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ORIGINAL ARTICLE

Physico- chemical parameters and algal composition of wetlands in Eastern Hararghe Oromia regional state, Ethiopia

Arayaselassie A. [1] Tesfaye M. [2*] Hiwot A. [3] Dage B. [2] and Brehanu Y. [3]**
1, School of Animal and Range Science, Haramaya University. P.O.Box 138. Dire Dawa
2* Department of Biology Haramaya University,
2** Department of Chemistry Haramaya University,
3 Department of Environmental Health Haramaya University,

ABSTRACT
Wetlands are natural resources that play vital role in the existence of life. They are transitioning between land and water. This study focuses on identifying algal diversity and abundance and provides a general ecological character of the wetlands in eastern Hararge Oromia regional state Ethiopia. For this study three wetlands were taken which are found in the Eastern Hararghe zone: namely Haramaya, Adele and Teneke. Data were taken from three spots on the wetland shore, middle and edge of the wetlands where the anthropogenic effect is assumed to be high respectively. The water temperature ranged from 22.38 to 25.26 °C the highest conductivity was recorded in H^1 319.5 µs/cm. The highest value of PO_4^{-3} was 0.405 mg/L in site A^2 and the highest value of NO^-_3 was 4.813 mg/L recorded in site A^2. Nine algal species belonging to 4 families were collected from the Adele sites, whereas, from Haramaya and Teneke sites 7 species of 4 families were collected (cyanophyta, chlorophyta, bacillaropyta and Euglenophyta). The highest level of BOD 4.1 and lower level of DO 12.3 was recorded near the edge of the wetlands. It can be concluded that anthropogenic pressure, such as agricultural practices and waste disposal practice deteriorated the water quality and richness of biodiversity of these wetlands.
Key words: *wetland, aquatic ecosystem, physicochemical parameters, anthropogenic effect*

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INTRODUCTION

Wetlands are one of the complex ecosystems occupying the interface between land and water. They do have numerous roles in the ecosystem among these ecological and hydrological functions are basic ones. These functions include flood control, water purification, sediment and nutrient retention, dry season grazing, agriculture, micro-climate, recreation and cultural values and water supply for both domestic and livestock [15]. Wetlands are taken as the most productive of ecosystems on planet earth, in the contrary they are also the most threatened habitats [1, 3].

Most Ethiopian wetlands are found in the vicinity of urban settlements and surrounded by agricultural land, which exposes water quality changes which results from land use and unmanaged irrigation system. The diversion of the tributaries of wetland water for irrigation and sanitation due to deforested or heavily grazed catchments may have contributed to the decrease in the water level and beings increase in the concentrations of ions in water [20].

Presently, most of the aquatic ecosystems and wetlands of Ethiopia and elsewhere in the world are threatened to the extent of extinction mainly due to eutriphication and conversion into agricultural land. Substantial changes in land-use/cover have occurred over Southern and Eastern part of Ethiopia in the past few decades [14]. Spread of settlement due to uncontrolled urbanization and increasing the use of land resources for agricultural and economic development mainly service industry (Hotel, lodges and recreational areas) [18]. Understanding the characteristics of hydrological processes is vital for bringing solutions to wise use of wetlands and for limiting environmental degradation in wetlands [21].

Eastern Hararghe has a number of wetlands all are categorized as freshwater wetlands. Like any other wetlands in the country these wetlands also deprived of a conservation scheme designed for the country. They have been used as a sink for disposing different liquid and solid west and in some areas; the farmers are using it for irrigation purpose. Moreover, the wetland near Lake Haramaya is devoid of apparently all its natural vegetation and is highly populated, with the majority of the land being used for horticultural crops and a stimulant plant locally known as "chat" (*Catha edulis*) for export to neighboring Djibuti and Somali [4]. Thus, it appears important to study these wetlands to understand the physicochemical composition and biotic components.

MATERIAL AND METHODS

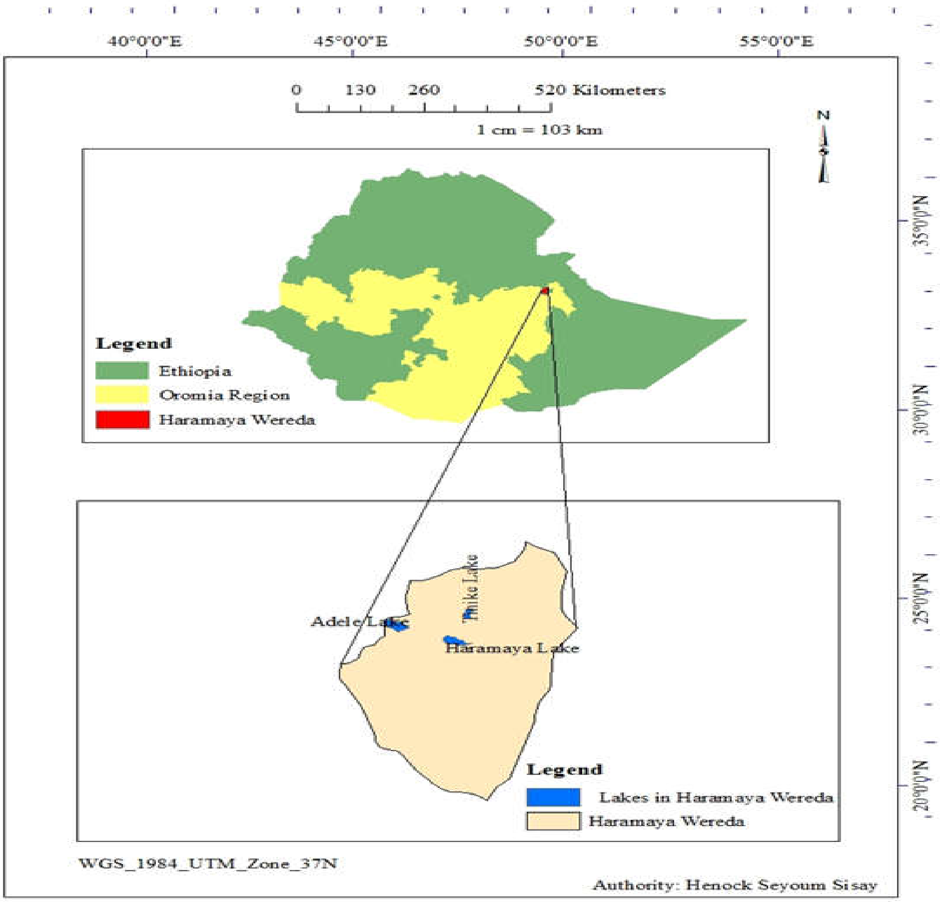

Figure 1 map of the study area

Study area description

East Hararge takes its name from the former province of Hararghe. East Hararge is bordered on the southwest by the Shebelle River which separates it from Bale, on the west by West Hararghe, on the north by Dire Dawa and on the north and east by the Somali Region. The Harari Region is an enclave inside this zone. Towns and cities in East Harerge include Haramaya, Awaday, Babille and Fugnan Bira. Its highest point is Gara Muleta. Local landmarks include the Harar Wildlife Sanctuary and Haramaya University [8].

Demographics

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 2,723,850, an increase of 48.79% over the 1994 census, of whom 1,383,198 are men and 1,340,652 women; with an area of 17,935.40 square kilometers, East Hararghe has a population density of 151.87. While 216,943 or 8.27% are urban inhabitants, a further 30,215 or 1.11% are pastoralists. A total of 580,735 households was counted in this Zone, which results in an average of 4.69 persons to a household, and 560,223 housing units. The two largest ethnic groups reported were the Oromo (96.43%) and the Amhara (2.26%); all other ethnic groups made up 1.31% of the population. Oromiffa was spoken as a first language by 94.6%, Somali was spoken by 2.92% and Amharic by 2.06%; the remaining 0.42% spoke all other primary languages reported. The majority of the inhabitants were Muslim, with 96.51% of the population having reported they practiced that belief, while 3.12% of the population professed Ethiopian Orthodox Christianity

Sampling method and data collection

Three sampling sites were selected for the collection of phytoplankton and physicochemical parameters of each wetland. These sampling sites were sore (1), middle (2), and (3) anthropogenic area of the

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wetlands. Integrated water samples for physicochemical analyses and phytoplankton were collected twice, i.e. first from the end of August to September, 2015 and the second in January to mid February, 2016 to represent samples in the wet and dry seasons respectively.

Physicochemical parameter

To study the physico-chemical parameters of the wetlands Water samples were collected and analyzed for total phosphorus (TP) and total nitrogen (TN). A 125 ml acid-washed (HCl), polyethylene bottles were used to collect samples from surface water and stored in refrigerator before analysis. Form deep water sample was also collected from the Lower Break with an alpha bottle at approximately 1.5 to 2.8 m and transferred to a polyethylene bottle. Samples were analyzed for TP and TN using standard methods in Haramaya university analytical chemistry lab.

Some of the physicochemical parameters were determined by using on-site examinations and subsequently a few of them were measured under laboratory conditions. Parameters like temperature , conductivity (Knick Portamess® 911 conductivity meter), pH (Knick Portamess® 911 pH meter) and oxygen saturation (Knick Portamess® 911 oxygen probe), were measured on-site at each sampling site.

Phytoplankton samples

Phytoplankton samples were collected in the same locations selected for the physicochemical parameters. Plankton net with a mouth aperture of 200 mm and mesh size of 50 µm was used to collect phytoplankton (algae). All samples were preserved in seventy percent alcohol and kept in a cool and dark room for further analysis. The samples examined with a microscope to identify phytoplankton to their respective genus or species on the basis of various taxonomic literature available on phytoplankton.

Data analysis

To analyze the row data SPSS version 21 was used. Spearman bivariate correlation tests of the physicochemical were undertaken to evaluate the relationship of the different variables. In addition, Kruskal-Wallis test was performed to evaluate the presence of significant differences of physicochemical and biological parameters between the wetlands (n=12, four from each sampling date) at 5 % degree of error. Mann–Whitney test was performed to test algal species differences between the sampling sites. Descriptive statistics also used to describe physicochemical and algal composition of the wetlands. The result was presented using tables and graphs.

$$H = \left[\frac{12}{n(n+1)} \sum_{j=1}^{c} \frac{T_j^2}{n_j} \right] - 3(n+1)$$

Where:

- n = sum of sample sizes for all samples,
- c = number of samples,
- T_j = sum of ranks in the j^{th} sample,
- n_j = size of the j^{th} sample

RESULTS

Physicochemical Parameters

The results of physicochemical analysis of the three wetlands in eastern hararge, Adele (A^1, A^2, and A^3) and Teneke (T^1, T^2, and T^3) and Haramaya (H^1, H^2, and H^3) at each sampling stations are shown in Table 1. In the three wetlands the water temperature ranges from 22.38 °C to 25.26 °C. Among the twelve sites with the highest value of $PO_4{}^{-3}$ and $NO-_{-3}$ were found to be 0.405 mg/L and 4.813 mg/L respectively recorded in site A^2. The trend in BOD, DO and algal richness along different sampling sites of Adele and Teneke and Haramaya wetlands shown in Fig. 2. BOD concentration at Adele wetland sample sites A^1, A^2 and A^3 significantly differ from the rest of the two wetland ecosystems Haramaya and Teneke (p-value<0.01).

The phosphate concentration at A^1 and A^2 is 0.405 and 0.394 respectively, and also significantly different from A^3 and samples from Teneke (T^1-T^3) and Haramaya wetlands (H^1 and H^3) (p-value<0.05). The electrical conductivity of T^1 and T^2 were found168. 1 and 168.9 respectively, and it is to be much smaller than the rest of the sample sites. However, other physicochemical parameters didn't show significant difference between the sampling sites.

Table 1 Physicochemical parameters of water sample of the study sites in Eastern Hararghe.

Physico chemical characteristics	Haramaya wetland			Adele wetland			Teneke wetland		
	H1	H2	H3	A1	A2	A3	T1	T2	T3
Temperature ^{o}C	22.5	23.26	22.3	23	22.35	24.4	24.9	23.067	25.26
pH	7.705	8.59	9.21	7.95	9.045	9.55	7.45	7.63	9.54
Turbidity	.25	.23	0.21	.24	.22	.20	.25	.28	.45
Conductivity (µS/cm)	319.5	310	298	279	312	302	72.25	168.1	168.9
DO mg/l	7.1	7.6	8.8	8.1	8.22	9.1	12.3	9.95	9.2
TDS (g/l)	0.69	0.23	0.23	0.32	0.655	0.47	3.57	0.08	5.26
NO^{-3}	4.806	4.68	4.71	4.74	4.813	4.66	4.473	4.66	2.47
PO^{-3}_{4}	0.16	0.03	0.251	0.405	0.394	0.09	0.1	0.21	0.075
BOD	3.01	3.1	3.22	4.1	5.0	6.3	5.9	3.4	3.11

Phytoplankton

In a phytoplankton algal study of the wetlands nine-algal species belonging to 4 families were identified from Adele sites, whereas, in the Haramaya and Teneke sites 6 and 8 species from 4 families were identified respectively (Table 2). In Teneke only seven species were identified, which is the lowest from the rest of all the sampling sites. Algal taxa richness at Adele A1, A2 and A3 significantly differ from the samples from Haramaya and Teneke (p-value<0.05).

Table 2. Percentages of each species found in the sample sites

Family	Species	Teneke	%	Haramaya	%	Adele	%
Cyanophta	Anabena	124	45.7	225	57.54	569	48.30
	Spirulina	7	2.6	6	1.53	41	3.48
	Oscillatoria	9	3.3	16	4.09	23	1.95
Chlorophyta	Spirogyra	25	9.2	71	18.15	18	1.52
	Volvox	16	5.9	10	2.55	22	1.86
	Chlamydomonas	3	1.1	0	0	54	4.58
Bacillariophyta	Bacillariophyta	7	2.6	63	16.11	182	15.44
Euglenophyta	Euglenophyta	80	29.6	0	0	209	17.74
	Cryptomonas	0	0	0	0	60	5.09
Total		270	100	391	100	1178	100

In the overall species in Texas comparison Adele wetland showed a higher number of Phytoplankton content as compared to Haramaya and Teneke wetlands (table 2). The highest percentages of Anabaena were found in Haramaya (57. %) and Adele (51 %), respectively. Percentages of Bacillaropyta at Haramaya and Adele were lower than in Teneke. Cyanophyta and Chlorophyta were represented by three representative species and each family is found in each wetland.

The species interaction and associated with physicochemical parameters like BOD and DO show that as DO and BOD increases the species availability also increases. On the contrary, if the physical, chemical parameters also increased the number might not increase with it. In Fig3 the data show that the BOD level has a higher effect in the species composition and richness than DO.

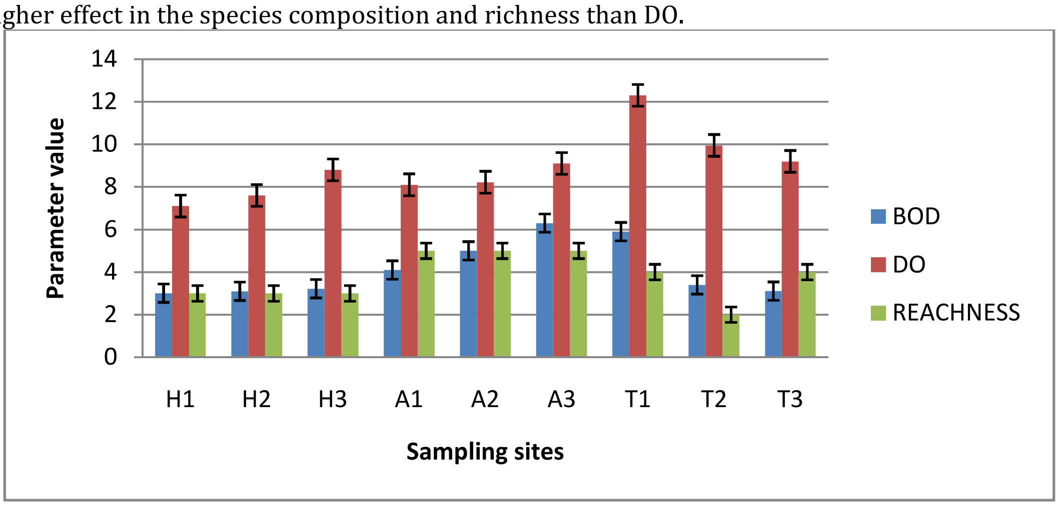

Fig. 2. The average values of BOD, DO and richness in the sampling sites of Haramaya, Adele and Teneke wetlands. The error bar shows the standard deviation (n=9)

Significant correlations (r_2>0.224, p-value<0.05) were observed between water temperature and Species richness (positive), conductivity with pH and phosphate (positive), nitrate with turbidity and BOD (positive), DO with conductivity and phosphate (negative).
The Kruskal-Wallis test revealed that the percentage of all species and BOD concentration in the Adele wetland significantly differed from that of Haramaya and Teneke wetlands (p-value<0.05). However, for the other physicochemical and biological parameters no significant differences were observed between the wetlands.

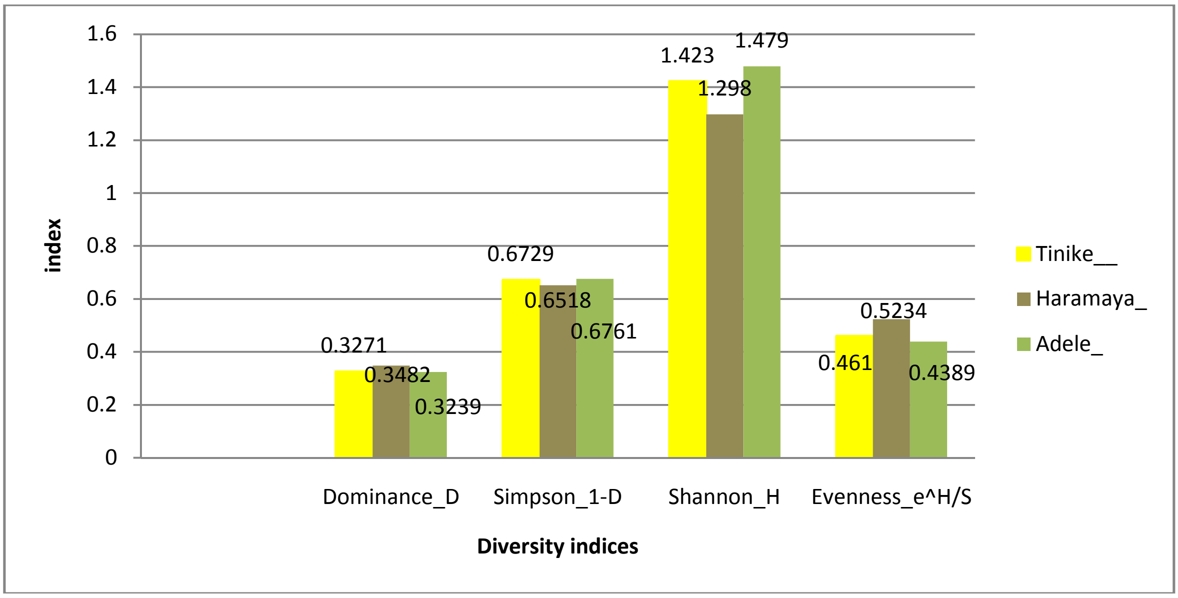

Fig.3. Biodiversity indices of the three wetlands.

DISCUSSION
Wetlands are habitats that store water during the rainy season and release most of the water during the dry season. These habitats provide irrigation water for farmers living in semiarid areas for growing crops and cash crops. In addition, wetlands provide other ecosystem services that support human welfare like livestock grazing and water for irrigation, water supply for domestic use, fishing, and production of natural products. The same result was reported in Getachew et al. 2012. The BOD which is taken as an indicator of pollution was greater in all the sampling sites of Adele also the highest concentration (6.3 mg/L) was recorded site A^3.
It has been recorded that the DO is greater than 4 mg/L in all the sampling sites of the wetland. A DO which is believed to have implications in the physical nature of the wetlands, water in the has been exhibited to be higher. However, between the observations there is no statistically significant difference (p-value>0.05). This was similarly explained in [11] due to the result of anthropogenic activities such as intensive agricultural practices in the area.
As discussed in Chapman and Kimstach [6], if the concentration of DO is below 5 mg/L it has an adverse effect on the functioning and survival of biological communities and also if it is below 2 mg/L it may also lead to the death of most fish. In similar manner all the sampling sites in Adele showed higher BOD values compared to Teneke and Haramaya. This reveals clearly that Adele wetland was not experiencing pollution problems than Teneke and Haramaya wetlands (Fig. 2). The cause of the two wetlands pollution might be due the introduction of inorganic pollution via the use of inorganic fertilizers, insecticides and other agro chemicals. The relatively higher load of pollution is correlated closely with decreased pollution sensitive species diversity and increased abundance of a number of certain pollution tolerant species. The results of the current study were in line with different studies in different wetlands of Ethiopia. [1].
The diversity or richness of some species increased and the others which are phobic to pollution and anthropogenic effect's dominance decreased considerably as a result of various anthropogenic threats such as rapid unplanned urbanization and other interrelated activities (Fig. 3). Nitrate concentration of unpolluted surface water seldom exceeds 0.1 mg/L and whenever it is above 0.2 mg/L, it enhances eutrophication according to [10]. The intense agricultural activities, wastes of domestic animals, and dumping of various liquid and solid wastes by the nearby community in the wetlands (Table 1) could have been major nutrient sources.

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The major anthropogenic sources of nitrate in the aquatic ecosystems are sewage, fertilizers, and waste from farmyards and a domesticated animal the result of this research is also confirmed similar reasons as of [2]. Similarly, the concentration of phosphate was much higher than the critical value of 0.05 mg/L in surface water in most of the sites except at H^2 the same result and conclusions were made by [2]. The reasons for the increase in the concentration of these minerals were due to fertilizer runoff from agricultural farmlands, pasture catchments, and wastewater release. Similarly, in other researches it has also been reported that the grazing fields, agricultural croplands, waste discharges, and other anthropogenic activities taken as the major causes of nutrient enrichment and threats for wetland deterioration as reported in Cooke [7]; Getachew *et al.* [11].

Biodiversity indices are measures of the distribution and richness measures of biodiversity like Simpson and Shannon indices were used in order to estimate the level of ecological disturbances of these wetlands (Fig. 3). These indices used in order to show relative differences among the sites. Shannon index values greater than three indicate higher diversity and good water quality, while the Simpson index (D) values less than one indicate severe pollution and intermediate values are characteristic of moderately polluted conditions. With this analogy the wetlands of the sampling area's diversity show that the diversity in Shannon of the three wetlands is less than 2. The Simpson index also shows similar results with that of Kratzer and Batzer [12]. According to Zelalem Dessalegn [20] 21 algae species belonging to 6 families were recorded in Adele wetlands in the current study only 9 species belonging to 4 families were recorded.

The size of these wetlands has been decreasing from time to time because of agricultural production and climate change, it was reported in a similar way in Brook Lemma, 1995. The degradation of these selected wetlands could also be associated with policy related issues, on site and off site wetland management problems, cultivation of wetlands, draining, and waste dumping according to Bognetteau *et al.* [5] similar problems were reported as the cause for the decrease in wetland coverage. Studies conducted in various parts of the world and at different times also show that 85 % of wetland conversion happens due to conversion to agricultural land, 8 % to urban growth, and 5 % to industrial development Legesse [13] and Bognetteau *et al.* [5].

In a country like Ethiopia, a wise use wetland program would need a responsible agency to co-ordinate national action. Because wetlands fall within the scope of a crosscutting issue like environmental protection, both public and private institutions would need to contribute their expertise and work together. The development of a management plan for Ethiopia's wetlands will need basic studies, including awareness, surveys, and inventories, which should be part and parcel of a wetland development program Davis [9]; Ramsar [16].

CONCLUSION

Our world is composed of various ecosystems our existence in this would not be possible without the habitats life-supporting services they provide. Wetlands provide a wide range of environmental and socioeconomic benefits for the populations surrounding the wetlands. The result of physicochemical and algal composition analysis of these wetlands from different sampling stations indicates that the higher level of BOD and lower DO occur in the vicinity where there is a much anthropogenic effect.

This correlates with higher values of polluted nutrient (PO_4^{-3}). Generally, this study shows that Adele wetland was relatively more polluted due to intensive agriculture and disposal of wastes by the nearby community. In general, the direct and indirect effects of agricultural land use, liquid and solid waste disposal, cattle-raising, other anthropogenic pressures have deteriorated the biodiversity and water quality of these wetlands. The diversity indices clearly show that the diversity is being affected. At the moment, preserving the wetlands from the anthropogenic threats is one of the key concerns of the developing world. This can be achieved by creating awareness among the people by applying appropriate communication strategy about the importance of wetlands. Notably, in Ethiopia, wetlands are very often considered as wastelands and are thought as obstacles to agricultural development and human and animal health, and associated with nuisances and calamities such as floods and diseases like malaria. This sort of perception must be changed among the inhabitants; those are living in and around wetlands by implementing effective community oriented awareness campaigns on the importance of wetlands.

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Appendix 1

Correlations

Spearman's rho	temperature Correlation Coefficient	temperature Sig. (2-tailed)	temperature N	pH Correlation Coefficient	pH Sig. (2-tailed)	pH N	turbidity Correlation Coefficient	turbidity Sig. (2-tailed)	turbidity N	conductivity Correlation Coefficient	conductivity Sig. (2-tailed)	conductivity N	DO Correlation Coefficient	DO Sig. (2-tailed)	DO N
temperature	1.000	.	9	.033	.932	9	.444	.232	9	-.533	.139	9	.533	.139	9
pH	.033	.932	9	1.000	.	9	-.502	.168	9	.317	.406	9	-.100	.798	9
turbidity	.444	.232	9	-.502	.168	9	1.000	.	9	-.485	.185	9	.301	.431	9
conductivity	-.533	.139	9	.317	.406	9	-.485	.185	9	1.000	.	9	-.850**	.004	9
DO	.533	.139	9	-.100	.798	9	.301	.431	9	-.850**	.004	9	1.000	.	9
TDS	.444	.232	9	.084	.831	9	.328	.389	9	-.017	.966	9	.142	.715	9
NO3	-.870**	.002	9	-.059	.881	9	-.429	.250	9	.753*	.019	9	-.770*	.015	9
PO4	-.733*	.025	9	-.217	.576	9	-.176	.651	9	.033	.932	9	-.133	.732	9
BOD	.183	.637	9	.083	.831	9	-.393	.295	9	-.350	.356	9	.550	.125	9
species	-.450	.224	9	.383	.308	9	-.753*	.019	9	.483	.187	9	-.500	.170	9

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-.067	.864	9	.611	.081	9	.483	.187	9	.367	.332	9	1.000	.	9
.067	.864	9	-.167	.667	9	.250	.516	9	1.000	.	9	.367	.332	9
-.251	.515	9	.644	.061	9	1.000	.	9	.250	.516	9	.483	.187	9
-.227	.557	9	1.000	.	9	.644	.061	9	-.167	.667	9	.611	.081	9
1.000	.	9	-.227	.557	9	-.251	.515	9	.067	.864	9	-.067	.864	9
.142	.715	9	-.770*	.015	9	-.133	.732	9	.550	.125	9	-.500	.170	9
-.017	.966	9	.753*	.019	9	.033	.932	9	-.350	.356	9	.483	.187	9
.328	.389	9	-.429	.250	9	-.176	.651	9	-.393	.295	9	-.753*	.019	9
.084	.831	9	-.059	.881	9	-.217	.576	9	.083	.831	9	.383	.308	9
.444	.232	9	-.870**	.002	9	-.733*	.025	9	.183	.637	9	-.450	.224	9
Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N
TDS			NO3			PO4			BOD			div		

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CITE THIS ARTICLE

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