PROGRAM ON WATER GOVERNANCE

IMPROVING WATER QUALITY WITH NOVEL DIAGNOSTICS: POLICY BRIEF ON THE POTENTIAL USE OF METAGENOMICS FOR IMPROVED WATER QUALITY TESTING

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INTRODUCTION

Scientists at universities and public health institutions across Canada, including the *BC Centers for Disease Control Public Health Laboratory*, are using metagenomics to study the microbial communities in the water in order to develop new tests to assess water quality. Metagenomics has the potential to revolutionize our understanding of how perturbations in these microbial communities are linked to water quality with ramifications for drinking water and other applications. Although chemical pollution is not a focus of the current research, the state of these microbial communities can also indicate whether chemical or other contamination has occurred (e.g., temperature or other biophysical changes also shift the composition and function of these microbial communities).

This policy brief was developed as part of the **Applied Metagenomics of the Watershed Microbiome project** (www.watersheddiscovery.ca). Here, we outline some of the major findings related to the project from a GE^{3}LS perspective (Genomics and its Ethical, Environmental, Economic, Legal and Social Aspects), highlighting several key insights and references that may be of interest to policymakers and stakeholder communities.

Our work uses, as its foundation, an anticipatory governance approach—working to identify key issues from a diverse group of stakeholders, publics, and likely future users of novel water quality tests to inform the ongoing research and test development.

BENEFITS AND POTENTIAL ADOPTION OF NEW TESTS

A significant appetite and enthusiasm for metagenomics-based water quality tests was identified in multiple aspects of the GE^{3}LS work. Much of this support stems from key features of the anticipated tests that are expected to address current issues, barriers and opportunities identified by stakeholders related to water quality testing, evidence-based legal proceedings, and microbial risk governance. Aspects of the anticipated tests that particularly interest policy makers and watershed and laboratory managers include:

- Having enhanced knowledge about source water, such as an improved understanding of problem spots in a watershed and the functional role of microbes in an ecosystem.
- Having information about contamination events at the source, which would enable a more rapid and targeted response.
- Having enhanced knowledge about source water, such as an improved understanding of problem spots in a watershed and the functional role of microbes in an ecosystem.
- Improving decision-making about water quality, public health and ecosystem health using a more comprehensive and accurate set of water quality indicators.
- Informing the political process by empowering decisions to be based on more accurate, sensitive and comprehensive evidence rather than speculation about what activities and animals are impacting water quality.

Scientists and policy makers identify the following as key criteria for adopting new tests derived from metagenomic analysis:

- Ability to forecast between harmful and benign organisms via indicator test results
- Test sensitivity (analytical and applied)
- Test reproducibility/repeatability (lab-to-lab and equipment-to-equipment)
- Affordability (at least as affordable as current water monitoring technology)
- Test specificity (analytical and diagnostic)

A clear opportunity for early adoption of the new test is supplementary testing (in which the new test is used in addition to, rather than replacing, current methods). This parallel uptake will strengthen the evidence basis related to the value of the test, and its potential for uptake for regulatory purposes.

RECOMMENDED ACTIONS

Based on our key findings (see below), we recommend the following actions:

- Develop interpretive tools (e.g., rating systems) to accompany new tests in order to contextualize test results and make the data more useable and shareable between end-users.
- Disseminate best available methods and facilitate the sharing of best practices amongst stakeholders using existing forums such as the Canadian Council of Ministers of the Environment, the Council of Chief Medical Health Officers and the Federal-Provincial-Territorial Committee on Drinking Water.
- Create multi-stakeholder engagement opportunities with publics, scientists, and policymakers throughout the *entire* innovation cycle from design to translation to diffusion.
- Develop criteria for prioritizing the adoption of metagenomics-based test candidates in water safety (based on input from scientists and policymakers). [see Section on Key Findings]
- When developing a new water quality test, explicit consideration should be given to institutional/organizational challenges and management science capacities to support effective implementation of a source-to-tap framework.
- In the absence of a harmonized regulatory scheme across Canada, consideration should be given to the use of accreditation bodies that are recognized in multiple provinces. These organizations have the ability to sanction the scientific validity and use of new testing methods, which may help to overcome unnecessary delays in the adoption and uptake of new tests linked to the fragmented regulatory approval processes across Canada's provinces and territories.
- When creating new policies and regulations, aim to align them with existing procedures of potentially impacted groups (e.g., farming associations may have processes – either formalized or informal norms– for dealing with polluters and there may be greater acceptance of new policies if they complement existing practices).
- Develop a comprehensive framework for microbial risk communication that includes strong planning and evaluation, and incorporates a detailed analysis of specific user needs.
- Given the interest and need regarding new methods for water quality testing, support should be given to enable and foster innovations in this area.

KEY FINDINGS

The above recommendations are based on the following key findings:

- Current approaches to microbial water quality testing were developed over 100 years ago. There is a recognized need for new scientific tools capable of accurately identifying microbial pollution sources, particularly to overcome current technical and legal challenges associated with generating reliable (environmental) water quality information, including that used for forensic evidence (i.e., for water quality monitoring, remedial measures, litigation, etc…).
- Scientists and policymakers agree that even though more work is needed, metagenomics has the potential to be a game changing technology for water safety and public health –providing new and crucial information on water safety, which can be more timely, accurate and comprehensive than information available from traditional techniques.
- The fragmented nature of the Canadian regulatory approval system and governance more broadly could impact uptake of the new technology. In Canada, as compared with the U.S., certain regulatory aspects such as the varied provincial approval processes and the lack of nationally enforceable water quality standards can slow the widespread uptake of novel water quality tests.
- This research indicates that the general public has limited knowledge and understanding of water quality issues, particularly regarding the impacts and risks of microbial water contamination. This suggests the need to more meaningfully engage the public about water quality issues.
- Among scientists and policymakers who are engaged with the potential for improved water quality tests, there is a belief that engagement should occur after the tests have been developed, rather than in the test-design phase. This finding suggests the need to also educate scientists and policymakers on the value of engaging with publics *early on* at the design and planning stage so the new generation tests can have broader societal relevance, in addition to efficient translation between laboratory and society.
- Members of the public stated a strong preference for water quality data to be shared with interpretative tools or frameworks. For example**,** an index (similar to an air quality index or UV index) that reflects water quality and/or risks to human health, particularly to aid in making choices about water use (e.g., suitability for recreational use, etc…).
- The current state of limited application, evaluation and engagement with microbial risk assessment and management in the water realm (in Canada) provides an opportunity to incorporate new water quality tests (and associated data) into the risk assessment “toolkit.” For successful adoption, test developers and provincial/federal policies should take into account financial, capacity and related challenges that could support microbial risk assessment along the source-to-tap framework.
- Overall, we found that potential of novel water quality testing for ecosystem health is an exciting element of this work. Developing a test for use at the source has the advantage of providing a tool for assessing water quality that is currently lacking,

yet likely crucial. At present, our work has shown that there are key limitations that prevent regular and comprehensive source water monitoring and assessment. An affordable and reliable test that is readily available and intuitive to use could help to overcome some of the existing barriers.

More information about the GE^{3}LS team results and implications of the findings are available in our reports and publications. Please refer to the references provided in section 6 to access these documents. Project website at: wwww.watersheddiscovery.ca

LIST OF PROJECT TEAMS

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