

Consider How Social Distancing Policies Can Affect Drinking Water Infrastructure Performance

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In response to the COVID-19 pandemic, social distancing policies (SDPs) have been implemented in communities worldwide. By design, these policies have caused massive changes in our behavior as families shelter at home and industry and commerce pause or reduce operations. These changes have altered water consumption patterns, and in some cases they have likely degraded the drinking water quality in distribution systems. Although some drinking water utilities have the resources to discover and mitigate any potential negative effects, many do not have

the capacity to implement testing protocols beyond regulatory requirements.

SDPs and Water Quality

Drinking water distribution systems (DWDSs) are designed for a given range of operational conditions (Faust & Kaminsky 2018). However, a DWDS might be operating outside of those design conditions during the COVID-19 pandemic because SDPs are driving significant changes in water use. Although residential water demand is expected to increase when SDPs are in force, this might be offset by a sharp decrease in nonresidential water consumption, which typically accounts for more than half of all water consumption. Such changes in water use create zones with reduced flow/velocity, water stagnation, and increased water age.

Increased water age can result in decreased disinfectant residuals (Wang et al. 2012) and conditions that promote growth of microorganisms, such as pathogenic *Legionella* spp. (Waak et al. 2018). Proactive monitoring in

a DWDS could be used to trigger operational changes to mitigate these consequences. However, some utilities might not have the financial, workforce, or instrumentation resources needed to monitor in real time and beyond regulatory requirements.

The following guidance outlines ways in which SDPs could affect water infrastructure and provides some suggestions for monitoring DWDSs. This discussion is intended primarily to aid resource-limited utilities that are responding to substantial changes in water use caused

by the current and potential future waves of the COVID-19 pandemic, recognizing that not all utilities will experience substantial changes in water use.

Management and Water Use Challenges

The water industry has faced some challenges associated with workforce absenteeism and continuity of operations during the pandemic (AWWA 2020). Today's older water professionals, who hold much of the institutional knowledge of our systems, is at disproportionate risk from COVID-19. Moreover, field staff face workforce safety issues because of SDPs and potentially reduced access to personal protective equipment. For systems with one operator (or a single operator shared among multiple water treatment plants), continuity of operations and the ability to monitor for abnormalities in operations are concerning (AWWA 2020). In addition, the water sector faces challenges related to water flow and water quality.

Water Flow

In areas that usually have substantial commercial or industrial water use, a reduction or pause in operations during the pandemic could lead to significantly decreased water use. In contrast, DWDS zones dominated by residential water use could exhibit temporally shifted and increased aggregate daily demand because more people remain at home as a result of SDPs. For water utilities that do not have substantial changes in total water demand during the pandemic, changes in temporal and spatial water usage can still affect water quality in ways that could threaten public health. Water use reductions, if not accompanied by corrective actions (e.g., changing pumping operations), naturally decrease flow velocities that control the amount of time treated drinking water spends in the pipelines. This additional residence time enables treated water to undergo various chemical, physical, and biological transformations (Abokifa et al. 2020, Zhuang & Sela 2020).

In summary, spatial, temporal, and volumetric changes in water use are expected when SDPs are in force, and these changes will lead to zones with low or intermittent flows in a DWDS compared with pre-pandemic conditions.

Water Quality

Zones in a DWDS where flow has dramatically increased or decreased create a complex situation in which flow velocity/regime, water quality, reaction rates, and hydraulic residence time change simultaneously. For instance, the flow regime (laminar versus turbulent) has been shown to affect disinfection decay constants and the concentration of disinfection byproducts (Zhang & Andrews 2013). Machell and Boxall (2012) showed only a

weak association between mean water age and water quality in a DWDS, but the associations became stronger when the maximum water age contribution was considered. For instance, chlorine residual decreased and the heterotrophic plate counts increased as the maximum water age contribution increased.

The effects of stagnation on corrosion have been shown to vary with metal ions released (e.g., iron versus copper) and water chemistry (i.e., pH, temperature, alkalinity, chloride, and sulfate) (Li et al. 2020, Zlatanovic et al. 2017, Boulay & Edwards 2001). This suggests that extreme changes in water age, such as during periods of social distancing or shutdowns, could substantially affect water quality.

In summary, where SDPs lead to increases in the maximum water age, the disinfectant residual could decrease while microbial growth and corrosion could increase compared with pre-pandemic conditions.

Increased Monitoring During Social Distancing

One easily monitored indicator of change in aggregate water use patterns are tank turnover rates. Systems that have observed reduced tank turnover rates during the COVID-19 pandemic should view this as a potential indicator of water age issues in the DWDS and should strongly consider additional water quality testing. Utilities with hydraulic models can estimate changes in water use profiles, which lead to demand changes, to identify potentially vulnerable DWDS areas where water quality could be monitored in a targeted fashion.

We recommend surveillance (i.e., nonregulatory monitoring) of disinfectant residual, lead, and copper concentrations in DWDSs when SDPs are in force. Nondetectable disinfectant residuals indicate reduced protection against microbial pathogens. Lead or copper concentrations above their respective drinking water action levels indicate potential corrosion issues, possibly because of changing water quality. Moreover, lead exposure can result in acute (Hon et al. 2017) and chronic (NTP 2012) health effects. Lead testing can indicate short-term or extended exposure to higher lead concentrations during the pandemic.

Additionally, for DWDSs using chloramine as a residual disinfectant, we recommend nitrite testing because its level can indicate the growth of nitrifying bacteria and potential issues for maintaining measurable chloramine residuals. This type of surveillance allows utilities to identify and monitor DWDS areas that experience substantial declines in water quality during the pandemic. Such monitoring also could be used to demonstrate how operational changes could improve water quality.

The SDP effects and implications described here are not expected to be uniformly distributed throughout a DWDS.

SDPs likely have exacerbated or spatially shifted the challenges each utility typically faces. Until research can provide better guidance, we expect the potential effects of SDPs on DWDSs are more likely in the following systems:

- Those with significant industrial and commercial components that have paused or reduced operations
- Those with a long or nonlooped DWDS
- Those that habitually have higher water age as compared with other systems

Monitoring Methods

We realize the need for increased water quality testing comes when utilities are facing workforce and financial challenges from the COVID-19 pandemic (AWWA & AMWA 2020). State/province or federal support could help utilities meet these challenges. For example, traveling teams of water professionals (with adequate pandemic-related safety protocols) could provide supplemental testing that goes beyond regulatory requirements. Alternatively, funds could be provided for utilities to perform testing themselves.

In areas that usually have substantial commercial or industrial water use, a reduction or pause in operations during the pandemic could lead to significantly decreased water use.

Particularly for utilities that are extremely resource limited, but also for utilities that want to engage more with their communities in a safe manner, citizen science or crowdsourcing might be appropriate ways to monitor water quality. Utilities could provide low-cost kits to customers with accompanying protocol instructions to sample disinfectant residuals, lead, and copper as well as nitrite. Water samples for analyzing lead and copper could be collected at the point of entry and at the tap within homes, with the samples returned via mail or drop-off at testing locations. Occupants could monitor residual chlorine and nitrite levels, using off-the-shelf water quality test strips, and could send the results to their utility via a smartphone application or website.

With adequate privacy protections, geotagged sample results could be displayed using an application or website, thereby providing operators with real-time

awareness of system vulnerability. Notably, such data should be carefully analyzed to avoid biases associated with many samples taken at one site. Although such data do not replace standard water quality measurements, they would allow utilities to more quickly identify areas of potential concern for additional water quality testing and, if warranted, corrective action.

Response Plans and Cooperation

Broadly, utilities should leverage existing emergency response and hazard mitigation plans as they continue to respond to the challenges triggered by COVID-19, whether or not a pandemic was a previously identified hazard. In particular, plans for mutual assistance among utilities help ensure continuity of operations (e.g., to provide a temporary workforce in case of infection or support for additional water quality testing).

The effects of pandemic-induced changes in water use or DWDS water quality remain largely unknown. Therefore, to maintain DWDS integrity, water quality sampling and hydraulic modeling must inform appropriate operational mitigation strategies.

Notes for a Concerned Public

Despite the concerns described here, the authors do not believe the public should avoid piped drinking water unless they observe changes in their water supply or are instructed to do so by their water utility. The Centers for Disease Control and Prevention notes there is no evidence for the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is the causative agent of COVID-19, through drinking water (CDC 2020). 📍

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