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INVENTORY AND EVALUATION OF AQUATIC MACROPHYTE DIVERSITY OF ERNAKULAM DISTRICT, KERALA, SOUTH INDIA

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ABSTRACT
Inventory of aquatic plant diversity was conducted in 22 ponds of Ernakulam district in Kerala, South India during 2022 July to 2023 May. During the period of study 50 macrophytes were identified, which comes under 37 genera and 29 families. Kerala has an abundance of indigenous aquatic plants but it is not yet well documented or utilized for the purpose. Hence it is felt urgent to have a data on the availability and suitability of the aquatic plants of Ernakulam district as ornamental aquarium plants. The aquatic plants collected from different localities were they were categorized into emergent, submerged, floating and marshy plants. Out of the fifty plants, 8 plants belonging to 4 families are emergent plants, 14 plants belonging to 5 families are submerged plants,18 plants belonging to 7 families are floating plants and 10 plants belonging to 7 families are marshy plants. Attempts were made to propagate the plants under captivity. There is a huge diversity of aquatic plants in the natural ecosystems of Ernakulam district which can be exploited judiciously and propagated under captive conditions for ornamental purposes such as aquascaping and aquarium keeping. This can serve as an employment opportunity for the women and unemployed youth. This baseline date on the biodiversity of aquatic plants of Ernakulam district will be helpful for the conservation and management strategies of wet land and aquatic habitats. In Ernakulam district the natural ecosystems are deteriorating at an alarming rate due to various reasons. It is important to conserve the natural ecosystems otherwise; there will be a significant loss in the germplasm of the precious unexploited aquatic flora.

***Keywords**: Aquatic Plants, Macrophytes, Ernakulam, Submergent Plant, Emergent Plant, Free Floating Plants, Attached Floating Plants*

INTRODUCTION
Plants that have adapted to live in aquatic environments, either in salt water or freshwater are known as aquatic plants. They are also referred to as hydrophytes or macrophytes to distinguish them from other microphytes, such as algae. Most water bodies have a few dozen different species of aquatic plants growing in them. Aquatic plants provide many of the same functions as terrestrial plants. Macrophytes have several intrinsic properties that makes them an indispensable component of the ecosystem. Plants are the primary producers in an ecosystem since they produce their own food as well as food for the consumers or animals of that ecosystem. In addition, they provide oxygen through photosynthesis and habitat for many aquatic organisms. They also remove carbon dioxide in the process of photosynthesis. They have a significant effect on soil chemistry and light levels as they slow down the flow of water and capture pollutants and trap sediments. The macrophytes stabilize the surface of the beds, provide good conditions for physical filtration, prevent vertical flow systems from clogging, insulate against frost during winter, and provide a huge surface area for attached microbial growth (Brix H 1994).They play an important role in oxygen production, nutrient cycling, water quality improvement and sediment stabilization (Mohan and Hosetti 1999).There are three common categories of aquatic vegetation: Emergent, Submerged, Floating and Marshy. Emergent vegetation is one of the most common types of aquatic vegetation and it grows with its

roots down in the sediment of water and the majority of the shoots stick up out of the water. Emergent vegetation provides a habitat for certain songbirds, or wading birds that may nest at these sites or use them as feeding areas. Submerged plants are those that are wholly underwater and may be rooted or unrooted. They are usually in depths of 2-10 or more feet. Submerged vegetation provides a habitat for small fish, which may seek refuge from predators. They may also use this vegetation.

In the present study, it is intended to document a baseline date on the biodiversity of aquatic plants of Ernakulam district, which will be helpful for the conservation and management strategies of wet land and aquatic habitats. Suitable plants can be used for ornamental purposes in aquariums and paludariums that will fetch employment opportunities for many women and unemployed youths. In recent years, the global market for aquariums and fish-keeping has experienced remarkable growth and India has emerged as a prominent player in the industry. The term aquascaping has now become a valued art and better known by aquarists all over the world. It is the craft of arranging aquatic plants, as well as rocks, stones, cave work, or driftwood, in an aesthetically pleasing manner within an aquarium—in effect, gardening under water. The biodiversity of aquatic plants in this district can be exploited for the purpose. The global aquarium plant market size was valued at USD 1.4 billion in 2021 and is expected to expand at a CAGR of 5.8% from 2021 to 2030.The aquascaping trade in India is still in infancy and only having demand in the major cities. All these information shows that there is a growing demand for suitable ornamental aquatic plants in the market. In Ernakulum district the natural ecosystems are deteriorating at an alarming rate due to various reasons. It is important to conserve the natural ecosystems, otherwise, there will be a significant loss in the germplasm of the precious unexploited aquatic flora.

MATERIALS AND METHODS

The present work was conducted in Ernakulam district. An inventory of aquatic plants was conducted in twenty two ponds of twelve aquatic habitats such as Moothakunnam, Puthenvelikkara,Varappuzha,Thiruthipuram,Andipillykavu, Ernakulam proper, Madavana, Kundannur, Thevera, North Parur, Nettur, and Kunnukara of Ernamkulam district, Kerala, during the period from July 2022 to April 2023 .The twigs of plants were collected periodically with flowers and fruits. The habit, morphology and floristic characters are recorded during the time of collection. The plants collected were identified with the help of Ansari *et al.*, (2016).

RESULTS AND DISCUSSION

During the period of study from July 2022 to April 2023 Fifty species of plants were collected from twenty two ponds/aquatic habitats of twelve different aquatic localities.

List of plants collected during the study period with their scientific name and family is presented in table 1. List of ponds/aquatic habitat and localities are given in table 2**.**

List of plants and the ponds from where they are collected is given in the table 3 Out of the fifty plants, 26% are submerged plants, 5% are emergent hydrophytes, 3% comes under the category of floating and attached floating plants and 30% are marshy plants Paul (2022) made a study on the aquatic plant diversity studies of the ponds of Trichur district. She collected 41 types of plants from different ponds of Trichur. She also got a higher percentage of marshy plants.

The categorical list of the plants is given in table 4. These plants come under 37 genera and 29 families. The most diverse family is Menyanthaceae followed by Hydrocharitaceae. Out of the 50 plants collected, 57% plants are fit for aquarium setting, 44% plants are suitable for as spawning beds to lay their eggs.

Floating leaved plants are those that have leaves that float on the surface of the water and can be rooted or unrooted. Many insects use the leaves of floating plants to deposit eggs and to feed. Marshy plants are seen in marshy areas which has high potential for ornamental purposes. Eventhough some of the aquatic plants are nuisances which require removal, most of the native plants provide many benefits to the ecosystem including spawning and habitat areas for organisms in the ecosystem, as well as fishing and wildlife viewing areas for the residents around.

Plate 1: Photographs of plants collected during the study


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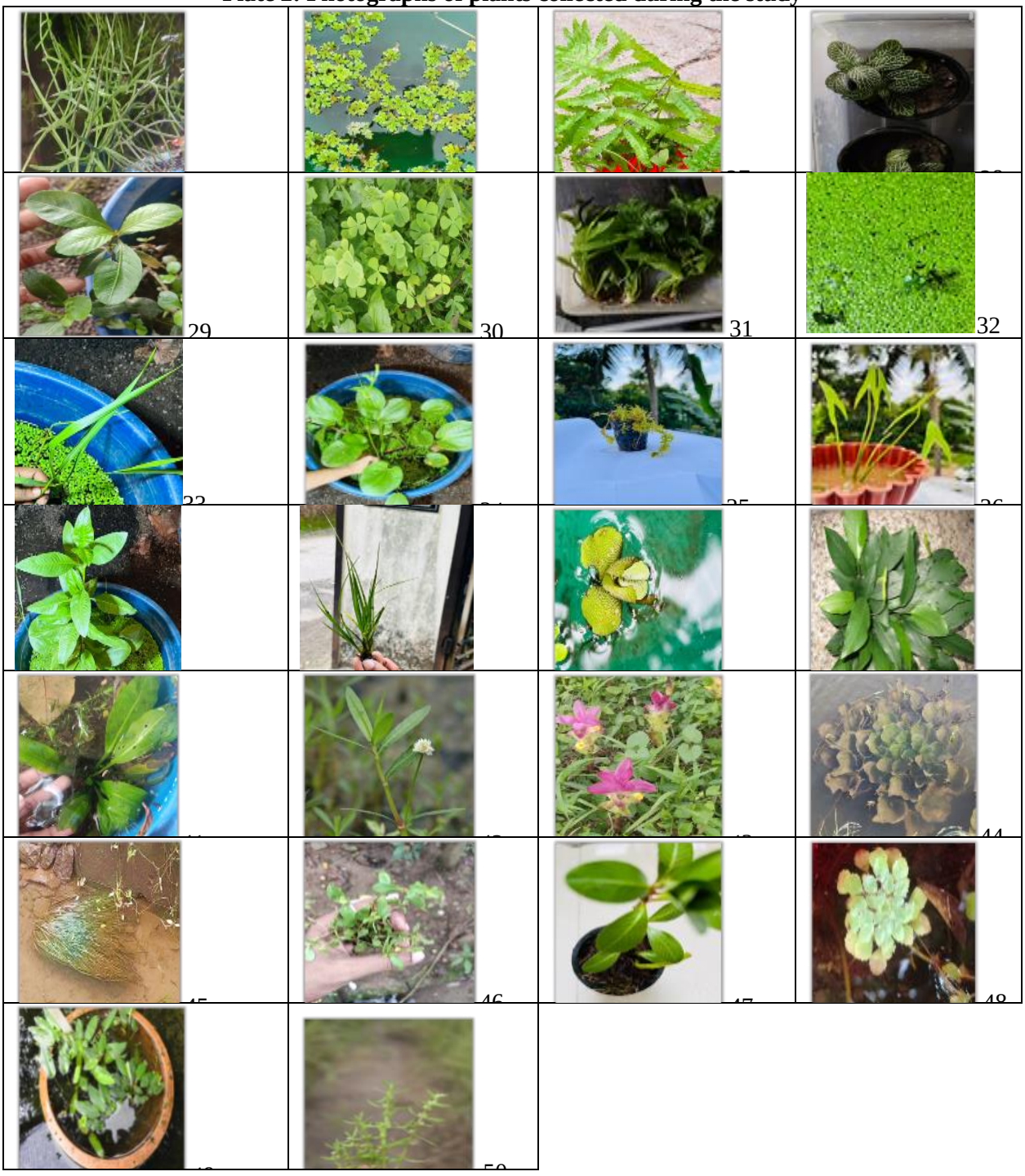
Attempts were made to propagate the plants under captivity. Emergent plants such as *Veronica baccabunga* and *Myriophyllum oliganthum* could be propagated by vegetative propagation. Submerged plants such as *Cerratophyllum, Hydrilla, Cabomba, Rotala, Vallisneria, Bacopa*, could be propagated by vegetative

Plate 2: Photographs of plants collected during the study



propagation and floating plants such as *Lemna minor Eicchornia, Azolla, Aponogetonnatans, Pistia, Nymphoides*(af) and marshy plants such as *Ascentella,Fittonia,Ldwigia could be propagated by vegetative propagation. Rotala rotuntifolia* was propagated by their seeds. Experiments were also done to study the adaptability of these plants under aquarium conditions. *Vallisneria, Cerratophyllum, Hydrilla, Anubias barteri, Cabomba, Sagittaria, Fittonia, Bacopa, Veronica, Ludwigia* were seen growing well in aquairums

and hence can be recommended for aquascaping. Many of the submerged plants such as *Vallisneria, Nymphoides, Sagittaria, Cerratophyllum, Hydrilla, Myriophyllum, Bacopa, Aponogeton apendiculus* are found suitable for paludariums.

PLANTS' NAMES

1. *Centella asiatica*	26. *Azolla pinnata*
2. Pista tratiotes	27. *Dryopteris marginalis*
3. Cabomba caroliniana	28. *Fittonia albivenis*
4. Cabomba caroliana	29. *Veronica beccabunga*
5. Cerratophyllum demersum	30. *Marsilia minuta*
6. Rotala rotundifolia	31. *Aponogeton appendiculus*
7. Rotala rotundensis	32. *Lemna minor*
8. Hydrilla verticillata	33. *Brachiaria mutica*
9. Ottelia alismoides	34. *Echinodorus chordifolius*
10. Vallisneria natans	35. *Elodea canadensis*
11. Nymphoides auratiacum	36. *Sagittaria sagittifolia*
12. Nymphoides hydrophylla	37. *Eclypta prostrate*
13. Nymphoides indica	38. *Acorus calamus*
14. Nymphoides malabarica	39. *Salvinia molesta*
15. Nymphoides micranta	40. *Anubias barteri*
16. Nymphoides nauchali	41. *Echinodorus osiris*
17. Eichornia crassipes	42. *Alternanthera philoxeroides*
18. Bacccopa monnieri	43. *Curcuma angustifolia*
19. Trapa natans	44. *Ottelia pers*
20. Myriophyllum oliganthum	45. *Vallisneria spiralis*
21. Sagittaria guayasensis	46. *Limnophila rugosa*
22. Salvinia natans	47. *Ludwigia adscendens*
23. Lymnobium laevigatum	48. *Ludwigia sedoides*
24. Hydrocleys nymphoides	49. *Apponogeton natans*
25. Cerapteris thalicoides	50. *Bacopa hamiltoniana*

Species diversity is more in Puthenvlikkara followed by Thiruthipuram. Most of the species collected from Varapuzha belong to the family Hydrocharitaceae whereas most of the plants of Thiruthipuram belong to the family of Manyanthaceae.

CONCLUSION

The study is aimed to make an inventory of the availability and suitability of the aquatic plants of Ernakulam district as ornamental aquarium plants. In the present study, fifty numbers of aquatic plants were collected from different localities of Ernakulam district. They were categorized into emergent, submerged, floating and marshy plants. Out of the fifty plants 8 plants belonging to four families are emergent plants 14 plants belonging to 5 families are categorized as submerged plants.18 plants belonging to 7 families are floating plants and 10 plants belonging to 7 families are marshy plants. Attempts were made to propagate the plants under captivity. There is a huge diversity of aquatic plants in the natural ecosystems of Ernakulam district which can be exploited judiciously and propagated under captive conditions for ornamental purposes such as aquascaping and aquarium keeping. This can serve as an employment opportunity for the women and unemployed youth. This baseline date on the biodiversity of aquatic plants of Ernakulam district will be helpful for the conservation and management strategies of wet land and aquatic habitats. In Ernakulum district the natural ecosystems are deteriorating at an alarming rate due to various reasons. It is important

to conserve the natural ecosystems otherwise; there will be a significant loss in the germplasm of the precious unexploited aquatic flora.

TABLE 1 COLLECTED PLANTS DURING THE STUDY PERIOD WITH THEIR SCIENTIFIC NAME AND FAMILY

SL	PLANT (COMMON NAME /LOCALNAME)	SCIENTFICNAME	FAMILY	COLLECTED AREA
1.	Indian pennywort (Kodakan)	*Centella asiatica*	Apiaceae	Moothakunnam
2.	Pistia (aakashathaamara, kudappaayal)	*Pistia stratiotes*	Araceae	Moothakunnam
3.	Waterchestnut	*Trapa natans*	Trapaceae	Moothakunnam
4.	African paayal	*Salvinia molesta*	Salviniaceae	Moothakunnam
5.	Fanwortgreen	*Cabomba caroliniana*	Cabombaceae	Puthenvelikara
6.	Fanwortred	*Cabomba caroliana*	Cabombaceae	Puthenvelikara
7.	Hornwort	*Cerratophyllum demersum*	Ceratophyllaceae	Puthenvelikara
8.	Roundleaftoothcap	*Rotala rotundifolia*	Lythraceae	Puthenvelikara
9.	Rotala	*Rotala rotunadensis*	Lythraceae	Puthenvelikara
10.	Ribbonplant	*Vallisneria natans*	Hydrocharitaceae	Puthenvelikara
11.	Waterweed, Canadian pond weed	*Elodea canadensis*	Hydrocharitaceae	Puthenvelikara
12.	Creeping burhead	*Echinodorus chordifolius*	Alismataceae	Puthenvelikara
13.	Arrow head	*Sagittaria sagittifolia*	Alismataceae	Puthenvelikara
14.	Horsetail plant	*Ceratopteris thalictroids*	Pteridaceae	Puthenvelikara
15.	Azola	*Azolla pinnata*	Azollaceae	Puthenvelikara
16.	Woodfern	*Dryopteris marginalis*	Dryopteridaceae	Puthenvelikara
17.	Fittonia	*Fittonia albivenis*	Acanthaceae	Puthenvelikara
18.	Paragrass	*Brachiaria mutica*	Poaceae	Puthenvelikara
19.	Sweet flag	*Acorus calamus*	Acoraceae	Puthenvelikara
20.	Koova	*Curcuma angustifolia*	Zingiberaceae	Puthenvelikara
21.	Mossy speedwell	*Veronica beccabunga*	Plantaginaceae	Puthenvelikara
22.	Water thyme	*Hydrilla verticillata*	Hydrocharitaceae	Varapuzha

23.	Duck letuse	*Ottelia alismoides*	Hydrocharitaceae	Varapuzha
24.	Paruakizhangu	*Ottelia pers*	Hydrocharitaceae	Varapuzha
25.	Aponogeton	*Aponogeton appendiculus*	Aponogetonaceae	Varapuzha
26.	False daisy	*Eclypta prostrata*	Asteraceae	Varapuzha
27.	Naali thalthaamara	*Marsilia minuta*	Marsileaceae	Andipillykavu
28.	Brahmi	*Bacopa monnieri*	Plantaginaceae	Andipillykavu
29.	Eel grass	*Vallisneria spiralis*	Hydrocharitaceae	Andippillykavu
30.	Yellow flowered snowflake	*Nymphoides auratiacum*	Menyanthaceae	Thiruthipuram
31.	Neythel	*Nymphoides hydrophylla*	Menyanthaceae	Thiruthipuram
32.	Chinnambal	*Nymphoides indica*	Menyanthaceae	Thiruthipuram
33.	Vellambal	*Nymphoides malabarica*	Menyanthaceae	Thiruthipuram
34.	Violetambal	*Nymphoides micrantha*	Menyanthaceae	Thiruthipuram
35.	Poothali,Ambal	*Nymphoides nauchali*	Menyanthaceae	Thiruthipuram
36.	Kulavazha	*Eichornia crassipes*	Pontederiaceae	Ernamkulam
37.	Waterpoppy	*Hydrocleys nymphoids*	Alismataceae	Thevara
38.	Duck potato	*Sagittaria guayasensis*	Alismataceae	Thevara
39.	Watermilfoil	*Myriophyllum oliganthum*	Haloragaceae	Thevara
40.	Duckweed	*Lemna minor*	Araceae	Thevara
41.	Melon sword	*Echinodorus osiris*	*Alismataceae*	Parooor
42.	Anubias	*Anubias barteri*	Araceae	Parooor
43.	Water prime rose	*Ludwigia adscendens*	Onagraceae	Kunnukara
44.	Mosaic flower	*Ludwigia sedoides*	Onagraceae	Kunnukara
45.	Bacopa	*Bacopa hamiltoniana*	Plantaginaceae	Kunnukara
46.	Floating lace plant	*Aponogeton natans*	Aponogetonaceae	Kunnukara
47.	Wrinkled marsh weed	*Limnophila rugosa*	Plantaginaceae	Kunnukara
48.	Amazon frogbit plant	*Lymnobium laevigatum*	Hydrocharitaceae	Kundannoor
49.	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Nettoor
50.	Water fern	*Salvinia natans*	Salviniaceae	Madavana

TABLE 2. LIST OF PONDS/AQUATIC HABITAT AND LOCALITIES FROM WHERE PLANTS ARE COLLECTED

Number of ponds/aquatic habitat	Name of Locality	GPS location of pond
P1	PUTHENVELIKARA	Lat:10.190844° Long:76.23692°
P2	Elanthikara, Puthenvelikara	Lat:10.1405022° Long:76.23051558°
P3	Stationkadav, Puthenvelikara	Lat:10.179321° Long:76.244463°
P4	Gothuruth, Puthenvelikara	Lat:10.18857° Long:76.20879°
P5	Chenthamangalam, Puthenvelikara	Lat:10.16772° Long:76.25085°
P6	Polistation road, Puthenvelikara	Lat:10.14724° Long:76.25085°
P7	Arankavu, Puthenvelikara	Lat:10.17650° Long:76.25485°
P8	Andippillykavu	Lat:10.178252° Long:76.215202°
P9	Andippillykavu temble	Lat:10.1784° Long:76.21106°
P10	Madaplathuruth, andippillikavu	Lat:10.154894° Long:76.224098°
P11	Thekkethuruth, andippillykkavu	Lat:10.18357° Long:76.21969°
P12	Paroor	Lat:10.154894° Long:76.224098°
P13	Kunnukara	Lat:10.1568978° Long:76.3040481°
P14	Thiruthipuram	Lat:10.178252° Long:76.215202°
P15	Varapuzha	Lat:10.076323° Long:76.277644°
P16	Kadamakudi,varapuzha	Lat:10.0634103° Long:76.2493503°
P17	Thevara	Lat:9.937906° Long:76.294666°
P18	Nettoor	Lat:9.936615° Long:76.313612°
P19	Madavana	Lat:9.909712° Long:76.317992°
P20	Ernamkulam	Lat:9.931714° Long:76.318002°
P21	Moothakunnam temple pond	Lat:10.1886° Long:76.2028°
P22	Moothakunnam	Lat:10.189429° Long:76.201744°

TABLE 3. Showing Plants and their category and locality.

PLANT NAME	CATOGORY	POND NO.
Centella asiatica	*marshy*	P1, p8, p18, p20
Pistia stratiotes	*free-floating*	*P1, p8, p14, p17, p22*
Lemna minor	*Free floating*	*P17, p22*
Anubias barteri	marshy	P12
Cabomba caroliniana	*submerged*	*P1, p10, p17, p22*
Cabomba caroliana	*submerged*	*P1, p10, p17, p22*
Cerratophyllum demersum	*submerged*	*P1, p10, p17, p22, p13*
Rotala rotundifolia	*Submerged and marshy*	*P1*
Rotala rotunadensis	*Submerged and marshy*	*P1, P2, P15, P21*
Hydrilla verticillata	*submerged*	*P2, P15, P21, P22*
Ottelia alismoides	*submerged*	*P1, P2, P3, P15, P22*
Vallisneria natans	*Sub merged*	*P1, P2, P3*
Lymnobium laevigatum	*free-floating*	*P2, P18, P20*
Elodea canadensis	*submerged*	*P1, P2, P3, P5*
Ottelia pers	*submerged*	*P15, P16, 17, P21*
Vallisneria spiralis	*submerged*	*P3, P8*
Nymphoides auratiacum	*Attached floating*	*P2, P3, P14*
Nymphoides hydrrophylla	*Attached floating*	*P2, P3, P14*
Nymphoides indica	*Attached floating*	*P2, P3, P4, P14*
Nymphoides malabarica	*Attached floating*	*P1, P2, P3, P4P14*
Nymphoides micrantha	*Attached floating*	*P1, P2, P3, P14*
Nymphoides nauchali	*Attached floating*	*P1, P2, P3, P14*
Eichornia crassipes	*free-floating*	*P5, P20, P21, P22*
Hydrocleys nymphoids	*Attached floatig*	*P17, P18, P14*
Sagittaria guayasensis	*Attached floating*	*P14, P17*
Echinodorus chordifolius	*Emergent*	*P6, P7*
Sagittaria sagittifolia	*Attached floating*	*P6, P7*
Echinodorus osiris	*Emergent*	*P12.P13*
Trapa natans	*free-floating*	*P14, P22*
Myriophyllum oliganthum	*Emergent*	*P17, P15, P6*
Ceratopteris thalictroids	*Emergent*	*P7, P18*
Azolla pinnata	*Free floating*	*P4, P6, P9*
Dryopteris marginalis	*Marshy*	*P3, P4*
Fittonia albivenis	*marshy*	*P7*
Bacopa monnieri	*submerged*	*P9, P10, P11*
Bacopa hamiltoniana	*submerged*	*P13*
Veronica beccabunga	*emergent*	*P1*
Limnophila rugosa	*emergent*	*P13*
Marsilia minuta	*marshy*	*P7, P10*
Aponogeton appendiculus	*submerged*	*P15*
Aponogeton natans	*free-floating*	*P13*
Brachiaria mutica	*emergent*	*P2*
Acorus calamus	*emerged*	*P3*
Eclypta prostrata	*marshy*	*P15, P22*
Salvinia molesta	*free-floating*	*P4, P6, P8, P21, P22*

Salvinia natans	*free-floating*	*P19, P20, P22*
Alternanthera philoxeroides	*marshy*	*P18*
Curcuma angustifolia	*marshy*	*P1*
Ludwigia adscendens	*marshy*	*P21*
Ludwigia sedoides	*marshy*	*P13*

CATEGORY	NUMBEROF PLANTS
Free floating (FF)	18
Submerged (S)	14
Emergent (E)	8
Marshy (M)	10

Fig. 1 number of plants category- wise

Table 4: SHOWING SUITABILITY LIST OF PLANTS

Sl. No.	**PLANTS FIT FOR AQUARIUM**	**PLANTS FIT FOR PALUDARIUM**	**FIT FOR BOTH AQUARIUM AND PALUDARIUM**
1.	*Hydrocleys nymphoides*	*Dryopteris marginalis*	*Baccopa monnieri*
2.	*Ceratopteris thalicoides*	*Fittonia albivenis*	*Fittonia albivenis*
3.	*Fittoniav albivenis*	*Baccopa monnieri*	*Limnophila rugosa*
4.	*Marsilia minuta*	*Bacopa hamiltoniana*	*Acorus calamus*
5.	*Aponogetonappenticulatus*	*Veronica beccabunga*	*Ludwigiaadscenens*
6.	*Vallisneria spiralis*	*Limnophila rugosa*	*Vallisneria spiralis*
7.	*Limnophila rugosa*	*Acorus calamus*	*Centellla asiatica*
8.	*Ludwigia adscendens*	*Eclypta prostrata*	*Anubias barteri*
9.	*Centella asiatica*	*Alternanthera philoxeroides*	*Rotala rotundifolia*
10.	*Cabomba caroliniana*	*Curcuma angustifolia*	*Rotalarotunadensis*
11.	*Cabomba caroliana*	*Ludwigia adscenens*	*Vallisneria natans*
12.	*Cerratophyllum demersum*	*Vallisneria spiralis*	*Cabomba caroliana*
13.	*Rotala rotundifolia*	*Centellla asiatica*	
14.	*Rotala rotunadensis*	*Anubias barteri*	
15.	*Hydrilla verticillata*	*Rotala rotundifolia*	
16.	*Vallisneria natans*	*Rotala rotunadensis*	
17.	*Bacopa monnieri*	*Vallisneria natans*	
18.	*Trapa natans*	*Lymnobium laevigatum*	
19.	*Myrioohyllum oliganthum*	*Elodea canadensis*	
20.	*Sagittarius guayasensis*	*Ceratopteris thalictroids*	
21.	*Aponogeton natans*	*Cabomba caroliana*	
22.	*Echinodorus chordifolius*	*Cabomba caroliniana*	
23.	*Eloda Canadensis*		
24.	*Sagittarius sagittifolia*		
25.	*Acorus calamus*		
26.	*Anubias barteri*		
27.	*Echinodorus osiris*		

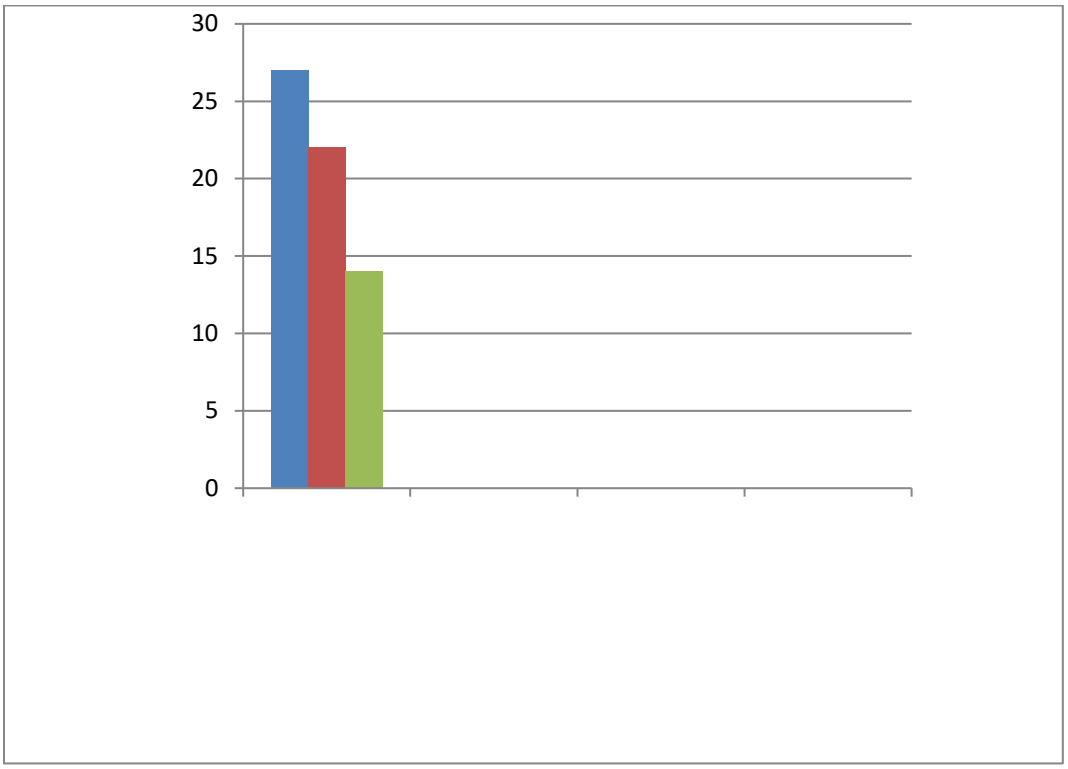


FIGURE 2: SHOWS SUITABILITY OF PLANTS

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