ONE HEALTH – ONE WATER

WORKSHOP REPORT ON
WASTEWATER & ENVIRONMENTAL SURVEILLANCE
AS A TOOL FOR PUBLIC HEALTH ACTION USING ONE HEALTH APPROACH

5th June 2026

Organised by

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EXECUTIVE SUMMARY

Over the past five years, wastewater and environmental surveillance in Bengaluru has emerged as a transformative public health innovation, demonstrating how cities can detect disease risks early and respond proactively. In this first phase, since 2021, the city has implemented one of Asia's first large-scale wastewater surveillance systems, routinely monitoring sewage across multiple sewer-sheds covering a substantial proportion of the urban population. This system enabled regular tracking of viral activity and identification of emerging variants through genomic analysis, providing near real-time insights into community-level disease dynamics.

Wastewater surveillance captures signals from both symptomatic and asymptomatic individuals, making it a cost-effective and unbiased method for monitoring population health, even when clinical testing rates decline. A key lesson from this experience is the value of wastewater surveillance as an early warning system. In Bengaluru, increases in viral RNA concentrations in wastewater were observed approximately 8–14 days before increases in clinically reported COVID-19 cases[1]. This lead time proved critical for activating preparedness measures such as hospital readiness, targeted testing, and public risk communication.

Bengaluru has a significant water footprint, with treated used water (treated wastewater) increasingly being reused for multiple purposes. The Minor Irrigation Department pumps treated used water to fill lakes in Kolar and Chikkaballapur districts to support groundwater recharge, while within Bengaluru, the BWSSB supplies treated used water to around 40 lakes, creating thriving biodiversity habitats.

Expanding surveillance for pathogens, antimicrobial resistance (AMR), antimicrobial resistance genes (ARGs), pharmaceutical residues, endocrine disruptors, and microplastics can strengthen public health protection and guide improvements in treatment systems. The most common methods for achieving this include nature-based solutions like constructed wetlands, and advanced technologies such as activated carbon filtration and other adsorption-based methods.

Bengaluru also has more than 3,500 decentralized wastewater treatment plants mandated for apartments and communities, enabling reuse of treated water for landscaping, toilet flushing, and other non-potable applications.

Building on the success of pandemic surveillance, the platform has evolved into a broader environmental health monitoring system capable of detecting multiple pathogens of public health importance, including respiratory viruses and emerging infectious threats. This shift reflects a growing recognition that wastewater is not merely a sanitation by-product but a valuable public health resource —a pooled biological sample that reflects the health status of entire communities and at the same time available for reuse.

Why Wastewater Surveillance Matters Now

Rapid urbanization, climate variability, and population growth are increasing the risk of infectious disease transmission in cities. Urban systems are becoming more complex, with significant variation in infrastructure, sanitation access, and environmental conditions across neighborhoods. Treated used water is also finding many applications, such as environmental regeneration, groundwater recharge, lake filling, and agricultural reuse among others. These realities require surveillance approaches that are timely, scalable, and capable of capturing population-level trends.

Wastewater surveillance addresses these needs by translating environmental signals into actionable public health intelligence. It enables early detection of outbreaks, continuous situational awareness, identification of localized transmission hotspots, and monitoring of intervention effectiveness. Most importantly, it supports evidence-based decision-making at the operational level — allowing authorities to act before health systems are overwhelmed.

From Surveillance to Ground-Level Action

The true strength of wastewater surveillance lies in its ability to inform timely interventions on the ground. In a rapidly growing metropolitan setting, environmental surveillance can directly support:

- Early outbreak alerts for public health departments and healthcare facilities
- Rapid deployment of targeted testing, vaccination, and risk communication campaigns
- Identification of high-risk neighbourhoods and vulnerable populations
- Monitoring disease trends, emerging contaminants, and the effectiveness of public health interventions
- Integration with surveillance for other health threats, including vector-borne diseases such as dengue
- Strengthening preparedness for future epidemics and public health emergencies

Recent operational experience has also highlighted the importance of establishing sentinel or "bellwether" monitoring sites—strategically selected locations that provide reliable signals of city-wide disease trends.[2] These sites form the backbone of sustainable, long-term surveillance systems.

Water Security and Collaborative Capacity Building

A central priority for the next phase is to strengthen multi-sector collaboration. Wastewater surveillance operates at the intersection of public health, urban governance, environmental management, and water security. Effective

implementation therefore requires coordinated engagement among municipal wastewater authorities, public health agencies, environmental regulators, academic institutions, and community stakeholders.
Expanding the surveillance framework to include ecological and environmental indicators—such as water flow dynamics, nutrient loading, infrastructure conditions, and land-use patterns—will enable a more comprehensive understanding of how environmental change influences health risks. This integrated approach supports not only disease surveillance, but also broader goals related to climate adaptation, water sustainability, and urban resilience.

Key areas of collaboration include:

- Linking environmental data with public health decision-making
- Strengthening laboratory and field capacity for routine monitoring
- Developing standardized protocols and data-sharing mechanisms
- Building workforce skills across sectors
- Promoting community engagement and awareness
- Supporting sustainable water governance and climate-resilient urban planning
- Developing improvement in used water quality using Nature Based and other solutions

Future Direction: Institutionalizing Wastewater Surveillance

Bengaluru's experience demonstrates that wastewater environmental surveillance has moved beyond the pilot stage—it is now operational, scalable, and policy-relevant.[3,4] The next strategic step is to institutionalize this system as a routine component of public health infrastructure.

This will involve integrating wastewater surveillance into existing disease surveillance networks, aligning it with epidemiological and environmental monitoring systems, and establishing clear pathways for translating surveillance data into public health action. Sustained investment in infrastructure, workforce development, and governance frameworks will be essential to ensure long-term impact.

Purpose of the Workshop

This workshop aims to bring together government leaders, public health professionals, urban planners, water and sanitation authorities, researchers, and development partners to:

- Review lessons learned from the past five years of wastewater surveillance implementation of wastewater surveillance
- Identify operational priorities for scaling and sustaining surveillance systems

- Strengthen cross-sector coordination and governance mechanisms
- Define pathways for integrating environmental surveillance into routine public health practice
- Develop a shared roadmap for building resilient, data-driven health systems
- Develop a better understanding of treatment and reuse for various purposes.

Cities are increasingly facing interconnected challenges—emerging infectious diseases, climate change, water stress, and rapid urban expansion. Wastewater surveillance offers a practical, scalable solution that addresses these challenges simultaneously by providing early signals of risk and enabling faster, smarter responses.
In essence, wastewater surveillance transforms urban infrastructure into a city-wide health sensor—helping communities detect threats earlier, respond more effectively, and build stronger, more resilient public health systems for the future.

Select publications

1. Lamba S, Sutharsan G, Daroch N, Paul K, Joshi SG, Darshan S, Annamalai N, Vishwanath S, Mishra R, Ramakrishnan U, Ishtiaq F (2023). SARS-CoV-2 infection dynamics and genomic surveillance reveals early variant transmission in urban wastewater. *Lancet Regional Health Southeast Asia*. https://doi.org/10.1016/j.lansea.2023.100151

2. Daniel R, Subash KK, N Daroch, S Ganesan, F Mozaffer, Vishwanath S, LS Shashidhara, R Mishra, F Ishtiaq (2025). Identifying bellwether sewershed sites for sustainable disease surveillance in Bengaluru-a longitudinal study. Lancet Regional Health SE Asia. Volume 39, August 2025, 100619. DOI: https://doi.org/10.1016/j.lansea.2025.100619

3. Nataraj N, Mondhe D, Srikantaiah V, Ishtiaq F. Metagenomic analysis reveals differential effects of sewage treatment on the microbiome and antibiotic resistome in Bengaluru, India. Water Reuse (2024) 14 (3): 418–433 https://doi.org/10.2166/wrd.2024.032

4. Daroch N, Subash KK, Vishwanath S, R Mishra, F Ishtiaq. Respiratory virus infection dynamics and genomic surveillance to detect seasonal influenza subtypes in wastewater: a longitudinal study in Bengaluru, India. PLoS Global Public Health 5(9): e0004640 DOI: https://doi.org/10.1371/journal.pgph.0004640

“One Health – One Water”

Workshop on “Wastewater & Environmental Surveillance as a tool for Public Health Action using One Health Approach” – 5th June 2026

Venue: Ectoderm, New inStem Building, NCBS Campus, Bangalore

Agenda

Time	Activities	Speakers / Lead
8.00 am	**Assembly at TIGS Campus,** Bengaluru Life Science Cluster, NCBS Campus.	
08.00 am - 10.00 am	Field Visit to Jakkur Lake & return to TIGS Campus	Mr. Vishwanath, Biome Environmental Trust
	Tea Break	
10.30 am to 10.40 am	Welcome Note	Mr. R. Anantharaman (CEO, BeST)
10.40 am to 10.50 am	Wastewater surveillance in Indian Context	Dr. Rakesh Mishra (Director, TIGS)
10.50 am to 11.30 am	Workshop Context Setting & Expectations from the workshop from Bengaluru Perspective	Dr. Farah Ishtiaq (Principal Scientist TIGS)
	Tea Break (15 Min) + Group Photograph	
12.00 pm to 1.00 pm	**Discussion session 1** Title: Aspects of wastewater rejuvenation and challenges, innovation showcases involved	Name of the Moderator – **Mr. Vishwanath S**, Panel – Dr. Shridhar Narayanan, Dr. LN Rao, Dr Chanakya H., *Dr. Taslimarif Saiyed (not available),* Dr Kate Medlicott
	Lunch Break (45 Min)	
1.45 pm to 2.45 pm	**Discussion session 2** Title: Insights on Wastewater and environmental surveillance	Name of the Moderator - **Dr. Farah Ishtiaq**, Panel – Dr Mary Dias, Dr Chitra P, Dr Varsha S, Dr Maheshwari, Dr. Giridhar Babu
2.45 to 3.15	**Karnataka State Level overview on Wastewater surveillance**	**Dr. Sweta Raghavan**
3. 15 pm to 4.00 pm	**Discussion session 3** Title: “Costing for wastewater surveillance in India”	Name of the Moderator – **Dr. Gayatri Saberwal,** Panel – Dr. Sarang Rao (ISB), Dr Shariff Mahamood, Dr. Satya Prakash Pandey (TIGS), Dr Sweta Raghavan
4.00 pm- 4.15 pm	**Closing remarks**	Dr. L. Shashidhara (Director NCBS / BeST)
4.15 pm to 4.30 pm	**Consolidation & creating an actionable blueprint for “One Health – One Water “- for Bengaluru**	**Dr. Farah Ishtiaq / Mr. Vishwanath S**
4.30 pm to 5.00 pm	**High Tea & Networking (30 Min)**	

Field visit to Jakkur wastewater treatment plant (WWTP) and lake

During the field visit to Jakkur WWTP and Lake led by Dr Chanakya and Mr Vishwanath, Biome Environmental Trust, 20 participants learned about Bengaluru's wastewater management system and the integration of treated wastewater with urban lake restoration.

Mr.Vishwanath highlighted that Bengaluru currently treats approximately 1,342 million litres/day (MLD) of wastewater through 34 sewage treatment plants (STPs). The city's treatment capacity is expected to expand to 2,400 MLD through 62 STPs by the end of the year. At Jakkur STP, an ultra-filtration unit with a capacity of 15 MLD/day and pore size of approximately 0.2 microns has been installed for advanced treatment. The wastewater treatment process begins with wastewater entering the Terminal Sewage Pumping Station (TSPS), where it first passes through a fine screen with a mesh size of 6 mm. It then moves through a grit classifier, equalization tank, anaerobic tank for nitrogen removal, and the IFAS (Integrated Fixed-film Activated Sludge) tank, where aeration and biological treatment occur. Secondary treatment follows, during which water quality is tested daily. Total Suspended Solids (TSS) measurements are routinely monitored as part of the treatment process.

The group observed the wastewater treatment process, from inflow through the Terminal Sewage Pumping Station (TSPS), screening, grit removal, equalization, anaerobic treatment, IFAS-based biological treatment, and secondary treatment. Routine monitoring of parameters such as Total Suspended Solids (TSS) and daily water quality testing was explained.

The visit also covered the management of different treatment outputs. Sludge generated at the plant is reused by farmers, with regular collection of approximately two truckloads. Treated water, around 71 MLD is further purified through ultra-filtration, while other treated streams are discharged into Jakkur Lake or routed through tertiary treatment systems. It was noted that apartments will increasingly be connected to STP lines, as sewage treatment facilities are becoming mandatory for residential developments. In situations where ultra-filtration is not applied, secondary-treated water is discharged into the lake, while tertiary treatment is carried out through the Tertiary Treatment Plant (TTP).

Dr Chanakya explained the design of the system within the lake to treat untreated sewage entering the lake.

The Jakkur STP–lake integration model was recognized as a pioneering initiative in the region and later served as an inspiration for projects such as Koramanagala Challaghatta Valley, in another part of Bengaluru. Since its development in 2006, Jakkur has become a key learning site for researchers, policymakers, and practitioners working on wastewater reuse, lake restoration, and sustainable urban water management.













Sessions in Ectoderm, New InStem Building, NCBS Campus (10:30am to 5pm)

Welcome note from Mr. Anantharaman, CEO, BeST

Mr Anantharaman welcomed and thanked all the organizations and individuals — government representatives, scientists, innovators, and ecosystem players for joining the workshop. Our goal from this workshop, through panel discussions and policy conversations, is to produce a meaningful action plan that can be followed up in the coming months and lead to real impact.

Wastewater and environmental surveillance in the Indian context by Dr. Rakesh Mishra, Director, TIGS

Dr. Rakesh Mishra welcomed attendees and highlighted the importance of wastewater surveillance in the Indian context. TIGS is deeply committed to wastewater and environmental surveillance—sampling water, air, and the environment as part of the national One Health Mission—to provide basic information for strategic actions.

Environmental change is accelerating due to anthropogenic activity. As we approach tipping points, pathogens and microbes are shifting their landscapes, and human encroachment into wildlife areas is creating unprecedented exposure to previously isolated pathogens. New threats emerge every few months, so surveillance is urgently needed for an early warning system.

Environmental surveillance and understanding pathogen ecology is one of TIGS's three core programs. Our strategy is collaboration—with government agencies, municipal corporations, NGOs, and the public—so that lab-generated knowledge reaches society. Meetings and workshops like this build networks, align strengths, and enable coordinated action.

Workshop context setting & expectations from Bengaluru Perspective by Dr Farah Ishtiaq, Principal Scientist, TIGS

A brief presentation on the evolution of wastewater surveillance in Bengaluru and how environmental surveillance can be used as a proactive, One Health approach in the face of changes in land use, land cover, and climate, with shifts in host-parasite interactions. There is a need for a robust surveillance system that can bridge different aspects of ecology and epidemiology, and also bring together different expertise from a One Health lens.

From John Snow's 19th-century identification of cholera hotspots in London to the eradication of polio, wastewater surveillance has consistently demonstrated its power in disease control. By integrating clinical data with wastewater analysis, we gain a comprehensive understanding of public health challenges. The COVID-19 pandemic further highlighted this synergy: Bengaluru, for instance, established a One Health Cell—a collaboration between BBMP and the BeST cluster—to transform into a One Health city. This initiative leverages city-wide wastewater collection data and combines genomics with SARS-CoV-2 viral load measurements to make evidence-based decisions. The SARS-CoV-2 pandemic, therefore, stands as a prime example of how interdisciplinary teams can utilize this scientific approach to inform public health strategies.

Using wastewater metrics, bellwether WWTPs were identified as a cost-effective model without compromising data quality. Now, we are moving towards multi-pathogen surveillance, which can be vaccine-preventable (e.g., human papillomavirus) or serve as an early warning system (e.g., respiratory viruses).

Bengaluru has the largest water footprint of any Indian city. It is also the second city, after Mexico City, to use treated wastewater for agriculture and for recharging groundwater in drought-prone regions outside the city. There is immense potential to address water scarcity using this treated water, but this requires a policy shift regarding water treatment methods, contaminant levels, and antimicrobial resistance (AMR).

There are several bottlenecks: how do we prioritize pathogens; how do we institutionalize wastewater surveillance and how much will it cost as a long-term strategy; and how do we go about mapping sewage sites for public health actions?


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Panel Discussion 1

Topic: Aspects of wastewater rejuvenation and challenges; innovation showcases involved.

Moderator: Mr. Vishwanath S., Biome Environmental Trust

Panelists:

- **Dr. LN Rao, Professor, IISc:** A chemical engineer and faculty member at the Centre for Sustainable Technologies, IISc Bangalore, with over 25 years of experience in the field. Dr. Rao developed decentralized wastewater treatment systems and improved treatment efficiencies. He has also worked on water quality issues, reuse challenges, and upgrading treatment plants for cities, including the Bangalore International Airport.
- **Dr. Shridhar Narayanan, FNDR:** Chairman, Foundation for Neglected Disease Research — a not-for-profit with BSL-2 and BSL-3 facilities in Doddaballapura. Core focus: new drugs and diagnostics for infectious diseases. AMR concerns and wastewater's role in spreading antimicrobial resistance pulled them into this space ~7 years ago. Designed a filtration device that removes antibiotics from wastewater — different from standard activated charcoal systems. The device achieves >90–95% removal efficiency and works from 100-litre scale up to millions of litres.
- **Dr. Chanakya Narayan, IISc:** 40+ years at the Center for Sustainable Technology. Specializes in anaerobic digestion — possibly the only specialist in the country. Serves as an advisor BBMP (now GBA), BWSSB.
- **Dr. Kate Medlicott, WHO:** developed a Sanitation safety plan, a risk-based tool to manage sanitation and public health interface (Online).

The One Health + One Water Convergence

The panel opened with a framing: One Health places environmental health alongside human, animal, and plant health. The parallel concept of **One Water** treats rainwater, surface water, groundwater, and treated used water as a single planning unit. In cities, water and wastewater are the dominant disease vectors — yet the institutions managing them (BWSSB, KSPCB) are not yet at the One Health table. The core question: how do we bring them in as equal partners with a shared language and accountability structure?

1. The Institutional Gap

The workshop converges two worlds: sanitation safety planning (preventing pathogen exposure) and wastewater environmental surveillance (tracking untreated wastewater for public health). Many diseases of interest (mpox, influenza) are not waterborne — wastewater surveillance opens use cases beyond traditional sanitation. Both sectors are fragmented. Wastewater surveillance can serve as a horizontal tool, cutting across silos.

A central challenge: **coordination between fragmented sectors**. Sanitation has many actors with coordination gaps; public health is siloed into vertical disease programmes. Wastewater environmental surveillance can serve as a **horizontal tool** cutting across these silos — but only if a clear public health use case is demonstrated first.

The WHO lesson from Sanitation Safety Planning (SSP): Once value is concrete and compelling, institutions coalesce around a shared objective. SSP works because it (a) clarifies roles and (b) engages regulators with an enforcement mechanism.

Wastewater Surveillance — What, Where, and How

Bangalore's wastewater impact extends ~120 km into the hinterland. What surveillance is needed? How do we frame it as an early warning system, not a contamination alarm?

Most water quality data come from one-off studies with no follow-up or ownership. The Pollution Control Board is already responsible for the chain — how do we strengthen it with a low-cost, credible, acceptable surveillance framework?

2. The Surveillance Gap: Wrong Parameters, Wrong Benchmarks: Current monitoring covers only **10 parameters** (pH, BOD, COD, Nitrogen, Ammonia, E. coli, Phosphates). Panellists pointed out that even drinking water standards (last updated in 2012) don't cover emerging contaminants — so monitoring wastewater for what we don't track in drinking water is logically inconsistent.

- **Historical blind spot:** India's 1980s shift from lakes to borewells was framed as progress but reflected an anthropocentric view — water for humans first, everything else second.
- **Imported standards don't fit India.** BOD_5 was designed for English rivers that reach the sea in five days — irrelevant to India's climate, hydrology, and waste pathways. Nitrate persists in cold temperate zones but breaks down rapidly in India's high temperatures. India needs ecologically grounded, locally relevant parameters.
- **Natural immunity is ignored.** Most *E. coli* strains are non-pathogenic, and populations develop some immunity through long-term exposure. Detection is not equal to real-world risk.
- **The methodology problem:** Studies using Atomic Absorption Spectroscopy (too coarse) report alarming numbers that make headlines. For trace-level work, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) is needed.
- **Alarm without rigor erodes credibility.** Scientists must validate pathogen, compound detection against chemistry, solubility, and health outcomes before raising alarms — like the shift from qualitative to quantitative MIC

made AMR data actionable. Move from alarm-based to awareness-based communication — like weather forecasts. Give people usable context, not scary numbers.
- **Communication gap**: Scientists do good work but don't communicate it well. Translate publications into Kannada/local languages. Open channels.

Bottom line: India needs ecologically grounded water quality standards, not borrowed temperate benchmarks. Detection should trigger calibrated risk assessment, not panic.

3. The Cost Barrier and the Proxy Question

Testing is expensive — ₹28,000 per sample for a single NABL-accredited drinking water test. Wouldn't it make more sense to deploy AMR-absorbing devices at the supply side rather than wastewater?

- FNDR's filtration device that removes antibiotics from wastewater with **>90–95% efficiency**, demonstrated at scale (100 litres to millions of litres) in hospital settings.
- **The adoption paradox:** Despite consistent data across hospitals, animal husbandry, poultry, and fisheries — and a cost of only a few thousand rupees extra per month — **no sector is adopting it**. The barrier is not technical or economic; it's regulatory. No mandate exists requiring such a device. Without policy, even proven solutions remain unused.
- Capacity problem: PCB recruits civil/environmental engineers with no biology or ecology training. Burdening them with AMR surveillance is a real problem.
- No regulation exists: BIS 10500 doesn't cover these parameters. NGT 2019 rules don't address them.
- Way forward — proxies: Since direct AMR/ARG monitoring is complex and expensive, can we find proxies (like E. coli for pathogens)? KSPCB could help develop and implement this.
- Humans don't excrete heavy metals in meaningful amounts — domestic sewage isn't a significant source. Any metals entering via runoff precipitate as sulfides and settle into sludge (published in Current Science).
- What needs measuring: antibiotic accumulation and AMR genes in groundwater over time, and long-term human health effects.
- Most antibiotics get oxidized or metabolized — activity of metabolites on organisms is poorly understood.
- Solve at source: remove antibiotics before they reach groundwater, across all sectors.
- Need thresholds: define what level of resistance is concerning vs. normal and communicate that clearly.

Panelists converged on a **tiered approach**:

Acute risk (sick in 2 days)	Simple presence/absence pathogen test	Residual chlorine as proxy
Chronic risk (groundwater, heavy metals)	Detailed testing (ICP-MS, etc.)	RO decisions, long-term monitoring
Environmental amenity (lakes)	Citizen-measurable parameters	Secchi depth, odour, algae presence

Panelists proposed piloting a **proxy-based approach** with KSPCB — using simple, measurable indicators — then scaling it to the Central Pollution Control Board as national policy. Bangalore, as a knowledge hub, is well-placed to lead this. Fix the chain — from lab to ground-level operation, the response protocol must be clear, fast, and actionable.

4. What GBA Needs from Researchers

GBA laid out a clear ask: **Can sewage surveillance data be used to build predictive models for disease outbreaks?** GBA already has disease surveillance data and is willing to share the data with the consortium. They are working on ward-level forecasting (temperature, humidity, rainfall, container indices) to anticipate outbreaks 4 weeks ahead. They want technical inputs to move from reactive to preventive public health.

The vision: A unified One Health platform bringing together stormwater, roads, forestry, horticulture, solid waste, and pollution control — translating research into actionable frontline impact.

5. Key Open Questions

What practical, measurable proxies can replace expensive testing?
Do antibiotic metabolites pose AMR risk even when parent compounds are absent?
How do we scale testing and response capacity to match peri-urban sprawl?
Can residual chlorine serve as a real-time AMR proxy for public alert systems?
What threshold of resistance is concerning vs. normal background?

6. Key Recommendations

1	Develop India-centric water quality standards grounded in local ecology, not temperate benchmarks	IISc + KSPCB
2	Pilot a proxy-based surveillance framework with KSPCB, then scale to CPCB as national policy	Scientists/IISc
3	Create a regulatory mandate for AMR removal devices in hospitals and industry — the technology exists	KSPCB + MoEFCC
4	Build a unified One Health platform integrating BWSSB, KSPCB, GBA, and health departments	GBA + BeST +One Health Consortium
5	Establish a citizen-level early warning system using residual chlorine sensors + dashboards	BWSSB + citizen groups
6	Fund long-term groundwater studies on antibiotic accumulation and health effects under Indian conditions	City government + research institutes

Panel Discussion 2
Topic: Insights on Wastewater and environmental surveillance

Moderator: Dr. Farah Ishtiaq (TIGS)
Panelists:

- **Dr. Varsha Shridhar, CEO, Molecular Solutions:** public health laboratory, interested in infectious diseases, environmental surveillance and primary care.
- **Dr. Chitra Pattabiraman, Gates Foundation**: lead the diagnostics work for infectious diseases at the Gates Foundation in the India country office and has been associated with environmental surveillance in Bengaluru as part of Infectious Disease Research Foundation (IDRF).
- **Dr. Mary Dias, Head of the Department of Microbiology at St. John's Medical College:** Dr Dias has been involved in environmental surveillance of COVID-19.
- **Dr. Maheswari Bhaskar, medical officer of health at South City Corporation, basically representing GBA**
- **Dr. Giridhara R. Babu, Qatar University,** worked with disease surveillance in polio and other surveillance programs.

Question 1. What do you think have been the most important lessons for wastewater surveillance so far in Bangalore? And what kind of challenges or problems encountered in the laboratory or in data interpretation for Bangalore?

1. The early days of wastewater surveillance

Wastewater surveillance works — but the science is still evolving. Wastewater surveillance worked for polio, but COVID revealed how much was unknown — sample volumes, cycle threshold (CT) value interpretation, and which pathogens are reliably detectable. It performs well for SARS-CoV-2, influenza, measles, and mpox, but not equally for all. IDRF took a hyperlocal approach (apartments, airports, hospitals) while TIGS worked through WWTPs. Panelists agreed: asking for policy-ready insights when the methods were still being figured out was a persistent tension.

2. Stakeholder Complexity > Technical Complexity

The hardest lesson wasn't the lab work — it was managing funders, academic institutes, NGOs, government, and corporate social responsibility (CSRs), each with competing priorities and branding expectations. One Health problems are multi-stakeholder by nature. Doctors and scientists alone cannot solve them. The real challenge is learning to communicate across groups to drive action without causing panic.

The core problem: technical teams don't know what's happening on the ground, and action teams don't understand the data. A permanent consortium or intermediary body is needed to bridge this gap.

Question 2. How do you think this environmental surveillance has changed our understanding of population level health?
The polio effort built what they call the world's best disease surveillance system — not just through the AFP (acute flaccid paralysis) network in humans, but also through a sewage surveillance "nervous system" that can now be tapped for other diseases.

Initially, environmental surveillance was not seen as essential for polio eradication. But persistent detection of the virus in Mumbai sewage samples proved its value. Today, it's an integral part of polio eradication globally — and India showed the world it could be done.

Sewage surveillance already "whispering" into existing systems like Integrated Health Information Platform (IHIP), but we are pretending not to hear it. The bottlenecks aren't about unwillingness. The real gap is that stakeholders have different priorities, and teamwork across them isn't effective yet.
The practical ask: not necessarily a full predictive model but using environmental surveillance as an **early trigger layer** — catching signals before complications and deaths occur. The potential of integration hasn't been fully tapped.

Question 3. We can't surveil everything, so how do we prioritize which diseases or pathogens to look for? Should it be common diseases, neglected tropical diseases, or something else?

A tiered approach for prioritizing which diseases to integrate into environmental surveillance — moving away from the current "all or none" pattern where resources flood during a pandemic and vanish after.

Tier 1 — High priority (eradication/elimination goals + active pandemics + AMR intersections):
- Diseases categoried under public health eradication/elimination targets
- Active pandemics (e.g., SARS-CoV-2)
- The often-missed intersection of AMR with existing infections — e.g., typhoid *Salmonella*

Tier 2 — Ongoing programs (long-term, lower outbreak potential):
- Gastroenteric infections (hepatitis A & E)
- Iinfluenza-like illness surveillance networks (strengthened by Bangalore's programs)
- Measles elimination efforts

Tier 3 — Pandemic preparedness & emerging threats:
- Country-level preparedness goals

- Detection of novel pathogens (e.g., Ebola)
- Platform to be used for metagenomic potential and AES (Acute Encephalitis Syndrome) or JEE (Japanese Encephalitis) pathogens

The broader point: integration should cut across all surveillance systems — not be siloed. Surveillance is collection of data for action. If there's no action tied to it, there's no point collecting the data. Prioritization must be grounded in what the system can actually act on.

Question 4. To make it actionable now, what measures should one think of? What kind of system do you need in place?

- Need for a consortium that sits between the technical/scientific surveillance data and the on-ground actionable decisions.
- During COVID-19, such intermediary sessions existed and worked. This need to be **continued as a permanent structure**. Without this bridge, scientific insights stay as documents sitting in inboxes — never translated into action.
- The core problem: the technical team doesn't know what's happening on the ground in real time, and the action team doesn't fully understand the technical data. A consortium is needed to connect the two and make the data actually useful.
- As clinician highlights a critical **translation gap** exists. Surveillance data is being generated (salmonella, polio, etc.), but it stays siloed within scientific and public health bodies. It never reaches the clinicians on the ground who need it.
- The issue of **data transparency and access** — a topic that usually comes up but wasn't discussed much today. The point: not all data needs to be public immediately, but there should be a **convenient, tiered access system** for legitimate researchers.

The broader point ties back to the consortium idea — **data management and access policies should be part of what the consortium discusses and decides**, not an afterthought.

Question 5. If we want to expand surveillance (started as a COVID-19 exercise, now extended to other pathogens) to more cities or across Karnataka, what would it take?

The backbone is the strength of the public health system — and right now, that's the weak link.

- **Polio network dismantled** — India had the best surveillance workforce for polio, but last year the entire network was taken down. Those were the people who connected labs, clinicians, and government to execute a specific program.
- **The real agents of change are the government public health workforce** — not WHO or National Polio Surveillance Project. They need to be strengthened

at every level. If they exist, they know what to do: outbreak control, infection prevention for AMR, risk communication.
- **Bangalore has no ASHA equivalent.** Rural areas have ASHAs. In Bangalore, COVID required specially arranged volunteers. Without people who can go into communities and initiate action, nothing gets implemented.
- **Feasibility is proven** — Influenza-like illnesses /Severa Acute Respiratory Illnesses surveillance and IHIP were done in Bangalore. The problem isn't whether it *can* be done. It's that we aren't taking targeted, specific actions.
- **Money is spent but impact isn't measured** — no quantification of diseases prevented or deaths averted. The accounting isn't there.

Bottom line: The challenges are known — integration, manpower coverage, and real-time data flow. Work is underway, but these need to be solved in concert, not in silos.

Question 6. What do you think would be useful technology for environmental surveillance- Is it genomics or PCR or other methods?

parallel tracks for wastewater surveillance:

1. Deployed surveillance tool — at point of need, not lab-based
- Must be **low-cost, continuous, usable by anyone** — think electrochemical sensors sitting in the water at BWSSB level.
- Start simple (e.g., chlorine monitoring), then build additional sensors.
- For a small set of priority diseases (say 3) already validated as useful in wastewater, this can be implemented at the utility level.

2. Lab-based toolkit — for R&D and emerging threats
- Expensive, genomic, targeted — figuring out methodologies (sample volume, extraction, assays).
- Needed to keep up with evolving pathogens (e.g., Ebola) and advance the technology.
- Not meant for deployment — that's where you innovate and validate.

Key cross-cutting need: Stakeholders must collaboratively define the **target product profile** — end user, setting of use, what the deployed tool needs to do.

Question 7. Do you think that monitoring AMR in wastewater helps with the clinical scenario?

The value of wastewater surveillance for AMR, isn't detection — it's **data standardization and sharing**. Tertiary care hospitals already generate rich clinical data that isn't standardized or shared. For Tier 2/3 populations without microbiology labs, wastewater could fill a critical blind spot. But without first solving the data standardization and feedback-loop problem, environmental AMR detection adds marginal value.

Environmental surveillance isn't competing with clinical data. It fills a specific niche — detecting pathogens where clinical surveillance is absent — but only after basic public health workforce and feedback loops are functional.

Key points:

Three criteria for environmental surveillance:

1. **Feasibility** — not every pathogen can be detected in the environment.
2. **Relevance** — does what you find actually help reduce disease burden?
3. **Gap analysis** — does it help control asymptomatic cases, symptomatic cases, or complications? When can you declare eradication?

- **Environmental surveillance is an *additional layer*, not a replacement** for clinical surveillance. WHO has already prioritized six diseases (Cholera, Influenza, Mpox, SARS_CoV-2, Typhoid and paratyphoid) where it's useful.
- **For AMR specifically:** If clinical data already exists but no action is taken and microbiologists don't get feedback, the first fix is **strengthening the public health workforce** — not adding a new surveillance layer.
- **Where environmental surveillance *does* add value:** Areas where surveillance is weak or absent — it helps answer "where are these pathogens?" when clinical detection isn't happening.

Bottom line: Environmental surveillance isn't competing with clinical data. It fills a specific niche — detecting pathogens in places with no clinical surveillance — but only after you've ensured the basic public health workforce and feedback loops are functional.

Question 8. What would be one action that we can take to take environmental surveillance forward?

i) Building on COVID-era infrastructure in a structured way.

Key points:

- **COVID-19 taught us what works** — the informal, ad-hoc surveillance that happened during the pandemic now needs to be done **systematically and organized**.
- **Government has already set up Metropolitan Surveillance Units** — a centralized point where a city's health data converges and reflects its health picture.
- **Proposed next step:** A **One Health cell** under the **Metropolitan Working Consortium** could be the right institutional platform to take this forward — integrating human, animal, and environmental health data in one place.

Bottom line: The infrastructure (metropolitan surveillance units) already exists. The opportunity is to formalize and integrate it under a One Health framework — turning COVID-era improvisation into a permanent system.

ii) Complementarity between data.

1. **Research** — generating evidence
2. **Tools** — developing practical methods
3. **Impact** — demonstrating real-world outcomes
4. **Cost-effectiveness** — proving it's worth the investment

Key point: Perceived impact feeds into cost-effectiveness — if people *see* the value, the economic case becomes easier to make. The conversations happening in this discussion are themselves a step toward filling each of those four buckets.

Bottom line: It's a call to action — keep talking, keep building the evidence chain from research through to cost-effectiveness, because each piece reinforces the next action.

Focusing on meaning before measurement. people from different disciplines actually talking to each other, not working in silos.

iii) The bottleneck is no longer data or intelligence — it's **governance and implementation**.

Key points:

- We already have enough information. The missing piece is the **institutional framework** to act on it.
- The core challenge: a unified method to **prioritize pathogens** and close the **signal-to-action loop** — from detection to response.
- **IHIP** (Integrated Health Intelligence Platform) is proposed as the single platform to make this happen.
- **Environmental surveillance** is just one component under that broader umbrella — not the whole picture.

Insights into Karnataka state level wastewater surveillance of AMR

Dr. Shweta Raghavan, Advisor, Lead on AMR, Govt of Karnataka

The bottleneck isn't data generation — it's **data silos, delayed sharing, and poor usability**.

Key points:

- Researchers create **data lakes**, not continuous real-time data flows. Each group keeps its pool ring-fenced. Nobody outside the immediate circle can access it.
- Government needs **consumable, palatable data** — something a decision-maker can glance at in minutes. Instead, they get complex diagnostics proposals unusable at PHC level (66% doctor vacancy, no microbiologists, no technicians).
- **Workforce crisis**: PHCs can't even identify heat stress symptoms, let alone handle AMR. The system is **reacting**, not responding.
- Government has done its part: amended the Drugs & Cosmetics Act (state-level, bold move without centre's go-ahead), capped diagnostic prices, mapped antibiotic availability gaps, launched wastewater surveillance with TIGS.
- **What's missing from researchers**: practice-oriented research (not just drugs/diagnostics), alternatives for farmers who understand AMR but need viable substitutes, and data presented in an actionable format.

Bottom line: Share data openly, make it real-time and simple, and research **alternatives and implementation** — not just diagnostics.

Panel Discussion 3

Topic: Costing of wastewater surveillance in India

Moderator: Dr. Gayatri Saberwal (TIGS)
Panelists:

- **Dr. Saran Deo, Indian School of Business:** lead on costing for wastewater surveillance
- **Dr. Sripad, Indian School of Business**: lead on costing for wastewater surveillance
- **Dr. Satyaprakash Pandey, TIGS: Diagnostic and Technology Transfer:**
- **Dr. Mahamood Shariff: Deputy Director- NVBDCP, Directorate of Health & F W Services, Karnataka**
- **Dr. Shweta Raghavan: AMR Lead, Govt of Karnataka**

10 min presentation by Professor Sarang Deo (Indian School of Business): **costing analysis for wastewater and environmental surveillance (WES)** using a bottom-up, activity-based approach — only answering "how much does it cost," not where the money comes from or whether it's worth it.

Key points:

- **Methodology:** Bottom-up costing — track every step (collection, processing, reporting), every resource (analyst time, equipment, materials), and calculate cost per sample and per 100,000 population.
- **Cost today (respiratory viruses, 3 cities):** Two models — dedicated lab vs. shared resources. Shared model is cheaper. Sample processing (not PCR detection) is the main cost driver.
- **Cost drivers / how to reduce:** Economies of scale — expanding from 10 to 50 sites can cut cost per sample nearly in half (₹4,500 → ₹2,500). Sharing lab resources across pathogens or with clinical surveillance also reduces cost.
- **Three takeaways:** (1) How to do costing, (2) what it costs today, (3) what drives future cost reduction — costs aren't static.

Question 1. From prior experience, which categories or targets can be added to a PCR panel with very little incremental cost? And are there any nuances or caveats for specific categories — aside from ones already decided?

The cost of the test itself would not be the limiting factor — the bigger challenge is total infrastructure. If infrastructure costs can be brought down, overall costs drop significantly.

- A 20-target multiplex PCR currently costs about ₹600 – working with indigenous manufacturers to cut sample processing costs further — aiming for at least half of what was shown earlier, driven by scale.
- Indigenization: Developing a single reagent that works for both RNA viruses and DNA bacteria — this simplifies supply chains and reduces cost.

Question 2. So how do we drastically reduce costs across the *entire complex chain* — manufacturing, logistics, facilities — for a surveillance system? And specifically, scaling from 10 sites to 50 sites — would that only cut costs by about half, or is there a path to much more?

- **Avoid site duplication** — scaling from 10 to 50 sites isn't the right approach. Instead, take a **phased, tiered approach**.
- **Increase pathogen coverage, not sites** — add more pathogens to existing panels (high-priority, outbreak-prone, pandemic preparedness). If needed, **mask data** for public sharing, but keep collecting it.
- **Reduce total number of sites** — TIGS research shows fewer, well-chosen sites have **far better impact**, especially given India's **diverse geographies** and uneven infrastructure.

Bellwether sites — fewer, strategically chosen	TIGS reduced 28 to 10 sites in Bengaluru. Site selection must be disease-specific: airports, tertiary hospitals, migratory labour hubs. Can detect outbreaks 10–15 days earlier than clinical cases.
Wider coverage — more sites, lower per-test cost	India's ecological, demographic, and infrastructural diversity demands broader sampling. The goal should be making testing cheap enough to cover widely, not shrinking the network.

Resolution: Both approaches are compatible — a phased, tiered strategy. Start with bellwether sites for early warning, then expand coverage as costs drop.

Question 4. Do we have the figures for the budget for WES currently for Bangalore? Or do any of the government representatives have a feel for the budget for wastewater surveillance in Bangalore?

No dedicated budget for AMR or One Health within the ministry	State Level AMR surveillance has recently been announced by Karnataka Govt.
Fragmented financing — Virus Research and Diagnostic Laboratories (VRDL), Department of Biotechnology (DBT), and state labs fall under different departments	Disconnect in budget heads
Recommendation	Move toward a **consolidated source of financing** at the state level, giving government control over the testing agenda
Existing infrastructure can be leveraged	RT-PCR machines bought for COVID sit idle in every district. Vector Control Research

	Centre (VCRC) already trained district microbiologists for vector-borne genome monitoring. The equipment and people exist — only the administrative will is missing.

Potential solution is **the CSR-as-Investment Model:**
The challenge: CSR prefers quick, low-rigor wins (feeding 1000 people, planting trees) over structured accountability. But industry's rigor is exactly what government lacks.
The opportunity: Companies at CCAMP see surveillance scaling faster than clinical portfolios, because clinical work is bogged down by regulations. Institutions like TIGS already have samples and can serve as regulatory and validation bodies.

5. The Real Bottleneck: Governance, Not Cost

Multiple panelists converged on a sobering conclusion:

- **Cost-effectiveness analysis exists** — Health Technology Assessment has structured protocols. But in practice, tendering is driven by relationships, not formulas.
- **The elevator pitch problem** — decision-makers want a 3-minute sell for problems that need 30 hours of debate.
- **Institutional resistance is deep** — water department don't know about pathogen screening, health won't touch animal health, and cross-sector collaboration hasn't happened in years.
- **The system is set up to say no.** Getting a single bureaucrat convinced takes months.

A concrete path: **leverage the VRDL network** in medical colleges. If wastewater surveillance proves useful for early detection, the state can propose and include it in the state budget as a routine surveillance activity.

6. Open Questions for Future Work

What is the minimum municipality size and infrastructure needed for viable wastewater surveillance beyond Tier 1 cities?
Can bellwether sites be identified at the state level for equivalent prediction coverage?
How much value does a formal cost-effectiveness analysis hold for emerging interventions like WES at the state level?
Can point-of-testing (at collection site, as done in Mumbai) reduce costs further?

Key Recommendations

1	Move toward a **consolidated state-level financing source** for wastewater surveillance	GoK / State Health Dept.
2	Adopt a **phased, tiered site selection** — bellwether sites first, expand as costs drop	BeST consoritum + GBA
3	**Leverage existing VRDL infrastructure** and idle RT-PCR capacity — equipment is already in place	GoK + ICMR
4	Pilot a **CSR-as-investment tripartite model** with accountability oversight	CCAMP + TIGS + CSR
5	Conduct a **minimum-viable-municipality study** to define the lowest feasible geographic scale for WES	TIGS + ISB + Govt.
6	Build a **costing model that combines protocol rigor with a clear financial picture** for pitching to ICMR/NCDC	ISB + TIGS +Govt partners

Bottom line: The per-sample cost of wastewater surveillance is known and reducible through scale and resource-sharing. The equipment and trained personnel already exist from COVID-era investments. What's missing is not evidence or technology — it's a consolidated financing mechanism, cross-departmental coordination, and the administrative will to move from pilot to routine surveillance.

Closing remarks

Dr. LS Shashidhara, Director, NCBS

Environmental surveillance (wastewater surveillance) has matured to a point where it meets the criteria of being affordable, accessible, and high quality. However, this is only true if rigorous scientific and epidemiological thinking is applied to every step, including sampling design, frequency, location, and inference across sites. Epidemiology here extends beyond just virus-in-human; it encompasses an ecological lens on the entire human-virus ecosystem. A key tension arises because the government needs to own and control the information (given its implications), but the actual execution needs to be decentralized enough to maintain quality and integrity on the ground. Affordability is measured at the government level, not individually, and based on quick estimates, it works. For a city like Bangalore (14M+ population), the per-person annual cost would be under ₹10—possibly under ₹5. Compared to the economic damage from even a short disruption (e.g., two days of lockdown or work-from-home), that cost is negligible. The point: **at scale, city-level economics make wastewater surveillance trivially cheap relative to the losses it prevents.**

Consolidation & creating an actionable blueprint for “One Health – One Water “- for Bengaluru

- Multi-topic discussion (research + water security) and propose a **formal next step** — forming a working group or consortium to take wastewater surveillance forward.
- **Need for actionable support** — GBA, BBMP, and the health department need practical, immediately doable assistance to make wastewater surveillance work.
- **Get BWSSB on board** — Every wastewater treatment plant already has a lab mandated to test 8 parameters daily. With Pollution Control Board + BWSSB buy-in, these labs can be upgraded for epidemiology testing at marginal additional cost.
- **Cost is manageable** — Jakkur plant's ₹60 Cr tertiary upgrade shows the scale of investment BWSSB already makes; the added testing cost is not a barrier. The real challenge is getting BWSSB to see value in the data.
- **Consortium model** — A consortium is needed to generate and demonstrate that value, making the case to BWSSB and other agencies.
- **Regulatory leverage** — The Pollution Control Board, as regulator, can influence lab design and testing protocols — bringing them on board is a key step.
- **Window of opportunity via GBA** — The newly constituted GBA is keen to coordinate lakes, groundwater, water, and wastewater under one ambit. This creates a natural institutional home to embed structured, regular surveillance.
- **Reuse potential** — Treated/used wastewater has significant reuse potential for environmental, agricultural, and urban/industrial applications. Monitoring treated wastewater helps assess the health of ecosystems, including lakes, wetlands, streams, rivers, aquifers, and their associated flora and fauna.
- **Emerging contaminants** — Wastewater surveillance helps identify emerging contaminants, which in turn helps direct suitable nature-based solution and other solutions for fit-for-purpose reuse.
- **One Health, One Water, One Community**— is the goal in the era of El Niño, climate change, pandemics, and water shortage to build resilient, healthy communities and ecosystems.

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List of acronyms

AFP- Acute Flaccid Paralysis
AMR -Antimicrobial Resistance
ARG – Antimicrobial resistance genes
ASHA- Accredited Social Health Activist
BBMP – Bruhat Bengaluru Mahanagara Palike
BeST – Bengaluru Science and Technology Cluster
BOD – Biological Oxygen Demand
BWSSB – Bengaluru Water Supply and Sewerage Board
COD -Chemical Oxygen Demand
CSR – Corporate Social Responsibility
DNA – Deoxyribonucleic acid
GBA – Greater Bengaluru Authority
ICMR – Indian Council for Medical Research
IFAS - Integrated Fixed-film Activated Sludge
IISc – Indian Institute of Science
ICP-MS – Inductively Coupled Plasma Mass Spectrometry
KSPCB – Karnataka State Pollution Control Board
MLD – Million Litres per Day
PCR- Polymerase Chain Reaction
PHC- Public Health Centre
R & D -Research and Development
RNA - Ribonucleic acid
RO – Reverse Osmosis
RT-PCR – Real-time Polymerase Chain Reaction
SARS-CoV-2 – Severe Acute Respiratory Syndrome Coronavirus 2
STP – Sewage Treatment Plant
SSP – Sanitation Safety Planning
TIGS – Tata Institute for Genetics and Society
TSPS – Terminal Sewage Pumping Station
TSS – Total Suspended Solids
TTP – Tertiary Treatment Plants
VRDL- Virus Research and Diagnostic Laboratories
VCRC- Vector Control and Research Centre
WES – Wastewater & Environmental Surveillance
WHO- World Health Organisation
WWTP – Wastewater Treatment Plants

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