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Diversity, Phytochemical Screening and Ethnobotany of Macrophytes Within Freshwater Streams in the Coastal City of Limbe (Cameroon)

Miranda Egbe Awo[1]*, Bernadette Noumsi[1], Lambert Fosso[1] and Beatrice Ambo Fonge[1]
Department of Plant Science, University of Buea, Southwest Region, Cameroon
***Corresponding Author: awo.miranda@ubuea.cm; Orcid:0000-0003-3965-2818**

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ABSTRACT

The emergence and spread of diseases continue to be a major public health concern. Despite the successful management of common tropical diseases by conventional medicine, the high cost of drugs and the lack of health facilities in rural areas of most developing countries limit its use and promote over reliance on alternative medicine for the treatment of diseases. Freshwater streams are good sites harboring some of these medicinal plants. There is very little information on the floristic composition of these streams. The main objective of this study was to assess the floristic composition, ethno-botanical uses and to conduct a phytochemical screening of some aquatic macrophytes in Limbe 1 Municipality. Following the floristic survey on three prominent streams, 300 semi-structured questionnaires were purposively administered to inhabitants of Limbe 1 Municipality. A show-and-tell method was used to identify aquatic plants with medicinal value. Qualitative phytochemical analysis of nine selected plants was done using standard procedures. A total of 46 macrophytes from 23 families and 41 genera were identified across these streams; Forty were emergent. Submerged plants were *Ceraptoteris thalictroides*, *Hydrocharis dubia*, *Anubias bateri*, and *Persicaria amphibia* while *Lemna minor* and *Nymphaea lotus* were floating. A high Shannon diversity (2.70, 2.68 and 2.66) was recorded in Moliwe, Bosumbu and Laverie Espoir, respectively. Only 24 aquatic plants identified had medicinal value, with *Commelina benghalensis*, *Costus lucanucianus*, *Eremomastax speciosa*, *Acmella caulirhiza* and *Ageratum conyzoides* having the highest use value and had varying quantities of flavonoids, alkaloids, glycosides, saponins, steroids, tannins, cardiac glycosides and terpenes in their methanol extracts. Most cited disease categories treated using these aquatic plants were gynecological, respiratory and dermatological, etc. Further empirical investigations to characterize these bioactive phytochemicals and their biosafety should be carried out. These valuable ecosystems should be protected for their valuable ecosystem services.

INTRODUCTION

Aquatic macrophytes are plants that occupy different ecological niches in the aquatic ecosystem and are morphologically adapted to live in this environment **(Fonge *et al.*, 2023)**. They play crucial roles in the ecosystem and generate diverse ecosystem services, ranging from absorbing and sequestering of nutrients and heavy metals, provision of food,

serving as habitats to a wide range of macro and microorganisms living in and around these sites **(Anyinkeng *et al*., 2020; Fonge *et al*., 2023)**. They also maintain water quality and contribute to the overall biodiversity of the aquatic ecosystem. According to the Food and Agriculture Organization **(FAO, 2012)**, just 2% of vascular plants are aquatic but the number of aquatic plants species worldwide is substantial, with an estimated range of about 30,000 to 50,000 species worldwide occurring in 33 plant families **(Ryan & John, 2012)**. Despite implicated in the above-mentioned ecosystem services, most aquatic plants are treated as weeds, and are given very less attention.

Ethnobotany, which is the scientific study of the relationships between plants and people, involves investigating how various cultures use plants for purposes such as shelter, medicine, food and rituals **(Patiola *et al.*, 2023)**. Despite the vulnerability and constant negligence of aquatic plant roles, they possess ethnobotanical potentials that are still untapped reservoirs of antimicrobial and functional compounds which have potentials as medicinal ingredients for the development of novel functional drugs and neutraceutical products **(Pooja *et al*., 2020)**. These aquatic plants contain secondary metabolites, which are organic compounds that are not directly involved in the growth, development, and reproduction process in them, but play crucial roles in their defense mechanism interactions with other organisms and adaptation to environmental stress. Beyond the roles these secondary metabolites (alkaloids, flavonoids, terpenoids, phenols etc.) play in the wellbeing of plants, they also provide the medicinal, nutraceutical/pharmaceutical services that are useful for mankind **(Ntie-Kang *et al*., 2013)**. Among the roles plants play is for example the use of alkaloids like quinine to treat malaria **(Uzor, 2020)** and also the use of *Daucus carota* seed oil which actively contains terpenoids, particularly monoterpenes like limonene and β-pinene which inhibit *Helicobacter pylori* by disrupting the cell membrane **(Bansel & Priyadarsini, 2022)**.

Several studies have been carried out in the aquatic ecosystems in Cameroon, addressing different aspects such as toxicological aspects **(Ndjonka *et al.*, 2017)**, freshwater quality **(Awo *et al*., 2020; Fonge *et al.*, 2023; Kenko *et al*., 2023; Asmare *et al*., 2024; Djouego *et al*., 2024; Njouondo *et al*., 2024)**, inventories, spatial distribution and diversity of aquatic plants including algae **(Anyikeng *et al.*, 2020; Awo *et al*., 2021; Nwamo *et al*., 2023)**. There has been a complete neglect on the diverse medicinal roles these plants may be playing in our traditional ecosystems, especially highlighting their cultural values. During the era of COVID-19 (outbreak in 2019), several plant based remedies were preferred over vaccines due to the controversies and myths that were associated with their production, coupled with the unavailability of these vaccines in certain localities of most African countries.

Numerous ethnobotanical surveys carried out across Cameroon have focused on terrestrial plants to treat different ailments like amoebiasis, wound healing, cough, fever, gastritis, and gynecological complications **(Adjanohoun *et al*., 1996; Focho *et al*., 2009; Jiofack *et al*., 2009; Mpondo *et al*., 2012)**. Additionally, the proportion of the community using these herbal medicines varies considerably between ethnic groups and urban and

rural areas **(Titanji *et al*., 2008)**. Herbal medicines are preferred to orthodox drugs in some communities like the Baka pygmies of Cameroon **(Mpondo & Dibong, 2012)**. Significant research has been carried out on medicinal plants and their bioactive compounds **(Titanji *et al*., 2008; Ntie-Kang *et al*., 2013; Fedzoung *et al*., 2020)** in major plant families such as Fabaceae, Moraceae, Brassicaceae, Rutaceae, Meliaceae, Euphorbiaceae, Asteraceae, Zingiberaceae, Ochnaceae, Bignionaceae, and Sapotaceae. Terpenoids are the most abundant secondary metabolites in Cameroonian medicinal plants, making up 26.0% of the isolated compounds, followed by flavonoids, alkaloids, xanthones, quinines, and glycosides, all of which are potent secondary metabolites active in their therapeutic properties **(Ntie-Kang *et al*., 2013)**. Given the diverse use of plant-based remedies by different populations in different cultural settings, there is a need to document the different plants and preparation methods available in the management of disease to develop potent and affordable remedies. The objectives of this study were to carry out a floristic and ethno-botanical survey of aquatic plant composition and their medicinal uses and to screen the medicinal aquatic plants for phytochemicals.

MATERIALS AND METHODS

1. Description of study area

1.1 Geographical location of study area

Limbe town formally known as Victoria is a coastal city located in the southwestern part of Cameroon between latitudes 4º and 4º20’ North and between longitude 9º and 9º25’ East and lies along Ambas Bay in the Gulf of Guinea, at the southern foot of Mount Cameroon **(Nchia, 2010)**. It is renowned for its rich biodiversity and unique ecosystems such as the presence of the Atlantic Ocean and many fresh water bodies, which harbor many life forms. This region has a sub-equatorial climate with two main seasons, the rainy season that runs from March to October with an average annual rainfall, which ranges from 2,000 to 10,000mm and the dry season that runs from November to February. Fako has a humid climate with an annual relative humidity of 70-80% **(Nchia, 2010)**. Currently Limbe is sub divided into three administrative sub divisions: Limbe 1, Limbe 2 and Limbe 3 (Fig. 1). This research was carried out in three streams in Limbe 1 Municipality, including Moliwe stream (4.06'13.94" N and longitude 9.7'38.155" E), Bosumbu stream, (latitude 4.06'29.23"N and longitude 9.21'15.61"E), and Mile 2 stream (Latitude 4.02'7.93"N and longitude 9.20'45.95" E).

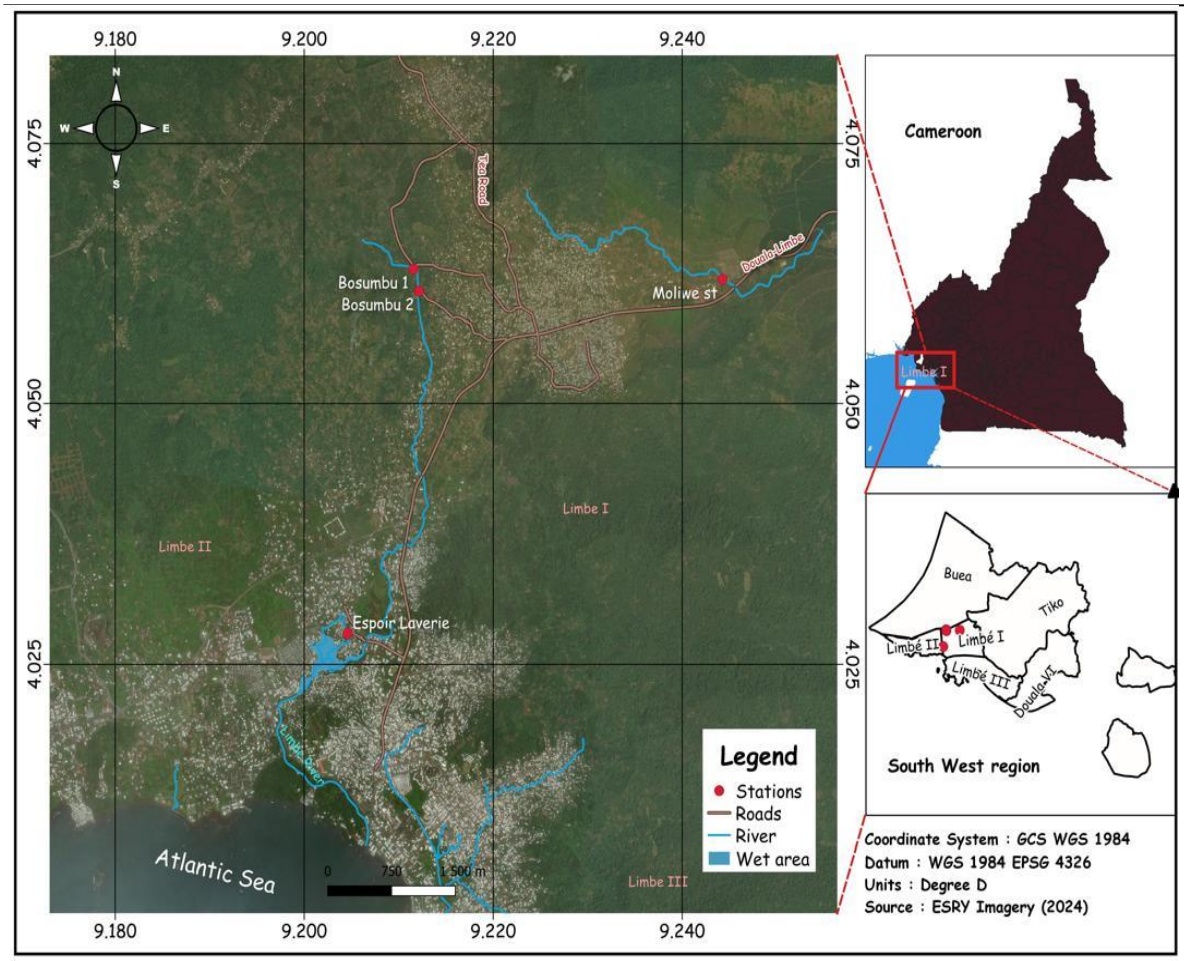

Fig. 1. A map of Limbe Municipality in Southwest region Cameroon

2.Determination of the floristic composition of aquatic macrophytes in study area

Two transects of 500 meters were placed across streams. Measurements were across the entire width of the stream, up to 4 meters of the banks to capture riparian plants. Within each transect, three plots of 100 meters were laid, each separated by 50 meters. Within each plots, sub-plots of 10m by 10m were labeled. Quadrats were mapped measuring 1m by 1m. Within each quadrat, all plant species were counted, identified and recorded. Plant sampling was carried out in the month of November during the ends of the raining season for two weeks. Individual plant species were counted in each quadrat and the number from all other plots were summed to give the total. Plant identification was done by comparative morphology and the use of identification keys in textbooks and journals. Plants that could not be identified in the field were taken to the Limbe Botanic Garden Herbarium for proper identification **(Kefalides, 1989; Liyama *et al.*, 1999; Latham, 2003; Folefack *et al.*, 2010; Van der veken *et al.*, 2012)**.

3. Ethnobotanical survey of aquatic macrophytes

The field survey was conducted between January and February 2024. The purposive sampling technique was used to sample 300 participants, aged between 20 years and above who had knowledge about medicinal plants. Through a consultative meeting with a few elders and quarter heads in the community, an initial number of respondents was selected who later referred us to others through an existing network within the study area. Saturation was reached when no new data on medicinal plant species or methods of preparation was derived. Three hundred close ended semi structured questionnaires were made and distributed to the three communities in Limbe 1 Municipality. The questionnaires comprised of 4 sections: the demographic information, botanical information (local name of the plant, plant part used, method of drug preparation, duration and frequency of administration/treatment and their conservation). The show and tell method was carried out coupled with live plant samples gotten from macrophytes diversity studies. Participants also responded to oral interviews to confirm their responses. This was complimented with photographs and live plant specimens of these plants for confirmation. These specimens were collected directly from the freshwater streams in the study area and were identified by a set of experts from the Limbe Botanical Garden. Only photographs of plants with lone occurrence were provided to ensure their conservation. All respondents filled the informed consent form before taking part in the study.

4. Phytochemical screening of some aquatic macrophytes

4.1. Plant selection and extraction procedure

Nine plants were screened for the presence of phytochemicals (Table 1). Plants with the highest use value selected were *Commelina benghalensis* L., *Ageratum conyzoides* L., *Acmella caulirhiza* Delile, *Costus lucanusianus* J. Braun & K. Schum and *Eremomastax speciosa* (Hochst) Cufod were screened for phytochemical based on their high use value gotten from ethno-botanical data. Four typical aquatic plants like *Nymphaea lotus* L., *Hydrocharis dubia* (Blume) Backer, *Persicaria amphibia* (L.) Gray, and *Anubias barteri* var *barteri* Schott, though with little or no citation, they were reported as useful elsewhere. The two criteria used for the selection of these nine plants species were based on their use value and typical aquatic plants. The eight phytochemicals screened were alkaloids, flavonoids, cardiac glycosides, phenols, saponins, steroids, tannins and terpenoids.

Table 1. Plants used for phytochemical screening

S/N	Plant name	Family	Plant parts	Use value
1	*Eremomastax speciosa* (Benth.)	Acanthaceae	Leaves	0.053
2	*Commelina benghalensis* L.	Commelinaceae	Leaves/stem	0.037
3	*Acmella caulirhiza* (L.) R.K.	Asteraceae	Whole	0.053
4	*Costus lucanusianus* Braun & K.	Costaceae	Leaves/stem	0.057
5	*Nymphaea lotus* L.	Nymphaeaceae	Leaves	0.003
6	*Hydrocharis dubia* (B) Backer	Hydrocharitaceae	Leaves	0
7	*Persicaria amphibia* (L.) Gray	Polygonaceae	Leaves	0
8	*Ageratum conyzoides* L.	Asteraceae	Whole	0.053
9	*Anubias barteri* Schott.	Araceae	Leaves	0

Fresh plants were harvested randomly from the streams, washed and oven-dried to constant weight at a temperature of 50ºC in the Life Science Laboratory of the University of Buea. The dried materials were removed and macerated using a mortar and pestle to give a fine powder. Ten (10) grams of each plant were weighed and placed in 500ml of methanol for three days inside air tight containers. Methanol was chosen as the extraction solvent due to its polarity, low toxicity, and compatibility with analytical techniques such as chromatography **(Smith *et al*., 2018)**. After extraction, the mixture was filtered using a Whatman filter paper with a pore size of 25µm.

5. Qualitative phytochemical screening

Pure extracts were subjected to different analytical procedures to detect the presence of the various secondary metabolites, as presented in Table (2). The results from the qualitative phytochemical screening were confirmed using a color chart as described by **Mudiana *et al.* (2023)**.

Table 2. Standard analytical methods and observations used for phytochemical screening

Test	Method	Observation	Reference
Saponins	Frothing test	Persistent foaming	**Visweswari *et al.* (2013)**
Flavonoids	Cyanidine test	A brick red coloration	**Savithramma *et al.* (2011)**
Tannins	Ferric chloride test	A blue-black color	**Preeti *et al.* (2017)**
Alkaloids	Dragendorf's tets	An orange spot against a yellow background	**Ndam *et al.* (2014)**
Cardiac glycoside	Killer-Killani test	A brown ring followed by a greenish ring in the acetic layer	**Jeyabaskar *et al.* (2019)**
Phenolic	Ferric chloride test	Greenish precipitate	**Ndam *et al. (*2014)**
Steroids	Lieberman-Burchad test	A blue green coloration	**Rahman *et al.* (2017)**

6. Data analyses

Data from macrophytes diversity were entered in Microsoft Excel 2013 and analyzed for the ecological parameters as described by **Awo *et al*. (2021)**.

a) Relative frequency

Relative frequency was calculated as follows:

(Absolute frequency / total number of individuals) x 100-------- (1)

b) Shannon-Weiner diversity

Shannon Wiener diversity index was used to determine plants diversity of the three streams:

$H' = -\sum_{i=1}^{s} Pi \ln Pi$ ---------- (2)

Where, H'= Shannon index of species diversity

Pi= Proportion of total sample belonging to the i^{th} species

c) Sorenson's similarity index

Similarity index was calculated using the Sorenson's similarity index as shown below:

$Ci = \frac{2C}{a+b}$ ---------- (3)

Where, c is the number of species common to both sides,

a is the number of species in the first site

b is the number of species in the second site,

The following indices were used to analyze data generated from ethno-botanical survey as described in **Rosangela *et al.* (2019)**.

a) Relative frequency of citation (RFC)

$RFC = \frac{FC}{N}$---------- (3)

Where, FC= the number of informants who mentioned the plant

N= the number of informants participating in the survey

b) The Use Value (UV)

UV= $\Sigma(\frac{Ui}{N})$_____ (4)

Where, Ui is the Number of uses mentioned by each informant for a given species

N is the total number of informants participating in the survey.

c) Fidelity level (FL)

$FL = \frac{Ip}{Iu} x\ 100$---------- (5)

Where, Ip is the number of citations for a use given by an informant; Iu is the total number of informants that mentioned the plant for any use; data from physicochemical parameters were analyzed using the R statistical analyzing package and all data are represented in tables, chart and graphs.

RESULTS

1. Macrophyte diversity and physicochemical parameters in Moliwe stream, Bosumbu stream and Laverie Espoir

1.1. Macrophyte diversity in Moliwe, Bosumbu and Laverie Espoir

Results of the floristic survey are presented in Table (4). A total of 46 macrophytes were identified across the three streams from 23 families and 41 genera. A majority of all identified macrophytes present were emergent plant (86.95%). Just a small proportion was submerged plants (10.86%). The submerged plants present were *Ceraptoteristhalictroides*, *Nymphaea lotus*, *Hydrocharis dubia*, *Anubias bateri*, and *Persicaria amphibia* (L.) Gray. Just two macrophytes were floating (*Lemna minor* L. and *Nymphaea lotus* L.). Moliwe stream had a total of 25 plants species, Bosumbu stream had 24 plants species, and Laverie Espior stream, 26 plants plant species, as shown in Table (3).

Table 3. Plant species and their relative abundance across the three streams; Moliwe, Laverie Espoir, Bosumbu watershed

S/N	Species	Habit/Form	Family	M	RA(%)	B	RA(%)	E	RA(%)
1	*Justicia secunda* vahl	Herb/Emergent	Acanthaceae	0	0	21	1.16	0	0
2	*Eremomastax speciosa* (Hochst) Cufod	Herb/Emergent	Acanthaceae	0	0	181	10	0	0
3	*Dicliptera chinensis* (L.) Juss	Herb/Emergent	Acanthaceae	70	3.4	0	0	103	7.77
4	*Alteranthera sesilis (L.) R.Br ex DC.*	Herb/Emergent	Amaranthaceae	33	1.61	0	0	0	0
5	*Colocasia esculentus* (L.) Schott	Herb/Emergent	Araceae	93	4.52	13	0.71	10	0.75
6	*Alocasia microrrhizos* (L.) G. Don	Herb/Emergent	Araceae	37	1.79	0	0	0	0
7	*Anubias barteri* var *barteri* schott	Herb/Submerged	Araceae	0	0	460	25.41	36	2.72
8	*Lemnar minor* L.	Herb/Floating	Araceae	109	5.29	0	0	47	3.54
9	*Alocasia cucullata* (Lour.) G.Don	Herb/Emergent	Araceae	75	3.64	0	0	7	0.52
10	*Ageratum conyzoides* (L.)	Herb/Emergent	Asteraceae	66	3.21	67	3.7	91	6.87
11	*Eclipta prostrata* (L.)L.	Herb/Emergent	Asteraceae	11	0.53	0	0	0	0
12	*Crassophalum crepidioides* (Benth.)S. Moore	Herb/Emergent	Asteraceae	0	0	21	1.16	0	0
13	*Emilia coccinea* (Sims) G.Don	Herb/Emergent	Asteraceae	17	0.83	38	2.1	3	0.22
14	*Chromolaena odorata* (L) R.M. Kings & H.	Herb/Emergent	Asteraceae	0	0	0	0	17	1.28
15	*Acmella caulirhiza* Deilie	Herb/Emergent	Asteraceae	15	0.73	0	0	46	3.47
16	*Adenostemma lavenia* (L.)Kuntze	Herb/Emergent	Asteraceae	0	0	0	0	13	0.98
17	*Nasturium officinale* W.T. Aiton	Herb/Emergent	Brassicaceae	0	0	55	3.04	47	3.55
18	*Commelina benghalensis* L.	Herb/Emergent	Commelinaceae	450	21.85	173	9.56	33	2.49

S/N	Species	Habit/Form	Family	M	RA(%)	B	RA(%)	E	RA(%)
19	*Aneilema umbrusum* (Vahl) Kunth	Herb/Emergent	Commelinaceae	25	1.21	47	2.59	0	0
20	*Commelina diffusa* Burm.f.	Herb/Emergent	Commelinaceae	0	0	139	7.68	0	0
21	*Calystegium sepium* (L.) R.Br	Herb/Emergent	Convolvulaceae	0	0	41	2.27	16	1.20
22	*Costus lucanusianus* J. Braun & K. Schum	Herb/Emergent	Costaceae	34	1.65	24	1.32	7	0.53
23	*Luffa aegyptiaca* Mill	Herb/Emergent	Cucurbitaceae	35	1.69	0	0	0	0
24	*Dulichium arundinaceum* (L.) Britton	Herb/Emergent	Cyperaceae	0	0	0	0	7	0.52
25	*Cyperus distans* L.F.	Herb/Emergent	Cyperaceae	23	1.12	50	2.76	0	0
26	*Cyperus diformis* L.	Herb/Emergent	Cyperaceae	0	0	19	1.05	107	8.08
27	*Cyperus iria* L.	Herb/Emergent	Cyperaceae	61	2.96	0	0	14	1.05
28	*Cyperus alternifolius* L.	Herb/Emergent	Cyperaceae	0	0	20	1.1	25	1.88
29	*Desmodium adscendens* (SW.) DC	Herb/Emergent	Fabaceae	0	0	88	4.86	0	0
30	*Hydrocharis dubia* (Blume) Backer	Herb/Submerged	Hydrocharitaceae	0	0	0	0	325	24.54
31	*Coleus monostachyus* (O.Beauv.) A.J. Paton	Herb/Emergent	Lamiaceae	0	0	60	3.31	41	3.09
32	*Nymphaea lotus L.*	Herb/Floating	Nymphaeaceae	0	0	0	0	191	14.42
33	*Ludwigia decurrens* Walter	Herb/Emergent	Onagraceae	107	5.19	0	0	32	2.42
34	*Piper umbellatum* L.	Shrub/Emergent	Piperaceae	0	0	95	5.25	0	0
35	*Oplismenus hirtellus* (L.) P. Beauv	Herb/Emergent	Poaceae	226	10.97	0	0	0	0
36	*Leersia oryzoides* (L.) Sw. Grant L, Pyrah	Herb/Emergent	Poaceae	279	13.55	0	0	35	2.64
37	*Coix lacryma-jobi* (L.)	Herb/Emergent	Poaceae	136	6.61	0	0	0	0
38	*Pogonatherum crinitum* (Thunb.) Kunth	Herb/Emergent	Poaceae	0	0	0	0	45	3.39
39	*Persicaria amphibia* (L.) Gray	Herb/Submerged	Polygonaceae	71	3.44	0	0	0	0

S/N	Species	Habit/Form	Family	M	RA(%)	B	RA(%)	E	RA(%)
40	*Ceraptoteris thalictroides* (L.) Brongn	Herb/Submerged	Pteridaceae	2	0.09	0	0	0	0
41	*Dioda virginiana L.*	Herb/Emergent	Rubiaceae	2	0.09	0	0	0	0
42	*Solanum scabrum* Mill	Herb/Emergent	Solanaceae	57	2.76	0	0	0	0
43	*Cyclosorus interuptus* (Wild.) Hlto	Herb/Emergent	Thelypteridaceae	0	0	53	2.57	0	0
44	*Christella dentata (*Forssk) Brownsey & Jermy	Herb/Emergent	Thelypteridaceae	0	0	41	2.27	0	0
45	*Musanga cecropioides* R.Br & Tedlie	Tree/Emergent	Urticaceae	0	0	29	1.41	5	0.37
46	*Pilea pumila* (L.) A.Gray	Herb/Emergent	Urticaceae	25	1.21	75	4.14	21	1.58
	Total		**23**	**2059**	**100%**	**1810**	**100%**	**1324**	**100%**

* M=Moliwe stream, B= Bosumbu water, E= Laverie Espoir, RA=Relative

All 46 macrophytes species were distributed across 23 families (Fig. 2). Amongst these 23 families, Asteraceae was the most represented, with seven species (7 Species), followed by Cyperaceae (5 Species), Araceae (5 Species), and Poaceae (4 Species).

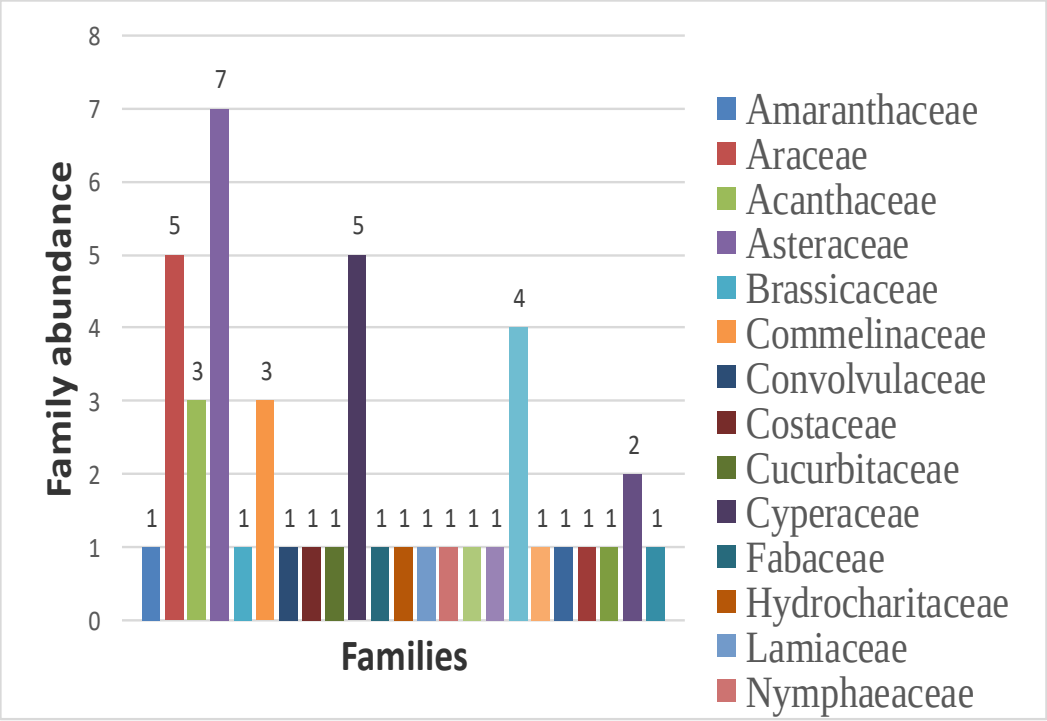

Fig. 2. Plant families and their frequencies across the three streams in Limbe 1 Municipality

Amongst the 25 plants that were found in Moliwe stream, *Commelina benghalensis* L. was the most abundant with over 21.85%, followed by *Leersia oryzoides* (L.) Sw Grant L.Pyrah with 13.55%. In Bosumbu Water which had a total of 24 plants species, *Anubias barteri* var *barteri* schott was the most abundant with 25.41% of the plant population, followed by *Eremomastax speciosa* (Hochst) Cufod with a of 10%. Laverie Espoir had a total of 26 plants. *Hydrocharis dubia* (Blume) Backer was the most abundant with 24.54% dominating the stream vegetation, followed by *Nymphaea lotus* L with 14.42%.

Some species were present across all three streams, these are common species that influence the similarity index; *Commelina benghalensis* L., *Ageratum conyzoides* L., *Costus lucanusianus* J. Braun & K. Schum, *Emilia coccinea* (Sims) G.Don, *Pilea pumila (L.)* A.Gray and *Colosia esculentus* (L.) Schott.

Bosumbu water had a total of five unique species which included the following: *Cyclosorus interuptus* (Wild.) H.lto, *Eremomastax speciosa* (Hochst) Cufod, *Christella*

*dentata (*Forssk) Brownsey & Jermy, *Desmodium adscendens* (SW.) DC, and *Commelina diffusa* Burm.f. while Laverie espior had six unique species which included *Dulichium arundnaceum* (L.) Britton, *Chromolaena odorata* (L) R.M.Kings &H, *Hydrocharis dubia* (Blume) Backer, *Nympheae lotus L.*, *Pogonatherum crinitum* (Thunb.) Kunth, and *Adenostemma lavenie* (L.)Kuntz.

Moliwe had a total of ten unique species, such as *Persicaria amphibia* (L.) Gray, *Oplismenus hirtellus* (L.) P. Beauv, *Eclipta prostrata* (L.)L, *Luffa aegyptiaca* Mill, and *Alocasia microrrhizos.*

2. Diversity and similarity across the three streams in Limbe 1 Municipality

All three streams had similar level of richness in diversity, however Moliwe had a slightly higher Shannon diversity index, H' =2.70, followed by Bosumbu water with H'=2.68, and Laverie Espior (H' =2.66).

Sorenson's similarity index calculated for the three streams is presented in Table (4). There was a close similarity between Moliwe stream and Laverie Espior (0.5). Moliwe and Bosumbu stream had a similarity index of 0.326. The least similarity index was between Laverie Espoir and Bosumbu stream (0.26).

Table 4. Sorensen's similarity index

	Moliwe stream	**Bosumbu stream**	**Laverie Espior**
Moliwe stream	1		
Bosumbu stream	0.326	1	
Laverie Espior	0.509	0.26	1

Ethnobotanical survey

3. Demographic information of respondents in study areas

Demographic information is presented in Table (5). All 300 semi-structured questionnaires administered were recovered, giving a 100% recovery rate.

Table (5) shows the percentage of respondents in terms of age range, educational level, gender, marital status, religion and profession. The respondents were mostly women (68%), and only 32% were men. Most respondents had attended the secondary level of education (48.66%), and only 22% had university education. Respondents who attained only Primary level of education were 18% and individuals with no formal level of education (10.66%). With respect to marital status, 45% were married, 39.66% single, and 11% were widows and widowers, while 4.33% were divorced.

Table 5. Demographic information of respondents in Limbe 1 Municipality

Demographic Parameters		**Description**	**Total (N=300)**	**Percentage (%)**
Age	Youth	20-40	166	55.33
	Adult	41-60	75	25.00
	Elderly	>61	59	19.66
Gender		Male	96	32.00
		Female	204	68.00
Education		Primary	56	18.66
		Secondary	146	48.66
		University	66	22.00
		No formal	32	10.66
Marital status		Married	135	45.00
		Single	119	39.66
		Divorced	13	4.33
		Widow/widower	33	11.00
Religion		Christians	290	96.66
		Muslims	8	2.60
		Non (Pagans)	2	0.74
Profession		Business persons	109	36.33
		Builders	20	6.66
		Students	49	16.33
		Farmers	59	19.66
		Caterer	14	4.60
		Herbalist	8	2.66
		Tailor	8	2.66
		Hair dressers	5	1.66
		Teachers	11	3.66
		Electricians	6	2.00
		Housewives	2	0.66
		Glazier	2	0.66
		Carpenters	1	0.33
		Security guards	6	2.00

A vast majority of the respondents were Christians with over 96.66%, Muslims were 2.60% and a total of 0.74 % of non-believers. Over the 300 respondents, 14 occupations were given. Business persons had a total of 109 from all respondents giving a percentage of 36.33%. Farmers were second in terms of population with a total of 59 (19.66%). Students were the third largest group with over 16.33% (49).

4. Ethnobotanical uses of aquatic macrophytes

4.1. Quantitative (Use value, frequency of citation and fidelity level) and qualitative Ethnobotanical information of aquatic macrophytes

Results of ethnobotanical indices are presented in Table (6). Among all the 46 aquatic macrophytes identified during floristic survey, only 24 of them were identified as being medicinal.

Plants with the highest use value were *Costus lucanucianus* (0.057), *Ageratum conyzoides* (0.053), *Acmella caulirhiza* (0.053), *Commelina benghalensis* (0.037) and *Eremomastax speciosa* (0.033) while, *Alocasia microrrhizos, Lufa aegyptiaca, Crassocephalum crepidioides, Dioda virginiana, Pilea pumila, Dicliptera chinensis* and *Nymphaea lotus* had the least use value (0.003). Plants which were most cited by respondents were, *Justicia secunda* (51), *Acmella caulirhiza* (50), *Ageratum conyzoides* (36), *Commelina benghalensis* (32), and *Costus lucanusianus* (29).

Ten (10) of these medicinal aquatic plants had the highest fidelity level (100% fidelity level). These were *Lufa aegyptiaca, Alocasia microrrhizos, Persicaria amphibia, Crassocephalum crepidioides, Cyclosorus interruptus, Cyperus distans, Dioda virginiana, Nymphaea lotus, Pilea pumila,* and *Dicliptera chinensis.* All plants with high fidelity levels were plants with low use values and low number of citations from respondents.

Table 6. Results of indices from ethnobotanical survey in Limbe 1 Municipality

Species	**NUPS**	**NOC**	**RFC**	**UV**	**FL**
Commelina benghalensis L.	11	32	0.10	0.03	34.4
Persicaria amphibia (L.) Gray	1	1	0.003	0.003	100
Ageratum conyzoides (L.)	16	36	0.12	0.053	44.4
Costus lucanusianus J. Braun & K. Schum	17	29	0.09	0.057	58.6
Colosia esculentus (L.) Schott	3	5	0.01	0.01	60
Lufa aegyptiaca Mill	1	1	0.003	0.003	100
Alocasia microrrhizos macrorrhiza (L.) G. Don	1	1	0.003	0.003	100

Justicia secunda Vahl	3	51	0.17	0.01	5.8
Crassocephalum crepidioides (Benth.)S. Moore	1	1	0.003	0.003	100
Piper umbellatum L.	3	9	0.030	0.010	33.3
Coleus monostachyus (O.Beauv.) A.J. Paton	1	2	0.007	0.003	50
Musanga cecropioides R.Br & Tedlie	2	3	0.010	0.007	66.7
Cyperus distans L.F	2	2	0.007	0.007	100
Emilia coccinea (Sims) G.Don	4	6	0.020	0.013	66.7
Cyclosorus interuptus (Wild.) H.lto	2	2	0.007	0.007	100
Eremomastax speciosa (Hochst) Cufod.	10	28	0.093	0.033	35.7
Solanum scabrum Mill	5	9	0.030	0.017	55.6
Dioda virginiana L.	1	1	0.003	0.003	100
Chromolaena odorata (L) R.M. Kings & H.	7	16	0.053	0.023	43.8
Desmodium adscendens (SW.) DC	2	2	0.007	0.007	100
Acmella caulirhiza Delile	16	50	0.167	0.053	32
Nymphaea lotus L.	1	1	0.003	0.003	100
Pilea pumila (L.) A.Gray	1	1	0.003	0.003	100
Dicliptera chinensis (L.) Juss	1	1	0.003	0.003	100

NUPS=Number of uses per plant, NOC=Number of citations, RFC=Relative frequency of citation, UV=Use value, FL=Fidelity level

The following disease categories were mentioned during the survey: respiratory diseases, gastro-intestinal, dermatological, anaemia, musculoskeletal, gynecological, antimicrobial, infectious diseases, non-infectious diseases, poison, and other organs.

Twelve plants were cited for the treatment of gastro-intestinal ailments, 11 plants were used for dermatological ailments, 9 plants were used to treat anaemia (blood deficiency). *Costus lucanusianus* was implicated as a treatment for many ailments, except in musculoskeletal ailments and anti-poison. The families with the most plant species with medicinal values were Asteraceae (4), Acanthaceae (3), Araceae (2), Commelinaceae (2), and Urticaceae (2).

Table 7. Qualitative information on medicinal macrophytes

Plant name	Family	P	R	GI	OO	D	A	MS	GY	AM	ID	NID
Commelina diffusa	Commelinaceae		√	√		√					√	
Acmella caulirhiza	Asteraceae	√	√	√	√			√			√	√
Costus lucanucianus	Costaceae		√	√	√	√	√		√	√	√	√
Ageratum conyzoides	Asteracea**e**		√	√	√	√	√					
Cyperus distans	Cyperaceae					√						
Commelina benghalensis	Commelinaceae		√	√		√		√	√	√		
Emilia coccinea	Asteracea**e**			√	√		√					
Coleus monostachyus	Lamiaceae					√						
Colocasia esculentus	Araceae	√				√						
Piper umbellatum	Piperaceae			√		√			√	√		
Alocasia cuculata	Araceae										√	
Pilea pumila	Urticaceae			√		√		√				
Eremomastax speciosa	Acanthaceae			√		√	√		√		√	√
Solanum scabum	Solanaceae			√			√					
Desmodium adscendens	Fabaceae											
Lufa cylindrica	Cucurbitaceae						√					
Justicia secunda	Acanthaceae						√				√	
Dicliptera chinensis	Acanthaceae			√								
Dioda virginiana	Rubiaceae			√								

Plant name	Family	P	R	GI	OO	D	A	MS	GY	AM	ID	NID
Musanga cecropioides	Cecropiaceae								√		√	
Chromolaena odorata	Asteraceae					√	√	√			√	
Nymphaea lotus	Nymphaeaceae									√		
Cyclosorus interruptus	Thelypteriaceae						√					
Persicaria amphibia	Polygonaceae			√								

*P= Poison (Anti-Poison), R=Respiratory, GI=Gastro-intestinal, D= Dermatological, MS=Musculoskeletal, GY=Gynecological, ID=Infectious-disease, NID=Non-infectious disease, OO=other organ**,** A=Anaemia, AM=Anti-microbial.

4.2 Plant parts used for different therapies

A total of 112 therapeutic preparations were mentioned during survey. Different plant parts were used for the therapies as opined by respondents. Generally, leaves, flowers, stems, seeds, roots, and the entire plant were the parts used in the preparation method. Some preparations required either both flowers or stems, roots and leaves, flowers and leaves, or stems and leaves, making the classification of parts used, based on the particular remedy. Leaves used singly were the most used plant part (42.%), leaves and flowers of the plant used together (20.3%), and stems (17.9%), flowers singly (8.035%), entire plant (8.035%), root and stems used together and seed had the least percentage (0.89%).

4.3 Mode of preparation and administration of aquatic plant- based remedies

The various remedies with their methods of preparation, administration and dosage as cited by various respondents are represented in Table (8). A total of 112 therapeutic preparations were mentioned on the 24 medicinal plants.

Gastrointestinal ailments had the most remedies with 35 remedies. The most common remedies were for diarrhoea and pile (hemorrhage).

Dermatological had over 15 remedies and most of the remedies were for skin or dermatological ailments such as eczema and "*jeti jeti*" (a common fungal infection in children. Respiratory ailments and other organ both had 7 remedies with cough and spleen respectively been the most illness treated with the remedies.

Gynecological ailments had 14 remedies with fertility and labor difficulties being the most treated. Muscoskeletal ailment had 4 remedies for both rheumatism and movement difficulties in children. Anemia had 10 remedies for which these remedies treated mostly blood pressure and blood deficiency. The category of non-infectious diseases had 5 remedies and it was mostly for the treatment of migraine and frontal headache. Anti-microbial uses had four remedies of which all are for wounds or cuts.

Table 8. Mode of preparation and administration of plant-based remedies from the survey

Plant name	Common name	Additive	Plant part used	Ailment category	Traditional use	Preparation and Administration method	Dosage/Duration
Commelina diffusa	Commelina	None	Stem	Respiratory	Cough	Direct intake; chewing	1 Full stem 7 days
Acmella caulirrhiza	Eye for fowl	Alligator pepper	Leaf, Flower	Respiratory	Cough	Direct intake; chewing	7 flowers 7 pepper
Costus lucanucianus	Monkey sugarcane	None	Stem	Respiratory	Cough	Direct intake; chewing	Few stems everyday
Ageratum conyzoides	King grass	Black kernel oil	Leaf, Flower	Respiratory	Cough	Maceration, infusion	1 teaspoon daily
Costus lucanucianus	Monkey sugarcane		Stem	Respiratory	Measles	Maceration, Enema	Once weekly for 2 weeks
Commelina benghalensis	Commelina		Leaf, stem	Respiratory	Measles	Maceration, Enema	once weekly for 2 weeks
Acmella caulirhiza	Eye for fowl	Sweet Alligathar	Leaf	Respiratory	Sore throat	Direct intake; chewing	15 leaves, 7 seeds for adults(9 leaves, 5 seeds for children) twice daily(morning and at bedtime)

Plant name	Common name	Additive	Plant part used	Ailment category	Traditional use	Preparation and Administration method	Dosage/Duration
Ageratum conyzoides	King grass	Alligathar pepper	Leaf, Flower	Gastro-intestinal	Diarrhea	Direct intake; chewing	5 head, 7 seeds, twice daily
Commelina benghalensis	Commelina		Leaf	Gastro-intestinal	Diarrhea	Maceration; Drinking	1 glass daily for 2 days
Piper umbellatum	Elephant ear		Leaf	Gastro-intestinal	Diarrhea	Infusion; Drinking	3 cups daily for 7 days
Acmella caulirrhiza	Eye for fowl	Groundnuts	Leaf	Gastro-intestinal	Diarrhea	Direct intake; chewing	3 leaves, 5 groundnut (trice daily)
Pilea pumila	Scratching grass		Leaf	Gastro-intestinal	Diarrhea	Direct intake; chewing	4 leaves morning and evening
Eremomastax speciosa	Two side leaf		Leaf	Gastro-intestinal	Diarrhea	Maceration, Drinking or by enema	1 glass daily for 3days, 1 enema can
Solanum scabrum	Njama njama		Leaf, Flower	Gastro-intestinal	Diarrhea	Maceration; Drinking	1 cup twice daily and 3 teaspoons for children
Desmodium adscendens	Groundnut leaf		Entire plant	Gastro-intestinal	Diarrhea	Boiling, Drinking	1 glass daily
Costus lucanucianus	Monkey sugarcane	*Emilea coccinea*, *chromolaena odorata*, soft guava	Stem	Gastro-intestinal	Diarrhea	Concoction; Drinking	Boil in 5 litters of water, drink a glass twice daily

Plant name	**Common name**	**Additive**	**Plant part used**	**Ailment category**	**Traditional use**	**Preparation and Administration method**	**Dosage/Duration**
		leaves,and honey					
Commelina diffusa	Commelina		Leaf, stem	Gastro-intestinal	Dysentery	Direct intake; chewing	Handful, twice daily
Dicliptera chinensis			Leaf, stem	Gastro-intestinal	Dysentery	Maceration; Drinking	2 teaspoons for children, 1 cup for adult daily
Dioda virginiana		Kernel, aligathar pepper	Entire plant	Gastro-intestinal	Dysentery	Direct intake; chewing	Few kernels, 5 flowers daily
Costus lucanucianus	Monkey sugarcane		Stem	Gastro-intestinal	Gastric	Maceration; Drinking	Half glass daily for 3 days
Chromolaena odorata	Achacasala		Leaf	Gastro-intestinal	Gastric	Direct intake; chewing	Few leaves each take in a day
Acmella caulirrhiza	Eye for fowl	Black kernel oil	Leaf, Flower	Gastro-intestinal	Gastric	Maceration, infusion	1 teaspoon daily
Ageratum conyzoides	King grass	kernel	Leaf, Flower	Gastro-intestinal	Gastric	Direct intake; chewing	7 heads, 5 kernels daily
Pilea pumila			Leaf	Gastro-intestinal	Gastric	Maceration; Drinking	1 glass a day, 2 teaspoon for children

Plant name	Common name	Additive	Plant part used	Ailment category	Traditional use	Preparation and Administration method	Dosage/Duration
Emilia coccinea	Dog ear		Leaf	Gastro-intestinal	Gastric	Direct intake; chewing	Few leaves each take in a day
Costus lucanucianus	Monkey sugarcane		Stem	Gastro-intestinal	Constipation	Direct intake; chewing	Few stems everyday
Ageratum conyzoides	King grass	*Aloe vera*, salt	Leaf, Flower	Gastro-intestinal	Constipation	Direct intake; chewing	7 heads, a pinch of salt and half *Aloe vera*
Eremomastax speciosa	Two side leaf	warm water	Leaf	Gastro-intestinal	Constipation	Enema	Enema in children, twice just for 1 day
Ageratum conyzoides	King grass		Leaf, Flower	Gastro-intestinal	Worms	Direct intake; chewing	A handful
Desmodium adscendens	groundnut leaf	kernel	Leaf	Gastro-intestinal	Worms	direct intake; chewing	3 heads, 4 Kernels 2x a day
Acmella caulirrhiza	Eye for fowl	small water	Leaf, Flower	Gastro-intestinal	Intestinal pain for babies	Maceration, Enema	1 enema can for children
Solanum scabrum	Njama njama		Seed	Gastro-intestinal	stomach ache	Maceration, Enema	1 enema can once
Commelina benghalensis	Commelina	Two side leaf, massepo,	Leaf, Stem	Gastro-intestinal	Intestinal fungi	Concoction, Drinking (Maceration, enema)	1 enema once in a month,/ 1 glass twice daily for drinking

Plant name	Common name	Additive	Plant part used	Ailment category	Traditional use	Preparation and Administration method	Dosage/Duration
		king grass					
Persicaria amphibia			Leaf, stem	Gastro-intestinal	intestinal cleansing	Maceration, Enema	1enema for children, 2 for adults, done just once
Piper umbellatum	Elephant ear	Allagathar pepper	Leaf, Flower	Gastro-intestinal	Pile (external)	Maceration, insertion	Grind 7 pepper, wrap in piper leaf and divide in 3 portions. To be inserted every after stool, clean the pile with ground piper leaf
Piper umbellatum	Elephant ear		Leaf, Flower	Gastro-intestinal	Pile (internal)	Direct intake; chewing	3 leaves, 3 flowers, twice daily everyday
Acmella caulirrhiza	Eye for fowl	3 kernels	Leaf, Flower	Gastro-intestinal	Pile (external)	Direct intake; chewing	Chew 3 kernels and 3 heads of eye for fowl twice daily

5 Phytochemical screening of aquatic macrophytes in Limbe 1 Municipality

Generally most plants specimens showed positive qualitative results for at least four phytochemicals. All tested phytochemicals were present in various quantities in the test plants (Table 9)

Table 9. Phytochemical composition of the methanolic extracts of some medicinal plants

Plants information		**Phytochemical constituents**						
Plants names	**Plant part**	**Saponin**	**Alkaloid**	**Cardiac glycoside**	**Phenolic**	**Tannin**	**Flavonoid**	**Steroid**
Eremomastax speciosa	Leaves	++	-	-	-	-	-	+++
Commelina benghalensis	Leaves	+	+	-	-	+	++	++
Ageratum conyzoides	Whole	+	-	++	-	-	+	++
Acmella caulirrhiza	Whole	+	-	-	-	-	+++	++
Costus lucanusianus	Leaves	++	-	-	-	-	-	+
Nymphaea lotus	Leaves	-	+	++	++	++	++	-
Hydrocharis dubia	Leaves	+	-	-	-	-	+	+
Persicaria amphibia	Leaves	-	-	+	++	++	-	++
Anubia bateri	Leaves	++	-	+	-	+	-	+++

+=small quantity, ++=medium quantity, +++=large quantity.

Saponins were detected in small quantities (+) in *Commelina benghalensis*, *Ageratum conyzoides*, *Acmella caulirhiza*, and *Hydrocharis dubia*. Medium quantities of

saponin content (++) were recorded in *Eremomastax speciosa, Costus lucanucianus* and *Anubias bateri.*

Small quantities (+) of alkaloids were detected in *Commelina benghalensis*, and *Nymphaea lotus*. Alkaloids were absent in the other test plants species. Cardiac glycosides were detected in medium quantity (++) in *Ageratum conyzoides* and *Nymphaea lotus*. It was also detected in *Persicaria amphibia* and *Anubias bateri*, but in small quantities (+). It was absent in the others.

Phenolics were present in medium quantities (++) in *Persicaria amphibia* and *Nymphaea lotus.* Of all the plants, tannins were only present in the leaves of *Commelina benghalensis* (+), *Nymphaea lotus* (++), *Persicaria amphibia (++),* and *Anubias bateri*.

Flavonoids were also detected in small quantities (+) in *Ageratum conyzoides* and *Hydrocharis dubia*. Very large quantities of flavonoids (+++) were found in *Acmella caulirhiza*. Medium quantities (++) of flavanoids were found in *Nymphaea lotus*, while small quantities (+) were detected in *Commelina benghalensis*.

All plants tested positive for the presence of steroids except *Nymphaea lotus*. Large quantities of steroids (+++) were detected in *Eremomastax speciosa* and *Anubias bateri*. Medium quantities (++) were found in *Commelina benghalensis, Acmella caulirrhiza, Ageratum conyzoides,* and *persicaria amphibia*. Small quantities (+) were found in *Costus lucanusianus,* and *Hydrocharis dubia.*

DISCUSSION

1. Aquatic plant species diversity across three selected streams in Limbe 1 Municipality

Aquatic plants are important components of wetland ecosystems and carryout very vital roles in maintaining biodiversity within these ecosystems while also providing diverse ecosystem services.

This study recorded 46 macrophytes in the three streams in Limbe 1 municipality (Moliwe, Bosumbu, and Laverie Espoir) which were distributed across 23 plant families. These streams were dominated by emergent vegetation, with just 2% floating macrophytes. Asteraceae had the highest number of species (7 species), followed by Cyperaceae (5 species), Araceae (5 species), and Poaceae (4 species). Similar findings have been done by **Awo *et al*. (2023)** and **Fonge *et al*. (2023)** in their studies on nutrient retention by aquatic macrophytes in roadside streams in Mount Cameroon region. This is also in accordance with the findings of **Wouokoue *et al.* (2020)**, who found the families Asteraceae and Poaceae to be the most common families found in Bamboutos in the Western Region of Cameroon. The abundance of Asteraceae and Poaceae could be attributed to their great range of ecological tolerance and great capacity of seed dispersal

which make this family cosmopolitan. Their large seed production is a good ecological dominance strategy, coupled with prevailing genes encoding for the hydric habitat **Wouokoue *et al.* (2017)**.

Obligate aquatic species like *Anubias barteri, Hydrocharis dubia* were recorded in these streams. *Anubias barteri* (25.41%) was the most abundant species in Bosumbu stream followed by *Commelina benghalensis* (21.85%) from Moliwe. *Hydrocharis dubia* (24.54%) was the most abundant species from Laverie Espoir. These results are similar to results from **Awo *et al.* (2023)**, who assessed macrophytes communities in some streams in Limbe and Ombe, and recorded similar aquatic plant species. Other findings by **Anyinkeng *et al.* (2020)**, reported these species in Buea wetlands in Buea Municipality. These similarities indicate the fact that both Limbe and Buea are within the same ecological zone (Agroecological zone IV) with similar characteristics.

Differences recorded with respect to Shannon-Weiner diversity of the macrophytes in these streams could be attributed to the different levels of anthropogenic activities carried out in and around them since all three streams were flowing in human-dominated areas. Moliwe stream, as compared to others, had a higher Shannon-Weiner diversity of 2.7. This is probably due to its natural flow of the water through its path with little or no disturbance from man-made infrastructures, unlike Bosumbu and Laverie Espoir whose flow of water has been tempered by man through building of catchments, and whose pathways have been directed through farmlands and houses. This very high plant diversity in these streams signifies that water quality of these streams is suitable for the growth of a wide range of aquatic plants. The striking floristic similarity between these streams as revealed by Sorensen's similarity index could be attributed to the interconnectedness in the hydrological network, which facilitates water dispersal of many aquatic species to closer wetlands, hence accounting for this gross similarity.

2. Medicinal aquatic macrophytes

Herbal medicine plays an important role in the treatment of many diseases, especially in rural areas of developing countries. However, due to lack of appropriate documentation, critical and valuable ethnobotanical information is lost. Thus ethnobotanical documentation is important conservation strategy since it is only through such research that aquatic plant potentials in medicine can be revealed and valued. From this study, twenty four aquatic macrophytes were known to be medicinal to respondents. These plants were distributed across sixteen plant families and were found to have fifty two therapeutic uses and a hundred and twelve different remedies.

Costus lucanucianus, *Acmella caulirrhiza*, *Ageratum conyzoides, Eremomastax speciosa* and *Commelina benghalensis* had the highest use values during the survey. Other aquatic plants had very low use values such as *Lufa aegyptiaca* (0.003) and *Alocasia microrrhizos* (0.003). Having a low use value does not necessary mean the plant did not possess medicinal values, but it could be due to the fact that, respondents during the survey (Limbe 1 Municipality) were less knowledgeable on the medicinal values of

these plants or maybe knowledge of this plant has slowly been lost due to people with this information dying without passing it on to others. A total of 112 therapeutic preparations were mentioned by respondents for the 24 aquatic macrophytes, with the highest use value from *Costus lucanusianus*.

All ailments had at least two aquatic macrophytes present in across their therapeutic remedies and at most 12 macrophytes. The most ailment category with plant treatments were, Gastro-intestinal with over 12 plant from 6 families, and dermatological ailments with 11 plants from 9 families. This could be due to the fact that, the common issues that usually affect individuals are skin issues and intestinal issues, Thus since most plants are available mainly in particular seasons and individuals are unable to wait for plants during particular seasons to provide them with their medicinal value, they had to look for other plants present from different families or the same family for recovery purpose.

Among all these plants families, Asteraceae was the most involved, with over 4 medicinal plants (*Chromolaena odorata*, *Emilia coccinea*, *Ageratum conyzoides* and *Acmella caulirhiza),* followed by Acanthaceae with 3 plants; *Justicia secunda*, *Eremomastax speciosa,* and *Dicliptera chinensis.*

Families such as Commelinaceae had 2 plants, *Commelina benghalensis* and *commelina diffusa* both with mostly different uses. For example, *Commelina diffusa* treats cough and dysentery, while *Commelina benghalensis* treats diarrhea, measles and infertility in women. This difference could be from the different genetic modification and adaptations between the two plants which brings about different medicinal attributes and difference in some phytochemicals.

Commelianaceae, Costaceae and Asteraceae were the families which cut across almost all ailments, and are deemed the most useful families according to this research. This may be due to the familiarities of individuals with these families and their plants over the years, providing many individuals with its experience over time.

Plants parts used for preparation of medicine included leaves, inflorescence (flower), root, stem, and seed. Some other parts were used jointly, like leaves and stems, or leaves and flower from their various preparations.

The most use plant part recorded were leaves used singly with a percentage of 41.96% across all preparation, and secondly with flower and leaves used together with over 20.3%. These high levels used of leaves in medicine could be as result of the high phytochemical levels stored in tissues of leaves as compared to the other parts **(Abiodun *et al.*, 2022)**. All respondents admitted to the use and implementation of herbal medicine over chemically made drugs. Respondents referred to traditional or herbal medicine as being the best, safest and most reliable form of preserving health as well as the treatment of illness. The most common herbal preparation methods included infusions, enema, direct intake (orals), decoction and topical administration. Some modes of preparation

included water, seeds of other plants, honey to enhance the taste and to improve its potency **(Kimondo *et al*., 2015; Faruque *et al*., 2018)**.

Results from our study have also revealed that the mode and type of administration, and the dosage and plant part to be used varied for each disease category and age of the patient. This implies that respondents were knowledgeable about the basic principles of pharmacology. They also understood the implications of administering overdose and therefore emphasis was laid on the treatment frequency and duration. This is corroborated by the findings of **Mokua *et al*. (2021)** in Mwingi west county, Kenya where respondents demonstrated a mastery of basic pharmacological principles associated with the use of medicinal plants in the treatment of snake envenomation.

3. Phytochemical screening of aquatic macrophytes

It is difficult to compare the results of phytochemical screening with literature review because several variables influence the results of every phytochemical production in plants **(Ndam *et al*., 2014)**. The quantity and composition of bioactive compounds present in plants are influenced by genotype and climatic conditions and plant growth phase **(Culei & Istodor, 1995)**.

Phytochemical screening of *Costus lucanusianus* showed positive results for test for saponins and steroids, known for their biological effect in aphrodisiac, cholesterol reduction, neuroactive and neuroprotective attributes **(Visweswari *et al*., 2013)**. Saponins have been implicated in their roles in emulsification, surfactants, antimicrobial and antioxidant activities, immune-modulatory activities **(Sapna, 2009)**. *Costus lucanusianus* according to respondents was capable of treating cough (anti-microbial), measles (anti-microbial), constipation (regulation of metabolism), spleen treatments (immune functions), mumps (immunomodulatory), and diabetes (anti-diabetic). Steroids and saponins present in *Costus lucanusianus* may be responsible for most of these treatment characteristics since they perform most of these functions.

Acmella caulirhiza showed the presence of saponins, flavonoids and steroids, with flavonoids being in large quantities. Flavonoids according to **Ouedraogo *et al.* (2018)** and **Xu *et al.* (2018)** have an antioxidant, antimicrobial, and enzyme inhibition effect. This plant was indicated (*Acmella caulirhiza*) to treat diarrhea (anti-microbial), cough (anti-microbial), gastro-intestinal, and fungal infections in little children "*jeti-jeti*" (anti-microbial) and others. The presence of phytochemicals in this plant explains some of its medicinal attributes provided by respondents.

Ageratum conyzoides showed positive results for saponins, cardiac glycosides, flavonoids and steroids, with cardiac glycosides proving to be capable of being a sedative, muscle relaxant, and diuretic. Linking saponins and steroids content in *Ageratum conyzoides*, claimed by respondents, are confirmed by the presence of phytochemicals in these plants to be capable of treating cough (anti-microbial), diarrhea (anti-microbial), gastric (enzyme inhibition), pile/ hemorrhage.

These findings are consistent with **Ndam *et al.* (2014)**, who screened for the presence of phytochemicals in common plants such as *Eremomastax speciosa*, *commelina benghalensis* and *Ageratum* sp. using methanol as the solvent.

Commelina benghalensis stem showed the presence of only flavonoids, meanwhile the leaves showed the presence of alkaloids, tannins, saponins, steroids and flavonoids. Alkaloids according to **Visweswari *et al.* (2013)** had biological uses which include anti-microbial, sedative, relaxant, and anti-spasmodic, for treating tumors, cramps, diarrhea, psychiatric and palpitation. Steroids have proven to be capable of acting in reproductive measures according to several studies. According to respondents, *Commelina benghalensis* is capable of treating gynecological complications in both females and males, which is a biological effect of steroids. It also had a range of uses such as enabling movement in young kids (bone synthesis provided by steroids), reducing menstrual cramps in adolescent women and also applied topically on wounds to reduce bleeding. These results are confirmed by **Faroque *et al.* (2014)**, who studied the analgesic and anti-inflammatory activity of *Commelina benghalensis.*

The screening of four other macrophytes which did not possess any use value during the ethnobotanical survey (*Nymphaea lotus*, *Anubias barteri*, *Hydrocharis dubia*, *Persicaria amphibia*) revealed the presence of four phytochemicals and had been reported to be medicinal in other parts of the world. Lack of medicinal knowledge among respondents buttresses the fact that the use of plants varies between different ethnic groups and traditions **(Faruque *et al.*, 2018)**.

CONCLUSION

A total of fourty six aquatic macrophytes were recorded across three major streams in Limbe 1 Municipality (Moliwe, Bosumbu and Laverie Espoir streams), with the most abundant plants in these streams being *Commelina benghalensis, Anubias barteri,* and *Hydrocharis dubia.* Moliwe stream was found to be more diverse than Bosumbu and Laverie Espoir streams, with Shannon-Weiner diversity of 2.70, 2.68 and 2.66 respectively. Fourty macrophytes were emergent, four submerged, and two floating macrophytes plants. These aquatic plants belong to twenty three plant families, with Asteraceae, Cyperaceae, and Araceae being the most species-rich families.

The study also revealed twenty four medicinal aquatic plants in Limbe 1. These medicinal plants were cited to treat diseases like, fungi infections, rheumatism, whitlow, hemorrhage, increase blood pressure, diabetes, infertility in women, menstrual pain, fibroid, malaria and typhoid, convulsion in children, sexual transmitted diseases etc. Five macrophytes (*Commelina benghalensis, Costus lucanusianus, Eremomastax speciosa*, *Acmella caulirhiza* and *Ageratum conyzoides*) with the highest use value screened for the presence of phytochemicals that play roles in their medicinal values, as provided by respondents. The screening of other aquatic plants (*Nymphaea* lotus, *Anubias barteri*, *Hydrocharis dubia*, *Persicaria amphibia*) did not possess any use value during the

ethnobotanical survey, revealing the presence of four phytochemicals that have been reported to be medicinal in other parts of the world.

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