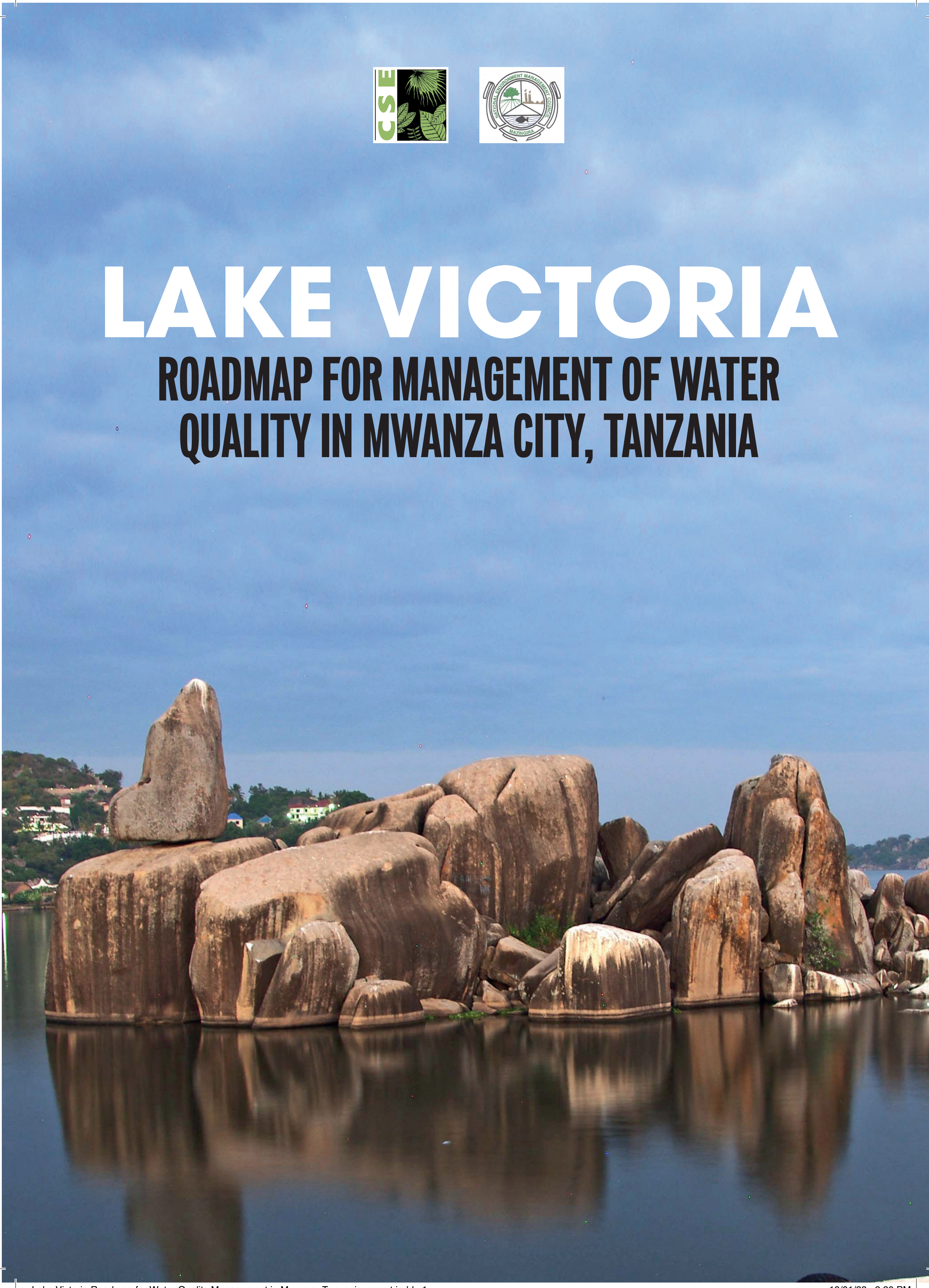
LAKE VICTORIA

ROADMAP FOR MANAGEMENT OF WATER QUALITY IN MWANZA CITY, TANZANIA



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ROADMAP FOR MANAGEMENT OF WATER QUALITY IN MWANZA CITY, TANZANIA

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Background

Lake Victoria is a world-renowned ecologically unique waterbody and is shared by three countries—Tanzania (51 per cent), Uganda (44 per cent) and Kenya (5 per cent)—using its resources for fisheries, freshwater and transportation. The lake supports the most productive freshwater fishery in the world, worth US $600 million annually. The basin of Lake Victoria also supports extensive agriculture; over 70 per cent of the population in the catchment area depends on agriculture. The natural ecosystem of the lake and its flora and fauna are the basis for an expanding population and burgeoning economic activity in the region.

Despite being the source of livelihood for 45 million people, Lake Victoria has however suffered immensely from a variety of unsustainable human activities over the last five decades. Activities, including deforestation, poor waste management, destructive fishing practices, introduction of invasive fish, wetland encroachment, unsustainable farming practices, and uncontrolled mining, have rendered the lake into a sink for excess nutrients and untreated effluent. This has led to fish die-offs, algal blooms and the spread of the ferocious waterweed water hyacinth. Parts of the lake, especially the deeper areas, are already considered dead zones that are unable to sustain life due to deficiency of oxygen deficiency in the water. Deteriorating water quality has reduced the lake's biodiversity, most notably affecting the phytoplankton and fish, and is causing hardship for populations dependent on it for their livelihoods.

This fragile ecosystem could be damaged irreversibly in the absence of appropriate interventions. Thus, it calls for devising intervention measures aimed to improve the situation. Therefore, the National Environmental Management Council (NEMC), Tanzania, felt the need to develop a management strategy for Lake Victoria in Tanzanian waters. NEMC in collaboration with the Centre for Science and Environment (CSE), India, worked extensively to collect and collate data, identifying various stakeholders and understanding the pollution issues around Lake Victoria. This was done through series of activities, including online workshops, site visits, on-site meetings and water sample collection (see *Figure 1: Chronology of activities performed by CSE in preparing the report*).

With these activities, primary and secondary research, and collected data, a discussion paper on Lake Victoria was released in July 2022. The paper identified Mwanza city as a hotspot contributing a substantial pollution load in the form of industrial effluent, domestic sewage and dumping of solid waste. It was perceived that a large swathe of Mwanza city's population disposes of domestic wastewater in the open while faecal sludge is managed by being transferred to pit-emptier trucks. A significant percentage of the population, however, was found to store faecal sludge in pits and dispose of it in storm water during rain.

The two rivers, the Mirongo and Nyashishi, were recognized as the major carriers of these pollutants into Lake Victoria. These rivers traverse long distances, flowing through habitation, industrial areas and agricultural fields before meeting the lake at Mwanza Bay. While the Mirongo is a carrier of domestic waste, Nyashishi mainly carries industrial effluent.

Considering the extent of pollution from Mwanza city, it was decided to consider the river for the pilot study for the various pollution control measures; the interventions proposed for Mwanza city could be applied to other areas. The measures included identification of point source of pollution to map out specific locations where waste is discharged into streams and providing source specific treatment. Since domestic sewage is a major issue, it was proposed to develop a shit flow diagram (SFD) to understand the quantity of excreta being treated and interventions required for

Figure 1: Chronology of activities performed by CSE in preparing the report

May 2021	• NEMC collaborates with CSE to work on Lake Victoria
October 2021	• First on-line stakeholder meeting
July 2022	• On-site stakeholder meeting at Mwanza • Site visit to Lake Victoria and areas of Mwanza • Water sampling • Release of discussion paper
November 2022	• Second on-line stakeholder meeting • Second site visit to different areas of Mwanza • Second set of water sampling • On-site meeting with stakeholders
January 2023	• Release of final report on Lake Victoria • Workshop with stakeholders for implementation strategies

the untreated part. Additionally, solid waste management at lake shore colonies, a treatment facility at the mouth of the Mirongo River, development of water-quality monitoring network and identification of stakeholders were measures proposed in the report.

During the first site visit in July 2022, we were told that both the identified rivers carried maximum pollution load during the rainy season. Thus, to understand of seasonal variation in the pollution load in the rivers we decided to do another site visit and water sampling in November 2022. Since discharge of industrial effluent was also identified as a source of pollution in the discussion paper, we visited a few industries to understand the pollution control measures installed in their premises and gauge the efficacy of their effluent treatment plants. For this, influent and effluent samples were collected from the effluent treatment plants of the industries.

This report has been prepared with sampling data from two seasons and information gathered from relevant stakeholders. It highlights the degree of industrial and municipal pollution in the rivers and streams and eventually Lake Victoria. Various interventions are provided to mitigate pollution at source and reduce its disposal in the waterbodies. The report also proposes a monitoring programme to analyse the effectiveness of measures on ground. It aims to develop a holistic management strategy that requires inter-disciplinary actions between various stakeholders for Lake Victoria.

1. Lake Victoria: Assessment of pollution sources

Based on primary and secondary research and discussion with various stakeholders, discharge of municipal sewage, industrial effluent and poor solid waste management were clearly identified as the major sources of pollution in Lake Victoria. Since the three areas have different waste characteristics and pollution potential, it is prudent to perform a deep dive in all three areas to understand the issues, identify the gaps and provide mitigation measures.

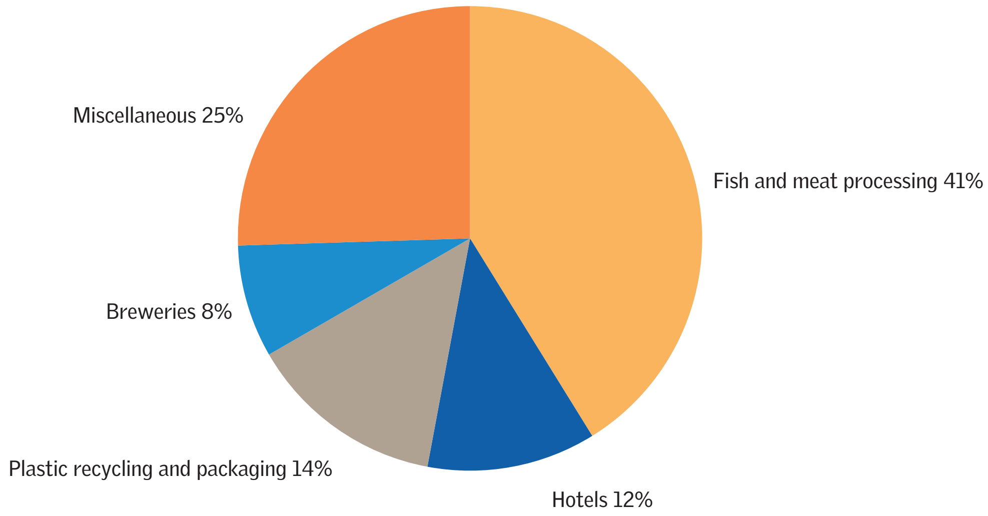
This report discusses the challenges of each sector, analyses their degree of pollution and proposes interventions to reduce the pollution at source, thereby reducing its disposal in waterbodies.

Industrial pollution

Mwanza region has seven districts, of which Nyamagana and Ilemela districts (which comprise Mwanza city) are the major industrial hubs. These two areas which are in close proximity in total have 51 industries out of which only 26 industries operate with a valid EIA/EA certificate (information provided by NEMC). Out of two areas, llemela district houses the major chunk of industries—26 out of total 51—followed by Nyamagana district, with 13 industries; the remaining 12 are spread in different areas. Fish processing is the major industrial sector operating in these two areas, contributing 41 per cent of the share, followed by plastic recycling and packaging and hotels (see *Figure 2: Industrial sectors in Mwanza city*).

All the industrial sectors mentioned above are water intensive, which implies that they require large amounts of water for their processing, and consequently generate significant amounts of wastewater. The source of water intake for these industries is either supply water from the Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA) or Lake Victoria; the discharge of wastewater is also into one of the above sources. All the water-polluting industries are required to have adequate wastewater treatment plants to ensure no untreated wastewater is discharged outside the industrial premises. The industries that abstract water or discharge wastewater into Lake Victoria are required to obtain a water use permit and a water discharge permit respectively from the Lake Victoria Basin Water Board (LVBWB). As per the data received from LVBWB, 13 industries currently have the permit from the board to discharge wastewater into the lake.

Figure 2: Industrial sectors in Mwanza city



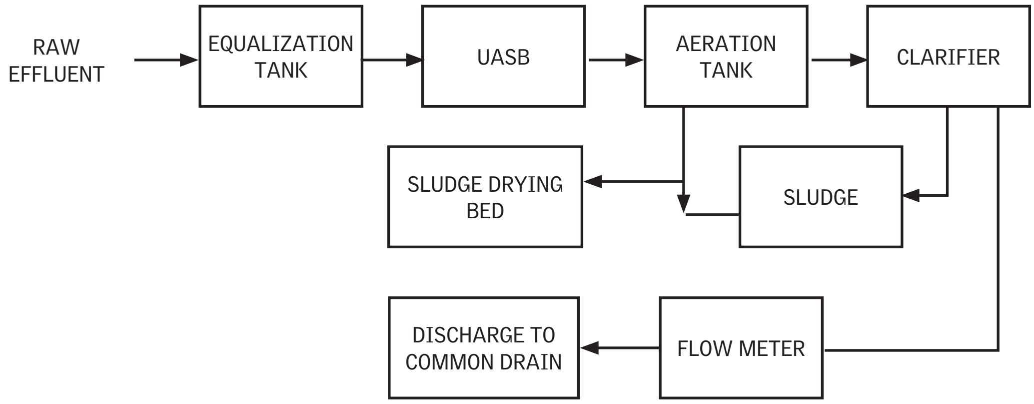
Many such industries are housed in Nyakato Industrial Area, located in Ilemela district of Mwanza, with the Nyashishi River on one side and Lake Victoria on the other. Some prominent industries are Tanzania Breweries Ltd, Serengeti Breweries Ltd, Nyanza Bottling Co. Ltd, Nile Perch Fisheries Ltd, Mwatex Ltd, SBC (T) Ltd, Sayona Drinks Ltd, etc. Apart from Tanzania Breweries, all other industries discharge the effluent from their plant into a common drain that meets the Nyashishi stream. On the way, effluent-laden water from the drain is used for agricultural purposes by the people living in the vicinity.

Since the industrial effluent is used in agriculture activities and reaches the Nyashishi River, the effluent treatment plants should be adequately efficient. To understand the type of treatment technologies used in these industries and collected influent and effluent samples to estimate the efficacy of the effluent treatment plants, the Centre for Science and Environment (CSE) along with the National Environmental Management Council (NEMC) visited some industries, including Serengeti Breweries Ltd, Tanzania Breweries, Nile Perch Fish Processing and Mwatex (Textile). The observation for the units are discussed below:

I. Serengeti Breweries Ltd

This industry operates with a production capacity of 500,000 hectolitre/annum and uses barley, malt, sorghum, hops and maize as the raw material. The water requirement of the unit is 600–700 m^3/day and is supplied by Mwanza Urban Water Supply and Sanitation (MWAUWASA). The unit generates 400–500 m^3/day of wastewater which is directed to effluent treatment plant before discharge.

Figure 3: Effluent treatment scheme at Serengeti Breweries



The treatment involves removal of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) through anaerobic followed by aerobic operation. The unit has installed an electromagnetic flow meter at the discharge point (see *Figure 3: Effluent treatment scheme at Serengeti Breweries*).

Before collecting the samples from the effluent treatment plant, the CSE team visited the industry premises. The following were the observations:

- The plant is well maintained with satisfactory housekeeping;
- Layout plan is demarcated properly with respect to production and administrative area storage etc. Pedestrian paths are marked with proper lines;
- The wastewater is collected and transferred to the effluent treatment plant through a close conduit;
- The effluent treatment plant is well maintained and has adequate safety measures; and
- The storm-water drain needs attention; the drains are open and do not have designated outlets.

Samples were then collected from the inlet and outlet of the effluent treatment plant. The analysis showed that the efficiency of BOD and COD removal was around 95 per cent, which is adequate (see *Table 1: Performance evaluation of Serengeti's effluent treatment plant*). Generally, when the BOD/COD ratio of InDesign is >= 0.45, the wastewater is considered biodegradable and thus the biological treatment plant performs effectively. Since the BOD/COD ratio is favourable (0.45) for effective removal of BOD and COD in Serengeti, removal of BOD and COD is effective.

Table 1: Performance evaluation of Serengeti's effluent treatment plant

Sampling points	pH	Conductivity (µS/cm)	Total dissolved solids (mg/l)	BOD (mg/l)	COD (mg/l)	Total phosphate (mg/l)	Total nitrogen (mg/l)
Standard*	-	-	-	30	60	-	-
Inlet to ETP	6.0	2,610	1,304	524	1,154	7.5	2.0
Outlet from ETP	7.2	2,220	1,108	30.5	58.4	5.7	0.4
Efficiency of removal (%)	-	-	15	94	95	24	80

* Standard refers to the Environmental Management (Water Quality Standards) Regulation, 2007

However, the removal of total dissolved salts (TDS) and phosphate is minimum since the effluent treatment plant is designed for removal of biodegradable materials. The mixed liquor suspended solids (MLSS) seemed to be old and required to be removed periodically.

II. Tanzania Breweries Ltd

Tanzania Breweries Ltd (TBL) is located in the Pasiansi area in Ilemela district. It has a production capacity of 1.5 million hectolitre/annum. The industry uses malted barley, maize grains and sugar as raw material along with 900 m^3/day of raw water sourced from Lake Victoria.

The wastewater generated of 150–200 m^3/day is collected and subjected to treatment (see *Figure 4: Effluent treatment scheme at Tanzania Breweries*).

Figure 4: Effluent treatment scheme at Tanzania Breweries

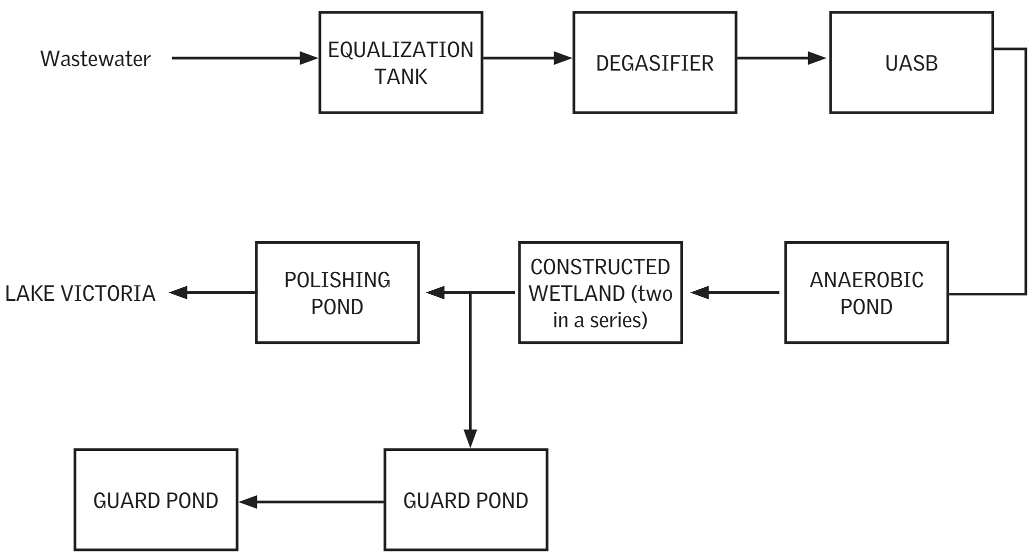


Table 2: Performance evaluation of Tanzania Breweries Ltd's effluent treatment plant

Sampling points	pH	Conductivity (µS/cm)	Total dissolved solids (mg/l)	BOD (mg/l)	COD (mg/l)	Total phosphate (mg/l)	Total nitrogen (mg/l)
Standard*	-	-	-	30	60	-	-
Inlet to ETP	11.2	3850	1920	184	387	8.1	1.73
Outlet from ETP	8.1	2550	1330	31.1	65.3	7.2	0.10
Efficiency of Removal (%)			30.7	83.0	83.0	11.0	94.2

* Standard refers to the Environmental Management (Water Quality Standards) Regulation, 2007

The CSE team's observations were the following:
- The plant is well maintained with satisfactory housekeeping;
- Layout of the industry comprises two distinct sections separated by a field;
- The first section comprises a production area and storage of raw material and products. The section also involves collection of effluent through close conduit and gets subjected to primary treatment in form of pH correction, degasified followed by UASB (upflow anaerobic sludge blanket) treatment;
- The treated effluent gets collected in the second section and passes through anaerobic treatment followed by constructed wetland; and
- If the treated effluent complies with the standards is disposed to Lake Victoria; if not, it gets diverted to a guard pond from where it gets pumped back to equalization tank.

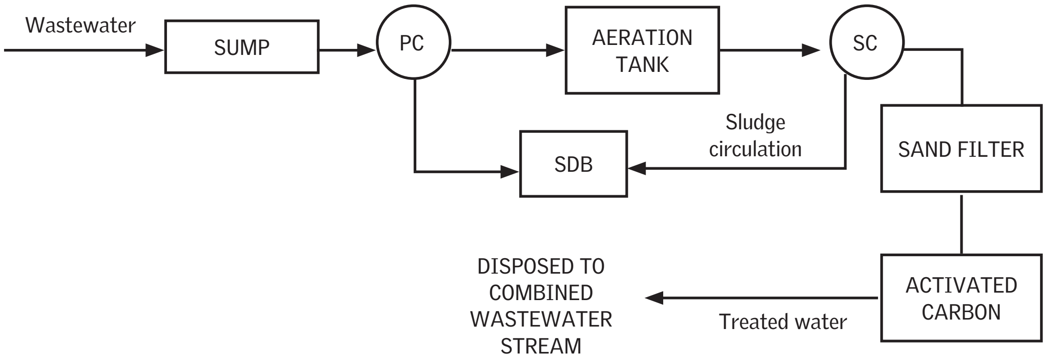
Samples were collected from the inlet and outlet of the effluent treatment plant. The analysis showed that the removal efficiency of BOD and COD is lower (83 per cent) than expected despite of favourable conditions in terms of BOD/COD ratio (0.47) and elaborate arrangement made in terms of unit operation (see *Table 2: Performance evaluation of TBL's ETP*). The anaerobic pond was also observed to be under-functioning since the depth was less than the designed depth. The depth is reduced due to improper removal of sludge from the pond.

The guard pond used to store high COD/BOD effluent, located very close to Lake Victoria, seems to be unsafe as any accidental release or overflow during rainy season to Lake Victoria will result in significant amount of COD and BOD in the lake. Since the industry discharges its wastewater after treatment into Lake Victoria, it should conduct a performance evaluation of each unit operation at periodic intervals.

III. Nile Perch

Nile Perch is a fish-processing unit located in the Nyakato Industrial Area. The industry has a production capacity of 600 tonne/month and processes only

Figure 5: Effluent treatment scheme at Nile Perch



PC: primary clarifier, SC: secondary clarifier, SDB: sludge dying bed

the Nile perch species. Water consumption in the process is 300 KL/day and wastewater generation is 200 KL/day. The water is sourced from MWAUWASA; the wastewater generated is collected in a close conduit and subjected to the activated sludge process (ASP) with tertiary treatment (see *Figure 5: Effluent treatment scheme at Nile Perch*).

The CSE team's observations were the following:

- The industry has satisfactorily maintained the effluent treatment plant in terms of performance. However, the housekeeping also needs attention;
- Accessibility to the effluent treatment plant was not adequate as the stairs to the aeration tank and sedimentation tank were rusted and risky. They require renovation;
- The industry does not have open channels for inflow and outflow of effluent for collection of samples. Thus free flow sampling is not possible. Effluent outflow channel should be fitted with V-notch or calibrated real time flow meter; and
- The industry does not have provision for collection and discharge of storm water through designated drains.

The analysis result of the samples collected from influent and effluent indicates that the efficiency of the effluent treatment plant is adequate with respect to BOD and COD removal (see *Table 3: Performance evaluation of Nile Perch effluent treatment plan*). Overall, it was observed during the visit that the plant was well maintained. The mixed liquor suspended solids (MLSS) in the aeration tank was sufficient and periodically rejected the sludge to the sludge drying bed. Since the effluent was subjected to a sand filter and activated carbon to treat unknown non-biodegradable organic, the final effluent was clear and free from turbidity.

Table 3: Performance evaluation of Nile Perch effluent treatment plant

Sampling points	pH	Conductivity (µS/cm)	Total dissolved solids (mg/l)	BOD (mg/l)	COD (mg/l)	Total phosphate (mg/l)	Total nitrogen (mg/l)
Standard*	-	-	-	30	60	-	-
Inlet to ETP	7.9	1191	595	569	1252	8.6	1.4
Outlet from ETP	7.3	741	370	22.9	50.5	5.0	0.32
Efficiency of removal (%)			37.8	96	96	42	77

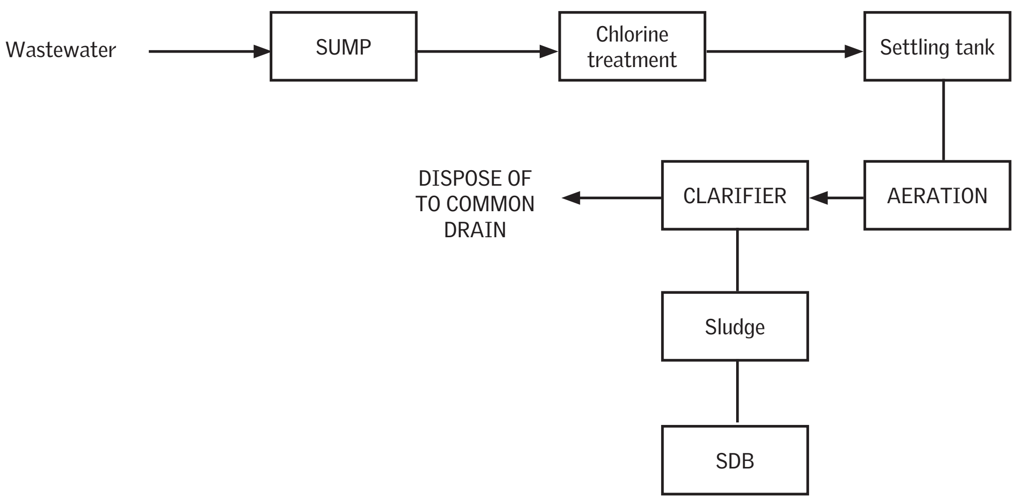
* Standard refers to the Environmental Management (Water Quality Standards) Regulation, 2007

IV. Mwatex Ltd

Mwatex is a textile plant situated in Nyakato industrial area, with a production capacity 1,000,000 metre/month. The production process involves ginning, spinning, weaving and processing, and requires 400–500 KL/day of water supplied by MWAUWASA. The generated wastewater of 350 KL/day is collected through a close conduit and sent for treatment.

Generally, the wastewater generated from different sections of textile fabric manufacturing process varies in characteristics, desizing unit (high BOD), scouring (alkaline, high BOD), bleaching (high COD, low BOD), mercerizing (low BOD, strongly alkaline), drying (BOD, COD with coloured effluent) and printing (moderate BOD) (see *Figure 6: Effluent treatment scheme at Mwatex Ltd*).

Figure 6: Effluent treatment scheme at Mwatex Ltd



The CSE team had the following observations for the industry:

- The current treatment scheme provided was inadequate as it was inefficient to perform de-colouration of the wastewater. The industry should have activated carbon for de-colouring of the effluent followed by sand filter;
- The ETP structure was completely dilapidated. It needs complete renovation before operation;
- The present condition of the ETP is far from satisfactory. It is not in a position to treat any effluent;
- The performance of ETP cannot be evaluated since the samples were not collected due to non-operation of plant.

To understand the reason for these gaps, the permit conditions were analysed. It was observed that the requirements were not demanded in the permit. Moreover, the permit lacked information such as production capacity, water consumption details, ETP details etc. For instance, the permit states that the industry should install an adequate ETP but does not provide any specifications. In such a scenario, it would be difficult to inspect the compliance of the industry. Thus, it is felt that the permit must be updated and provide clear required specifications.

As mentioned earlier, the industries in the Nyakato Industrial Area discharge their treated effluent in a common drain that finally meets the Nyashishi River after flowing through agricultural fields. The quality of water in the common drain thus can also determine the performance of the industrial ETPs. With this objective, a sample from the drain was collected and analysed (see *Table 4: Water analysis for common drain*). The drain has a flat gentle slope, with medium velocity. The wastewater flowing was turbid in nature. On analysing the results, it is observed that both BOD and COD had significantly high values exceeding the standard by **19 times and five times respectively**. Since Tanzania does not have surface-water quality standards, the Indian Central Pollution Control Board's (CPCB's) designated best-use water-quality criteria—which allows 3 mg/l of BOD and 25 mg/l of COD in a surface waterbody—was referred to. It is pertinent to mention that most of the water from the common effluent drain is used for agricultural purposes, and such high concentrations of BOD and COD will leave the soil septic, eventually impacting the food chain and human health.

Table 4: Water analysis for common drain

Unit	Parameters						
	pH	Conductivity (μS/cm)	TDS	BOD	COD	Total P	Total N
mg/l	6.8	528	290	57.2	126	4.1	0.26
Tonne/day (flow = 155,520 m^3/day)			45.0	9.0	20.0	0.6	0.04

Similarly, after receiving water from the referred common drain, the Nyashishi River passes through dense agricultural fields and wetlands, finally meeting the Mwanza Bay of Lake Victoria. However, the flow of the river is usually less, except in extreme rains as the most of the water is taken by the agricultural fields. As this report focuses on rivers and streams flowing to Lake Victoria to understand pollution loading from each source, surface-water samples were collected from two locations of the Nyashishi River, one downstream of the common drain along the Mwanza–Musoma Road (adjacent to the bridge) and other at the Nyashishi Bridge (see *Figure 7: Schematic diagram of industrial wastewater discharge to Nyashishi riverine system*).

Analysis of the results indicates that the river carries high concentrations of both BOD and COD at the downstream location, exceeding 30 times for BOD and eight times for COD with the BIS standards (see *Table 5: Water analysis for Nyashishi River*). The daily COD load of **33 tonne and BOD of 15 tonne** is substantially high and is of serious concern.

The values of BOD and COD at the Nyashishi Bridge reduces by 60 per cent and 76 per cent respectively when compared to its previous location. This, however, is not a positive situation as this pollutant load is minimized by the agricultural fields. Thus, instead of going into the lake, it may enter the food chain. An important fact to note is that although the pollution concentration has reduced, it still exceeds the standards by nine times for BOD and by two times for COD. Since the water from the Nyashishi River is used for agricultural purposes, the focus on it should be doubled as any pollutant in the river will adversely impact both the crops and the water quality of Lake Victoria.

Table 5: Water analysis for Nyashishi River

Location	Unit	Parameters						
		pH	Conductivity (μS/cm)	TDS	BOD	COD	Total P	Total N
Downstream of common drain: Mwanza–Musoma Road (adjacent to the bridge)	mg/l	7.7	920	451	91.6	202	1.9	0.39
	Tonne/day (Flow = 164,160 m^3/day)	-	-	74.0	15.0	33.0	0.3	0.06
Nyashishi Bridge	mg/l	5.9	725	363	26.9	49.8	0.51	0.26
	Tonne/day (flow = 224,640 m^3/day)	-	-	82.0	6.0	11.0	0.1	0.06

Figure 7: Schematic diagram of industrial wastewater discharge to the Nyashishi riverine system

Downstream of the Nyashishi River along the Mwanza–Musoma Road (adjacent to the bridge)

Upstream of the Nyashishi River before it meets common effluent drain

Agricultural fields near Nyashishi Bridge

Common drain from the industrial area

Solid waste

Mwanza city comprises two districts, namely Ilemela and Nyamagana. Mwanza City Council is the administrative body with jurisdiction over Nyamgana district, and Ilemela Municipal Council has jurisdiction over Ilemela district. Although these two bodies are different, due to their close proximity they share key sanitation infrastructures such as the sanitary landfill operated and managed by Mwanza City Council. According to the existing solid waste management framework, the

Mwanza City Council is responsible for collection and disposal of waste generated from the two districts. According to data provided by the Mwanza City Council, the total number of households in Mwanza city is 280,734 with a population of 1,104,521. The settlements in Mwanza city can be categorized into two distinct types, i.e. planned settlements and unplanned settlements. Land utilization in Mwanza city is dominated by unplanned settlements (43 per cent) followed by planned settlements (30 per cent), and other (27 per cent), which includes industrial, institutional, special areas and wetlands.

Mwanza city collection points are operated by the city and municipal councils and community-based organizations. The system in Mwanza city is based on door-to-door collection whereby the vehicle of a private operator or of community-based organization (CBO) members passes along the roads and collects waste stored in plastic sacks and public and private dustbins. Most of the community organizations send the waste to public collection points that have a skip bucket which will be picked by the city skip master and taken to the dumpsite. Collection and transportation of waste in Mwanza city is largely conducted by private operators and community-based organizations due to the limited number of equipment owned by the city and municipal councils. Some of the collection points in Mwanza city have skip buckets while others are just open grounds with no measures to control disbursement of the waste.

Municipality-wise, Ilemela Municipal Council has a total area of 1,080.55 sq. km, out of which 828.45 km^2 (77 per cent) is covered by water and 252.10 km^2 (23 per cent) is dry land. The Council currently has 127,507 households with a population of 509,687. Approximately 679 tonne per day of waste is generated from the Council. Approximately, 70–80 per cent of the waste is collected via 16 collection points or bays and 34 community-based organizations. The council does not practise segregation and thus all the collected waste is transported and dumped at the Buhongwa landfill. Only a small percentage of waste is diverted for reuse, recovery and recycling business through informal collectors or street-waste pickers. As of June 2022, out of a total of 19 wards, 14 wards have been provided with cleaning, solid waste collection and disposal services; the remaining five wards which are in peri-urban areas practice burying of solid waste in pits (data provided by the Mwanza City Council).

Compared to Illemela, Mwanza City Council covers a small area of 256.45 sq. km of which 173 sq. km (67.6 per cent) is dry land and 83 sq. km (32.4 per cent) covered by water, mostly Lake Victoria. Most of the dry land (94 per cent) is urbanized while the remaining area (6 per cent) consists of forested land, valleys, cultivated plains, grassy and undulating rocky hill areas. The urbanized area houses 153,227

Table 6: Waste management in Ilemela and Nyamagana districts

Description	Ilemela district (Ilemela Municipality)	Nyamagana district (Mwanza city)
Households	127,507	153,227
Population	509,687	594,834
Waste generation	679 tonne/day	357 tonne/day
Waste collection	~ 500 tonne/day	~ 340 tonne/day
Segregation	No	No
Recycle/reuse	Only glass bottles and plastics	Only glass bottles and plastics
Disposal	Buhongwa dumpsite	Buhongwa dumpsite

households, with a current population of 594,834. The council generates 357 tonne of solid waste per day out of which 341 tonne of waste is collected via 20 collection points. Like Illemela, Mwanza City Council also does not practise waste segregation except recycling of plastic and glass bottles, plastic bags and scrap metal, which is approximately 19 per cent of the collected waste. The remaining 81 per cent waste is disposed of at the Buhongwa dumpsite. Substantial quantities of waste was also observed being dumped in storm-water drains at various locations. This dumped waste will be carried to waterbodies during the rainy season along with storm water. An effort should be made to minimize the waste going into drains.

The Buhongwa landfill, about 18 km from the city centre, covers an area of 33.81 hectare. It receives mixed and unsegregated waste from Ilemela Municipal Council and Mwanza City Council and surrounding rural and peri-urban settlements. The landfill site comprises two parts: one a newly constructed lined landfill and the

MWANZA CITY COUNCIL'S STRATEGY FOR SOLID WASTE MANAGEMENT

The strategic plan prepared by Mwanza City Council for 2022–26 aims for solid waste minimization and an increase in reuse and recovery from 24 per cent to 30 per cent. However, the targeted vision seems to be very lean. Mwanza is a growing city, and with the increased influx of visitors waste generation is bound to increase exponentially. With such small targets of recycling and reuse, all the generated waste will eventually find a place in the landfill. Thus, the council should enhance the targets and come up with the strategies to maximize recycling and reuse of the waste.

The city has made good efforts in waste collection due to which the city has maintained the status of cleanest city in the country for nine consecutive years. However, the city should also focus on segregation of waste and reduce the load on the landfill. The city's bylaws of 2017 also do not talk much about segregation but concentrate more on collection and disposal of waste. The only sorting criteria mentioned in the bylaws is for hazardous material, needles and recyclable items. It, however, does not specify which items fall in the recycling category. The bylaws should be strengthened regarding waste segregation and should have the provision of a penalty in case of failure to comply.

other a shear dumpsite. CSE along with NEMC visited the landfill site in July 2022. During the survey it was observed that the lined landfill was not in use, and waste was dumped at the dumpsite. The landfill did not have any waste-processing or treatment facilities within the premises. Only recyclables such as glass bottles and plastic materials were collected from the landfill by the informal sector. Further, the weigh bridge was not in working condition. Hence the quantity of incoming waste was not logged properly. Typically, waste was disposed of haphazardly at the dumpsite, with no system of leachate collection due to which the leachate flowed to a natural wetland through which the Nyashishi River flows before meeting Lake Victoria. Overall, the entire facility was poorly managed due to lack of manpower, equipment and technical capacity on the part of the city government staff responsible for managing the facility.

All kinds of waste is dumped at the non-lined sections of Buhongwa landfill

Waste is dumped in storm-water drains

Management of municipal sewage

Mwanza city lies at an altitude of 1,140 metre above sea level. The city experiences annual rainfall of 700–1,000 mm in two fairly distinct seasons, October–December (short rainy season) and February–May (long rainy season). The city has fairly high undulating surface, with as many as 16 hills inside the urban boundary. The hills have steep slopes but are not hight (nearly 100–200 m).

The water supply and wastewater management falls under the mandate of MWANZA Urban Water Supply and Sanitation Authority (MWAUWASA), an autonomous authority under the Ministry of Water, Government of Tanzania. MWAUWASA abstracts approximately 108,000 cubic metre of water from Lake Victoria, the only source of drinking water, and supplies it after treatment through the water-treatment plant installed at Capri Point near the lake. Water is supplied to 90 per cent of population in urban areas by means of pipes, water kiosks and tankers.

As informed by MWAUWASA, close to 50 per cent of population lives either at the foothills or on the hills, making it difficult to provide regular and efficient sanitation services on the hills. Due to this undulating topography, it is difficult to practise centralized solutions for management of excreta and wastewater. Thus, both on-site and off-site sanitation are followed in the city. To understand these practices, the CSE team conducted a survey in November 2022.

Off-site sanitation

The city has a sewerage network of 132.82 km that receives the domestic greywater and black water of approximately 6,780 households out of 0.28 million households in the city. This network mostly covers households residing in the plains and the valley. Currently MWAUWASA is undergoing a project of connecting approximately 12,830 additional households in the urban hills to the sewerage network by means of simplified sewers. Around 2,346 households have already been given connections via simplified sewers while the remaining 10,490 households will be connected soon. This project will make the total number of households connected to the **sewerage network 9,126,** which represents around **3 per cent** of the households.

On-site sanitation

Approximately 93 per cent population in the Mwanza city is dependent on on-site sanitation systems (data from MWAUWASA). The two prevalent on-site

Simplified sewers connected to households on the hills sanitation systems observed in the city are fully lined tanks and lined tanks. Fully lined tanks are either completely sealed and are emptied by tankers or have a connection directly or indirectly to a waterbody. Lined tanks have impermeable walls and open bottoms connecting to waterbody. It was observed during the household survey that in areas at the bottom of the hills, plains and plateaus the common containments were fully lined tanks with outlets to a waterbody. The local community considers these types of containments as septic tanks. The standard design of a septic tank is, however, not being followed while constructing these tanks. Areas close to a sewer network and urban centres were observed to be using sealed fully lined tanks (acting like a collection tank) with no outlets.

Other

During the field visit and household survey, the CSE team observed that a few households in the city, especially along the Mirongo River, do not have any connections to a sewer system or containment system and directly discharge greywater and black water into streams or the Mirongo River. This systems is assumed to be practised by 1 per cent of the population. The remaining 2 per cent of the population practices open defecation, especially several pockets of lower income settlements and urban slums. The usual practice of defecation in households in these areas is alongside water streams or the banks of the Mirongo River.

For cleaning of on-site sanitation systems, MWAUWASA provides the services of emptying and transport of faecal sludge by means of truck-mounted vacuum tankers. On discussion with tank operators, however, it was found that the faecal sludge by private tankers is brought to the waste stabilization pond for disposal usually when the household is in the range of 15 km. The rest of the time, faecal sludge is dumped on agricultural lands, in drains or in other areas. This is usually done to increase the number of trips as the tankers are paid based on the number of trips made per day. Further, the tanks on the upper hills are never emptied by vacuum machines but are opened by owners in the rainy season. The waste is flushed from these tanks into water streams which finally end in Lake Victoria.

All the waste from the on-site and off-site sanitation systems is directed to a waste stabilization pond operated by MWAUWASA. The waste stabilization pond, in Butuja area, has a capacity of 7 million litre per day (MLD) and is the only source of treatment for domestic wastewater and faecal sludge in Mwanza city. Currently, the plant receives 5.5 MLD of wastewater which is treated by means of the anaerobic, facultative and maturation ponds (see *Figure 8: Treatment of wastewater at waste stabilization pond*). Faecal sludge is brought to the plant by

Types of on-site sanitation systems

Fully lined tanks connected to the ground in the Ibungilo area

Sealed fully lined tanks in the Busewelu area

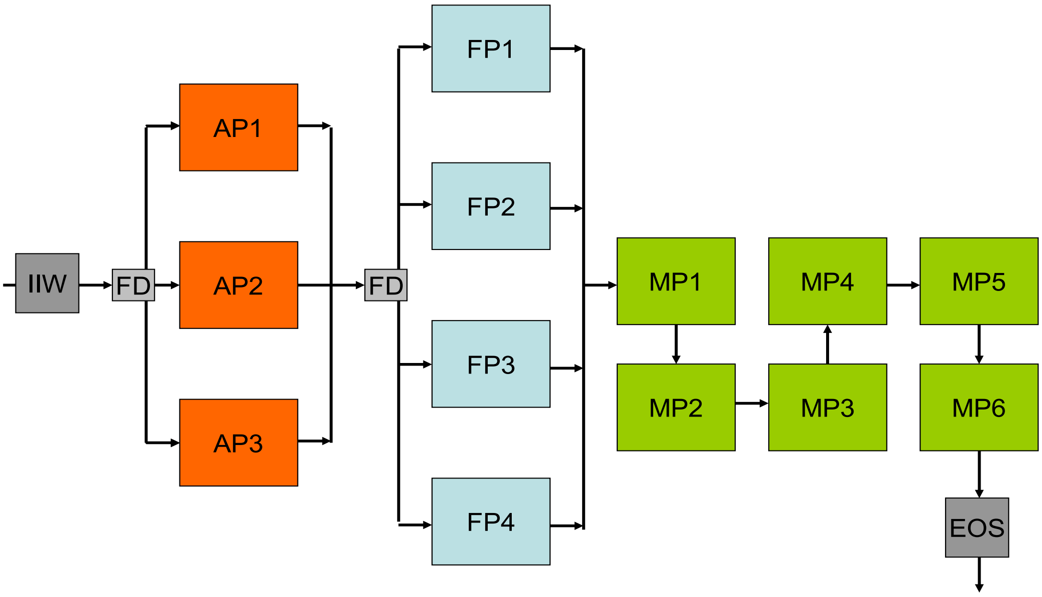
Lined tanks found in Pasiansi East

Hidden outlets of lined tanks with impermeable walls and an open bottom

government and registered private desludgers and decanted at the inlet made for decanting of faecal sludge, which further connects it to the anaerobic pond.

The outlet of the maturation pond-6 (MP6) discharges the treated wastewater in a water stream coming from the hills. The stream further meets the lake after passing through agricultural lands, unauthorized slums or informal settlements, mixing the waste of these settlements into the treated water.

Figure 8: Treatment of wastewater at waste stabilization pond



Challenges with the waste stabilization pond: CSE observations

- Anaerobic ponds have not been desludged in the last 10 years. As a result, the retention time has been reduced and the pond is no more anaerobic;
- The retention time of the facultative ponds has also decreased due to non-removal of sludge;
- The compromised depth of ponds has made the waste stabilization pond run at 80 per cent efficiency;
- Since the sludge removal has not been practised from inception, the sludge drying beds have become defunct;
- No laboratory service is provided for testing faecal sludge before decanting it at the waste stabilization pond; and
- Operation and maintenance needs immediate attention.

On the basis of the sanitation facilities, CSE has prepared a shit flow diagram (SFD) for Mwanza city. The population of Mwanza city in the current shit flow diagram is taken as 1,684,000 persons who reside in 280,734 households, with an average household size of six persons considered. The SFD shows only **29 per cent** of excreta flow is "**safely managed**" while 71 per cent is "unsafely managed" (see *Figure 9: Shit flow diagram (SFD) for Mwanza city*). Unsafely managed excreta includes waste from open defecation (2 per cent); wastewater directly discharging to water streams (1 per cent); faecal sludge contained, emptied but not delivered to treatment (30 per cent); faecal sludge not contained not emptied (30 per cent);

Anaerobic pond outlet to facultative ponds

Private desludger decanting at the faecal sludge decanting point at the waste stabilization pond at Butuja

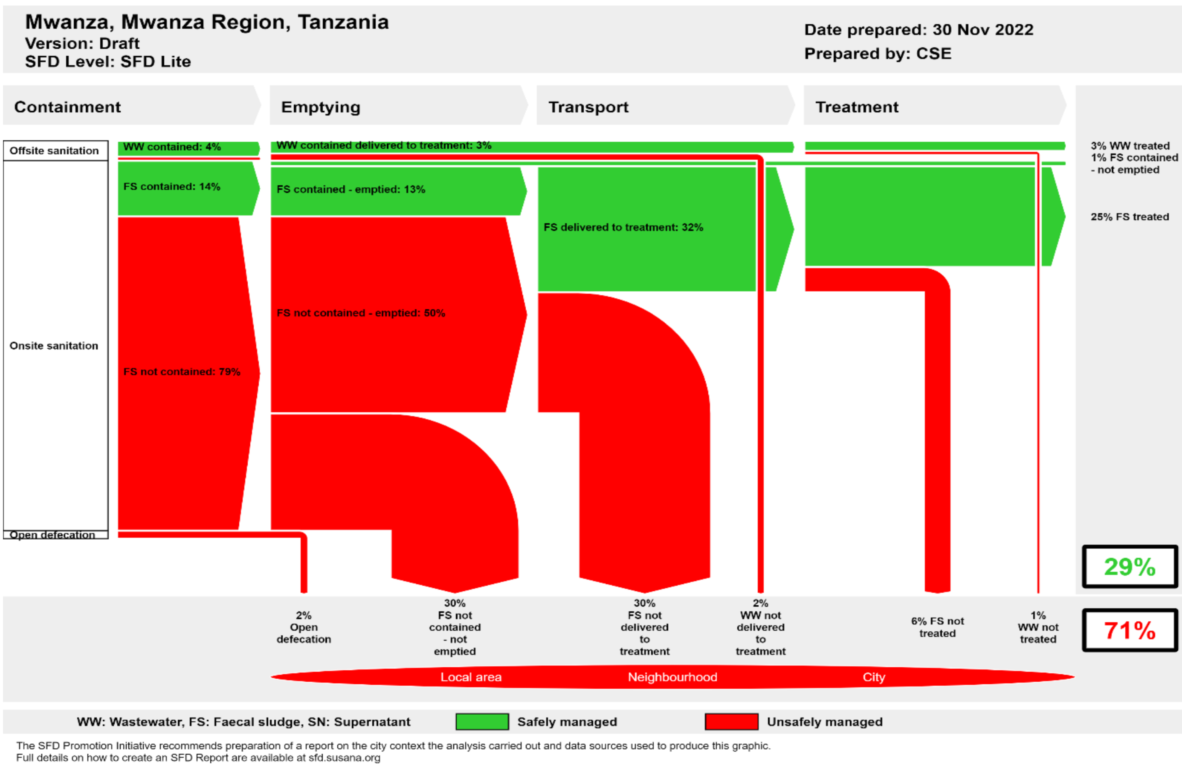
Unused anaerobic ponds with uncleaned sludge

Defunct sludge drying beds

faecal sludge not treated (6 per cent) and wastewater not treated (2 per cent). Twenty-nine per cent of total excreta (wastewater plus faecal sludge) is safely managed, of which 3 per cent is treated wastewater and 26 per cent is treated faecal sludge. Most of the households with fully lined tanks with outlets connected

Discharge of effluent from a waste stabilization pond to a stream

Figure 9: Shit flow diagram (SFD) for Mwanza city



directly or indirectly to a waterbody lack an understanding of type, size and design of tanks and desludging intervals.

Unsafely managed excreta finds its way directly or through streams to the Mirongo River, which is one of the major rivers of Mwanza. The Mirongo stretches over around 8 km and passes through most densely populated areas of the city before ending in Lake Victoria. During its flow, the Mirongo carries storm water in the rainy season along with untreated sewage, and municipal solid waste is dumped along the banks of the river.

CSE along with NEMC visited the river and collected water samples from various locations of the river. The sampling was done twice: once in the dry season (July 2022), when four samples were collected, and again in the rainy season (November 2022), when three samples were collected (see *Figure 10: Schematic diagram of Mirongo River*).

Figure 10: Schematic diagram of Mirongo River

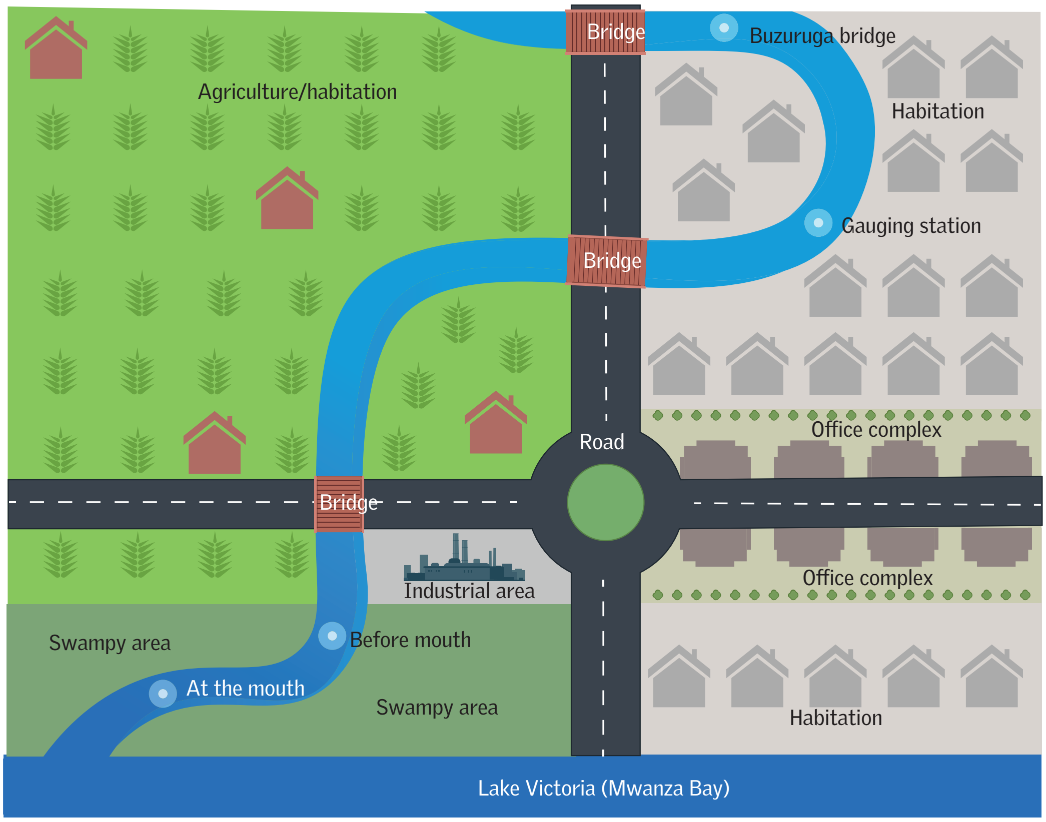


Table 6: Water sample analysis of the Mirongo River (July and November 2022)

Location	Parameters													
	pH		Conductivity (µS/cm)		TDS (mg/l)		BOD (mg/l)		COD (mg/l)		Total P (mg/l)		Total N (mg/l)	
Month	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov
Near Buzuruga Bridge	7.5	6.5	617	807	314	403	21	26.5	46	58.3	1.0	0.16	6.65	14.8
At the gauging station	6.9	6.3	517	803	260	402	38.8	52.8	62.7	116	1.0	0.21	11.27	11.3
Before the mouth of Lake Victoria	7.3	6.6	675	810	337	405	41.1	125	89.3	275	1.4	0.47	6.6	29.4
At the mouth of Lake Victoria	7.2	-	790	-	391	-	84		183	-	2.2	-	4.14	-

Table 7: Pollution load in the Mirongo River (November 2022)

Location	Flow	Parameters				
		TDS (tonne/day)	BOD (tonne/ day)	COD (tonne/ day)	Total P (tonne/day)	Total N (tonne/day)
Near Buzuruga Bridge	164,160 m^3/day)	66	4.0	10.0	0.03	2.4
At the gauging station	397,440 m^3/day)	160	21.0	46.0	0.08	4.5
Before the mouth of Lake Victoria	95,040 m^3/day	39	12.0	26.0	0.05	2.8

Analysis of samples for both seasons shows exceeding BOD and COD at all locations (see *Table 6: Water sample analysis of Mirongo River [July and November 022]*). These values increase for November as more sewage is carried by the river then. Before meeting Lake Victoria, the Mirongo River carries approximately **12 tonne of BOD and 26 tonne of COD** every day (see *Table 7: Pollution load in Mirongo River [November 2022]*). As the mouth of the river was not accessible during the rainy season, the sample could not be collected; almost the same load of BOD and COD as before the mouth was assumed to be discharged into Lake Victoria every day. This is a significant amount of pollution load discharged by the Mirongo River, which will further intensify during the rainy season.

Along with the huge pollution load discharged by the Mirongo River, various small streams carrying municipal sewage discharge directly into Lake Victoria. One

The Mirongo River carrying waste during a short spell of rain

Waste dumped at Mkuyuni drain

Water overflowing in the rainy season from the Mirongo River onto adjacent land such drain—the Mkuyuni drain—was visited and sampled by CSE and NEMC in November 2022. The Mkuyuni drain passes through various informal settlements, carries their waste and discharges into Lake Victoria. Visually, the drain has black water and a lot of solid waste can be observed both on the banks and in the drain. The BOD and COD concentrations greatly exceed the limits. Since the flow was less during the sampling, however, the pollution load contributed to 150 kg of BOD and 320 kg of COD per day. Like the Mirongo River, the pollution load for the Mkuyuni drain will surely increase during the rainy season.

Table 8: Water sample analysis of Mkuyuni drain

Location	Unit	Parameters						
		pH	Conductivity (µS/cm)	TDS	BOD	COD	Total P	Total N
Mkuyuni drain	mg/l	7.5	514	257	56.4	124	0.23	14.4
	Kg/day (flow = 2,592 m^3/day)			666	146	321	0.6	37.4

2. Conclusion and recommendations

It is evident that industrial effluent, municipal wastewater (treated and untreated) and solid waste are eventually deposited in Lake Victoria via Mwanza Bay. The three riverine systems of Nyashishi, Mirongo and Magogo act as carriers of this pollution load to the Mwanza Bay. Besides the riverine system, there are drains carrying untreated sewage and directly discharging into the Bay. Thus, Mwanza Bay receiving pollution load as a sink is bound to be impacted. The impact is seen in the form of **algal boom, loss of fishes, and decrease in fish diversity and water hyacinth**. Another indicator that shows the impact of pollution in Mwanza Bay is the decrease in its transparency. As per data provided by the Tanzania Fisheries Research Institute (TAFIRI), deep-water transparency in Mwanza Bay has seen a sharp decrease from 7.5 m in 1927 to 3.3 m in 2020. Similarly, its transparency in shallow water has decreased from 2.3 to 0.3 m in the same period. The decrease in transparency is related to chlorophyll A concentration; the higher the chlorophyll A, the lower the transparency. The high concentration of chlorophyll A is indicative of eutrophication.

With the pollution issue so evident, there is need for a holistic approach to river basin management, including various strategies for source treatment to reduce pollution entering the rivers along with monitoring of the waterbodies. However, results from the approach will be achieved only with the collaborative involvement of all stakeholders.

The following strategies are recommended:

Demarcation of drains, streams and wetlands around Lake Victoria

The first step in minimizing pollution in Lake Victoria is to have an understanding of various waterbodies, including drains, rivers and streams discharging water into the lake. During CSE's visits in July and November 2022, it was observed that apart from the Mirongo and Nyashishi, there are numerous small drains and streams that meet the lake directly. These drains and streams flow through habitation and may carry municipal sewage and/or household waste. CSE collected samples from one such drain, the Mkuyuni drain. The results showed exceeding values of BOD and COD. Thus, it is prudent to **identify and demarcate these drains and streams on a map** to enable regular monitoring at such sites and take timely measures in case of increased pollution load. The National Environmental Management Council (NEMC), Lake Victoria Basin Water Board (LVBWB), Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA) should carry out a combined reconnaissance survey and identify such drains carrying sewage.

A similar activity is required for wetlands. As per the stakeholders and CSE observation during the visit, the Nyashishi wetland has been significantly encroached for habitation and agricultural activities. The encroachment is to the extent that the river loses its natural flow in the dry season, turning the wetland entirely into agricultural fields. Since the Nyashishi River flows through this wetland before discharging into Mwanza Bay of Lake Victoria, a substantial amount of pollutants are removed in the wetland and clean water reaches the lake. With the encroachment of the wetland, however, this process of natural cleaning has been severely affected. Several similar wetlands along Lake Victoria have been encroached for human activities, impacting water treatment through natural phenomenon. It is, therefore, imperative to **protect and restore these wetlands**. The National Environmental Management Council (NEMC) along with Lake Victoria Basin Water Board (LVBWB) should identify and demarcate these wetlands on a map and notify them as sensitive areas under Section 56 of the Environmental Management Act, 2004.

Once the rivers, streams, drains and wetlands are identified, the next step is to intervene on sources of pollution, including industrial effluents, municipal sewage and solid waste entering these waterbodies. The streams can be treated in a decentralized manner before they enters the river or can be combined, treated and discharged back into the river (interception, diversion and treatment).

Strengthening industrial wastewater management

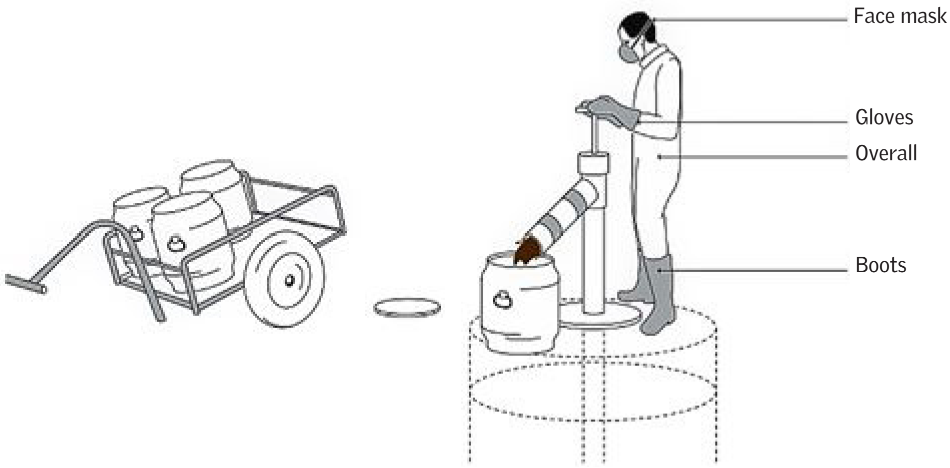
As discussed in the previous chapter, the inadequacy in a few areas in industries is due to the lack of specificities in the permit issue to the industries. If permit conditions are specific and measurable, they can be easily assessed for compliance by inspection. Analysis of the current permit conditions shows missing information, including details of production capacity, quantity of raw material, water consumption, improper storm-water management, absence of designated outlet for final discharge of effluent or storm water, poor housekeeping etc., at various points (see *Annexure 1a*). Thus, CSE suggests **strengthening permit conditions**, which will not only help in generating data but also support the inspectors to carry out inspection to gauge the level of non-compliance. CSE has proposed a revised permit format (see *Annexure 1b*) that can be used by LVBWB while issuing the permits. Additionally, NEMC should come up with **industry-specific guidelines** on best practicable technologies (BPT) for effluent treatment plants and use of treated effluent for recycling and agricultural activities. These guidelines will aid industries in treating and using effluent efficiently.

Several water-intensive industries abstract water directly from Lake Victoria or take from the Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA), which abstracts water from lake. The abstracted water is then used in process and is discharged directly or indirectly into the lake. Thus, in order to improve the water conservation, it is pertinent to introduce concept of water audit which will help in providing measures to reduce water intake, thereby reducing the water discharge too. NEMC, through a relevant act, should **introduce the concept of water audit** for water-intensive industries to evaluate and minimize their water footprint.

Enhancing municipal wastewater management

To enhance municipal wastewater management, efficient functioning of the existing waste stabilization pond must first be ensured. As observed during the visit that the waste stabilization pond is operating at 80 per cent efficiency due to improper maintenance. The sludge has not been removed since last ten years from the ponds, reducing the retention time and thus treatment efficiency. Foremost, appropriate operation and maintenance of existing waste stabilization pond with periodic **desludging from ponds should be planned and ensured**. The removed sludge should be kept in sludge-drying beds and dried sludge should be analysed for suitability to use in agricultural or organic manure. Additionally, a laboratory may be established by MWAUWASA for the day-to-day measurement of water quality parameters both at inlets and outlets.

Figure 11: Working mechanism of the gulper system



The second impediment to enhancing municipal wastewater management is the unavailability of sludge removal facilities at the higher portions of the hills. Although MWAUWASA is doing a commendable job of developing simplified sewerage system at the hills, at some locations this is challenging. Consequently, during the rains, people discharge their waste, which reaches the rivers and eventually Lake Victoria. The solution to this issue can be to **adopt the gulper system, a manually operated pump to empty contents from pit latrines**. It can be employed at locations where commuting a wheelbarrow is feasible to transport buckets containing faecal sludge.

Last, a **decentralized faecal sludge treatment plant** is recommended in areas that are far from the waste stabilization pond and existing sewer lines (more than ~ 25 km). Since it was observed that bringing faecal sludge to the waste stabilization plant from a faraway places (average ~16 km) was challenging for private desludgers, a separate faecal sludge treatment plant can be installed.

Action plan for making Mwanza city a zero-landfill site

Currently, the Mwanza City Council and Ilemela Municipal Council have made efforts in waste collection with efficiency of 70–80 per cent of generated waste. However, since no segregation practice is followed, all this collected waste is dumped at the landfill. With such a good collection strategy, the city should now focus on segregation of waste to reduce the load on the landfill. Out of the total collected waste, approximately 70 per cent comprises organic waste (wet waste from kitchens) and the remaining 30 per cent is dry waste. Organic waste can be composted and the compost, which is valuable as a soil mender, can be made available to farmers for their crops. Dry waste should be sorted for recycling, recover and reuse and sold to authorized dealers. The remaining unused waste should be dumped at the lined or engineered landfill site instead of the current practice of dumping at unlined sites. Reduced waste dumped at the site will significantly reduce the quantity of leachate generation. The generated leachate should be collected and treated before disposing of it into the Nyashishi wetland.

NEMC along with the Mwanza City Council and Ilemela City Council should develop a **strategy with an aim to make Mwanza city a zero-landfill site**. This should start with strengthening the bylaws by initiating waste segregation, maximizing treatment and recycling, and minimizing dumping at landfills.

Constructive wetland at mouth of Mirongo River for terminal treatment

The current scenario of municipal sewage and faecal sludge collection is limited to only a few households. A substantial percentage of faecal sludge is unsafely managed, which means it find its way directly or indirectly to the Mirongo River and ultimately to the lake. Analysis of water samples of the Mirongo River also shows huge loads of BOD (12 tonne) and COD (26 tonne) being discharged into Lake Victoria. Thus it is suggested that **a wetland on the mouth of the Mirongo River be constructed** to provide terminal treatment before effluent is discharged into the lake. Since the area around the mouth of the Mirongo is already swampy, it would be feasible to convert it into a wetland. MWAUWASA, NEMC and the Mwanza City Council can explore the possibility of constructing a wetland and can engage experts for the design of the same.

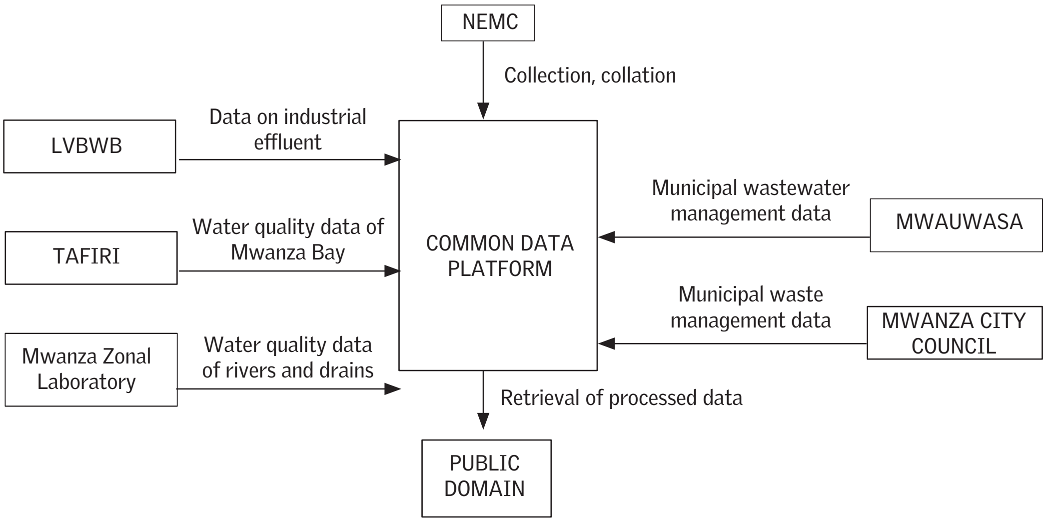
Developing water-quality monitoring network

Once the pollution sources have been intervened, the effectiveness of the measures are required to be assessed. This can be done by having good monitoring data for different parameters. High-quality and regular monitoring data will act as a tool to assess the changing quality of Lake Victoria and for effective decision-making.

CSE has developed a water-quality monitoring strategy for the riverine system and Lake Victoria for the Mwanza region (see *Annexure 2*). The monitoring network has been designed for the Mirongo, Nyashishi and Magogo Rivers. As all three rivers discharge into Mwanza Bay, a sampling strategy has also been developed for the bay. Additionally, a monitoring programme for Mkuyuni drain and other similar drains has been proposed.

NEMC can implement this monitoring strategy along with Tanzania Fisheries Research Institute (TAFIRI) and Mwanza Zonal Laboratory. To further strengthen the monitoring regime, NEMC may mandate the **installation of online water-quality monitoring stations** at all facilities operating within the lake shore, and data should be transferred to the online portal. This will serve two purposes: first, real-time data from various areas will be available and, second, the facilities operating near the lake shore will take efficient measures to not discharge untreated wastewater directly into the lake. NEMC should also consider having their own laboratory at Mwanza; the lab facilities can be used as and when required for compliance and enforcement. Generation of data as per the proposed monitoring network should be the responsibility of TAIFRI and Mwanza Zonal Laboratory. The organizations should also explore the possibilities of financial support for lab

Figure 12: Data-sharing platform



operations through government and international donors or introduce innovative measures such as implementing inspection fees for the industries.

Common platform for data sharing

Several stakeholders, including the National Environmental Management Council (NEMC), Lake Victoria Basin Water Board (LVBWB), Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA), Mwanza Zonal Water Laboratory, Tanzania Fisheries Research Institute (TAFIRI), MWANZA City Council etc., are working in varied domains. All these entities, however, work mutually exclusively, with no process of integration with them. Since every stakeholder generates data relevant to the overall water quality of Lake Victoria, it is essential to integrate and share the data generated by every stakeholder on a common platform. This integrated data management will aid in keeping track of fluctuations in water quality at different locations and developing a comprehensive management strategy. **NEMC should take the lead to develop such an on-line portal** to upload the data from different stakeholders. This portal should also have monitoring data from different locations as per the monitoring programme and the real-time data from the facilities near the shore.

Formation of a committee

It is understood that the Lake Victoria Basin Commission already exists to regulate and monitor the activities associated with the lake. However, joint efforts of stakeholders at the regional level are required to achieve the results envisaged.

CSE feels that a separate committee should be constituted to oversee management of water quality of Lake Victoria. Members of the committee shall be appointed from various stakeholder group such as MWAUWASA, LVBWB, MCC, TAIFRI etc. so that the committee can have members with diverse opinions who work together in a balanced manner by building consent. This committee will monitor the progress achieved in different aspects of lake restoration and will provide the way ahead as and when required. It can be constituted at the regional level for regions such as Mwanza, Mara, Geita, Kagera etc. to watch over region-specific issues, mitigation measures required and progress thereof. A central committee can also be constituted with representatives from different regional committees to monitor the overall progress on Lake Victoria. This committee should also stay engaged with international organizations working directly or indirectly on Lake Victoria.

Strategy to upscale the learning

CSE and NEMC have spent considerable time understanding the reasons for pollution in Lake Victoria from the Mwanza region. The exercise was exhaustive and required significant manpower and financial expenditure. Thus it would be challenging to perform similar studies in other regions in the Lake Victoria watershed areas. It is therefore prudent that these **regions take the learning from the current study and come up with their own matrix of problem identification, interventions required and implementation strategies**.

CSE can provide technical assistance on preparing a water-quality monitoring network, an industry-specific action plan, sector-specific guidelines, guidance on waste management and decentralized sewage treatment, and provision of capacity-building programmes as required.

Annexures

Annexure 1a: Analysis of current license conditions issues by Lake Victoria Basin Water Board (LVBWB)

S. no.	Description	Condition as mentioned in permit issued by Lake Victoria Basin Water Board	CSE suggestion	Remarks
1	Validity of permit condition	Initially one year, renewed after one year	Agreed	May be asked to renew before three months of expiry.
2	Quantity of water consumption	Not mentioned	Utility-wise quantity needs to be mentioned	Will help in understanding the scope of recycling of treated wastewater.
3	Quantity of wastewater discharge	Mentioned	Agreed	Reuse of treated water can be introduced.
4	Effluent quality	Regulation 8 of EMA 2004	Parameters to be mentioned with their limit (both in concentration and load)	Unnecessary parameters can be avoided
5	Designated outlet	Not mentioned	Permit should mention clearly the designated outlet.	Treated wastewater shall be discharged through designated outlet bi-fitted with V-notch or real-time properly calibrated flow meter. This will help inflow measurement required for calculating pollution load.
6	Collection of waste water through close conduit	Not mentioned in the permit but industries follow this practice.	To be mentioned in the permit	Open drain may result in mixing of surface runoff with effluent
7	Collection of storm water	Not mentioned	To be mentioned in the permit.	Storm-water drains shall be deep and closed provided with manholes
8	Adequacy of ETP scheme	Permit only mentions provision of adequate treatment but lacks specificity.	Minimum requirement of unit operation for ETP should be mentioned. NEMC should take initiative to develop industry-specific best practice guidelines.	Guidelines will help LVBWB in checking the adequacy of proposed ETP during permit condition.

S. no.	Description	Condition as mentioned in permit issued by Lake Victoria Basin Water Board	CSE suggestion	Remarks
9	Capacity of production	Not mentioned	Waste water generation is dependent on production capacity thus to be mentioned.	At the time of inspection, the inspector can understand whether the industry is under/over production.
10	Housekeeping	Not mentioned	Permit should mention following requirements: 1. No visible spillage of oil 2. Used container, cardboards etc. shall be stored at designated place 3. Any other, as considered by the authority	Good housekeeping will prevent contamination of storm water. Layout plan if altered shall be apprised to LVBWB.
11	Reporting system	Not mentioned	Periodic submission of compliance should be asked in permit	It will help in updating the compliance status of industries and action thereof

Annexure 1b: License format as recommended by CSE

To

M/s X. Fisheries

____

____

Sir,

The X Fisheries has submitted an application for permit for discharging water into Lake Victoria as per application [form no.] under the [name of Act] Act, dated _________.

The Lake Victoria Basin Water Board examined the said application form with due diligence and is pleased to offer a 'permit' for intake or discharge of wastewater in the waterbodies of Lake Victoria basin by the industry with following conditions.

1. Validity period of the permit is for [number of years] years from the date of issuing the permit. In order to renew the permit, the industry has to apply three months before the date of expiring.

2. The production capacity of the industry is _____________ Mt/year.

3. Quantity of raw material consumption per month [kg/MT of product per month].

   I. _________________ .
   II. _________________ .
   III. _________________ .
   IV. _________________ .

4. Water consumption requirement is ______________________ Kl/day and source of raw water is _________________.

5. Quantity of wastewater discharge shall be within the limit of __________________ Kl/day.

6. Quality of industrial water discharged shall conform within or equal to the limit of the following parameters.
   pH: 6.5–8.5
   BOD: _____________ mg/l
   COD: ______________ mg/l

7. Industrial wastewater shall be collected and transported in a closed conduit to the effluent treatment plant and discharged through a designated outlet to the receiving waterbody [Mention the name of receiving water body].

8. The designated outlet shall have a sampling facility and be fitted with a V- notch or real-time flow water with calibration at regular intervals.

9. The effluent treatment plant shall be designed and installed as per the best practicable technology (BPT) guidelines published by NEMC. In the absence of guidelines, the industry shall adhere to the design submitted with the application form. Any change in design needs to be apprised to the Lake Victoria Basin Water Board.

10. The industry shall conduct a performance evaluation of unit operations of their effluent treatment plant once in three months and the report shall be submitted to the board.

11. The storm-water drain shall be covered, have provision of a manhole and shall be discharged through a designated outlet to the receiving waterbody [mention the name of receiving waterbody]. The outlet should be separate from that of industry effluent.

12. The industry shall submit a quarterly (once in three month) report on the status of compliance with respect to each condition of the permit.

13. The industry shall maintain good housekeeping in the premises with respect to solid waste such as used cardboard, containers etc. Waste shall be stored in designated place as mentioned in the layout plan.

14. Impervious pavement, lawn, gate with visiting register and staircase shall be maintained on the premises.

15. The layout plan submitted with the application form shall be strictly adhered to. Any alteration needs to be apprised to the Lake Victoria Water Basin Board; failure to comply with the consent condition shall attract actions from the board.

16. The industry shall conduct a water audit through a third party once a year and submit the report to the basin board.

Yours faithfully

____

Director
Lake Victoria Basin Water Board

Annexure 2: Water quality monitoring network

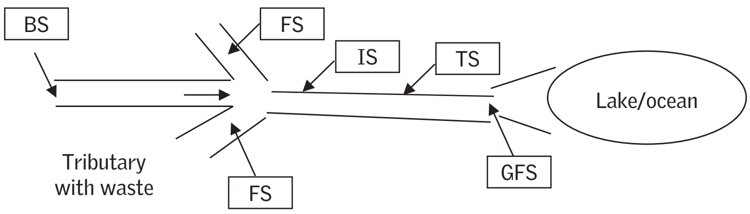
Monitoring is a programme for periodic observation in order to draw inferences about the experiment or the phenomenon for which it is designed. Designing of a water quality monitoring network requires three essentials components, namely sampling location, parameters to be monitored and frequency of monitoring. The three components are discussed as below.

Sampling location

To get correct results from the monitoring network, selection of sampling location is a significant requirement. The sample location selection should consider the following stations

- Baseline station (BS): The monitoring location, with no or minimum human activities;
- Flux station (FS): A point where a tributary, irrigation drain carrying industrial effluent or sewage (treated or untreated) discharges pollution load into the main stream;
- Impact station (IS): Where pollutants are well mixed with the main stream;
- Trend station (TS): A station designed to show how a particular point on a water course varies over time with the influence of human activity;
- Global flux station (GFS): A station where a river empties into a lake or the ocean (see figure below).

Types of sample location



Frequency

Frequency is considered on the basis of seasonal variation with regard to rainy or dry season

Parameters

Selection of parameters depends upon human activities such as agricultural practices, industrialization and surface runoff during the rainy season.

With the aforementioned in view, a water quality monitoring plan network has been designed for

- The riverine system;
- Mwanza Bay; and
- Drains directly discharging to Lake Victoria.

Monitoring network at riverine system

There are three rivers discharging to Mwanza Bay: Mirongo, Nyashishi and Magago. Nyashishi is proposed to have four stations; baseline at the upstream preferably near it origin, flux station at the industrial combined drain, impact station at the Mwanza–Musoma highway near bridge and trend station at Nyashishi bridge. No global flux station at discharge in Mwanza Bay is proposed since the river has lost its flow in agricultural field after the Nyashishi Bridge (see *Table: Proposed monitoring network for Nyashishi River*).

Proposed monitoring network for Nyashishi River

Type of sampling location	Name of Sampling location	Frequency	Parameters
Baseline station	Upstream near the origin	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Impact station	Downstream at Mwanza-Musoma highway near bridge	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Trend station	Downstream at Nyashishi bridge	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Flux station	Combined industrial effluent drain	Once a month (since it is a sensitive point w.r.t industrial discharge, it should be under surveillance)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P

Since the CSE team could not visit the location near the origin of the Mirongo River, the location near Buzurga Bridge is proposed as a baseline station for the Mirongo. If the location near the origin is accessible, it should be taken as the baseline station. The gauging station installed by LVBWB at the Mirongo River is considered as the trend station while the location before the mouth of Lake Victoria is taken as the impact station. Since the mouth of Lake Victoria is not accessible during the rainy season, the impact station can be considered as the global flux station. Additionally, if any drain is identified to discharge into the river, it should be considered as a flux station (see *Table: Proposed monitoring network for Mirongo River*).

Proposed monitoring network for Mirongo River

Type of sampling location	Name of sampling location	Frequency	Parameters
Baseline station	Near Buzurga Bridge	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Trend station	Nukuruman Gauzing Station	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Impact station	Before the mouth of Lake Victoria	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Global flux station	At the mouth of Lake Victoria	Six times/year (two each in two rainy seasons and two in the dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P

The Magago River has not been visited by CSE. However, based on the strategy used for other rivers, a tentative monitoring plan is proposed for the Magago River (see *Table: Proposed monitoring network for Magago River*). The sampling frequency has also been reduced because of the same reason.

Proposed monitoring network for Magago River

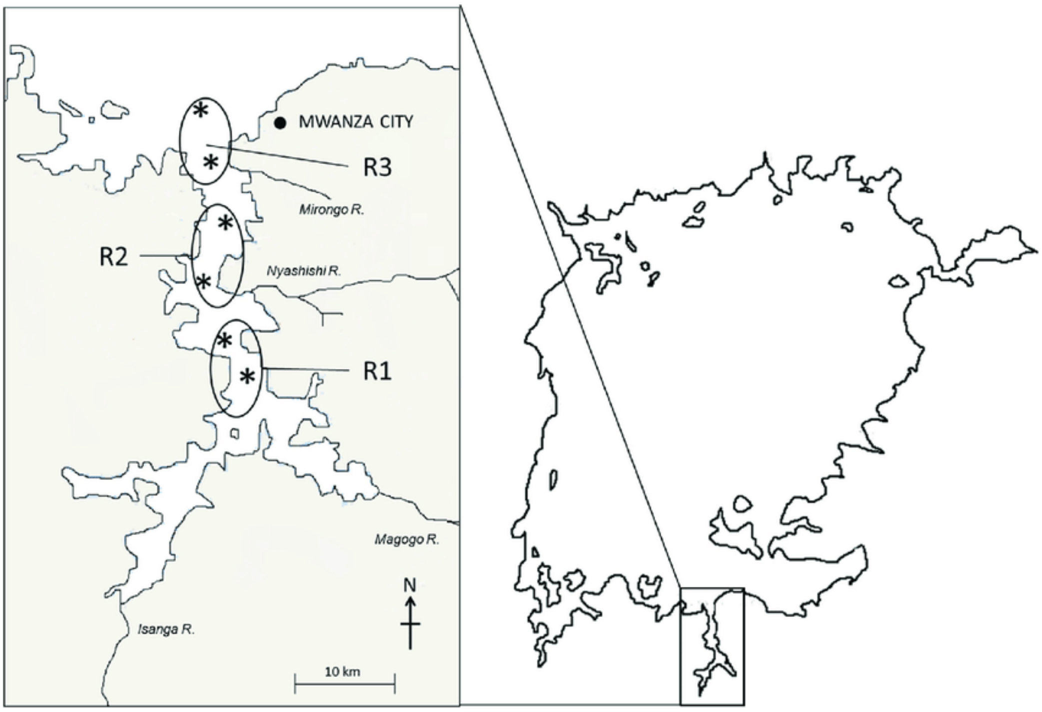
Type of sampling location	Name of sampling location	Frequency	Parameters
Baseline	Upstream of Magago	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, Total P
Impact	Downstream of Magago Industrial Area	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, Total P
Global flux	Magago at discharging point	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, Total P

Note: If any drain is identified discharging in Magogo River, it will be considered as a flux station.

Monitoring network at Mwanza Bay

Since Mwanza Bay is a part of Lake Victoria, the location of monitoring stations is considered in two dimensions: linearity and depth. The entire stretch is divided into three regions with respect to depth (see following map) and for each region two monitoring stations are proposed. The frequency of monitoring is proposed three times a year, assuming two rainy and one dry season. Parameters of transparency (secchi disk) and chlorophyll A are included in addition to other parameters in the riverine system (see *Table: Proposed monitoring network for Mwanza Bay*). Dissolved oxygen can be monitored in the morning and evening to observe the diurnal behaviour.

Monitoring regions of Mwanza Bay



Proposed monitoring network for Mwanza Bay

Name of sampling points	Number of sampling points	Frequency	Parameters
Region 1 (0–5 m depth)	Two sampling points	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P, chlorophyll A, transparency (secchi disk)
Region 2 (5–10 m depth)	Two sampling points	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P, Chlorophyll A, transparency (secchi disk)
Region 3 (10–15 m depth)	Two sampling points	Three times/year (one each in two rainy season and one in dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P, chlorophyll A, transparency (secchi disk)

Monitoring network for drains directly discharging into Lake Victoria

For drains carrying treated or untreated sewage, only a flux station is proposed. The proposed monitoring network is for the Mkuyuni drain and two unidentified drains that may be identified during the reconnaissance survey (see *Table: Proposed monitoring network for drains*).

Proposed monitoring network for drains

Name of sampling points	Frequency	Parameters
Mkuyuni drain	Once in every season (two rainy and one dry season)	Flow, pH, conductivity, BOD, COD, TDS, total N, total P
Drain 2 (unidentified)	Once in every season (two rainy and one dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P
Drain 3 (unidentified)	Once in every season (two rainy and one dry season)	Flow, pH, conductivity, DO, BOD, COD, TDS, total N, total P

Lake Victoria, the source of livelihood for 45 million people, is in a state of degradation as a result of a variety of unsustainable human activities over the last few decades. Parts of the lake, especially deeper areas, are already considered dead zones that are unable to sustain life due to deficiency of oxygen in the water.

This report focuses on Mwanza city, identified as a hotspot. It highlights the degree of industrial and municipal pollution from the city in its rivers, streams and ultimately in Lake Victoria. It proposes various interventions to mitigate pollution at the source and reduce its disposal in the waterbodies. A monitoring programme to analyse the effectiveness of measures on ground is also discussed.

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