*Available online at* **www.joac.info**

ISSN: 2278-1862

*Journal of Applicable Chemistry*

2019, 8 (1): 329-334

(International Peer Reviewed Journal)

# Wallo Wetland, its Regulatory Role and Implications to Downstream Lake Chamo, Ethiopia

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**Accepted on 23rd December, 2018**

## ABSTRACT

*Wetlands are important ecosystems because of their hydrological and ecological functions. The provision of screening, regulatory, protective and filtration services are among the prominent contributions of wetlands. The present study was carried out to investigate the regulatory functions of Wallo wetland, found between lake Abaya and river Kulfo (Lake Chamo main tributary). A total of six sampling sites were selected for water sampling. Among those sites three were selected around inlet of wetland at the outskirt of lake Abaya; and the other three at outlet of wetland before joining river Kulfo. Sampling was made during months of dry season January and rainy season of August. The analyses were made for 13 water quality parameters both on site and in laboratory. Standard method of sampling, storage and analysis was done according to APHA. The study revealed a significant variation in physico-chemical characteristics of the water between the inflow and outflow. A significant decrease in concentration was recorded except for DO. Removal percentages of above 50% was recorded for parameter like Turbidity, TDS, EC and TSS with values of 83.3, 63.1 54.4 and 52.9 respectively. In addition, the removal efficiency of the wetland for Mn, Salinity, T-N, Cr, T-$PO_4^{3-}$, Cu, was found to be 43.1, 40.7, 40.2, 37.2, 33.6 and 22.1 respectively. The surface water pH has improved by average value of 1.2; and a decrease in temperature up to 11.2$^o$C was recorded. Hence, it could be concluded that Wallo wetland has been playing an effective regulatory function when overflows of lake Abaya pass through it. The wetland has had great role in improving the water quality discharged from lake Abaya (less productive) to lake Chamo(highly productive lake).*

### Graphical Abstract

Wallo wetland

**Keywords:** Wallo wetland, Lake Abaya and Chamo, Regulatory Function.

## INTRODUCTION

Wetlands are important natural resources that provide diverse ecosystem services. They are found in all pockets of the world in different coverage size except in Antarctica. About 4 to 6% of the earth's landmass which accounts about 7 to 9 million $km^2$ is covered by wetland [1]. In Africa, wetland covers 131 million hectares of land (345,000 $km^2$). In Ethiopia, an estimated 1 to 1.5 % of the total landmass (18,587 $km^2$) is covered with wetland [2]. Wetlands are commonly known for their impact on water-quality improvement of downstream inhabitants. Regulatory functions of wetlands. Usually improve the quality of water passing through them, acting as "living filters" and serving as transitional zones or "ecotones" between terrestrial and aquatic systems [1]. They provide several physical, chemical, and biological processes thereby contributing for an improvement of water quality. The wetlands of Ethiopian rift valley lakes are in peril because of agricultural expansion, shrinking and expansion of lakes and other several reasons [3]. The wetland found at the South end of lake Abaya, Wallo wetland, allows the passage of water to lake Chamo via Kulfo river. Lake Abaya water over flown to Wallo wetland passes in steady, slow and undistributed way without having any clear channel connecting the edge of lake Abaya to the outlet before joining river Kulfo. Hence, the wetland in between would have some ecological and hydrological contribution to the downstream aquatic ecology. However, the role of this wetland has not been assessed yet. Hence, there is a need to study the role played by the wetland so that the management plan to conserve the wetland could be considered.

The main objective of the study was to investigate the regulatory role of Wallo wetland and valorize its contribution towards the aquatic ecology of the downstream lake Chamo so that conservation options of the wetland could be sought.

## MATERIALS AND METHODS

**Description of study area:** Wallo is 57 hectare broad wetland located at the South most tip of Lake Abaya, South Ethiopia. Astronomically, it is found at 37°35' 36''Eand 6°00' 46''N and altitude of 1176 m asl. The wetland was formed by over flow of Abaya lake. The overflowed water from lake Abaya joins the wetland and pass through the wetland without clear channel (Figure 1). Then it joins river Kulfo, a river that flows to lake Chamo. Lake Abaya does not always have an outflow, but the wetland becomes flooded when Lake Abaya receives high runoff. The vegetation of the wetland itself is dominated by *Eichhornia crassipes*, *Cyperus papyrus* and *Typha latifolia*.

**Climate:** Bimodal type of rainfall prevails in the study area (Figure 2). The mean annual rainfall is 871.64 mm. The mean minimum and maximum temperature are 17.37ºC, and 30.30ºC, respectively [4].

**Apparatus and Instrument:** Apparatus like glassware's, polyvinyl plastic bottles, plastic bag, pipette, ice bathe and GPS were used. Laboratory instrument sensitive electronic balance (OHASUS E11140), HQ40D (HQ40D53000000 HACH), DR900 Robust portable data logging colorimeter (HACH LANGE NV/SA, Motstraat 54, B-2800), Magnetic bided hot plate (CB162 R000100037, UK), Centrifuge ( model L020D), oven (British B35), Furnace (FUSEF1AH, R000047 UK), flame spectrophotometer (JENWAY) and atomic absorption spectroscopy (AAS210VGP) were used throughout the experimentation.

**Sampling design:** The sampling was carried out on two sites (at the inlet and outlet of wetland). Samples were taken from three randomly chosen places of each site; (Station-1, station-2 and station-

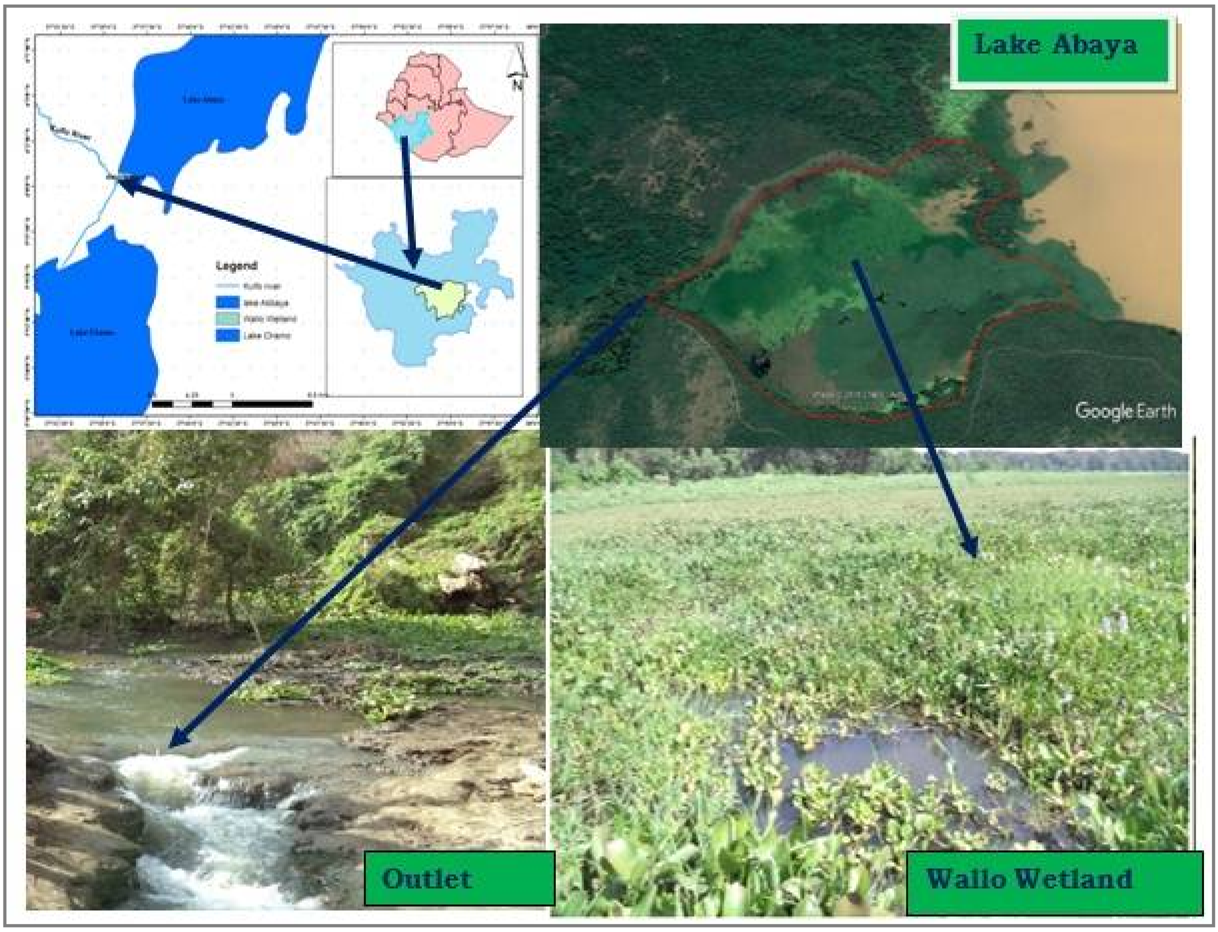


**Figure 1.** Location of Wallo wetland.

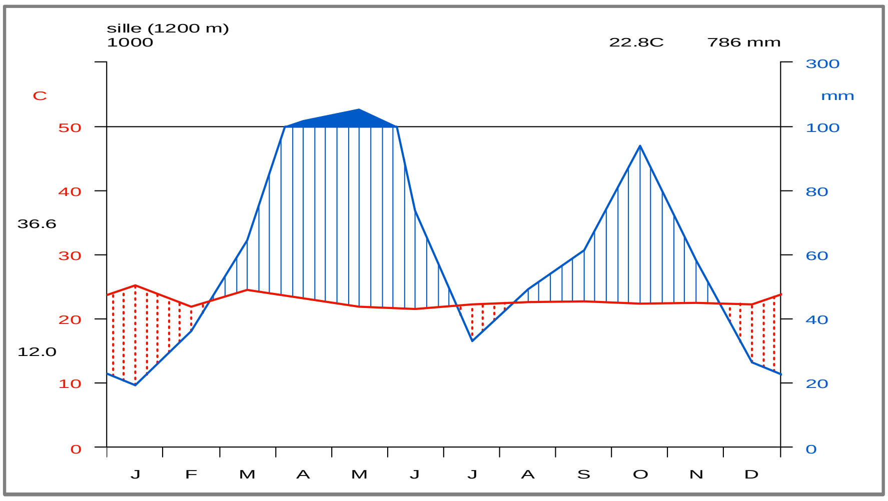


**Figure 2.** Climadiagram of the study area

3 for the inflow, station-4, station-5 and station-6 for outflow of the wetland). A total of 12 water samples were taken from six stations. Following sampling, characterization of the samples was made both on-site and in laboratory at Arba Minch University science laboratory. The samples required for laboratory analyses were kept at 4°Cand other preservatives were added depending on the parameter to be determined and duration of the preservation as described by APHA [5].

**On site physico-chemical analysis:** eight water quality parameters: water surface temperature, pH, Specific Electric Conductivity (EC), Salinity, Total Dissolved Solid (TDS) and Dissolved Oxygen (DO), of the water were measured at the field using a HACH HQ40d multifunctional portable meter. Chlorophyll a and Turbidity parameters were done using Aqua Fluor model 8000-010.

**Laboratory analysis:** the rest five parameters: concentrations of Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), Chloride (Cr), Copper (Cu), and Manganese (Mn) was done in laboratory. All chemical parameters were determined according to the American Public Health Association [5] standard methods for the examination of water and waste water.

**Figure 3.** Measuring onsite physico-chemical parameters.

**Data analyses:** The data of physic-chemical parameters, nutrient concentrations and heavy metal accumulations of the samples were measured by mean standard deviation of each sample tests, and finally the data was analyzed with Microsoft Excel Sheet.

## RESULTS AND DISCUSSION

### Physico-Chemical characterization of inlet and outlet waters

**Water surface temperature and dissolved oxygen:** From the result, the surface water temperature was in the range between 29.215°C± 0.26 at the inlet and 25.95± 1.62°C at the outlet of the wetland. Nearly an average of 3.27°C (11.19%) reduction in surface water temperature after passing through the wetland was recorded. Such significant reduction would contribute to dissolved oxygen retaining potential. Accordingly, the dissolved oxygen level was improved from 5.88 mg $L^{-1}$ at inlet to7.98 mg $L^{-1}$ at the outflow of the wetland. Several studies have also shown the significant influence of temperature in regulating the dissolved oxygen status in water body. Alan and Werner [6] clearly described the pronounced effect of temperature on the growth of fish and survival of aquatic life through improvement of dissolved oxygen. Besides, Hence, the role of the Wallo wetland between lake Abaya outlet and river Kulfo played a great role in reducing the surface water temperature thereby replenishing its dissolved oxygen level by 33.06% (from 5.88mg $L^{-1}$ to 7.985mg $L^{-1}$) and made it fit to the downstream aquatic ecology (Table 1).

Numerous scientific studies suggest that 4-5 ppm of DO is the minimum amount that will support the larger diverse fish population. However, having a pH value that averages about 9 ppm is highly recommended [7]. This is nearly similar to the DO level of the water at the outlet of the wetland (Table 1).

**Table 1.** Average values of parameters at the inflow and outflow of the wetland

| Parameters | Inflow | | Outflow | | Difference Inflow-outflow | % of Improvement |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Temp(°C) | 29.22 | 0.26 | 25.95 | 1.63 | 3.27 | 11.19 |
| pH | 8.93 | 0.32 | 8.82 | 0.68 | 0.11 | 1.23 |
| DO(mg $L^{-1}$) | 5.88 | 0.95 | 7.99 | 0.16 | 2.11 | 35.80 |
| Conductivity(μs $cm^{-1}$) | 1355.00 | 4.71 | 637.84 | 32 .76 | 717.17 | 52.93 |
| Salinity(‰) | 1.45 | 0.07 | 0.87 | 0.28 | 0.59 | 40.34 |
| TDS(mg $L^{-1}$) | 1313.50 | 5.41 | 484.50 | 208.59 | 829.00 | 63.11 |
| TSS(mg $L^{-1}$) | 235.67 | 48.41 | 107.40 | 8.58 | 128.27 | 54.43 |
| Turbidity(NTU) | 41.35 | 22.54 | 6.24 | 1.04 | 35.12 | 84.92 |
| T-N(mg $L^{-1}$) | 0.46 | 0.07 | 0.28 | 0.18 | 0.19 | 40.22 |
| T-PO4(mg $L^{-1}$) | 0.57 | 0.21 | 0.38 | 0.01 | 0.20 | 34.21 |
| Cu(mg $L^{-1}$) | 0.85 | 0.09 | 0.67 | 0.08 | 0.19 | 21.76 |
| Mn(mg $L^{-1}$) | 3.67 | 0.21 | 2.09 | 0.15 | 1.59 | 43.19 |
| Cr(mg $L^{-1}$) | 3.73 | 0.28 | 2.35 | 0.11 | 1.39 | 37.13 |

**Water pH, Conductivity, Salinity, TDS, TSS and Turbidity:** Both measurements at inflow and outflow of the wetland show alkaline readings. The insignificant change in the water alkaline nature could be attributed to the dilution potential of the increased in flooding by rain. However, the value is within the limit recommended for aquatic life by USEPA [8] i.e. (6.5-9).

From the result a significant decrease in conductivity was observed from 1355.33 µS $cm^{-1}$ at the inflow to 637.83 µS $cm^{-1}$ at the outlet (Table 1). Theses significant (52.93%) decrease in ionic concentration could be attributed to the regulatory role of the wetland by trapping ions introduced into lake Abaya from its watershed. The result has shown similar trend with salinity, TDS, TSS and Turbidity removal efficiency with 40.34, 63.11, 54.43and 84.92 respectively. This improved percentage removal could be attributed to low velocity coupled with the presence of the vegetation and gravel substrate [9].

**Nutrient load (Nitrogen and phosphorus):** The concentration of total nitrogen has reduced from 0.46 mg $L^{-1}$ at the inlet to 0.27 mg $L^{-1}$ at the outlet (Table 1).Such decrease by (40.22%) could be as a result of denitrification [10], uptake by wetland plants [11]. The total phosphate was reduced by 34.21% at the outlet of the wetland (Table 1). Decrease in the concentration of phosphate could be due to adsorption of phosphates onto mineral sediments [12]. The high concentration of phosphate at the inlet could be attributed to introduction of phosphate containing eroded water from upper watershed.

**Concentration of heavy metals (Chromium, Manganese and Copper):** As it can be seen from the table 1, the concentration of the metals has decreased by 21.76%, 43.19% and 37.13% Cu, Mn and Cr (III) from inflow to outflow respectively. This clearly shows the role of the wetland in screening and regulating heavy metals concentrations which improve water quality to downstream aquatic ecology (Lake Chamo). Decrease in the concentration of the heavy metals could be attributed to accumulation on the roots surfaces of plants [1].

## APPLICATION

The present study of improvement of the water quality made the water fit to the downstream productive lake which has a different limnology from the upstream lake. Hence, the wetland needs to be under protection for its ecological services as a regulatory.

## CONCLUSION

The wetland found between the South tip of lake Abaya and inlet of river Kulfo removes organic loads heavy metals and input materials like TSS, TDS, salinity and the turbidity of the upstream water. Such regulatory function of Wallo wetland was accompanied by replenishment of dissolved oxygen. Such improvements of the water quality made the water fit to the downstream productive lake which has a different limnology from the upstream lake. Hence, the wetland needs to be under protection for its ecological services as a regulatory.

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