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SARS-CoV-2: The Increasing Importance of Water Filtration against Highly Pathogenic Microbes

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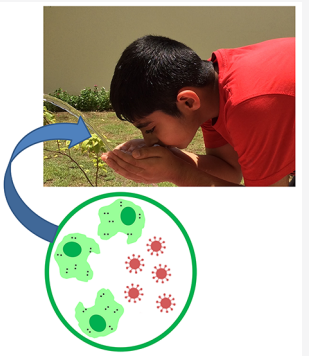
ABSTRACT: The presence of SARS-CoV-2 in human wastewater together with poor quality of public drinking water supplies in developing countries is of concern. Additionally, the frequent use of contaminated water for bathing, nasal irrigation, swimming, and ablution can be a risk factor in contracting infectious agents such as the brain-eating amoebae and possibly SARS-CoV-2. The use of appropriate tap water filters should be encouraged to remove pathogenic microbes, together with restrained nasal irrigation (not forcing water inside nostrils vigorously) during ritual ablution or bathing to avoid dangerous consequences for populations residing in developing countries.



KEYWORDS: *Severe acute respiratory syndrome coronavirus 2, COVID-19, ablution, nasal irrigation, microbial removal*

The detection of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) in feces suggested the presence of viral particles in human wastewater.[1] By RT-PCR assay, SARS-CoV-2 was detected in wastewater samples accumulated at Amsterdam Schiphol Airport, suggesting the need for surveillance systems for early warning of COVID-19 outbreaks, as well as implementation of effective filtration or disinfection systems to eradicate viral particles at wastewater treatment plants. These findings were strengthened further with the recovery of SARS-CoV-2 in wastewater collected near the first COVID-19 case in the community in Amsterdam.[1] Although the presence of SARS-COV-2 in wastewater may not be a peril to the local community in Amsterdam, similar scenarios could be a major hazard for public health in developing countries. The environmental transmission potential of SARS-CoV-2 to spread in communities via fecal−nasal route presents an important risk factor in COVID-19 outbreak recurrence, especially for developing countries where diseases with rapid clinical onset can go unnoticed. For example, the observation of primary amoebic meningoencephalitis due to brain-eating amoebae (i.e., *Naegleria fowleri*) is mostly unnoticed, especially in rural areas and disadvantaged communities, and is known to be associated with nasal irrigation for cleansing, ritual ablution, bathing, and swimming. This highlights the need for safe and effective water disinfection systems, as well as personal hygiene, to ensure protection against infectious agents.[2−4] Given that SARS-CoV-2 also uses the nose as a portal of entry and the fact that it has been detected in human wastewater, can there be fecal−nasal transmission as observed with the brain-eating amoebae?

While the connection of human wastewater and clean drinking water may be alien to the public in developed nations, it can be common in developing countries. For example, in a city such as Lahore (Pakistan), thousands of people turn to the canal that passes through the city during summer months (Figure 1A). With high temperatures (40−50 °C), as well as power cuts, while water temperatures are recorded at comfortable 28−35 °C, people turn to canals for water-related recreational activities. The troops of people are never ending and are visible for kilometers along the canal, and this "recreational activity" occurs virtually every day, during the summer months (Figure 1A).[2] Furthermore, there is a dearth of available toilet facilities and often the same canal waters are utilized to defecate in, with no evident warning signs depicting the potential dangers of swimming visible, representing a major risk factor for the community. Needless to say, the situation must be more challenging in rural areas (comprising >70% of the population) due to limited public awareness of associated risks, absence of effective control measures, and poor health care infrastructure.[2] In remote villages with prolonged hot

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Figure 1. (A) Thousands of people can be seen swimming in the canal that passes through the city of Lahore, Pakistan, without nearby facilities for defecation and urination. (B, C) Children swimming in muddy water or swimming in unchlorinated pools can lead to exposure to infectious agents. (D) Millions of people gather at the Kumbh Mela yearly to take part in the holy bathing. (E) Ritual ablution for nasal cleansing using contaminated water. (F) The use of neti pots for nasal irrigation using contaminated water can lead to contracting infectious agents. Reproduced from ref 2. Copyright 2014 the Authors.

summer months together with power cuts, the only recreational activity available to the public is swimming in contaminated water without knowing the associated risks (Figure 1B,C). Our recent interview of selected few members of a small community in India highlighted that COVID-19 infection was considered to be associated with "touching door handles" with no understanding of safe water and nasal irrigation. Similarly, religious commemorations like the Kumbh Mela, where up to 100 million people congregate in the Indian metropolis of Allahabad to take part in the holy bathing festival in the holy Ganges River, can present a major hazard to public health aiding in the transmission of infectious agents like SARS-CoV-2 (Figure 1D).[2] In supplementation to the diagnosis of COVID-19 cases, there is a clear and urgent need for surveillance systems for monitoring SARS-CoV-2 prevalence in such environments to counter potential disease outbreaks.

To further exacerbate the situation, developing nations like India and Pakistan are challenged with water shortages, and there is disproportionate public dependence on water storage wells or tanks. These water storage tanks are thriving with microbial communities. The drinking water supplies are rarely chlorinated. For example, the sewage management in Karachi (Pakistan) was built by the British during colonial days and needs urgent restoration. Scores of hospitalizations are accredited to breakage of sewage lines and merging with drinking water supplies. Thus, the contamination of human waste as well as human wastewater into drinking water supplies highlights a major risk factor in contracting infectious agents such as brain-eating amoeba and possibly COVID-19, especially for developing countries. Although the effective implementation of preventative strategies requires long-term planning and is very costly, the use of simple measures to decontaminate water in household settings can be placed in the interim.

Notably, *N. fowleri* goes through the nasal cavity and then migrates along the olfactory neuroepithelial route to reach the brain to produce a fulminating meningoencephalitis.[4] The use of the nose as a portal of entry for SARS-CoV-2 suggests that preventative measures can be tailor-made to be collectively effective against both infectious agents. Previous studies indicated that nose clips or boiling of water prior to nasal irrigation should be utilized as a preventative measure; however these measures are not always feasible. The use of simple tap water filters in households prior to ablution or nasal irrigation (Figure 1E,F) can be effective in eradicating microbial contaminants. Water filters have been used traditionally and effectively in eradicating bacteria, fungi, protozoa, and other parasites. However, viruses are considerably smaller, with most viruses ranging in size from 5 to 300 nm, and depending on the size, they may slip through filters with larger pore size. As SARS-CoV-2 is approximately 125 nm, the use of simple tap filters with ultrafiltration (pore size of ca. 10 nm) or nanofiltration (pore size of ca. 1 nm) can be effective, but not microfiltration (pore size of ca. 100 nm). Thus, the use of nanofilters is highly recommended to eliminate almost all microbes. Due to the small size of viruses, microfiltration is not effective for viruses but is reasonably effective for bacteria and protozoa. In addition to pore size, viral surface properties are also important in the design of effective filters. As the viral cell surfaces possess net negative electrostatic charge, adsorption on solid surfaces with modified positive charge centers can be used to capture viral particles. Such surfaces are also shown to be effective in eliminating heavy metals that occur in anionic complexes, for example, arsenate or chromate, although negatively charged surfaces, like montmorillonite, the clay mineral, may eradicate heavy metals in their cationic configurations.[5] In this regard, mechanical purifiers with modified solid surfaces with positive charge can be used to physically remove selected contaminants such as SARS-CoV-2.

In summary, the poor infrastructure of wastewater management and sanitation in developing countries together with limited public awareness suggests the need for behavioral modification and educational strategies to counter outbreaks of diseases such as COVID-19. The use of tap water filters should be encouraged to remove pathogenic microbes coupled with restrained or cautious nasal irrigation (not forcing water inside nostrils vigorously) during ritual ablution or bathing to evade dangerous consequences for those communities residing in the developing nations.

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Author Contributions

N.A.K., T.H., and M.K. envisaged the concept amid discussions with R.S. R.S. reviewed literature, and N.A.K. prepared the first draft of the manuscript. R.S. finalized the manuscript. All authors contributed equally to the manuscript and will act as guarantors.

Notes

The authors declare no competing financial interest.

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