International Water
Management Institute

Country Water Quality Profiles: Towards Developing an African Water Quality Program (AWaQ)

Patience Mukuyu, Nilanthi Jayathilake, Moshood Tijani, Josiane Nikiema, Chris Dickens, Javier Mateo-Sagasta, Deborah V. Chapman and Stuart Warner

Country Water Quality Profiles: Towards Developing an African Water Quality Program (AWaQ)

Patience Mukuyu, Nilanthi Jayathilake, Moshood Tijani, Josiane Nikiema, Chris Dickens, Javier Mateo-Sagasta, Deborah V. Chapman and Stuart Warner

The authors:

Patience Mukuyu was Researcher – Transboundary Water Management at the International Water Management Institute (IWMI), Pretoria, South Africa, at the time this study was conducted; Nilanthi Jayathilake is Researcher – Septage Management and Reuse at IWMI, Colombo, Sri Lanka; Moshood Tijani is Senior Policy Officer – Water Resources Management at African Ministers' Council on Water (AMCOW), Abuja, Nigeria; Josiane Nikiema is Professor in the Department of Construction Engineering at the University of Québec, Canada. She was Research Group Leader - Water Pollution and Circular Economy at IWMI, Accra, Ghana, at the time this research was conducted; Chris Dickens is Principal Researcher - Ecosystems at IWMI, Colombo, Sri Lanka; Javier Mateo-Sagasta is Senior Researcher and Coordinator – Water Quality at IWMI, Colombo, Sri Lanka; and Deborah V. Chapman and Stuart Warner are independent consultants based in Ireland.

Mukuyu, P.; Jayathilake, N.; Tijani, M.; Nikiema, J.; Dickens, C.; Mateo-Sagasta, J.; Chapman, D. V.; Warner, S. 2024. *Country water quality profiles: towards developing an African Water Quality Program (AWaQ)*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 86p. doi: https://doi.org/10.5337/2024.215

Acknowledgements

The authors acknowledge funding from the CGIAR Initiative on NEXUS Gains for conducting this research study. Additional funding came from the World Water Quality Alliance (WWQA) of the United Nations Environment Programme (UNEP), which oversees the periodic World Water Quality Assessment and contributes to an understanding of emerging water quality issues around the world. The respondents to the water quality questionnaires – country representatives working on water quality issues – are thanked for the time taken to submit a detailed response that informed the project about country capacity to deal with water quality issues in their countries. Furthermore, the authors would like to thank the African Ministers' Council on Water (AMCOW) for their collaboration and guidance in the design of the framework for developing an African Water Quality Program (AWaQ). As the original survey was conducted in 2021, data might have changed since then.

Project

This study was undertaken out under the CGIAR Research Program on Water, Land and Ecosystems (WLE) and finalized under the CGIAR Initiative on NEXUS Gains. It also received support from UNEP as part of the WWQA Pan African Water Quality Program in Africa (Small Scale Funding Agreement reference SSFA/2021/4657).

Collaborators

International Water Management Institute (IWMI)

African Ministers' Council on Water (AMCOW), Abuja, Nigeria

Donors

This work was carried out under the CGIAR Research Program on Water, Land and Ecosystems (WLE) and finalized under the CGIAR Initiative on NEXUS Gains, which is grateful for the support of CGIAR Trust Fund contributors (www.cgiar.org/funders).

World Water Quality Alliance (WWQA) of the United Nations Environment Programme (UNEP)

Introduction

As water quality challenges continue to escalate in Africa, a collective response is needed to stem the tide and improve the quality of water for millions of people and the environment that depend on it. Rampant population growth in Africa together with progressive industrialization, and agricultural expansion and intensification are driving the increasing loads of pollutants into waters. Anthropogenic water pollution can be exacerbated by climate change impacts such as changes in hydrological regimes and increased temperatures. Climate change worsens water quality degradation through higher pollutant concentrations from decreased flows during periods of drought and acceleration of chemical reactions in warmer waters, among others.

To respond to these surface water and groundwater quality challenges, the African Ministers' Council on Water (AMCOW) envisages an African Water Quality Program (AWaQ) with the aim of informing a continent-wide response. Water quality directly impacts human and ecosystem health and ultimately socioeconomic development. An Africa-wide program will rally countries in the continent to highlight the importance of good ambient water quality and the direct benefits to be derived from monitoring and managing water quality. Further, enhancing the availability and application of water quality data will strengthen management strategies and ultimately improve water quality.

Responding to water pollution challenges on the African continent requires concerted efforts across various actors. A Pan-African Water Quality Programme is envisaged by the African Ministers' Council on Water (AMCOW) to accelerate the water security agenda for Africa. The design of this programme is supported by the International Water Management Institute (IWMI), taking place in five phases between 2021 and 2022, resulting in the main output – a framework for the African Water Quality Programme (AWaQ). This report covers the first two phases, which provide a baseline assessment of the status of water quality monitoring and assessment, including the capacity available across African countries to monitor water quality and control pollution. This assessment considers various past and ongoing initiatives related to water quality monitoring and assessment, capacity development and water pollution control and impact mitigation. While the initiatives presented are not exhaustive, they do provide a starting point for understanding the state of water quality monitoring – the available capacity and pollution control measures currently implemented and how the AWaQ can be designed to fill gaps and strengthen ongoing initiatives.

This report contains the results of an Africa-wide survey implemented to gain a better understanding of the countries' water quality situation. Although there are variations across countries in terms of the status of available capacity for water quality monitoring and assessment as well as pollution control, water pollution remains a critical challenge that provides an impetus for the AWaQ program. The survey was rolled out across Africa through the AMCOW network of African country representatives. 31 out of 54 countries responded to the survey offering their inputs on different water quality-related aspects. Profiles on 17 of these countries are presented here. As the original survey was conducted in 2021, data might have changed since then.

Key findings coming out of the survey showed that:

- There is an encouraging availability of national water testing laboratory facilities across African countries. Nonetheless, there are weaknesses in

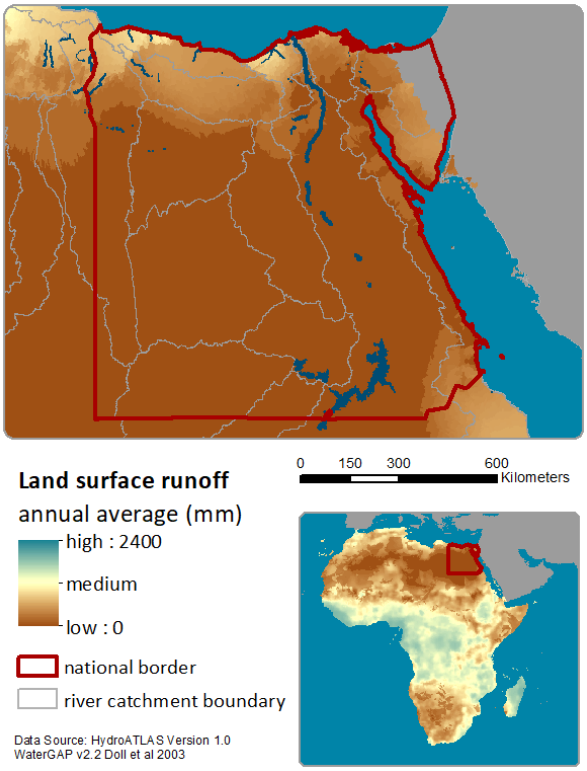
existing capacity which require attention to ensure effectiveness and sustainability.

- Ongoing regular training is needed to keep up with laboratory testing methodologies. The observed low trend in regular training does not auger well for keeping abreast with developments in water quality monitoring best practice. In view of emerging pollutants, training needs to be more regular than is currently experienced.
- Water quality and monitoring and assessment capacity is patchy. Capacity related to staff training, laboratory infrastructure as well as monitoring programme activities needs strengthening.
- Pollution control mechanisms are facing challenges. Regulatory mechanisms and wastewater treatment technologies which are the most widely deployed pollution control solutions may benefit from more concerted investment and political will to boost their effectiveness.

Egypt

BACKGROUND/ CONTEXT:

- **Population:**100.4 million
- **Water supply:** National water coverage – 99.7%; Rural -99.7%; Urban -99.7% (JMP, 2021)
- **Sanitation:** National sanitation coverage – 98.9%; Rural -98.2%; Urban -99.9%; National open defecation-0%; Rural- 0%; Urban- 0% (JMP, 2021)
- **Major water bodies:** Nile River. The river (represents 97% of all renewable water resources).
- Groundwater aquifers: the Nile Aquifer, the Nubian Sandstone Aquifer, the Moghra Aquifer and the Coastal Aquifer. (National Water Research Center, 2007)
- **SDG 6.3.2. score (2020) – No data available**



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Egypt is considered one of the largest water consumers in Africa despite being facing severe water scarcity. The Nile River is the largest water source that provides water for drinking among other purposes in Egypt. The River supplies 65% of Egypt's industrial water needs, and receives more than 57% of its effluents (Abdou, 2018). Abdel-Satar et al. (2017) reports that the Nile River water quality has been steadily deteriorating over several decades due to the dumping of untreated effluents and anthropogenic inputs.

In general, Water quality related impacts are highly prevalent in the country. For example it has been identified that drinking unsafe water and exposure to pesticides as the cause of renal diseases for an estimated 72% of patients. Loss of fishermen livelihood, loss of tourism, increased cost of treating polluted water are among the major impacts associated with water quality degradation (Bottoms, 2014). Due to high water demand, Egypt encourages wastewater reuse for selected farming activities, depending on its quality and are relatively advanced as regards practising wastewater reuse (AfDB, 2020).

Major pollution categories and example of their occurrence in Egypt

Major Categories	Case of pollution	References
Organic pollutants	The results of water pollutants in El-Mahmoudia Agricultural Irrigation Stream at El-Beheira Governorate reported the presence of organic chemicals, pesticides, oils, fatty acids, carboxylic acids, plant metabolites, and plasticizers in the water stream.	Radwan et al., 2019
Pathogens	Water supplies in El-Minia Governorate reported poor microbial quality due to protozoan pathogens which potentially attributed to improper operational skills and management of the various water treatment plants	Khalifa et al., 2014
Nutrients and agriculture runoff	Rosetta Branch of Nile river is contaminated by El-Rahawy drain in the southern part and industrial pollution at Kafr El-Zayat whereas Damietta Branch is affected by industrial wastewater from Talkha fertilizer factory.	El Gohary, R.,2015
Inorganic pollutants (salts and metals)	Water quality in the Nile river is mainly affected by nutrient, salts and heavy metals from agricultural runoff, industrial and municipal wastes. The pollutants enter into the Nile system by direct discharges or surface runoff. The aquatic Water Quality Index indicated deteriorating water quality.	Abdel-Satar et al., 2017

POLICIES AND INSTITUTIONS

Egypt has a centralized institutional framework where key functions of policymaking, regulation, planning and investment are done at the national level by the Ministry of Housing, Utilities and Urban Communities (AfDB, 2020).

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Scope of water quality related responsibilities
Ministry of Water Supply and Sanitation Facilities	Responsible for water supply and sanitations sector
The Ministry of Water Resources and Irrigation	In charge of water resources management and irrigation.
Egyptian water and wastewater regulatory agency (EWRA)	In charge of the economic and technical regulation of utilities and of supervising, reviewing and monitoring all water and wastewater activities.
Holding company for water and wastewater (HCWW)	The HCWW and Affiliated Companies (AC) are under the status of Public Sector Companies. Purify, distillate, transport, distribute and sell drinking water in addition to collecting, treating and safe disposal of wastewater. Monitors and provides technical assistance and training to the ACs, insures maintenance, operation and rehabilitation of infrastructures.
National Authority of Potable Water and Sewage (NOPWASD)	Planning, designing and implementation of water supply, sewerage and sanitary drainage project
Ministry of Health and population	Enforces the drinking water standards, monitors and protects the quality of surface waters, inspects the wastewater treatment plants
Egyptian Environmental Affairs Agency (EEAA)	Responsible for environmental affairs and the assessment and monitoring of water use

Source: Soulie et al., 2013

Water pollution monitoring and control: Policies and regulatory environment

Policy and regulations	Description
National Water Resources Plan, 2017	Describes how Egypt will safeguard the quality and quantity of its water resources and the best manner to use such resources.
Water and Wastewater Sector Policy Paper, September 2010	protects the human right to water in the policy
Current enabling laws	• Law No. 27 of 1978 on the organization of public sources of potable water and water for human use • Presidential Decree No. 178 of 2012 concerning the organization of the Ministry of Drinking Water and Sanitation • Ministerial Decree No. 219 of 2010 on the exploitation of water sewage • Resolution No. 458 of 2007 defining maximum limits for criteria and requirements necessary for drinking water and domestic use • Resolution No. 331 of 2007 adopting the Egyptian Code for drinking water and sewage water

Source: AfDB, 2020

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Main stakeholders	Scope
National Water Quality Monitoring Program of Egypt	National Water Research Center	A national water quality and quantity monitoring network in the Nile delta and Fayoum
National water quality monitoring programme on the River Nile, two branches, the main canals and drains and on Lake Nasser	Ministry of Water Resources and Irrigation in coordination with other ministries	To stop the discharge of untreated industrial wastewater into the main stem of the River Nile

WATER QUALITY MONITORING AND TESTING CAPACITY

Although, several agencies under different ministries have monitoring activities within their working program, most of these activities are not conducted on regular basis (El Gohary, 2015). AMCOW/IWMI (2021) survey results revealed water quality programmes exist at all levels; national, regional, provincial and local level in the country that led by the government institutions.

Laboratory Facilities and Capacity

At national government level, the Ministry of Water Resources and Irrigation has both competent technical staff as well as laboratories that are equipped with advanced water equipment for conducting water quality monitoring activities (Egyptian Environmental Affairs Agency, 2009). AMCOW/IWMI survey (2021) also indicated that there are accredited laboratories in the country with adequate capacity and technical expertise in conducting water quality testing and monitoring activities.

References

Abdel-Satar, A. M., Ali, M. H., & Goher, M. E. (2017). Indices of water quality and metal pollution of Nile River, Egypt. *The Egyptian Journal of Aquatic Research*, *43*(1), 21-29. https://doi.org/10.1016/j.ejar.2016.12.006

Bottoms I. 2014. Water Pollution in Egypt Causes and Concerns. Egyptian Center for Economic & Social Rights Environmental Justice Programme

El Gohary, R. (2015). Agriculture, industry, and wastewater in the Nile Delta. *Int. J. Sci. Res. Agric. Sci*, *22*, 159-172.

Goher, M. E., Hassan, A. M., Abdel-Moniem, I. A., Fahmy, A. H., & El-sayed, S. M. (2014). Evaluation of surface water quality and heavy metal indices of Ismailia Canal, Nile River, Egypt. *The Egyptian Journal of Aquatic Research*, *40*(3), 225-233.

Ibrahim, M., Al-Zyoud, S., & Elhaddad, E. (2018). Surface water quality monitoring for River Nile, Egypt using GIS-techniques. *Open Journal of Geology*, *8*(02), 161.

Khalifa R. M. A., Ahmad A. K., Abdel-Hafeez E. H., Mosllem F. A. 2014. Present Status of Protozoan Pathogens Causing Water-Borne Disease in Northern Part of El-Minia Governorate, Egypt. Journal of the Egyptian Society of Parasitology. https://jesp.journals.ekb.eg/article_90143_567f67f83f12b544aa6673a7c27104db.pdf

Kholy,R.M.S.I., Khalil.B.M., Gawad.S.T.A., Assesment of the National Water quality Monitoring program Egypt,National water research center,NWRC,

Mumssen, Y.U. and Triche, T. (2017). Status of water sector regulation in the Middle East and North Africa (English). Washington, D.C.: World Bank Group. https:// openknowledge.worldbank.org/handle/10986/27465

National Water Research Center, Ministry of Water Resources and Irrigation (2007), Actualizing the Right to Water: An Egyptian Perspective for an Action Plan

Radwan E,. Eissa E., Nassar A. M. K., Salim Y., Hashem H. Abdul-Aziz K., Abdel-Hakeem N. 2019. Study of Water Pollutants in El-Mahmoudia Agricultural Irrigation Stream at El-Beheira Governorate, Egypt. Journal of Bioinformatics and Systems Biology. doi: 10.26502/jbsb.5107004

Sanitation and wastewater atlas of Africa, 2020, ISBN: 978-82-7701-194-3, https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/545/original/WWAtlas_lores.pdf?1594115866

Soulie, M., Taha, S., Khordagui, H., & Constantianos, A. (2013). Review and analysis of status of implementation of wastewater strategies and/or action plans. National report-Egypt. *Work package (WP1)«Water Governance and Mainstreaming»-Activity*, *1*(2).

Taha, A. A., El-Mahmoudi, A. S., & El-Haddad, I. M. (2004). Pollution sources and related environmental impacts in the new communities southeast Nile Delta, Egypt. *Emirates Journal for Engineering Research*, *9*(1), 35-49.

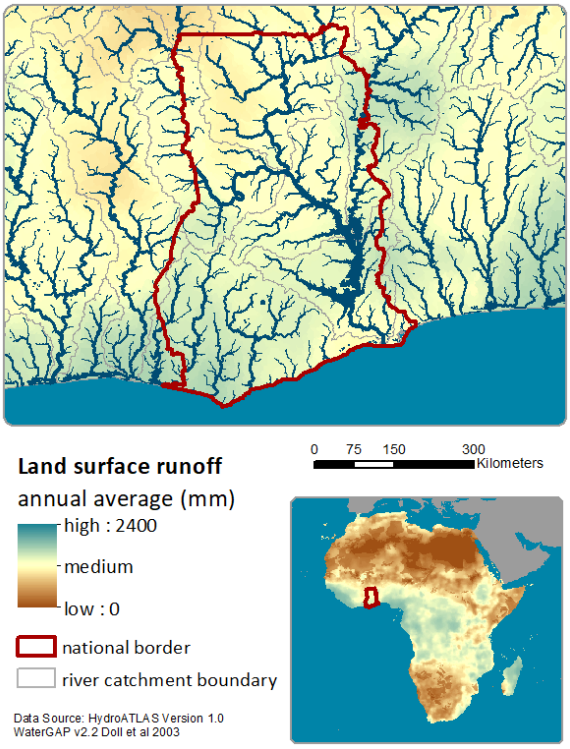
Volunteer Lake Monitoring Program, Grater Egypt regional planning and development committee, http://greateregypt.org/volunteer-lake-monitoring-program/

WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2017, https://washdata.org/data/household#!/

Ghana

BACKGROUND/ CONTEXT:

- **Population:** 30.42 million
- **Water supply** : National improved water supply – 92.4%; Rural-83.8%; Urban-98.7% (JMP, 2021)
- **Sanitation**: National improved sanitation – 71.1%; Rural-52.8%; Urban-84.8%; National open defecation - 18%; Rural- 31.6%; Urban- 7.5% (JMP, 2021)
- **Major Rivers systems**: Coastal river systems (Tordzie/Aka, Densu, Ayensu, Ochi-Nakwa and Ochi-Amissah), South-Western (Bia, Tano, Ankobra, Pra), Volta (Red, Black and White Volta Rivers and Oti River)
- **Major water bodies**: Lake Bosumtwi
- **SDG 6**.3.2. – No data available



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Ghana is well endowed with freshwater resources which have been explored and exploited to meet socio-economic and environmental needs of individuals and the country, a key example being fish production. However, these water resources are increasingly being polluted at an alarming rate due to anthropogenic causes such as illegal artisanal and small-scale mining, rapid urbanization and inappropriate agricultural practices (ISSER, 2020). A review conducted by Yeleliere et al. (2018) outlined high microbial contamination of surface water as almost all surface waters were contaminated with either E. coli, faecal coliforms, total coliforms or all.

Nearly 23 million of people in Ghana (73% of the population), use water that may not follow sanitary standards (Williams, 2019). The AMCOW/IWMI survey (2021) indicates that health and environmental impacts including diseases, biodiversity loss, reduced fish catches and loss of recreational opportunities are among the critical issues associated with water pollution in Ghana. One of the leading diseases in Ghana is Cholera which spreads primarily through the use of faulty toilets and plumbing (Williams, 2019). Moreover, diarrheal diseases associated with inadequate water, sanitation and hygiene accounts for 25% of deaths among Ghanaian children under five years of age (Binka et al., 2011).

Major pollution categories and example of their occurrence in Malawi

Major Categories	Examples	References
Organic pollutants	Korle Lagoon in Accra is polluted due to the discharge of untreated municipal waste from domestic and industrial effluent	Yeleliere et al. (2018);
Pathogens	A bacteriological analysis of Aboabo River in Kumasi pointed to a degradation of water quality in the River with large amounts of faecal coliform indicating possible pollution from human sources	Danquah, 2011
Nutrients and agriculture runoff	A study in 2020 reported high NO_3^- contamination in the Lower Volta River Basin due to Manure, septic effluents and mineralized fertilizers	Egbi et al.,2020
Suspended solids and sediments		
Inorganic pollutants (salts and metals)	WQI of River Bonsa indicated poor quality of water due to illegal mining and is likely to result in water-related diseases among the inhabitants in the catchment area of the river.	Samlafo & Ofoe, 2017
	River Pra, Daboase, and River Ankobra in the Western Region have been polluted due to the illegal mining activities.	Mantey, 2017; Owusu et al., 2016

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Main Role/Responsibilities
Ministry of Sanitation and Water Resources	Overall policy formulation, planning, coordination and harmonization, monitoring and evaluation of programs for the water supply and water resources.
Ministry of Local Government and Rural Development	Sets the policy framework for the development of local communities and oversees the performance of local administration.
Ghana Standards Authority (GSA)	GSA is responsible for setting drinking water standards in Ghana.
Water Resources Commission (WRC)	Regulation and management of the utilization of water resources. Water quality monitoring and surveillance. propose comprehensive plans for the utilization, conservation, development and improvement of water resources
Environmental Protection Agency (EPA)	Formulation of policies on the environment and in particular to make recommendations for the protection of the environment. Co-ordinate the activities of bodies concerned with the technical or practical aspects of the environment
Public Utilities Regulatory Commission	To monitor standards of performance for provision of services
Ghana Water Company Limited (GWCL)	GWCL has a responsibility to deliver water quality that meets the Ghana Standards.
The Water Research Institute	Generate, develop and transfer appropriate technologies, information and services for sustainable development, utilization and management of surface and groundwater resources

Community Water and Sanitation Agency (CWSA)	is an executive agency under Ministry of Works and Housing, mandated with the responsibility for water supply to rural communities, including small towns

Source: Water and Sanitation Program (2011)-second round of Country Status Overviews (CSO2)

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
Water Resources Commission Act, 1996	This Act establishes the Water Resources Commission in its responsibility to regulate and manage the use of water resources
Water Use Regulations, 2001	These are regulates to authorize various water uses through permits and water rights
Ghana National water Policy, 2007	The policy guide the sustainable use of water resources in Ghana including the prevention of water resources pollution.

Source: National Water Policy 2007; Ministry of Sanitation and Water Resources; Water Resources Commission Act, 1996; Water Use Regulations, 2001

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Main stakeholders	Scope
National water Quality Management framework in Ghana (2015)	The Ministry of Water Resources, Works and Housing (MWRWH)	Operational monitoring–drinking water system. Turbidity, residual chlorine, pH, structural integrity, regular inspections of the catchment, plant equipment, wellhead protection areas, storage reservoirs and tanks.
GEMS/ Water Quality Program (Warner, 2019)	WRC, EPA, GWCL, Community Water and Sanitation Agency (CWSA), Council for Scientific and Industrial Research Water Research Institute (CSIR-WRI)	to ensure countries have the capacity to collect and use water quality data for evidence-informed decision making. conducted on selected water bodies
IQUEST: Ghana Water Quality project	Ghana Water Company Ltd	Developing a new open-source tool and geographic decision support system that harnesses crowdsourced water data for monitoring residential water service quality
Fosu Lagoon water quality monitoring program	Cape Coast Metropolitan Assembly (CCMA)	Water quality monitoring to obtain regular data. Long-term program help track the effects of future rehabilitation activities on the lagoon ecosystem.

Initiative	Main stakeholders	Scope
Monitoring water quality in River Bodies of Mining communities in Ghana (Arash, 2015)	Academic and research institutions, community groups like "Wassa Association of Communities Affected by Mining" (WACAM), NGOs like ActionAid Ghana, government institutions, Mining companies	Measurable indicators being monitored- presence of heavy metals like Mercury (Hg), Arsenic (As), cadmium (Cd), lead (Pb), zinc (Zn) and copper (Cu) in the water (Boamponsem et al., 2010); and levels of nitrates, chemical oxygen demand (COD), sulphates, electrical conductivity (EC), and pH of water bodies (Armah et al., 2012),Total Suspended Solids (TSS), color and turbidity (Arah, 2015)
Capacity building in water quality Monitoring and surveillance in Ghana (2011-2014)	IWA, European Union – Africa, Caribbean and Pacific (EU-ACP), ProNet (a local NGO)	National water quality testing, monitoring and surveillance within the service areas of GWCL. Awareness raising in water quality, mobilize community members, schools and youth groups, and quality monitoring activities through the World Water Monitoring Challenge (WWMC) program.

REFERENCES:

Addo , H. O., Amegah K. E., Xonam, T. A., Kabenlah, E., Ameyaw, C., Graham, L/ O., Tobigah, T., Hammond, B., Maxwell, D., Bimi, L. (2020). Consumer Preference and Quality of Sachet Water Sold and Consumed in the Sunyani Municipality of Ghana. BioMed Research International Volume 2020, Article ID 3865895

https://doi.org/10.1155/2020/3865895

Arah, I. (2015). Monitoring water quality in river bodies of mining communities in Ghana. https://www.researchgate.net/publication/283507821_Monitoring_Water_Quality_in_River_Bodies_of_Mining_Communities_in_Ghana

Binka E., Vermund S. H. & Armah G. E. (2011). Rotavirus as a cause of diarrhea among children under 5 years of age in urban Ghana: prevalence and serotypes/genotypes. The Pediatric Infectious Disease Journal 30 (8), 718–720. https://doi.org/10.1097/INF.0b013e318223bd85.

Danquah, L., Abass, K., & Nikoi, A. A. (2011). Anthropogenic pollution of inland waters: The case of the Aboabo River in Kumasi, Ghana. *Journal of Sustainable Development*, *4*(6), 103.

Egbi, C. D., Anornu, G. K., Ganyaglo, S. Y., Appiah-Adjei, E. K., Li, S. L., & Dampare, S. B. (2020). Nitrate contamination of groundwater in the Lower Volta River Basin of Ghana: sources and related human health risks. *Ecotoxicology and environmental safety*, *191*, 110227.

Fosu Lagoon Water Quality Monitoring Programme, Ghana(2019),Ocean Conservation Trust, https://oceanconservationtrust.org/fosu-lagoon-water-quality-monitoring-programme-ghana/

Ghana Star, 2017, Pollution Destroying Water Bodies In Ghana, https://www.ghanastar.com/stories/galamsey-pollution-destroying-water-bodies-in-ghana/

GWCL (Ghana Water Company Limited), n.d. Accessed on https://www.gwcl.com.gh/)

GWCL (Ghana Water Company Limited) 2018. Laboratory Quality Assurance Manual. Accessed on https://www.epa.gov/sites/default/files/2018-10/documents/quality_assurance_manual_for_ghana_water_company_limited.pdf

IQUEST- Ghana water quality project, http://lienbtran.com/design/iquest/

Institute of Statistical, Social and Economic Research. (2020). Policy Brief : Water Pollution in Ghana. ISSER. College of Humanities, University of Ghana. Accessed on https://isser.ug.edu.gh/sites/isser.ug.edu.gh/files/Water%20Pollution%20in%20Ghana%20-%20Simon%20Bawakyillenuo.pdf

IWA (International Water Association) n.d. Capacity Building in Water Quality Monitoring and Surveillance in Ghana, Accessed on https://iwa-network.org/projects/capacity-building-in-water-quality-monitoring-and-surveillance-in-ghana/

Mantey, S (2017) Galamsey, pollution destroying water bodies in Ghana—Water Company, March 22, 2017. The Head of Communications at the Ghana Water Company

National Drinking Water Quality Management Framework for Ghana (2015), Ministry of Water Resources, Works and Housing Government of Ghana. http://www.gwcl.com.gh/national_drinking_water_quality__management_framework.pdf

Samlafo, V.B & Ofoe, E.B, (2017), Water Quality Assessment of River Bonsa in Tarkwa, a Mining-impacted Area of Ghana

Warner, S. (2019) UN Environment GEMS/Water Capacity Development Center, Water quality Monitoring capacity scoping report for Africa part 1: Irish Aid countries (2018)

Water and Sanitation Program (2011)-second round of Country Status Overviews (CSO2)

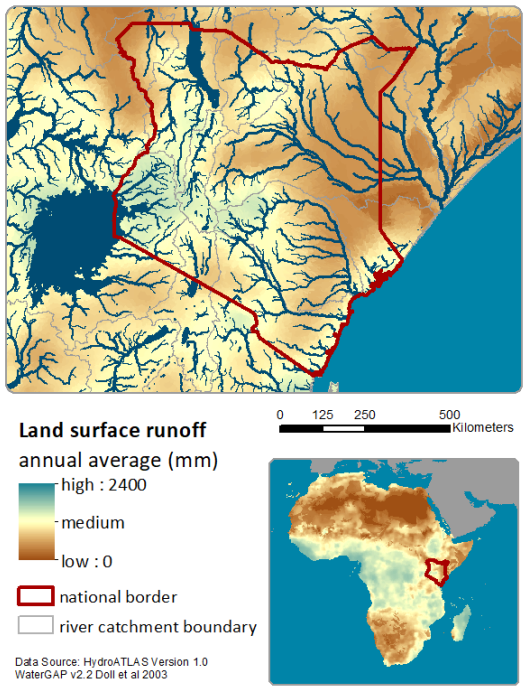
WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2017, https://washdata.org/data/household#!/

Williams, C. (2019). *8 Facts About Ghana's Water Crisis. Published on the Borgen Project. Accessed on* https://borgenproject.org/8-facts-about-ghanas-water-crisis/#:~:text=Seventy-three%20percent%20of%20the%20population%2C%20or%20about%2023,in%20Ghana%20can%20access%20water%20that%20is%20safe

Kenya

BACKGROUND/ CONTEXT:

- **Population:** 47.2 million
- **Water Supply**: National water coverage – 71.2%; Rural -63.3%; Urban -91.3% (JMP, 2021)
- **Sanitation:** National sanitation coverage – 58.2%; Rural -48.1%; Urban -84%; National open defecation-8.5%; Rural- 11.3%; Urban- 1.3% (JMP, 2021)
- **Major water bodies**: Lake Victoria, Athi-Galana-Sabaki River, Tana River, Turkwel, Kerio, Athi-Galana, Northern and Southern Ewaso Ng'iro, Lakes- Magadi, Naivasha, Turkana, Elementaita, Nakuru, Bogoria and Baringo.
- **SDG 6.3.2. score (2020)–** 86.52 (UNEP, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Kenya is classified as a water scarce country with many in the rural areas having limited access to quality water. In addition, water resources in Kenya are under pressure from agricultural chemicals (fertilizers and herbicides) and urban and industrial wastes, as well as from use for hydroelectric power (Kithiia, 2012). Past studies highlight as the major water pollution sources in the urban areas such as city of Nairobi as the raw sewage which is overflowing from blocked or collapsed sewers as well as from filled up septic tanks and pit latrines. On the other hand, in the rural areas locating the wells in close proximity to the pit latrines that increases the likelihood of microorganism contamination is a major risk (Njoroge et al., 2018).

Major pollution categories and example of their occurrence in Kenya

Major Categories	Examples	References
Organic pollutants	Lake Naivasha- Water quality of the Northern sector is influenced by the agricultural activities whereas the North East sector is dominated by domestic effluent.	Ndungu, 2014
	The water in the Likii River is not safe for human consumption, because of the presence of pesticide residue	Githinji et al., 2019

Pathogens	The microbiological contamination of Nairobi and Athi rivers was high as per Kenya standards, and WHO guidelines for drinking water and agricultural use. The waters were highly contaminated with human pathogenic bacteria, most dominant bacteria being *Escherichia coli.*	Musyoki et al., 2013
Inorganic pollutants (salts and metals)	The Ngong River at Embakasi indicates high values for most of polluting substances including manganese, lead and mercury, as a result of the upstream industrial activity.	Kithiia (2012)

POLICIES AND INSTITUTIONS

Stakeholders and their responsibilities

Stakeholders	Main Responsibilities/Duties
Ministry of Water and Irrigation (MWI)	Responsible for the water sector in Kenya. Formulation of policy and strategies for water and sewerage services, sector coordination and monitoring of other water services institutions.
Water Services Regulatory Board (WASREB)	Regulation and monitoring of urban and rural water service
National Environment Management Authority (NEMA)	Promote the integration of environmental considerations into government policies, plans, programs and projects in water. NEMA is in charge of formulating water quality regulations
Water Services Boards (WSBs)	Water Services Boards are responsible for asset management that is, for the development and rehabilitation of water and sewerage facilities, for investment planning and implementation. There are eight regional WSBs.
Water Appeals Board	To settle water-related disputes and conflicts

Source: Water and Sanitation Program (2011)-second round of Country Status Overviews (CSO2); NWSS, (2007)

Water pollution monitoring and control: policies and regulatory environment

Policies, act, regulations	Description
Water Act (2002)	provide for the management, conservation, use and control of water resources and for the acquisition and regulation of rights to use water; to provide for the regulation and management of water supply and sewerage services
Environmental Management and Coordination (Water Quality) Regulations, 2006 (Cap. 387).	provides rules relative to the use and discharge of water for different purposes, make provision for the protection of water resources from pollution and define water quality standards
Guidelines on Drinking Water Quality and Effluent Monitoring, 2008	focus on drinking-water quality, and industrial effluents. Provides guidelines to water service providers (WSPs) to determine the effluent quality, check on the operational efficiency of the wastewater treatment system; and monitoring of industrial effluent in their areas

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Programme	Status/ Year	Objective	Monitoring	Clients
GEMS/Water Quality Monitoring Program (Warner, 2019)	Active	Extensive ambient water quality monitoring in surface and ground water	Collects data from surface and groundwater between two and four times per year.	UN Environment GEMS/Water Capacity Development Centre
Aquaya Institute's monitoring for Safe Water (MfSW) research program(Ethiopia, Guinea, Kenya, Senegal, Uganda, and Zambia)	(2012-2016)	To build capacity for conducting monitoring of water safety in sub-Saharan Africa	The program has collected qualitative and quantitative data on microbial water quality monitoring activities among the engaged monitoring institutions in six countries	UK Aid from the UK Foreign, Commonwealth and Development Office (FCDO)
EOI - Kenya - Water quality monitoring and assessment of Nairobi Rivers - NARSIP II	2021	Improve access to improved sanitation services in Nairobi city; while improving the quality of the Rivers within the Nairobi Metropolis	Water quality assessment of Nairobi City and satellite towns & rivers and subsequently carries out quarterly surface/ground water quality monitoring	African Development Bank (AfDB), The Government of Kenya

WATER QUALITY MONITORING AND TESTING CAPACITY

Laboratory Facilities and Capacity

The main WRA laboratory in Nairobi, Kenya has the ability to analyse an extensive range of parameters and is staffed by an enthusiastic and well-trained team. The laboratory works to ISO 17025. This is certified through KEBS (Kenya Bureau of Standards). There is an extensive ambient water quality monitoring programme in place that collects data from surface and groundwaters between two and four times per year. There are several regional laboratories that support the main central laboratory and together they analyse over 3000 samples per year (Warner, 2019).

References:

AfDB. EOI - Kenya - Water quality monitoring and assessment of Nairobi rivers - NARSIP II, 2021.02.08, https://afdb.org/en/documents/eoi-kenya-water-quality-monitoring-and-assessment-nairobi-rivers-narsip-ii

Aquaya , From Data to Decission,Water Quality Monitoring Program in Sub-Saharan Africa, 2020, https://www.aquaya.org/wp-content/uploads/2020_Research-Brief_REACH_WQMonitoringPrograms-SubSaharanAfrica.pdf

EOI - Kenya - Water quality monitoring and assessment of Nairobi rivers - NARSIP II,(2021.02.08), https://afdb.org/en/documents/eoi-kenya-water-quality-monitoring-and-assessment-nairobi-rivers-narsip-ii

Githinji, M. W., Mwaura, F., & Wamalwa, J. (2019). Land use and water pollution along the altitudinal gradient of the Likii River, Laikipia County, Kenya. *Journal of Environment Pollution and Human Health*, *7*(1), 39-52.

Kithiia S.M. (2012). Water Quality Degradation Trends in Kenya over the Last Decade, Water Quality Monitoring and Assessment, Dr. Voudouris (Ed.), ISBN: 978-953-51-0486-5, InTech

Mbui, D., Chebet, E., Kamau, G., & Kibet, J. (2016). The state of water quality in Nairobi River, Kenya. *Asian Journal of Research in Chemistry*, *9*(11), 579.

Musyoki, A. M., Abednego, M., SULEIMAN, M. A., MBITHI, J. N., & MAINGI, J. M. (2013). Water-borne bacterial pathogens in surface waters of Nairobi river and health implication to communities downstream Athi river.

Ndungu, J,N.(2014), Assessing Water quality in Lake Naivasha,[University of Twente], https://webapps.itc.utwente.nl/librarywww/papers_2014/phd/ndungu.pdf

Njoroge L. W., Wahab A. A., Tracey S.A, Oting W. K. A. 2018. Water Resource in Kenya: Impact of Climate Change/ Urbanization. International Journal of Scientific and Research Publications. Vol 8. http://dx.doi.org/10.29322/IJSRP.8.4.2018.p7606

The National Water Services Stratergy(NWSS),Ministry of Water and Irrigation (2007), https://wasreb.go.ke/downloads/NWSS.pdf

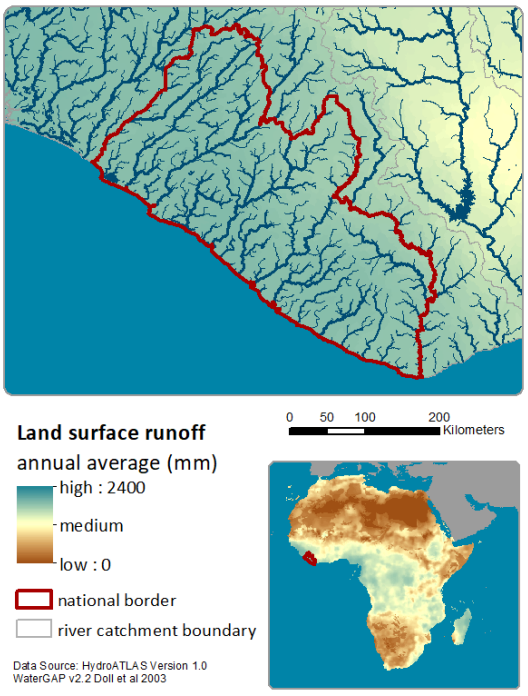
Warner, S. (2019) UN Environment GEMS/Water Capacity Development Center, Water quality Monitoring capacity scoping report for Africa part 1: Irish Aid countries (2018)

WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2017, https://washdata.org/data/household#!/

Liberia

BACKGROUND/ CONTEXT:

- **Population:** 5.058 million
- **Water Supply**: National water coverage –84%; Rural -70.6%; Urban -96.2% (JMP, 2021)
- **Sanitation:** National sanitation coverage – 47.5%; Rural -25.2%; Urban -68%; National open defecation-37.7%; Rural- 59.1%; Urban- 18% (JMP, 2021)
- **Major water bodies**: The Mano and Morro rivers in the northwest and the Cavalla in the east and southeast are major rivers and form sections of Liberia's boundaries. Other major rivers are the Lofa, St. Paul, St. John, and Cestos, Farmington River.
- **SDG 6.3.2. score (2020)–** 50% of water bodies have good ambient water quality (UN Water, 2021UNEP, 2021).



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Despite being one of the wettest countries in the world with enormous water resource potential, less than 10% of Liberians have access to safely managed drinking water and sanitation services. Lack of proper water and sanitation facilities has been a key cause in spreading illness. It has been reported that more than 800 children under five die a year from diarrhoea caused by dirty water and poor toilets.

Inadequate access to proper sanitation and indiscriminate solid and liquid waste disposal are major issues that affect the water quality in the country. In addition, there are indications that water quality is deteriorated due to mining, agricultural and industrial activities in some areas. Groundwater quality is threatened by the high prevalence of unprotected wells and pit latrines, which are easily contaminated by sewage, especially during wet season flooding (USAID, n,d,).

However, data on the pollution levels of the water resources are scarce in the country.

Major pollution categories and example of their occurrence in Liberia

Major Categories	Examples	References
Organic pollutants	Leachates discharges from the Whein Town Sanitary landfill were responsible for the contamination of the water sources. The results indicated higher BOD and TDS levels than WHO permissible limits	Gibson, 2019
Pathogens	Of the 405 water points for which a coliform test was performed, 18.7% had an intermediate risk, 9.6 % had high risk, and 2.6% had very high risk according to WHO definitions (Ministry of Public Works, 2018).	Government of Liberia, 2018
	A 2011 survey of groundwater quality in Monrovia found that E. Coli was present in all of the unprotected wells, 52 percent of protected hand dug wells, and 44 percent of drilled wells	USAID, n.d.
Nutrients and agriculture runoff	In Monrovia, out of the water samples collected from public sources (predominantly shallow dug wells), 22% of sources (out of 204 sources) had nitrate levels that exceeded standards.	Kumpel et al., 2016
Inorganic pollutants (salts and metals)	Water quality results from China Union Iron Ore Mine of Liberia revealed that there is a potential of surface and ground water pollution by iron ore mining.	Gleekia et al., 2016
	Water bodies such as Mafa (in Golakonneh) and Sien Creek (in Kokoya), which used to serve as the main sources of water for domestic purpose in the surrounding townships, had been heavily polluted by mining activities especially those of illegal small-scale mining.	Dorko, 2018
	Recent studies in Cape Mount County and Bong County documented mercury levels there were up to 150 times higher than WHO guideline values for drinking water near small-scale gold mining operations.	USAID, n.d.

Water pollution monitoring and control: policies and regulatory environment

Policies, Acts, regulations	Description
Environment Protection and Management Law of the Republic of Liberia, 2002	Establish a legal framework for the sustainable development, management and protection of the environment by the Environment Protection Agency in partnership with regulated Ministries and organizations
Water supply and sanitation policy, 2009	To provide guidance and direction in institutional, economic and legal reforms that will lead to improved water governance at national, local and community levels, and improved access to safe water supply and adequate sanitation, in an affordable, sustainable and equitable manner, to all the peoples of Liberia .
The National Water, Sanitation & Hygiene	Establishes the National Water, Sanitation & Hygiene Commission of Liberia (NWSHC), defines its functions and powers and provides with respect to its administration and organization.

Commission Act of 2012	

Source: Water supply and sanitation policy, 2009, Environment Protection and Management Law of the Republic of Liberia, 2002; The National Water, Sanitation & Hygiene Commission Act of 2012; Sanitation and wastewater atlas of Africa, 2020

WATER QUALITY MONITORING AND TESTING CAPACITY

Comprehensive water quality assessments are scarce in Liberia. In 2017, the Ministry of Public Works completed a survey of over 20,000 water points across all counties, although the survey provided only limited water quality data related to fecal coliforms and basic chemical parameters (USAID, n.d.).

Laboratory Facilities and Capacity

There are six key agencies involved in monitoring water quality: the EPA, Ministry of Lands, Mines and Energy, Ministry of Public Works, Ministry of Health, Ministry of Education and Liberia Water and Sewer Corporation. However, major challenges such as civil war and the Ebola crisis has resulted in the loss of water quality monitoring capacity in Liberia (Warner, 2019). According to the AMCOW/IWMI survey (2021), it is perceived that the country lacks capacity in water quality testing, monitoring water resources as well as water quality data management in terms of equipment, infrastructure & reagents. The survey further revealed that water quality monitoring mostly focuses on the groundwater sources.

References:

An African Ministers' Council on Water (AMCOW) Country Status Overview, 2011.Water Supply and Sanitation in Liberia, https://www.wsp.org/sites/wsp/files/publications/CSO-Liberia.pdf

Country Story: Liberia and an Innovative Data Source,2020

Environment Protection and Management Law of the Republic of Liberia,2002

Dorko K. W. D. 2018. Environmental Impacts of Gold Mining in Liberia: A Case Study of New Liberty and MNG Kokoya Gold Mines. University of Liberia. https://limpac.org/wp-content/uploads/2019/03/Korlah-WD-Dorko-Environmental-Impacts-of-Gold-Mining-in-Liberia-.pdf

Gibson, S. M. (2019). *Evaluation of Landfill Effects on Soil and Water Sources, A Case Study of the Whein Town Sanitary Land Fill, Montserrado County-Liberia* (Doctoral dissertation, University of Ghana).

Gleekia, A., Pradhan, D., & Sahu, H. (2016). Impacts of Iron Ore Mining on Water Quality and the Environment in Liberia. In 6th Asian Mining Congress (pp. 371-380).

Government of Liberia. 2018. Water, Sanitation and Hygiene. Sector Performance Report.

Kamara, A. M. (2019). Assessment of Heavy Metal Pollution in Soil and Surface Water in Mng-Gold, Kokoya District, Bong County, Liberia (Doctoral dissertation).

Kumpel E., Albert J., Peletz R., De Waal D., Hirn M., Danilenko A., Uhl V., Daw A., Khush R. 2016. Urban water services in Fragile States: An analysis of drinking water sources and quality in port Harcourt, Nigeria, and Monrovia, Liberia. Am. J. Trop. Med. Hyg. 2016;95:229–238. doi: 10.4269/ajtmh.15-0766.

Liberia, Global water organization,https://www.globalwaters.org/wherewework/africa/Liberia

Ministry of Public Works. 2019. The Liberia Country Profile. Sector Ministers' Meeting 2019. https://www.sanitationandwaterforall.org/sites/default/files/migrate_default_content_files/Liberia_Country_Brief.pdf

Sanitation and wastewater atlas of Africa, 2020, ISBN: 978-82-7701-194-3, https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/545/original/WWAtlas_lores.pdf?1594115866

USAID Liberia Municipal Water Project (LMWP), 2016 https://usaidlearninglab.org/sites/default/files/resource/files/liberia_municipal_water_projects_sustainability_monitoring.pdf

USAID. n.d. Liberia Water Resources Profile Overview. Water Resources Profile Series. https://pdf.usaid.gov/pdf_docs/PA00XV5T.pdf

Warner, S. (2019) UN Environment GEMS/Water Capacity Development Center, Water quality Monitoring capacity scoping report for Africa part 1: Irish Aid countries (2018)

Water supply and sanitation policy, 2009, Ministry of lands, mines and energy In Collaboration with the Ministry of Health and Social Welfare (MOH), Ministry of Public Works (MPW), and Liberia Water and Sewer Corporation (LWSC)

WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2017, https://washdata.org/data/household#!/

Malawi

BACKGROUND/CONTEXT

Population: 19.1 million

Water Supply: 92.0% of the total population have access to improved water supply; 91.0% in rural and 96.7% basic water supply in urban areas (JMP, 2021)

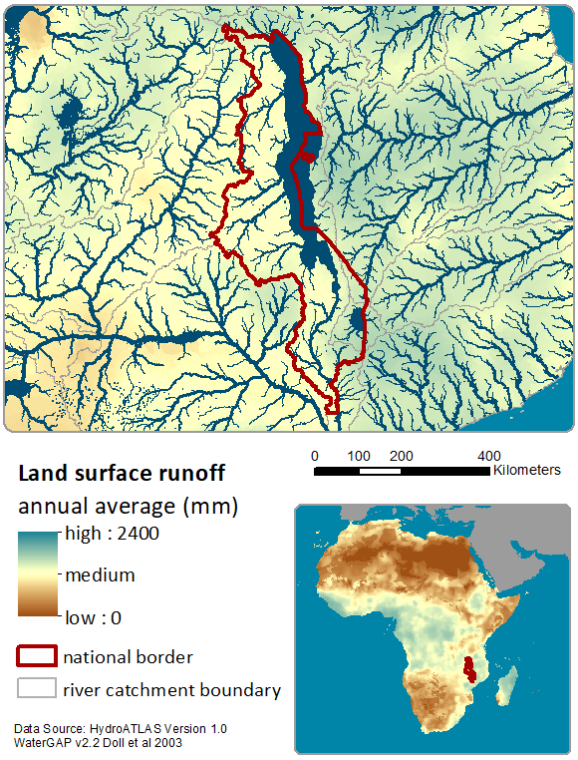
Sanitation: 40.0% of the total population have improved sanitation services 35.9% in rural areas and 59.9% in urban areas.

4.5% of the total population practice open defection; 5.1% in rural and 1.2% in urban areas (JMP, 2021).

Major River systems: Shire, Songwe, South Rukuru, North Rukuru, Dwangua, Linthipe, Lilongwe River and Bua

Major water bodies: Lake Malawi,

SDG Indicator 6.3.2: No available data.



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Groundwater quality is mostly acceptable in Malawi; however, it is not the case with surface waters as most of the sources are polluted or under pressure from unsustainable agriculture, deforestation, settlements, mining, industry, commerce, tourism and climate change. Sediment loads are also a major challenge in rivers and streams due to soil erosion mainly caused by deforestation resulting in restricted river flows, causing flooding and water pollution (Kandodo, 2017).

Insufficient waste disposal mechanisms across the country have resulted in the dumping of solid waste and industrial effluent into water bodies in urban areas like Lilongwe River and Mudi River the main water sources of drinking water supporting Malawi's two largest cities (Lilongwe and Blantyre respectively) posing a greater health risk to the local population (Kumwenda et al., 2012 and Nyasulu 2012). Cholera and diarrhoea are endemic in Malawi and have all been linked to polluted water.

Major pollution categories and example of their occurrence in Malawi

Major Categories	Examples	References
Organic pollutants	Findings revealed that despite the banning of POPs in Malawi as a signatory to the Stockholm Convention of 2001, the illegal usage and selling of banned POPs is rampant. These pops eventually make their wat into water resouces.	Makaya, E. & Tanyanyiwa, V, (2016)

Major Categories	Examples	References
Pathogens	Water in sources especially boreholes, open wells and selected households in four Malawian villages situated in Bangwe Township, Blantyre city were fund to be contaminated with Faecal coliform exceeding WHO and MBS safe standards and were detected in 79% of all samples analysed.	Kaonga et al., 2013
	In Lilongwe, faecal contamination (*Escherichia coli*) was detected in 10% of the 40 samples collected from planned areas, in 59% of the 64 samples collected from kiosks in the unplanned areas and in 75% of the 32 samples of water stored at household level.	Akosua et al., 2016
Nutrients and agriculture runoff	In southern Malawi, the Likangala River, which is important for irrigation, domestic use and fishing, is affected by various land uses within its catchment. The impact of urbanisation and agriculture on the water quality of this river was investigated in 2013 and increased anions and cations were found downstream of urban areas, although most values were within acceptable levels.	Pullanikkatil D et al., 2015
Inorganic pollutants (salts and metals)	Water samples were collected from five main streams around Blantyre city, and were analysed for phosphates (P O4 3−), biochemical oxygen demand (BOD), nitrates (NO3 −), sulphates (SO4 2−), suspended solids (SS), pH, oil and grease, and electroconductivity (EC). Results showed that the impairment of water quality in those streams was dependent on the type of surrounding industries..	Kuyeli, S et al., 2009

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

State Agency or Department	Main Role/Responsibilities
Ministry of Agriculture, Irrigation and Water Development.	Responsible for policy, regulation, water service provision, and surveillance in urban areas and carries out direct operational monitoring of rural supplies and audits water quality testing of rural Water Boards
Catchment Management Committee (CMC)	Broad scale institutional arrangement and Water resources conservation, activities, works, use and allocation
City and Regional Water boards	Responsible for the provision of water supply services and manage and monitor water quality of the source of raw water. Abstract and treat water in full compliance with regulatory bodies such as World Health Organization (WHO) and Malawi Bureau of Standards (MBS)
Ministry of Health and Population	Water sanitation and hygiene programs.
Malawi Bureau of Standards (MBS)	Provides standards for water quality, standards for effluent discharge quality and guidance on the conduct of water quality sampling program
National Water Resources Authority (NWRA)	Developing principles, guidelines and procedures for the allocation of water resources, monitor, and from time to time reassess, the National Water Policy and the National Water Resources Master Plan Regulate and protect water resources quality from adverse impacts.

Source: Sanitation and Wastewater Atlas of Africa 2021; Integrated Water Resources Management and Water Efficiency (IWRM/WE) Plan 2008 -2012

Water Pollution Monitoring and Control: Policies and Regulatory Environment

Policies/Regulations	Description/ scope
National Environmental Policy 2004	Promote effective water pollution monitoring and prevention programs based on enforceable water quality guidelines and standards. Provide training in specialized areas of environmental management including environmental(water) quality monitoring.
Integrated Water Resources Management and Water Efficiency (IWRM/WE) Plan 2008 - 2012	Ensures the coordinated development and management of water, land and related resources by maximizing economic and social welfare without compromising the sustainability of environmental systems, water quality and pollution control
Malawi Water Works Act 1995	Defines the responsibilities of agencies working in the sector, specifically the water boards, and provides a legal framework for implementation of integrated water resources management policy.
Water Resources Act,1213 (No. 2 of 2013)	Provide for the management, conservation, use and control of water resources; for the acquisition and regulation of rights to use water; and for matters connected with water resources.
National Water Policy 2005	Management of water resources and development, water quality and pollution control, water utilization, disaster management and institutional roles and linkages.
National Environmental Action Plan - 1994	provides the framework for integrating environmental protection and management in all national development programs with the view to achieving sustainable socio-economic development.
Environmental Management Act, No. 23 of 1996, Article 43	Provides requirements for Discharge of any effluent
Water Resources (Water Pollution Control) Regulations, 1978	Effluent Discharge Consent which aims to control water pollution. Effluent must conform to standards set by the Malawi Bureau of Standard
Malawi Bureau of Standards, 2011	Provides guidance on the conduct of water quality sampling program

Source(s): Sanitation and Wastewater Atlas of Africa 2021; Integrated Water Resources Management and Water Efficiency (IWRM/WE) Plan 2008 -2012

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Main stakeholders	Scope
Sustainable Rural Water Infrastructure for Improved Health and Livelihoods (SRWIHL) 2015 - 2020	African Development Bank; African Development Fund; Ministry of Irrigation and Water Development; Government of Malawi.	Supports catchment protection measures to sustain raw water sources and also supports the installation of groundwater monitoring and stream hydrometry stations in key locations including rehabilitation of water quality laboratories to enhance water quality and pollution monitoring.

Initiative	Main stakeholders	Scope
Lake Malawi Ecosystems Monitoring Project (LMMP),	Ministry of Agriculture, Irrigation and Water Development; World Bank	Provide funds for monitoring of Lake Malawi
Malawi's Environmental Monitoring Program: MEMP	Environmental Affairs Department Malawi; Ministry of Natural Resources and Environmental Affairs.	MEMP combines the process of evaluating and monitoring the effects on the environmental policy reform activities with a broader process of Environmental monitoring including watershed monitoring program as part of the Malawi National Environmental Action Plan (NEAP) process.
Shire River Basin Management Program SRBMP	Ministry of Agriculture, Irrigation and Water Development;	strengthen the institutional capacities and mechanisms for Shire Basin monitoring, planning, management and decision support systems Reducing erosion in priority catchments and sedimentation and flooding downstream.

Sources(s) Malawi: Shire River Basin Management Program report of 2019; R.J. Tobin 1999; Malawi national guidelines: integrated catchment management and rural infrastructure volume 1 of 2015

WATER QUALITY MONITORING AND TESTING CAPACITY

The Ministry of Irrigation and Water Development in Malawi is responsible for policy, regulation, water service provision, and surveillance in urban areas and has been carrying out direct operational monitoring of rural water supplies and audits water quality testing of rural Water Boards (Rahman et al, 2011). There is no independent surveillance agency for water quality monitoring besides the National Water Resources Authority (NWRA) established in 2013 but it is mainly the duty of the five water boards in urban areas or the district assemblies in rural areas to monitor drinking water quality, however, inadequate human and financial resources limit the capacity to successfully carry out these duties (Kayser et al., 2015, Mulwafu et al., 2003)

Laboratory Facilities and Capacity

Major laboratories capable of testing most water quality parameters and have the capacity to monitor water quality.

1. Central Water Laboratory (National)
2. Blantyre water laboratory (regional)
3. Mzuzu Water Laboratory(regional)
4. Malawi Bureau of Standards Laboratory (National)
5. Water Boards Laboratories (Regional)
6. Blantyre City Council Lab (mostly for testing wastewater)
7. Mzuzu University Centre of Excellence in Water and Sanitation laboratory.

Blantyre, Mzuzu and central laboratories conduct routine water quality monitoring of major rivers, urban and rural water supplies, recreational waters and wastewater. They have the capacity to measure major cations and anions as well as microbiological quality of water.

REFERENCES:

Boakye-Ansah, A., Ferrero, G., Rusca, M., Van der Zaag, P. (2016). Inequalities in microbial contamination of drinking water supplies in urban areas: The case of Lilongwe, Malawi. Journal of Water and Health. 14. 10.2166/wh.2016.258.

Chiluwe, Q., Nkhata, B.A. (2014). Analysis of water governance in Malawi: Towards a favourable enabling environment. Journal of Water, Sanitation and Hygiene for Development. 4. 313. 10.2166/washdev.2014.087.

Döll, P., Kaspar, F., Lehner, B. (2003). A global hydrological model for deriving water availability indicators: model tuning and validation. Journal of Hydrology, 270, 105-134

Kaonga, C.C., Kambala, C., Mwendera, C., Mkandawire, T. (2013). Water quality assessment in Bangwe Township, Blantyre City, Malawi. Afr J Environ Sci Technol. 7. 259-266.

Kayser, G. L., Amjad, U., Dalcanale, F., Bartram, J., & Bentley, M. E. (2015). Drinking Water Quality Governance: A Comparative Case Study of Brazil, Ecuador, and Malawi. *Environmental science & policy*, *48*, 186–195. https://doi.org/10.1016/j.envsci.2014.12.019

Kumwenda, S., Tsakama, M., Kalulu, K., Kambala, C. (2012). Determination of Biological, Physical and Chemical Pollutants in Mudi River, Blantyre, Malawi. 2. 6833-6839

Kuyeli, S., Masamba, W., Fabiano, E., Sajidu, S., Henry, E. (2009). Temporal and spatial physicochemical water quality in Blantyre urban streams. Malawi J. Sci. Technol.. 9.

Makaya, E., Tanyanyiwa, V. (2016). Prevalence of Persistent Organic Pollutants in Blantyre -Malawi. 4. 61-66. 10.12691/env-4-3-1.

Mccullough, G. (2009). The Effect of Suspended Solids Loading from the Linthipe River on Light in Lake Malawi. Journal of Great Lakes Research. 33. 466-482. 10.3394/0380-1330(2007)33[466:TEOSSL]2.0.CO;2.

Mulwafu, W., Chipeta, C., Chavula, G., Ferguson, A., Nkhoma, B., Chilima, G. (2003). Water Demand Management in Malawi: Problems and Prospects for its Promotion. *Physics and Chemistry of the Earth.* 2003;28:787–796.

Najira, S., Monjerezi, M., Ngongondo, C., Banda, M.H. (ND). Hydrological and Water Quality Characteristics of Rivers Feeding into Small Earth Dams for Rural Water Supply: A Case Study of Traditional Authority Kalolo in Lilongwe District.

Phiri, O., Mumba, P., Moyo, B.H., Kadewa, W. (2005). Assessment of the Impact of Industrial Effluents on Water Quality of Receiving Rivers in Urban Areas of Malawi. International Journal of Environmental Science and Technology. 2. 10.1007/BF03325882.

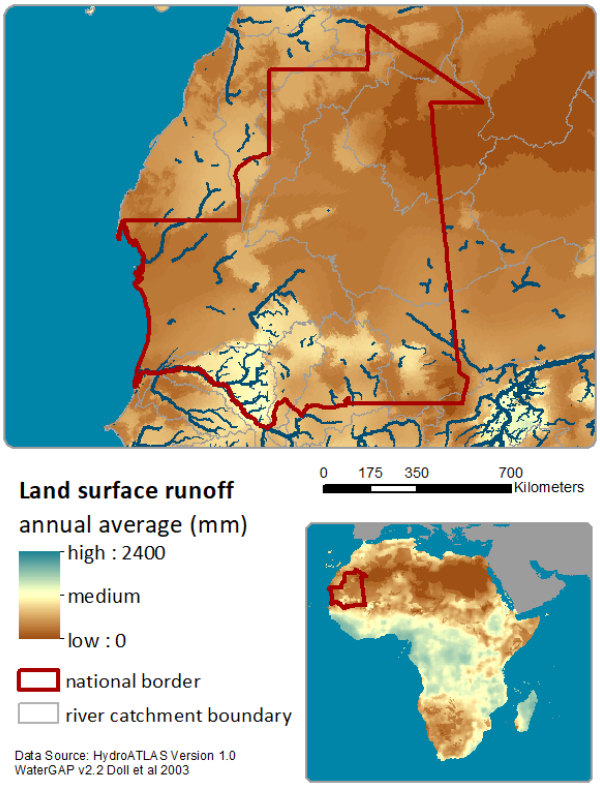
Pullanikkatil, D., Palamuleni, L.G., Ruhiiga T.M. (2015) Impact of land use on water quality in the Likangala catchment, southern Malawi, African Journal of Aquatic Science, 40:3, 277-286, DOI: 10.2989/16085914.2015.1077777 To link to this article: https://doi.org/10.2989/16085914.2015.1077777

Rahman, Z., Crocker, J., Chang, K., Khush, R., Bartram, J. A. (2011) comparative assessment of institutional frameworks for managing drinking water quality. *Journal of Water, Sanitation and Hygiene for Development.*

Mauritania

BACKGROUND/ CONTEXT:

- **Population:** 4.6 million (JMP, 2021).
- **Water supply** : National unimproved water supply –14.8%; Rural- 31.5%; Urban- 1.3%. (JMP, 2021).
- 68% of population have access to drinking water in Mauritania (Feukeng, 2019).
- **Sanitation**: National unimproved sanitation: Total- 11.8%; Rural- 16.3%; Urban-8.5% (JMP, 2021).
- 30.7% of the population still practice open defecation (JMP, 2021).
- **Sanitation**: National unimproved sanitation: Total- 3.8%; Rural-14.7%; Urban-9.5% (JMP, 2020). 2.0% of the population still practice open defecation (JMP, 2021).
- **Major Rivers systems:** Senegal River, Gorgol River, Karakoro River, and Kolimbine River
- **SDG 6.3.2 Indicator (2020):** No data available



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Access to water is a major and persistent challenge in Mauritania due to its geographic and climatic condition (SDG , 2021) as such, Mauritania is largely dependent on groundwater but there is little documentation about its quantity, quality and recharge rate (UN Water, 2021). Moreover, rapid urbanization in Mauritania puts pressure on the water and sanitation service sector. According to The World Bank, (2020), Senegal River is the only permanent river in the country and about 97 percent of the renewable water resources are concentrated in and around this river. It is the most critical river to the region, other rivers are temporary and short (Mahmoud-hamed et al., 2019).

Management of the water resources appears necessary in countries like Mauritania where the climate is arid and dry. Human induced factors like poor sanitation practices, inappropriate design impact water quality in the Senegal River and siting of latrines and garbage heaps along the coast find their way to the river. Agriculture activities including livestock grazing along the river and chemicals and pesticides used for farming contribute to the pollution burden (SWA, 2020).

Major pollution categories and examples of their occurrence in Mauritania*:*

Major Categories	Examples	References
High organic loads and high biological oxygen demand	A study was conducted on the national water supply in 14 municipalities (Nouakchott neighborhoods, El Mina, and Tevragh-Zeina). The supply of water is drawn from the Senegal River near the city of Nouakchott. Water samples identified faecal contamination through some parts of the water distribution network. The study could	(Traoré et al., 2015) (UNICEF, 2017)

Pathogens/ bacteriological contamination	link the contamination of water sources to the absence of proper standards in household sanitation technologies and transportation of waste using donkeys and metal drums often in poor condition and lack of maintenance and disinfection.	(Babah et al., 2016)
Trace metal (Hg, Pb, and Cd)	Mahmoud-hamed et al., (2019) reported trace levels of metals in the Senegal River. The assimilation of metals can occur because of the ingestion of particulate matter suspended in the water and contaminated food.	(Mahmoud-hamed et al., 2019)

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Main Role/Responsibilities
Development of the Senegal River (OMVS)	The aim of the OMVS is to integrate and coordinate management of the river basin to monitor quality and quantity levels
SNDE; National Water Company (Société Nationale De l'Eau)	SNDE responsible for the production, transport, distribution and sale of drinking water in the urban and central of Mauritania
NRWA; National Rural water Agency (Office National des Services d'Eau en Milieu Rural, ONSER),	Responsible to manage the quality and supply of about half of the country's rural piped water systems
ANEPA; National Agency for Water Supply and Sanitation (Agence Nationale de l'Eau potable et de l'Assainissement)	This agency handles the delivery of water supply and sewerage services including provision of oversight and support services to the local communities and other water supply service providers
CNRE; National Center for Water Resources (Centre national de ressources en eau)	CNRE is mandated to manage water resources nationwide

Source: (AMCOW, 2015; The World Bank, 2020)

Water pollution monitoring and control: policies and regulatory environment

Policies and regulatory for water pollution monitoring and control in Mauritania:

Policies/Regulations	Description/ Scope
National Strategy for Sustainable Access to Water and Sanitation	This strategy lays out the Government's priorities in the water sector and aligns with the Strategy for Accelerated Growth and Shared Prosperity.

Source: (Islamic Republic of Mauritania, 2020)

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative program for water quality monitoring, and pollution control in Mauritania*:*

Initiative	Main stakeholders	Scope
Emergency Development Programme (PDU)	Sahel Alliance members' activities, specifically those of the French Development Agency (AFD) and the European Union (EU),	Contribute to improving the living conditions of the populations through better access to water and sanitation. Monitoring the quality of water supply.
PNAR National Rural Sanitation Program (Programme National d'Assainissement Rural)	Mauritanian government and the Islamic Development Bank (IDB)	This project aims to combat the water shortages that have been affecting the North part of the country for some time and extend the national water quality and distribution network in the country
Water and Sanitation Sectoral Project	World Bank Group (WBG) Executive	This project contributes to the goals of the 2018-2023 "Country Partnership Framework" (CPF). The project will support the CPF by strengthening Mauritania's capacity to manage the groundwater resources and the quality rate, which are an important buffer for climate change-related water shortages.

(The World Bank, 2020)

WATER QUALITY MONITORING AND TESTING CAPACITY

According to AMCOW/IWMI Survey, (2021), they perceive that there is low priority towards water quality control and monitoring from the Government. Hence, there are several institutions engaged in water pollution control, monitoring, and quality analysis. Examples of such institutions are; The National Institute for Research in Public Health (Mauritania), SNDE Laboratory, National Water Resources Centre, and Laboratory of the Faculty of Sciences of Rabat in Morocco.

The AMCOW/IWMI Survey showed a lack of well-trained personal, equipment and materials, and data processing and analysis are the most important laboratory capacity needs in relation to water quality monitoring in the country. The non-government actors (communities, NGO etc.) are poorly informed and unaware of the potential dangers regarding water quality issues in Mauritania (AMCOW/IWMI Survey, 2021).

Laboratory Facilities and Capacity

The AMCOW/IWMI Survey result perceived that there are at least three equipped water testing laboratories in the country and all water testing laboratories require national-level registration to operate fully. (AMCOW/IWMI Survey, 2021).

REFERENCES:

AMCOW. (2015). Water Supply and Sanitation in Mauritania.

Babah, I. A., Froelich, D., Deida, M. F., & Blake, G. (2016). Evolution of the fresh water distribution in Nouakchott after the commissioning of the Aftout Es Saheli project (water from the Senegal River). Desalination and Water Treatment, 57(13), 5932–5945. https://doi.org/10.1080/19443994.2015.1049957

Mahmoud-hamed, M. S. El, Montesdeoca-esponda, S., Pino, A. S., Zamel, M. L., Brahim, M., & Hasni, T. (2019). Distribution and health risk assessment of cadmium , lead , and mercury in freshwater fish from the right bank of Senegal River in Mauritania.

Sanitation and Water for All. (2020). MAURITANIA; COLLABORATIVE BEHAVIOUR PROFILE (2020).

Sanitation and Water for All (SWA). (2021). SWA Partnership Strategy 2020-2030; SWA REGIONAL ROADMAPS 2021-2025.

The World Bank. (2020). The World Bank Mauritania Water and Sanitation Sectoral Project. In The World Bank.

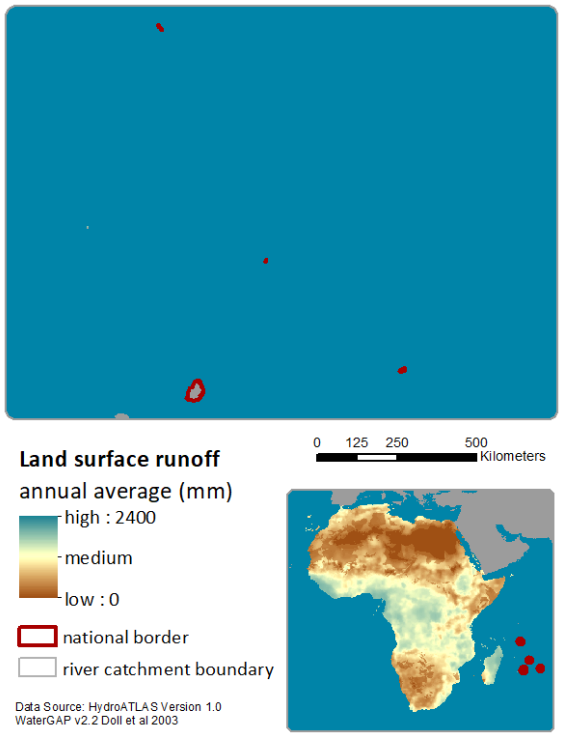
Traoré, D., Sy, I., Utzinger, J., Epprecht, M., Kengne, I. M., Odermatt, P., Faye, O., Cissé, G., & Tanner, M. (2015). Water quality and health in a Sahelian semi-arid urban context : an integrated geographical approach in Nouakchott , Mauritania. 8(1), 53–63.

UNICEF. (2017). Progress for Every Child in the SDG Era Country Profile UNICEF; Mauritania.

Mauritius

BACKGROUND/ CONTEXT:

- **Population:** 1.27 million
- **Water supply**: National improved water supply – 99.9%; Rural - 99.8%; Urban-99.9% (JMP, 2021)
- **Sanitation**: National and rural improved sanitation – no data available; Urban-99.9%; National and rural open defecation - no data available; Urban- 0.0% (JMP, 2021)
- **Major Rivers systems**: Mauritius is divided into 25 main catchment areas or river basins, each corresponding to a main river (Nigel, et al., 2005).
- **Major water bodies**: The Grand River Southeast and the Grand River Northwest are the largest river basins (Nigel, R et al., 2005).
- **SDG 6.3.2.** – No data available



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Although 99% of the population in Mauritius has access to clean water, The main water quality concerns include contamination of ground- and surface waters by discharge and seepage of wastewater originating from households, commercial buildings and industries occurring in both sewered and non-sewered regions into the natural environment; Untreated or poorly treated industrial waste; intensified use of fertilizers and pesticides these concerns pose a particular serious threat to the environment of Mauritius and the health of its people (Republic of Mauritius, n.d. ;Daby, 2006).

Sugar production, breweries, textile, food processing, leather tanning and galvanizing industries have also been reported to produce large amounts of industrial wastewater, with only small percentage directed to sewerage treatment plants. This plus brine from desalination used by plants used by some coastal hotels and tourist resorts are at times injected into existing boreholes posing a significant threat to aquifers in such vicinities (DRR – Team Mauritius Mission Report).

Major pollution categories and their status in Mauritius

Major Categories	Examples	References
Organic pollutants	Different sites around Mauritius were sampled and analysed. Total coliform (TC), faecal coliform (FC), and faecal streptococci (FS) contamination were reported during all surveys and at times exceeded	Daby, et al., 2002.

Major Categories	Examples	References
	the established Environment Protection Agency (EPA) standards for bathing water (e.g., with maximum densities in the ranges of 346–2020 TC, 130–2000 FC, and 180–1040 FS at one site) to qualify for beach closure.	
Pathogens	To gain a better understanding of the early bacterial biofilm community, microfiber nets were used as artificial substrates and incubated for a period of 24 h in Mauritius coastal waters by employing Next-generation sequencing technologies as a tool for identification of early bacterial communities, proteobacteria were identified as the predominant bacterial microorganisms in the biofilm within the 24 h incubation, of which members associated to ammaproteobacteria, Alphaproteobacteria and Betaproteobacteria were among the most abundant classes	Rampadarath et al., 2017
Nutrients and agriculture runoff	A study on microbial and nutrient pollution of coastal bathing waters in Mauritius found high nitrate, phosphate, and silicate concentrations in seepage water and a basis for concern when compared with levels in cleaner lagoon water samples of coastal bathing waters in Mauritius.	Daby, D et al., 2002.
Inorganic pollutants (salts and metals)	A study aimed principally to assess contaminant metals from sewage and industrial waste water discharge in Mauritius was conducted. Enhanced levels of contaminant metals (Cu, Cd, Zn,) were recorded exceeding the recommended limits and suitable bio monitors were identified.	Daby, 2006.

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Main Role/Responsibilities
The Ministry of Energy and Public Utilities (MEPU)	Parent body for management of water resources in Mauritius; assessment, management, development and conservation of water resources through WRU; enforcing inland water quality (groundwater and surface water) and counter pollution
Central Water Authority (CWA),	Responsible for potable water distribution, and to some degree the management of water supply infrastructure
Wastewater Management Authority (WMA),	Responsible for managing wastewater in sewered areas.
Ministry of Social Security, National Solidarity, Environment and Sustainable Development (MoE)	Hosts a division responsible for environmental safeguards during implementation of projects, a Pollution Prevention and Control Division and an Industrial Waste Audit Committee.
National Environmental Laboratory (NEL	Monitors environmental quality to ensure compliance with prescribed environmental standards.
Water Resources Monitoring Committee	Meets to discuss relevant strategies with regards to drought management, water conservation and other associated issues. This inter-agency mechanism is primarily concerned currently with sustainable resource allocation and meet on an ad hoc basis, primarily during the dry season

Ministry of Health and Quality of Life	Responsible for the collection of municipal wastes, also undertakes independent spot-checks of drinking water quality, thereby fulfilling a watch-dog function.

Source: Mauritius National IWRM plan; Sanitation and Wastewater Atlas of Africa 2021

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
National Water Policy – 2014	The Mauritius National Water Policy (NWP) is based on Government socioeconomic policies and development strategies, as well as national objectives and targets defined for the water and sanitation sectors. It is also based on national principles of integrated water resources management.
Central Water Authority Act (1971)	Provides for the establishment of a body corporate responsible for the control, development and conservation of water resources. The Authority has, amongst others, the duty to supervise the enforcement of any water legislation;
Environment Protection Act (2002)	A national legislative framework which provides for, inter alia, the protection and management of environmental assets, including, but not limited to water.
Ground Water Act (1970)	Aims to protect unlawful abstraction and pollution of ground water and makes it an offence to alter the composition or quality of ground water by any physical, chemical or biological means or process.
Water/WasteWater Master Plan, 2012	Elaborate a program for the development and management of wastewater in Mauritius for a period of 20 years 2014-2033.
Public Health Act (1925)	Seeks to primarily ensure there is no threat to public health. The Public Health Act also provides for water-related offences.
Waste Water Management Authority Act (2000)	Responsible for the waste water sector in Mauritius and to carry out, monitor, supervise, maintain, manage and control waste water works as well as to promote the treatment and reuse of waste water.
Rivers and Canals Act (1863)	Regulate the status and prevents the pollution of rivers, streams and canals.
Fisheries and Marine Resources Act (2007) 7	Consolidate the law relating to the management, conservation, protection of fisheries and marine resources and protection of the marine ecosystems. In order to safeguard waterbodies, section 69 of the Fisheries and Marine Resources Act makes it an offence to place, throw, discharge or cause to be placed, thrown or discharged into the maritime zones or into a river, lake, pond, canal, stream, tributary or wetland any poisonous substance.

Source: Mauritius National IWRM plan; Sanitation and Wastewater Atlas of Africa 2021

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Main stakeholders	Scope
Central national water resources database and Decision Support	MEPU, CWA, WRU, MoE, MoH	Water quality monitoring systems (surface water, groundwater and wastewater) integrated into national database Access protocols and database update

System (DSS) established		mechanisms implemented, including defined access rights for the public
Water and Air Quality Monitoring – Post grounding of the MV Wakashio	National Environmental Laboratory (NEL), Albion Fisheries Research Centre (AFRC) and Mauritius Oceanography Institute (MOI)	Water quality monitoring of 4 sites by the Ministry of Environment, Solid waste Management and Climate Change, namely Blue Bay, Pointe D'Esny, Pointe Jerome and Mahebourg Waterfront for various parameters including Oil and Grease and Total Hydrocarbons as from 26 July 2020.
Quarterly river monitoring	National Environmental Laboratory (NEL) of the Ministry of Environment, Solid Waste Management and Climate Change.	Monitoring river water quality of twenty-seven rivers throughout the island on a quarterly basis to assess the impacts of the National Sewerage Programme on water sanitation in Mauritius by the National Environmental Laboratory (NEL) of the Ministry of Environment, Solid Waste Management and Climate Change.
Water Quality Surveillance	Ministry of Energy and Public Utilities (MEPU); Water Resources Unit; Central Water Authority; Wastewater Management Authority; Ministry of Environment; Ministry of Agro-Industry & Food Security (Forestry Services); Ministry of Finance; Ministry of Health and Quality of Life.	MEPU set up a Water Quality Surveillance Committee in the year 2012 to look into the aspect of water quality in Rivers and Reservoirs of Mauritius.

WATER QUALITY MONITORING AND TESTING CAPACITY

Presently, Central Water Authority (CWA) has the primary responsibility for drinking water quality monitoring. In addition, the Ministry of Health functions as an independent watchdog and takes their own samples. The MEPU is responsible for enforcing inland water quality (groundwater and surface water) and counter pollution, but has at present no enforcement unit to do it. There is some duplication of monitoring activities between the CWA and Ministry of Environment for raw water and effluent discharge (Mauritius National IWRM plan).

The National Environmental Laboratory of the Department of Environment in collaboration with other laboratories (Ministry of Fisheries, Waste Water Management Authority, Central Water Authority) perform regular monitoring of inland and coastal water quality around the island. Key issues that need consideration to strengthen the capacity for water quality management in Mauritius include the limited enforcement capacity in local authorities and the lack of access by all responsible authorities to water quality data since there is no adequate central water quality database (Mauritius National IWRM Plan).

Laboratory Facilities and Capacity

National Environmental Laboratories

As the scientific arm of the Ministry of Environment, Solid Waste Management & Climate Change, the National Environmental Laboratory (NEL) monitors environmental quality to ensure compliance with prescribed environmental

standards. The NEL performs a number of physicochemical and micryobiological analyses to assess surface and groundwater quality and collaborates with other laboratories for monitoring, analysis and reporting. As an accredited laboratory (MS ISO/IEC 17025), the NEL also develops analytical methods. As per the MS ISO/IEC 17025 international standards.

Other Laboratories capable of carrying out water quality tests include

1. National Environmental Laboratory
2. Water Quality Laboratory of Central Water Authority
3. Wastewater Laboratory
4. MSB Laboratories
5. Abiolabs Ltd
6. Quantilab Ltd
7. Mauritius Sugarcane Industry Research Institute
8. Mauritius Sugarcane Industry Research Institute
9. CHEMCO Limited
10. Laboratoire International de Bio Analyse (LIBA) Ltee

REFERENCES

Daby, D., Turner, J., Jago, C. (2002). Microbial and nutrient pollution of coastal bathing waters in Mauritius. Environment international. 27. 555-66. 10.1016/S0160-4120(01)00109-X.

Daby, D.. (2006). Coastal Pollution and Potential Biomonitors of Metals in Mauritius. Water, Air & Soil Pollution. 174. 63-91. 10.1007/s11270-005-9035-4.

Döll, P., Kaspar, F., Lehner, B. (2003). A global hydrological model for deriving water availability indicators: model tuning and validation. Journal of Hydrology, 270, 105-134

https://www.mapsland.com/africa/mauritius/large-regions-map-of-mauritius

Mohammed, K. (2017) water quality in Mauritius. borgen projects. *https://borgenproject.org/water-quality-in-mauritius/*

Nigel, R., Rughooputh, S., Nathire, F. (2005). Delineation of Major Drainage Basins of Mauritius. 289-295.

Republic of Mauritius (n.d.). National Integrated Water Resources Management Plan. Accessed on 29th October 2021; accessed from http://extwprlegs1.fao.org/docs/pdf/mat194845.pdf

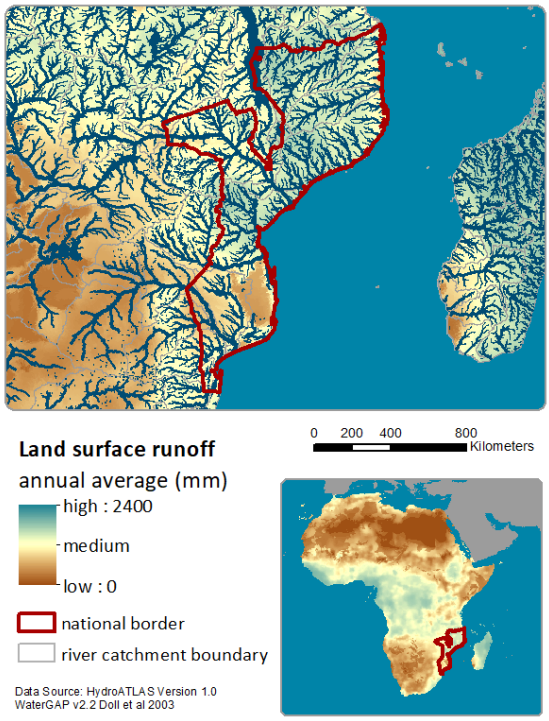
Sillma, R., Kushlata, B., Daneshwar, P., Rajesh, J., Subhasisa B. (2017). Early bacterial biofilm colonizers in the coastal waters of Mauritius, Electronic Journal of Biotechnology, Volume 29, Pages 13-21, ISSN 0717-3458, https://doi.org/10.1016/j.ejbt.2017.06.006. (https://www.sciencedirect.com/science/article/pii/S0717345817300386)

Mozambique

BACKGROUND/ CONTEXT:

- **Population:** 31.26 million
- **Water Supply**: National water coverage – 73.3%; Rural – 61.5%; Urban – 93.4% (JMP, 2021)
- **Sanitation:** National sanitation coverage – 42.2%; Rural – 24.7%; Urban – 71.9%; National open defecation- 20.7%; Rural- 30.0%; Urban – 5.1% (JMP, 2021)
- **Major water bodies**: Zambezi River, Limpopo River, Ruvuma River, Olifants, Komati, Shire, Pungwe, Mazowe, Save (Sabi) Lugenda, Lake Niassa and Lake chiura

- **SDG Indicator 6.3.2**: No available data.



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Mozambique has 104 identified river basins that drain the central African highland plateau into the Indian Ocean with the majority of the rivers being highly seasonal. There are two main natural lakes; Lake Niassa, shared with Malawi and the United Republic of Tanzania and Lake Chiura shared with Malawi (FAO, 2005).

Effluent from households, agriculture and industry, are the primary source of water pollution but the growing interest in exploiting natural gas, metals and other resources in the coastal areas of the country is also increasing the risk of polluting water resources (Norwegian School of Veterinary Science. (2013); FAO, 2005, UNEP, 2009)

Mozambique (Maputo) – Center for Environmental Research and Advocacy has also raised awareness on the growing concern of untreated sewage coming from new development that are not yet connected to the available sewage and drainage facilities in the capital of Mozambique, Maputo, which pollutes Maputo Bay waters, a popular destination for tourists and a valuable fishing ground for local fisher men.

Major pollution categories and their status in Mozambique

Major Categories	Examples	References
Organic pollutants	Absence of proper sewer systems and onsite sanitation in Maputo has resulted in to contamination of ground water sources and other fresh water ecosystems from domestic waste and sewage.	FAO. 2020; Wanda, et al., 2017.

Major Categories	Examples	References
Pathogens	E. coli, fecal, and total coliforms contamination in boreholes around peri-urban areas of Maputo were due to absence of sewers and seepage from on-site sanitation.	Wanda, E.M.M et al., 2017
	Macrocystin (MC) occurrence in Mozambique is an emerging and under studied pollution challenge attributed to eutrophication of water bodies. Only 50% of the population has access to safe drinking water, as such MC contamination poses a major public health risk.	Tamele, & Vasconcelos, 2020.
Nutrients and agriculture runoff	Improper management of domestic wastewater and fertilizers from agricultural activities resulted in high concentration of chloride and other nutrients.	Verlicchi, & Grillini, 2020.
Inorganic pollutants (salts and metals)	Artisanal and industrial gold mining activities have been affecting water resources in the Manica Province of Mozambique. An Observation and lab analysis of water quality for Révue and Chua rivers revealed poor water quality due to gold mining and other polluting activities in the river basin. High levels of turbidity, arsenic, chromium were observed.	Nhantumbo et al., 2020.
	High concentration of heavy metals such as Cadmium, Cobalt, Chromium, Copper, Iron, Manganese, Nickel, Vanadium, Zinc, and Aluminum are polluting the Incomati estuary	Gyedu & Soko, 2019.

POLICIES AND INSTITUTION

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	**Main Role/Responsibilities**
Ministry of Public Works and Housing (MOHP)	Responsible for all water related issues, specifically: to promote better use of national water resources; to propose policies for the development of water resources and their respective implementation; to propose the establishment of an inventory for water resources, demand and balance at national level and river basins and to regulate the usage of water resources
National Council of Water (CNA)	Advisory body for the Council of Ministers responsible for inter-sectoral co-ordination and strategic decision-making
National Directorate of Water (DNA)	The main institution under the MOPH responsible for the management of the Water Sector in the country; defining policies; Stock taking of water resources and requirements at all levels; Prepare legislation and inspect enforcement along others.
Regional water administrations (ARAs)	Responsible for carrying out operational management of water resources at regional scale, including the collection of hydrometeorological, data storage, dissemination, development of Flood Advisory System, registration of water users, billing and collection of water use charges, implementation of basin plans including the promotion of stakeholders' participation.
Director Nacional Abastecimento de Agua e Saneamento (DNAAS).	Responsible for drinking water and sanitation
Conselho de Regulacao do Abastecimento de Agua (CRA)	Ensures a balance between the quality of the service, the interests of consumers and the financial sustainability of the water supply systems by approving tariffs,

State Agency or Department	**Main Role/Responsibilities**
	setting service quality targets, monitoring compliance with the targets, Reviewing investment programs and hearing complaints by users and municipalities.

Sources: IWRM planning process Mozambique 2010; National water policy 2007; Nhantumbo, et al., 2015

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	**Description/ scope**
Water Law 1991	The country's main water Legislation based on a river basin approach towards water management and improved water and sanitation
National Water Policy 2007	Aims to achieve meeting the basic needs of human consumption of safe and reliable drinking water and improve sanitation as a basic essential tool for prevention of water-borne diseases.
Water Tariff Policy approved in 1998	Environmental protection and efficient use of water
National Water Resources Management Strategy 2007	Effectively guarantee the implementation of the National water plan and IWRM covering a whole range of water resources; water quality; protection of ecosystems; legal and institutional framework among others.
Rural Water Transition Plan 2001	A series of implementation strategies relating to the National Water Plan
Strategic Plan for Urban Water Supply & Sanitation 2006	
Strategic Plan for Rural Water Supply & Sanitation 2007	Explicates the medium- and long-term vision, objectives, priorities and strategic guidelines for the Water Sanitation and Hygiene sub-sector.
Implementation Manual for Rural Water Supply 1997	Operationalizes national water policy by providing implementation guidelines for relevant institutions at the national, provincial, district, and community level.

Source: Mozambique National water policy 2007; Munguambe, et al., 2010; Hall, et al., 2014; FAO, 2005

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	**Main stakeholders**	**Scope**
ARA-Zambezi water quality monitoring program	Zambezi River Basin Water Resources Managers and Dam Operators (ZAMDO); Zambezi River Authority; ARA-Zambezi	ARA-Zambezi is responsible for the water quality monitoring in Zambezi River Basin in Mozambique. Nhantumbo, et al., 2015
National groundwater monitoring	The water agency ARA-Sul	Collection of Hydrogeological information of a complete aquifer system in the metropolitan area of Maputo consisting of 25 ground water level monitoring points

		and 48 water quality monitoring points. Ground water levels are monitored on a monthly basis while electro-conductivity and chemical parameters monitored samples are taken on Quarterly basis.
Water & Sanitation for The Urban Poor (WSUP) – Mozambique	Thames water, Cranefield University, Care, Unilever, Borealis & Borouge	WSUP has worked in Greater Maputo and Beira since 2007, engaging with local government, service providers and communities to improve access to vital water and sanitation services for low-income urban families.
DNA based water quality testing 2017 – November 2018	VIA Water; Orvion; WE Consult; Ltd; AIAS; FIPAG; ARA-Zambeze	Introduced a field method for microbiological analysis, based on DNA technology that could be used in the field to improve water quality monitoring. The field device detects DNA of human pathogens in water samples, and integrates the digital data directly into web-based monitoring systems.

WATER QUALITY MONITORING AND TESTING CAPACITY

There is lack of consistent and comprehensive monitoring of surface and ground water quality in Mozambique. 34 surface water quality monitoring stations exist under the jurisdiction of ARAs, though no monitoring has been conducted by the ARA-Centro-Norte and ARA-Norte. Where functional monitoring networks exist, the process of data collection is usually slow and mostly with insufficient funding to increase monitoring coverage. Groundwater quality is not regularly monitored and the ARA-Sul Pilot Project is the only national groundwater monitoring program collecting data from 48 water points within the Maputo metropolitan area with limited water quality monitoring coordination between transboundary riparian countries (Government of Mozambique, 2018; IGRAC, 2013 Chilundo et al., 2008).

Laboratory Facilities and Capacity

The Ministry of Health is responsible for monitoring water quality following standards established with the 'Regulation on water quality for human consumption' and has laboratories across the country (Weststrate, et al., 2019). There other several NGO and private sector laboratories capable of water quality testing like the Watsan Mozambique water quality lab

References:

Chilundo, M., Kelderman, P., O´keeffe, J. H. (2008). Design of a Water Quality Monitoring Network for the Limpopo River Basin in Mozambique. Phys. Chem. Earth, Parts A/B/C 33 (8–13), 655–665. https://doi.org/10.1016/j.pce.2008.06.055.

Döll, P., Kaspar, F., Lehner, B. (2003). A global hydrological model for deriving water availability indicators: model tuning and validation. Journal of Hydrology, 270, 105-134

FAO. 2020. Organic and inorganic contaminants in marine sediments off Northern Mozambique – Results from the R/V Dr Fridtjof Nansen environmental survey. FAO EAF-Nansen Programme Report No. 18. Rome. https://doi.org/10.4060/ca9777en

FAO. 2020. Final Evaluation of "Disposal of Persistent Organic Pollutants and Obsolete Pesticides in Mozambique". Project Evaluation Series, 02/2020. Rome. https://doi.org/10.4060/ca7784en

Food and Agriculture Organisation(FAO). 2005. Aquastat Mozambique. Accessed at: http://www.fao.org/nr/water/aquastat/countries/mozambique/index.stm. Accessed on: May 18, 2010.

Government of Mozambique. (2018). Development of Master Plan for Water Resources Management in Mozambique; Maputo.

Gyedu-Ababio, T., Soko, M. (2019). Pollution Status of Incomati River Estuary Based on Meiofauna Analyses (Free-living Nematodes) in Maputo, Mozambique. Journal of Water Resources and Ocean Science. 8. 10.11648/j.wros.20190805.12.

Hall, R., Davis, J., Houweling, E., Vance, E., Carzolio, M., Seiss, M., Russel, Kory. (2014). Impact Evaluation of the Mozambique Rural Water Supply Activity. 10.13140/RG.2.1.1498.9844.

IGRAC. (2013). Ground water Monitoring in the SADC Region;

Mozambique National water Policy 2007

Munguambe, P., Chilundo, M., Massingue, F. (2010) The IWRM Planning Process: Mozambique (Achievements, Lessons & Challenges). Grobal water Parternship South Africa.

Nhantumbo, C., Larsson, R., Juízo, D., Larson, M. (2015). Key Issues for Water Quality Monitoring in the Zambezi River Basin in Mozambique in the Context of Mining Development. Journal of Water Resource and Protection. 07. 430-447. 10.4236/jwarp.2015.75035.

Nhantumbo, C., Pondja, E., Juízo, D., Cumbane, A., Matsinhe, N., Paqueleque, B., Uamusse, M., Gettel, G., Franca, M., Paron, P. (2020). Effect of Mining to Water Quality in Chua and Revué Rivers, Mozambique.

Norwegian School of Veterinary Science. (2013, December 6). Water pollution in Mozambique. ScienceDaily. Retrieved September 17, 2021 from www.sciencedaily.com/releases/2013/12/131206091425.htm

Tamele, I.J., Vasconcelos, V. (2020). Microcystin Incidence in the Drinking Water of Mozambique: Challenges for Public Health Protection. Toxins, 12(6), 368.

UNDP. 2016. Human development reports: Data. United Nations Development Programme. New York

Verlicchi, P., Grillini, V. (2020). Surface Water and Groundwater Quality in South Africa and Mozambique—Analysis of the Most Critical Pollutants for Drinking Purposes and Challenges in Water Treatment Selection. Water. 12. 305. 10.3390/w12010305.

Villanueva, C., Grau-Pujol, B., Evlampidou, I., Escola, V., Goñi, F., Kuckelkorn, J., Grummt, T., Arjona, L., Lazaro, B., Etxeandia, A., Ulibarrena, E., Nhacolo, A., Muñoz, J. (2021). Chemical and in vitro bioanalytical assessment of drinking water quality in Manhiça, Mozambique. Journal of Exposure Science & Environmental Epidemiology. 31. 10.1038/s41370-020-00282-5.

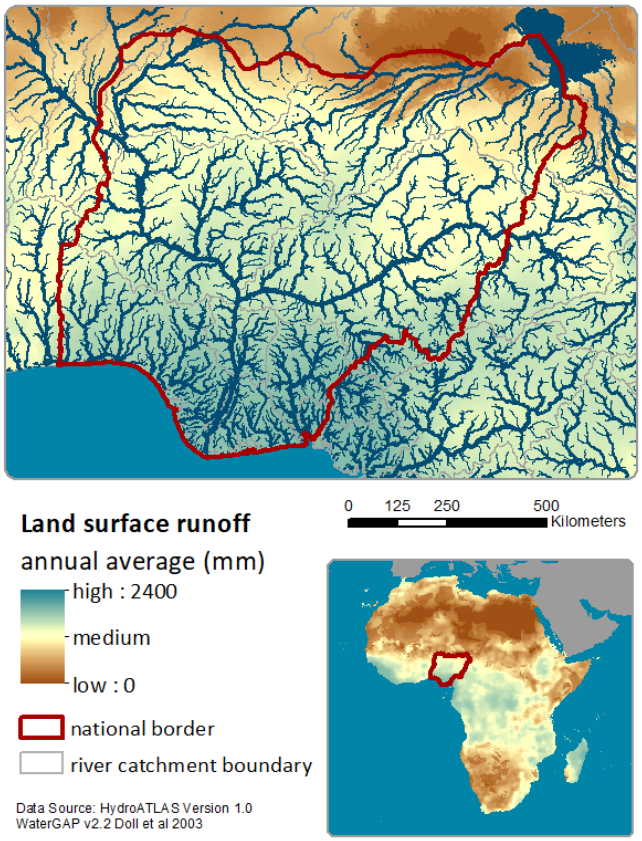
Wanda, E.M.M., Nyoni, H., Mamba, B.B., Msagati, T.A.M. (2017). Occurrence of emerging micropollutants in water systems in Gauteng, Mpumalanga, and North West Provinces, South Africa. Int. J. Environ. Res. Public Health, 14,

Weststrate, J., Gianoli, A., Eshuis, J., Dijkstra, G., Cossa, I.J., Rusca, M. (2019). The regulation of onsite sanitation in Maputo, Mozambique, Utilities Policy. Volume 61, ISSN 0957-1787, https://doi.org/10.1016/j.jup.2019.100968.

Nigeria

BACKGROUND/CONTEXT:

- **Population:** 199 million (Ighalo & Adeniyi, 2020)
- **Water supply** : National unimproved water supply – Total- 11.8%; Rural-20.9%; Urban- 3.4%. (JMP, 2021).
- **Sanitation**: National unimproved sanitation – Total- 19.1%; Rural- 28.9%; Urban- 10.0% (JMP, 2020). 8.5% of the population still practice open defecation (JMP, 2021).
- **Major Rivers systems:** River Niger originating from the Fouta Djallon highlands in Guinea, and River Benue originating from the Adamawa plateau in northern Cameroun mountains (Onafeso and Olusola, 2018).
- **Major water bodies:** There are four major drainage systems in Nigeria which each consist of rivers; the Atlantic Drainage System east of the Niger comprising the Imo, Qua Iboe, Cross and Kwa Rivers
  the Atlantic Drainage System west of the Niger made up of the Osun, Owena, Ogun and Benin Rivers.
  the Niger River Basin Drainage System with its major streams of Benue, Kaduna, Gongola, Sokoto Rima, Tarabe, Hawal, Katsina-Ala, Donga and Anambra Rivers and the Lake Chad Inland Drainage System comprising the Kano, Komadougou-Yobe, Hadejia, Jama'are Misau, Yedoseram and Ebeji Rivers (Onafeso and Olusola, 2018; Ighalo and Adeniyi, 2020).
- **SDG 6.3.2 Indicator (2020):** 12.46% of water bodies have good ambient water quality (UN Water, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Nigeria relies on surface waters (rivers, streams, ponds and lakes) as well groundwater (borehole and hand-dug wells). According to Eyankware and Ephraim (2021), water resources are highly prone to contamination from various sources including construction activities. It is further reported that groundwater pollution is on the increase across major towns and cities where human activities have a large impact. Further, most sewage systems constructed by individuals usually

lack proper design and environmental regulatory control (Eyankware & Ephraim, 2021; Adelagun et al., 2021). Generally, the cause of water pollution in Nigeria over the years has been due to agricultural activities, mining activities, oil exploration, commercial slaughter-houses/abattoirs, domestic activities and other industrial activities (Eyankware & Ephraim, 2021).

Major pollution categories and examples of their occurrence in Nigeria:

Major Categories	Examples	References
Inorganic pollutants (salts and metals)	In the Delta state, the Niger Delta and other surface water in oil producing communities are contaminated by the continual discharge of wastewater from petroleum flow stations. This results in the deterioration of water quality.	(Eyankware & Ephraim, 2021)
	Osun river in Osun State and streams in Cross River State have been polluted due to the illegal mining activities.	(Ochelebe et al., 2020)
High iron content	A study reported high levels of iron content (sodium (Na+) and chloride (Cl^-)) in ground water at Warri and its environs. This is as a result of the onsite septic system for feacal waste disposal.	(Eyankware & Ephraim, 2021)
Organic pollutants	Ogun River and River Benin are polluted due to sewage and waste water from homes that are discharged into the river.	(Taiwo et al., 2012)
Pathogens	A bacteriological analysis on many river bodies in different States pointed to large amounts of faecal coliform in the Rivers.	(Eyankware & Ephraim, 2021; Taiwo et al., 2012)

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Main Role/Responsibilities related to water quality
National Council on Water Resources(NCWR)	Responsible for policy formulating and this body is the central state agency which is chaired by the Federal Minister of Water Resources including representatives from the Federal Ministry of Environment and all State Government Commissioners for Water Resources
Federal Environmental Protection Agency (FEPA)	For industrial effluents, the body enforced to regulate and monitor the nature and quality of disposed effluent.
The Federal Ministry of Water Resources (FMoWR)	FMWR is created to provide sustainable access to safe and sufficient water to meet the cultural and socio-economic needs of all Nigerians. Responsible to formulate policies, regulate the water sector and provide technical and financial support to State Governments in the planning, implementation and monitoring of water supply projects. Also ensure that water utilities and others suppliers meet the requirements of the Standard.
Standard Organisation of Nigeria (SON)	SON is responsible for standardising and regulating the quality of all products, including drinking water in Nigeria.
Federal Ministry of Environment (FMoEnv)	Responsible to ensure environmental protection, urban sanitation, natural resources conservation and sustainable development.

State Ministries responsible for water resources (SMoWRs)	Responsible for drinking water supply at the state level and implementation of projects contrary to the policy intentions to keep ministries to policy, regulation, and monitoring.
Department of Water Quality Control and Sanitation (WES Depts)	Responsible in developing drinking water quality surveillance and enforcement procedures, communicating drinking water quality data to stakeholders and consumers, establishing national priorities in the sector of Drinking Water Quality Surveillance
River Basin Development Authorities/Boards (RBDAs)	Responsible to the development, operation, and management of reservoirs and provide bulk water supply for water utilities and for irrigation
National Water Resources Institute (NWRI)	Responsible to provides training and education, data collection, and dissemination services in the field of water resources development (not shown).
Local Government Areas (LGAs)	Responsible for the establishment, operation, and maintenance of rural water supply schemes and sanitation facilities.

Source: (Akpoborie, 2011; Ighalo & Adeniyi, 2020)

Water pollution monitoring and control: policies and regulatory environment

Policies and regulations for water pollution monitoring and control in Nigeria:

Policies/Regulations	Description/ scope
The Nigerian Standard for Water Quality (NSDWQ)	Provide standards to legally recognized and accept the quality for drinking water
Guidelines and Standards for Environmental Pollution Control in Nigeria (FEPA Guidelines)	Provides detailed specifications for ground water protection from waste disposal facilities
National Guidelines on Waste Disposal through Underground Injection (DUI)	The DUI guidelines oversee waste disposal practice for all industries including the petroleum industry. The guidelines cover the underground injection of hazardous and non-hazardous wastes.
Environmental Guidelines And Standards For The Petroleum Industry Of Nigeria (EGASPIN)	The document contains detailed guidance for underground waste disposal of all categories of wastes generated in the oil and gas industry.

Source: (Akpoborie, 2011; AMCOW, 2015)

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative program for water quality monitoring, and pollution control in Nigeria:

Initiative	Main stakeholders	Scope
National Water Monitoring Programme (NWMP)	The Standards Organization of Nigeria (SON), and the Federal Ministries of Water	Monitoring of quality and quantity of surface water bodies throughout the country
The National Water Supply and Sanitation Programme	UNICEF, the Standards Organization of Nigeria (SON), and the Federal Ministries of Water, Environment and Health	
National Urban Water Supply Reform Programme (NUWSRP)	Federal Ministry Programme supported by UNICEF	Monitoring the supply and quality of water in Urban areas
Small Towns Water Supply and Sanitation Programme	Federal Ministry Programme supported by UNICEF	Monitoring the supply and quality of water in small towns

WATER QUALITY MONITORING AND TESTING CAPACITY

According to Taiwo et al. (2012), monitoring and evaluation in Nigeria's water supply and sanitation sector is a challenge and at present, the monitoring of surface and ground water is carried out mainly by individual researchers in the Universities, Research Institutes, Government Agencies and some other organizations

Laboratory Facilities and Capacity

According to the AMCOW/IWMI Survey (2021) outcomes, there are about 20 water-testing laboratories currently in full operation across the country. Some of these laboratories are ISO accredited and are owned by either a government institution or a private entity.

REFERENCES:

Akpoborie, I. A. (2011). Regulatory mechanisms for underground waste disposal in Nigeria: review and implications for environmental management. Journal of Applied Sciences and Environmental Management, 15(4), 539-546–546.

AMCOW. (2015). Water Supply and Sanitation in Nigeria; Turning Finance into Services for 2015 and Beyond. November 2012, 1–12.

Eyankware, M. O., & Ephraim, B. E. (2021). REVIEW A Comprehensive Review of Water Quality Monitoring and Assess- ment in Delta State , Southern Part of Nigeria. Journal of Environmental & Earth Sciences, 03(01), 16–28. https://ojs.bilpublishing.com/index.php/jees%0AREVIEW

Ighalo, J. O., & Adeniyi, A. G. (2020). A comprehensive review of water quality monitoring and assessment in Nigeria. Chemosphere, 260, 127569. https://doi.org/10.1016/j.chemosphere.2020.127569

JMP.(2021). WHO/UNICEF; Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, (JMP). https://washdata.org/data/household#!/table?geo0=country&geo1=NGA

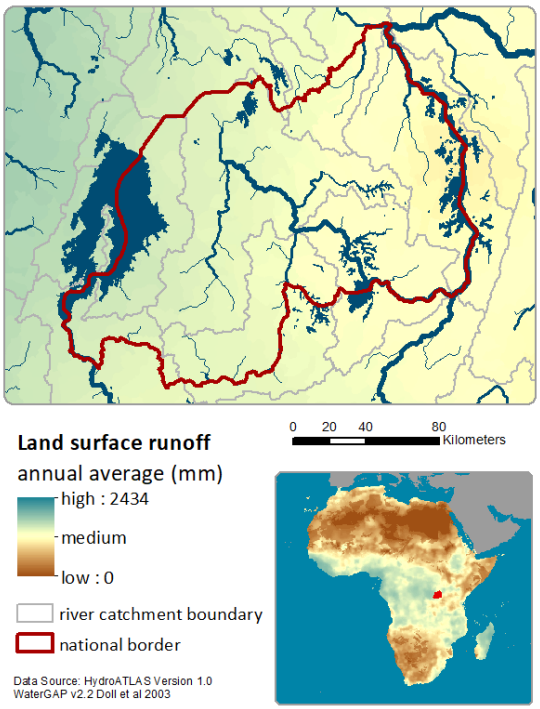
Ochelebe, I., Kudamnya, E. A., & Nkebem, G. E. (2020). An assessment of heavy metals concentration in water around quarries and barite mine sites in part of central Cross River State, Southeastern Nigeria. Global Journal of Geological Sciences, 18, 89–95. https://doi.org/10.4314/gjgs.v18i1.8

Taiwo, A. M., Olujimi, O. O., Bamgbose, O., & Arowolo, T. A. (2012). Surface Water Quality Monitoring in Nigeria: Situational Analysis and Future Management Strategy. Water Quality Monitoring and Assessment, April. https://doi.org/10.5772/33720

Rwanda

BACKGROUND/ CONTEXT:

- **Population:** 12.2 million (JMP, 2021).
- **Water supply** : Improved safe water source is 82% National unimproved water supply: Total- 13.2%; Rural- 14.8%; Urban- 5.5%. (JMP, 2021).
- **Sanitation**: National unimproved sanitation: Total- 13.8%; Rural-14.7%; Urban-9.5% (JMP, 2020). 2.0% of the population still practice open defecation (JMP, 2021).
- **Major water bodies**: Rwanda principally has only two hydrographic/ drainage basins. The Nile basin (67% of the territory) and the Congo Basin (33% of Rwanda's territory).
- **Major Rivers systems**: The Congo basin is mainly composed of two main lakes, namely Lake Kivu and Rusizi and rivers (Sebeya, Koko, Ruhwa, Rubyiro and Ruziz). The Nile Basin is mainly composed of Lake Victoria and 7 main rivers (Upper Nyabarongo, Lower Nyabarongo, Muvumba, Mukungwa, Migina, Akanyaru, Lower Akagera and Upper Akagera) (AMCOW, 2015; Kyimba, 2021).
- **SDG 6.3.2 Indicator (2020):** 78.79% of water bodies have good ambient water quality (UNEP, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

According to Asanziki et al. (2021), the government of Rwanda is still very far from achieving the expected target of 100% of safe drinking water especially in rural and peri-urban areas. Although in other report, Mukarugwiro et al., (2021), stated that the Rwandan government and other policy makers including the United Nations Environment Programme (UNEP) are committed to protecting Rwandan water resources by controlling pollutants such as heavy metals and suspended sediments.

Rwanda experiences high soil erosion and loss of water due to the vast number of hills and mountains. Community settlements are generally situated on hilltops and the waste from human activities works its way downwards to contaminate water bodies (Habimana & Nsabimana, 2020). Like in other parts of the world, pollution from human activities threatens water bodies in Rwanda, especially lakes. It is reported that unsustainable mining activities, lack of wastewater treatment facilities, and agricultural activities contributes to the water quality degradation in the country (RWFA, 2019; Habimana & Nsabimana, 2020; RWRB, 2021).

Major pollution categories and examples of their occurrence in Rwanda:

Major Categories	Examples	References
Organic loads	The Migina river is highly polluted with biological and inorganic harmful compounds, these are caused by discharges from wastewater sewer, liquid wastes from industries.	(Kasanziki et al., 2021; RWFA, 2019)
Pathogens	Poor sanitation practices in both urban and rural areas result in high concentrations of E-coli and Feacal coliform in many water bodies. Example; different kinds of untreated solid and liquid wastes wash down into the the Migina river crossing Huye, Gisagara and Nyaruguru districts.	(Kasanziki et al., 2021; RWFA, 2019)
Sediment loads and turbidity	Presence of high values of TSS in Akanyaru River border to Burundi, Sebeya and Secoko	(RWFA, 2019)
High concentration of metals and Heavy Metals	Intensive discharge of wastewater (containing paints) from car garages located close to Nyabugogo river. This explains the high levels of heavy metals reported by (Sekomo et al., 2011)	(Sekomo et al., 2011)
	Burera and Ruhondo lakes are polluted with high concentrations of Ca, Mg, Na, N and P. This may originate from mineral fertilizers, human and animal waste from the surrounding activities.	(Habimana & Nsabimana, 2020)

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Main Role/Responsibilities
Ministry of Natural Resources (MINIRENA)	Formulation of water resources management policy, strategic planning, coordination, quality assurance, monitoring, evaluation and capacity building. Establishing legal and regulatory framework.
Ministry of Infrastructure (MININFRA)	Development of institutional and legal frameworks, national policies, strategies and master plans relating to water supply and sanitation, energy and transport subsectors. MINUNFRA provides preventive, curative, and rehabilitative services.
Ministry of Local Government (MINALOC)	Establishment, development and facilitation of the management of efficient and effective decentralized government systems capable of law enforcement of water quality standards and delivery of required services such as water supply to the local communities.
Ministry of Commerce (MINICOM) and affiliated agencies	Policy formulation and promotion of investments by the private sector in water resources management (monitoring and control) /industries and manufacturing.
Ministry of Finance, Planning and Economic Development (MINECOFIN)	Mobilization and allocation of financial resources for water resources development which also focus on water monitoring and pollution control.
Rwanda Utilities Regulatory Agency (RURA)	Regulates water supply and sanitation services. Allows fair competition and protection of both consumers and operators, facilitates private sector involvement (PPP). Enforcement of compliance by public utilities with the laws governing water quality and sanitation activities.

Rwanda Bureau of Standards (RBS)	Provision of water quality standards based solutions for Consumer Protection and Trade promotion for socio-economic growth in a safe and stable environment.
Rwanda Natural Resources Authority (RNRA)	RNRA is autonomous agency responsible for management of natural Republic resources including water resources management
Energy, Water, and Sanitation Authority (EWSA)	Autonomous agency responsible for the delivery of water supply and sewerage services in the major towns and large urban centers including provision of oversight and support services to the local communities and other water supply service providers.

Source: (Ministry of Natural Resources, 2011)

Water pollution monitoring and control: policies and regulatory environment

Policies and regulatory for water pollution monitoring and control in Rwanda:

Policies/Regulations	Description/ scope
National Policy for Water Resources Management	The Government of Rwanda shall manage and develop the water resources of Rwanda in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs of the present and future generations
National Policy and Strategy for Water Supply and Sanitation Services	The Government of Rwanda shall foster co-operation in the sustainable management and equitable utilization of shared water resources
Water Law No. 62/2008	The water Law outlines the applicable rules to the use, conservation, protection and management of water resources. This also oversees the public works related to water and sanitation..

Source: (MININFRA, 2019; MINIRENA, 2011)

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative program for water quality monitoring, and pollution control in Rwanda:

Initiative	**Partners/Responsible Authority**	**Scope**
National Strategy on Sanitation and Promotion of Hygiene Management	Government	An initiative of a "Vision 2020" which target a 100 percent for both water supply and sanitation.
Water Resources Development	MINIRENA and Rwanda Natural Resources Authority (RNRA) are responsible	Perform physical activities to improve the beneficial use of water for different purposes.

Water Quality Monitoring and Testing Capacity

Annually, a campaign for Water flow measurement is done within the seasons to gathered principal information on the status of hydrological stations and the amount of water flowing in the rivers. It is done for the purpose of quantifying the changes of the natural surface water system as a result of implementation of development measures and assessing the performance of the control measures used to limit their impacts (RWRB [RWANDA WATER RESOURCES BOARD], 2020).

The campaign is designed to have 3 water flow measurements every year, the first measurement is done within the short rain season (between November to December) for collecting peak flows. The second is done in April to May for collecting the peak flows for long rain season and third in August to September for collecting peak flows for long dry season (i.e. collecting low flows for the whole year).

According to (RWFA, 2019), the most important water quality monitoring capacity needs identifies during their study are :

1. Quality Assurance,
2. Testing Methods (pesticides & heavy metals) and
3. Standardisation

Laboratory Facilities and Capacity

There following are water quality laboratories that are equipped to meet standard specifications (Otim, 2005)

1. The laboratory of the quality of the water of the department of water in the ministry of MINITERE :
2. University of Rwanda laboratory
3. Water and Sanitation Corporation laboratory
4. Rwanda Standard Board laboratory
5. Ministry of Health laboratory on water hygiene
6. Electrogaz company laboratory on water quality control
7. National university of Rwanda; Project PASI (intercollegiate Agricultural and Social Project) laboratory

REFERENCES:

AMCOW [African Ministers' Council on Water]. (2015). *Water Supply and Sanitation in Rwanda; Turning Finance into Services for 2015 and Beyond*.

Habimana, V., & Nsabimana, A. (2020). Water Physico-Chemical Characteristics of the Lakes Burera and Ruhondo, Rwanda. Rwanda Journal of Engineering, Science, Technology and Environment, 3(2), 80–87. https://doi.org/10.4314/rjeste.v3i2.5

Kasanziki, C., Miiro, R., Majaliwa, J. G. M., Naramabuye, F. X., & Sekomo, C. B. (2021). Surface Water Quality Characterization and Potential Pollution Sources in Migina River ; Southern Province of Rwanda ,. International Journal of Innovative Science, Engineering & Technology, 8(7), 511–536.

JMP.(2021). WHO/UNICEF; Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, (JMP). https://washdata.org/data/household#!/table?geo0=country&geo1=NGA

MININFRA [Ministry of Infrastructure]. (2019). National Guidelines for Sustainable Rural Water Supply Services.

MINIRENA [Ministry of Natural Resources]. (2011). THE REPUBLIC OF RWANDA National Policy for Water Resources Management.

Mukarugwiro, J. A., Newete, S. W., Adam, E., Nsanganwimana, F., Abutaleb, K., & Byrne, M. J. (2021). Mapping spatio-temporal variations in water hyacinth (Eichhornia crassipes) coverage on Rwandan water bodies using multispectral imageries. International Journal of Environmental Science and Technology, 18(2), 275–286. https://doi.org/10.1007/s13762-020-02824-8

Otim, M. (2005). National Nile Basin water quality monitoring baseline report for Uganda : Nil Basin Initiative Transboundary EnvironmentalAction Project. http://www.worldcat.org/oclc/633277647

RWFA[RWANDA FORESTRY AGENCY]. (2019). Water quality monitoring in Rwanda final report.

RWRB [RWANDA WATER RESOURCES BOARD]. (2020). SURFACE WATER MONITORING REPORT (Issue November).

RWRB [RWANDA WATER RESOURCES BOARD]. (2021). ANNUAL WATER STORAGE STATUS REPORT FOR 2020 -2021 (Issue June).

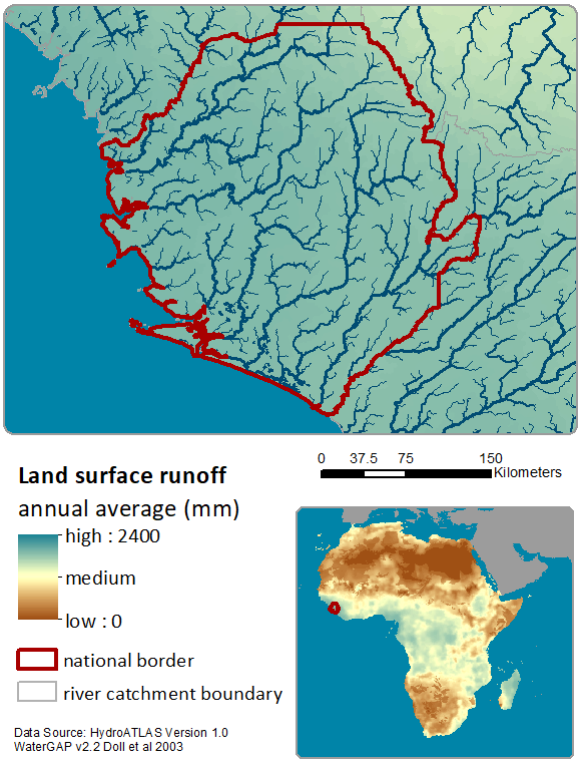
Sekomo, C. B., Nkuranga, E., Rousseau, D. P. L., & Lens, P. N. L. (2011). Fate of heavy metals in an urban natural wetland: The Nyabugogo swamp (Rwanda). Water, Air, and Soil Pollution, 214(1–4), 321–333. https://doi.org/10.1007/s11270-010-0426-9

UNEP [United Nations Environment Programme] (2021). Progress on ambient water quality. Tracking SDG 6 series: global indicator 6.3.2 updates and acceleration needs. Nairobi

Sierra Leone

BACKGROUND/ CONTEXT:

- **Population:** 7.9 million
- **Water Supply**: National water coverage – 72.8 %; Rural -58.0%; Urban -92.5% (JMP, 2021)
- **Sanitation:** National sanitation coverage – 54.4 %; Rural -35.5%; Urban -79.5%; National open defecation-16.4%; Rural- 25.0%; Urban- 5.0% (JMP, 2021)
- **Major water bodies**: Sewa River, Jong River, Little Scarcies River, Rokel River and Moa River Lake Sonfon, also known as Lake Confon,
- **SDG 6.3.2. score (2020)–** 41.70 (UNEP, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Poor water quality is a major threat to public health and aquatic life in Sierra Leone, and the main source of this problem emanates mainly from poorly regulated waste disposal. The civil war that ended in 2002 has presented a lot of serious issues in providing the people of Sierra Leone with adequate standard of living which has had a major impact on the general water quality in the country and it is reported that almost half of the population collect their drinking water from highly polluted sources with pollutants and sanitation being attributed to some of the health problems in the country (Mansaray et al., 2018).

Sierra Leone's Water, Sanitation and Hygiene Sector Performance Report of 2017 indicates that Urban Sanitation remains a huge challenge in the country especially in the areas of sewerage, on-site sanitation, faecal sludge and solid waste management causing severe pollution of water resources. These polluted water sources have been a magnet for waterborne diseases like cholera, malaria polio and diarrhoea which take the life of about one in every five children in Sierra Leone as reported by the World health Organisation (Chavez, 2013). The enforcement of existing laws and regulations on water pollution is challenged by many gaps and the pursuit to sustain natural resources exploitation (Mansaray et al., 2018).

Major pollution categories and example of their occurrence in Sierra Leone

Major Categories	Examples	References
Organic pollutants	Some of the small numerous water bodies in Freetown have been contaminated by poor sewage management and the disposal of solid and industrial wastes.	Kallon, 2009
Pathogens	Water samples collected in various water sources used by community members in Bo Sierra Leone revealed a high level of fecal contamination with only 38.95% of the samples collected meeting Word Health Organization microbial safety requirements.	Jimmy et al., 2013
Inorganic pollutants (salts and metals)	The concentration of heavy metals was measured in fish and river bank soils from Pampana river in Sierra Leone with high presence of active abandoned gold mines within the area. Dangerously high levels of heavy metals were recorded which is an indication of pollution of the water body from inorganic pollutants.	Sesay *et al.,* (no date)
	Concentrations of major and minor ions including Mn Cu and Fe in River Jong, Sierra Leone was determined in A study done by Wright in 1982 and relationships between seasonal variations in rain fall and metal concentrations was clearly established	Wright, 1982

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

State Agency or Department	Main Role/Responsibilities
Ministry of Energy and Water Resources (MEWR)	ensure that the roles and responsibilities of all stakeholders involved in the water and sanitation sector are clearly defined and allow for coordination and collaboration between stakeholders
National Water Resources Board (NWRB)	Assessment of water quantity and quality, as well as Water allocation and Pollution control.
The Energy and Water Regulatory Authority (EWRA)	Responsible for regulating water and sewerage services
Sierra Leone Water Company	Provision of portable water supply services
Sierra Leone Electricity and Water Regulatory Commission	Regulate the utility service providers in the electricity and water sectors in line with the provisions of the Sierra Leone Electricity and Water Regulatory Commission Act 2011.

Source: Sanitation and Wastewater Atlas of Africa 2021; Sierra Leone National Wash policy implementation strategy 2010

Water Pollution Monitoring and Control: Policies and Regulatory Environment

Policies/Regulations	Description/ scope
National Water and Sanitation Policy, 2008	Management and development of water as well as the provision of safe and adequate water sanitation facilities
National Water and Sanitation Policy Implementation Plan, 2010	Comprehensive framework for management of water resources and sustainable development of water supply and sanitation services within an effective legal and institutional framework
National Water Resources Management Agency Act (No. 5 of 2017)	Establishment of National Water Resources Management Agency as a body corporate, defines its functions and powers of the Agency, provides with respect to management of National Water Basins and Water Catchment Area Management Committees, and provides rule for water use and permit procedures. The Act also establishes the National Water Resources Management Fund.
Sierra Leone Water Company Act (No. 4 of 2017)	Provide for the continuance in existence of the Sierra Leone Water Company, to provide for a more efficient and effective management of community and rural water supply systems in specified areas, to provide for the facilitation of water related sanitation and delivery in Sierra Leone
Sierra Leone Electricity and Water Regulatory Commission (No. 13 of 2011)	Regulate and monitor water and electricity supply services. It is also responsible among other things for issuing licenses, protecting consumer interests and maintaining a register of public utilities.

Source(s): Sanitation and Wastewater Atlas of Africa 2021; Sierra Leone National Water and Sanitation Policy 2010

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Partner/Responsible Authority	Scope
Development of a water monitoring system and monitoring of Rokel Catchment	UNEP GEMS Capacity Development Center; MEWR	With support from UNEP GEMS/Water Capacity Development Centre and Irish Aid Sierra Leone officials have developed a water monitoring system and sections of the Rokel river are being teste for ambient water quality.
Drinking water quality monitoring	Ministry of Water Resources Ministry of Health and sanitation UNICEF Akvo	monitoring of drinking water quality at household level in 1100 communities, and at source level at 600 water sources

WATER QUALITY MONITORING AND TESTING CAPACITY

The sole responsibility of managing ambient water quality in Sierra Leone lies with the ministry of Water Resources (MWR), and the World Health Organization (WHO) drinking water guidelines are largely used to monitor ambient water due to the lack of the ministry's own guidelines. The country performs Irregular monitoring of rivers and some other project-based river basin monitoring activities do take place. The MWR has defined 32 surface water monitoring stations which are currently not being monitored and has proposed a ground water monitoring network (Warner, 2019).

Laboratory Facilities and Capacity

Currently a central laboratory and 13 district laboratories are present in Sierra Leone, however, these facilities are faced with many challenges like shortage of staff, instruments and reagents. United Nations Development Program (UNDP) has proposed to supply funding to monitor the basic water quality parameters (Warner, 2019).

REFERENCES:

Chavez, D. (2013, September 05). Sierra Leone: Where water is foul, diarrhoea is a killer. The World. https://www.pri.org/stories/2013-09-05/sierra-leone-where-water-foul-diarrhea-killer

du Plessis, Anja. (2021). Sanitation and Wastewater Atlas of Africa.

Jimmy, D., Sundufu, Abu., Malanoski, A., Jacobsen, K., Ansumana, R., Leski, T., Bangura, U., Bockarie, A., Tejan, E., Lin, B., Stenger, David. (2013). Water quality associated public health risk in Bo, Sierra Leone. Environmental Monitoring and Assessment. 185. 241-251. 10.1007/s10661-012-2548-6.

Kallon, S. (2009). Pollution and Sanitation Problems as Setbacks to Sustainable Water Resources Management in Freetown. Journal of environmental health. 71. 34-7.

Mansaray, A., Aamodt, J., Koroma, B. (2018). Water Pollution Laws in Sierra Leone—A Review with Examples from the UK and USA. Natural Resources. 09. 361-388. 10.4236/nr.2018.911023.

Sesay, P. B., Field, S. P., Marcantonio, R. A., & Lamberti, G. A. (n.d) *Identifying human health risks from precious metal mining in Sierra Leone*. Springer Heidelberg. https://doi.org/10.1007/s10113-020-01731-5

Sierra Leone National Wash policy implementation strategy 2010

Sierra Leone National Water and Sanitation Policy 2010

Warner, S. (2019). UN Environment GEMS/Water Capacity Development Center, Water quality Monitoring capacity scoping report for Africa part 1: Irish Aid countries (2018)

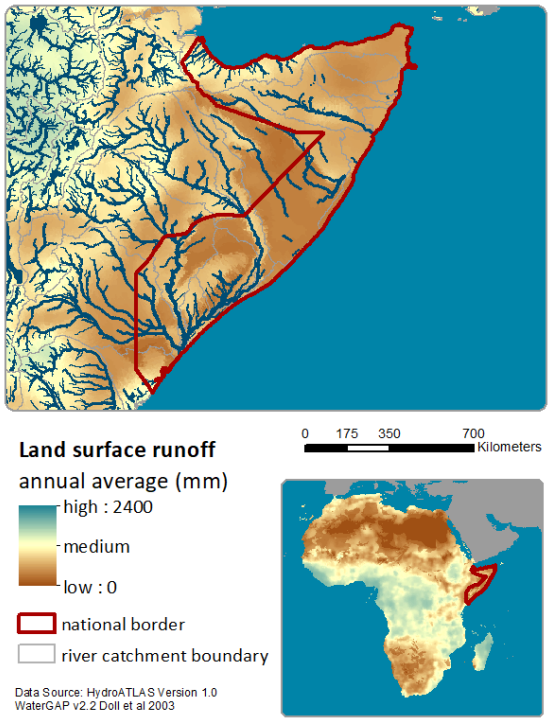
Water, Sanitation and Hygiene Sector Performance Report (2017). Government of Sierra Leone, Ministry of Water Resources and Ministry of Health and Sanitation.

Wright, R. (1982). Seasonal variations in water quality of a West African river (R. Jong in Sierra Leone). Rev.Hydrobiol.Trop., 15:193–9

Somalia

BACKGROUND/ CONTEXT:

- **Population:** 15.89 million
- **Water Supply**: National improved water coverage – 84.2%; Rural – 73.7%; Urban – 96.4% (JMP, 2021)
- **Sanitation:** National improved sanitation coverage – 56.2%; Rural – 33.8%; Urban – 82.4%; National open defecation- 23.1%; Rural- 42.3%; Urban – 0.7% (JMP, 2021)
- **Major water bodies**: Somalia has only two perennial rivers, **the Juba and the Shabelle**, both of which flow through the southern part of the country, but originate in neighbouring countries, principally Ethiopia. Besides these two the other major rivers are Ewaso Ng'iro (shared with Kenya); Dawa (shared with Ethiopia and Kenya)
- **SDG Indicator 6.3.2**: No available data



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACTS

In Somalia, water pollution is one of the most pressing issues. A combination of several factors causes water pollution in Somalia including water contamination agents of chemicals, human wastes, unregulated dumbing and presence of rubbish nearby water sites which leads to lack of safe drinking water (Mohamed, 2018).

Mohamed, (2018) also asserts that the absence of landfill sites in major cities of Hargeisa, Mogadishu, Garowe and Bassaso and worse still that most Somali houses both traditional and modern not having proper sewage storage facilities or connected to a functional sewer line to massive pollution of water resources especially during heavy rainy seasons. Due to challenges in access to clean water, toilets and good hygiene practices, the risk of contracting diseases such as diarrhoea, acute watery diarrhoea, cholera, and respiratory infections which can easily be prevented is high in Somalia (Vecchio, 2014; Ministry of Health, 2017).

Major pollution categories and examples of their occurrence in Somalia

Major Categories	Examples	References
Organic pollutants **And** **Inorganic pollutants (salts and metals)**	There is a wide spread of environmental degradation as a result of increasing pressure from human population and expansion producing large quantities of plastic waste, human sewage and industrial and domestic waste, including fertilizers and pesticides. These pollutants have been reported by WHO, (2011) to be dumped on the beaches and gradually make their way to the sea.	WHO 2011
	Adawe, (2015) assessed the fluoride content and other parameters in selected borehole waters in Hodan District area, Southern Mogadishu region, Somalia. It was found out that Hardness, chloride, electrical conductivity, total dissolved solids (TDS) and ammonium values were higher than WHO standard limits.	Adawe, 2015

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

Water Development Agency	To empower the people of Somalia to preserve, manage and protect the vital natural resources of land and water within their territories to improve the lives and livelihoods of all Somalis in this and in future generations
Ministry of Water Resources (MoWR)	The Ministry of Water Resources of the Republic of Somaliland (MoWR) is in charge of the development and regulation of Somaliland's water resources. This involves policy making, setting standard operation, national planning, regulation, monitoring, and technical support of regional states in relation to water resources.

Source: Sanitation and Wastewater Atlas of Africa 2021

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
Somaliland National Water Policy. 2002	Promotes the rehabilitation of existing water facilities and construction of new water facilities in order to improve human living conditions through enhanced accessibility, management, and awareness within a context of environmental sustainability and establish appropriate standards for the use, control, protection, management and administration of water resources.

Puntland Water Policy 2007	Sets out the key challenges and priority actions for the development of the water sector. Among the key actions there's establishing a framework for water resource management and overall water sector principle
Law No. 28 of 20 February 1971 governing the Water Development Agency	The Act provides for the establishment of the Water Development Agency as an autonomous body.
National Water Act (No. 49 of 2011)	makes provision for the conservation and development of water resources in Somalia. consists of 81 sections (divided into 16 Chapters), which define the objectives and general principles of the Act and provide with respect to, among other things: environmental protection and water resources; water conservation zones; water quality standards and quality of drinking water; agricultural water rights; highlands water conservation; groundwater protection; water pollution.
Puntland Water Resources Act of September 2018	Increase access to water in an equitable and sustainable manner in different forms of utilization, while following the most appropriate environmental (water inclusive) protection measures

Source: FAO 2021; Sanitation and Wastewater Atlas of Africa 2021

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Partner/Responsible Authority	Water Pollution Related Scope
SWALIM, the Somalia Water and Land Information Management project,	**(FAO); European Union (EU); Italian Cooperation (IC); Department of International Development of the United Kingdom (DFID); Office of U.S. Foreign Disaster Assistance (OFDA); Somalia Humanitarian Fund (SHF); Government of Switzerland and the Somalia Humanitarian Fund (SHF - OCHA).**	An information management program, technically managed by the Food and Agriculture Organization of the United Nations (FAO) in Somalia and funded by the European Union (EU), Italian Cooperation (IC), Department of International Development of the United Kingdom (DFID), Office of U.S. Foreign Disaster Assistance (OFDA), Somalia Humanitarian Fund (SHF), Government of Switzerland and the Somalia Humanitarian Fund (SHF - OCHA). SWALIM serves Somali government institutions, non-governmental organizations (NGOs), development agencies and UN bodies engaged in assisting Somali communities whose lives and livelihoods depend directly on water and land resources. The program aims to provide high quality water and land information, crucial to relief, rehabilitation and development initiatives in Somalia, in order to support sustainable water and land resources development and management.

WATER QUALITY MONITORING AND TESTING CAPACITY AND LABORATORY FACILITIES

The Ministry of Agriculture in Somalia operates a hydrometric network covering the Juba and Shabelle rivers providing flow data but due to the war these monitoring stations were abandoned and the collection of data ceased. After the war some of the stations were reinstated but for collecting data on water levels (WHO, 2011).

WHO, (2011) also reports, as of 2011 Somalia had no environmental health laboratories adequately equipped to carry out testing and analysis of sample including water and other hazardous substances. Apparently, the government of Somalia does not have any ambient water quality monitoring programs and it is not known if there exists a government laboratory fully equipped and capable of testing water quality (IWMI questionnaire 2021).

REFERENCES:

Adawe, A.M. (2015). Quality assessment of some selected water boreholes in mogadishu, Somalia[Master's thesis, University of Nairobi]. http://erepository.uonbi.ac.ke/bitstream/handle/11295/91405/Adawe_Quality%20assessment%20of%20some%20selected%20water%20boreholes.pdf?sequence=1&isAllowed=y

Country Environmental Profile for Somalia, from 1st March 2006 to 31 August 2006: IUCN Eastern Africa Regional Office, Nairobi, Kenya

du Plessis, Anja. (2021). Sanitation and Wastewater Atlas of Africa.

FAOLEX, (2009). Somalia Country Profiles. http://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=SOM

Houghton-Carr, H. A., Print, C. R., Fry, M. J., Gadain, H. & Muchiri, P. (2011) An assessment of the surface water resources of the Juba-Shabelle basin in southern Somalia. Hydrol. Sci. J. 56(5), 759–774.

Ministry of Health/WHO Cholera Epidemiological Weekly Sitreps 2017/18/19

Mohamed, R. (2018, March 21). Water pollution in Somalia. Ambasoder Report, TUNZA Eco Generation. https://tunza.eco-generation.org/ambassadorReportView.jsp?viewID=44396

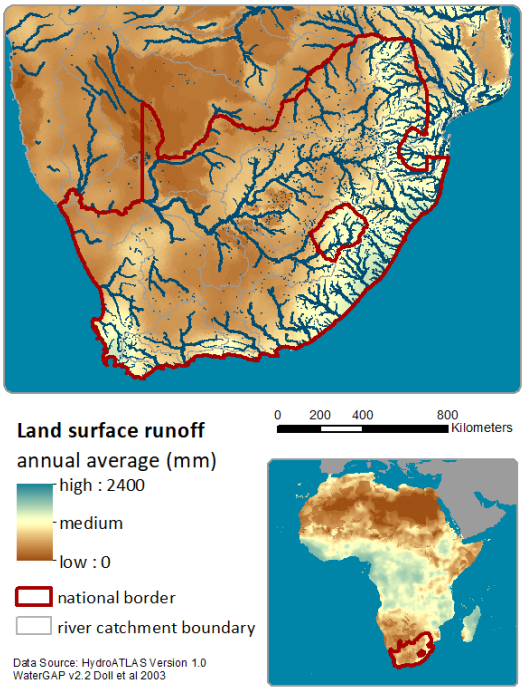
Vecchio, E. (2014, March 21). Contaminated water a grave threat to Somalis. OXFAM International. https://www.oxfam.org/en/press-releases/contaminated-water-grave-threat-somalis

WHO, (2011). Environmental health situation analysis in Somalia 2010. http://www.emro.who.int/images/stories/somalia/documents/environmental_health_report_200312.pdf

South Africa

BACKGROUND/ CONTEXT:

- **Population:** 58.56 million (2019)
- **Water supply**: National drinking water coverage – 93.9%; Rural -83.3%; Urban- 99% (JMP, 2021)
- **Sanitation**: National sanitation coverage – 93.2%; Rural- 86.4%; Urban- 96.6%; National open defecation- 0.2%; Rural- 0%; Urban- 0.3% (JMP, 2021)
- **Main rivers**: Orange River, Limpopo River, Incomati River, Maputo River, Tugela River, Olifants River (Limpopo), Breede River.
- **SDG 6.3.2. score (2020):** 83.89 % of water bodies have good ambient water quality((UNEP, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

South Africa is classified as one of the most water-stressed countries on the African continent. The country is currently facing a growing water crisis due to climate change and water pollution has exacerbated the situation becoming a major threat to ecological functions. The deteriorating state of wastewater treatment management in South Africa is one of the largest contributing factors to the numerous pollution problems experienced in most parts of the country. For example, of 824 treatment plants, it is estimated that only 60 release clean water (Herbig, 2019). Water bodies such as Olifants River, Vaal River, Umgeni River and Crocodile-West River are among the water bodies considered most polluted in South Africa. On the other hand, industrial activities such as gold mining and coal mining significantly contribute to the contamination of water sources in the mining districts (DWS, 2018).

Major Categories	Examples	References
Organic pollutants	Orange-Senqu basin: poor performance of WWTPs has caused water quality deterioration in the river basin	Quibell ,2011
	Vaal river- untreated sewage from poorly functioning WWTPs is discharged into the river deteriorating the water quality	
Pathogens	Apies river- A research found that in informal settlements where sanitation and waste management facilities were absent, a high number of bacteria were often present in the water.	The Conversion, 2020
Inorganic pollutants (salts and metals)	Salinity of the Vaal River, between the Vaal Dam and the Barrage has doubled as a result of the inflow of water from the Klip river and the Blesbokspruit which receive polluted water from old gold mines.	McCarthy, 2011; Ambani & Annegarn, 2015; McCarthy et al, 2007
	Industrial effluent and acid-mine drainage haven been major causes for water pollution in Olifants river.	Petrie et al, 2014
Groundwater pollution	The microbial water quality from the Chunies River in Limpopo Province is unacceptable for domestic use throughout the course of the river due to faecal and coliform pollution.	Odiyo & Makungo, 2012

POLICIES AND INSTITUTIONS

Table: Key stakeholders and their roles

Institution	Main Role/Responsibilities
Department of Water and Sanitation (DWS)	Responsible for formulation and implementation of policy governing water resources use and protection including drinking water supply
Water Boards	Primarily Provide bulk water, including retail services and operation of wastewater treatment plants, water resources management;
Municipalities	Provide water supply and sanitation services and own some of the bulk water supply infrastructure
Trans-Caledon Tunnel Authority	State-owned entity with the mission to finance and implement bulk raw water infrastructure.
Water Research Commission (WRC)	Supports water research and development , building sustainable water research capacity in South Africa
Catchment Management Agencies	Responsible for the protection and management of water resources at the catchment level including water quality monitoring.
The Development Bank of Southern Africa (DBSA)	Important player in water and sanitation sector, both financier and advisor and project promoter

Source: Mogakabe (2017)

Water pollution monitoring and control: policies and regulatory environment

Policies, acts, regulations and guidelines	Description
National Water Act 36 of 1998	Regulates pollution of water resources through water use licenses.
South African Water Quality Guidelines (1996)	Serves as the primary source of information for determining the water quality requirements of different water uses and for the protection and maintenance of the health of aquatic ecosystems. The guideline provides a series of eight volumes addressing eight different water uses.
National Sanitation Policy Framework (2016)	The focus is to ensure and strengthen: Integrated sanitation services, Institutional arrangements for sanitation services, Participation in sanitation services, Capacity and resources for sanitation services delivery, Financial effectiveness and efficient sanitation services, Sustainable sanitation provision in the country, Regulation of sanitation services.
National Water & Sanitation Masterplan (2018)	Sets out the critical priorities to be addressed by the water sector, in particular water and sanitation management and enabling environment in the period from 2018 – 2030.

South Africa National Water Act, 1998; South African Water Quality Guidelines, 1998; Velkushanova. K.; Department of Water and Sanitation, 2018

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Scope	Custodians
National Chemical Monitoring program	To assess the status and trends of water resource chemistry ,provide information to managers and public	DWS, Public
National Microbial Monitoring Program	To provide information on status and trends of fecal pollution and assess health risks	DWS, WUA, DoH, Municipalities
National Eutrophication Monitoring Program	To assess trophic status, problems and trends in dams & lakes, provide information manager and public	DWS DEA
National toxicity monitoring programme	To assess the status and trends of toxicity and toxicants in water resources and provide information to manager and the public	DWS, DEA, DAFF, DoH, public
National Radioactivity monitoring programme	To assess the status and trends of radiological quality of water resources and provide information to managers and the public	DWS, DEA DOH, DMR, NNR, public
Quality Monitoring & Laboratory Services by Water and Sanitation Services South Africa (Pty) Ltd (WSSA)	Sampling and analysis. Training of process controllers and samplers. Report writing and recommendation to optimise the processes.	Midvaal Local Municipality, Rustenburg Water Services Trust,Stellenbosch Local Municipality

	Development of monitoring programs in line with blue/green drop SANS 241.	

Source: Mogakabe (2017); WSSA(2016)

WATER QUALITY MONITORING AND TESTING CAPACITY

South Africa has been included in a number of inter-country water quality monitoring programmes such as part of The Orange-Senqu River Commission (ORASECOM) - Lesotho, South Africa and Namibia, Botswana; and the Limpopo Watercourse Commission (LIMCOM) - Botswana, Zimbabwe, RSA and Mozambique; KOBWA - Swaziland, RSA and Mozambique.

Laboratory facilities and Capacity

The analytical facilities are well-staffed by trained personnel. Stringent quality assurance and control measures are applied to all aspects of water quality monitoring. Resource Quality Information Services (RQIS) Laboratory Services analyse water quality samples collected from various monitoring sites across the country for National Chemical Monitoring Programme (NCMP), National Eutrophication Monitoring Programme (NEMP), National Toxicity Monitoring Programme (NTMP) and National Estuaries Monitoring Programme (NEsMP).

The average through flow is approximately 1300 samples per month. RQIS use a Laboratory Information Management System (LIMS) to log samples and document sample progress (Warner, 2019).

National Microbial Monitoring Programme (NMMP) and National Radioactivity Monitoring Programmes (NRMP) sample analysis is conducted by Nuclear Energy Corporation of South Africa (NECSA) due to the nature of parameters, instrumentation and expertise required for the analysis (Department of Water and Sanitation, unpublished).

REFERENCES

Ambani A., Annergarn H. 2015. A reduction in mining and industrial effluents in the Blesbokspruit Ramsar wetland, South Africa: Has the quality of the surface water in the wetland improved?. Water SA Vol. 41 No. 5 October 2015.

DWS (Department of Water and Sanitation) 2018. National Water and Sanitation Master Plan. Volume 1: Call to Action version 10.1 Ready for the future and ahead of the curve. Accessed on https://www.gov.za/sites/default/files/gcis_document/201911/national-water-and-sanitation-master-plandf.pdf

Department of Water and Sanitation. Unpublished. Water Monitoring Plan Draft, 2021. Republic of South Africa.

Edokpayi, J. N., Odiyo, J. O., Popoola, O. E., & Msagati, T. A. (2016). Assessment of trace metals contamination of surface water and sediment: a case study of Mvudi River, South Africa. *Sustainability*, *8*(2), 135.

Gyedu-Ababio, T.K and Wyk, F.V, (2011), Effects of human activities on the Waterval River, Vaal River catchment, South Africa, https://www.researchgate.net/publication/233053061

Herbig J. W. 2019. Talking dirty - effluent and sewage irreverence in South Africa: A conservation crime perspective. Cogent Social Sciences, 5:1, 1701359. doi: 10.1080/23311886.2019.1701359

McCarthy T.S., Arnold V., Venter J., Ellery W. N. 2007. The collapse of Johannesburg's Klip River wetland. South African Journal of Science 103, September/October 2007

McCarthy T.S. 2011. The impact of acid mine drainage in South Africa. S Afr J Sci. 107(5/6), Art. #712, 7 pages. doi:10.4102/sajs.v107i5/6.712

Mogakabe. E (2017), National water quality monitoring programs, Department water and sanitation Republic of South Africa https://www.dwa.gov.za/iwqs

Moyo, N.A.G, & Mtetwa, S, (2002) Water quality management and pollution control. In: Sonson, P., Maro, P., Chiuta, T.M. (Eds.), Determining the Mainstreaming Environmental Sustainability in Water Resources Management in Southern Africa

Naicker, K, Cukrowska, E., and McCarthy, T.S. (2003). Acid mine drainage from gold mining activities in Johannesburg, South Africa and environs. Environmental Pollution 122 29-40.

Nieuwoudt, W.L. (2007), Pollution policies and market approaches in the Olifants River, South Africa, DOI: 10.2495/WRM070481

Odiyo, J. O., & Makungo, R. (2012). Water quality problems and management in rural areas of Limpopo Province, South Africa. *WIT Transactions on Ecology and the Environment*, *164*, 135-146.

Quibell, G (2011) ,ORASECOM , A Scoping Report on Urban Pollution in the Orange-Senqu River System, ORASECOM Report No. 16/2011

Warner, S. (2019) UN Environment GEMS/Water Capacity Development Center, Water quality Monitoring capacity scoping report for Africa part 1: Irish Aid countries (2018)

Water and Sanitation Services South Africa, (2016), http://www.wssa.co.za/services-projects/quality-monitoring-laboratory-services/

Water and Sanitation Services South Africa (2016).Quality Monitoring and Laboratory Services, http://www.wssa.co.za/services-projects/quality-monitoring-laboratory-services/

WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2017, https://washdata.org/data/household#!/

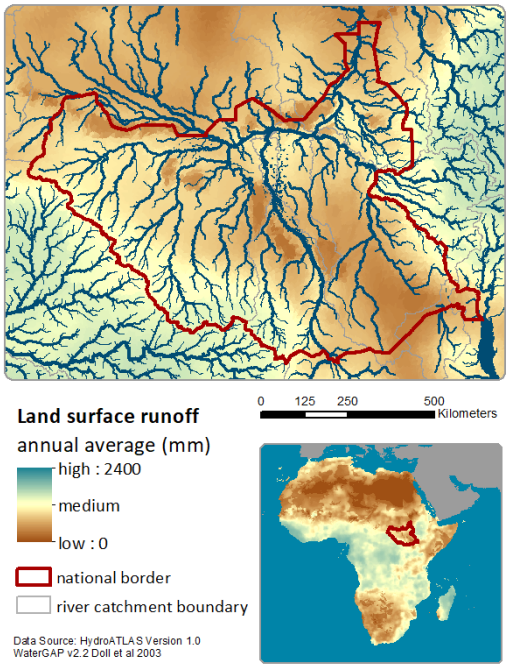
Petrie, B., Chapman, A., Midgley, A. and Parker, R. (2014) Risk, Vulnerability and Resilience in the Limpopo River Basin System: Climate change, water and biodiversity – a synthesis. For the USAID Southern Africa "Resilience in the Limpopo River Basin" (RESILIM) Program. OneWorld Sustainable Investments, Cape Town, South Africa.

Verlicchi P., Grillini V. 2020. Surface Water and Groundwater Quality in South Africa and Mozambique—Analysis of the Most Critical Pollutants for Drinking Purposes and Challenges in Water Treatment Selection. Water 2020, 12, 305; doi:10.3390/w12010305

South Sudan

BACKGROUND/ CONTEXT:

- **Population:** 11.19 million
- **Water Supply**: National improved water coverage – 78.4%; Rural – 75.8%; Urban – 88.7% (JMP, 2021)
- **Sanitation:** National improved sanitation coverage – 24.6%; Rural – 15.5%; Urban – 60.6%; National open defecation- 60.1%; Rural- 73.3%; Urban – 8.1% (JMP, 2021)
- **Major water bodies**: The White Nile River; The Blue Nile River; The Atbarah River and lake Ambadi which forms one of the world's largest wetlands
- **SDG Indicator 6.3.2**: No available data.



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACTS

The River Nile is one of major river systems in South Sudan and its water quality especially in the Juba area has become a major area of concern. Population growth, urbanization, and rural-town immigration have all contributed to a population boom in the Juba area and an increase in pollution of water resources and aquatic ecosystems.

Non-point source pollution and its impact on drinking water quality in River Nile were investigated. The results revealed that anthropogenic pollutants were contributing to pollution, non-anthropogenic factors also contributed to the pollution and this rendered raw water from River Nile as not suitable for drinking without treatment. Population growth, urbanization, and rural-town immigration have all contributed to a population boom in the Juba area and have all aggravated pollution of water resources and aquatic ecosystems (Harrison & Fang 2020; Ladu, et al., 2012).

Major pollution categories and examples of their occurrence in South Sudan

Major Categories	Examples	References
Organic pollutants	A study to investigate the impact of urbanization and industrialization on water quality of Nile River basin in South Sudan, Thecresults of the study found that anthropogenic pollutants were highly contributing to the pollution of the basin by 78%, where as non-anthropogenic factors contributed 22%. Very high levels of TDS (47–123 mg/100ml) and feacal coliforms (15.25–102.6 CFU/100ml) were recorded among other parameters.	Harrison & Fang 2020

Pathogens	A study aimed to investigate the occurrence of fecal contamination in 147 improved groundwater sources in Juba, South Sudan and to assess potential contributing risk factors, based on bivariate statistical analysis was conducted. Thermotolerant coliforms (TTCs) were detected in 66% of the investigated sources, including 95 boreholes, breaching the health-based recommendations for drinking water. the analysis indicated that an important contamination mechanism was fecal pollution from contaminated surface water.	Engstrom, et al., 2015
Nutrients	Animal production is one of the cultures in Juba of South Sudan for social and economic purposes with people rearing Goat, Sheep, Pigs, and Poultry on a small and large scale. With the growth of livestock farming, animal dung has increasingly become one of the sources of water pollution in the capital city through the excretion they produce that include feces and urine.	Harrison & Fang, 2020
Inorganic pollutants (salts and metals)	In the oil fields of Thar Jath, South Sudan, increasing salinity of drinking water was observed together with human incompatibilities and rise in livestock mortalities. Hair analysis was used to characterize the toxic exposure of the population. Very high concentrations and a toxic health endangerment were assessed for lead and barium and high concentrations of lead and barium were observed demonstrating clearly the health risk caused by harmful deposition of toxic industrial waste.	Pragst, et al., 2016
	A study by Ladu and colleagues in 2012 on water pollution tendencies around Lobuliet, Khor bou and Luri streams in Juba, South Sudan concluded that pollution tendencies were attributed to the discharge of municipal and industrial effluent to the streams and if not properly tackled, may pose adverse impacts to the biogeochemical cycle.	Ladu, et al., 2012

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

State Agency or Department	Water Quality Related Roles and Responsibilities
Ministry of Water Resources and Irrigation (MWRI)	- Water resource policy - Water use planning and regulations - Scientific research - Protecting wetlands. - Advises sub-national entities and builds local wrm capacity.
Water Council	Multi-stakeholder advisory body, on water resources
Water Resources Management Authority	- Regulates the management, development, and use of water resources under the Water Council. - Prepare IWRM plan based on sub-national IWRM plans.
Ministry of Lands, Housing and Physical Planning (MLHPP)	- Formulates policy, standards, and regulations on urban planning and urban land management, including urban water supply and sanitation. - Responsible for wastewater treatment and disposal.

Ministry of Environment	Responsible for environmental management policy and enforcement of environmental protection.
Ministry of Health	Manages water treatment, enforces drinking water quality standards, and coordinates responses to water borne diseases.
Ministry of Foreign Affairs and International Cooperation	Supports management of transboundary water resources.
South Sudan Urban Water Coordination (SSUWC)	Responsible for the production and distribution of improved water supply in urban areas
Basin Water Boards	- Responsible for basin management, including local monitoring and evaluation. - Prepares IWRM plans.

Source: (USAID, n.d.); USAID, 2015; Sanitation and Wastewater Atlas of Africa 2021

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
Southern Sudan Water Policy 2007	Promotes management of water resources and establishes appropriate legal framework to govern water use and water resources planning
Strategic Framework for Water, Sanitation, and Health 2011	Establishment of a Water Council, a multi-sectoral advisory board at the national level, and a Water Resources Management Authority to enforce water management and use regulations.
Water Bill 2013	protection of groundwater and surface water resources from pollution, erosion, and other adverse effects. Develops procedures to manage water allocation for different uses, conservation, water quality, water-related disasters, and intersectoral coordination.
National WASH Sector Strategic Framework 2011	Operationalizes and ensures implementation of the National Water Policy, including the priority strategic area of water resources management
National Environmental Policy 2012	Outlines sustainable use of natural resources, including guidance relating to water supply and sanitation; forestry; agriculture; fisheries; and wetlands, rivers, and lakes; which all impact water quality, availability, and use

Source: USAID, 2015; Sanitation and Wastewater Atlas of Africa 2021

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Partner/Responsible Authority	Water Pollution Related Scope
Southern Sudan Water Information Clearing House (SSWICH)	MWRI GoSS	A water Information system established to collect and process data, undertake surveys, store, and disseminate all information related to water resources.
water quality control testing hub	**WHO; Ministry of Health**	WHO in collaboration with the ministry of health established a water quality control testing hub within the national public health laboratory in Juba to test and monitor water quality within the country with mobile water quality and safety testing kits provided by WHO.

Sources: GoSS, 2011; WHO, 2017;

WATER QUALITY MONITORING AND TESTING CAPACITY

Water quality monitoring is generally limited in South Sudan with only 10 of 113 hydrological stations being operational due to the destruction of most of the meteorological and Hydrological data networks during the conflict (USAID, n.d.) The Ministry of Water Resources and Irrigation (MWRI) has only one small water quality laboratory (ADB 2013) however the Ministry of Health and MEDIWR currently are responsible for monitoring and setting guideline for water quality. Access to water quality data is currently a challenge due to the the lack of data, monitoring infrastructure, and information management systems (World Bank, 2013).

Laboratory Facilities and Capacity

- Laboratories at Juba and Malakal Water Treatment Plants (small lab facilities able to test pH, turbidity, residual chlorine, and TDS)
- Laboratory at Juba Central Hospital: measures the bacteriological quality of water samples.
- UNICEF Laboratory. Besides the UNICEF water quality testing laboratory in Rumbek (which is in fact being operated now by MWRI-GoSS),

Other existing water quality testing facilities include:

- Sudanese Standards and Metrology Organization (SSMO) testing laboratory in Juba,
- Swedish Free Mission (SFM) water quality testing laboratory in Juba,
- International Aid Services (IAS) water quality testing laboratory in Yei,
- Several NGOs in different states have field kits for water quality monitoring.
- Under the projects of technical cooperation with Egypt, a small Central Water Quality Testing Laboratory has been setup in Juba by MWRI, capable of testing physical, chemical and microbiological profiles of all types of water samples.

REFERENCES:

ADB, (2013). South Sudan: An Infrastructure Action Plan - A Program for Sustained Strong Economic Growth. Tunis, Tunisia. https://www.afdb.org/en/countries/east-africa/south-sudan/infrastructure-action-plan-in-south-sudan-a-program-for-sustained-strong-economic-growth

du Plessis, A. (2021). Sanitation and Wastewater Atlas of Africa.

Engstrom, E., Balfors, B., Mörtberg, U., Thunvik, R., Gaily, T., Mangold, M. (2015). Prevalence of microbiological contaminants in groundwater sources and risk factor assessment in Juba, South Sudan. Science of The Total Environment. 515-516. 181-187. 10.1016/j.scitotenv.2015.02.023.

Fraser, L.H., Keddy, P.A. (2005). The world's largest wetlands: ecology and conservation. Cambridge University Press. p. 354. ISBN 978-0-521-83404-9. Retrieved 4 August 2011.

Government Of Southern Sudan (GoSS), (2011). Preliminary Water Information Assessment Study. Ministry Of Water Resources And Irrigation (MWRI) Juba. https://documents1.worldbank.org/curated/es/992271468119645862/705850ESW0P1180s0Assessment00final0.doc

Harrison, B., Fang, P. (2020). Non-point source pollution and its impact on drinking water quality in River Nile- A case study of Juba South Sudan. International Journal of Scientific and Research Publications (IJSRP). 10. 483-496. 10.29322/IJSRP.10.09.2020.p10557.

Kut, K., Sarswat, A., Bundschuh, J., Mohan, D. (2018). Water as key to the Sustainable Development Goals of South Sudan – A water quality assessment of Eastern Equatoria State. Groundwater for Sustainable Development. 8. 10.1016/j.gsd.2018.07.005.

Kut, K., Sarswat, A., Bundschuh, J., Mohan, D. (2018). Water as key to the Sustainable Development Goals of South Sudan – A water quality assessment of Eastern Equatoria State. Groundwater for Sustainable Development. 8. 10.1016/j.gsd.2018.07.005.

Ladu, J.L.C., Lu, X., Loboka, M.K. (2012). Experimental study on water pollution tendencies around Lobuliet, Khor bou and Luri streams in Juba, South Sudan. International Journal of Development and Sustainability, Vol. 1 No. 2, pp. 381–390.

Mednick, S. (2020, February 13). South Sudan ignores reports on oil pollution, birth defects. Associate press news. https://apnews.com/article/united-nations-south-sudan-ap-top-news-international-news-health-f2f06cfa70126ad179445720d7c60b8a

Pragst, F., Stieglitz, K., Runge, H.., Runow, K., Quig, D.,. Osborne, R., Runge, C., Ariki, J. (2016). High concentrations of lead and barium in hair of the rural population caused by water pollution in the Thar Jath Oilfields in South Sudan. Forensic Science International. 274. 10.1016/j.forsciint.2016.12.022.

USAID, (2015). Sanitation Institutions Mapping in South Sudan. Burlington, Vermont 05401 USA.

USAID, (n.d.) South Sudan Water Resources Profile Overview. https://winrock.org/wp-content/uploads/2021/08/South_Sudan_Country_Profile_Final.pdf

World Bank, (2013). The Rapid Water Sector Needs Assessment and a Way Forward.

World Health Organization, (2017, November 22). WHO in collaboration with the Ministry of Health established water quality control testing hub within the National Public Health Laboratory to guide water safety management and prevent water-borne diseases in South Sudan. WHO. https://www.afro.who.int/news/who-collaboration-ministry-health-established-water-quality-control-testing-hub-within

Tanzania

BACKGROUND/CONTEXT

Population: 59,734,213 (World Bank Group, 2021)

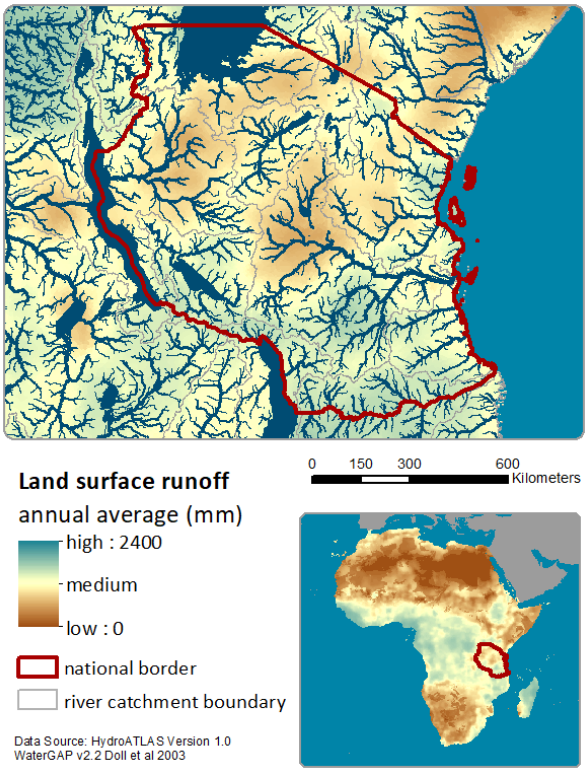
Water Supply: 60.7% of the total population have access to at least a basic water supply; 45.4% in rural and 88.8% basic water supply in urban areas (JMP, 2021)

Sanitation: 38.7% of the total population have unimproved sanitation services 9.2% in urban areas and 54.7% in rural areas. 10.9% of the total population practice open defection; 16.1% in rural and 1.4% in urban areas (JMP, 2021).

Major River systems: Ruvuma, Rufiji, Pangani, Wami, Kagera

Major water bodies: Lake Victoria, Lake Tanganyika, Lake Rukwa, Lake Nyasa

SDG Indicator 6.3.2: 85% of water bodies have good ambient water quality (UN Water, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACTS

Tanzania's ambient water quality varies across regions due to natural and human induced factors (Government of Tanzania, 2020). Pollution is largely reported in surface water compared to ground water sources, particularly in coastal waters. Major contributors to water pollution are discharge of poorly treated domestic and industrial wastewater, agriculture runoff, household waste, insufficient waste regulations to cater for expanding coastal populations and emerging industrial activities (Hellar-Kihampa, 2017). Over 80% of the industries in Tanzania are located in the Wami – Ruvu River basin and discharge poor quality wastewater (Government of Tanzania, 2019). The Msimbazi River in Dar es Salaam is considered one of the most polluted water bodies (IWMI/AMCOW Survey, 2021). In addition, uncontrolled mining activities have resulted in the contamination of freshwater resources with heavy metals such as mercury and arsenic (Hellar-Kihampa, 2017).

While open defecation have been steadily declining in Tanzania (Maliti, 2020), the impacts of water pollution are experienced in public health threats from water borne disease such as cholera which are reported almost yearly in particularly among populations living close to lakes (Hounmanou et al., 2019). Similarly, ecosystems services are under threat, for example wetland degradation from agricultural pollutants (Alavaisha et al., 2019; Twisa et al., 2020).

Major pollution categories and examples of their occurrence in Tanzania

Major Categories	Examples	References
Organic pollutants	Contamination from organochlorine pesticide residues from historical agricultural applications in the Pangani River Basin	Hellar-Kihampa et al. (2013b)
Pathogens	Ground water sources contaminated by bacteria due to poorly designed of pit latrines.	Elisante and Muzuka (2016)
Nutrients	High levels of dissolved solids, nutrients, and toxic metals in urban rivers receiving treated industrial wastewaters in Dar es Salaam.	Kihampa (2016)
Inorganic pollutants (salts and metals)	Increased use of agrochemicals associated with agricultural intensification. Heavy metal contamination such as mercury from mining activities in the Mugusu and Rwamagaza artisanal mines in the Lake Victoria goldfields.	Mng'ong'o et al. (2021); Hellar-Kihampa(2017).
	Heavy metal groundwater contamination in the Lake Victoria Basin including arsenic and fluoride across the country's drainage basins	Ligate et al. (2021)

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

State Agency or Department	Water Quality Related Roles and Responsibilities
Ministry of Water	National government authority responsible for national water policy and strategy formulation and implementation, formulation of guidelines and regulations, coordination of integrated water resources management and the provision of water supply and sanitation services.
National Water Board	Serves as an advisory board to the Minister of Water on matters related to multi-sectoral coordination in integrated water resources planning and management.
Basin Water Boards, Catchment Water Committee, Water Ussr Associations	Responsible for managing water resource in respective nine basins. Catchment water committees are working hand in hand with basin water boards, with roles including preparation and implementation of catchment plans.
Urban Water and Sewerage Authorities	Ensuring that water is continuously supplied to consumers in urban areas in acceptable standards both in terms of quantity and quality. Treatment of wastewater and sewerage
Rural Water Supply and Sanitation Agency	Responsible for implementation of rural water supply and sanitation projects
Community based water supply organizations	Established to enhance sustainability of rural water supply and sanitation services through public involvement and private sector participation in rural water services.

Water Institute	Builds capacity for water sector human resources. Programmes offered by the Institute are in the area of Water Supply and Sanitation Engineering, Hydrology and Meteorology, Hydrogeology and Water Well Drilling, Water Laboratory Technology and Irrigation Engineering – including tailor made short courses for water sector experts.
National Environment Management Council	Monitoring of water pollution in industrial areas as part of enforcement activities.

Source: United Republic of Tanzania, 2019; Government of Tanzania, 2021

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
The Water Resources Management Act No. 11 (2009)	Enacted to provide for sustainable management and adequate operation and transparent regulation of water supply and sanitation services
Water Supply and Sanitation Act No. 5 (2019)	Enacted to provide for institutional and legal framework for sustainable management and development of water resources; to outline principles for water resources management; to provide for the prevention and control of water pollution;

Source: Government of Tanzania, 2021

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Partner/Responsible Authority	Water Pollution Related Scope
Lake Victoria Environmental Management Project Phase 1 (1997-2005) Phase II (2009-2017)	Global environment Facility, The World Bank, Lake Victoria Basin Commission,	-Watershed management and land rehabilitation. -Point sources pollution control and prevention. -Monitoring and control of water hyacinth rehabilitation, sanitation and wastewater treatment facilities, and working with private companies to reduce industrial pollution. -Reduce environmental stress in targeted pollution hotspots and selected degraded subcatchments to improve the livelihoods of communities, who depend on the natural resources of LVB.
Lake Tanganyika Water Management (LATAWANA) 2019-2023	European Union Lake Tanganyika Authority Implemented by Enabel	To design, implement a water quality monitoring and control network tool for Lake Tanganyika including a measuring station, harmonization of parameters, monitoring sampling plan, validation, data editing, etc. Strengthening reference laboratories through the purchase of sampling, analysis and consumables equipment; Laboratory training, including in the data validation and interpretation process.

Initiative	Partner/Responsible Authority	Water Pollution Related Scope
Promotion of Resource Efficient and Cleaner Production (RECP) in small scale mining plants within the Lake Victoria Basin 2017-2019	Lake Victoria Basin Commission World Bank	Catalysing private sector investment in cleaner and more efficient industrial production and supply chains throughout the Lake Victoria watershed basin
National Water Quality Management and Pollution Control Strategy (WQMPCS).	**Ministry of Water**	Provides strategies for water pollution control including data management.
Proposed Wami-Ruvu Basin Water Quality Improvement Project 2020-2025	Wami-Ruvu Basin Water Board, National Environment Management Council, Water Supply and Sanitation Authorities, Government Chemist Laboratory Authority	Strengthening water pollution control within the basin, raising awareness on proper water resources management among stakeholders, enhancing proper management of industrial and municipal wastewater, and promoting water use efficiency

Sources: United Republic of Tanzania (2019); United Republic of Tanzania, n.d; Lake Tanganyika Authority, 2021

WATER QUALITY MONITORING AND TESTING CAPACITY

Tanzania implements the Water Quality Management and Pollution Control Strategy (Government of Tanzania, 2020) and monitors the ambient water quality of the country's water resources.

Laboratory Facilities and Capacity

There are 16 water-testing laboratories in the country. Current efforts are ongoing to upgrade and accredit the facilities towards ISO 17025 standards. Extension and rehabilitation of the Daar es Salaam water laboratories were close to completion as of June 2020. New construction of laboratories is also ongoing across several locations in the country. Between the period 2015-2020, 1540 samples were tested out of a planned 2250 (68%) as part of ambient water quality monitoring (Government of Tanzania, 2020).

REFERENCES:

AMCOW/IWMI Survey (2021). Pan Africa Water Quality Program: Africa wide survey implemented from July-September 2021 by the International Water Management Institute in collaboration with the African Ministers' Council on Water.

Alavaisha, E., Lyon, S. W., & Lindborg, R. (2019). Assessment of water quality across irrigation schemes: A case study of wetland agriculture impacts in Kilombero Valley, Tanzania. *Water*, *11*(4), 671.

Elisante E, Muzuka ANN (2016b). Sources and seasonal variation of coliform bacteria abundance in groundwater around the slopes of Mount Meru, Arusha, Tanzania. Environ. Monit. Ass.188(7):1-19.

Government of Tanzania (2020). Water Sector Status Report. 2015-2020. June 2020

Hellar-Kihampa H, De Wael K, Lugwisha E, Malarvannan G, Covaci A, Van Grieken R, (2013b). Spatial monitoring of organohalogen compounds in surface water and sediments of a rural–urban river basin in Tanzania. Sci. Total Environ. 447:186-197

Hellar-Kihampa, H. (2017). Another decade of water quality assessment studies in Tanzania: Status, challenges and future prospects. *African Journal of Environmental Science and Technology*, *11*(7), 349-360.

Hounmanou, Y. M., Mølbak, K., Kähler, J., Mdegela, R. H., Olsen, J. E., & Dalsgaard, A. (2019). Cholera hotspots and surveillance constraints contributing to recurrent epidemics in Tanzania. BMC research notes, 12(1), 1-6.

Ligate, F., Ijumulana, J., Ahmad, A., Kimambo, V., Irunde, R., Mtamba, J.O., Mtalo, F. and Bhattacharya, P., 2021. Groundwater resources in the East African Rift Valley: Understanding the geogenic contamination and water quality challenges in Tanzania. Scientific African, p.e00831.

Maliti, E., (2020). Evolution of open defecation prevalence in Tanzania 2002–2015: evidence from national demographic and health surveys, Development in Practice, DOI: 10.1080/09614524.2020.1828283

Mng'ong'o, M., Munishi, L. K., Ndakidemi, P. A., Blake, W., Comber, S., & Hutchinson, T. H. (2021). Toxic metals in east african agro-ecosystems: Key risks for sustainable food production. Journal of Environmental Management, 294 doi:10.1016/j.jenvman.2021.112973

United Republic of Tanzania (n.d). Short Brief on Lake Victoria Environmental Management Project (LVEMP). Ministry of Water Lake Victoria Environmental Management Project. Accessed on https://www.maji.go.tz/uploads/publications/sw1549607182-LVEMP%20Brief%20Summary%202-%20MoWI.pdf

Lake Tanganyika Authority (2021). Lake Tanganyika Water Management (LATAWAMA). Newsletter No1 and no2 February 2021. Accessed on https://latawama.org/wp-content/uploads/2021/02/Latawama-Newsletter-first-edition-Feb-2021-ENGLISH.pdf

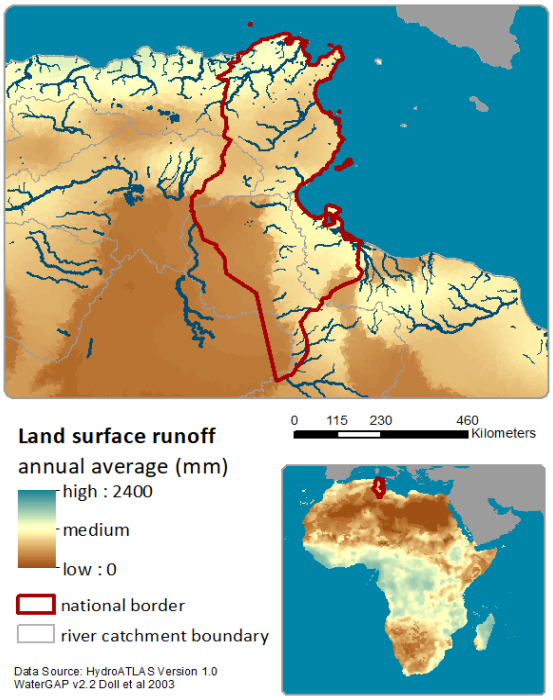
United Republic of Tanzania (2019). Health and Pollution Action Plan. Accessed on https://www.unido.org/sites/default/files/files/2019-10/Tanzania%20HPAP.English_2.pdf

United Nations Environment Programme [UNEP] (2021). Progress on ambient water quality. Tracking SDG 6 series: global indicator 6.3.2 updates and acceleration needs. Nairobi

Tunisia

BACKGROUND/ CONTEXT:

- **Population:** 11.82 million
- **Water Supply**: National improved water coverage – 99.2%; Rural – 97.3%; Urban – 100.0% (JMP, 2021)
- **Sanitation:** National improved sanitation coverage – 99.0%; Rural – 99.4%; Urban – 98.8%; National open defecation- 0.0%; Rural- 0.0%; Urban – 0.0% (JMP, 2021)
- **Major River systems**: The most important river system in Tunisia, the Medjerda, the only river that flows perennially;
- **Major water bodies**: the Chott el Djerid and Chott el Gharsa
- **SDG Indicator 6.3.2**: 84.94% of water bodies have good ambient water quality (UN Water, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACTS

Water pollution in Tunisia has been a long standing problem such that it now serves as a significant threat to human health in the country. Improper wastewater disposal is prevalent with agricultural activities and industrial expansion most likely to worsen water resources pollution and the sanitation issues. It is reported that over 40% of polluting industries in Tunisia are disconnected from sewerage networks and dump untreated loads of waste discharges into natural bodies of water (USAID, 2018; Word Bank 2014; METAP, n.d.; KFW, 2014; FAO, 2017).

There have been some considerable efforts made to create wastewater facilities in Tunisia however the overall quality of the water remains poor and could continue to worsen if more is not done to counter the increasing levels and sources of pollution (Venusti, 2017).

Major pollution categories and examples of their occurrence in Tunisia

Major Categories	Examples	References
Organic pollutants	A study to assess organic pollutants (PAH and PCB) in surface water: sediments and shallow groundwater of Grombalia watershed in northeast of Tunisia was caried out. The analysis indicated that High concentrations of these pollutants in waste water (varying from 0.37 to 0.83mg/l PAHs and 0.28 to 1.18mg/l PCBs) significantly alters the water quality with high traces in water sources within the water shed more especially near industrial areas of Bouargoub and Soliman, and wastewater discharge locations in Soliman.	Samia et al., 2018
Pathogens	Sixty wastewater samples were collected from fifteen different regions of Tunisia to assess bacteriological and physico-chemical parameters.The bacteriological control of wastewaters showed that, in entrance points, Escherichia coli (E.coli) was detected at the rate of 76.6%. Three E.coli pathotypes were found: ETEC (53.3%), EAEC (16.6%) and EIEC (6.6%).	Salem, et al., 2011
Inorganic pollutants (salts and metals)	The concentrations of nutrients and heavy elements in the surface water of the lake Ichkeul, main wadis which feed directly and thermal springs that flow into the lake, ware measured to evaluate these chemical elements. The results show that the highest concentrations are located in the eastern and south-eastern part of the lake where the polluted water comes from the lagoon of Bizerte through the wadi Tinja as well as from the city of Mateur through the wadi Joumine.	Yazid, et al., 2017
	Potential contamination of the sediments in the Sebkha of Moknine (Tunisia) ecosystem was assessed by means of enrichment factors (EFs) estimated against reference sediment located ≈70 km away from the Sebkha. results indicated that surface sediments were enriched up to 22.9, 13.2, 5.46 and 3.19 times with Pb, Cu, Cr and Zn, respectively.	Wali, et al., 2015

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control

State Agency or Department	Water Quality Related Roles and Responsibilities
Ministry of Agriculture, Water Resources and Fisheries (MARHP)	- Surface and ground water monitoring at national level, two parameters are measured (salinity and nitrates), - Dams water quality monitoring. - Drinking water monitoring,
Public Health Ministry	- Monitoring drinking water
Ministry of the Environment	- Treated waste water monitoring (released by water treatment plants) – Copeau : - National Network for water quality monitoring at national level, different types of water
National Office for Sanitation (ONAS	combating all sources of water pollution in the areas within its purview. monitors treated wastewater discharges management, operation, renovation and construction of all urban sanitation works such as treatment plants, pumping stations, networks and marine outfalls
National Water Exploitation and Distribution Company (SONEDE)	water production, treatment and transfer, water distribution (management and maintenance of the drinking water network) monitoring of drinking water quality.

Source: OECD, 2014; Grant, 2020; du Plessis, 2021

Water pollution monitoring and control: policies and regulatory environment

Policies/Regulations	Description/ scope
N.T 09.13 (1983)	Quality of surface water that can be used as potable water source.
N.T 09.14 (1983)	Water quality and national drinking water standards
National Water Council Decree No. 407/2010 of 9 March 2010.	Water allocations
Decree 2018-315 du 26 mars 2018	Regulating the discharge of treated wastewater
Decree No. 94-1885 (1994	Regulating the discharge of wastewater (other than domestic water) into the environment.
NT 106.03	Identifying conditions for the reutilization of treated wastewater for irrigation.
Decree 85-56 of 2 January 1985 on the terms of discharges into the receiving environment, changed in 1991 and decree 2005-1991 of July 2005 defining the study of environmental impact.	Industrial effluent standards

Source: OECD, 2014; Grant, 2020; du Plessis, 2021

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Initiative	Partner/Responsible Authority	Water Pollution Related Scope
Water quality monitoring of the Sejnane reservoir in northeast Tunisia	**General Directorate for dams; MARHP**	water quality monitoring of precipitation, evaporation, temperature, pH, conductivity, dissolved oxygen, turbidity, total suspended solids, major anions and cations, fluoride, BOD_5, NO_3^-, NO_2^-, NH_4^+, P tot, fecal coliform bacteria, boron and heavy metals (Fe, Zn, Cu, Ni, Pb, Cr and Cd) are reported.
Surface water quality network	**General Directorate for Water Resources; MARHP**	About 60 main hydrometric stations and 170 secondary monitoring points where a number of water quality measurements are performed such as: Water conductivity, turbidity and determination of major ions.
Groundwater quality network	**General Directorate for Water Resources; MARHP**	1200 shallow (729) and deep (471) monitoring boreholes for TDS and nitrates
Water Pollution sources network	**General Directorate for Water Resources; MARHP**	Abstraction of water samples once or twice a year from boreholes in the field and analyzing TDS and nitrates at the Water Resources General Directorate Laboratory.

Sources: Copeland, 2016; Besma, 2009

WATER QUALITY MONITORING AND TESTING CAPACITY

Water quality monitoring in Tunisia is conducted by many stakeholders. The directorate of Water Resources Monitors salinity and nitrates in surface and ground waters nationally; the General directorate of dams monitors water quality in dams; the National Company of Water Use and Distribution and the Ministry Health monitors drinking water; the National Agency for Environment Protection with more than 400 monitoring points in rivers, groundwaters, at discharge sites of treated and untreated waste, dams and wetlands monitors water quality nationally and waste water discharges is monitored by the National Sanitation Office (Grant, 2020).

Laboratory Facilities and Capacity

The National Agency for Environment Protection monitoring network ('Copeau' network) has a central laboratory and one regional laboratory that carry out sampling and analysis of water quality from 400 monitoring points. Water Research and Technologies Centre (CERTE), has a Wastewater Treatment Laboratory and Natural Water Treatment Laboratory. There are several other government and private laboratories that are capable of monitoring water quality in Tunisia.

REFERENCES:

AMCOW/IWMI Survey (2021). Pan Africa Water Quality Program: Africa wide survey implemented from July-September 2021 by the International Water Management Institute in collaboration with the African Ministers' Council on Water.

Besma, Z.A., Gueddari, M. (2009). Long-term water quality monitoring of the Sejnane reservoir in northeast Tunisia. Bulletin of Engineering Geology and the Environment. 68. 307-316. 10.1007/s10064-009-0186-1.

Copeland, E. (2016, October 9). Water Quality monitoring in Tunisia. SILO.TIPS. https://silo.tips/download/water-quality-monitoring-in-tunisia

du Plessis, Anja. (2021). Sanitation and Wastewater Atlas of Africa.

FAO, (2017). COUNTRY FACT SHEET ON FOOD AND AGRICULTURE POLICY TRNDS. https://www.fao.org/3/i7738e/i7738e.pdf

Grant, K. (2020). Ambient water quality: monitoring for management and SDG Indicator 6.3.2 reporting. Workshop report. UNEP GEMS/Water Capacity Development Centre, Environmental Research Institute, University College Cork, Cork, Ireland.

KFW, (2014). Ex post evaluation report- Tunisia. https://www.kfw-entwicklungsbank.de/PDF/Evaluierung/Ergebnisse-und-Publikationen/PDF-Dokumente-R-Z_EN/Tunesien_FODEPIII_2104_E.pdf

METAP, (n.d.). Water Quality Management- Tunisia. http://siteresources.worldbank.org/EXTMETAP/Resources/WQM-TunisiaP.pdf

OECD, (2014). Water Governance in Tunisia: Overcoming the Challenges to Private Sector Participation, OECD Studies on Water, OECD Publishing. http://dx.doi.org/10.1787/9789264174337-en

Salem, I.B., Ouardani, I., Hassine, M., Aouni, M. (2011). Bacteriological and physico-chemical assessment of wastewater in different region of Tunisia: impact on human health. BMC Res Notes 4, 144. https://doi.org/10.1186/1756-0500-4-144

Samia, K., Dhouha, A., Anis, C. Ammar, M., Rim, A., Abdelkrim, C. (2018). Assessment of organic pollutants (PAH and PCB) in surface water: sediments and shallow groundwater of Grombalia watershed in northeast of Tunisia. Arab J Geosci 11, 34. https://doi.org/10.1007/s12517-017-3362-9

Sebai, O. (n.d.). Tunisia experience in 6.3.2 Indicator submission. National Agency for environmental protection. Government of Tunisia. https://www.unescwa.org/sites/default/files/event/materials/Tunisia%20Experience%20SDG%206.3.2_E.pdf

United Nations Environment Programme [UNEP] (2021). Progress on ambient water quality. Tracking SDG 6 series: global indicator 6.3.2 updates and acceleration needs. Nairobi

Venusti, S. (2017, July 29). Efforts to improve the poor water quality in tunisia. The Borgen Project. https://borgenproject.org/water-quality-in-tunisia/

Wali, A., Kawachi, A., Bougi, M.S.M., Dhia, H.B., Isoda, H., Tsujimura, M., Ksibi, M. (2015). Effects of Metal Pollution on Sediments in a Highly Saline Aquatic Ecosystem: Case of the Moknine Continental Sebkha (Eastern Tunisia). Bull Environ Contam Toxicol 94, 511–518. https://doi.org/10.1007/s00128-015-1469-9

WGS Initiative, (2016). Local Water Security Assessment.

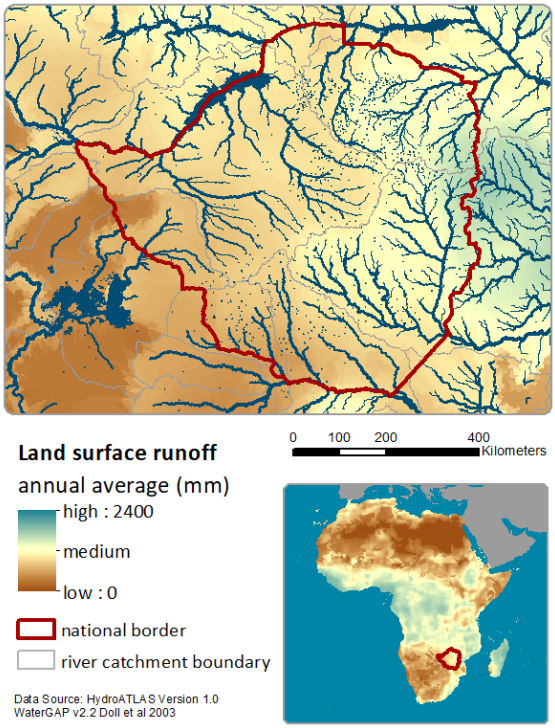
World Bank, (2014). Water: Tunisia's Other Development Challenge .https://www.worldbank.org/en/news/feature/2014/09/04/water-tunisia-s-other-development-challenge

Yazidi, A., Saidi, S., Mbarek, N.B., Darragi, F. (2017). Contribution of GIS to evaluate surface water pollution by heavy metals: Case of Ichkeul Lake (Northern Tunisia), Journal of African Earth Sciences, Volume 134, Pages 166-173, ISSN 1464-343X, https://doi.org/10.1016/j.jafrearsci.2017.06.009.

Zimbabwe

BACKGROUND/ CONTEXT:

- **Population:** 14.86 million (World Bank Group, 2021)
- **Water Supply**: 64% of the population has access to basic drinking water services with 92% coverage in urban areas and 51% un rural areas (GoZ, 2019)
- **Sanitation:** 37% of the national population has access to basic sanitation services. In urban areas, 43% and 34% in rural areas have access to basic sanitation services
- **Main rivers:** Hydrologically, the country's water management areas are delignated according to the country 7 main rivers - the, Gwayi, Manyame, Mazowe, Mzingwane, Runde, Sanyati and Save rivers
- **SDG 6.3.2 (2020)**: 83.3% of water bodies have good ambient water quality (UN Water, 2021)



WATER POLLUTION: POLLUTANTS, SOURCES AND IMPACT

Most of Zimbabwe's urban streams are heavily polluted as found in the cities of Harare, Kwekwe and Mutare (Basvi et al., 2018; Dube et al., 2020; Toriro, 2020). Lake Chivero (an inland man-made lake that supplies domestic water to the City of Harare) has a long standing history of pollution from urban wastewater and is arguably the most polluted water body in Zimbabwe (Dlamini et al., 2016; AMCOW/IWMI Survey, 2021). Studies have shown high nutrient loadings in the reservoir due to the discharge of raw sewage resulting in increased treatment costs for domestic water supply (Nhapi, 2004; Dlamini, 2016; Toriro, 2020). Generally the key drivers for pollution have been identified as increasing population and expansion of artisanal mining, and increased wastewater flows that have put pressure on the local infrastructure capacity to adequately treat wastewater (Davies and Hiriji, 2014; EMA, 2016).

The pollution situation reached critical levels in 2008 and 2009 when diseases broke out among the densely populated urban populations. Since then, there have been sporadic episodes of waterborne infections such as Cholera and Typhoid, with the latest outbreak reported during the latter part of 2018 and the early months of 2019 (GoZ, 2019). A growing water supply crisis has fuelled dependence on groundwater in urban centres such as Harare and Gweru, nonetheless contamination of groundwater due to improper waste management has been reported rendering groundwater unsafe for drinking in some urban areas (Murwira et al., 2014).

Major pollution categories and examples of their occurrence in Zimbabwe

Major Pollutant Categories	Cases of pollution	References
Organic pollutants	Lake Chivero highly polluted industrial effluent, with organic material and nutrients from sewage and urban agriculture.	Nhapi (2007); Manzungu and Chioreso, 2012; Toriro (2020)
Nutrients	High nutrient enrichment of the Khami and Umguza rivers (Bulawayo) from poorly treated urban-wastewater.	Hoko et al. (2021).
Inorganic pollutants (salts and metals)	In Bulawayo, water pollution indicators (Dissolved Oxygen, Total dissolved Sediments, salinity) were found to be above acceptable limits in the Umguza and Khami Rivers that drain wastewater from the city of Bulawayo.	Siziba et al., 2021
Emerging Pollutants	Toxins released by algae are a challenge for conventional water treatment technologies.	Hoko et al. (2021)

POLICIES AND INSTITUTIONS

Government agencies involved in water quality monitoring and pollution control:

State Agency or Department	Scope of water quality related responsibilities
Ministry of Ministry of Lands, Agriculture, Water Climate &Rural Resettlement	Parent ministry for the ZINWA and EMA.
National Action Committee on Water and Sanitation - NAC	A sub-committee on water resources management consists of several ministerial entities and ensures ecological and river systems integrity for including facilitating the monitoring of water quality.
Zimbabwe National Water Authority - ZINWA	Plan, develop and manage water resources, bulk water supply services (ZINWA,
Environmental Management Agency - EMA	Ambient water quality monitoring, regulation of polluting activities and enforcement of regulations
Ministry of Health and Child Care	Drinking water quality surveillance
Inter-Ministerial Cabinet Committee on Water pollution	High level government committee that calls for compliance among targeted heavy polluters

Source: (Government of Zimbabwe (GoZ, 2012))

Water pollution monitoring and control: Policies and regulatory environment

Several legislation regulates water pollution from an ambient and drinking water perspective.

Policy and Regulations	Scope
National Water Act (1998)	Gives effect to the management of water resources including managing pollution
ZINWA Act, 1998	Establishes the Zimbabwe National Water Authority
National Environmental Management Act (2002)	Regulates water pollution and issues permits and penalties
Urban Councils Act, 1996	Regulates the pollution of any water subject to the Zimbabwe National Water Act
Public Health Act	Drinking water quality surveillance

Source: (Government of Zimbabwe (GoZ, 2012))

WATER QUALITY MONITORING, AND POLLUTION CONTROL INITIATIVES

Water quality monitoring capacity has been steadily declining. Over 60% of gauging station are not in operation or are malfunctioning (Davies and Hiriji, 2014). Pollution control and monitoring activities are conducted under the Environmental Management Agency through its network of regional country offices. The agency employs regulatory tools based on the Polluter Pays Principle (GoZ, 2012). In 2016 out of the over 60, 000 inspection conducted, about 6% were directed at water and effluent (EMA, 2016). Permitting, fining are deployed towards mitigating pollution. Nonetheless the tools have their limited success in curbing the growing pollution problem with least to some impact reported (AMCOW/IWMI Survey, 2021). Conventional wastewater treatment technologies have been hampered by reduced efficiency as they operate above capacity (Hoko et al., 2020).

Initiative	Partners/Responsible Authority	Scope
National ambient water quality programme Ongoing	Environmental Management Agency	An ongoing national initiative for ambient water monitoring implemented across the country's seven catchments.
Zimbabwe - Strategy for managing water quality and protecting water sources 2014 - 2016	Funded by the World Bank	Zimbabwe - Strategy for managing water quality and protecting water sources was implemented in two phases: Phase 1 developed a methodology for conducting a rapid assessment of water quality in pilot areas using specialized tools and techniques including remote sensing, geographic information systems (GIS) and field sampling to identify pollution hotspots nationwide. Phase 2 focused on an in-depth assessment of all hotspots across the country
Environmental Monitoring Programme	Implemented by the Zambezi River Authority	Water quality data collection and processing activities are carried out for all stations on Lake Kariba and the Zambezi River. Water quality parameters monitored include Temperature, pH, Electrical Conductivity, Dissolved Oxygen,

Ongoing		Alkalinity, Total Suspended Solids, Total Dissolved Substances, Turbidity, Total and Ortho Phosphorus, Chlorophyll, Ammonia, Alkalinity and Faecal Coliforms.

WATER QUALITY MONITORING AND TESTING CAPACITY

Laboratory Facilities and Capacity

The National Environmental Quality Laboratory facilities are operated under the Environmental Management Agency (EMA). The laboratory predominately analyses water samples from ambient water quality monitoring through the seven-catchment offices across the country. In 2019, the laboratory analyzed close to 10,000 samples for chemical and microbiological indicators (EMA 2016). The Ministry of Health and Child Care conducts water quality surveillance initiatives from health perspectives, testing surface and groundwater in identified hotspots (GoZ, 2019). Current plans include the development of Water Quality Safety Plan, which will include a standardized water quality-reporting tool (GoZ, 2019).

REFERENCES

Basvi, A., Shambira, L. and Mapira, J., 2018. Challenges of River Pollution in the Dora Community, Mutare (Zimbabwe). *International Journal of Current Innovations in Advanced Research*, *1*(7), pp.42-56.

Davis, R; Hirji, R., 2014. *Climate change and water resources planning, development and management in Zimbabwe : main report (English).* Washington, D.C. : World Bank Group. Accessed on http://documents.worldbank.org/curated/en/925611468329355687/main-report

Dlamini, S., Nhapi, I., Gumindoga, W., Nhiwatiwa, T., & Dube, T. (2016). Assessing the feasibility of integrating remote sensing and in-situ measurements in monitoring water quality status of Lake Chivero, Zimbabwe. *Physics and Chemistry of the Earth, Parts A/B/C*, *93*, 2-11.

Dube, T., Chibanda, M., Manhire, B., Rutanhira, C., Mabugu, C., Makaka, C., Makaure, J. and Muteveri, T., 2020. Sewage Effluent Causes Metal Pollution of a Sub-tropical River System in Zimbabwe. *Bulletin of environmental contamination and toxicology*, *104*(3), pp.339-344.

Environmental Management Agency (EMA) (2016). 2016 Annual Report. Environmental Management Agency. Harare, Zimbabwe

Government of Zimbabwe (GoZ) (2012). National Water Policy. Ministry of Water Resources Development and Management

Government of Zimbabwe (GoZ) (2019). Water, Sanitation and Hygiene (WASH) Sector 2019 Joint Sector Review. Theme: Sustainable WASH Services for Zimbabwe's Economic Recovery Towards the SDGs

Hoko, Z., Toto, T. N., Mapenzauswa, C., Nhiwatiwa, T., Chipfunde, L., & Hunguru, S. (2021). Investigating use of chlorine dioxide for pre-treatment of raw water from polluted sources at Morton Jaffray Water Treatment Works, Harare, Zimbabwe. *Water Practice and Technology*.

Mapira, J. (2017). The mining industry in Zimbabwe: Challenges for sustainable development. *European Journal of Social Sciences Studies*.

Murwira, A., Masocha, M., Magadza, C.H.D., Owen, R., John S., Nhiwatiwa, T., Barson, M., Makurira, H..2014. *Zimbabwe - Strategy for managing water quality and protecting water sources (English).* Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/437091468190768634/Zimbabwe-Strategy-for-managing-water-quality-and-protecting-water-sources

Nhapi, I., Siebel, M. A., & Gijzen, H. J. (2004). The impact of urbanisation on the water quality of Lake Chivero, Zimbabwe. *Water and Environment Journal*, *18*(1), 44-49.

Siziba, N., Mwedzi, T., & Muisa, N. (2021). Assessment of nutrient enrichment and heavy metal pollution of headwater streams of Bulawayo, Zimbabwe. *Physics and Chemistry of the Earth, Parts A/B/C*, *122*, 102912.

Toriro, P., 2020. Pollution and Poor Land-use Management as Causes of the Harare Water Crisis. *Journal of Urban Systems and Innovations for Resilience in Zimbabwe-JUSIRZ*, *2*(2), pp.73-93.

WBG [The World Bank Group] 2021. Zimbabwe Country Profile. World Development Indicators. Accessed on https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=ZWE

Webster, M., 2014. *Rapid assessment, identification, and characterization of water pollution and source degradation in Zimbabwe (English).* The Zimbabwe water forum policy note, no. 12 Washington, D.C. : World Bank Group. Accessed http://documents.worldbank.org/curated/en/659751468196755638/Rapid-assessment-identification-and-characterization-of-water-pollution-and-source-degradation-in-Zimbabwe

Zimbabwe National Statistics Agency (ZIMSTAT) and UNICEF (2019). Zimbabwe Multiple Indicator Cluster Survey 2019, Snapshots of Key Findings. Harare, Zimbabwe: ZIMSTAT and UNICEF.

United Nations Environment Programme [UNEP] (2021). *Progress on ambient water quality. Tracking SDG 6 series: global indicator 6.3.2 updates and acceleration needs*. Nairobi

Headquarters
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Mailing address
P. O. Box 2075
Colombo
Sri Lanka

Telephone
+94 11 2880000

Fax
+94 11 2786854

Email
iwmi@cgiar.org

Website
www.iwmi.org

IWMI
International Water Management Institute
CGIAR
IWMI is a CGIAR Research Center