1. Introduction

The biological contaminants of emerging concern (BioCEC) team created an Excel table and a narrative explaining how the table was created, its findings, and how these findings can be used to develop BioCEC monitoring programs. The spreadsheet is meant to be useful for both environmental professionals and human health professionals. Monitoring programs highlighted in the spreadsheet can be used as examples for professionals who are interested in formulating their own monitoring programs, as well as for general edification as an overview of the sorts of monitoring programs that already exist within the United States, and to a limited capacity worldwide.

The Excel spreadsheet consists of two tabs. The first tab (Monitoring Programs) shows examples of monitoring programs, with columns specifying the organization initiating the program, the types of biocontaminants monitored, the medium that is being monitored, and links to websites for each of these programs. The second tab (Resource Hub) consists of a resource hub, which includes websites from federal agencies (and others) that have lists of BioCEC and infectious diseases that have recently attracted new attention.

The Monitoring Programs tab consists of nine columns identified alphabetically as A through I. The columns provide information on the name of each program (column A), the organization (column B), the state name (column C), specific pathogen (column D), health and environmental media (columns E and F), a brief discussion of each program (column G), and links to websites pertaining to each program (columns H and I). As noted above, two of the columns identify health and environmental media. The first media column (column E) consists of only those discrete media that are specified in the BioCEC definition spelled out in the Introduction section of the BioCEC framework document. The second media column (column F) provides a broader list of media that can be useful to environmental and health professionals trying to identify specific pertinent programs. The team selected monitoring programs and resources from federal agencies, states, and other authorities, including several international organizations. The spreadsheet includes programs focused on environmental media (such as soil, water, and air) as well as programs focused on vectors (such as mosquitoes and pathogens transmitted via human-to-human contact and animal-to-human contact). For the state monitoring programs, the team selected programs from one or more states in each region of the United States as defined by US Environmental Protection Agency (USEPA) regional offices. Methods for Consolidating the Table of Resources and Current Monitoring Methods, below, provides details on how the monitoring programs were selected.

2. Methods for Consolidating the Table of Resources and Current Monitoring Methods

A literature review was conducted to compile a list of state and federal programs responding to/preparing for emerging pathogens in environmental and public health settings. The review applied a common methodology to ensure a compilation of monitoring programs from 2010 to 2024. The review included information from diverse sources, including peer-reviewed literature and non-peer-reviewed gray literature. To capture relevant peer-reviewed articles, searches were performed in established academic databases, including Google scholar, PubMed, Scopus, and Web of Science. Gray literature was sourced from governmental websites, public health organizations, and conference proceedings to identify additional programs and data that may not be represented in traditional academic literature.

The inclusion criteria focused on programs specifically monitoring emerging pathogens within state or federal jurisdictions in the United States, particularly those operating in environmental or public health contexts. Programs were excluded if they targeted non-emerging pathogens, operated solely in international settings without US involvement, or lacked sufficient descriptive detail. A standardized spreadsheet was used for data extraction to ensure consistency and reliability. Key data points included the program’s name, the overseeing agency, the specific pathogens monitored, the methods employed for monitoring, the media monitored, and a program description.

The review included 59 monitoring programs that track pathogens. Of these, 22 states were identified primarily by programs managed by state, county, or city level entities, such as state departments of health; several of these states are covered by more than one program in the table. An additional five programs are associated with universities and are likely funded by state or federal agencies. Several examples of monitoring programs from hospitals are also included in the table. The remaining programs were at the federal level (e.g., Centers for Disease Control and Prevention [CDC] or USEPA), had an international focus (e.g., Global Polio Network or World Health Organization), or were broader programs that served multiple areas (e.g., Association of Public Health Laboratories).

The programs reviewed cover an extensive range of pathogens. For instance, four programs focus on polio, while others

monitor multiple pathogens, including influenza, *E. coli*, and vector-borne diseases like West Nile virus and Eastern equine encephalitis. Some programs address specific needs, such as the Global Polio Laboratory Network's specialized focus on polio eradication or wastewater surveillance efforts that enable early detection of SARS-CoV-2 and other emerging pathogens such as mpox. In some cases, the programs have state or federal mandates to report infectious diseases detected in the human population (i.e., the CDC National Notifiable Disease Surveillance System). Other programs monitor broader categories, such as antimicrobial resistance genes, zoonotic diseases, and communicable diseases reported under statutory requirements.

These programs use various media for pathogen detection, including water, vector populations (such as mosquitoes), human and animal tissues, and healthcare data systems. The summary sheet reflects the significant role of these monitoring programs in supporting early detection, surveillance, and response to emerging public health threats. The final dataset highlights the breadth of monitoring efforts across the United States and internationally and provides a valuable resource for stakeholders to strengthen public health and environmental protection initiatives.

The list should not be considered exhaustive of all states and jurisdictions that conduct pathogen monitoring. Rather it should be considered exemplary of the types of monitoring programs that could be developed by various state entities.

3. Overall Findings from the Systematic Review of BioCEC Programs

Most states generally have programs in place for monitoring biological contaminants in ambient environmental media such as surface water, recreational waters, and drinking water. Additionally, initiatives are in place that encourage states and municipalities to monitor for emerging contaminants in their waters. For example, USEPA's Contaminant Candidate List (CCL) is a list of drinking water contaminants that are known or anticipated to occur in public water systems and are not currently subject to USEPA drinking water regulations. Developing the CCL is the first step in evaluating drinking water contaminants.

The most recent CCL proposal, CCL 5, includes 12 microbial contaminants (USEPA 2022 [EL46QUXG] USEPA. 2022. "CCL 5 Microbial Technical Support Documents." https://www.epa.gov/ccl/ccl-5-technical-support-documents.). The USEPA continues to further evaluate contaminants on the list.

The results of the analysis indicate that the most prevalent national programs currently in place, pertaining to monitoring for BioCEC, are focused on detecting pathogens associated with new human health outbreaks or circulating through human populations. The most commonly used methods include wastewater monitoring, monitoring of human health exposures at public health facilities, and vector monitoring.

The analysis also concluded that there are very few monitoring programs in place for tracking ambient air monitoring. Indoor air monitoring is beyond the scope of this document.

Wastewater at a treatment plant can be a valuable tool for determining whether certain transmittable pathogens are present in a community. Although the BioCEC definition contained in this framework document does not specifically identify wastewater as a separate medium, wastewater monitoring is included in this section due to its value, the prevalence of programs in place for monitoring wastewater, and funding opportunities specific to wastewater treatment. The spreadsheet shows that a number of state and local authorities are monitoring for emerging diseases in their wastewater. For example, programs currently being implemented by the Arizona Department of Health Services, the New York State Department of Health, and Nevada's EMPOWER Program routinely test for pathogens in wastewater such as the viruses COVID-19, mpox, and influenza. These programs help to determine whether specific pathogens are present in the general population. The National Wastewater Surveillance System (NWSS) Utilities Community of Practice provides the opportunity for utilities to share best practices and lessons learned regarding sampling collection logistics, communication with health departments and lab partners, and conveying the value of wastewater surveillance to stakeholders. A link to the NWSS Community of Practice is included in the monitoring programs page of the spreadsheet. The NWSS tool allows for rapid assessment of outbreak trends across the country, and additional pathogens are expected to be added to the dashboard in the future (About CDC's NWSS).

There are many clinical and public health emerging biological contaminant monitoring programs that could be of interest to environmental BioCEC monitoring programs. For example, New York City routinely tracks emergency room visits, ambulance runs, and pharmacy sales to provide an early warning signal of a possible outbreak. The Arizona Department of Health Services routinely monitors for water, mosquito, and vector-borne diseases in environmental systems such as Lyme disease, Oropouche virus, and hantavirus. Further, because climate change is expected to exacerbate the spread of diseases to new areas, several public health agencies are increasing their monitoring of diseases such as Valley fever, Dengue, and malaria.

The Resource Hub section of the spreadsheet consists of resources from federal and international organizations including the CDC, National Institute of Allergy and Infectious Diseases, World Health Organization, and the USEPA. The material includes lists of emerging diseases, current outbreaks, and funding opportunities for states. Regarding funding opportunities, the Clean Water and Drinking Water State Revolving Fund (SRF) Provisions of Bipartisan Infrastructure Law of 2022 provides $5B through the SRF to reduce exposures to emerging contaminants from public drinking water and wastewater systems.

According to the Combined SRF Implementation Memo, the funding is available from 2022 to 2026 (USEPA 2022 [3VIBD2AB] USEPA. 2022. “FY 2022-2026 EPA Strategic Plan.” March. https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan.pdf., 10) and provides $1B for emerging contaminants in wastewater and $4B for emerging contaminants in drinking water. Biological contaminants and microorganisms such as antibiotic-resistant bacteria, biological materials, and pathogens are among the emerging contaminants covered under these provisions (USEPA 2022 [3VIBD2AB] USEPA. 2022. “FY 2022-2026 EPA Strategic Plan.” March. https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan.pdf., 36). Information regarding the extent to which funding can be provided to individual monitoring programs, and whether funding will continue as initially planned, is beyond the scope of the Interstate Technology and Regulatory Council BioCEC framework document.

4. Opportunities and Challenges to Leveraging Existing Programs to Improve BioCEC Monitoring

Although various monitoring programs have been established by public health agencies, there appears to be a lack of coordination and/or duplication between environmental monitoring programs and public health–focused monitoring of BioCEC. For example, the Wisconsin Department of Natural Resources, City of Milwaukee Health Department in Wisconsin, and the Michigan Department of Environment, Great Lakes and Energy are all independently monitoring the beaches along Lake Michigan. In some cases, these data are consolidated in one place (i.e., Wisconsin Department of Natural Resources); in other cases, different states are not sharing or reporting data efficiently (i.e., MiEnviro Portal that shows *E. coli* only for the Michigan beach results for Lake Michigan and not the Wisconsin beach results).

Many state and federal programs that are currently engaged in routine water and air quality monitoring programs could be extended to include emerging pathogen monitoring. For example, programs that are currently monitoring wastewater or surface water systems could be expanded using advanced diagnostic tools to detect multiple pathogens simultaneously. Multiplex polymerase chain reaction or metagenomic sequencing of these water samples could be used to detect multiple pathogens within the current monitoring workflows. More details on the monitoring methods and their strengths and weaknesses can be found in the Analytical Methods section.

Collaboration and data sharing among different states and federal agencies and incorporation of public-private partnerships could also enhance emerging pathogen monitoring. For example, development of centralized databases that integrate environmental and public health data could improve tracking and analysis of pathogen emergence and spread. Strengthening collaborations with academic institutions, private labs, and non-profits to leverage their expertise and technological innovations could enhance monitoring programs.

Extending existing surveillance programs both geographically and to include alternate media such as wildlife and vector surveillance could improve the sensitivity of monitoring programs by early detection of emerging threats in a state’s jurisdiction.

Barriers to expanded monitoring should also be considered as these restraints could limit the adoption of expanded emerging pathogen surveillance. Constraints to expanded monitoring include financial and resource constraints (e.g., laboratory infrastructure, trained personnel); diagnostic limitations for detection of novel pathogens; standardization issues including variability in sampling methods and analytical techniques; barriers to interagency and cross-sector coordination, collaboration, and data sharing; and limited policy or political support for emerging pathogens that may be perceived as low risk. Similarly, some BioCEC are naturally present in the environment at low concentrations. When BioCEC are naturally present, there may not be a threshold value for a BioCEC that indicates some protective action should be undertaken.

Implementation of enhanced monitoring should consider the regional context by tailoring the priorities for detecting the pathogen and considering regional risks, such as mosquito-borne diseases in the southern United States and hantavirus in the western states. These monitoring programs should undergo dynamic assessment and priorities should be regularly reassessed based on emerging data, environmental changes, and pathogen evolution. Finally, the emerging pathogen surveillance should be integrated into a type of One Health framework that monitors human, animal, and environmental

health.

The Monitoring Programs / Resource Hub spreadsheet is provided as a separate file.