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Macrophyte species, composition, abundance and diversity in relation to some environmental factors in Upper Awash River basin, Ethiopia

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Abstract

The study assessed the species composition, distribution, and diversity of macrophytes in the Upper Awash River during dry and wet seasons across seven sampling sites from October 2019 to April 2020. Macrophytes were collected manually using the quadrat method, and environmental factors were measured in situ using YSI 556 multi probe system. Nutrients (SRP, TP, TN, Nitrate) were analyzed from water and sediment. A total of 26 macrophyte species from 15 families were identified, with low species diversity (H' = 2.56). Emergent macrophytes dominated (92%), followed by free-floating and rooted floating types (4% each). Canonical Correspondence Analysis (CCA) revealed that Nitrate, SRP, TP, and flow velocity significantly impacted macrophyte diversity and distribution. Cyperus articulatus L., Echinochloa colona L., Solanum incanum L., Pontederia crassipes, Persicaria senegalensis, Rorripa nasturtium aquaticum, Ipomoea aquatica and Phragmites mauritianus were almost restricted to sites where there was higher Nitrate, SRP and TP while Ludwigia spp., Sida schimperiana, Alternanthera sessilis, Lagarosiphon cordofanus, Brachiaria mutica, Juncus effuses, Ludwigia abyssinica, Cyperus latifolius, and Cyperus papyrus were limited to sites where there was higher DO,TN and Silt. Half of the macrophyte diversity was explained by environmental factors like nitrogen, phosphorus, and sediment texture. Further investigation of unexplained factors is needed for sustainable river management. This factor is crucial for developing strategies to enhance the river's ecological health and resource utilization.

Keywords: *Awash River, canonical correspondence analysis, flow velocity, Macrophyte, principal component analysis, water hyacinth*

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1. Introduction

The habitats composed of Macrophytes play an important role in providing a stable habitat structure to aquatic ecosystems. They also assist as a base of aquatic food-chains and actively contribute to the promotion and maintenance of food webs and services in freshwater ecosystems (Ansari *et al.*, 2017). On the other hand, invasive macrophyte species have a negative facet as they distress the function, structure and composition of aquatic ecosystems (Stave *et al.*, 2017). A study of macrophyte species diversity, composition and distribution is an essential component of understanding river ecosystems. This is due to their valuable indicators of environmental health; as such, they used to assess the ecological status of water bodies (Bytyçi *et al.*, 2022). Species composition and distribution of macrophytes in river ecosystems depend on various environmental factors such as light, water temperature, sediment nutrient, flow velocity, substrate composition, disturbance and quality of the river water (Birk & Willby, 2010). Awash River Basin is one of the most significant river basins in the country and it provides ecosystem services to 10.5 million inhabitants. Irrigation, electric power generation, fish production, as water sources for domestic consumption to the inhabitants dwelling nearby the river course, as well as for domestic and wild animals of the area are some of the most important services provided by the Awash River water (Degefu *et al.*, 2013). However, the Awash River ecosystem is being affected by catchment degradation, unregulated abstraction, industrial discharge at mojo area, sand mining at Ziquala area, flood hazard/ siltation, establishment of invasive species, expansion of water hyacinth in Koka and Guro ruta sites and uncontrolled fishing practices. This might be causes for the loss of some macrophytes in the aquatic ecosystem (Wondimu, 2014). Previous studies on the Awash River focused on flood hazard assessment (Sineshaw & Legesse, 2015), plant community distribution along the river corridor (Tikssa *et al.*, 2009), water quality degradation (Degefu *et al.,* 2013) and composition and diversity of phytoplankton (Wondimu, 2014). Wondimu (2014) noted the massive growth of macrophytes such as Eichhornia crassipes, Lemna sp and Azolla in Awash River but did not make further study. In general, the ecological factors that drive the diversity, composition and distribution of macrophytes in the Awash River have not been investigated. Therefore, the objective of this study was to assess the composition, diversity and distribution of macrophytes in relation to some selected environmental factors in the Upper Awash River which will aid to suggest proper measures that encourage the conservation and sustainable utilization of the river resources.

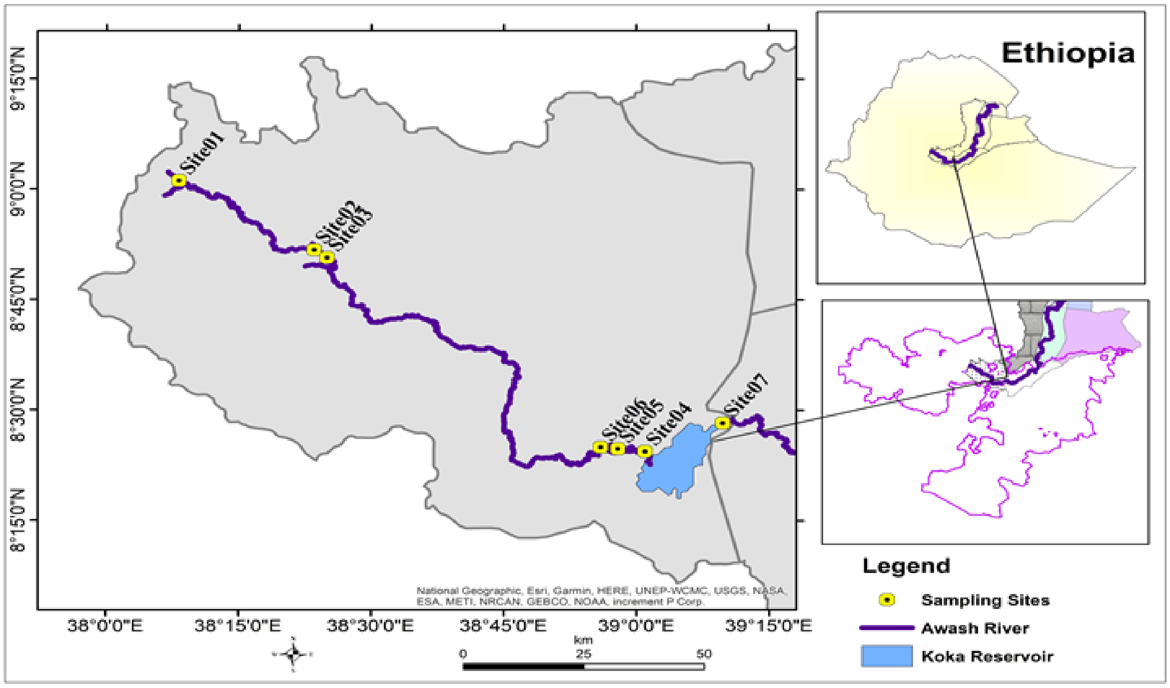
2. Materials and Methods

2.1 Study area

This study was done in the Upper Awash River (head water to Koka reservoir) which covered a total course of 500 km and downstream of Koka reservoir up to Siri Robi kebele. Upper Awash River located at 08 015’ 0’’- 09 015’ 0’’ N to 38 0 0’ 0’’ – 39 015’ 0’’E (figure 1) and at an elevation ranging from 1574 up to 2337m. A total of seven sampling sites were selected based on their distance from human settlements and other anthropogenic effect and accessibility for quantitative study. Guro Ruta and Koka sites were near to human disturbance activities.

Figure 1

Map of the study area and sampling locations



Note: S1 = Yejera bole, S2 = Yejera Ebu, S3 = Awash Bello, S4 = Koka, S5 = Guro Ruta, S6 = Awash Tuti and S7 = Sire Robi

2.2 Sampling design

A reconnaissance survey was conducted in October 2019 to identify sampling sites. Sampling sites were selected subjectively following the Braun-Blanquet approach (Westhoff & Van Der Maarel, 1978). Sample surveys were embarking from October-December 2019 (post rainy season) to February-April 2020 (dry season) to collect macrophytes and environmental data. Macrophytes were collected manually from seven sampling sites of the Upper Awash River ecosystem (figure 1).

Vegetation stands were analyzed along a 100m river reach. One sampling site is established for each physically homogeneous river reach: the reaches were identified according to a combination of geological background and slope. 10 quadrats (1*1 m) at every 10m distance (Gaudet & Muthuri, 1981) were established at each site. A total of 70 quadrats were placed during the study period. Percentage cover values for all macrophytes were estimated and later converted into the modified Braun-Blanquet scale following Van Der Maarel (1978). Plant specimens were collected, rinsed *in situ*, blotted, pressed and later identified at the National Herbarium (ETH), Department of Biology, Addis Ababa University, using Flora of Ethiopia and Eritrea (Hedberg & Edwards 1989; Mesfin & Hedberg, 1995). The relative frequency and relative density of each species of macrophytes were estimated as in the study by Singh *et al.* (2013).

2.3 Environmental factors

Dissolved oxygen, pH, electrical conductivity and temperature were measured in situ using YSI 556 multi-probe system and flow velocity measured in m/s using a lemon and a stopwatch (WeberOldecop, 1969). The analysis of SRP and nitrate were based on Palintest Phosphate LR method and Palintest Nitratest method respectively, whereas TP analysis was done for unfiltered water sample using standard procedures as indicated in APHA (1999), with a spectrophotometer (Jenway 6405 UV) at Addis Ababa Environmental Protection and Green Development Commission (AAEPGDC). Nitrate and SRP analyses were made immediately after sample collection using water samples filtered through Whatman GF/F. Sediment samples were taken from approximately 10 cm of the sediment surface at each study site, for analysis of TP, TN concentration and substrate type (soil texture) using core sampler. The collected sediment samples were air dried and sieved through a 2mm sieve. In the process 5g dry sediment was added to 50mL 0.002N H_2SO_4 solution in 500mL Erlenmeyer flask and shaken for 30 minutes with mechanical shaker and filtered through a Whatman No 42 filter paper. Finally, this solution was analyzed according to persulfate digestion followed by ascorbic acid method for total phosphorus, while for total nitrogen the Kjeldahl method which a two-step process was used. First, the sample was digested with a sulfuric acid to convert organic nitrogen compounds to ammonium ion. Secondly, the converted ammonium ion was converted to ammonia in an alkali distillation process. The liberated ammonia in this process was finally quantified for determination of the total nitrogen in the original digest as stated in APHA (1999).

2.4 Data analysis

The collected data were analyzed by using R-software version 3.6.2 (2019-12-12). A descriptive statistical method was used to analyze the data and to calculate percentages, frequency and mean. The relationship between macrophyte species abundance and environmental variables was evaluated by CCA using R- software version 3.6.2 (2019-12-12). T test was used to compare the temporal patterns of macrophyte abundance in the study area.

Macrophyte species diversity in the river was computed using Shannon-Weiner Diversity Index following Shannon and Weiner (1963). The dominance of macrophyte species in the river was calculated using Simpson index following Magurran (2004).

3. Results

3.1 Macrophyte species composition, abundance and distribution

A total of twenty-six macrophytes species which belonged to fifteen families were recorded, and their relative frequency and density were determined (table 1). One of the macrophyte is free floating (water hyacinth), one is floating rooted (*Ipomoea aquatica*) and the rest are emergent. Emergent macrophytes had the highest percentage composition (92%). All the sites were dominated by emergent macrophytes that attained the highest relative density and frequencies followed by floating rooted and free-floating species. Comparatively, the most frequent species recorded in the river were Cynodon dactylon (8.9%), *Brachiaria* sp, *Echinochloa colona* L. and *Persicaria senegalensis* (7.1%), *Leersia hexandra*, *Ipomoea aquatica* and *Megathyrsus maximus* (5.4%). The remaining species accounted for less than 4% of frequency of occurrence. The highest density was recorded *Persicaria senegalensis* (22%), *Pontederia crassipes* (13.2%), *Cyperus latifolius Poir* (9.29%) and *Megathyrsus maximus* (7.84%). The remaining species accounted for less than 7% of coverage. Poaceae, which has eight species, has the highest diversity of macrophytes, followed by Onagraceae and Cyperaceae, which each have three species. Whereas Amaranthaceae, Asteraceae, Polygonaceae, Pontederiaceae, Convolvulaceae, Solanaceae, Acoraceae, Juncaceae, Ceratophyllaceae, Brassicaceae, Hydrocharitaceae and Malvaaceae had only one species for each. However, there were no significant differences in the abundance of macrophytes between the two sampling seasons (t-test p-value= 0.33675 which is > 0.05).

Cyperus latifolius Poir and *Cyperus papyrus* L were the dominant macrophytes in Yejera Bole sites. *Persicaria senegalensis, Pontederia crassipes* and *Megathyrsus maximus* were the dominant macrophytes in Koka and Guro Ruta sites due to high Nitrate and phosphorous contents in the soil.

Table 1

Identified macrophyte species in Awash River and their relative frequency and density

Species	Family	Life form	Relative frequency (%)	Relative density (%)
Acorus calamus	Acoraceae	Emergent	3.6	1.95
Alternanthera sessilis L.	Amaranthaceae	Emergent	3.6	0.68
Brachiaria mutica	Poaceae	Emergent	1.8	0.5
Brachiaria sp.	Poaceae	Emergent	7.1	5.36
Cynodon dactylon	Poaceae	Emergent	8.9	4.15
Cyperus articulatus L.	Cyperaceae	Emergent	3.6	5.96
Cyperus latifolius Poir	Ceratophyllaceae	Emergent	1.8	9.29
Cyperus papyrus L.	Cyperaceae	Emergent	1.8	6.76
Echinochloa colona L.	Poaceae	Emergent	7.1	0.92
Echinochloa stagnina	Poaceae	Emergent	3.6	2.05
Eichhornia crassipes	Pontederiaceae	Floating	3.6	13.2
Ipomoea aquatica	Convolvulaceae	Floating	5.4	6.81
Juncus effuses	Juncaceae	Emergent	1.8	0.27
Lagarosiphon cordofanus	Hydrocharitaceae	Emergent	1.8	0.36
Leersia hexandra	Poaceae	Emergent	5.4	2.39
Ludwigia abyssinica A. R	Onagraceae	Emergent	1.8	0.05
Ludwigia erecta L.	Onagraceae	Emergent	1.8	0.75
Ludwigia spp.	Onagraceae	Emergent	3.6	0.27
Panicum maximum Jacq	Poaceae	Emergent	5.4	7.84
Persicaria senegalensis	Polygonaceae	Emergent	7.1	22.44
Phragmites mauritianus	Poaceae	Emergent	5.4	4.18
Rorripa nastrutium aquatic	Brassicaceae	Emergent	1.8	0.84
Scripus articulatus L.	Cyperaceae	Emergent	1.8	0.22
Sida schimperiana Hochst.	Malvaaceae	Emergent	3.6	0.5
Solanum incanum L.	Solanaceae	Emergent	1.8	0.56
Sphaeranthus bullatus Mat	*Asteraceae*	Emergent	5.4	1.69

Table 2

Mean and standard deviation of environmental factors of the seven study sites n = 7

Sites	DO Mg/l	EC Mg/l	NO3 Mg/l	SRP Mg/l	pH Mg/l	TN Mg/l	TP Mg/l	TPW Mg/l	FV m/s	Tm cº	Clay %	Silt %	Sand %
Yb	7.84 ± 0.01	340.3 ± 0.41	3.80 ± 0.26	0.00 ± 0.00	7.66 ± 0.43	254.30 ± 1.47	120.20 ± 0.58	0.04 ± 0.86	0.00 ± 0.00	23.21 ± 0.17	8.40 ± 0.7	54.4 ± 1.07	37.2 ± 1.14
Ye	6.83 ± 0.13	316.62 ± 94.77	3.65 ± 0.05	0.00 ± 0.00	7.89 ± 0.09	142.60 ± 3.93	105.1 ± 10.58	0.00 ± 0.00	0.22 ± 0.03	23.45 ± 0.74	9.10 ± 1.2	29.9 ± 1.45	61.0 ± 2.26
Ab	5.90 ± 0.27	338.30 ± 1.06	0.00 ± 0.00	0.00 ± 0.00	8.08 ± 0.13	121.20 ± 1.28	2.520 ± 0.49	0.00 ± 0.00	0.33 ± 0.04	24.13 ± 0.53	1.40 ± 0.52	27.3 ± 0.82	71.3 ± 1.25
Ko	4.38 ± 0.33	488.10 ± 5.49	18.2 ± 0.17	8.72 ± 0.73	8.06 ± 0.19	155.15 ± 3.77	125.6 ± 3.44	7.63 ± 1.01	0.17 ± 0.03	24.87 ± 1.12	1.80 ± 0.79	56.1± 1.10	42.1± 0.99
Gr	4.72 ± 0.79	338.40 ± 7.17	29.7 ± 1.50	8.56 ± 0.74	7.71 ± 0.60	189.29 ± 1.55	127.6 ± 2.86	6.14 ± 0.72	0.15 ± 0.03	24.55 ± 0.87	41.3 ± 1.34	48.4 ± 2.01	10.3 ± 2.06
At	5.65 ± 0.28	425.72 ± 1.53	5.21 ± 0.22	0.00 ± 0.00	8.08 ± 0.10	113.25 ± 2.28	61.29 ± 3.42	6.06 ± 0.69	0.30 ± 0.01	24.76 ± 0.32	29.7 ± 1.06	19.4 ± 1.65	50.9 ± 2.47
Sr	5.79 ±	310.95 ± 6.80	8.24 ± 0.49	0.82 ± 1.83	7.20 ± 0.55	37.45 ± 1.85	31.51 ± 1.42	3.89 ± 0.59	0.36 ± 0.04	25.50 ± 0.74	13.3± 170	3.60 ± 1.43	83.1 ± 3.03

Note: DO (Dissolved oxygen); EC (Electrical conductivity); No3 (Nitrate); SRP (soluble reactive phosphate); TN (Total nitrogen); TP (Total phosphorus in soil); TPW(Total phosphorus in water); FV (Flow velocity) and Tm (Temperature)

3.2 Physicochemical parameters in the study sites

The spatial variation of environmental factors investigated is given in table 2. High variation of environmental factors among sites was observed for all parameters. The mean values ranged between 4.38 – 7.84 mg/l for dissolved oxygen, 340.3 – 488.10 µs/cm for electrical conductivity, 0.0 - 29.73 mg/l for nitrate, 7.20 – 8.08 for PH, 37.45 – 254.30 mg/l for total nitrogen, 0.0 – 8.72 mg/l for soluble reactive phosphate, 2.520 – 127.6 mg/l for total phosphorus, 0.0 -7.63 mg/l for total phosphorus in water, 0.0 – 0.36 m/s for flow velocity, 23.21 – 25.5 0^C for temperature, 1.4 – 41.3% for clay, 3.6 – 56.1% for silt, 10.3 – 83.1% for sand, respectively. The study showed certain temporal variation in environmental factors. The mean concentration of dissolved oxygen, total phosphorus, total nitrogen, Flow velocity, nitrate and soluble reactive phosphate were higher during post rainy season than dry season. Whereas the mean pH value and water surface temperature were lower in the post rainy season than dry season, but the variations were not significant (Two sample t test p-value = 0.9874 which is > 0.05%).

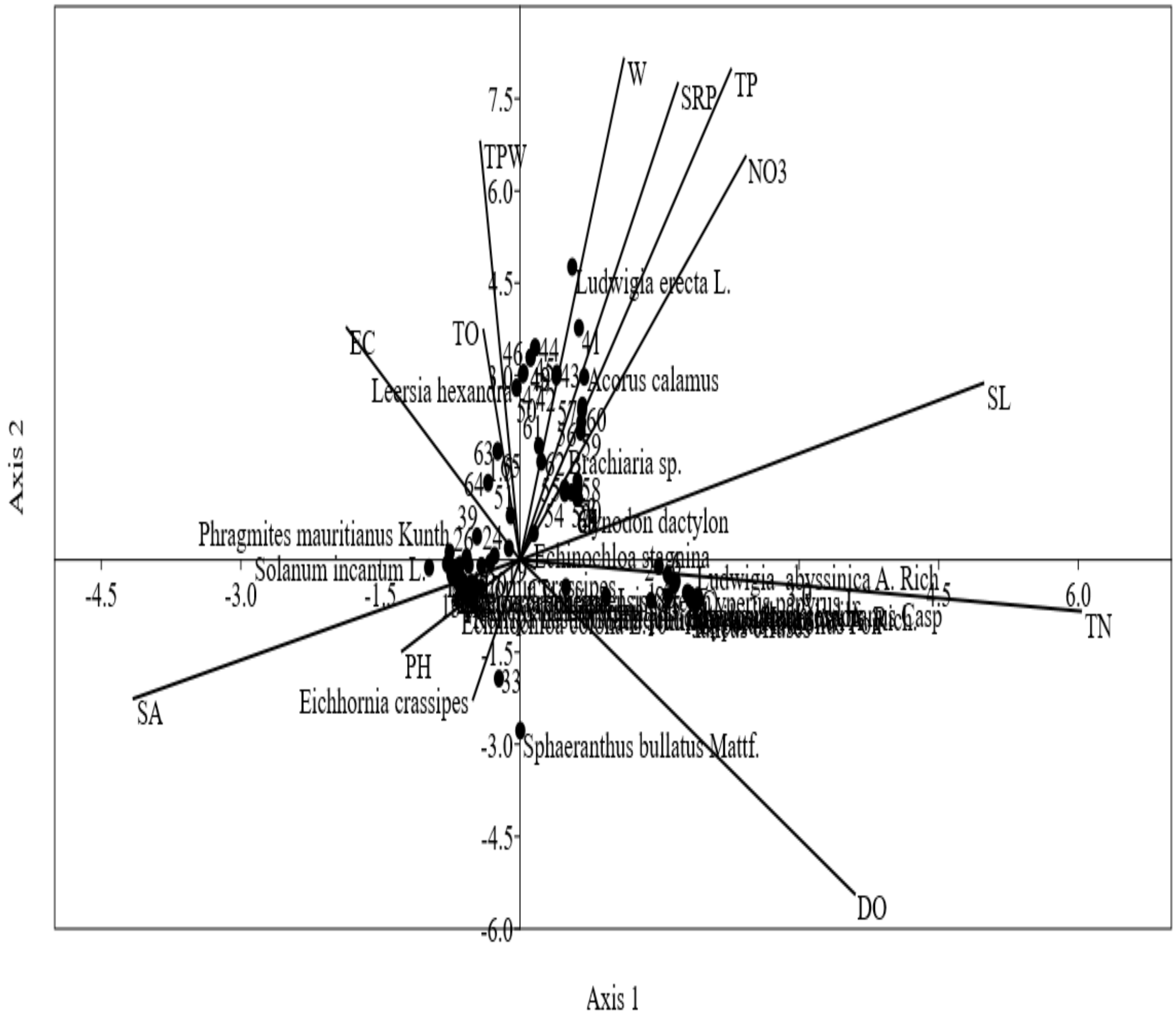
3.3. Relationship between environmental factors and density of macrophyte species

The results of Canonical Correspondence Analysis (CCA) between environmental factors and macrophyte data showed that the first two axis have made up 50.39% of the cumulative percentage of variance in species–environmental factor (table: 3). The first axis, which contributed 27.39% of the variance, were positively correlated with TPW, W, NO_3 and SRP and the second axis with DO and TN. The abundance of *Cyperus articulatus* L., *Echinochloa colona* L., *Solanum incanum* L., *Pontederia crassipes*, *Persicaria senegalensis*, *Rorripa nasturtium aquaticum*, *Ipomoea aquatica* and *Phragmites mauritianus* was positively correlated with TPW, NO_3, SRP and TP of the first axis, whereas the abundance of other species had negative association with those physicochemical parameters (figure: 2). Especially, the abundance of, *Persicaria senegalensis, Ipomoea aquatica* and had a strong positive correlation with TPW, NO_3, SRP and W. In contrast the abundance of Persicaria senegalensis, Ipomoea aquatica and *Pontederia crassipes* had a weak positive association with Clay, EC, TO and pH. On the other hand, the abundance of *Sphaeranthus bullatus*, *Ludwigia spp., Sida schimperiana, Alternanthera sessilis, Lagarosiphon cordofanus Casp, Brachiaria mutica, Juncus effuses, Ludwigia abyssinica, Cyperus latifolius, and Cyperus papyrus* L., was positively correlated with DO, TN and Silt. Moreover, the abundance of

Cynodon dactylon, Leersia hexandra, *Acorus calamus* and *Brachiaria sp*, had non- linear association with almost all physicochemical parameters.

Figure 2

Plot of the first two axis of the Canonical Correspondence Analysis (CCA) for macrophyte species and environmental variables



Abbreviations: E.crassipes: Eichhornia crassipes; C. dactylon: Cynodon dactylon; S.bullatus: Sphaeranthus bullatus; S.incanum: Solanum incanum L; J. effuses: Juncus effuses; L. abyssinica: Ludwigia abyssinica; L. cordofanus Casp: Lagarosiphon cordofanus Casp; B. mutica: Brachiaria mutica; S.schimperiana: Sida schimperiana; C. latifolius: Cyperus latifolius; C.papyrus L: Cyperus papyrus L.; A. sessilis: Alternanthera sessilis, P.mauritianus: Phragmites mauritianus; E. colona L: Echinochloa colona L; C. articulatus L: Cyperus articulatus L; C. articulatus L: Cyperus articulatus L.

Table 3

Eigenvalues, cumulative percentage variance of species-environment relation, and correlation coefficient of environmental factors with the first two axes in Awash River

Parameters	Axis 1	Axis 2
Eigenvalues:	0.7593	0.6374
Cumulative percentage of variance of species data	27.39	23
Dissolved oxygen (DO)	-0.822	-3.80E-02
Electrical conductivity (EC)	0.303	-2.80E-02
Nitrate (NO3)	0.655	-3.90E-01
Soluble reactive phosphate (SRP)	0.68	-4.40E-01
Total nitrogen (TN)	0.465	5.40E-01
Total phosphorus (TP)	0.683	-4.30E-01
Total phosphorus in water (TPW)	0.703	8.20E-05
Flow velocity (FV)	-0.596	-5.70E-01

4. Discussion

4.1 Macrophyte abundance and distribution

Ethiopian rivers, like other tropical rivers, are endowed with diverse populations of riparian vegetation which vary in nature, density, types and functions according to locations. Aquatic macrophyte species composition assessment in the Awash River revealed that there were 26 species which belonged to 15 families. Similar or less numbers of macrophyte species were documented from other studies. Ekpo *et al.* (2016) identified 33 families and 98 species of macrophyte in Odot river, Nigeria, while Dienye (2016) noted that there were 10 families of macrophytes representing 12 species in the New Calabar River, among others. The family Poaceae had the highest number of species, while Onagraceae and Cyperaceae had the second in this study. This result is in consonance with the report of Dienye (2016). Seasonal variations of aquatic macrophyte species diversity followed the order: post rainy season greater than dry season, although the variation was not significant (t-test, p-value = 0.2406 which is > 0.05). Ali and Kushi (2001) reported that Poaceae and Cyperaceae were most represented with 19 and 13 species in the post rainy season and 9 and 6 in the dry season, respectively. In post rainy season the numbers of individual macrophyte species a little bit more than the dry season, which might be due to different factors such as lack of precipitation and human utilization in dry season. The work of Kassa *et al.,* (2021) also indicated that macrophytes were more common in the post rainy season because of the absence of human interference due to the high volume of water and flood condition. The absence of significant differences in density and species composition of macrophytes in Awash River could be due to the lack of significant variation between post rainy and dry seasons in environmental factors that determine the abundance of macrophytes, and this result is contrary to the work of Pompeo and Moschini-Carlos, (1996). In their study, there were significant difference in density of macrophytes in Mogi Guacu River due to seasonal variations of temperature and rainfall.

4.2 Macrophyte species diversity in Awash River

The highest macrophyte species diversity index (H′) and evenness index values among the seven sampling sites in the Guro Ruta site was with H′ value of 1.96 and Awash Tuti site had highest evenness index value of 0.84 and Koka site with H′ value of 1.72 and with evenness index value of 0.70. Yejera Bole and Yejera Ebu sites were with medium anthropogenic impacts not threatened by industrial and urban expansions and expected to have high diversity of species and low evenness value compared with other sites in the study area. The decreases in evenness index might be due to the presence of diversified macrophyte species such as, Cyprus *papyrus*, *Cyperus latifolius* and *Persicaria senegalensis*. These lower evenness values indicated that the sites are diversified by macrophyte species. Lower diversity index (H ′) value of 0.89, 1.21, 1.29, were observed in Awash Bello, Awash Tuti and Sirie Robi sampling sites, respectively. Higher anthropogenic impacts could be expected to cause a decrease in species diversity and composition and the mean value of sediment texture 71.3%, 50.9% and 83.1% were sandy, respectively. Among the sampling sites Koka Nagawo and Guro Ruta were highly invaded by water hyacinth. This has an impact on the diversity of macrophytes and other aquatic organisms. The macrophyte species diversity of Awash River is low compared with some published data of similar work on tropical and temperate Rivers (Ekpo *et al.*, 2016). According to the work of Ekpo *et al*. (2016) on abundance, distribution and biotic indices of aquatic macrophyte community in Odot River, Niger obtained Shannon diversity index (H’) value of 2.64. Also, Biswas *et al*. (2016) biomonitoring macrophytes diversity and abundance in Ganga River, India obtained Shannon diversity index (H’) value of 2.74. But the value obtained in Awash River was higher than that of Wel river, Poland with Shannon diversity index (H’) value of 0.74 (Szoskiewicz *et al*., 2014). Mechore *et al*., (2010) reported that homogeneity of habitats favored lower diversity of macrophytes in water courses of Bloscica and Cerkniscica (Slovenia).

4.3 Influence of environmental variables on macrophyte abundance

Environmental drivers that influence the macrophyte distribution in rivers and streams are comparable across the world (Johnson & Hering, 2009). Numerous studies have displayed that the distribution and composition of macrophytes in the river is a result of the interactions of numerous ecological variables, including abiotic, biotic and anthropogenic factors (Kennedy *et al*., 2016). In this study, 50% of the explained variations in macrophyte diversity were due to concentration of nutrients (N and P), SRP, soil texture and flow velocity (figure 2) and half of the unexplained variation in macrophyte diversity could be due to the influence of human and livestock activities on the river bank and riparian agricultural activities. Among the study sites, Koka and Guro Ruta were characterized by having higher nitrate, soluble reactive phosphate, and sediment and water total phosphorus. However, *Cyperus articulatus*, *Persicaria senegalensis*, *Ipomoea aquatica*, *Panicum maximum* Jacq and *Phragmites mauritianus* were found in nutrient rich sites whereas *Echinochloa colona* was found on both nutrient rich and poor sites. The occurrence of this macrophyte in the river seems not to be affected by differences in the nutrient condition among sites, and ability to colonize these varied sites indicates its potential to adapt to diverse trophic conditions (Tamire & Mengistou, 2012). On the other hand, *Cyperus articulatus* was restricted to sites where there was higher nutrient concentration, which suggests that this species needs high nutrient levels. Similarly, the abundance of *Eichhornia crassipes* was positively correlated with total phosphorus, soluble reactive phosphate and nitrate. *Cyperus papyrus* and *Cyperus latifolius* were observed in relatively low nitrate, sediment phosphorus and very low soluble reactive phosphate sites. Similar observations of the negative effects of increase pH, SRP and TP on *Cyperus papyrus* and *Echinochloa stagnina* was noted in some studies in the Ethiopian rift valley lakes (e.g., Tamire & Mengistu, 2012). The result indicated that the increase in pH, soluble reactive phosphate and TP could significance negatively affect the density of *Brachiaria* species, *Ludwigia abyssinica* and *Leersia hexandra* (figure 2). Similar observations of negative effects of increase pH, soluble reactive phosphate and TP on the density of *Leersia hexandra*, *Nymphaea lotus*, *Phragmites karka* and *Ipomoea aquatica* and *Ludwigia abyssinica* were found in both nutrient-rich and nutrient-poor sites, as noted in some studies in Lake Tana (Kassa *et al.*, 2021). *Ipomoea aquatica* was found in Koka and Gro Ruta sampling sites which had high concentration of TP, SRP and Nitrate. Kassa *et al.* (2021) noted that *Ipomoea aquatica* have the ability to colonize varied sites which indicates their potential to adapt diverse tropic conditions. Total composition and abundance of macrophyte communities in Awash River was positively correlated with sediment nutrient (total nitrogen ($r = 0.5$) and total phosphorus ($r = 0.58$) and inversely (negatively) correlated to flow velocity ($r = - 0.59$) and sandy sediment ($r = - 0.4$) which might be related to the observation that finer sediments tend to have higher nutrient (e.g., nitrogen and phosphorus content) than coarser sediments and significant ($p = 0.004$). The observation that the flow velocity is one of environmental factors affecting composition and abundance of macrophytes is consistent with Chambers *et al.* (1991) who found that the abundance of macrophytes was significantly ($P < 0.0005$) and inversely correlated ($r > - 0.68$) with flow velocity over the range 0.01- 1m/s in the Bow River, Alberta.

Flow velocity is an important environmental factor that determines the species composition and abundance of macrophyte communities. Thus, *Cyperus latifolius* and *Cyperus papyrus* were the dominant species on Yejera Bole sites of Awash River with stagnant water (no flow) whereas Persicaria senegalensis dominated in Yejera Ebu, Guro Ruta and Koka Nagawo sites of moderate flow velocity within the range of (0.15 - 0.22 m/s).

4 .4 Physico-chemical conditions in comparison with past data

The range value of DO in this study was 4.38 - 7.84 mg/L. This was similar to the same range of previous studies 4 – 8.6 mg/L by Wondimu, (2014) and 4.67- 7.84 by Degefu *et al.* (2013) in Awash River. The possible entry of organic matter during runoff from the surrounding agricultural fields and their decomposition contributed to the low levels of dissolved oxygen in the bank sites.

The Awash River, is an important center for dry- land biodiversity conservation with relatively low water temperatures, varying only within small limits Tikssa *et al.* (2009). The range value of the surface water temperature showed almost no change during the last decade as the mean value found in this study 23.21 -25.50 °C. This fell within the range value 23.53 -25.65 reported by Degefu *et al.* (2013). The range was within the range of variation observed in most tropical water bodies (John, 1986). The observed pH value 7.20- 8.08 also fell within the range of 7.79-8.24 reported by Tikssa *et al.* (2009). The pH value could mainly be controlled by freshwater swamp exudates that regulate the acidity of the water body. Conductivity showed almost no change during previous studies as the mean values found in this study ranged 340.3 - 488.1 µs/cm. This was comparable with the values 327.67 - 492.87µs/cm reported by Degefu *et al.* (2013). The long-term similarity of physico chemical conditions might be good for macrophyte dynamics because the climate and other factors may not change the physico chemical properties of the river. This implies that the composition and diversity of macrophyte species might be stable.

5. Conclusion

This is the first study to investigate the effect of environmental factors on macrophyte species diversity, composition and abundance in the Upper Awash River. The study of macrophyte species in the Upper Awash River basin revealed notable variation in species composition, abundance, and diversity, strongly influenced by environmental factors such total nitrogen and phosphorus, flow velocity, nitrate and sediment texture. 50% of the macrophytes diversity was determined by the environmental factors like total nitrogen and phosphorus, flow velocity, nitrate (water) and sediment texture. The dependence of macrophyte abundance on some environmental factors suggests that small increase in nutrient levels may initiate significant changes in the abundance of observed macrophytes. This study may be used as a starting point for future work, particularly in the framework of the ecosystem services, monitoring of aquatic ecosystems and conservation programs. Further studies should continue on the middle and lower Awash River catchments. For the Upper catchment half of the unexplained environmental factors that influence the macrophyte distribution in the Awash River basin could be due to the intense human and livestock activities on the river bank and riparian agricultural activities. The impact of these factors on the macrophytes should be investigated in the future, nevertheless regulations should be in place to prevent or reduce these impacts in and around Awash River.

Disclosure statement
No potential conflict of interest was reported by the author(s).

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