E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(3): 405-412

www.fisheriesjournal.com
Received: 25-03-2020
Accepted: 27-04-2020

Derribew Hailu
Oromia Agricultural Research Institute, Batu Fish and Other Aquatic Life Research Center, Batu, Ethiopia

Alemayehu Negassa
Ambo University Department of Biology, Ambo, Ethiopia

Birhanu Kebede
Ambo University Department of Biology, Ambo, Ethiopia

Corresponding Author:
Derribew Hailu
Oromia Agricultural Research Institute, Batu Fish and Other Aquatic Life Research Center, Batu, Ethiopia

Study on the status of some physico-chemical parameters of Lake Koka and its relation with water hyacinth (*Eichhornia crassipes*) invasion

Derribew Hailu, Alemayehu Negassa and Birhanu Kebede

Abstract
Aquatic ecosystem, a key resource to support biodiversity of this sphere is continuously degraded due to synergetic impact of natural and anthropogenic activities. Lake Koka is one of the Ethiopian water bodies currently invaded by water hyacinth there by impacting environment and social activities of the surrounding community which calls for effective solution. So, the study was attempted to provide information on the status of some physico-chemical properties of Lake Koka and its relationship with water hyacinth invasion in the Lake. To compare some physico- chemical parameters with water hyacinth invasion, water samples were monthly collected from three different sampling sites; Metoleka highly water hyacinth invaded area (S1), Mallima Bari moderately water hyacinth invaded site(S2) and Koka Bridge low water hyacinth invaded area (S3) and analyzed for selected parameters. The result indicated that average value of TDS, Conductivity, Transparency, Salinity, Nitrate Nitrogen and Total phosphorus were highest at S3 with values of 599.35 ± 43.45mg/l, 684.57 ± 192.8 µS cm-^{1}, 32.27 ± 2.04 cm, 0.43 ± 0.01 ppt, 0.41± 0.06 mg/l and 0.92± 0.21 mg/l respectively. Water temperature and Resistivity were high at S1 with average values of 25.57 ±1.78^{O}C and 2.07 ± 0.41 kΩ followed by S3 25.41 ± 1.8 ^{O}C and (S2) 1.42 ± 0.24 kΩ and the least value of resistivity was recorded at Koka Bridge. pH and Total Phosphorus were the highest at S2 with values of 8.74 ± 0.37 and 0.48± 0.2 mg/l respectively. From the current result, it can be concluded that, availability of nutrient was the lowest at highly water hyacinth invaded area which indicates the nutrient was highly utilized by the plant and vice versa.

Keywords: Lake Koka, physico-chemical parameters, water hyacinth

1. Introduction
Aquatic ecosystem is a key resource to support biodiversity of this sphere. Biodiversity is also fundamental to sustaining life and supplying all critical ecosystem services, climate regulation, biological control of populations of flora and fauna, use of genetic resources, and to safeguarding the wealth of the world for future generations (Ayalew Wondie, 2006; Samuel and Netsanet, 2014 ; OECD, 2014) [1-3]. It is estimated that, globally, nature provides services worth around US$125 trillion a year (WWF, 2018) [4].
Despite the significant economic, social and cultural values of biodiversity and ecosystem services, biodiversity worldwide is being lost, and in some areas at an accelerating rate (OECD, 2014) [3].The five greatest threats that leads mass extinction of biodiversity are summarized by HIPPO acronym which stands for Habitat loss, Invasive species, Pollution, Population growth and Overexploitation of resources (Andrew, 2010) [5].
Water hyacinth is one among the threats to biodiversity which leads the degradation of aquatic ecosystem. Combinations of various natural factors and anthropogenic activities in the rivers and their catchments are affecting the river water qualities and their biodiversity (Fasil *et al*., 2013) [6].This is a case in Ethiopia where by degradation in water quality results in Water hyacinth *(Eichhornia crassipes)* invasion. The expansion of water hyacinth from its original site into Africa, Asia, Australia and North America was facilitated by human activities posing continuous impacts (Dagno *et al*., 2012; Samuel and Netsanet, 2014; Julien *et al*., 1999) [7, 2, 8].
Even though water hyacinth tolerate a wide range of environmental conditions, rivers and dams that suffer from nutrient pollution, in particular nitrogen and phosphorus are optimal places for the rapid proliferation of water hyacinth (Hossain *et al*., 2015) [9].

Water hyacinth has become a major weed invading different water bodies in Ethiopia posing a serious threat to the country's aquatic biodiversity and socio-economic activities of the society which calls for urgent solution (Dereje Tewabe, 2015; Derje Tewabe *et al* 2017; Ferihun Yirefu, 2007; Ferihun Yirefu, 2013; Ferihun Yirefu, 2017; Hailu *et al*., 2004 and Taye *et al*., 2009) [10-16].

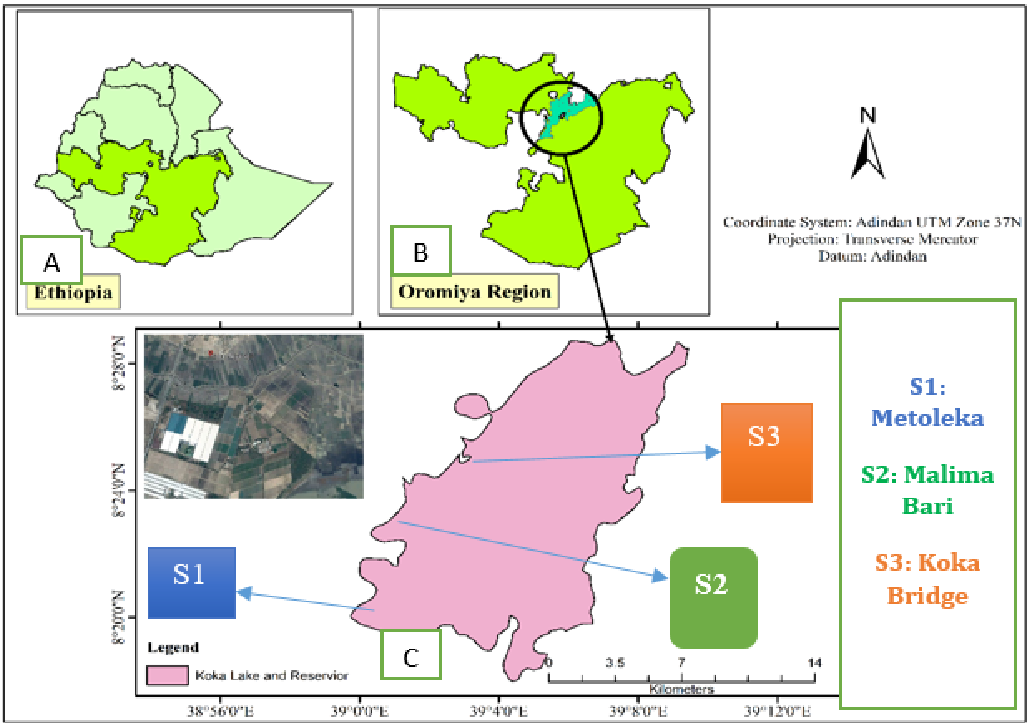
So, the study was attempted to provide information on the status of some physico-chemical properties of Lake Koka and the relationship of water hyacinth in the Lake with some physico-chemical properties which in turns used to minimize the water hyacinth impact.

2. Materials and Methods

2.1 Description of study area

Lake Koka is one of Awash River Basin Lake. It is found in Oromia Regional State, East Shoa Zone (between Lome and Bora Weredas), and Arsi Zone (Dodota Wereda) (Abebe Cheffo, 2013) [17].The Lake has 255km^2 area, maximum depth of 14 meters, minimum depth of 9 meters, maximum length of 20 kilometers, maximum width of 15 kilometers, shore line of 195-205 kilometers and water temperature of 20 ^oC. According to Hadgembes Tesfay (2007) [18], the Lake has a maximum and mean depth of 14 and 9m, respectively. Awash and Mojo (tributary to Awash) rivers are the inflowing rivers to the Lake. The Lake has an outflow called Awash River. It is located between $8^0$2´ to $8^0$26´N latitude, 39^0 to $39^0$10´E longitude and an altitude elevation of 1660 meters above sea level.

In the present study, the water samples were collected from three different points of Lake Koka (Fig. 1). Namely; Metoleka (S1) the highly water hyacinth infested area and located at 39^o E and 8^o 2' N , Mallima Bari (S2) poorly water hyacinth infested area and located at 39^{o}2' E and 8^{o}24' N and Koka Bridge (S3) free from WH invasion during the study period and located at 39^{o}3' E and 8^o 26' N. All sites were selected purposely to analyze the physico - chemical properties of Lake Koka and to analyze the impact of physico - chemical on the growth of water hyacinth and to compute the physico- chemical parameters that can represent the Lake.



Source: Own

Fig 1: Map of Ethiopia (A), Oromia (B) and Lake Koka with sampling sites (C)

2.2 Sample collection

Water samples were monthly collected from three sites of Lake Koka for nutrient and physico- chemical analysis. Accordingly, the water samples were collected from January 2019 – March 2019 twice a month and twice a day in a month (Morning from 2:30-4:00 and afternoon 10:30- 11:30 local time). This means, Koka Lake was sampled twelve (12) times for parameters like pH, conductivity, salinity, resistivity, temperature, TDS, transparency and inorganic nutrients in each sites. The sample size well represents the study target.

2.3 Sampling technique

Quantitative sampling method was used to study physico-chemical parameter of Lake Koka.

2.4 Laboratory work

Collected water samples from Lake Koka for Nitrate Nitrogen and total phosphorus was analyzed at Ambo University according to (USEPA, 1983) [19] using colorimetric method of 352.1 and 365.2 respectively. Before laboratory analysis, one liter water sample was collected from each sites and preserved using 2ml Con. H_2So_4 for about 10 hrs.(the time wasted during journey from Koka to Ambo) and then kept in freezer until analysis started for both nitrate and total phosphorus.

2.5 Data collection

2.5.1 Data for physico- chemical parameters of Lake Koka

Some highly unstable parameters of physico- chemical parameters such as pH, temperature, transparency, TDS, Salinity, Resistivity and Conductivity were measured in situ at Lake Koka using portable multi probe and digital measuring material of Model SX723 PH/mV/Cond/Meter.

Transparency: Was determined using Secchi disc.

Procedure: To measure transparency of Lake Koka, the 20 cm diameter secchi disc was lowered into the water up to the point where it was no longer visible (X1) and this depth was noted. Again it was lowered further from this point of invisibility and then slowly raised up while being observed until it just reappears and this depth of reappearance(X2) was noted again. The two readings were averaged to give the secchi depth transparency of Lake Koka (Fig. 2).

Transparency (Secchi Disc in cm) = $(X_1 + X_2)/2$……………………………..…Equation 1

Where, X_1 = Depth at which Secchi disc disappears
X_2 = Depth at which Secchi disc reappears

Source: Own

Fig 2: Measuring of some physic-chemical parameters from Lake Koka

2.6 Data analysis
The physico chemical parameters status of Lake Koka were described using tables and descriptive statistics and compared against parameters required for the establishment of water hyacinth.

3. Results and Discussions
3.1. Physico -chemical parameters of Lake Koka
3.1.1 Water temperature of Lake Koka
From the current study, the average water temperature of Lake Koka was 25.29± 1.94 ºC. However, there was spatial variation (Table 1) where high temperature was observed at Metoleka (S1). The average water temperature was 25.57 ±1.78 at Metoleka (S1) a very water hyacinth invaded area, 25.05 ± 2.26 at Mallima Bari (S2) shallow and poorly water hyacinth invaded area during the study period and 25.41 ± 1.8 at Bridge (S3) the inlet of Awash river to Lake Koka almost no water hyacinth during the study period. Water temperature is one controlling factor as it determines the distribution and diversity of aquatic flora and fauna due to its interference in the metabolism activities of organism and influencing the survival and abundance of organism (Fasil Degefu *et al.*, 2011) [20].
The current recorded temperature of Lake Koka was greater than a report by (Fasil Degefu *et al.*, 2011) [20] with the value of greater than 19 ^{0}C. But, it was less than a value recorded by Hadgembes Tesfay (2007) [18] which was 28.7 ºC and slightly greater than a value recorded by Yeshimebet Major (2016) [21] which was 23.9±2.0 for the same Lake while it was similar to a value recorded by Fasil Degefu *et al.* (2013) [6] for middle Awash River 25.65 ºC.
Many scholars (Dereje Tewabe *et al.*, 2017; Mironga *et al.*, 2012; Uka & Chukwuka, 2007; Jagaveerapandian and Thamizharasu, 2015) [11, 22-24] reported high temperature at water hyacinth infested area than none water hyacinth infested area with values of 25.57 ± 3.4 for water hyacinth infested part of lake Tana and 24.12 ± 1.95 none infested area, mean temperature of WH infested area 27.5±0.60 ºC as opposed to shoreline without water hyacinth 26.7±0.52 ºC for Navashia lake, Mean water temperature of the infested area 27.5±0.60 °C as opposed to open water 26.7±0.52 °C for AWBA Reservoir, 31.53±0.95 for dense water hyacinth pond, 31.19±1.38 moderate water hyacinth pond and less water hyacinth infested pond 31.24±1.06 respectively as cited in the beginning of the paragraph.
According to Mironga *et al* .(2012) [22], the slight increments of temperature in water hyacinth invaded area is as a result of the dense mats of water hyacinth over the water surface, which blocks the exchange of heat between the lake surface and the atmosphere. "At the same time the decaying of organic matter from water hyacinth results in heat generation and therefore the rise in temperature''.
However, the result of Dereje Tewabe (2015) [10], was different from the above recorded results where high temperature was observed at none water hyacinth (25.9 ºC) for Lake Tana as opposed to Qumen river mouth (23.94 ºC) which was water hyacinth infested area.
Different authors (Sotolu, 2013; Uka & Chukwuka, 2007; Mironga *et al.*, 2012) [25, 23, 22] concluded that, the optimum temperature requirement of water hyacinth is between 25 and 30 ºC. According to these authors, water hyacinth turn off growth above 30ºC and below 13 ºC.
From the current study, the water temperature of all studied sites of Lake Koka was so suitable for growth of water hyacinth as it was found in temperature ranges that support water hyacinth growth. This is a parameter that determines its growth creating optimum requirement of the weed water hyacinth so that it appears densely making mat at the studied area. Generally, water temperature was high at highly water hyacinth invaded area than the two other sites.

3.1.2 pH of Lake Koka
From the current study, the average pH value of Lake Koka was 8.7 ± 0.23. However, the value was varied from site to site (Table 1). The highest pH was recorded at Mallima Bari (S2) with an average value of 8.74 ± 0.37 and Bridge (S3) the second higher value site with pH of 8.7 ±0.1. The least pH was recorded at Metoleka (S1) with average value of 8.66

±0.1. The current pH value was almost similar with the value of Yeshimebet Major (2016) [21] which was 8.27 ± 0.35 and the value recorded by Fassil Degefu *et al*. (2011) [20] which ranged between 8 and 9.The value of Fasil Degefu *et al.* (2013) [6] was also close to the current study which falls between 8.15 and 8.63 for upper Awash River system to Koka Bridge.

Even though it was not much different, it can be concluded that, pH value was greater at poorly water hyacinth invaded and water hyacinth free area than fully water hyacinth invaded area. Research suggests Uka & Chukwuka (2007) [23] that, pH value was higher at poor WH infested area than highly infested area. According to their report, water hyacinth infested area showed low pH values 6.92±0.04. Other findings Mironga *et al* .(2012) [22] also reported similar result in such a way that water hyacinth infested area showed low pH values as 6.92±0.04, while shoreline without water hyacinth had higher values (7.71±0.05). Even though the value was different, the current pH value of Lake Koka was similar with the value studied by Dereje Tewabe (2015) [10] who reported high pH value at Lake Tana (9.34) with none WH infested area as compared to Qumen river mouth (6.93) with water hyacinth infested area. However, it was different from Dereje Tewabe *et al.* (2017) [11] who reported high pH value for water hyacinth infested area 7.64 ± 0.56 and low value for none water hyacinth infested area 7.61 ± 0.34 for Tana lake.

According to Tellez *et al.* (2008) [26], the pH of water body invaded by water hyacinth should have to be between 6 and 8. When the values move outside this interval, the plant can regulate pH of the medium within this range with its growth frequently resulting in the alkalization of the water. Accordingly, the value of recorded pH in the Guadiana river basin was ranged from 7.25 to 8.1 the conditions that are near optimal for the growth and vegetative reproduction of WH which is almost similar with current value of Lake Koka. Generally, pH was relatively high at moderately water hyacinth invaded area than highly and less water hyacinth invaded area during the study time.

3.1.3 Transparency of Lake Koka

The average secchi disc value of Lake Koka during the study period (January 2019- March 2019) was 21.41 ± 10.21 cm. There was highly great difference of secchi disc depth from site to site (Table 1) with high secchi depth value of Koka Bridge (S3) ranged from 29.85 cm - 35.6 cm with average value of 32.27 ± 2.04 cm followed by Metoleka (S1) ranged from 14.75 - 25.65cm with average value of 23.31 ± 4.28 cm and least secchi depth value recorded at Mallima Bari (S2) ranged from 6.6 -12cm with average value of 12.29 ± 2.12 cm. The reason why low secchi disc value recorded at Mallima Bari (S2) during the study period might be being a shallow as compared to the remaining two sites and a continuous disturbance of water by local community including livestock. According to Yeshimebet Major (2016) [21],"with the flow of the two feeder rivers, particularly Awash River, into the Lake, large quantities of allochthonous particulate matter are imported, and this substantially contributes to the Lake poor underwater light climate".

Though the sampling time was different, the current Secchi disc value of Lake Koka was greater than a value reported by Yeshimebet Major (2016) [21] with average value of 0.12 ± 0.03 m for the same Lake and Hadgembes Tesfaye (2007) [18] with mean value of 12.7 cm. But the value for Mallima Bari (S2) was similar with both Yeshimebet (2016) and Hadgemes Tesfaye (2007) [21] and [18]. However, the present Secchi depth (ZSD) value was lower than the value recorded by Elizabeth Kebede *et al*. (1994) [27] which was 28 cm. When compared with other Rift Valley Lakes invaded with WH, the current value was almost similar to a value recorded for Ziway Lake Girma Tilahun (1988; 2006) [28, 29] which was 13-27 cm and 14-22 cm, respectively and Dessie Tibebe (2017) [30] a value ranged from 16 cm to 30 cm with mean value of 20cm.

The current value was shallower than Tana Lake (51 –182 cm) as reported by (Ayalew Wondie 2006 and Yezbie Kassa 2016) [1, 31] which ranged from 29 - 68 cm. In relation to water hyacinth availability, the current value was also different from a value for Navaisha a tropical African lake ranged from (10–75 m) as reported by Mironga *et al.* (2012) [22]. This variation might be due to the increased anthropogenic activities around the Lake and the Feeder Rivers of Awash and Mojo to the Lake due to the incoming turbid substances with flowing water. From the current result, secchi disk value was the highest at less water hyacinth invaded area.

3.1.4 TDS of Lake Koka

Total Dissolved Solid is also a determining parameter for water hyacinth growth. The current TDS mean value of Lake Koka was 472.03 ± 122.76 mg L^{-1}. The highest TDS site during study period was Koka Bridge (S3) with a value of 599.35 ± 43.45 mg L^{-1}. Followed by Mallima Bari (S2) with a value of 484.88 ± 78.23 mg L^{-1} and Metoleka (S1) with the least value of 331.87 ± 34.4 mg L^{-1}(Table 1)

Even though the TDS value was high in all studied areas of Lake Koka, it was the reverse value studied by many scholars in relation to WH invaded area for other water bodies. For instance, the result of Dereje Tewabe (2015) [10] showed that high TDS value was recorded in WH infested area as compared to none water hyacinth infested area with values of (0.11 mg L^{-1}) for Qumen river mouth and 0.1 mg L^{-1} for Lake Tana). Other scholars Dereje *et al.* (2017) [11] were also reported 0.109 ± 0.03g/L for WH infested area of Lake Tana and 0.092 ± 0.03g/L for none WH infested area of the same lake and Yezbie Kassa (2016) [31] reported values of 93.25 – 127.75 mg L^{-1} with the highest value measured at littoral sites of WH infested area of Rib and Agid Kirgna sampling sites while the lowest value for TDS were measured at open water zones in ADO and DSO respectively for lake Tana.

On the other hand, Jagaveerapandian and Thamizharasu (2015) and Saeed and Al-Nagaawy (2013) [24] and [32] reported high TDS values for control ponds without WH and low TDS values for experimental ponds with WH. Accordingly, Saeed and Al-Nagaawy (2013) [32] reported the highest total mean value (345.7 mg L^{-1}) at control, while the lowest (293.8 mg L^{-1}) one at T2 ponds and Jagaveerapandian and Thamizharasu (2015) [24] reported 0.56±0.20 ppm for dense WH pond, 0.66±0.33ppm for moderate WH pond and 0.65±0.26ppm for less WH pond. According to Saeed and Al-Nagaawy (2013) [32], the reduction in TDS values in ponds with water hyacinth revealed that water hyacinth mat highly absorbs various salts from pond water.

The current recorded low TDS value at WH invaded site of Lake Koka was also similar with the finding of Saeed and Al-Nagaawy, (2013) [32]. Total dissolved solid may be utilized by water hyacinth causing comparatively low TDS value at Metoleka (S1) while it was high at Koka Bridge (S3) and Mallima Bari (S2) without water hyacinth indicating accumulation of unutilized TDS during the study period (January-March, 2019).

3.1.5 Conductivity of Lake Koka

Conductivity is a measure of the concentration of ions and salts in water samples. The current average conductivity value of Lake Koka was 684.57 ± 192.8 µS cm^{-1}. Like other parameters, conductivity value was varied from site to site. High conductivity value was recorded at Koka Bridge (S3) with average value of 877.99 ± 58.02 µS cm^{-1} followed by Mallima Bari (S2) with a value of 716.34 ± 105.95 µS cm^{-1} and the least average value recorded at Metoleka(S1) 459.39 ± 88.15 µs/cm (Table 1). The higher the value, the greater the concentration of the pollutants (Moyo *et al.*, 2013) [33]. Reduction in the measure indicates remediation action by the plant. Water hyacinth reduce the E. Conductivity.

The current conductivity was higher than a value recorded by Fasil Degefu *et al*. (2013) [6] for Koka Bridge with the value of 492.87 µS cm^{-1} from July 2008- July 2009 and Fasil Dedefu *et al*. (2011) [20] reported specific conductivity ranged from 203-393 µS cm^{-1} during September 2009- August 2010.A study conducted by Yeshimebet Major (2016) [21] also indicated that, a conductivity value of Lake Koka as 318.17 ± 51.96 µS cm^{-1} which was lower than the current recorded value.

Increment of conductivity value for Lake Koka from the current observation as compared to previous working may be due to variation in sampling time and accumulation of organic and inorganic dissolved solid which was not leave the Lake in dry season as there was no dilution during the study period. According to Fasil Degefu *et al*. (2013) [6], conductivity increase along the river course (downstream) coupled with increasing perturbation. Koka bridge is located downstream of different factories which are known to discharge wastes containing ions using the river as main waste dumping site.

Even though high conductivity values were recorded at all sites, it was different as compared to other scholars in relation to water hyacinth availability in other water bodies consisting water hyacinth. Accordingly, Dereje Tewabe (2015) [10] reported a high conductivity value in WH infested area as compared to non-water hyacinth infested area with values of (169 µS cm^{-1} for Qumen river mouth and 152 µS cm^{-1} for Lake Tana). Other scholars, (Dereje *et al.* 2017; Yezbie Kassa 2016; Uka and Chukwuka 2007 and Mironga *et al*. 2012) [11, 31, 23, 22] also reported high specific conductivity of 168.57 ± 43.7 µS cm^{-1} for WH infested area of Lake Tana and 138.7 ± 44.6 µS cm^{-1} for non WH infested area of the same lake, the values of 142 – 225 µS cm^{-1}, with the highest value measured at littoral sites with WH infested area of Rib and Agid Kirgna sampling sites while the lowest value for conductivity were measured at open water zones in ADO and DSO respectively for lake Tana, high conductivity value ranged between 314-338 µs cm^{-1} (328.8±2.32 µS cm^{-1}) for water hyacinth infested area while open water values ranged between 270-312 µs cm^{-1} (290.3±4.39) and high conductivity value 323.8±2.32 µs cm^{-1} for water hyacinth infested area and 290.3±4.39 µs cm^{-1} for non WH infested area were reported respectively for different water bodies according to the findings of scholars mentioned above.

Even if they did it on small experimental ponds that cannot be compared with natural lakes and Reservoirs, Jagaveerapandian and Thamizharasu (2015) [24] reported high conductivity values for control ponds without WH and low conductivity values for WH infested area. Accordingly, low conductivity (0.77±0.21 µs cm^{-1}) was recorded for dense WH pond, 0.86±0.46 µs cm^{-1} for moderate WH pond and 0.90±0.44 µs cm^{-1} for less WH pond was observed.

Low recorded conductivity value at WH invaded site of Lake Koka is also indirectly similar with the finding of Saeed and Al-Nagaawy, (2013) [32] as conductivity is related with TDS. High value TDS indicates high conductivity value. From the current study, it can be concluded as high TDS value at less water hyacinth area and vice versa.

3.1.6 Salinity of Lake Koka

From the current observation, salinity was high at all sites but still below one (Table 1). Accordingly, salinity of Lake Koka was ranged from 0.45- 0.18 ppt with average value of 0.33 ± 0.09 ppt. However, it varied during the study period from site to site like other parameters mentioned above. The site with highest salinity concentration was Koka Bridge (S3) a value ranged from 0.42 - 0.45 ppt with average value of 0.43 ± 0.01 ppt followed by Mallima Bari (S2) with a value ranged from 0.32 - 0.39 and average value of 0.34 ± 0.03ppt. The site with least concentration value of salinity was Metoleka (S1) ranged from 0.18- 0.27 with average value of 0.22 ± 0.03.

When compared with previous studies, Wood and Talling (1988) [34] reported a salinity concentration of 0.319 g L^{-1} and Elizabeth Kebede *et al*. (1994) [27] reported 0.2 g L^{-l} for the same Lake which is less than the current recorded value. When compared with other Ethiopian Rift Valley Lakes contaminated with WH, the current value was less than a value recorded for Ziway Lake (0.4 g L^{-l}) and Abaya Lake (0.9 g L^{-l}) as of Elizabeth Kebede *et al* .(1994) [27]

When compared with other Ethiopian high land lakes, the current Lake Koka salinity was greater than Lake Tana with values of (0.08 g L^{-l}) for WH invaded area and (0.07 g L^{-l}) for non WH invaded area (Dereje Tewabe, 2015) [10] and (0 .0757 ± 0.022 g L^{-l}) for WH infested area and (0.064 ± 0.022 g L^{-l}) for non WH infested area (Dereje Tewabe *et al*., 2017) [11]. On the other hand, Jagaveerapandian and Thamizharasu (2015) [24] reported that high salinity concentration (1.00±0.74 ppt) recorded at dense WH infested area, medium (0.92±0.58 ppt) at moderate WH infested area and less (0.90±0.55 ppt) at poor WH infested area respectively.

The current recorded salinity concentration for Lake Koka in relation to WH invasion was the reverse of Dereje Tewabe (2015) and Dreje Tewabe *et al*. (2017) [10, 11].This different observation from current study of Lake Koka (high salinity value) with site of non WH invaded area (S3) and (S2) may be due to additional input of different sources from Awash river like nutrient concentration [18] and other parameters which were higher at the Awash River mouth station.

3.1.7 Resistivity of Lake Koka

Resistivity is the opposite of conductivity which is used to determine the availability of soluble electrolyte ions and total dissolved solids and thereby used as indicator parameter during study of water quality.

From the current observation, the resistivity value of Lake Koka was ranged from 1.04 - 2.68 kΩ (Table 1) with average value of 1.58 ± 0.5 kΩ. The highest site with resistivity was Metoleka (S1) ranged from 1.40-2.68 kΩ with average value of 2.07 ± 0.41 kΩ followed by Mallima Bari (S2) ranged from 1.06 - 1.77 kΩ with average value of 1.42 ± 0.24 kΩ and the resistivity least site was Koka Bride (S3) a value ranged from 1.04 1.84- with average value of 1.26 ± 0.30 kΩ which was slightly different from S2. Presence of high resistivity at highly WH invaded site (S1) might be due to presence of low values for TDS and Conductivity at the site (S1) as compared to the remaining two sites (S2 and S3). Because resistivity is inversely proportional to TDS and conductivity. From the current study, high resistivity value was recorded at highlywater hyacinth invaded area.

3.2 Inorganic Nutrients of Lake Koka

3.2.1 Nitrate Nitrogen (NO_3-N)

Nitrate nitrogen is a determining factor and an essential nutrient for plant growth. From the current study, nitrate content was ranged from 0.18-0.49 mg/L with the average concentration of 0.32 ± 0.09 mg L^{-1}. However, the concentration was varied from site to site with highest concentration site of Koka Bridge (S3) which ranged from 0.37-0.49 with average value of 0.41± 0.06 mg L^{-1} followed by Mallima Bari (S2) with a value ranged from 0.32 - 0.35 mg L^{-1} and average value of 0.34± 0.01 mg L^{-1} and the least Nitrate concentration site of Metoleka (S1) ranged from 0.18 - 0.25 with average value of 0.21± 0.03 mg L^{-1} (Table 1).

The current value of nitrate concentration was quite higher than previously recorded value by Hadgembes Tesfaye (2007) [[18] which was 40- 267 µg l-1 and Fasil Degefu *et al*. (2011) [20] 44.4 µg L-^{1}. According to Hadgembes Tesfaye (2007) [18], presence of high nitrate levels in Lake Koka is as the result of inputs from the surrounding agricultural lands on which fertilizers are commonly applied to boost crop yield. However, the current recorded value was less than a value recorded by Yeshimebet Major (2016) [21] with values of 253.47 ± 322.86 µg/L and Fasil Degefu *et al*. (2013) [6] with a values of 2.90 mg L^{-1}, 17.50 mg L^{-1} and 44.70 mg L^{-1} for Awash river system at its starting point, at the middle and Koka bridge respectively increasing downstream.

When compared with other Ethiopian water bodies contaminated with WH, it was greater than Ziway Lake with nitrate concentration of 0.21 mg L^{-1} a value reported by Dessie Tibebe, (2017) [30]. However, the current nitrate concentration value of Lake Koka was less than Tana Lake with values of (1.49 ± 0.65 mg L^{-1}) at WH infested area and (1.53 ± 0.51 mg $L^{-1)}$ at non-water hyacinth infested area (Dereje Tewabe, 2015) and Yezibie Kassa (2017) [10 and 31] with values ranging from 0.28 -1.56 mg L^{-1} for lake Tana. Even if values were different, the trends in decreasing of nitrate concentration at WH infested area as compared to none WH infested area in Lake Tana was similar with the current value of Lake Koka indicating that nitrate is highly utilized by WH. Total nitrogen concentration of Navashia lake with sites of WH infested area and non WH infested area was also studied by Mironga *et al*. (2012) [22]. Their report indicates that, WH infested area consisted low total nitrogen (6.91±1.09 mg L^{-1}) as compared to non WH infested area with value of (12.36±1.07 mg L^{-1}). Other scholars Uka and Chukwuka (2007) [23] also confirmed the above observation with lower mean values (6.91+1.09) of nitrate concentration at WH infested area as compared to open water with mean values of (12.36±1.07).

3.2.2 Total Phosphorus

Like nitrate, phosphorus is also a determining factor for growth of aquatic plants. From the current study, Phosphorus was ranged from 0.05-1.2 mg L^{-1} with the average concentration of 0.56 ± 0.33 mg L^{-1}. However, the concentration varied from site to site with highest concentration site of Koka Bridge (S3) ranged from 0.7-1.2 with average value of 0.92± 0.21 mg L^{-1} followed by Mallima Bari (S2) ranged from 0.33-0.76 and average value of 0.48± 0.2 mg L^{-1} and the least Phosphorus concentration site of Metoleka (S1) ranged from 0.05 - 0.43 with average value of 0.3± 0.2 mg L-^{1} (Table 1).

The current value of total phosphorus concentration was quite higher than previously recorded value by Yeshimebet Major (2016) [21] which was 167.54± 115.23µg L-^{1} and Fasil Degefu *et al*. (2011) [20] 477.2 µg L-^{1}. “Total Phosphorus is obviously linked to the increasing and intensive human activities taking place within the catchments area of the Lake” (Yeshimebet Major, 2016) [21]. However, the current recorded value was less than a value recorded by Fasil Degefu *et al*. (2013) [6] with a values of 49 mg L^{-1}, 50 mg L^{-1} and 56 mg L^{-1} for Awash River system at its starting point, at the middle and Koka Bridge respectively increasing downstream.

When compared with other Ethiopian rift valley lakes, it was greater than Ziway Lake with total Phosphorus concentration of (0.069 mg L^{-1}) and (0.311 mg L-^{1}) as reported by Girma and Gunnel (2010) and Dessie Tibebe (2017) [35 and 30] respectively. However, the current value for Lake Koka was almost similar with a value reported for Tana lake which was ranged from 0.44 – 2.06 mg L^{-1} (Yazibie Kassa, 2017) [31] with the highest value recorded at WH infested area (Agid Kirgna littoral) with average value of 2.06±8.32 mg L^{-1}, followed by rib littoral with non WH infested area with highest average value of 1.20±1.57 mg L^{-1} and minimal WH infested area (Dirma Littoral site) with highest average value of 1.07±3.64 mg L^{-1}.

Many scholars Dereje Tewabe *et al*. (2017), Mironga *et al*. (2012) and Dereje Tewabe (2015) [11], [22] and [10] reported the value of phosphate in relation to availability and presence of WH as (1.31 ± 1.25 mg L^{-1}) for WH infested area and (0.46 ± 0.39 mg L^{-1}) for none WH infested area, (2.67±0.21 mg L^{-1}) for WH infested area and (2.62±0.19 mg L^{-1}) none WH infested area and (0.42 mg L^{-1}) WH infested area and (0.4 mg L^{-1}) free area without WH respectively according to citation order. According to the above mentioned authors, phosphate concentration was high in the area of WH infested area than non WH infested area. According to Roger and Davis in Dereje Tewabe *et al*. (2017) [11], “the uptake of nitrogen by water hyacinth is 5 to 10 times as rapidly as phosphorous”. That may probably why they had observed high phosphate concentration at WH infested area as opposed to non WH infested area.

Even though different scholars observed high concentration of phosphate at WH infested area as compared to non WH infested area, my current observation was different from this. In fact, total phosphorus concentration was higher than the value of nitrate nitrogen at WH invaded area which supports the observation of Roger and Davis as cited in Dereje Tewabe *et al*. (2017) [11].

Table 1: Mean and standard deviation of some physic-chemical parameters of Lake Koka from January- March, 2019.

Parameters	(Mean and STD)			Average
	S1	S2	S3	
Temperature(ºC)	25.57 ± 1.78	25.05 ± 2.26	25.41 ± 1.8	*25.29± 1.94*
pH	8.66 ± 0.1	8.74 ± 0.37	8.7 ± 0.1.	*8.7 ± 0.23*
Transparency (cm)	23.31 ± 4.28	12.29 ± 2.12	32.27 ± 2.04	*21.41 ± 10.21*
TDS(mg/l)	331.87 ± 34.4	484.88 ± 78.23	599.35± 43.45	*472.03± 122.76*
Conductivity(μS cm-1)	459.39 ± 88.15	716.34 ± 105.95	877.99± 58.02	*684.57 ± 192.8*
Salinity (ppt)	0.22 ± 0.03	0.34 ± 0.03	0.45-04. 2	*0.33 ± 0.09*
Resistivity (kΩ)	2.07 ± 0.41	1.42 ± 0.24	1.26 ± 0.30	*1.58 ± 0.5*
Nitrate Nitrogen(mg/l)	0.21± 0.03	0.34± 0.01	0.41± 0.06	*0.32 ± 0.09*
Total Phosphorus(mg/l)	0.3± 0.2	0.48± 0.2	0.92± 0.21	*0.56 ± 0.33*

Note: S1 is site one, S2: Site two and S3: Site three.

4. Conclusion and Recommendations
4.1 Conclusion
From the current result, it can be concluded that Lake Koka is polluted by anthropogenic activities through using intensive inorganic fertilizers and chemicals from the surrounding land farms and factories which in turns creates favorable environmental requirement for the invasion of current most dangerous aquatic weed the water hyacinth (*Eichhornia crassipes).* Almost all studied parameters were high at Koka Bridge the inlet of Awash river to the Lake system indicating availability of nutrient loads from upper Awash and the surrounding factories.

Decreased nutrient availability like nitrate nitrogen and total phosphorus at highly water hyacinth invaded area at Metoleka (S1) is the indicator of nutrient utility by the plant there by making high dense mat of water hyacinth at the mentioned site (S1).Availability of less nutrient at highly water hyacinth invaded area is not to mean no nutrient at the site; there was high nutrient at the site before water hyacinth invasion that makes suitable environment for the weed and gradually decreased due to nutrient utility by the plant. Generally, availability of nutrient was less at highly WH invaded area than less WH invaded area during the study period.

4.2 Recommendations
- Necessary measure should be taken to protect the Lake from further pollution and invasion by water hyacinth and associated impacts
- Private organizations who pollute Koka reservoir should have to plant a waste treatment plant before releasing to Koka reservoir to minimize the impact of WH invasion as the waste they release facilitate growth and reproduction rate of WH.
- There may be seasonal variation in concentration of physico-chemical parameters and its relation with water hyacinth invasion. So, the concentration of physico-chemical parameters and its relation with water hyacinth invasion of Lake Koka should be studied all the seasons of the year.

5. Acknowledgements
We would like to thank Ambo University for providing all necessary materials to analyze nutrient content of Lake Koka. Our great appreciation goes to Mr. Miresa Tadese and Lemessa Benti (Staff of Ambo University) to give a time and support us during Lab. analysis of Nitrate nitrogen and total phosphorus. We would also like to thank very much Batu Fish and Other Aquatic Life Research Center for providing facilities used for field trip during data collection. This research was funded by Oromia Agricultural Research Institute; so, we appreciate and thanks this institute for providing all financial support used to do this experiment.

6. References
1. Ayalew Wondie. Dynamics of the Major Phytoplankton and Zooplankton Communities and Its Role in the Food Web of Lake Tana, Ethiopia. Ph.D. Dissertation, Addis Ababa University, Addis Ababa, 2006.
2. Samuel Tegene, Netsanet Ayele. Prevalence and Intensity of Water Hyacinth Infestation in the Water Bodies of Rift Valley, Ethiopia. The Journal of Agriculture and Natural Resources Sciences. 2014; 1(2):118-126.
3. The Organization for Economic Co-Operation and Development Biodiversity and Ecosystems: Better polices for better lives, 2014.
4. World Wide Fund. Living Planet Report: Aiming Higher. Grooten, M. and Almond, R.E.A. (Eds). Gland, Switzerland. 2018, 1-75.
5. Andrew WT. Patent Law, HIPPO, and the Biodiversity Crisis, 9 Journal of MARSHALL Review on Intellectual Property Law, 2010.
6. Fasil Degefu, Aschalew Lakew, Yared Tigabu, Kibru Teshome. The water quality degradation of upper awash river, Ethiopia. Ethiopian Journal of Environmental Studies and Management. 2013; 6(1):58-66
7. Dagno K, Lahlali K, Diourté M, Jijakli M. Fungi occurring on water hyacinth (*Eichhornia crassipes* [Martius] Solms-Laubach) in Niger River in Mali and their evaluation as mycoherbicides. J. Aquat. Plant Manage. 2012; (50):25-32.
8. Julien MH, Griffiths MW, Wright AD. Biological control of water hyacinth. The weevils *Neochetina bruchi* and *N. eichhorniae*: biologies, host ranges, and rearing, releasing and monitoring techniques for biological control of Eichhornia crassipes. ACIAR Monograph No. 1999; 60:87.
9. Hossain E, Sikder H, Kabir H, Sarma SM. Nutritive value of water hyacinth (*Eichhornia crassipes*), Online Journal of Animal and Feed Research. 2015; 5(2):40-44.
10. Dereje Tewabe. Preliminary Survey of Water Hyacinth in Lake Tana, Ethiopia. Glob J Allergy. 2015; 1(1):13-18
11. Dereje Tewabe, Erkie Asmare, Wondie Zelalem, Brehan Mohamed. Identification of impacts, some biology of water hyacinth (*Eichhornia crassipes*) and its management options in Lake Tana, Ethiopia: Net Journal of Agricultural Science. 2017; 5(1):8-15
12. Firehun Yirefu, Abera Tafesse, Tariku Gebeyehu, Taye Tessema. Distribution, impact and management of water hyacinth at Wonji-Shoa sugar factory. Ethiopian Journal of Weed Management. 2007; 1(1):41-52.

13. Ferihun Yirefu, Struik PC, Lantinga EA, Taye Tessema. Joint use of insects and fungal pathogens in the water hyacinth (*Eichhornia crassipes*): Perspectives for Ethiopia: Journal of Aquatic Plant Management. 2013; (51):109-121
14. Ferihun Yirefu, Struik PC, Lantinga EA, Taye Tessema. Occurrence and diversity of fungal pathogens associated with water hyacinth and their potential as biocontrol agents in the Rift Valley of Ethiopia. International Journal of Pest Management. 2017; 63(4):355-363.
15. Hailu Shiferaw, Demel Teketay, Sileshi Nemomissa, Fassil Assefa. Some biological characteristics that foster the invasion of *Prosopis juliflora* (Sw.) DC. At Middle Awash Rift Valley, North-Eastern Ethiopia. Journal of Arid Environment. 2004; (58):135-154
16. Taye Tessema, Rezene Fisshaie, Firehun Yirefu, Derje Tewabe, Tamado T. A review of invasive weed research in Ethiopia. In: Abraham, T. (Ed.), increasing crop production through improved plant protection: Plant Protection Society of Ethiopia, Addis Ababa, Ethiopia ; 2009, 381-407
17. Abebe Cheffo. A report of M.Sc. thesis on Market Chain Analysis of Lake Koka Fish in Ethiopia, Haramaya University, 2013.
18. Hadgembes Tesfay. Spate- Temporal Variations of the Biomass and Primary Production of Phytoplankton in Lake Koka: A thesis submitted to the School of Graduate Studies Addis Ababa University. Addis Ababa, Ethiopia, 2007.
19. United States of Environmental Protection Agency Methods for Chemical Analysis of Water and Wastes. United States, 1983, 1-491.
20. Fasil Degefu, Kibru Teshome, Gashaw Tesfaye, Fikadu T, Aschalew Lakew. Some limnological aspects of Lake Koka, a shallow tropical artificial lake, Ethiopia. J. Recent Trends Biosci. 2011; 1(1):94-100.
21. Yeshiemebet Major. Plankton community structure and interactions in a cyanobacteria-dominated tropical Reservoir (Koka, Ethiopia). A PhD dissertation Presented to the School of Graduate Program of the Addis Ababa University. Addis Ababa, Ethiopia, 2016.
22. Mironga MJ, Mathooko MJ, Onywere MS. Effect of Water Hyacinth Infestation on the Physicochemical Characteristics of Lake Naivasha. International Journal of Humanities and Social Science. 2012; 2(7):103-113
23. Uka NU, Chukwuka SK. Effect of Water Hyacinth Infestation on the Physicochemical Characteristics of AWBA Reservoir, Ibadan, South-West, Nigeria. Journal of Biological Sciences. 2007; 7(2):282-287
24. Jagaveerapandian T, Thamizharasu K. Effect of water chemistry on Anuran species diversity in the water hyacinth (*Eichhornia crassipes*) infested ponds in Cauvery delta regions of Tamil Nadu. Journal of Scientific Transactions in Environment and Technovation 2015; 9(1):92-97
25. Sotolu AO, Sule SO. Digestibility and performance of water hyacinth meal in the diets of African Catfish (*Clarias gariepinus*; Burchell, 1822). Tropical and Subtropical Agroecosystems. 2011; 14(1):245-250.
26. Tellez T, Lopez E, Granado G, Perez E, Lopez R, Guzman J. The water hyacinth, *Eichhornia crassipes* an invasive plant in the Guadiana River Basin (Spain). Aquatic Invasions. 2008; (3):42-53
27. Elizabeth Kebede, Zinabu G Mariam, Ahlgren I. The Ethiopian Rift valley lakes: Chemical characteristics of a salinity –alkalinity series. Hydrobiologia. 1994; (288):1-12.
28. Girma Tilahun. A seasonal study on phytoplankton primary production in relation to light and nutrients in Lake Ziway, Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa. 1988, 62.
29. Girma Tilahun. Temporal dynamics of the species composition, Abundance and size fractionated biomass and primary production of phytoplankton in Lakes Ziway, Awassa and Chamo (Ethiopia). PhD Dissertation submitted to Addis Ababa University, Addis Ababa, Ethiopia, 2006.
30. Dessie Tibebe Ayele. Internal and external agrochemical loads, dynamics and impacts on the freshwater ecosystem of Lake Ziway, Ethiopia. Ph.D. Dissertations, Addis Ababa University, Addis Ababa. 2017, 181.
31. Yezbie Kassa. Macrophyte Ecology, Nutrient Dynamics and Water Quality of the Littoral Zone, and Yitamot Wetland, Lake Tana, Ethiopia. A Thesis submitted to Addis Ababa University, Addis Ababa, Ethiopia. 2016, 205
32. Saeed SM, Al-nagaawy AMA. Impact of Water Hyacinth (*Eichhornia Crassipes*) on Physico-Chemical Properties of Water, Phytoplankton Biomass and Nile Tilapia Production in Earthen Ponds. Journal of the Arabian aquaculture society 2013; 8(2):249-262.
33. Moyo P, Chapungu L, Mudzengi B. Effectiveness of water Hyacinth (*Eichhornia crassipes*) in remediating polluted water : The case of Shagashe River in Masvingo, Zimbabwe. Advances in Applied Science Research. 2013; 4(4):55-62.
34. Wood RB, Tailing JF. Chemical and algal relationships in a salinity series of Ethiopian inland waters. Hydrobiologia. 1988; 158:29-67.
35. Girma Tilahun, Gunnel A. Seasonal variations in phytoplankton biomass and primary production in the Ethiopian Rift Valley lakes Ziway, Awasa and Chamo – The basis for fish production, Lim-nologica, 2010; 40:330-342.