

Northern Africa Regional Workshop on Wastewater Surveillance for Environmental and Public Health

The WHO Regional Office for the Eastern Mediterranean

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Executive Summary

In July 2024, UNEP launched the “Wastewater Surveillance for Africa (WWS)” Initiative, funded by the European Union Health Emergency Preparedness and Response Authority (HERA). The initiative aims to strengthen wastewater and environmental surveillance (WES) systems across the continent to enhance public health and ecosystem protection, environmental sustainability, and pandemic preparedness through evidence-based decision-making and cross-sectoral collaboration.

As part of this continental effort, the Northern Africa Regional Workshop was convened in Cairo, Egypt, bringing together stakeholders from Algeria, Djibouti, Egypt, Libya, Morocco, and Tunisia. Organized by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) and the United Nations Environment Programme (UNEP) in collaboration with the World Health Organization (WHO) and its Regional Office of the Eastern Mediterranean (WHO-EMRO) with generous support by the European Union Health Emergency Preparedness and Response Authority (HERA). The workshop aimed to strengthen regional capacity for WES through knowledge exchange, capacity building, and the development of a harmonized roadmap for implementation. The hybrid event included presentations, a site visit, and networking opportunities, with a focus on fostering collaboration between health and environmental sectors in Northern Africa. Participants shared information about ongoing initiatives, challenges, and opportunities related to WES across Northern Africa, emphasizing the need for harmonized approaches, capacity building, and cross-sectoral collaboration. Furthermore, the participants discussed the importance of WES in early detection, disease trend monitoring, and response to health threats, particularly in resource-limited settings.

The workshop concluded with agreement on next steps toward the development of a regional roadmap for WES in Africa, aligned with continental initiatives led by Africa CDC and global efforts under the Global Consortium for Wastewater and Environmental Surveillance for Public Health (GLOWACON). Participants reaffirmed their commitment to strengthening collaboration, sharing best practices, and integrating WES into national health and environmental monitoring systems.

Overall, the Northern Africa Regional Workshop enhanced regional awareness, technical capacity, and cooperation in wastewater surveillance. It established a foundation for harmonized approaches and sustained collaboration among North African countries to protect public health and ecosystems, contributing to pandemic preparedness, environmental sustainability, and the achievement of the One Health vision across the African continent.

The Northern Africa Regional Workshop on Wastewater Surveillance for Environmental and Public Health contributes to UNEP’s *‘Preventing and Addressing the Degradation of Freshwater and Marine Ecosystems from Source to Sea’* project, which promotes a Source-to-Sea approach to address wastewater, nutrient pollution, and habitat degradation. The workshop advances multiple project targets to protect freshwater and marine ecosystems from land and sea-based harmful activities, including: (Summary of results).

- Increasing the number of best practices, experiences, and/or examples shared by stakeholders, including via digital platforms/hubs, to prevent ecosystem degradation and pollution, with UNEP's support (Outcome 3.2),
- supporting more countries to strengthen cross-sector coordination and integrated approaches (Output A3),
- Supporting countries via technical assistance/advisory services to protect freshwater and marine ecosystems from (Output B1)
- expanding capacity development initiatives and training government officials, who report with increased knowledge gains on wastewater and environmental surveillance, (Outputs B2 and B3),
- Increase in the number of representatives from governments, trained in the use of tools and methodologies, (C.2)
- and engaging stakeholders through webinars/trainings to change behaviour to increase awareness, access information, including but not limited to digital platforms/hubs, and acquire new knowledge and drive action (Outputs D2, D3 and D4).

Introduction

The United Nations Environment Programme (UNEP) is the leading global authority on the environment. UNEP helps countries transition to low-carbon and resource-efficient economies, strengthening environmental governance and law, safeguarding ecosystems, and providing evidence-based data to inform policy decisions. On water and the ocean, UNEP works closely with governments and relevant stakeholders to protect freshwater and marine ecosystems, addressing land-based sources of pollution, including wastewater, from source to sea.

Correspondingly, the United Nations University Institute for Water, Environment and Health (UNU-INWEH) is known as the UN's Think Tank on Water and is dedicated to advancing global sustainable development through evidence-based policy on water issues. UNU-INWEH's core mandate is to bridge the gap between scientific research and practical policy solutions. The institute leads this effort by harnessing innovative tools to advance efficient water use and clean energy access, while also improving wastewater management to monitor public health and inform community decisions for a healthier, more equitable environment.

The potential of wastewater and environmental surveillance (WES) became prominent in relation to poliovirus and was greatly accelerated during the COVID-19 pandemic. WES activities were implemented in many global settings and provided an important line of data to support early detection of viruses causing COVID-19 waves. In addition, WES has potential to provide useful data to tackle land-based sources of pollution, maintain ecosystems services and protect freshwater and marine ecosystems. WES programmes are being established and expanded to a broader array of pathogens and other targets in many global settings including as part of early warning surveillance and pandemic preparedness. The African region has seen growing interest, with research, innovation and implementation of WES programs. However, action and information exchange across the whole of the African continent remains limited.

To establish and strengthen WES programmes in Africa, there is a need to build literacy among practitioners and stakeholders on the application and benefits of wastewater surveillance for public health and the ecosystem. Exchanging knowledge and best practices from within the African continent and beyond is an integral part of this effort.

UNEP, in collaboration with UNU-INWEH is implementing an initiative called “*Support strategies, capacity and data for global wastewater and environmental surveillance*,” in short “*Wastewater surveillance for Africa (WWS)*,” aimed at supporting governments and relevant stakeholders to establish and scale up wastewater surveillance systems for environment and public health purposes in Africa.

Specifically, the initiative aims at:

- Developing wastewater and environmental surveillance strategies to contribute to pandemic preparedness and response in Africa.
- Developing capacity building strategies especially for low resource settings and in strategic locations.
- Contributing to global transparency in data exchange and enhance collaboration.

The initiative started in July 2024 and has four main outputs:

- 1) Harmonize monitoring approaches for wastewater surveillance between regions of Africa for ecosystem and public health.
- 2) Foster enabling environments in all five African sub-regions to enhance coordination, good governance and scaling up of wastewater surveillance.
- 3) Promote and facilitate knowledge exchange and outreach on wastewater surveillance.
- 4) Enhance capacity building for wastewater monitoring on aircrafts and vessels involving at least 3 airports and 1 port in Africa.

The initiative is aligned with the goals of the Global Consortium for Wastewater and Environmental Surveillance for Public Health (GLOWACON), the Libreville Declaration on Health and Environment in Africa, the UNEP-WHO Health and Environment Strategic Alliance (HESA) and aims to contribute to other existing initiatives or similar activities led by other key stakeholders. The target beneficiaries of the initiative are governments, including ministries of environment, water and health, private sector actors, academia, research institutes, national and international NGOs, development partners, and experts involved in wastewater surveillance in Africa. Some of the key partners include the World Health Organization (WHO), the Africa Centres for Disease Control and Prevention (Africa CDC), the Global Wastewater Initiative (GWWI), and other relevant national and regional stakeholders. The initiative is generously supported by the European Union Health Emergency Preparedness and Response Authority (HERA).

North Africa faces unique challenges in wastewater management and surveillance capacity, with varying levels of infrastructure development across countries. Some countries are more advanced than others. There might be limited laboratory infrastructures and capacity, as well as resource constraints in implementing wastewater surveillance systems. Finally, data might not be easily shareable and available. At the same time, the region is home to great innovation, projects and examples of sustainable wastewater management and wastewater surveillance.

The Northern? Africa regional workshop hosted in Egypt brought together the main stakeholders from Algeria, Djibouti, Egypt, Libya, Morocco, and Tunisia across Northern Africa in a workshop where exchange of information, learning and discussion strengthened capacity of member states and empowered participants with tools and knowledge on how to establish and strengthen wastewater surveillance systems.

Objectives

The overall objective of the workshop was:

1. To strengthen regional capacity for implementing and managing wastewater surveillance systems in North African countries through knowledge sharing.
2. To support governments and relevant stakeholders to plan to establish, strengthen and/or scale up wastewater surveillance systems for environment and public health purposes.

The specific objectives included:

1. The identification of the most relevant needs for strengthening capacities on WWS in the target countries.
2. Discussion of a roadmap for wastewater surveillance for Africa.
3. Discussion a harmonized approach to wastewater surveillance for environmental and public health purposes for Africa.
4. Transfer knowledge across countries from North Africa.
5. Fostering exchange of information across the region and strengthen regional networks for ongoing collaboration.

Methodology

The workshop adopted a participatory, hands-on approach together with a mix of presentations and discussions. The workshop was conducted in hybrid format with in-person participation from country representatives and online presentations from experts. It provided an opportunity to discuss the current capacity, challenges and opportunities of wastewater surveillance for environmental and public health across Northern Africa and , in Africa, in general. The workshop consisted of several sessions of interaction with the participants about capacity needed for WES, a roadmap for WES in the region, a harmonized approach for WES, and pathogen prioritization. The sessions was a mix of presentations by national representatives, international experts, scholars, practitioners, and actors, followed by Q&A and discussions. Some session took place in plenary, some through group work, and breakout sessions were also used as needed. During the workshop, a specific training session was organized with the idea of providing participants with targeted knowledge on WES. A certificate was granted upon successful attendance and inputs during the training session. Surveys used throughout the workshop and after the event are be used to assess the capacity and increased knowledge of stakeholders, as well as to collect their overall feedback regarding the workshop.

Expected outputs and follow-up

The expected outputs of this workshop were:

- Increased knowledge, awareness and capacity among relevant stakeholders, especially government representatives from Northern Africa on wastewater surveillance for environmental and public health is enhanced.
- Strengthened regional capacity on wastewater surveillance, including exchange of data, information and best practices among North African countries.
- A harmonized approach, as well as a roadmap document and elements of a capacity needs assessment on wastewater surveillance are discussed and feedback from the participants is collected.
- A workshop report documenting the proceedings of the event.

Organizers

The workshop was organized by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) and the United Nations Environment Programme (UNEP) in collaboration with the World Health Organization (WHO) and its Regional Office of the Eastern Mediterranean (WHO-EMRO). The workshop was generously supported by the European Union Health Emergency Preparedness and Response Authority (HERA).

North Africa Regional Workshop Deliberation and Highlights

Session 1: Opening session and welcoming remarks

The opening session of the Cairo workshop brought together representatives from multiple organizations, including the United Nations University Institute for Water, Environment, and Health (UNU-INWEH), WHO, UNEP, the Egyptian Ministry of Health and Population, and the European Delegation to Egypt. Opening remarks emphasized the essential role of wastewater surveillance at the intersection of environmental and public health and recognized the rapid collaborative efforts to organize the event. The session highlighted the significance of wastewater surveillance for early disease detection, antimicrobial resistance monitoring, and environmental protection, especially in the African context. Speakers called attention to challenges in regional infrastructure, cooperation, and data sharing, framing the workshop as an opportunity to learn and align national efforts on capacity building, policy development, and research. International partners, including WHO, UNEP, HERA, and the Global Consortium for Wastewater and Environmental Surveillance (GLOWACON), were acknowledged for their support of African wastewater surveillance initiatives. The workshop was positioned as a platform for multisectoral collaboration under the One Health approach to address growing infectious disease threats exacerbated by urbanization and environmental changes. The session concluded with participants expressing optimism for meaningful discussions and knowledge exchange in the following days.

Session 2: Wastewater surveillance for environmental and public health

This session provided foundational insights into the role and significance of wastewater and environmental surveillance (WES). The session opened with a presentation by Popi Karaolia and Taru Miller, wastewater surveillance experts (UNEP), emphasizing WES as a cost-effective, non-invasive approach to monitor pollutants, pathogens, and chemicals in wastewater and impacted environmental waters. They highlighted the relevance of wastewater surveillance as it serves both public health and ecosystem protection, offering early warnings of disease outbreaks and environmental risks. Challenges such as microbial indicator adequacy, infrastructure costs, and environmental impacts were noted. The session stressed the growing importance of WES due to urbanization and population growth, highlighting the urgent need for collaboration, investment, and policy integration. The public health perspective was then outlined, showing WES as a complementary tool to traditional clinical surveillance, capturing community-level infection data, including asymptomatic cases. Key steps in WES implementation, from design and sampling to data interpretation, were outlined alongside challenges in capacity and coordination. Importantly, WES was recognized for its potential in anonymous surveillance, overcoming cultural barriers and enabling cross-border health monitoring.

The session also featured the UNEP-led Wastewater Surveillance (WWS) for Africa Initiative, aimed at harmonizing monitoring strategies, building capacity, and enhancing data exchange across African countries. Riccardo Zennaro (UNEP) and Josphine Nduguti (UNEP) outlined the outputs of the initiative and highlighted that it engages diverse stakeholders – from ministries to private sectors – and aligns with global frameworks like the One Health Quadripartite Alliance Joint Plan of Action which includes UNEP, WHO, the Food and Agriculture Organization (FAO) and the World Organization for Animal Health (WOAH). The initiative also aligns with UNEA Resolution 5/6 for Biodiversity and Health which calls to address the specific health challenges faced by developing countries in implementing the One Health approach, including by “strengthening capacity for health surveillance and promoting responses in line with national circumstances and priorities”. Progress on the WWS Initiative has included regional workshops, webinars, and pilots targeting surveillance expansion in airports and ports.

Salmaan Sharif (WHO EMRO) presented an overview of WHO initiatives for poliovirus detection and highlighted that polio surveillance is particularly important because the same sampling and testing framework used for poliovirus can be applied to detect a broader range of pathogens; a practice already implemented in several countries. Specific challenges to wastewater surveillance were also highlighted such as non-availability of sewer networks, geo-representativeness and quality of sites, biosafety and security issues in shipments, and laboratory capacity. The presentation explored early polio detection practices currently taking place across the Eastern Mediterranean Region, with Sharif stating that the Acute Flaccid Paralysis (AFP) surveillance system is the gold standard for monitoring poliovirus which is used by WHO EMRO, and it significantly enhances the sensitivity of the overall surveillance network, often identifying the virus in the absence of any reported paralysis cases.

The session also featured case studies for WES in North Africa, specifically Tunisia, presented by Fatma Guerfali (Institut Pasteur Tunis) and Olfa Mahjoub (INRGREF). It was highlighted that Tunisia has high basic sanitation in the region as the Ministry of Health has prioritised diagnostics

and public health, research and training and bioproduction. Despite this, gaps such as lack of access to clinical data, the absence of WES in national strategies, and a lack of access to decision and policymakers limits national WES practices. It was emphasised that the role of research is critical for surveillance and monitoring, as this contributes to setting regulations on water reuse, raising awareness to stakeholders, and leads to funding for data production and innovations.

The session concluded by positioning WES as a critical, collaborative approach to safeguarding environment and public health in Africa.

Session 3: Capacity needs assessment for wastewater surveillance in Africa

Session 3 focused on national capacity needs assessments for wastewater and environmental surveillance. The session took the form of an “Elevator Pitch” where country representatives briefly presented on their specific contexts, progress, capacity and challenges in relation to wastewater surveillance. Egypt detailed its multi-ministerial approach involving the Ministries of Health, Environment, Water Resources, Housing, and Higher Education. Egypt also highlighted successes in national compliance monitoring, data mapping, and partnerships, but noted gaps such as insufficient lab infrastructure, funding, and modern technology. Tunisia presented its strategies for sustainable water management, including ecological transition, water reuse, and the One Health approach, earning international recognition. Tunisia’s challenges include fragmented coordination, limited funding, rural network gaps, and data reliability; however, opportunities exist through ongoing institutional reforms, policy frameworks, and awareness campaigns. Algeria emphasized national investment in water resource infrastructure and multi-agency collaboration in environmental monitoring. Surveillance activities in Algeria include significant lab networks for water quality, epidemiological data collection, and environmental virology, with Pasteur Institute serving as a key hub. Challenges remain around coordination, reliable data collection, and technical skills. The session concluded with the facilitator, Bernard Mware (ILRI - Kenya), stressing the importance of country surveys to identify gaps and opportunities for policy and capacity building.

The session concluded with instructions being given for logistical arrangements, such as session timing and site visits, before ending with practical reminders for participants.

Field Visit

As part of the programme, the participants visited the historic Nilometer on Rhoda Island in Cairo; one of the world’s oldest water monitoring structures. The visit provided a symbolic connection between Egypt’s ancient water observation heritage and modern wastewater surveillance efforts, underscoring the enduring importance of water monitoring in sustaining human and environmental health.

-End of Day One-

Session 4: Protecting Public Health and Ecosystems: Interactive exercise on wastewater and environmental surveillance for public health

The session was conducted in two parts and began with “Elevator Pitch” presentations from Morocco, Libya, and Djibouti, highlighting national wastewater surveillance contexts and strategies. Morocco discussed infrastructure development, pollutant monitoring programs, and the need to strengthen technical capacity and expand monitoring beyond current parameters. Djibouti outlined its wastewater management aligned with climate resilience strategies, describing its polio surveillance system with sample analysis conducted in Kenya due to limited local lab capacity. Libya emphasized critical water scarcity challenges and pollution control efforts, including coastal monitoring and plans to establish wash units in health institutions.

Following these presentations, the session shifted to an interactive pathogen prioritization exercise involving country groups including Tunisia, Morocco, Algeria, Djibouti, Libya, and Egypt. Participants assessed their infectious disease contexts, surveillance gaps, and where wastewater and environmental surveillance (WES) could add value. Pathogens were prioritized based on criteria like detection frequency, contagiousness, hospitalization rates, and local epidemiological nuances such as migrant flows. Tunisia prioritized respiratory diseases including influenza and SARS-CoV, arboviruses like West Nile virus, hepatitis A, salmonella, polio, cholera, zoonoses, and emerging rabies. Morocco emphasized measles, hepatitis A, polio, salmonella, cholera, and zoonoses. Libya focused on cholera, measles, and polio, while Egypt prioritized antimicrobial resistance (AMR), valuing the exercise for fostering coordination under a One Health approach grounded in evidence-based decision making. Djibouti highlighted malaria, tuberculosis, and polio, noting the need for external laboratory support. The exercise underscored WES as complementary to clinical surveillance, aiming for early warning, epidemiological trend monitoring, and genomic data integration. Challenges such as laboratory capacity, funding, technical expertise, and multisectoral collaboration were noted. The session concluded emphasizing the technical feasibility, cost considerations, and WHO’s continued support in developing sustainable, context-sensitive surveillance programs.

Session 5: Interactive session on wastewater and environmental surveillance for ecosystem protection

Note that due to time constraints, session 5 did not take place.

Session 6: Opportunities for synergies on wastewater surveillance for environmental and public health in Africa

The session began with a presentation by Popi Karaolia (UNEP) on a draft harmonized approach document developed by UNEP, entitled: "Harmonization of Wastewater and Environmental Surveillance in Africa, Universal Guidance and Opportunities for Synergies". It was noted that the document is subject to future revisions and modifications based on feedback. This harmonization document aims to provide standardized guidance, leverage African countries' collective experience, highlight cross-sectoral synergies, and ultimately enhance the comparability, reliability, and usefulness of wastewater and environmental surveillance data

across Africa. It was emphasized that this harmonized approach, built through inclusive regional workshops and consultations, strengthens Africa's global policy position by combining adaptable guidance with existing systems like polio surveillance, while ensuring equitable participation and supporting countries of all capacities. The methodology follows a Theory of Change approach, which outlines a logical sequence from inputs to long-term impacts. The document includes six key elements, starting with an analysis of the status and challenges of WES in Africa as a baseline, defining the desired long-term goals, and proposing specific activities and interventions. The document proposes a two-tiered program, with a core portfolio of essential targets (such as polio, COVID-19, and influenza) and a flexible, Tier 2 for context-specific targets that countries can adapt to their own needs.

In line with exploring opportunities for synergies in Africa, Vivi Maketa (ODIN Project) presented on harmonization efforts across sub-Saharan Africa with experience from the ODIN project, which is a consortium for WES with several members, and it is implemented in 3 different countries: Democratic Republic of the Congo, Tanzania, and Burkina Faso. The project workflow begins with environmental surveillance of pathogens, then metagenomic training for detection, strengthening of the genomic and epidemiological capacity across Africa – with a focus on bacteria.

The Session also featured a presentation by Sogol Jafarzadeh (UNU-INWEH) and Tariro Mbiba (UNU-INWEH) highlighting future plans under the WWS for Africa project, specifically the development of two policy briefs for the continent as well as an e-learning tool for WES in Africa, and how these link to UNU-INWEH's core pillars of policy, capacity building and research. Other similar UNU-INWEH initiatives utilizing decision-support tools, such as the Sustainable Development Goal 6 Policy Support System (SDG-PSS), were also presented as possible approaches to support national policymaking in the WES sector.

To explore potential synergies among WES stakeholders and between WES for ecosystem protection and public health, a SWOT analysis was conducted to aid strategic planning. During the workshop, participants identified Strengths, Weaknesses, Opportunities, and Threats related to leveraging WES synergies for both public health and ecosystem protection, based on their areas of expertise. Each participant shared their insights, which were then presented and discussed with the wider group. The organizing team compiled and documented the key themes that emerged from these discussions, forming the basis for the core elements to be addressed in the Initiative's deliverables and roadmap.

The main themes of SWOT identified were:

1. Cross-sector collaboration and the One Health approach

The recognition of shared goals between public health and ecosystem protection highlights the value of the One Health framework. Strengthening cross-sector cooperation can enhance information sharing and coordination, though siloed systems and institutional barriers remain significant challenges.

2. Existing surveillance and laboratory Infrastructure

Established WES systems (e.g., poliovirus environmental surveillance, GPEI) and laboratory capacities provide a strong foundation for integrated monitoring. However, uneven analytical capacities and limited lab coverage restrict scalability and data harmonization.

3. Shared environmental and health targets

Common contaminants and indicators, such as heavy metals or pathogens, create a scientific and operational overlap between health and ecosystem protection. This shared evidence base can drive joint action plans and cost-efficient surveillance.

4. Institutional and regulatory fragmentation

A lack of harmonized frameworks and joint guidelines leads to fragmented approaches between sectors. This misalignment constrains data comparability and weakens the policy impact of WES-derived evidence.

5. Capacity gaps and resource limitations

Deficiencies in funding, skilled personnel, and analytical tools limit the full implementation of integrated WES initiatives. Competition for scarce resources can further reinforce silos rather than collaboration.

6. Training and workforce development

Targeted training and joint educational programs offer opportunities to build shared expertise. Cross-disciplinary skill development is key to bridging gaps between environmental science, epidemiology, and policymaking.

7. Partnerships and international cooperation

Global and regional partnerships (e.g., UNEP, GLOWACON, WHO) can accelerate integration by offering platforms for coordination, funding, and technical guidance. Leveraging these collaborations supports policy alignment and innovation.

8. Emerging and evolving risks

New pathogens, demographic shifts, and climate change introduce dynamic risks that demand adaptive surveillance strategies. Integrated WES can help anticipate and respond to these threats, highlighting its growing relevance.

Following the SWOT session, there was a presentation by Amar Abdu-Amad (Islamic Development Bank) which highlighted its work in implementing major infrastructure projects in sanitation, including sewage management, waste management, and stormwater drainage. In the health sector, it provides comprehensive support ranging from primary to tertiary care, drug supply, and vaccine production, with assistance levels adapted to each member country's economic situation, including emergency health relief services where needed.

The session ended with participants reflecting on the results of the SWOT session and WES synergies, differences, similarities and challenges across the region.

-End of Day Two-

Session 7: Wastewater surveillance at airports, aircrafts and ports

Session 7 addressed wastewater surveillance at airports and ports, emphasizing its importance for early pathogen detection and pandemic preparedness. Bernd Gawlik from the European Commission's Global Consortium on Wastewater and Environmental Surveillance for Public

Health (GLOWACON) presented the aviation program, which pilots synchronized sampling across multiple international airports. This program targets aircraft and terminal wastewater to detect pathogens like SARS-CoV-2, influenza A, mpox, and dengue, demonstrating successful early warnings that support public health actions and business continuity. The session highlighted collaboration between airlines, airport operators, biosecurity, and border management agencies to ensure data privacy and effective communication. Economic benefits were noted, with surveillance programs preventing costly flight disruptions, illustrated by a Barbados program funded partly through visitor fees. African experiences were shared by Fiona Els (NICD – South Africa), Bernard Mware (ILRI) and Jean-Pierre Musabyimana (RBC), including South Africa's Johannesburg Airport with regular sampling and multi-pathogen testing, Kenya's Nairobi Airport focusing on capacity and stakeholder engagement, and Rwanda's plans to expand surveillance with metagenomic techniques to track pathogen variants and antimicrobial resistance across transport and community sites respectively. Advanced metagenomic analyses were discussed, enabling the transformation of complex genomic data into actionable information, crucial for managing infectious diseases and antimicrobial resistance. WHO reaffirmed support to help countries build sustainable, integrated surveillance systems at transport hubs, with resources and training tailored to local contexts.

The session also featured a presentation on best practices and global approaches on WES, as well as the experience of Türkiye presented by Bilge Kocacemi (Turkish Water Institute). It was highlighted that Türkiye has used unique forms of wastewater surveillance by participating in the Europe-wide SCORE project, which uses wastewater surveillance to monitor illicit drug use as well as applying WES in two distinct scenarios: to monitor for potential disease outbreaks in a disaster zone following an earthquake and to conduct surveillance for COVID-19 within a large, binational military base.

Session 8: Roadmap for wastewater surveillance in Africa

In this session a presentation by Emily Atuheire (Africa CDC) on the ongoing development of a continental strategy to scale up wastewater and environmental surveillance across Africa was featured. It reviewed Africa's surveillance history, emphasizing the limitations of clinical surveillance alone and the urgent need to enhance population-level systems for early outbreak detection and response. The presentation highlighted collaborative efforts through consultative meetings and lessons learned from regional workshops in Johannesburg, Nairobi, and Cairo, focusing on harmonizing methods, data sharing, and multisectoral coordination. Key recommendations include standardizing protocols from sampling to data use, integrating wastewater surveillance with existing health data, mobilizing resources, strengthening capacity for data analysis and lab support, creating communities of practice, and establishing a coordination consortium with regional hubs across Africa.

The thematic areas of the roadmap for wastewater surveillance in Africa, developed by UNEP, were then distributed to the participants for their inputs and reviews and they needed to select three, thematic areas that should be prioritised within the region. It was emphasised that their responses will be included in the roadmap.

The session concluded with an overview of the WHO's Sanitation Safety Planning (SSP) tool, a risk-based management approach for ensuring safe sanitation systems from containment to

disposal. Rola Al-Emam (WHO EMRO) explained how SSP guides countries in identifying prioritizing health risks along the sanitation chain, implementing improvement plans, and monitoring effectiveness in collaboration with multiple stakeholders. A recent WHO-FAO webinar series aims to build capacity for SSP in the region, highlighting its integration potential with wastewater surveillance under a One Health framework.

Session 9: Next steps for country specific planning

This session was divided into two sections, in the first section, Ahmed Sharabia of the Port Training Institute presented on the environmental impacts of ship wastewater and ballast water in Egyptian ports. Ship wastewater includes sewage (black and gray water) and ballast water carrying invasive species that harm marine ecosystems. Egypt adheres to international conventions such as the Ballast Water Convention and MARPOL, with infrastructure for treatment and monitoring. The presentation highlighted pollution in Alexandria, including illegal sewage discharges causing red tides that kill fish, and invasive species transported by ballast water disrupting biodiversity and coastal economies. The Mediterranean and Red Seas are identified as sensitive areas. These marine threats affect public health, fisheries, tourism, and the economy. The Port Training Institute leads in maritime environmental protection through research, training, and collaboration, while the Maritime Research Consultation Center advises on environmental solutions aligned with Egypt's 2030 vision. The session concluded with discussions on data sharing challenges, emerging pollution like microplastics, and the need for enhanced coordination. The workshop then moved to a final breakout session on country-specific next steps for wastewater and environmental surveillance planning.

The participants then had the opportunity to discuss country-specific steps for WES, in an effort to lay the ground for the development of the roadmap document. They were able to put in writing their own immediate, medium- and long-term proposed next steps and specific WES-related action items, once they leave the workshop and return to their own countries. Each participant country was asked to note the specific actions that they should engage in within their country's context and at a regional level, in order to enhance WES and progress the activities to the next level. Based on the answers, five thematic areas were distinguished:

Table 1. The proposed immediate and medium/long-term actions of Northern African countries towards strengthening WES frameworks.

Thematic Area	Level	Immediate Actions	Medium /Long Term Actions
Governance, coordination, and stakeholder engagement Countries emphasized the importance of strong intersectoral coordination and stakeholder involvement to ensure alignment between public health	National	- Conduct consultations and multi-sectoral meetings - Introduce the WES concept to national stakeholders.	- Establish formal partnership agreements and ensure integration of WES into national surveillance systems. - Maintain continuity through regular coordination mechanisms.
	Regional	- Strengthen coordination between countries and launch a regional platform for collaboration and data sharing.	- Develop a harmonized regional framework for WES implementation and promote continuous

and ecosystem protection agendas.			information exchange among member states.
Capacity building and workforce development Limited technical expertise and analytical capacity were mentioned as recurring challenges. Countries identified workforce training and laboratory strengthening as foundational for sustainable WES programs.	National	- Organize workshops and training sessions on WES methodologies. - Assess current diagnostic and analytical capacities.	- Develop comprehensive capacity-building programs and strengthen laboratory infrastructure and equipment. - Ensure continuous training and knowledge exchange across sectors.
	Regional	- Facilitate regional workshops and training sessions through WHO, Africa CDC, and regional stakeholders as part of the platform's early activities.	- Institutionalize continuous regional capacity development programs and knowledge-sharing mechanisms.
Laboratory infrastructure and technical strengthening Laboratory systems are central to the operationalization of WES for both health and environmental protection. Enhanced technical capacity and quality assurance were seen as prerequisites for reliable data.	National	- Improve laboratory capacity and diagnostic tools. - Establish data collection mechanisms.	- Develop advanced laboratory networks and technical support structures for sustained surveillance, including airports and marine environments.
	Regional	- Launch pilot WES activities with support for analytical equipment and standardized protocols.	- Reinforce regional surveillance systems and laboratory infrastructure to ensure sustained data generation and analysis capacity.
Data integration, surveillance, and research The integration of WES data with existing surveillance and environmental monitoring systems was widely prioritized. Countries highlighted the need for mapping, harmonization, and applied studies to guide evidence-based decision-making.	National	- Map current surveillance protocols and data systems. - Define corrective actions and priority targets.	- Implement integrated surveillance plans, including wastewater-based surveillance. - Conduct research on pollution impacts on ecosystems and public health.
	Regional	- Improve surveillance actions to monitor the marine environment, ensuring consistent data collection and analysis across countries.	- Implement integrated regional surveillance systems and conduct collaborative research studies on marine fish and ecosystem pollution to inform policy and preventive measures.
Financial and technical support Most countries underscored the need for sustained financial resources and technical assistance to develop, implement, and scale up WES initiatives.	National	- Identify financial gaps and mobilize support for pilot projects and laboratory upgrades.	- Secure funding for ongoing WES implementation, including large-scale pilot studies and the establishment of global or regional wastewater monitoring networks.
	Regional	- Mobilize financial and technical resources to support the establishment of pilot projects, regional coordination mechanisms,	- Ensure stable funding streams for the implementation of harmonized regional

		and laboratory equipment upgrades.	frameworks and surveillance networks.
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Stakeholders to be involved

The implementation of WES for both public health and ecosystem protection requires the active engagement of a wide range of stakeholders at national and regional levels. Key actors communicated included Ministries of Health, Environment, Agriculture, Water, and Irrigation, as well as national and regional laboratories, research institutions, and airport and port authorities. International and regional partners such as WHO, WHO EMRO, Africa CDC, UNEP, FAO, and UNICEF play an essential role in providing technical guidance, coordination platforms, and capacity-building support. Active collaboration between these entities will ensure coherence, data sharing, and cross-sector integration within the One Health framework.

Support needed for the next steps

Across all participating countries, the main support needs identified were technical assistance, financial resources, and capacity building. Countries emphasized the importance of strengthening laboratory infrastructure and analytical equipment, securing sustained funding for pilot and long-term surveillance programs, and developing tailored training initiatives. Continued regional and international cooperation is considered crucial to mobilizing these resources and to ensure harmonized, sustainable WES systems that benefit both human health and environmental protection.

Session 10: Way forward

The closing session featured key reflections and acknowledgements, beginning with Dr. Mona Ezzat Abdel Tawab from the Ministry of Health and Population of Egypt, who underscored the integration of wastewater and environmental surveillance for public health protection and environmental sustainability. She highlighted emerging issues like microplastics monitoring. Popi Karaolia, Senior Wastewater Surveillance Expert representing UNEP, outlined the next steps and reiterated the need for a harmonized approach to wastewater-based epidemiological surveillance across the continent to enhance surveillance effectiveness and protect both environmental and public health. Angela Tessarolo, Policy Officer at the European Commission's Health Emergency Preparedness and Response Authority (HERA), joined the session online, reaffirming HERA's continued support for the project and expressing appreciation to all partners for their collaboration. Sogol Jafarzadeh, UN and Government Relations Coordinator at UNU-INWEH, conveyed UNU-INWEH's gratitude to the Government of Egypt and WHO EMRO for hosting this important workshop. She acknowledged the valuable contributions of UNEP and WHO as project partners and announced that the next sub-regional workshop for West and Central Africa will take place in Dakar, Senegal, at the end of January 2026.

The session concluded with remarks delivered by Dr. Asmus Hammerich, Director of Noncommunicable Diseases and Mental Health, at the WHO Eastern Mediterranean Region Office, who praised the fruitful discussions and reaffirmed the vital role of collaborative surveillance for public health and policy. He emphasized wastewater surveillance as a powerful

tool expanding beyond polio to multiple diseases, affirming WHO's commitment to supporting integration, standardization, and sustainability of these efforts. UNEP summarized key workshop messages, focusing on collaboration within a One Health framework and regional challenges such as water scarcity and wastewater reuse safety. HERA encouraged ongoing engagement with the GLOWACON, promoting a harmonized regional approach to wastewater surveillance as part of global health security. As the workshop came to an end, the certificate ceremony was conducted, where participants received UNU-INWEH certificates acknowledging their participation. The session also included logistical notes on feedback surveys and upcoming events, wrapping up the successful three-day workshop with expressed gratitude to hosts, partners, organizers, and participants, leaving a foundation for future collaborative efforts.

-End of Day Three-

-END OF WORKSHOP-

Annex:

1: Northern Africa Regional Workshop on Wastewater Surveillance for Environmental and Public Health

Agenda

Venue: World Health Organization Regional Office for the Eastern Mediterranean

Day 1 – Sunday, 19 October 2025		
8:20	Shuttle pickup from Holiday Day Inn	
08:30 – 09:30	Registration	
09:30 – 10:15	Session 1: Opening session and welcoming remarks - Sogol Jafarzadeh – UN and Government Relations Coordinator & Gender and Capacity Building Focal Point for Africa, United Nations University Institute for Water, Environment and Health (UNU-INWEH) (5 min) - Mona Ezzat Abdel Tawab – General Director of Environmental Monitoring & Climate Change, Ministry of Health and Population, Egypt (5 min) - Osama Ali Maher – World Health Organization Regional Office for the Eastern Mediterranean (EMRO) (5 min) - Alex Pires – Programme Management Officer, United Nations Environment Programme (UNEP) (5 min) (<i>online</i>)	Moderator: Sogol Jafarzadeh, UNU-INWEH Rapporteur: Alexander Tajmar, UNU-INWEH

	• Monica Nolan – Senior Technical Advisor for Wastewater and Environmental Surveillance, World Health Organization (WHO) (5 min) • Ayman Ayad – Project Manager, Water & Social Infrastructure, European Union Delegation to Egypt (5 min) • Angela Tessarolo – Policy Officer, The European Commission's Health Emergency Preparedness and Response Authority (HERA) (<i>online</i>) <i>Participants' introduction (10 min)</i>	
10:15 – 10:30	Coffee break	
10:30 – 12:00	Session 2: Wastewater surveillance for environmental and public health • Setting the scene: the relevance of wastewater surveillance for people and the environment Popi Karaolia – Senior Wastewater Surveillance Expert, UNEP & Taru Miller – Wastewater Surveillance Expert, UNEP (10 min) • Wastewater Surveillance for Africa (WWS) Initiative: Riccardo Zennaro – Project Management Officer, UNEP & Josphine Wairimu Nduguti – Programme Associate, UNEP (10 min) • Wastewater surveillance for Africa: overview of WHO initiatives: Environment Surveillance Network for Poliovirus detection, Eastern Mediterranean region: Salmaan Sharif – Laboratory Coordinator, World Health Organization (WHO EMRO) (10 min) <i>online</i> • Wastewater surveillance: examples, usefulness and case studies from North Africa (20 min) Fatma Guerfali – Professor, Laboratory of Transmission, Control and Immunobiology of Infections, Institut Pasteur Tunis	Moderator: Sogol Jafarzadeh, UNU-INWEH Rapporteur: Shooka Bidarian, UNU-INWEH

	Olfa Mahjoub – Associate Professor, Water Quality & Reuse, National Research Institute for Rural Engineering, Water, and Forestry (INRGREF) <i>Questions and answers (30 mins)</i>	
12:00 – 13:00	Session 3: Capacity needs assessment for wastewater surveillance in Africa <i>Elevator pitch:</i> countries briefly presenting their status of capacity vis a vis wastewater surveillance • Presentation of responses to the survey • Discussion about the elevator pitch • Practical examples <i>Questions and answers</i>	Moderator: Bernard Mware, ILRI Rapporteur: Josphine Wairimu Nduguti, UNEP
13:00 – 14:00	Lunch - WHO EMRO Pergola Area	
14:00 – 18:00	Field visit - Nilometer	

Day 2 – Monday, 20 October 2025		
8:45	Shuttle pickup from Holiday Day Inn	
09:00 – 10:30	Session 4: Protecting Public Health and Ecosystems: Interactive exercise on wastewater and environmental surveillance for public health Wastewater and environment surveillance prioritization, implementation and integration framework for one or more pathogens (link - available in English and French) • Introduction to World Health Organization WES package • Breakout group work part 1: using WHO tools	Moderator: Monica Nolan, WHO and Dahbia Leila Anes-Boulahbal, WHO AFRO Rapporteur: Alexander Tajmar, UNU-INWEH Resource people: From UNEP, WHO (HQ, AFRO, EMRO)
10:30– 10:45	Coffee break	
10:45 – 12:00	Session 4 (continued): Protecting Public Health and Ecosystems: Interactive exercise on wastewater and environmental surveillance for public health Wastewater and environment surveillance prioritization, implementation and integration framework for one or more pathogens • Breakout group work - <i>part 2: using WHO tools</i> • Report back	Continued as above
12:00 – 13:00	Lunch - WHO EMRO Pergola Area	
13:00 – 15:00	Session 5: Interactive session on wastewater and environmental surveillance for ecosystem protection <i>Group work with scenarios and reporting back to plenary</i> • Scenario-based training materials	Resource persons: Popi Karaolia and Taru Miller, UNEP

	<i>Session 5 did not take place as a result of time constraints</i>	
15:00 – 15:30	Coffee break	
15:30 – 17:00	Session 6: Opportunities for synergies on wastewater surveillance for environmental and public health in Africa • Harmonized Approach Document: Popi Karaolia – Senior Wastewater Surveillance Expert, UNEP (10 min) • Harmonization efforts across sub-Saharan Africa: experiences from the ODIN project: Dr. Vivi Maketa, Professor, University of Kinshasa (10 minutes) • Policy Briefs and E-Learning for Africa: Sogol Jafarzadeh – UN and Government Relations Coordinator & Gender and Capacity Building Focal Point for Africa, United Nations University Institute for Water, Environment and Health (UNU-INWEH) (10 minutes) • Wastewater management and surveillance: the experience of the Islamic Development Bank: Ammar Abdo Ahmed Manager, Human Development, Economic & Social Infrastructure (10 min) <i>Breakout group work (1 hour) and reporting back to plenary (20 min)</i>	Moderator: Popi Karaolia and Taru Miller, UNEP Rapporteur: Shooka Bidarian, UNU-INWEH
17:00 – 19:00	Evening Networking Reception Venue: WHO EMRO Pergola Area	
19:15	Shuttle pickup from WHO EMRO	

Day 3 – Tuesday, 21 October 2025		
8:45	Shuttle pickup from Holiday Day Inn	
09:00 – 10:30	Session 7: Wastewater surveillance at airports, aircrafts and ports - Wastewater surveillance at airports and aircrafts: efforts by GLOWACON (20 min) Bernd Gawlik – Portfolio Leader for Climate and Water Resilience, European Union Joint Research Centre (EU-JRC) (<i>online</i>) - Wastewater surveillance in East and Southern Africa (30 min) Fiona Els – Epidemiologist, National Institute for Disease Prevention and Control, South Africa (NICD) Bernard Mware – Research Scientist, International Livestock Research Institute (ILRI) Jean-Pierre Musabyimana – Research Lead, Rwanda Biomedical Centre (RBC) (<i>online</i>) - Türkiye Experience and Global Approaches on WES (Best Practices) (10 min) Bilge Kocamemi – Turkish Water Institute <i>Questions and answers (20 min)</i>	Moderator: Riccardo Zennaro, Project Management, Officer, UNEP Rapporteur: Josphine Wairimu Nduguti, Programme Associate, UNEP
10:30 – 11:00	Coffee break	
11:00 – 12:00	Session 8: Roadmap for wastewater surveillance in Africa	Moderator: Popi Karaolia, Senior Wastewater Surveillance Expert, UNEP and

	Continental Strategy for Africa: Emily Atuheire – Surveillance Unit Lead, Africa CDC (10 min) <i>(online)</i> <i>Open discussion (60 min)</i>	Riccardo Zennaro, Project Management Officer
12:00 – 12:15	Awareness Sanitation Safety Planning for public health (15 min) Rola Al-Emam – Technical Officer, WHO EMRO	Moderator: Shooka Bidarian, UNU-INWEH
12:15 – 13:00	Lunch - WHO EMRO Pergola Area	
13:00 – 13:15	Wastewater surveillance at African ports (10 min) <i>(online)</i> Captain Ahmed Sharabia – Head of the Mandatory Courses Unit, Port Training Institute and the Maritime Research and Consultation Center, Egypt.	Moderator: Riccardo Zennaro, Project Management Officer, UNEP
13:15 – 14:45	Session 9: Next steps for country specific planning <i>Breakout group work</i>	Moderator: Popi Karaolia and Taru Miller, UNEP
14:45 – 15:15	Session 10: Way forward - Popi Karaolia – Senior Wastewater Surveillance Expert, UNEP (5 min) - Angela Tessarolo – Policy Officer, The European Commission's Health Emergency Preparedness and Response Authority (HERA) <i>(online)</i> - Sogol Jafarzadeh – UN and Government Relations Coordinator & Gender and Capacity Building Focal Point for Africa, United Nations - Asmus Hammerich – Director, Noncommunicable Diseases and Mental Health, WHO EMRO (5 minutes) <i>End-of-workshop survey, discussion and way forward (10 min)</i>	Moderator: Riccardo Zennaro, Project Management Officer, UNEP Rapporteur: Taru Miller, Wastewater Surveillance Expert, UNEP
15:30	Shuttle pickup from WHO EMRO	

2: List of Participants

	NAME	COUNTRY/INSTITUTION
1.	Farida Aliane	Algeria Ministry of Health, Population and reform
2.	Fathia Farah Iyeh	Djibouti Ministry of Health
3.	Mona Ezzat Abdel Tawab	Egypt Ministry of Health and Population
4.	Sofyan Alkhitouni	Libya Ministry of Health
5.	Mohamed Salem Hamouda	Libya Ministry of Environment
6.	Abid Abdeslam	Morocco Ministry of Energy Transition and Sustainable Development
7.	Mouna Sfaxi	Tunisia National Environmental Protection Agency
8.	Siouar Guermazi	Tunisia Ministry of Health
9.	Ayman Ayad	European Union Delegation to Egypt

10.	Fatma Guerfali	Institut Pasteur Tunis
11.	Olfa Mahjoub	National Research Institute for Rural Engineering, Water, and Forestry (INRGREF)
12.	Fiona Els	South Africa National Institute for Communicable Diseases (NICD)
13.	Bernard Mware	ILRI - International Livestock Research Institute
14.	Ghada Mostafa	Africa Development Bank (AfDB)
15.	Monica Nolan	World Health Organization
16.	Dahbia Leila Anes-Boulahbal	World Health Organization Regional Office for Africa (AFRO)
17.	Osama Ali Maher	World Health Organization Regional Office for the Eastern Mediterranean (EMRO)
18.	Rola Al-Emam	World Health Organization Regional Office for the Eastern Mediterranean (EMRO)
19.	Sohaib Abuhamoor	World Health Organization Regional Office for the Eastern Mediterranean (EMRO)
20.	Popi Karaolia	United Nations Environment Programme
21.	Taru Miller	United Nations Environment Programme
22.	Riccardo Zennaro	United Nations Environment Programme
23.	Josphine Nduguti	United Nations Environment Programme
24.	Sogol Jafarzadeh	United Nations University Institute for Water, Environment and Health (UNU-INWEH)
25.	Shooka Bidarian	United Nations University Institute for Water, Environment and Health (UNU-INWEH)
26.	Alexander Tajmar	United Nations University Institute for Water, Environment and Health (UNU-INWEH)
ONLINE PARTICIPANTS		

27.	Kate Medlicott (online)	World Health Organization
28.	Salmaan Sharif (online)	World Health Organization Regional Office for the Eastern Mediterranean (EMRO)
29.	Angela Tessarolo (online)	European Union Health Emergency Preparedness and Response (HERA)
30.	Emily Atuheire (Online)	Africa CDC
31.	Bernd Gawlik (Online)	European Union Joint Research Centre
32.	Vivi Maketa (Online)	University of Kinshasa
33.	Idrissa Dia (Online)	Islamic Development Bank
34.	Dr Ammar Abdo (Online)	Islamic Development Bank
35.	Vinod Pericherla (Online)	Islamic Development Bank
36.	Sadik Tayeb (Online)	Islamic Development Bank
37.	Nizar Zaied (Online)	Islamic Development Bank
38.	Bakhodir Mirzaev (Online)	Islamic Development Bank
39.	Tariro Mbiba (Online)	United Nations University Institute for Water, Environment and Health (UNU-INWEH)
40.	Elliot Mur (Online)	United Nations University Institute for Water, Environment and Health (UNU-INWEH)

3. Workshop contribution to achieving the results (Outputs/Outcomes) for PoW (Program of Work) UNEP Indicators for the 'Preventing and addressing the degradation of freshwater and marine ecosystems from source to sea' project.'

1. **Outcome 3.2: 11 Best practices**, experiences and/or examples shared by stakeholders, with UNEP's support, to prevent ecosystem degradation and pollution via the workshop. The best practices, experiences and examples shared by stakeholders were delivered via presentations and statements.
 - a) Representatives from six member states shared their specific country experiences with tackling WES during sessions 3 and 4 (Elevator pitches), (Algeria, Egypt, Libya, Morocco, Tunisia, Djibouti). (+6)
 - b) In line with exploring opportunities for synergies in Africa, the ODIN project presented on harmonization efforts across sub-Saharan Africa with experience from the ODIN project, which is a consortium for WES with several members, and it is implemented in 3 different countries: Democratic Republic of Congo, Tanzania, and Burkina Faso. The project workflow begins with environmental surveillance of pathogens, then metagenomic training for detection, strengthening of the genomic and epidemiological capacity across Africa – with a focus on viruses and bacteria (+1)
 - c) A presentation by the Islamic Development Bank highlighted work in implementing major infrastructure projects in sanitation, including sewage management, waste management, and stormwater drainage. In the health sector, it provides comprehensive support ranging from primary to tertiary care, drug supply, and vaccine production, with assistance levels adapted to each member country's economic situation, including emergency health relief services where needed. (+1)
 - d) The European Commission's Global Consortium on Wastewater and Environmental Surveillance for Public Health (GLOWACON) presented the aviation program, which pilots synchronized sampling across multiple international airports. This program targets aircraft and terminal wastewater to detect pathogens like SARS-CoV-2, influenza A, MPOX, and dengue, demonstrating successful early warnings that support public health actions and business continuity. The session highlighted collaboration between airlines, airport operators, biosecurity, and border management agencies to ensure data privacy and effective communication. (+1)
 - e) Overview of the WHO's Sanitation Safety Planning (SSP) tool, a risk-based management approach for ensuring safe sanitation systems from containment to disposal. WHO EMRO explained how SSP guides countries in identifying prioritizing health risks along the sanitation chain, implementing improvement plans, and monitoring effectiveness in collaboration with multiple stakeholders. (+1)

f) Continental Strategy for Africa: Africa CDC (+1)

2. **Output A.3: 6 countries** (Algeria, Egypt, Libya, Morocco, Tunisia, and Djibouti) received UNEP's support to strengthen coordination of cross cutting issues and the application of integrated approaches across sectors via:

a) Providing a Regional Platform for Collaboration:

Countries (Algeria, Djibouti, Egypt, Libya, Morocco, Tunisia) were brought together in Cairo under UNEP's facilitation, creating a neutral platform to exchange knowledge, share challenges, and align strategies. This strengthened coordination across health, environment, and water sectors.

b) Promoting Integration Across Sectors:

The workshop explicitly emphasized the One Health approach, linking public health, environmental protection, and ecosystem sustainability. Countries received UNEP's support in framing wastewater surveillance not just as a health tool, but as a cross-sectoral mechanism for environmental monitoring, pollution control, and pandemic preparedness.

c) Capacity Needs Assessment:

Through "Elevator Pitch" presentations and interactive exercises, UNEP enabled countries to articulate their national contexts, gaps, and opportunities. This participatory method helped governments identify cross-cutting issues (e.g., lab infrastructure, data sharing, coordination between ministries) and receive tailored guidance.

d) Pathogen Prioritization Exercise:

UNEP facilitated interactive exercises where countries jointly prioritized pathogens of concern. This strengthened integrated approaches by aligning epidemiological priorities with environmental monitoring needs, fostering multisectoral coordination.

3. **Output B.1: 6 countries** (Algeria, Egypt, Libya, Morocco, Tunisia, and Djibouti) participated and were supported by UNEP (technical assistance/advisory services) to protect freshwater and marine ecosystems from wastewater during this workshop., particularly:

a) Knowledge Transfer on Ecosystem Protection: UNEP experts, provided technical presentations highlighting wastewater surveillance as a cost-effective, non-invasive tool to monitor pollutants and protect ecosystems alongside public health.

b) Draft Harmonized Guidance Document: UNEP presented a draft guidance on harmonization of wastewater and environmental surveillance in Africa, explicitly designed to enhance comparability and usefulness of data for both public health and ecosystem protection.

c) SWOT Analysis on Synergies: Participants identified shared environmental and health targets (e.g., heavy metals, pathogens) as overlapping indicators that drive joint action plans for ecosystem protection. UNEP facilitated this advisory exercise to help countries recognize opportunities for integrated monitoring.

4. **Output B.2:** One capacity development initiative held. The Northern Africa Regional Workshop on Wastewater Surveillance for Environmental and Public Health served as a capacity development initiative which included countries/national governments, and other stakeholder groups to protect freshwater and marine ecosystems from wastewater pollution as well as the destruction of habitats. (+1)
5. **Output B3** - During the Northern Africa Regional Workshop on Wastewater Surveillance for Environmental and Public Health – Cairo, Egypt, 13 government officials were trained on WES for ecosystem protection and reported an increased knowledge on the protection freshwater and marine ecosystems from wastewater and nutrient pollution, as well as the destruction of habitats. (see)
6. **Output D2 ,D3 and D4** – 55 stakeholders from the workshop (excluding UNEP personnel), have engaged in events/campaigns organized to increase awareness, have had access to information including but not limited to digital platforms/hubs, and were engaged to acquire new knowledge via the workshop training organized to change behavior and drive action on WES for evidence based decision making to protect freshwater and marine ecosystems from land and sea-based harmful activities.