

2021

ROKEL RIVER WATER QUALITY MONITORING REPORT

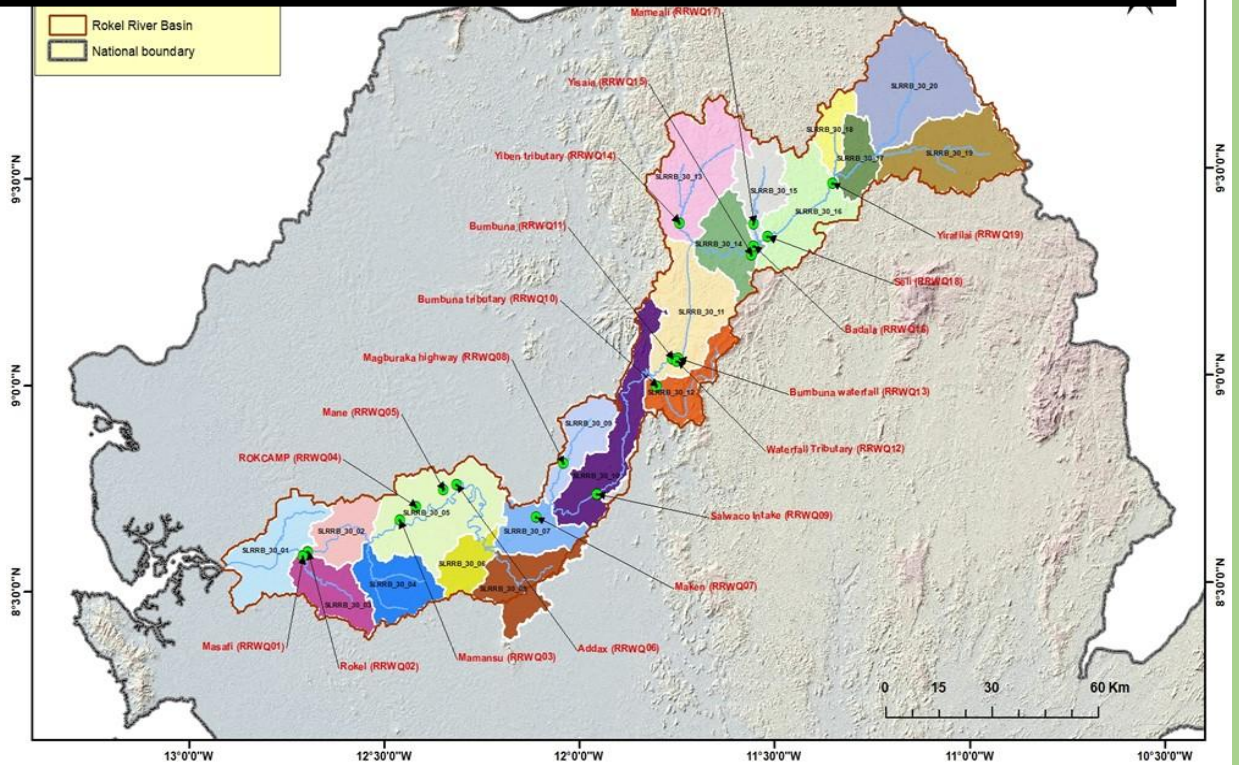


Table of Content

Contents

Table of Content	1
Background.....	2
Methodology	4
Water Quality Parameters	5
Results	6
SDG 6.3.2 indicator results.....	6
Core parameter results	8
pH	8
Electrical Conductivity.....	9
Dissolved Oxygen	9
Orthophosphate.....	10
E. coli.....	11
Land use and Land Cover	12
Groundwater quality monitoring.....	14
Findings.....	15
Outcomes.....	16
Recommendations.....	16

Background

The National Water Resources Management Agency was established in 2019 by 2017 Act No. 5 of parliament. This act gives the Agency broad functions entailing regulation, utilisation, protection, development, conservation, control, and management of water resources throughout Sierra Leone. The Agency has the vision of becoming one of the leading water resources management agencies in West Africa.

However, to achieve its policy objectives, it has developed its five-year strategic development plan, which serves as a road map for effective and efficient water resources in Sierra Leone. One of the six goals in the strategic development plan is "Water Resources Assessment and Monitoring". Against this background, the Agency is gradually rolling out water quality and quantity monitoring across Sierra Leone.

The Rokel River basin is facing diverse threats and challenges. These threats include an increase in deforestation, land degradation, new settlements, mining, pollution from mining companies, climate change impacts, population increase and increase in water users for diverse purposes. These threats in the Rokel River basin are a microcosm of the general threats facing other river basins in Sierra Leone. Also, the Rokel river is a home for major water users in Sierra Leone: the Bumbuna Hydropower Dam, the SALWACO Magburaka water supply system, the SUNBIRD Bioenergy that uses the water for irrigation and the proposed Freetown water supply project.

The Rokel River basin originates from the North-East and flows through, Koinadugu, Tonkolili, Bombali and Port Loko districts; it then empties into the Atlantic Ocean in the West. The basin has an area of 8,236 km² and stretches for 390 km. Historical River flow data (1970 to 1976) indicates that the river discharge could be as high as 500 m³ in the peak of the rains and as low as 2 m³ in the peak of the dries. Figure 1 below is a map of the Rokel river basin.

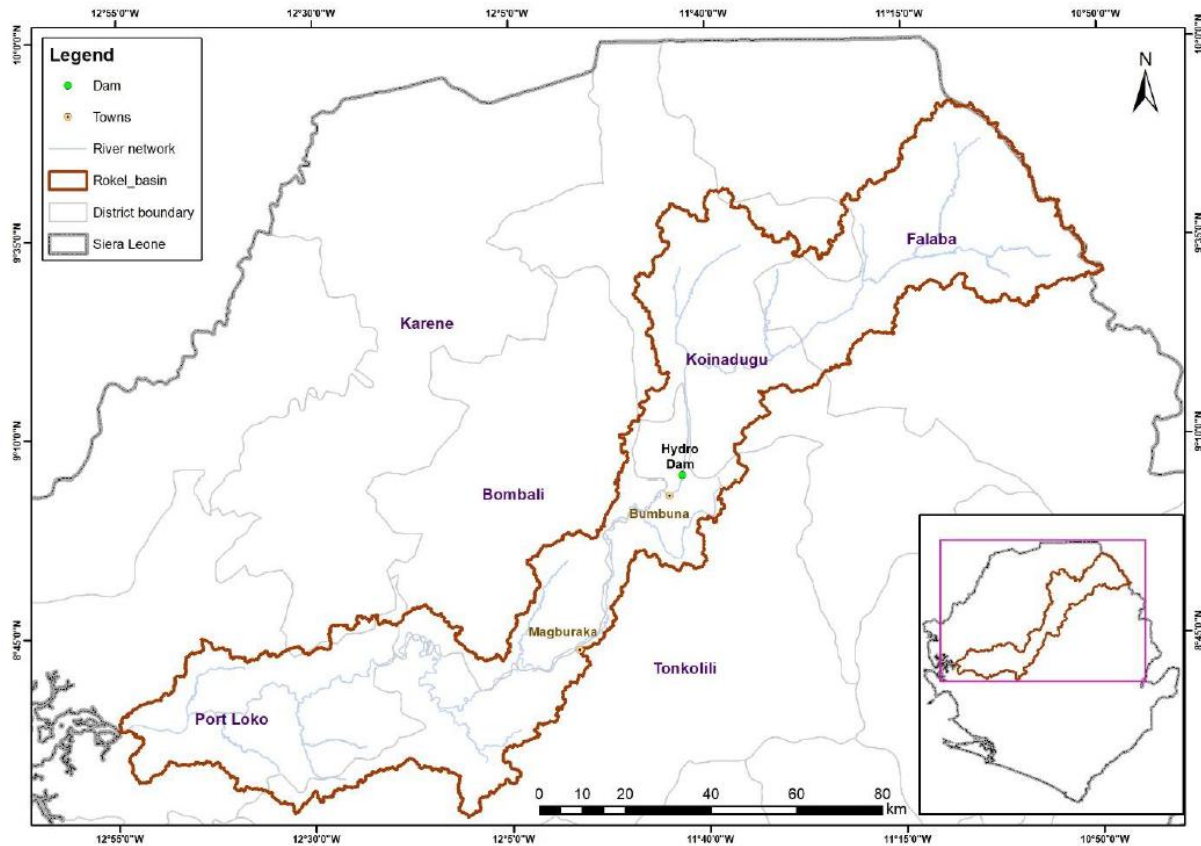


Figure 1 Map of the Rokel river basin and the ongoing socio-economic activities.

With regards to the above issues and limited resources, the Agency prioritise the Rokel River basin to commence routine water quality monitoring in November 2019.

The following are the objectives for the water quality monitoring at the Rokel River basin:

1. To report SDG 6.3.2 indicator (Proportion of water bodies that meets ambient water quality).
2. To determine trends in the physical, chemical, and bacteriological parameters of ambient freshwater quality.
3. To determine point source contamination along the river basin.
4. To determine the impact of anthropogenic activities on the river body.
5. To provide recommendation for environmental protection and pollution control.

Methodology

Before the water quality monitoring and assessment intervention, the Hydrological Services department held consultative meetings in which site monitoring stations were established following international principles and guidelines for establishing surface water monitoring stations. The Rokel River basin boundary with its respective sub-catchments was obtained from the 30m digital elevation model dataset delineation in the ArcGIS environment. A GIS map containing river basin and stream network, tributaries and elevation was developed by staff. The Agency identified a total of nineteen (19) locations across the Rokel River basin in twelve (12) sub-catchments, as shown in figure 1 below.

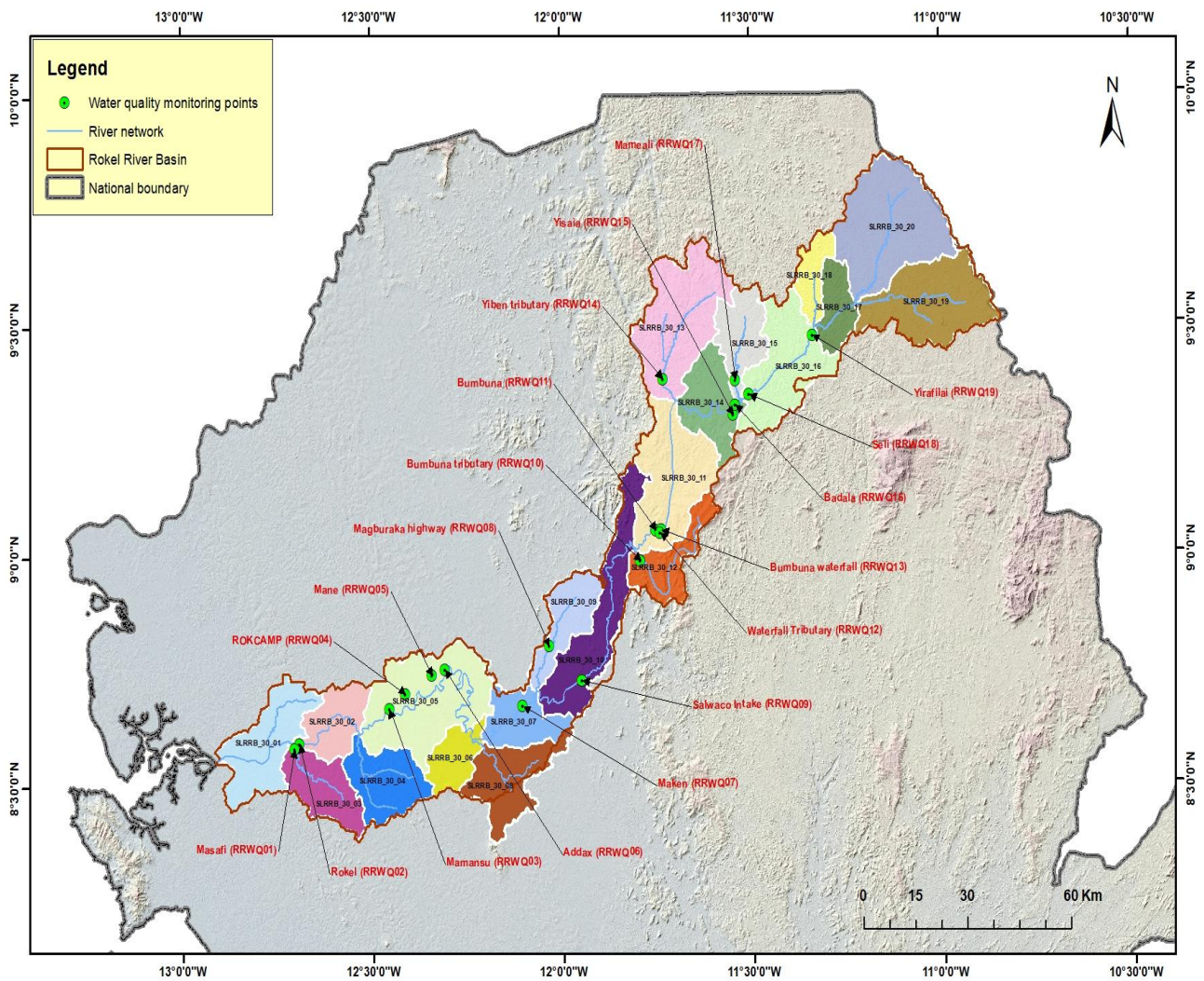


Figure 2 Surface water monitoring stations

Water Quality Parameters

For the National Water Resources Management Agency to commence the SDG 6.3.2 indicator's reporting, the Hydrological Services Department agreed on the following core and progressive parameters listed in table 2.0 below.

Table 1.0: Core and some progressive water quality parameters

	Parameters	Parameter Short Name	Target Value	Unit	Target Type
Core Parameters	Dissolve Oxygen	DO	6	mg/l	Lower
	Electrical Conductivity	EC	500	us/cm	Upper
	pH	pH	8-Jun		Range
	Orthophosphate	OP	0.035	mg P/l	Upper
	Total Oxidised Nitrogen (Nitrate + Nitrite)	TON	1.8	mg N/l	Upper
	Progressive Parameters (WHO)				
	Water Temperature (°C)				
	Turbidity		<5.0	NTU	Upper
	Conductivity		<450	µS/Cm	Upper
	Total Dissolve Solids	TDS	<248	ppm	Upper
	Fluoride	F	<1.5	mg/l	Upper
	Iron	Fe	<0.3	mg/l	Upper
	Nitrite	NO ₂ ⁻	3	mg/l	Upper
	Nitrate	NO ₃ ⁻	<10	mg/l	Upper
	Potassium	K	<6.0	mg/l	Upper
	Phosphate	P	<20	mg/l	Upper
	Sulphate	S04	<400	mg/l	Upper
	E. Coli		0		Lower

Every month, a team from the Hydrological Services department travel to all the surface and groundwater monitoring stations and conduct on-site testing of all the parameter listed in table 1 above. The team observes all quality assurance and control procedures as per ISO standards in sample collection, preservation, analysis, storage, and data management.

The following are the equipment used for the water quality testing

1. MD 610 photometer for chemical and some physical parameter testing
2. SD 400 for dissolved oxygen measurement
3. SD 70 for testing of some physical parameters.

Results

The results from the water quality monitoring and assessment are given and discuss in this section. The table below gives the annual average results of the surface water quality monitoring stations.

Table 2 Average annual water quality result of the core parameters for the sub-catchments in the Rokel river basin

Water Bodies	pH	EC ($\mu\text{S}/\text{Cm}$)	DO	Turb (NTU)	TON (mg/l)	Orthophosphate (mg/l)
SLRRB_30_02	7.25	20.54	7.03	7.39	1.01	0.47
SLRRB_30_03	7.02	20.74	5.40	9.63	1.02	0.63
SLRRB_30_05	7.12	28.92	6.08	24.52	1.07	0.79
SLRRB_30_07	7.42	22.18	7.57	26.82	1.01	0.90
SLRRB_30_09	7.09	19.42	6.20	16.42	1.07	0.58
SLRRB_30_10	7.32	22.00	8.08	32.25	1.10	1.02
SLRRB_30_11	7.40	30.24	8.00	31.04	1.14	1.10
SLRRB_30_12	7.07	17.27	7.07	75.17	1.28	0.70
SLRRB_30_13	7.03	31.55	6.93	14.73	1.03	0.54
SLRRB_30_14	7.21	37.01	7.13	24.75	1.08	0.98
SLRRB_30_15	7.21	31.29	7.27	22.54	0.94	1.15
SLRRB_30_16	7.33	35.11	7.71	30.96	1.08	0.89

SDG 6.3.2 indicator results

One of the monitoring objectives is to report SDG 6.3.2 indicators in the river basin. This was done by calculating the core parameters like Dissolved Oxygen, pH, Total Oxidised, Nitrogen (TON) and Electrical Conductivity against target values stated in table 1 above. The percentage compliance for each core parameter at each monitoring station is shown in the table below.

Table 3 Percentage compliance of core parameters in each surface water quality monitoring station

	Addax	Badala	Bumbuna Bridge	Bumbuna Bridge Tributary	Bumbuna Waterfall	Bumbuna Waterfall Tributary	Magburaka Highway	Magburaka Intake	Maken	Mamaeli	Mamansu	Mane	Masafi	Rokcamp	Rokel Village	Seli	Yebebi Tributary	Yisaia	Yirafilaia	Average
DO	100	100	100	100	100	100	58	100	100	83	83	25	42	40	100	100	82	75	100	84
EC	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
O-pht	8	0	8	8	17	0	8	0	0	17	8	25	17	0	0	8	27	8	8	9
TON	92	83	92	75	75	91	92	90	91	100	92	100	92	80	100	92	91	92	100	90
pH	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	Meet targets
	Did not meet target

From table 3 above, Orthophosphate is the parameter that entirely does not comply. In other words, there are higher values of Orthophosphate in each monitoring station that are above the target value of 0.03 mg/l

For the Agency to determine SDG 6.3.2 indicator in the river basin, the basin was divided into sub-catchments, and the percentage compliance for each sub-basin was determined. This was then followed by determining the indicator (SDG 6.3.2) indicator in the entire river basin. The result of the SDG 6.3.2 indicator is given in table 4 below. A water body must score percentage compliance of 80% for it to be classified as good at the sub-basin body. The indicator for the river basin is then calculated by dividing the number of sub-basins that are not good by the total number of sub-basins and expressed as a percentage.

Table 4 Percentage compliance for each water body and the indicator value.

No	Water body	SLRRB_30_02	SLRRB_30_03	SLRRB_30_05			SLRRB_30_07	SLRRB_30_09	SLRRB_30_10	SLRRB_30_11			SLRRB_30_12	SLRRB_30_13	SLRRB_30_14		SLRRB_30_15	SLRRB_30_16		
1	Stations	Rokel Village	Masafi	Mamansu	Rokcamp	Mane	Addax	Maken	Magburaka Highway	Magburaka Intake	Bumbuna Waterfall Tributary	Bumbuna Bridge	Bumbuna Waterfall	Bumbuna Bridge Tributary	Yebebi Tributary	Yisaia	Badala	Mamaeli	Seli	Yirafilaia
2	% compliance per station	78	70	77	64	70	80		72	78	78	80	78	77	80	75	77	80	80	82
3	% compliance per water body	78	70	73				78	72	78	79			77	80	76		80	81	
	Water body Classification	Not good	Not good	Not good				Not good	Not good	Not good	Not good			Not good	Good	Not good		Good	Good	

$$\text{Indicator Calculation 6.3.2} = \frac{\text{Not good}}{\text{Total}} \times 100 = 25$$

The indicator calculation from the table above gives a result of 25% for the Rokel river basin.

Also, from the figure below, only the two sub-catchments score the required 80% of SDG 6.3.2 indicator for the waterbody to be classed as good.

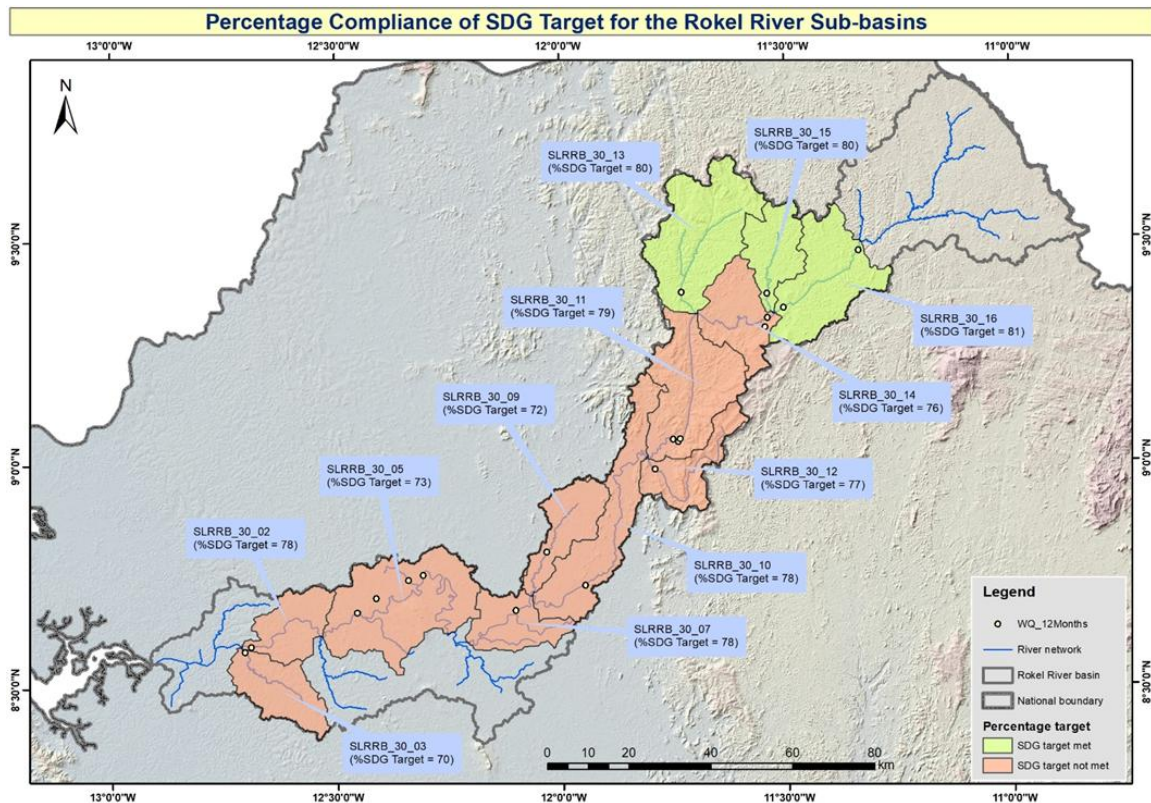


Figure 3 Percentage compliance of SDG target for sub-basins

Core parameter results

pH

From figure 4 below, most of the water bodies have average pH values within the target values (7 to 8) except SLRB_30_08. However, the pH values are gradually increasing as you move downstream.

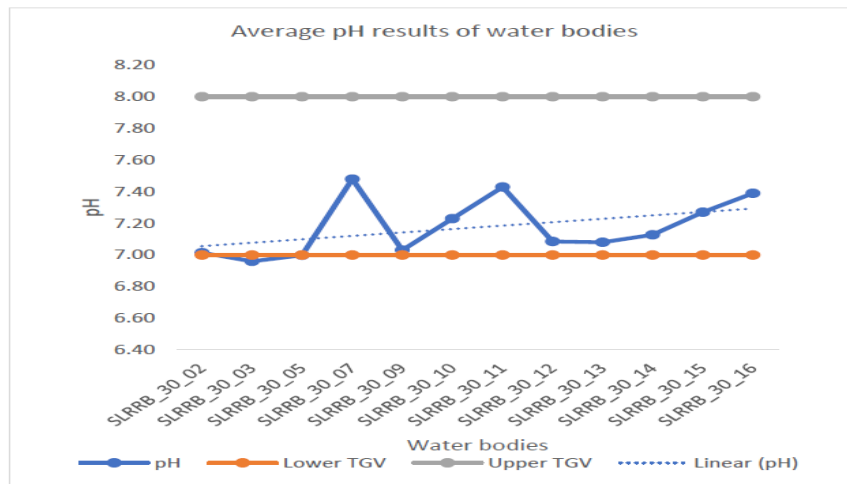


Figure 4 Average pH results of water bodies in the Rokel River basin

Electrical Conductivity

The electrical conductivity values for the water bodies in the Rokel River basin are shallow. As shown in the figure below, they are well below the prescribed target value of 500 micro siemens, which indicates natural water that is diluted.

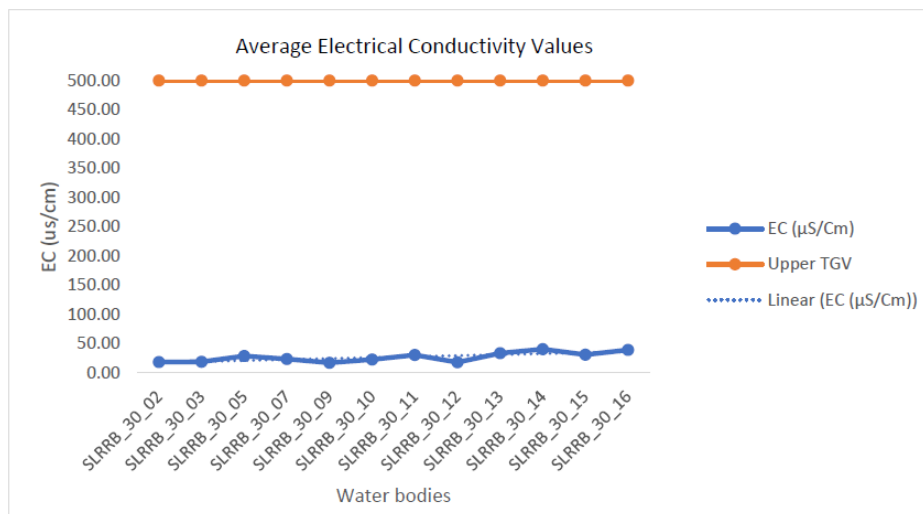


Figure 5 Average electrical conductivity values of water bodies in the Rokel river basin

Dissolved Oxygen

The dissolved oxygen for most water bodies is above the lower target value of 6, as seen in the figure below, except SLRB_30_03, SLRB_30_05 and SLRB_30_09. Water bodies with less

dissolved oxygen is an indication that the water body organic matter and other sources of pollution are absorbing the oxygen. Waterbodies with less dissolved oxygen become inhabitable for aquatic organisms.

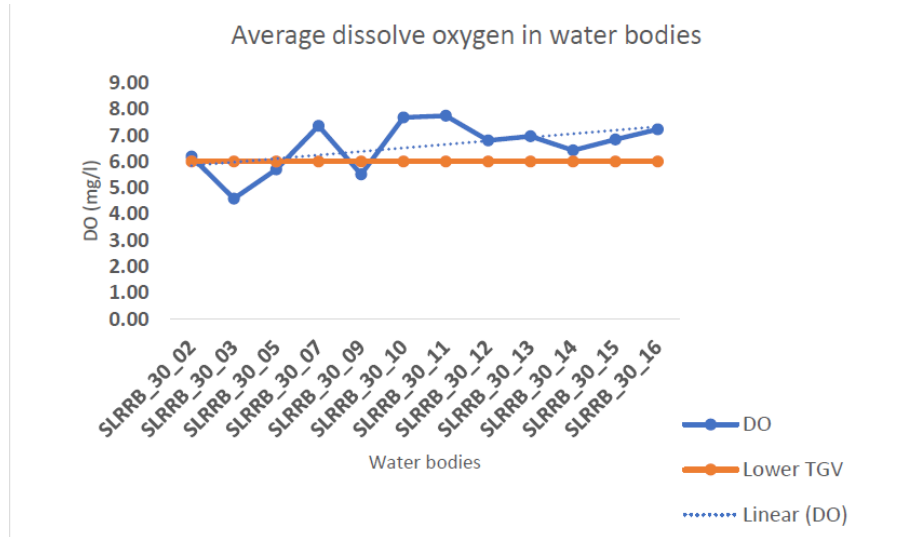


Figure 6 Average dissolved oxygen in water bodies in the Rokel river basin

Orthophosphate

Orthophosphate average values for each water body fail to comply with the prescribed target value of 0.03 mg/l. This can be seen in the figure below, as all the readings are way above the target value line.

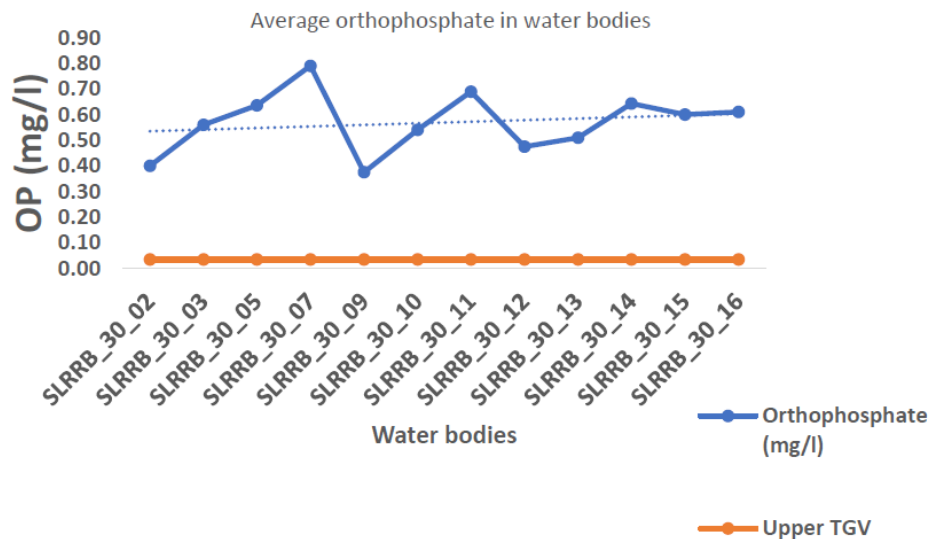
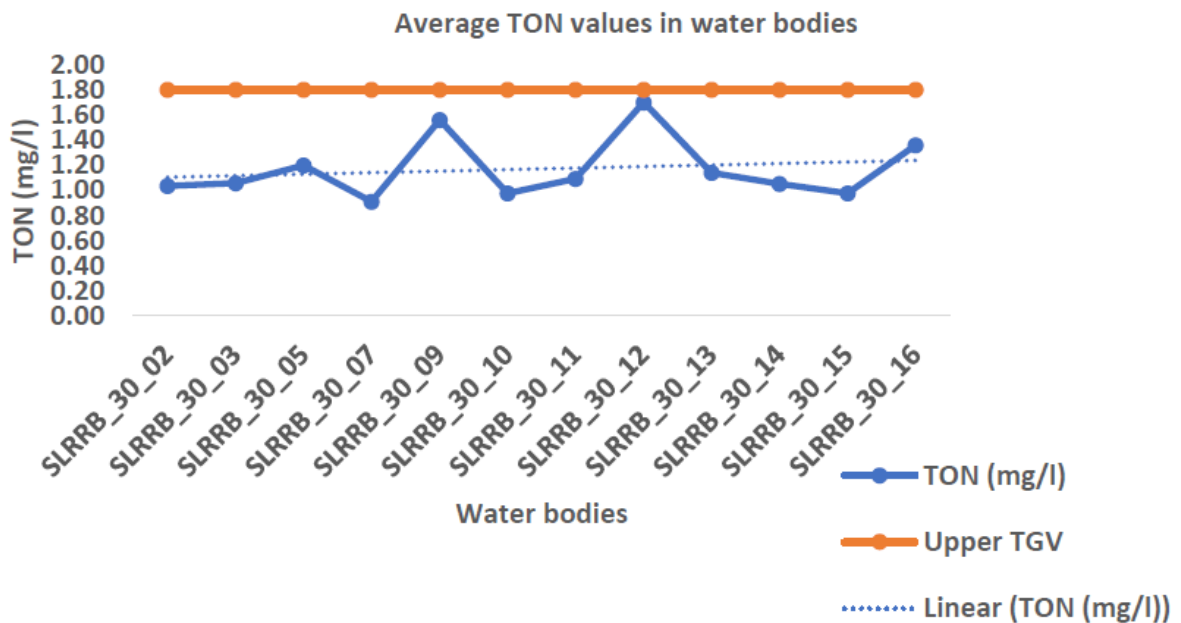


Figure 7 Average orthophosphate values for water bodies in the Rokel river basin

The high orthophosphate value could be a result of pollution from sewage, agricultural runoffs, or phosphate bearing rocks.

Total Oxidised Nitrogen (TON).

This parameter is determined by adding Nitrite and Nitrate values. The presence of this parameter in a higher concentration indicates pollution from agricultural runoff, environmental waste, and sewage. However, from the figure below, most of the water bodies are below the upper target value of 1.8 mg/l



E. coli

The presence of E. coli in the water bodies directly indicates that the water bodies are contaminated with faecal matter. From the figure below, all the water bodies have E. coli counts above 0 per 100ml of water sampled. E. coli could be due to open defecation and runoff from communities with limited access to improved sanitation facilities. It could also be due to runoffs from agricultural farms that are rearing livestock

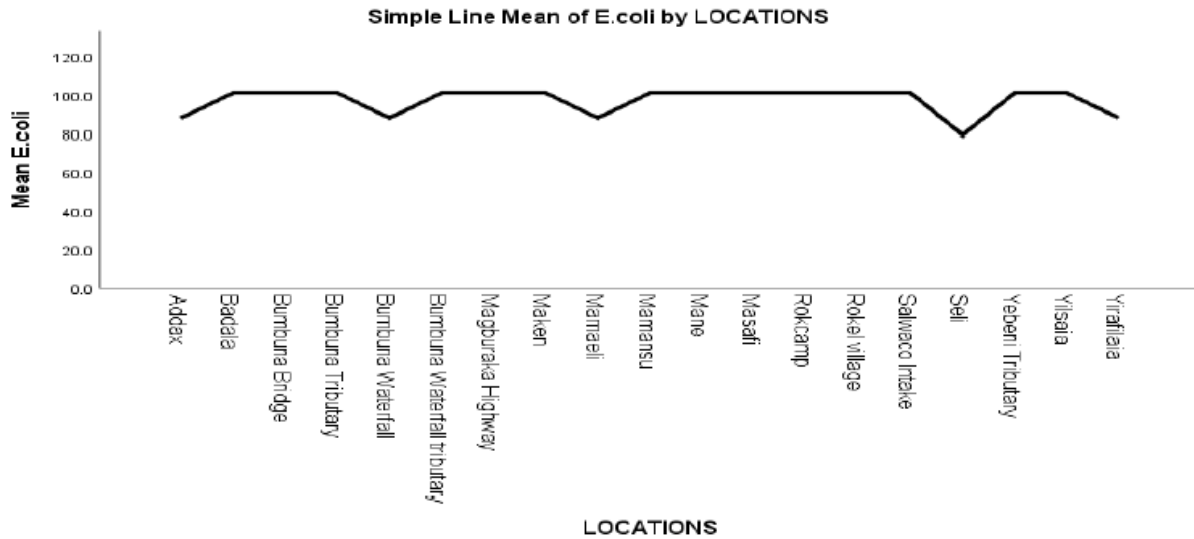


Figure 8 E. coli results obtained for each surface water monitoring station

Land use and Land Cover

A land use and land cover (LULC) assessment was conducted in the Rokel River basin. This was done to determine the status of deforestation and general degradation and how these land use and land cover patterns impact river water quality. The LULC was determined using GIS and the software ArcGIS.

The competing use of water resources resulting from population growth has led to the basin's fluctuation and deterioration of water quality. These mining and agricultural activities significantly affect the Rokel River Basin's Forest ecology with a 5.7% forest cover loss between 2002 and 2010, particularly within the downstream sub-watersheds. Many of these mining and agricultural companies located within the basin have been mapped and identified. Also, there is ongoing monitoring of their activities.

Presently, the forested area in the basin's upper section is undergoing severe deforestation, mainly for timber logging, cattle grazing, and unsustainable farming. The middle section of the basin is host to the Bumbuna hydro dam, the Kingho iron ore company, artisanal gold mining activities and significant settlements. The basin's lower area, which comprises the coastal and interior plain zones, is recognised for its farming activities and iron ore, sand mining, and artisanal gold mining activities. This area has gradually developed into shrubs and grassland areas due to massive

agricultural activities by the Addax bioenergy and lots of unstainable farming activities. Figure 10. below is a map of mining and farming activities in the basin.

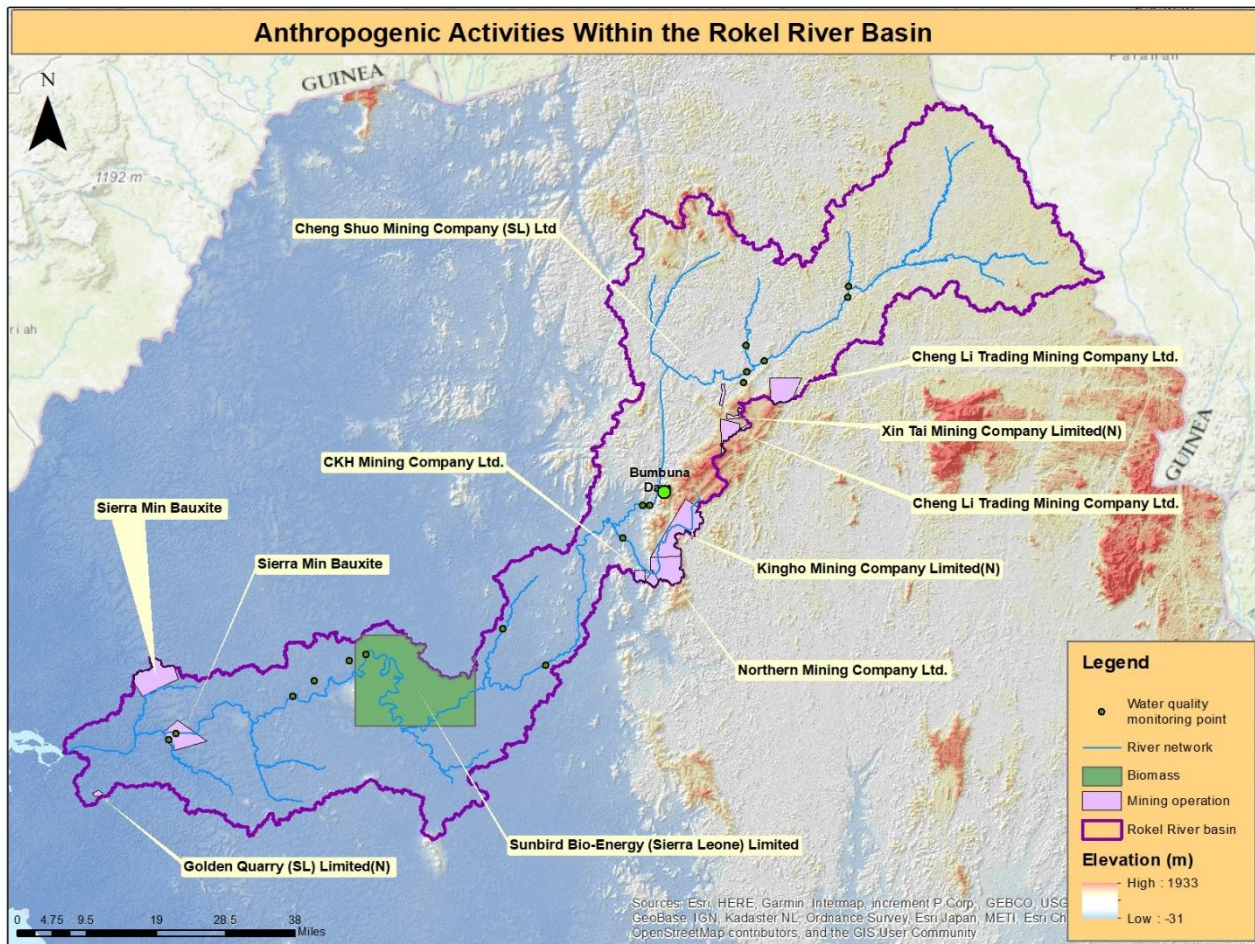


Figure 9 Mining and agricultural activities in the Rokel River basin.

The increment of urbanisation in the Rokel basin significantly impacts groundwater, and it is substantial concern over the few years for domestic, industrial, and food production. The enlargement of the urbanisation area results in a decrease in infiltration, affecting groundwater recharge and storage. The Agency is presently proposing a pilot project to accurately conduct 2020 land use/land cover mapping using Landsat 8 imagery to obtain seven (7) land use/cover classes within the basin. This can be evaluated using conventional and the latest Remote Sensing and Geographical Information System (GIS) techniques.

The figure below gives the land use and land cover map of the Rokel River basin

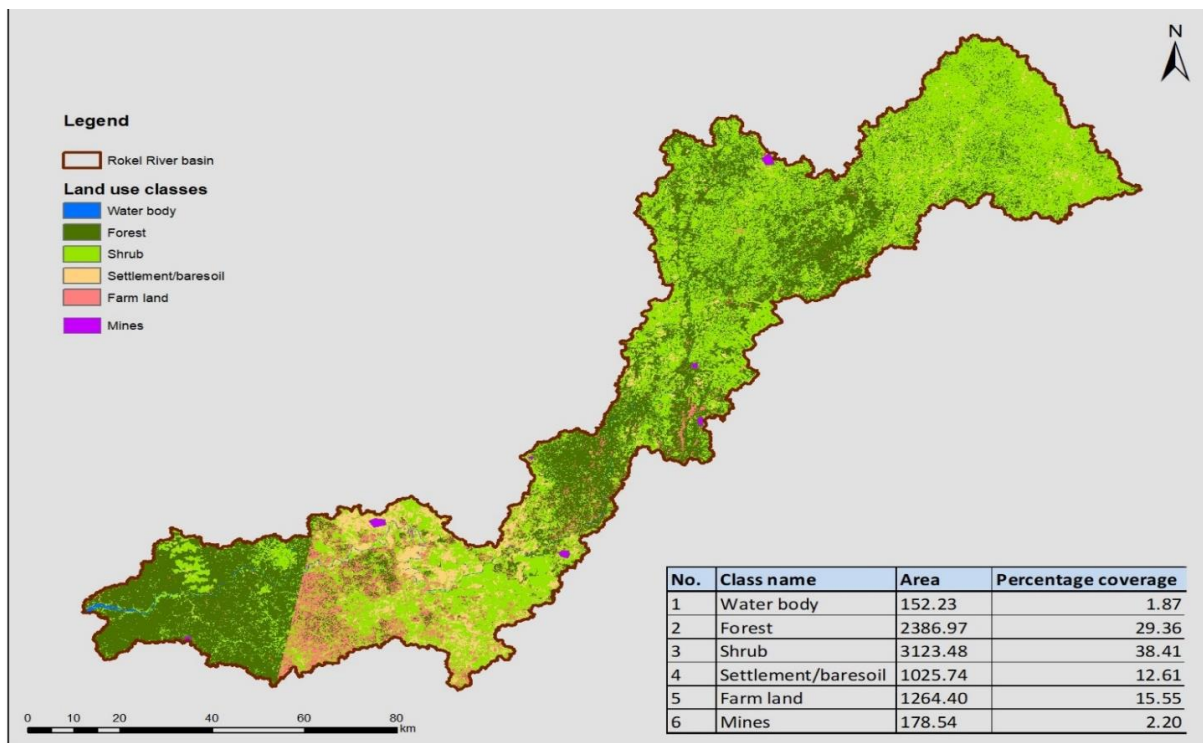


Figure 10 Land use/ Land cover map of the Rokel River basin for the year 2020

Groundwater quality monitoring

In addition, after about a year of monitoring, the Agency has also established groundwater monitoring stations. The groundwater monitoring stations were selected using GIS and represent the geological formations in the river basin. Figure 11 below show the map of the groundwater monitoring stations in the Rokel river basin

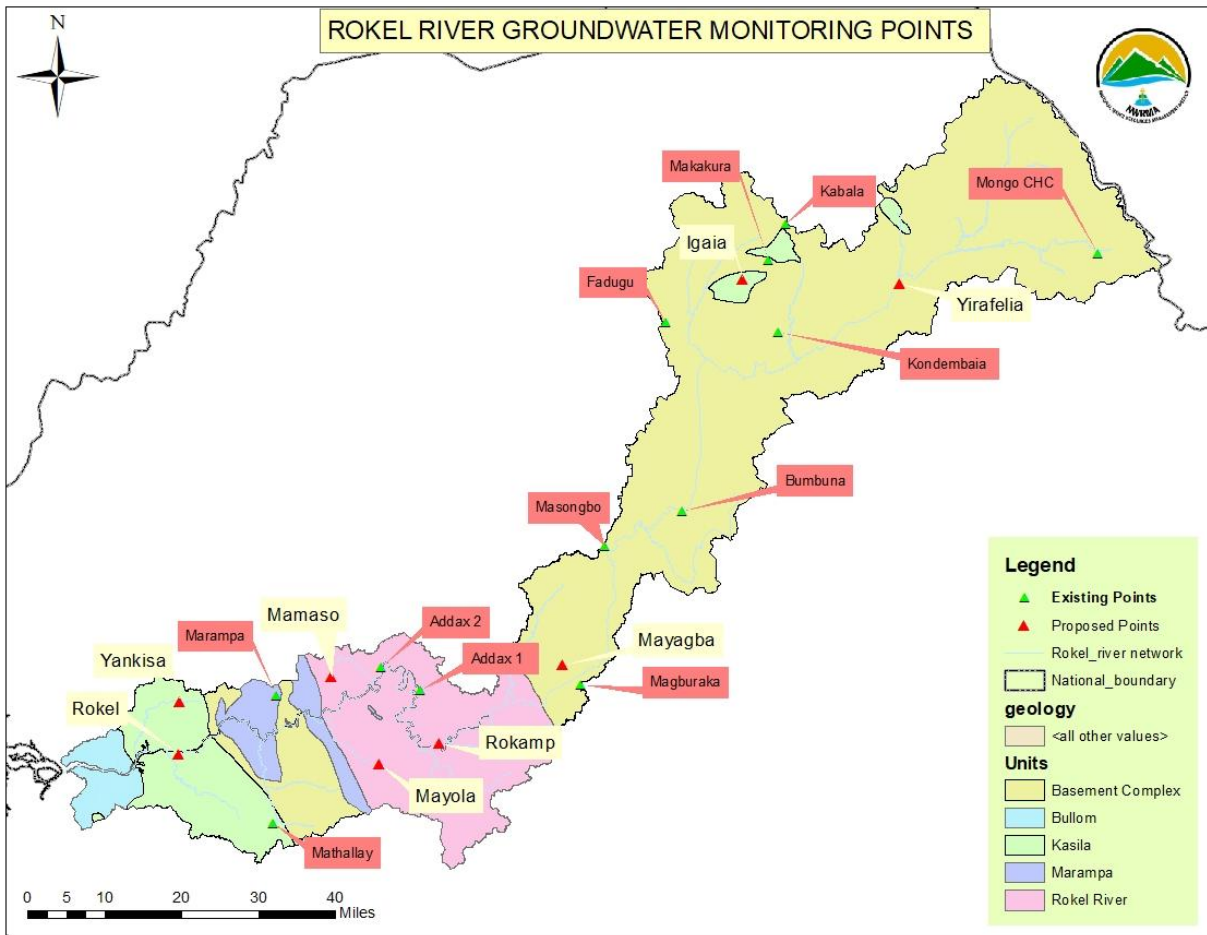


Figure 11 Groundwater monitoring stations.

One of the significant findings with the groundwater monitoring stations is that many of them are contaminated with E. coli

Findings.

The following are the significant findings from the routine water quality monitoring of surface and groundwater monitoring stations:

1. The surface water bodies have a high amount of Orthophosphate, which greatly contributed to Sierra Leone not scoring the 80% SDG 6.3.2 indicator value. The presence of high levels of phosphorous could lead to algal bloom, especially in stagnant waters. Also, high phosphorous levels are a result of contamination from sewage and poor waste management practices.

2. Most of the community groundwater sources selected for the groundwater monitoring stations are contaminated with E. coli. This could be due to poor siting and proximity to pit latrines or septic tanks.
3. The river water is also highly contaminated with E. coli
4. There is an increase in unregulated and illegal gold mining in the Rokel River basin.
5. The water quality at the upper catchments is more improved than in the lower catchments with a higher population density and a huge presence of anthropogenic activities.
6. Deforestation is happening in the river basin at an alarming rate. The consequence is that the river flow will continue to decrease without meeting the needs of water users. This has also led to an increase in the river turbidity due to surface runoffs. The increase in turbidity will also make water treatment at the SALWACO Magburaka Water Supply System very expensive. Also, if the current trend continues, it adds a severe risk to the proposed Freetown Water Supply System's sustainability, increasing its intake at the Rokel village.

Outcomes

1. Through the effort of the NWRMA, Sierra Leone has reported for the first time in history the SDG 6.3.2 indicator to the United National Environmental Program.
2. Pollution sources have been mapped along the river basin.
3. The Agency now has the human capacity to monitor Sierra Leone's water quality fully, adhering to best international quality assurance and quality control measures.
4. The land use and land cover pattern in the Rokel River basin has been mapped.

Recommendations

1. The report should be presented to stakeholders in the water sector, including the WASH, mining, lands, and the environment, for collaborative response in protecting and managing the environment.
2. Detailed water quality reports should be shared with MOWR District WASH Engineers, WASH INGOs, and NGOs to eliminate contaminated wells.
3. The Ministry of Water Resources should seek funding from donors to restore the Rokel river basin using the Ecohydrological approach and nature-based solutions.
4. The Ministry of Water Resources should direct its WASH partners to implement WASH programs for riverine communities along the Rokel River. The interventions should be

directed towards sensitisation on open defecation. In addition, the construction of improved WASH facilities. These interventions should be done in partnership with the Agency for site identification and evaluation of the projects that will be implemented.

Ishmail Kamara

Manager, Hydrological Services

National Water Resources Management Agency.