International Journal Of
Recent Scientific Research
ISSN: 0976-3031
Volume: 6(12) December -2015

CCME WATER QUALITY INDEX AND ASSESSMENT OF PHYSICO- CHEMICAL PARAMETERS OF LAKE HAWASSA, ETHIOPIA

Praveen Mallampati and Mukemil Kemal Osman

THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 6, Issue, 6, pp. 7891-7894, December, 2015

International Journal of Recent Scientific Research

ISSN: 0976-3031

RESEARCH ARTICLE

CCME WATER QUALITY INDEX AND ASSESSMENT OF PHYSICO- CHEMICAL PARAMETERS OF LAKE HAWASSA, ETHIOPIA

Praveen Mallampati* and Mukemil Kemal Osman

School of Civil Engineering Hawassa University, Ethiopia

ARTICLE INFO

Article History:

Received 16thSeptember, 2015
Received in revised form 24th October, 2015
Accepted 23rd November, 2015
Published online 28st December, 2015

ABSTRACT

Lake Hawassa is one of the eight Major Ethiopian Rift Valley Lakes and the smallest among them, which is situated in southern regional state; it is a closed basin system and receives water from only perennial Tikurwuha River and runoff from the catchment areas. A water quality index (WQI) developed by the Canadian council of ministers of the Environment (CCME) was applied to Lake Hawassa. The present study was designed to determine the water quality status of the lake for drinking water use by employing the water quality index. To assess the status, water samples were collected in 15 days intervals for a period of 60 days from October to December 2015. From all water quality parameters analyzed the water quality of lake Hawassa falls under marginal category for drinking, which reveals the water is frequently threatened and impaired, and as well departs from natural condition.

INTRODUCTION

Fresh water is essential in many spheres of human life (witek z *et al*., 2009) and in general it is seen as an essential input to human production and an effective tool of economic development (chen c., 2007). It plays a significant role in social prosperity and the wellbeing of all people. Unfortunately, in many countries around the world, including Ethiopia, some drinking water supplies have become contaminated and the deteriorated quality of surface waters is becoming a grave issue in many parts of the globe. So, study of water quality on surface waters will give you the condition of water at a particular place (lake, river or reservoir etc). Limnology is an interdisciplinary science which involves a great deal of detailed field as well as laboratory studies to understand the structural and functional aspects and problems associated with the fresh water environment from a holistic point of view (Adoni *et al*., 1985). The ecological studies of water bodies has gained immense important in recent year because of multiple use of water for human consumption on agriculture and industry resulting in most spectacular hydrobiological changes occurred in water system (Amit Kumar, 2012). The quality of water is determined by its physical, chemical and biological characters. The quality of water can be determined by using various techniques as water quality indices, one such technique is the Canadian Council of ministries of the environment (CCME) Water quality Index (WQI). It facilitates to evaluate surface water for protection of aquatic life with the help of specific guidelines. The guidelines for each parameter are numeric values that define physical, chemical or biological characteristics of the water that cannot be exceeded without causing harmful effects (CEQG, 1999).

Study Area

Ethiopia is a developing country that is endowed with a number of lakes and large rivers, which gives immense value to overall economic development. For instance, the country has 12 river basins, 11 fresh lakes, 9 saline lakes, 4 crater lakes and over 12 major swamps/wetlands. However, the water scarcity and inadequacy is the main feature of the country today. In addition to scarcity the quality of water is also threatened as common to all developing countries (Milda, 2009). Among freshwater resources, Lake Hawassa is one of the eight major Ethiopian Rift Valley lakes, which cover an area of about 94km2 (Yemane, 2004) and the smallest in comparison with other central Rift Valley natural lakes. It is situated 275 km south of the capital city Addis Ababa and west of Hawassa town. The lake is located between 06° 58′to 07° 14′ N latitudes and 38° 22’ to 38° 28’ E longitudes with an elevation of 1685 masl and is bounded by various mountains such as Mt. Tabor (1810 masl) and Mt. Alamura (2019 m.a.s.l) (Yemane, 2004). Hence,

Corresponding author:* **Praveen Mallampati
School of civil engineering Hawassa University, Ethiopia

the surface and sub-surface drainage is towards the lake and it's the main destination for any type of contaminants generated from catchment areas. The catchment area of the lake is 1250 km2 (Girma and Ahlgren, 2009) with closed basin feature and receives only one perennial river from eastern escarpment, TikurWuha River. But the lake has been subjected to many pollutants generated from neighboring industries (like Hawassa Textile factory, floury factory, sisal factory, etc), agriculture activities, service rendering centers (near the lake which release their effluent without any treatment like resorts), hospitals, urban storm water and sewage, and other activities on the catchment (Zinabu and Zerihun, 2002). Specifically, Hawassa textile factory and Hawassa Referal Hospital's discharge to the lake is seriously degrading its viability since their effluents has become over the set standards to the environment (Yosef *et al*., 2010; Abayneh *et al*., 2003; Demeke, 1989).

The area receives a mean annual rainfall of 950 mm and has a mean annual air temperature of 19.8°C (Arkady and Brook, 2008). The area is characterized by three main seasons; long rainy season (locally called kiremt) in the summer from June-September (mean annual total rainfall accounts from 50 to 70%), dry period (locally called bega) which extends between October and February and short rain season (locally called belg) during March and May, when about 20 to 30% of the annual rainfall falls. Mean monthly rainfall is above 100 mm from April to September with August showing the highest 124 mm and the lowest rainfall occur in November, December and January (Halcrow, 2010). It has maximum depth of 22 m and a mean depth of 11 m (Elias, 2000). Evaporation from the lake is estimated to be 1710 mm/year, the average annual inflow and outflow (underground flow) is 1440 and 570 mm, respectively as well as the total volume of the lake water is 1.3 km3 (Tenalem, 1998; Gugissa, 2004; Arkady and Brook, 2008). Research on lakes water quality status on regular basis and its impact on the lake ecosystems are very limited. Therefore, this study was undertaken to avail basic information for the determination of the water quality status of the lake.

Materials and Methods

Surface water samples were collected with in a frequency of 15 days from all the four selected sites like Tikarwuha, Haile resort, Fikar Haik and Amorageddle. This study is a short period study for 60 days (October, November and December 2015). The water samples were analyzed to study the physico - chemical parameters. The chemical parameter Dissolved oxygen test is carried at the site to get the accurate results. The other parameters were tested in the laboratory. CCME- WQI was developed with the intent of providing a tool for simplifying the reporting of water quality data (CCME 2001). It is a tool that provides meaningful summaries of water quality data that are useful to technical and policy individuals as well as the general public interested in water quality results.

$$CCMEWQI = 100 - \left(\frac{\sqrt{(F1^2 + F2^2 + F3^2)}}{1.73} \right)$$

Where F1 (scope)-is the number of variables whose objectives are not met, F2 (frequency)-is the frequency with which the objectives are not met and F3 (amplitude)-is the amount by which the objectives are not met The divisor 1.732 normalizes the resultant values to a range between 0 and 100, where 0 represents the "worst" water quality and 100 represents the "best" water quality. The calculations of these three parameters to determine CCME WQI were described as follows:

F1 (Scope) represents the percentage of variables that do not meet their objectives at least once during the time period under consideration ("failed variables"), relative to the total number of variables measured:

$$\textbf{F1} = \left(\frac{\textit{Number of failed variables}}{\textit{Total number variables}}\right) \textbf{X 100v}$$

F2 (Frequency) represents the percentage of individual tests that do not meet objectives ("failed tests"):

$$\textbf{F2} = \left(\frac{\textit{Number of failed tests}}{\textit{Total number Of tests}}\right) \textbf{X 100}$$

F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps:

a. excursion = $\left(\frac{Objective j}{Failed\ Test\ Value j}\right)$ -1

b. nse= $\frac{\sum_{i=1}^{n} \text{excursion}}{\textit{number of tests}}$

c. **F3** = $\left(\frac{nse}{0.01nse+0.001}\right)$

F3 is an asymptotic function that scales the normalized sum of the excursions from objectives (nse) to yield a range between 0 and 100. The quality criteria of each analyzed parameters were compared to prescribed limits of various international and national standards like WHO (2004), CCME (2009), USEPA (2000), FAO (1985), EEPA (2003) and other guidelines for those designated water uses. After the CCME WQI value was determined with respect to site and month the lake water quality was ranked as per the CCME WQI ranking.

Table 1 Standard water quality parameters determination instruments used.

Parameters	Determination instrument
pH, Temperature	Wagtech international pH meter
Electric conductivity, TDS	SX713 model Electric conductivity,TDS meter
Dissolved oxygen	Wagatech DO meter
Turbidity	Wagatech turbidity meter wag-WT3020
Fe, Fluoride, Magnesium, Nitrate, Nitrite, Manganese	Wagtech Photometer 7100

RESULTS AND DISCUSSIONS

The determination of pH of the water is very important since it affects the solubility and availability of micronutrients like Zn, Mn, Fe and Cu and how they can be utilized by aquatic organisms and also reduces the performance of water treatment systems and disinfectants in water supply. The pH value ranges from 6.03 to 8.47with an average value of 7.73. Nevertheless, with reference to pH value it is within the permissible limit (6.5-8.5) for drinking (WHO, 2006; CCME, 2001; EEPA, 2003). Temperature is an important factor, which regulates the biogeochemical activities in the aquatic environment. The water temperature ranges from 24.2°C to 26.5°C with an average value of 25.7°C. Electric conductance is a tool to assess the purity of water and is the measure of water capability to transmit electric current. The Electric conductance recorded ranges from 560 to 888 with an average value of 806.7

Turbidity is the measure of suspended matter in water. Suspended matter often includes mud, clay and silt. The consumption of more turbid water may constitute a health risk as excessive turbidity can protect pathogenic microorganisms from the effect of disinfectants, and stimulate the growth of bacteria (Zvikomborero, 2005). The turbidity of the lake water was found to be higher than the prescribed limits (<5NTU) for drinking (WHO, 1993; CCME, 1999). Turbidity ranges from 4.49 NTU to 25.4 NTU with an average value of 11.5 NTU. The most prominent sources of fluoride in water are a natural weathering of mineral bedrocks (WHO, 2004) and it is a common problem mainly in the Rift Valley lakes of eastern African countries (Tamiru, 2006) due to geological factor. In the present investigation the concentration of fluoride ranged from 1.52 mg/L to 15 mg/L with an average value of 12.1 mg/L. Drinking water with high fluoride concentration above the permissible limit (1.5 mg/L) may causes dental fluorosis and if continuously consumed for a long period with the concentration 3 to 6 mg/L and above may lead to skeletal fluorosis and skeletal crippling (Kloos and Redda, 1999).

Figure 1 Testimg the water samples of lake Hawassa by using Wagtech Photometer 7100

The lake water fluoride concentration is twelve times higher than the permissible limits for drinking, irrigation and livestock watering purposes (CCME, 1999; WHO, 1998, 2006) and hence not suitable for these designated purposes. The most known principal limiting nutrients in freshwater lakes of Rift Valley lakes are nitrogen and phosphorus. Nitrogen can exist in water in four forms like NH_3, NO_3^-, NO_2^- and NH_4^+ which may cause groundwater and surface water pollution in excessive quantity through leaching, stimulate algal growth in surface water that increases maintenance costs in irrigation practices, carcinogenic and blue-baby diseases in infants of human being. But currently the concentration of the NO_3^- in the lake is not with in the permissible limits.

Iron also promotes the growth of "iron bacteria", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. At levels is usually no noticeable taste at iron concentrations below 0.3 ove 0.3 mg/l, iron stains laundry and plumbing fixtures. There mg/l, although turbidity and colour may develop. But currently the concentration of the Iron in the lake is within the permissible limits. At levels exceeding 0.1 mg/l, manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking water, like that of iron, may lead to the accumulation of deposits in the distribution system. Concentrations below 0.1 mg/l are usually acceptable to consumers. But currently the concentration of the manganese in the lake is within the permissible limits. When comparing the results with the past researcher (Adimasu 2015), which he conducted his analysis in the year 2011/12 the parameters like pH, Dissolved oxygen gave similar result. There is no significant change in few of the parameters in the water quality even after 4 years.

CCMEWQI = 62.625

Figure 2 Testing Dissolved oxygen in the site by usingWagatechDO meter.

Water quality index (WQI) calculation

The WQI was computed based on the three parameters F1, F2 and F3 for drinking water uses. The values obtained were

$$F1 = \left(\frac{Number\ of\ failed\ variables}{Total\ number\ variables}\right) X\ 100 \quad = \left(\frac{4}{12}\right) x\ 100 = 33.33$$

$$F2 = \left(\frac{Number\ of\ failed\ tests}{Total\ number\ 0f\ tests}\right) X\ 100 \quad = \left(\frac{15}{48}\right) x\ 100 = 31.25$$

$$F3 = \left(\frac{nse}{0.01nse+0.001}\right) = \left(\frac{0.847}{0.01(0.847)+0.01}\right) = 45.858$$

$$\textbf{CCMEWQI} = 100 - \left(\frac{\sqrt{(F1^2 + F2^2 + F3^2}}{1.73}\right)$$

$$\textbf{CCMEWQI} = 62.625 \left(\frac{\sqrt{(33.33^2 + 31.25^2 + 45.85^2)}}{1.73}\right)$$

Table 2 □ Average results of Physico- Chemical Analysis of lake Hawassa at four different sites

Parameters	pH	Temp	DO	turbidity	TDS	EC	Fe	Mg	F	Mn	No4	No3
22.10.2015	6.8	24.8	12.2	14.7	447	632	0.08	28.54	2.8	0.006	0.79	0.03
06.11.2015	8.0	26.1	18.5	14.4	557	848	0.03	24.1	15.4	0.002	0.69	15
21.11.2015	7.7	24.5	18.6	7.09	588	866	0.06	26.1	15.2	0.005	0.61	28.7
06.12.2015	8.2	27.6	18.4	9.93	598	879	0.06	26.02	15	0.003	0.61	15

All units are in mg L^{-1} saving temperature, tubidity, EC and pH are expressed in °C, NTU,$\mu S\ cm^{-1}$ and non dimensional respectively

Table 3 Characterization of the water Quality Index (CCME-WQI, 1991)

Rating	CCME-WQI	Characterization of water
Excellent	95.0-100	Water quality intact, conditions to natural levels
Good	80.0-94.9	Water quality is protected with only a minor degree of threat or impairment, conditions often deviate from natural levels
Fair	65.0-79.9	Water quality usually intact, but occasionally endangered, conditions deviate from natural levels
Marginal	45.0-64.9	Water quality frequently endangered, conditions very often deviate from natural levels
Poor	0.0-44.9	Water quality always endangered, conditions regularly deviated from normal levels

CONCLUSIONS

The current study evaluated the physicochemical water quality characteristics of Lake Hawassa for designated water uses like drinking. The parameters of water quality analyzed and examined from various sampling sites in the lake show unsuitability of the water for drinking. Based on the selected variables the water quality of lake comes under marginal category for drinking. 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 beside the natural factors. Hence checking the effluent standards of the surrounding factories, controlling the service rendering center waste disposal system and constructing the municipal wastewater and storm water treatment plant are extremely essential to protect the lake water quality from further deterioration.

Acknowledgements

The authors would like to thank the Head of the Department Civil Engineering DESTA BASORO of Hawassa university for providing laboratory facilities, and also the Lab attendant Aschalew Timothewos for his assistance during the tests.

References

1. Tamiru A (2006). Groundwater occurrence in Ethiopia. Addis ababa University, Ethiopia. With the support of UNESCO.
2. Tenalem A (1998). The hydrological system of the Lake District basin, Central Main Ethiopian Rift. PhD thesis. International Institute for Geographic Information Science and Earth Obseration (ITC), Enschede.
3. Witek Z. Jarosiewicz A Long term Changes in Nutrient Status of River Water. Pol. J. Environ. Stud. 18.(6) 1177. 2009
4. Chen C.C A freme work for Graywater Recycling of Household Wastewater. Pol. J. Environ. Stud. 16.(1), 23, 2007.
5. Adoni. A, Joshi.D, Gosh.K, Chourasia S.k, Viashya. A, Yadav M and Verma H G, "A workbook on liminology" Pratiba Publisher, Sagar, 1985.
6. Amit Kumar and Radha Sahu, "Ecological Studies of Cyanbacteria in sweage pond of H.E.C. Industrial area, Ranchi, India", Bioscience Discovery, Vol 3(1), pp 73-78, 2012.
7. Milda L (2009) The environmental impact caused by the increasing demand for water. Water and resources management - a case study in Ethiopia. Msc thesis. TAMK University of applied sciences Environmental Engineering, Tampere.
8. Yemane G (2004). Assessment of the water balance of lake Awassa catchment, Ethiopia, M.sc thesis, International institute for Geo-information Science and Earth Observation (ITC), Enscheda, Netherlands.
9. Girma T, Ahlgren G(2009). Seasonal Variations in phytoplankton biomass and primary production in the Ethiopian Rift Valley lakes Ziwa, Awassa and Chamo- The basis for fidh production. Elsevier Sc. Limnologica 40(2010):330-342.
10. ZInabu G, Zerihun D (2002). The Chemical composition of the effluent from Awassa Textile factory and its effects on aquatic biota. SINET Ethiop.j.sci. 25(2):263-274.
11. Yosef HG, Bekele L, Behailu B, Kefyalew S, Wondewosen S (2010). Environmental impact assessment and policy on Lake Hawassa, SNNPRs. SOS-Sahel Ethiopia.
12. Abayneh A, Taddese W, Chandravanshi BS (2003). Trace metals in selected fish species from lake Awassa and Ziway. SINET: Ethiopia j. sci. 26(26):103-114.
13. Demeke A (1989). Study on the age growth of adult Oreochromis nilticus in lake Hawassa, Ethiopia. M.Sc. Thesis. School of graduate studies, Addis Ababa University.
14. Arkady MD, Brook A (2008). Water balance and level of regime of Ethiopian Lakes as Integral Indicators of Climate change. Faculty of Hydrology, Russian State Hydrometeorology University, Saint Petersburg, Russia.
15. Halcrow G (2010). Rift valley lakes basin integrated resources development plan study project. Lake Hawassa sub-basin integrated watershed management feasibility study. Main report Vol 1
16. Elias D (2000). Reproductive biology and feeding habits of the cat fish Clarias garipinus (burchell) in lake Awassa, Ethiopia. SINET: Ethiopia J. Science 23:2
17. Gugissa E (2004). Urban Environmental impacts in the town Awassa Ethiopia, Addis ababa University ,
18. Zvikomborero H (2005) An assessment of the water quality of drinking water in rural districts in Zimbabwe. The case of Gokwe south, Nkayi, Lupane and Mweezi districts. Physics chemistry Earth 30: 859-866.

****

How to cite this article:

Praveen Mallampati and Mukemil Kemal Osman.,Ccme Water Quality Index and Assessment of Physico- Chemical Parameters of Lake Hawassa, Ethiopia. *Int J Recent Sci Res* Vol. 6, Issue, 12, pp. 7891-7894.

ISSN 0976-3031

9 770976 303009 >