., 2015) for instance Halogenic acetic acids (HAAs) and Trihalomethanes (THMs) which are extremely carcinogenic for the humans. Another approach is alternative oxidants which is known as ozone and ozone-hydrogen peroxide AOP which is one of the most proficient solutions that may significantly decrease the risk sat by microorganisms of evolving concerns within treated sewage effluent (TSE) (Wang *et al*., 2015).

QMRA assessment

One of the most famous approach for viral risk assessment is quantitative microbial risk assessment (QMRA) which usually rely upon to create mandatory treatment levels that should be useful to sufficiently diminish infection problem related with contact with pathogens in TSE. General protocol to determine the level of water treatment needed to make a TSE supply adequately harmless for a specific type of risk includes an appropriate degree of danger, identifying expected exposure levels, and choosing proper dose response function that associates exposure towards risk of infection (Stanford *et al*., 2015). This approach is highly promising for viral pathogens found in water because of their dose-response relationships. Water quality standards monitoring viral pathogens, comprising human deadly viruses and coliphages, have been established previously. Although these approaches deliver information only on viability of virus, they are normally less promising to detect viruses because of their lesser concentrations in sewage and TSE**.** An alternate method is using assays that are based on nucleic acid of virus (Crank *et al*., 2019). A proper sequencing of virus is done and traces are detected from the water sample after PCR and sequences are matched by molecular markers.

CONCLUSION

This review recommends the further investigations of irrigation resources to ensure the crop quality and public health. Utilization of sewage effluent water (TSE), as a substitute approach of irrigation purpose, is an accredited policy for the proficient usage and inhibition of ecological and aquatic contamination that is acquiring increased application throughout the world, particularly in regions where water is scarce. However, there are some risks connected that should be evaluated against some indigenous guidelines, taking TSE irrigation of public places and crops which are frequently handled and visited by people around. There is an absence of quantifiable assessment of microbial risk, may lead to suspecting the concentration of COVID 19 RNA virus in TSE, is the missing piece in the puzzle that is mandatory for the appropriate application in agricultural reutilization of sewage water. It is suspected that improper handling of sewage water and direct exposure of TSE to the public and environment can lead to the future wave of pandemic which may prove to be the catastrophe in history of viral outbreaks.

Statement of conflict of interest

The authors have declared no conflict of interests.

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