

The need of an environmental justice approach for wastewater based epidemiology for rural and disadvantaged communities: A review in California

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Abstract

Amid the 2019 coronavirus disease pandemic (COVID-19), the scientific community has a responsibility to provide accessible public health resources within their communities. Wastewater based epidemiology (WBE) has been used to monitor community spread of the pandemic. The goal of this review was to evaluate the need for an environmental justice approach for COVID-19 WBE starting with the state of California in the United States. Methods included a review of the peer-reviewed literature, government-provided data, and news stories. As of June 2021, there were twelve universities, nine public dashboards, and 48 of 384 wastewater treatment plants monitoring wastewater for SARS-CoV-2 within California. The majority of wastewater monitoring in California has been conducted in the urban areas of Coastal and Southern California (34/48), with a lack of monitoring in more rural areas of Central (10/48) and Northern California (4/48). Similar to the access to COVID-19 clinical testing and vaccinations, there is a disparity in access to wastewater testing which can often provide an early warning system to outbreaks. This research demonstrates the need for an environmental justice approach and equity considerations when determining locations for environmental monitoring.

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Keywords

Equity, SARS-CoV-2, COVID-19, Public health, Environmental surveillance, Geospatial analysis.

Introduction

Equitable access to environmental and public health resources is needed for the fairness and advancement of all groups. Both rural [1,2] and urban communities in the U.S [3,4] experience COVID-19 disparities. The Center for Disease Control (CDC) published a report revealing populations at risk of COVID-19 infection, hospitalization, and death by race/ethnicity on July 16, 2021 [5]. Black or African American communities were 1.1 times at risk of contraction [6], 2.8 times at risk of hospitalization [7], and 2.0 times at risk for death [8]. American Indian or Alaska Native populations resulted in 1.7 times at risk of contraction [6], 3.4 times at risk of hospitalization [7], and 2.4 times at risk of death [8]. Hispanic/Latino communities were 1.9 times at risk of contraction [6], 2.8 times at risk of hospitalization [7], and 2.3 times at risk of death [8].

To further understand community transmission, scientists have turned to wastewater based epidemiology (WBE) [9]. WBE involves the examination of wastewater for traces of SARS-CoV-2 RNA, the virus that causes the COVID-19 disease, to analyze the prevalence of community viral load. WBE can serve as a lower cost tool to support individual testing in communities [10], and optimize resources within a specific testing site, such as a university campus [11]. One wastewater sample can represent the disease burden of hundreds and even millions of people depending on the location of the wastewater treatment sample (treatment facilities, pumping stations, manholes, and other sewer locations), and thus allow for more widespread, equitable, and less invasive testing [12]. Despite this ability, wastewater monitoring has not been deployed equitably globally, but primarily in high income countries like the U.S. [13].

Even within the U.S. there may be testing disparities similar to access to clinical testing and vaccinations [14].

The purpose of this review of California WBE efforts is to assess the need for an environmental justice approach to COVID-19 monitoring efforts. Environmental justice [15] is defined by the U.S. Environmental Protection Agency (EPA) as "... the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies". The pandemic has shed light on areas that need improvement within the nation's public health systems in both rural and urban communities. Equity of wastewater monitoring efforts for SARS-CoV-2 is a principal component to consider.

An environmental justice evaluation of California's COVID-19 wastewater monitoring efforts

The COVIDPoops19 framework for the State of California

The COVIDPoops19 global dashboard was created in 2020 from publicly-accessible data from six different data sources (literature searches, the COVID-19 WBE website, webinars, Google Form submissions, Twitter keyword searches, and Google keyword searches) [13]. The dashboard serves as a compilation of monitoring efforts of SARS-CoV-2 in wastewater to aid researchers and the public to identify where testing is occurring in their area. COVIDPoops19 literature and news sources were filtered on June 8, 2021 for this review.

After filtering the COVIDPoops19 dashboard data for the state of California, the site names, along with the corresponding latitude and longitude were extracted for each location. The data was then uploaded to ArcGIS Online as individual points portraying the known wastewater treatment plants (WWTPs) in California [16–23], the sites (universities and WWTPs) monitoring their wastewater for SARS-CoV-2 [24–39], and public dashboards [29] that display COVID-19 wastewater data.

In the state of California in June 2021, there were 384 wastewater treatment facilities and 48 (12.5%) of those facilities monitor SARS-CoV-2 in their influent wastewater [40]. There were 12 known universities publishing WBE efforts from their campuses and communities, along with nine public dashboards throughout the state displaying their public health efforts through wastewater monitoring in their local facilities.

Urban and rural review

A key component of equity is access for both rural and urban areas. Rural areas often lack access to health care

and education resources [41]. In addition, rural areas typically consist of smaller treatment plants spread out between communities compared to urban areas, and this provides economic and logistical challenges to wastewater monitoring [42]. Initially rural areas were not hard hit by COVID-19 potentially due to the lower population densities, but eventually the pandemic spread to many of these areas and overloaded their limited hospital capacities [43]. Figure 1 displays the map of WWTPs in rural, urban, and frontier communities in California and those monitoring SARS-CoV-2 [46]. From the three layers, urban communities in California currently comprise 41 out of the 48 (85%) total WWTPs monitoring SARS-CoV-2 throughout the state. Rural communities comprise 7/48 (15%), and there are no wastewater treatment plants monitoring in frontier communities.

Regional equity of California's wastewater monitoring

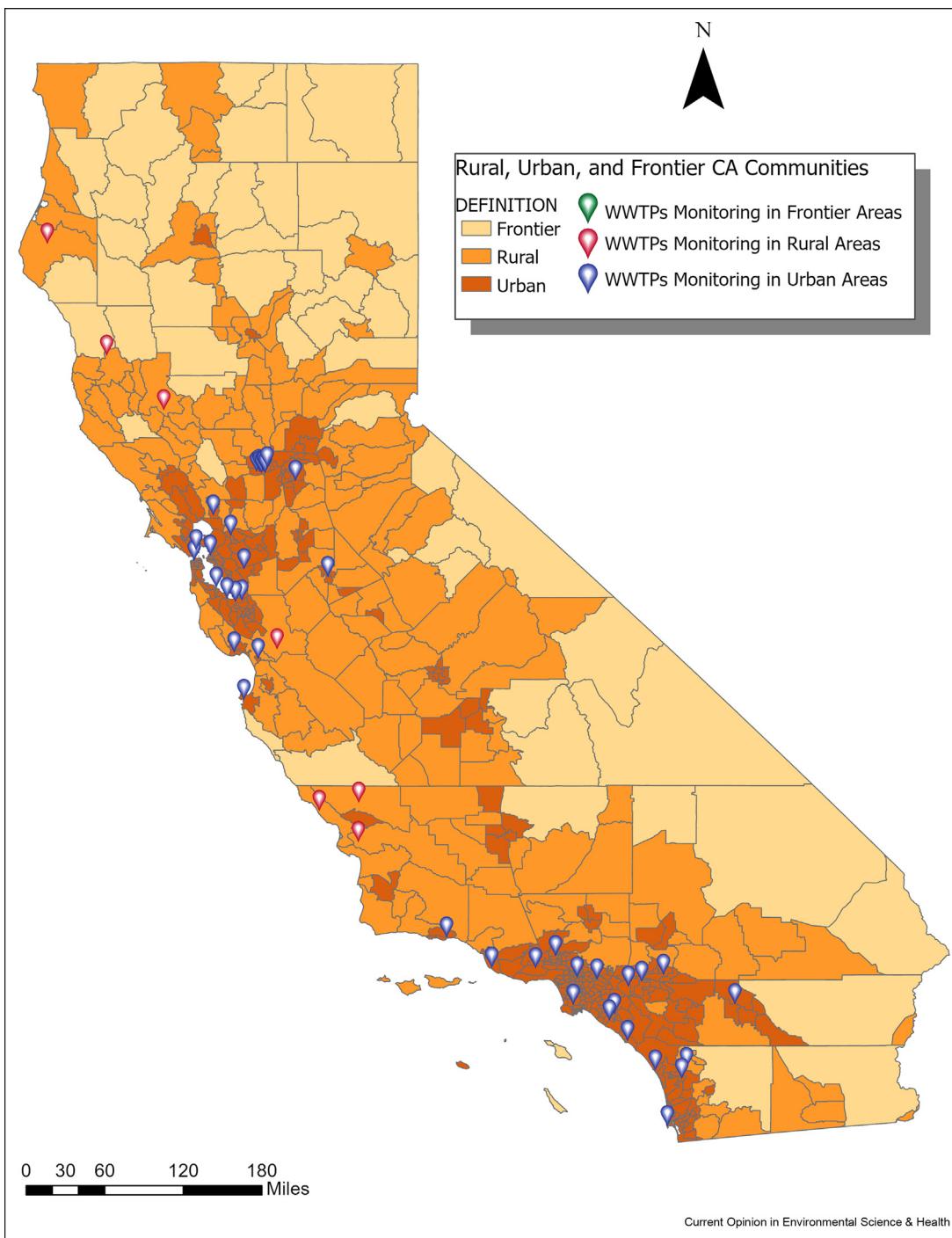
In addition to rural and urban representation, regional equity must also be considered for states and country monitoring efforts. Figure 2 shows the WWTPs monitored for SARS-CoV-2 in California over the major regions of California (Central, Coastal, Southern, Northern) [44,48]. There are 10 WWTPs monitored in the Central region, 18 in the Coastal region, 16 in the Southern region, and four in the Northern region (see Figure 2).

The total treatment plants per region in California include: the North (79 treatment plants), South (75 treatment plants), Central (122 treatment plants), and Coastal (102 treatment plants) [44]. Central (10/122, 8.2%) and Northern California (4/79, 5.1%) lack access to COVID-19 wastewater monitoring efforts [44] compared to Coastal (18/102, 18%) and Southern (16/75, 21%) California (see Figure 2).

Map of WBE efforts over environmental justice layers in California

The California Office of Environmental Health Hazard Assessment (OEHHA) classifies Disadvantaged Communities (DAC) [45] as communities that may include, but are not limited to: "areas disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation, and areas with concentrations of people that are of low-income, high unemployment, low levels of home ownership, high rent burden, sensitive populations, or low levels of educational attainment". A higher percentile value for a county signifies greater environmental, economic, and/or educational disparities. CalEnviroScreen [45] defines a DAC as the top 25% scoring areas with high levels of pollution and smaller populations. Figure 3 displays WWTPs in DACs [45] in California compared to the WWTPs monitoring for SARS-CoV-2 throughout the state.

Figure 1

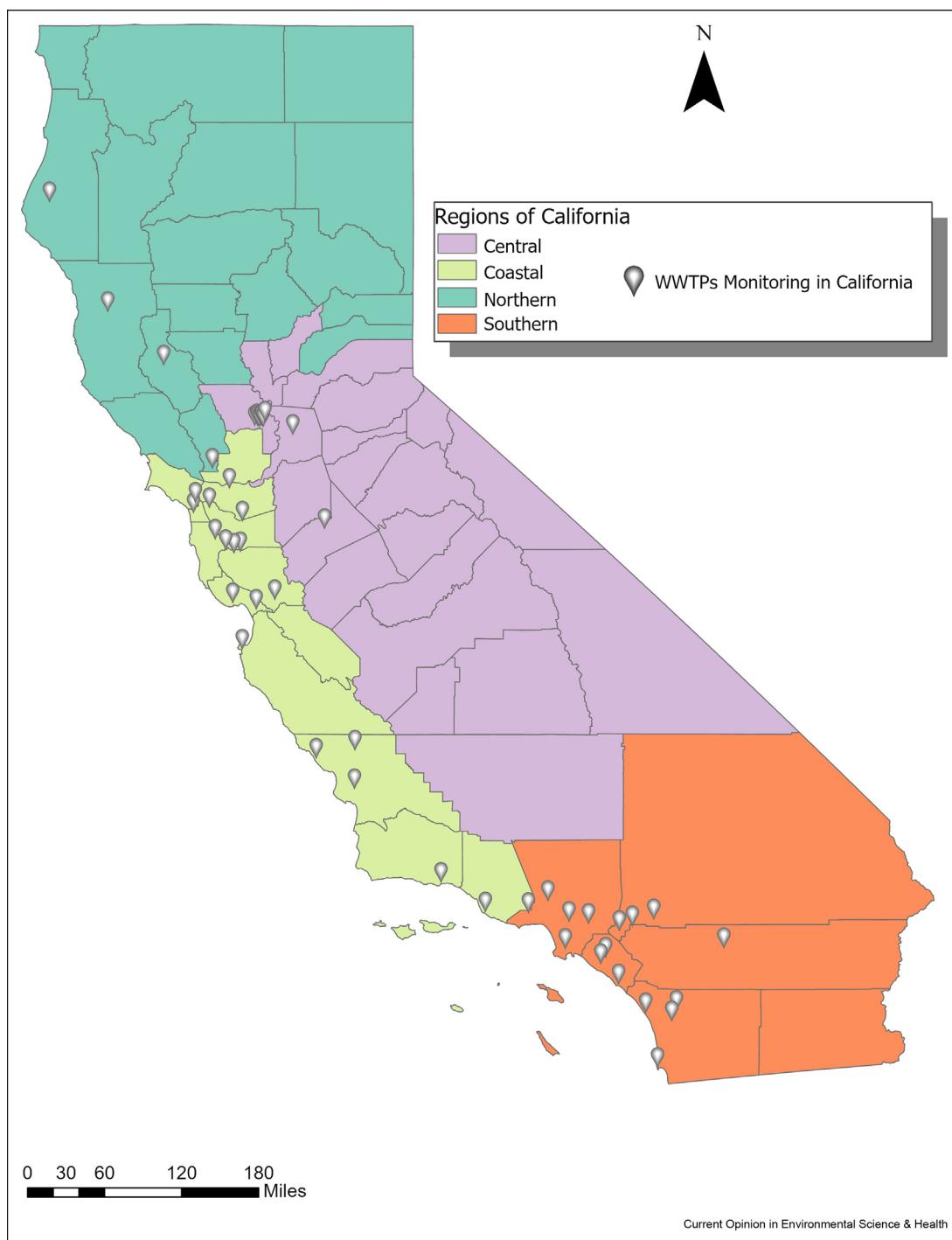


Map of wastewater treatment plants monitored for SARS-CoV-2 in rural, urban, and frontier communities [46] in California.

There are 2022 DAC communities out of 8035 total communities throughout the state of California (25%) [45]. Out of the 48 WWTPs monitoring throughout California, 10 of them are located within DAC communities (21%) [45]. There are 90 total WWTPs located in DAC communities, and 10 of these are monitoring for

SARS-CoV-2 (11%) [45]. This indicates a lack of wastewater monitoring for SARS-CoV-2 within DACs located throughout the State of California. Comparatively, 38 treatment plants were monitoring in non-DACs of 294 non-DAC wastewater treatment plants (12.9%). Though the percent monitoring in DACs and

Figure 2

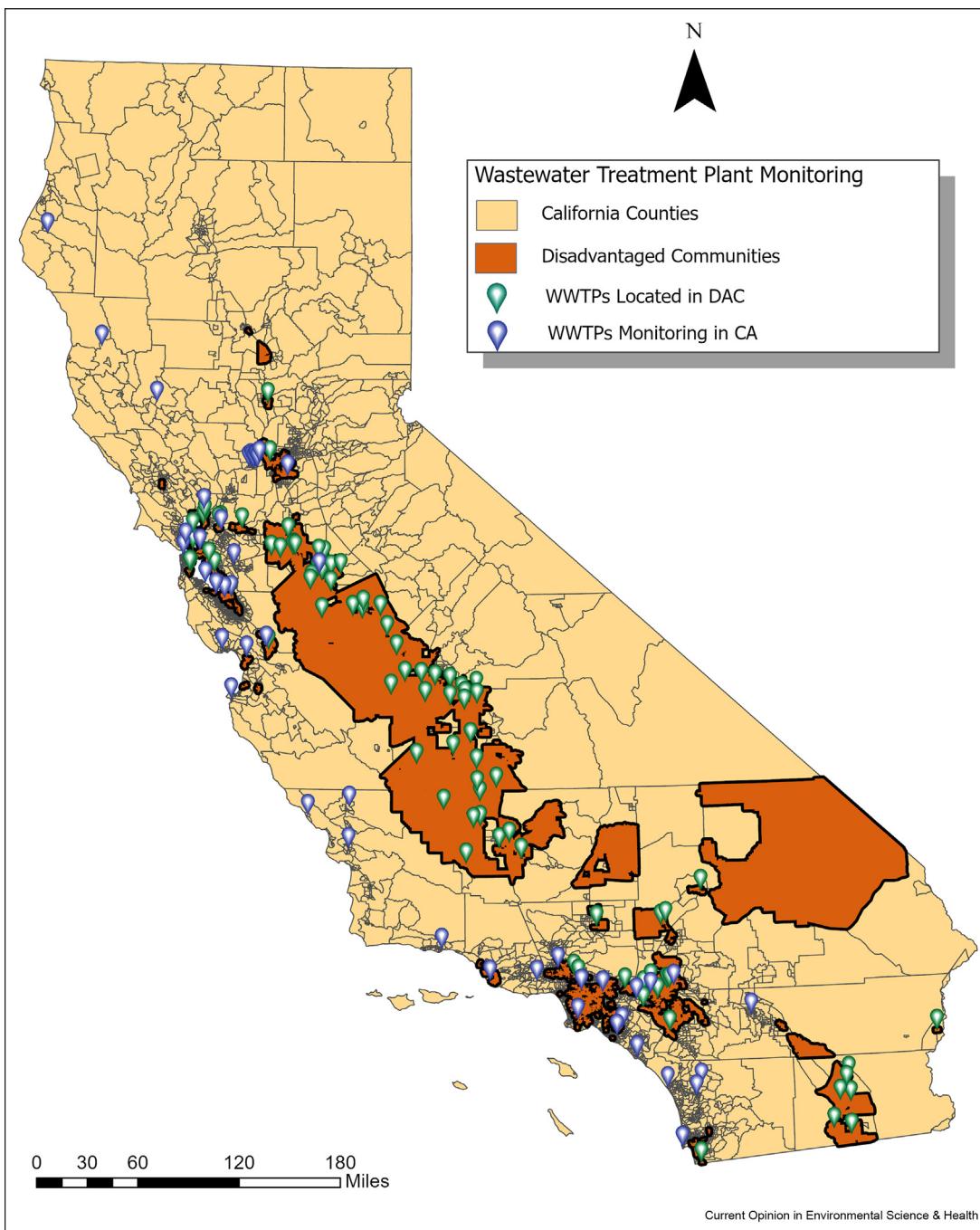


non-DACs is relatively similar (11.1%–12.9% respectively), DACs have higher COVID-19 cases, hospitalizations, and deaths and have less access to public health resources as well as other environmental health burdens and need greater access to wastewater monitoring.

COVID-19 case proportion to population and wastewater monitoring in California

Another component of equity to consider is whether WBE monitoring of COVID-19 is occurring in the areas of highest COVID-19 prevalence and need. [Figure 4](#)

Figure 3

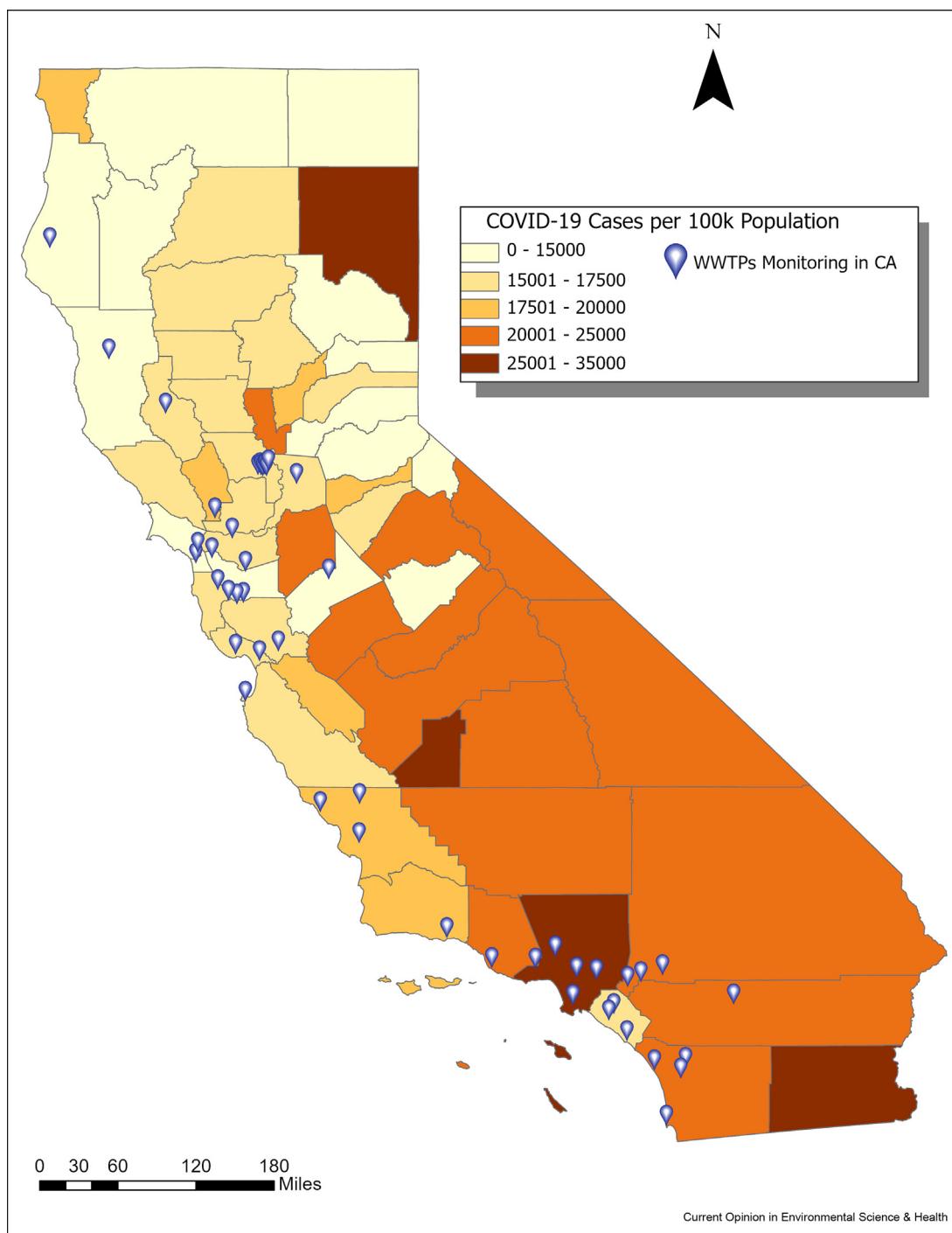


Map of wastewater treatment plants in Disadvantaged Communities (DACs) [45] in California compared to the wastewater treatment plants monitoring for SARS-CoV-2 throughout the state.

overlays WWTPs monitored for SARS-CoV-2 in California and the cumulative COVID-19 case counts, from March 3, 2020 to February 8, 2022, [47,49] per 100,000 population by county [48,50]. The highest ranking counties with COVID-19 cases per 100,000 population are Lassen (north), Kings (central), Los Angeles

(south), and Imperial (south) counties. Out of these counties, Los Angeles has the highest number of wastewater treatment plants monitoring in the area. Central and Southern California counties experience moderate-high levels of COVID-19 cases per 100,000 population with little access to wastewater monitoring.

Figure 4



Map of wastewater treatment plants monitoring for SARS-CoV-2 in California compared to the cumulative COVID-19 case counts [47,49] per 100,000 population distributed by county [48,50].

Conclusions and recommendations

The world can utilize WBE as a public health tool to inform communities of potential outbreaks and use the data for localized solutions. WBE can additionally serve as a lower cost tool for COVID-19 testing and help focus

resources to support individual testing efforts [13]. Mapping testing disparities like our review of COVID-19 wastewater monitoring efforts in California demonstrates the need for an environmental justice approach for WBE efforts overall. The application of WBE

provides opportunities for equitable public health initiatives through systematic data collection. We encourage the expansion of wastewater testing to areas of need in California and globally particularly in Low and Middle Income Countries. Providing greater access to COVID-19 WBE will require improved [51] and innovative sampling methods such as sensors [52] especially for areas without centralized wastewater systems.

Credit author statement

Clara Medina: Conceptualization, Methodology, Formal Analysis, Writing - Original Draft **Krystin Kadonsky:** Data Curation, Writing -Review & Editing, Visualization **Fernando Roman:** Data Curation, Writing -Review & Editing, Visualization **Arianna Tariqi:** Data Curation, Writing -Review & Editing, Visualization **Ryan Sinclair:** Writing -Review & Editing **Patrick D'Aoust:** Writing -Review & Editing **Robert Delatolla:** Writing -Review & Editing **Heather Bischel:** Writing -Review & Editing **Colleen Naughton:** Conceptualization, Methodology, Writing -Review & Editing, Supervision, Project Administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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Proc Natl Acad Sci Unit States Am 2021, **118**:1–6, <https://doi.org/10.1073/pnas.2019378118>.

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