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Open Access Journal of Agricultural Research
ISSN: 2474-8846

Review on the Water Quality Status of Lake Hawassa, Central Rift Valley Lakes, Ethiopia

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Review Article
Volume 8 Issue 4
Received Date: October 18, 2023
Published Date: November 10, 2023
DOI: 10.23880/oajar-16000335

Abstract

Population growth, urbanization, and modernization are all contributing to sewage disposal issues and lake poisoning. The physical, chemical, and biological properties of water are typically used to describe its quality. Numerous factors, including BOD, temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, etc., can be used to measure the quality of water. Because they pollute water or induce chronic poisoning in aquatic creatures, heavy metals like Pb, Cr, Fe, and Hg are particularly concerning. This review study stresses the Lake Hawassa water quality status using various research findings from both published and unpublished web documents. It was noted that the water from Lake Hawassa is extremely contaminated and may not meet the requirements for drinking and recreational uses, although with great care, it benefits aquatic life and irrigation. Pesticides were found in significant concentrations in Lake Hawassa's water, sediments, and fish species as a result of its exposure to effluent from industrial, urban, and agricultural runoff. As a result, the lake has become poisoned, threatening the aquatic ecosystem's biodiversity, which includes fish. Therefore, in order to protect Lake Hawassa's water supply, the government should implement the necessary controls to prevent the discharge of pollutants from agricultural fields, ceramics, textiles, plastics, urban storm water, leather tanning, and food processing sectors.

Keywords: Agricultural Fields; Effluent; Lake; Wastes; Water Quality

Abbreviations: WAWQI: Weighted Arithmetic Water Quality Index; CCME WQI: Council of Ministers of the Environment Water Quality Index.

Introduction

Water is the most valuable natural resource in the world, and water resource contamination is one of the most urgent worldwide environmental problems [1]. Ethiopia's lakes are vital to both the local population's existence and the country's economy. However, rising consumption and environmental deterioration pose a threat to them [2]. 11 fresh lakes, 9 salt lakes, and 4 crater lakes exist in Ethiopia. According to Awulachew SB, et al. [3], the Rift Valley Basin is home to the vast bulk of the lakes. Water quality indicators are helpful tools for monitoring the ecosystem's integrity and as an indicator for the appropriateness of the water for the intended uses Goshu G, et al. [4], some studies have been conducted regarding surface water pollution due to human-induced impacts in Ethiopia [5]. The physico-chemical properties of the Rift valley lakes have been thoroughly researched in southern Ethiopia, quoted in Wondim YK, et al. [6]. Lakes can experience a range of physical, chemical, and biological issues that can affect their aesthetic appeal, recreational value, water quality, and habitat appropriateness.

For Lake Hawassa, the values for DO, F^-, and turbidity are frighteningly rising. Additionally, the most recent EC values are frightening. Moreover, the pH is rising. The majority of these changes are linked to anthropogenic activity, namely those near the lake margins and their catchments. Water contamination can be accelerated by industrialization, excessive water consumption for irrigation and fertilizers, and increasing urbanization. The general objective of this paper is to review the Lake Hawassa water quality status using various research findings (Figure 1).

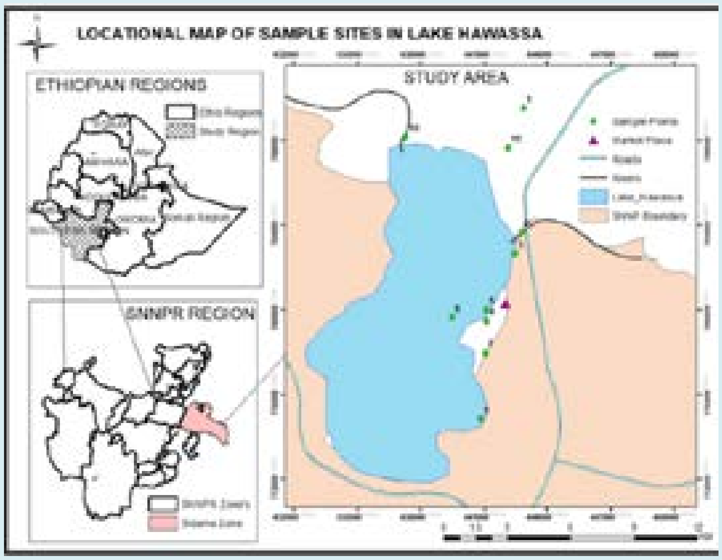

Figure 1: Map of Lake Hawassa Ethiopia Showing Various Sampling Sites as Evaluated by Melaku Z, et al. [7].

As a well-known lake, Lake Hawassa is impacted by point sources of pollution, such as those emitted by businesses and service providers, as well as diffuse sources, including intensive farming on the watershed [8]. According to Melaku Z, et al. [7] the monitored point sources indicate that the city of Hawassa and its numerous industrial discharges are major polluters, necessitating the rapid and subsequent establishment of an efficient wastewater infrastructure, accompanied by rigorous monitoring of large point sources (e.g., industry, hospitals, and hotels). Despite having a controlled drainage system, Lake Hawassa nevertheless drains a huge swampy area and has stayed relatively diluted. In some of the closed basins, solute losses are thought to be caused by seepage [9].

The smallest freshwater closed basin lake, Lake Hawassa is used for irrigation, pleasure, and small-scale commercial fishing. Due to the discharge of untreated wastewater from home and industrial sources, runoff of agricultural wastewater, and sediment influx from rains, it is also one of the most contaminated [10]. Lake Hawassa has been the subject of numerous researches on the characteristics of water quality, pesticide contamination, and trace metal levels [5,7,8,10-12]. However, there is no consolidated information on the trends in Lake Hawassa's water quality, so this review study intends to fill this informational vacuum and offer helpful data on these trends.

Materials and Methods

Between June 2021 and August 2021, a collection of literary sources was created; it consists of workshop proceedings, reports, bulletins, published journal papers, unpublished Papers (from online databases), and other materials.

Water Quality Characteristics of Lake Hawassa

Large amounts of sewage and industrial effluent dumped into the lake as a result of population growth, industry, and urbanization have considerably added to the lake's pollution [13]. We suggested several papers for investigation to a number of technical publications on water quality for a lake called Hawassa that have been presented at the research level. According to Melaku H, et al. [12] the concentration of metals of lake Hawassa was manganese (0.83 mg/L), Z (5.75 mg/L), Cr (0.22 mg/L), PO_4^{3-} (1.31 mg/L), and BOD 5 (BOD_5, 68.7 mg/L) exceeded WHO standard that could be due to point sources pollution from ceramics, textile, plastics, leather tanning, and food processing industries located near the rivers and streams that end up into the lake. According to Worako W [5], the Tikurwuha River Inlet has the highest average concentrations of Zn (0.317 mg/L), Fe (0.18 mg/L), Copper (0.046 mg/L), and Mn (0.489 mg/L) (Tables 1-3).

S/N	pH	Temp(oc)	TDS(ppm)	DO(ppm)	Turbidity(NTUs)	EC(µs/cm)	BOD_5	Authors
1	7.54	21.2	449.7	18.5	8.42	754.6	116.6	Worako W [5]
2	7.54	21.2	450.1	17.8	8.44	750	117	Abate, et al.
3	8.17 ± 1.05	24.5 ± 2.59	974.5 mg/L	5.48 mg/L	25.9	-	35.2 mg/L	Melaku Z, et al. [7]
4	8.67 ± 0.7	26.7 ± 2.0	974.5 ± 332.1	7.22 ± 0.9	47.9 ± 55.4	1851.4 ± 148	68.7 ± 7.5	Melaku H, et al. [12]
5	8.68	20.1	417	5.06	5.73	790.1	-	Menberu Z, et al. [10]
6	8.5	-	419	2.2 mg/L	10.7	811	23.6 mg/L	Lencha SM, et al. [11]

Table 1: Physical Parameters Result for Lake Hawassa.

S/N	Iron (Fe)	Potassium (K)	Magnesium (Mg)	Chromium (Cr)	Zinc (Zn)	Copper (Cu)	Authors
1	0.085mg/L	70.80±27.2	26.08±4.2mg/L	-	0.19 mg/L),	0.01 mg/L	Worako W [5]
	0.085	74.1	28.1	-	0.19	0.01	Abate, et al.
2	0.46 mg/L	74.8 mg/L.	-	-	-	-	Melaku Z, et al. [7]
3	0.13 ± 0.01ppm	74.2 ± 14.3ppm	27.6 ± 1.9ppm	0.22 ± 0.06ppm	5.75 ± 2.3ppm	0.05 ± 0.03ppm	Melaku H, et al. [12]
4	0.081mg/l	73.9	27.9	0.32ppm	0.2mg/l	0.01mg/l	Menberu Z, et al. [10]
5		18.9	7.3				Lencha SM, et al. [11]

Table 2: Heavy Metals Analysis of the Lake Hawassa.

S/N	Nitrate (NO3-)	Sulfate ($SO4^{2-}$)	Phosphate ($PO4^{3-}$)	Fluoride (F^-)	$NO2^-$	(NH4-N)	Authors
1	5.27	-	1.12	12.8	-	-	Worako W [5]
	5.27	-	1.12	12.8	-	-	Abate, et al.
2	3.86 mg/L	119.7 mg/L	-	13.5 mg/L	-	-	Melaku Z, et al. [7]
3	5.54 ± 1.8	11.6 ± 1.1	1.31 ± 0.1	15.3 ± 2.9	-	-	Melaku H, et al. [12]
4	6.81	-	-	-	-	-	Menberu Z, et al. [10]
5	7	-	3.34 mg/L	-	0.04 mg/L	2.35 mg/L	Lencha SM, et al. [11]

Table 3: Nutrients and Biological Parameters.

Compared to the ocean or sea and rivers, lakes are particularly vulnerable to pollution because of their size and proximity to the community. Lake Hawassa is threatened by a variety of point and non-point pollution sources, including land development, urban storm water runoff, agricultural runoff, and industrial waste from the ceramics, dye, plastics, and food processing industries. Additionally, according to Worako W [5], the lake in Hawassa was unfit for domestic use or drinking without treatment. These were caused by the water's severe impairment, which included bacteriological indicators including Total coliform (11 883 MPN/100 mL) and Fecal coliform (99.69 MPN/100 mL) that were over WHO, USEPA, and EU recommended standard values for F (12.8 mg/L), Na (331.14 mg/L), BOD (117 mg/L), COD (48.73 mg/l), and K (70 mg/l). The elevated concentrations of bacteriological parameters and low clarity of the lake make it unsuitable for recreational uses. In general, Worako W [5] concludes that the lake water is highly contaminated and may not fit for drinking and recreational uses but with some great care it is good for irrigation and aquatic life. Melaku H, et al. [12] quantified that the concentration of metals such as manganese, zinc, chromium, and nutrients like phosphate, BOD5 was found above the recommended WHO standard for drinking purposes and this could hurt aquatic life and humans and animals that use the lake water for various purposes. Elevated levels of these metals and nutrients could be due to point source pollution from ceramics, textile, plastics, leather tanning, and food processing industries located near the rivers and streams that end up into the lake. Menberu Z, et al. [10] used three water quality index methods to see the quality of Lake Hawassa, such as weighted Arithmetic index (WAWQI), Canadian Council of Ministers of the Environment water quality index (CCME WQI), and Bascarón water quality index, were used to compare the water quality of the Lake Hawassa. Found as the Hawassa Lake water quality was poor as per the weighted arithmetic and modified Bascarón methods. They conclude that the lake required mitigation measures to control Eutrophication and pollutants inflow. The lake was under the hypertrophic stage as per the standard based on the results of Secchi depth and nutrient concentration. The current study showed the lake being unfit for all purposes as per the WAWQI range (> 100). According to the physicochemical and biological parameters, of the lake, it requires mitigation measures to control Eutrophication and pollutants inflow [10]. Agumassie T [14] stated that the effluent contains severe toxic organic and inorganic compounds and this, in turn, can damage the aquatic biota including fishes. Based on the report of Lake Hawassa textile factory, the effluent contains high COD (3 times higher), and TDS (19 times higher); moreover, PO3-4 (39 times higher) was recorded in the textile effluent compared to the maximum permissible limit standardized by the Environmental Protection Agency.

Spatio-Temporal Variation

An increasing temporal trend was observed for Heavy metals Fe, K, Mg, Cr, Zn, and Cu. Whereas; Cu and Zn contents were above the recommended limits used only aquatic life. However, According to Worako W [5] except Mn, Cu, and Zn other metals such as Cd, Cr, Pb and Ni are within the permissible limits to all designated water uses. The concentration of heavy metals in the lake was relatively high at the Inlet of Tikurwuha River due to point sources of pollution from Hawassa textile factory and other factories which discharge their waste directly into this river. The concentration of metals such as manganese, zinc, chromium, and nutrients like phosphate, BOD5 was found above the recommended WHO standard for drinking purposes and this could hurt aquatic life and humans and animals that use the lake water for the various purposes [12]. Abebe Y, et al. [15] identified three saltation zones the northern, eastern, and western parts of the lake Hawassa bed representing their respective parts of the lake watershed. These zones were most probably linked with the anthropogenic factors of farming and urban development contributing to the lake's morphometric dynamics.

The pH level was somewhat acidic (5.85) and below the (WHO, 2004) guidelines at the SLW5 (Fikir Hayik Marsh) sampling location (stagnant water near the lake). Turbidity of the lake water was higher than (WHO, 2004) standard for drinking purposes. This may be attributed to the dissolution of carbon dioxide and nutrients created by bacterial decomposition of food waste and sewage waste around the lake. The highest value of turbidity was also recorded at SLW5 (177 ± 3.21 NTUs) followed Melaku H, et al. 2 [12]. Lower values of TDS below the WHO (2004) limits were observed at the SLW5 sampling site and could be due to the dilution effect from the inflow of water during the sampling periods of a small rainy season. A high concentration of sulfate at the SLW4 (Fikir Hayik) sampling site could be related to the discharge of sulfate-containing municipal sewage and surface runoff that contain organic fertilizers from agricultural activities or due to the variability of the distribution of soluble sulfate salts in the sampling sites. The lowest nitrate concentration was recorded at SLW5 Fikir Hayik Marsh) (2.83 ± 0.03mg/L) mg/L) sampling site showing that the sampling site was relatively less polluted by nitrogenous materials.

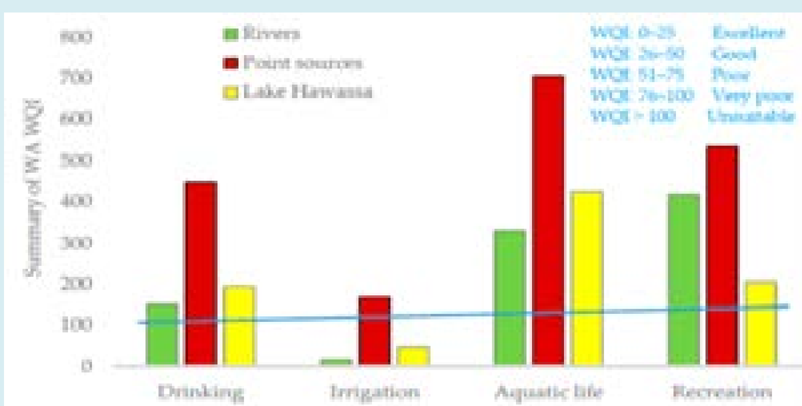

Figure 2: Summary of Results for Weighted Arithmetic Water Quality Index for Drinking, Irrigation, Recreation, and Aquatic Life for Rivers, Point Source, and Lake Hawassa [11].

According to Adimasu WW [16] in all sampled sites the value of K+ was beyond the permissible limits for drinking and irrigation water use WHO. An elevation of potassium in the lake indicates the effect of hospital effluents, septic system effluents, and other anthropogenic activities besides the natural sources. Water quality of the lake was highly impaired on the town side of Hawassa that's due to inlets of various factories effluents like Hawassa textile factory, sisal factory, soft drink factory, ceramic factory, and sewage as well as regional Hawassa referral hospital effluents. The lake is affected by both point and non-point sources of pollution besides the natural factors. Lencha SM, et al. [11] found the average pH value of the Lake Hawassa is 8.5 for this study and comparative observations were made in Lake Hawassa with previous studies and showed an increment from the results of Worako W [5]. The increased pH values are mainly due to the consumption of dissolved carbon dioxide by the autotrophic biomass in the upper layer of the eutrophic lake. The most heavily polluted site was MS10 (Fikerhayk recreation center), MS7 (Amora-Gedel), and MS8 (Gudumale) where there are hotels, restaurants, cafés, boating activities, maximum human intervention, and also there was a small fish market around that site Lencha SM, et al. [11] (Figure 2).

The findings revealed that the water quality of rivers in the upper catchment namely Wesha, Hallo, Wedessa, and Tikur-Wuha (middle part), and Lake Hawassa was generally unsuitable for drinking, aquatic life, and recreational purposes. However, the rivers possessed excellent water quality and Lake Hawassa water quality was good for irrigation purposes. Therefore, the cumulative result of WA WQI for drinking, aquatic life, and recreational uses showed that the environmental situation has become worse in the last few decades, Hence, Lake Hawassa watershed has been polluted and frequent monitoring of the watershed is necessary for proper management. The findings Lencha SM, et al. [11] announced that the lake is suffering from various deficits, high nutrient concentrations, ammonia toxicity and oxygen depletion. The high COD and BOD values are partly due to direct emissions but also to the growth of organic matter in the lake water. Its degradation leads to reduced DO levels or even anaerobic conditions in deeper layers.

Conclusion

Water quality is dependent on the type of pollutant added and the nature of the self-purification of water. The water quality of Lake Hawassa becomes deteriorated. Mainly because of anthropogenic activities in the vicinity of the lake shores and their catchments, the rapid urbanization, excessive water use for irrigation, fertilizers, and industrialization. The government authorities should take appropriate measures to control the effluent of wastes from agricultural fields, ceramics, textile, plastics, urban storm water, leather tanning, and food processing industries, into the lake Hawassa to conserve its water resource.

Conflict of Interests

The authors have not declared any conflict of interest.

Acknowledgments

We the authors express our deepest thanks to the previous authors who allowed him to use their publications to prepare this manuscript.

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