



Physico-Chemical Water Quality Analysis of Water Supply Reservoirs of Addis Ababa City

*A policy brief adapted from MSc research projects conducted by
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Summary

Water is one of the most important natural resources on earth. Currently, the safety of drinking water sources around the world is affected by various contaminants detrimental to health, and water pollution is an appalling problem.

Despite the increasingly common use of dams and reservoirs for domestic purposes, especially community water supply, these facilities are constantly threatened by pollution from both natural and anthropogenic activities.

According to a physicochemical and bacteriological analysis, water quality parameters for three major reservoirs and their tributaries that supply water to the Addis Ababa metropolitan area and small towns surrounding the city do not meet the standards set by the World Health Organization (WHO), European Union (EU) and Environmental Protection Agency (EPA) of the Government of Ethiopia. Further study and action are needed from all concerned bodies.

Introduction

Pollution of surface water: a great environmental concern

Water quality is vital to human health and welfare. Studies show that approximately 3.1 percent of deaths worldwide are attributable to lack of access to water.

The pollution of water bodies by anthropogenic and natural processes and the acceleration of their deterioration in quality are increasingly a very sensitive issue and a great environmental concern globally. The growth in discharge of urban waste, agricultural runoff, and industrial effluent to water bodies and in natural processes corresponding to changes in precipitation inputs, erosion, and weathering of crustal materials is posing an escalating danger of pollution to water bodies and degrading their quality.

Especially in emerging and developing countries, where industries are growing,

agricultural activity is expanding, and populations are rising, surface water bodies are under serious threat from the indiscriminate discharge of polluted effluents from industrial, agricultural, and domestic activities around watersheds.

Among the water bodies being affected and polluted by anthropogenic and natural activities are surface waters that supply domestic needs. At particularly high risk are reservoirs used as sources of drinking water.

Water Supply Reservoirs in Addis Ababa

Addis Ababa city and its metropolitan area receive 65 percent of their water supply from three major reservoirs—the Legedadi, Dire, and Gefersa reservoirs—located on the outskirts of the city (AAWSA, final report 2011). Various studies have shown a dramatic deterioration in the quality of water in these reservoirs as a result of natural and anthropogenic processes and activities.

In this study, researchers carried out a water quality assessment for these reservoirs, their tributary rivers, and one proposed site for reservoir construction to determine their level of pollution from mainly anthropogenic activities and the accompanying health risk.

To this end, water samples were taken from

the reservoirs and their tributaries, and selected physicochemical and microbiological water quality parameters were analyzed.

Findings

Legedadi Water Supply Reservoir

The Legedadi reservoir and treatment plant is on the outskirts of Addis Ababa, east of the city.

Table 1 shows the results of testing for major water quality parameters on samples collected using a cross-sectional approach during the dry season.

Water quality parameter	Analyzed value of physicochemical parameters	Ethiopia quality standard	WHO/EU quality standard
Turbidity (NTU)	9	-	5
Nitrate (mg/l)	63.12	50	50
Nitrite (mg/l)	6.53	-	3
Ammonia (mg/l)	3.07	-	2.0
Phosphate (mg/l)	7.78		0.54
BOD (mg/l)	10.74	-	<5

Table 1. Results of water quality analysis of Legedadi Reservoir

The results exceeded both the WHO/EU and the Ethiopia drinking-water quality standards.

Geffersa Water Supply Reservoir

The Geffersa water supply reservoir is west of the city of Addis Ababa. It has three major tributaries: Menjaro, Dima, and Geffersa Choresa.

Water samples taken from the tributaries were analyzed in a laboratory-based, cross-sectional

study using physicochemical and microbiological parameters. Table 2 shows the mean results of the analysis for major water quality parameters.

Water quality parameter	Analyzed value of physicochemical parameters	Ethiopia quality standard	WHO/EU quality standard
Turbidity (NTU)	22.5		5
TDS	50.16		500
Temperature (°C)	17.1		25
pH	6.5		5.5–9
DO (mg/l)	9.5		6–9
Nitrite (mg/l)	0.13		
Phosphate (mg/l)	0.09		
sulphate (mg/l)	1.05		250
BOD (mg/l)	6.6		<5
COD (mg/l)	13		40

Table 2. Results of water quality analysis of Geffersa Reservoir

Dire Water Supply Reservoir

The Dire water supply reservoir is northeast of Addis Ababa. It has three tributaries, Legsilmicha, Legdamo, and Legmiti.

Laboratory analysis of samples collected from the three tributaries and the reservoir using a composite method produced mean results for sampled streams indicating levels of DO, BOD₅, COD, FC, TC, TSS, and NO₂⁻-N exceeding the limits permitted by either the WHO/EU or the Ethiopia drinking-water quality standards. Temperature and values for EC,

TDS, PO₄, SO₄, alkalinity, BOD₅, and COD were likewise above the permissible standards, as was turbidity, which was measured in an in situ analysis.

Water quality parameter	Analyzed value of physicochemical parameters	Ethiopia quality standard	WHO/EU quality standard
TDS (ppm)	197		500
Temperature (°C)	24.9		25
Alkalinity(mg /l)	173		5.5-9
DO			6-9
Phosphate (mg/l)	0.775		
Sulphate (mg/l)	18.2		250
BOD (mg/l)	10.5		<5
COD (mg/l)	29		40

Table 3: Results of water quality analysis of Dire Reservoir

Overall, Legsilmicha, near which anthropogenic activity is high, was found to be the most polluted of the three tributaries; its computed water quality index fell into the category of “unsuitable to drink” (WQI >100). Water quality for Legdamo was found to be “very poor” (WQI 76–100), and Legmiti was in the “poor” category (WQI 51–75).

Finally, in addition to these findings, the analysis showed that a high concentration of phosphate, possibly generated from agricultural activities in the area, has led to reservoir eutrophication.

Sibilu Reservoir

The Sibilu River, located west of Addis Ababa, is a surface water source that has been proposed as a water supply for the city. Upstream of the proposed site for reservoir construction, lots of industries have recently emerged, increasing the danger of pollution to this water source.

A purposive sampling was done of the Orgogo River—one of the tributaries of the proposed reservoir—where the river crosses a leather manufacturing facility. The water quality analysis showed EC, TDS, Cl⁻, SO₄²⁻, levels were 4201µs/cm, 2699.3 mg/l, 645.75 mg/l, and 385 mg/l, respectively.

Also found were high concentrations of heavy metals, especially chromium. Previous reports have indicated a 77 percent increase in the chromium concentration within the past six years. A possible source is the leather factory, and it poses a major risk factor for the future Sibilu reservoir.

Samples from the Dima River, another tributary of this proposed reservoir that crosses a town, were taken and analyzed. The town disposes of solid waste in this river, and its water quality is characterized by concentrations of TC, PO₄, and NO₃ that are above standard.

Conclusion

This study found elevated concentrations of physicochemical and microbiological water quality parameters in the three reservoirs and their tributary rivers, based on water quality

standards set by the WHO, the Government of Ethiopia, and the EU for potable and surface waters. The reservoirs are highly contaminated with nutrients such as nitrate, phosphate, and ammonia—indications of pollution from agricultural and anthropogenic sources.

The high levels of NO₂⁻-N also indicate the use of chemical fertilizers in the catchment areas of the reservoirs. The results of the test analysis on the levels of BOD₅ and COD indicate the presence of organic pollutants, while TC and FC indicate the presence of bacterial contamination.

The presence of these pollutants, i.e. nitrate and nitrite, turbidity and bacterial contaminations have potential health risks.

According to reports from the Addis Ababa Water and Sewerage Authority (AAWSA), inadequate protection of the reservoirs' catchment areas has caused their water quality to deteriorate greatly over the years. The three reservoirs and their tributaries are downstream of public and private investment activities that expose them to pollution. Their catchment areas are characterized by heavy discharge of industrial waste, urban runoff, and leachate and agricultural chemicals.

A recent increase in the expansion of anthropogenic activities may worsen the pollution of the reservoirs; and, since heavily polluted water needs more treatment chemicals than less polluted water to be made safe, the cost of providing safe water will continue to rise.

Recommendation

As the City of Addis Ababa develops, its demand for water increases. To meet the greater demand without launching new water projects, the capacities of the current reservoirs must be protected and maintained through a source water protection program.

For such a program to be effective, pollution problems or risks within the reservoirs' watersheds need to be identified. The existing activities, which are mainly focused on the treatment of water, should concentrate more on the protection of the whole catchment area. Potential polluters have to be assessed and management intervention designed.

Also needed is enforcement of regulatory measures, with polluters held responsible for their actions, and concerned bodies should establish a reservoir buffer zone to minimize the existing potential for pollution. This last may be accomplished through watershed monitoring, including water quality monitoring and land use surveys. Generally, the establishment of integrated water resource management is recommended.

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