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Invasive Aquatic plants and their distribution: A Case Study

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Abstract

The present study deals with the documentation of invasive alien aquatic species at Mavoor wetland regions in Kozhikode district. Extensive and intensive floristic studies were conducted in these areas and voucher specimens were collected, identified and preserved in the form of herbarium following standard method. The present results revealed that there are 23 aquatic species under 22 genera and 18 families are distributed in the study area. Most of these species are of native to Tropical America and Asia and few of them are from other countries. Their growth rate was observed and found that they were spreading very fast which could be harmful for native plant species

1. Introduction

Plants which are adapted morphologically and anatomically to waterlogged habitat are called aquatic or wetland plants. These plants are the important biotic components which play the role of producer in aquatic ecosystems and as such maintain ecological balance in nature. Majority of aquatic Plants grow faster and interfere with the growth of other plants called weeds. These plants are also used in Food, fodder, fuel, medicine, water detoxification and other miscellaneous uses (Sahoo & Nayak, 2022).

Wetlands are increasingly being invaded by invasive alien species worldwide. According to Convention on Biological Diversity (1992), invasive alien species are the non-native species in an ecosystem which disturb the ecosystem function and the Convention visualizes "biological invasion of alien species is the second worst threat after habitat destruction" (Sahoo & Nayak, 2022). One of the biggest challenges to biodiversity in recent years has been the expansion of non-native, alien or exotic species, which threatens the ecological integrity of many natural habitats and drives certain rare species closer to extinction than habitat loss (Reddy, 2009. It has the potential to cause significant and permanent alterations to the structure and function of ecosystems (Mooney & Hobbs, 2000; Sakai *et al*., 2001). It generates significant economic losses and competes with natural species (Dukes & Mooney, 2004; Antonio & Hobbie, 2005).

Due to their uncontrolled growth, Introduced Invasive Alien Aquatic Plants (IAAPs) have the potential to endanger ecosystems and have an influence on the environment and the economy (Getsinger *et al*., 2014; Brundu, 2015). In terms of ecology, they alter the composition of macrophyte communities (Santos *et al*., 2011; Hussner, 2014), change the abundance and richness of macroinvertebrate species (Stiers *et al*.,

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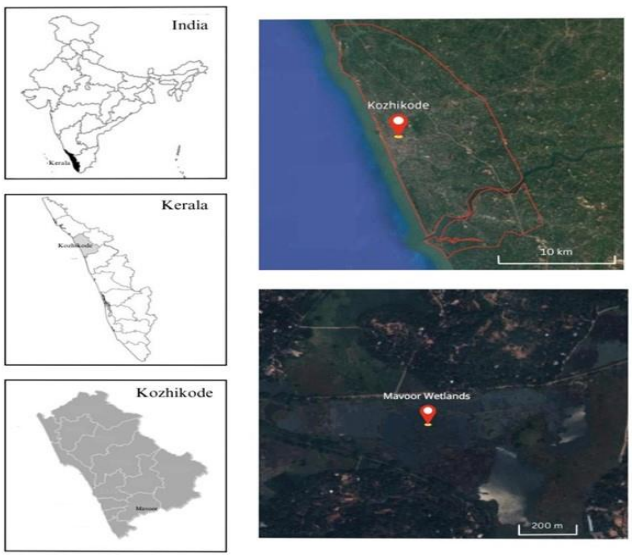
2011), deplete oxygen (Shillinglaw, 1981), and influence the structure of the food web (Villamagna & Murphy, 2010). Furthermore, by obstructing river flow, thick macrophyte stands might raise the risk of flooding (Holm *et al*., 1969; Wilcock *et al*., 1999; Thouvenot *et al*., 2013), hinder shipping and navigation (Holm *et al*., 1969) and impair recreational water sports activities, which decreases the value of lakefront property (Halstead *et al*., 2003). In addition, IAAPs decrease water flow and availability in irrigation and drainage systems (Holm *et al*., 1969) and block hydropower dams, which lowers hydropower generation (Clayton & Champion, 2006).

2. Materials and Methods

2.1 Study area

Kerala is one of India's most biodiverse states, encompassing a varied assemblage of aquatic plant species. It lies between the northern latitude of 8°.17′.30″ N and 12°. 47′.40″ N and east longitudes 74°.27′.47″ E and 77°.37′.12″ E. The tropical monsoon climate of Kozhikode, a district of Kerala, encourages the development of a wide variety of aquatic plants. Mavoor is a panchayat of Kozhikode district of Kerala which is located 20 Kilometers east of Kozhikode, near to the Chaliyar River, at 11o15′35″ N and 75o56′55″ E. (Fig.1). The months of March to May are the hottest in Mavoor's humid environment. The most significant rainy season is the Southwest monsoon, which starts the first week of June and lasts until September. A wide variety of aquatic plants, including submerged, floating and emergent ones. The present study areaconsists of roughly about 50 hectares of wetlands with wide variety of aquatics.

Fig.1 Map of the study area: Mavoor Panchayat of Kozhikode district in Kerala.



2.2. Documentation of invasive aquatic plants of the study area

The present study was based on an extensive survey and field observations during the period September 2024 to January 2025. It mainly focused on to document invasive aquatic plants, which are distributed in the Mavoor Grama Panchayat of Kozhikode District, Kerala. The collected plant specimens were identified taxonomically with the help of available Floras and literature (Hooker, 1984; Gamble & Fischer, 1915 – 1936; Sasidharan, 2004; Ansari, 2016; Pradeep *et al*., 2023). The nomenclature of each species has been brought up to date as per the rules given in the International Code of Nomenclature (ICN). The specimens were processed for the preparation of Herbarium by standard methods (Santapau & Hentry, 1973). The voucher specimens were deposited in the Herbaria of PG & Research Department of Botany, St.

Joseph's College, Calicut (DEV) for future reference.

3.Results and Discussion

3.1. Analysis of invasive aquatic plant diversity in the study area

The present floristic survey revealed that 23 invasive aquatic plant species belonging to 22 genera and 18 families have been reported from the Mavoor wetland of Kozhikode district of Kerala. Out of these, dicotsare of 9 species under 9 genera and 8 families, while monocotsconsists of 12 species under 11 genera and 8 families and pteridophytes are composed of 2 species under 2 genera and 2 families respectively (**Table-1** &**Fig. 2**). From the present investigation also observed that the following families such as Asteraceae, Hydrocharitaceae, Pontederiaceae, Araceae and Poaceae (2 species each) are the most dominant families. Other 13 families are represented by one species each. *Pontederia* is the dominant genera having 2 species.

Similar studies were conducted by Sahoo & Nayak, (2022) and observed that, there are 47 aquatic plant species under 35 genera and 27 families from Jajpur district of Odisha. In their investigation, it has been observed that, the family Asteraceae (06 Species) is the most dominant family and itwas followed by Poaceae (05 Species) and Cyperaceae, Onagraceae, Pontederiaceae (3 species each); Amaranthaceae, Polygonaceae, Convolvulaceae, Fabaceae, Araceae (2 Species each). Other 17 families are represented by one species each.

A study on Invasive alien plant species (IAPS) in the aquatic ecosystems of Kerala by Sabu, (2023), enlisted 18 truly aquatic IAPS (16 Angiosperms and 2 Pteridophytes) belonging to 16 families. All the aquatic IAPS listed except *Ipomoea carnea*subsp. *fistulosa* are herbaceous plants. Most of the plants are distributed all over Kerala and some are restricted to coastal areas only.

Similarly Lija & Radhamany, (2023), conducted a study on the invasive plants in the Poovar region of Neyyar river, in which they resulted in the documentation of 41 invasive species belonging to 34 genera of 20 families, of which 40 species are angiosperms and one is pteridophytes. Out of 41 invasive species reported from the study area, there are about 6 species were reported as aquatic invasives, which includes *Eichhornia crassipes* (Mart.) Solms, *Cabomba aquatic* Aubl, *Ceratophyllum demersum* L, *Hydrilla verticillata* (L.f.) Royle, *Pistia stratiotes* L. and *Salvinia molesta* Mitch.

Table-1: Analysis of the diversity of invasive aquatic plants in the study area

Analysis of the diversity of invasive aquatic plants		Families		Genera		Species	
Dicotyledons	Polypetalae	4	8	4	9	4	9
	Gamopetalae	3		4		4	
	Monochlamydae	1		1		1	
Monocotyledons		8		11		12	
Pteridophytes		2		2		2	
Total		18		22		23	

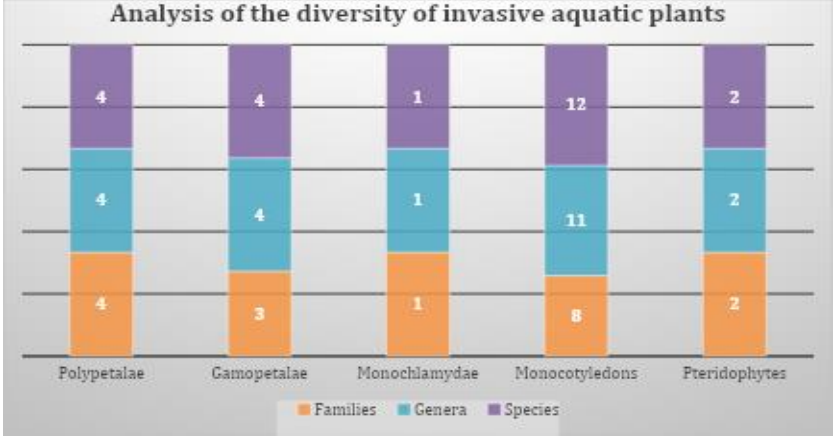


Fig-2: Analysis of aquatic plants with respect to their number of families, genera & species

Among the documented 23 invasive aquatic plants, 13 of them are truly aquatic, 6 are semi- aquatic and 4 are marginal plants. Among 13 truly aquatic plants, 7 are free floating, 3 submerged, 2 emergent rooted floating and 1 rooted floating plant. Moreover the present observation also noted that, half of the semi aquatic plants are creeping herbs and all of the marginal plants are herbs (**Table 2**).

Table-2: Classification of Invasive aquatic plants in the study area

Type of Aquatic Plant	Botanical Name	Life Form
Truly aquatic plants	*Utricularia aurea* Lour.	Free floating
	Pontederia crassipes Mart.	
	Pistia stratiotes L.	
	Lemna perpusilla Torr.	
	Azolla pinnata R. Br.	
	Salvinia molesta D.S. Mitch.	
	Potamogeton nodosus Poir.	
	Cabomba furcata Schult. & Schult.f.	Submerged
	Hydrilla verticillata (L.f.) Royle	
	Vallisneria spiralis L.	
	Nymphaea pubescens Willd.	Rooted floating
	Cyperus rotundus L.	Emergent
	Pontederia vaginales Burm.f.	
Semi-aquatic plants	*Leersia hexandra* Sw.	Creeping herb
	Sphagneticola trilobata (L.) Pruski	
	*Ipomoea aquatica*Forssk.	
	Ludwigia peruviana (L.) H. Hara	Shrub
	Colocasia esculenta (L.) Schott	Tuberous herb
	Saccharum spontaneum L.	Herb
Marginal plants	*Melochia corchorifolia* L.	Woody Herb
	Mikania micrantha Kunth.	Twining herb
	Alternanthera sessilis (L).DC	Creeping Herb
	Commelina benghalensis L.	

3.2. Analysis of Nativity of invasive aquatic plants from the study area

The present investigation on the diversity of invasive aquatic species reveals that, they were introduced from various countries and continents like Asia, Europe, Africa, Australia, China, Canada, USA, Tropical America, Tropical and subtropical Asia, South America, Central America, N. Australia, S. Europe, N. Africa, S. W. Asia, Tropical Gerontia, Pantropical, Tropical W. Asia and South eastern Brazil (**Table-3**).

Similar observant were made by Sahoo & Nayak, (2022) in Jajpur district of Odisha, they alsonoted that most of the species are the native of Tropical America (19 species) followed by Tropical Africa (07 species) and other countries represent less in number.

Table-3: Analysis of the of Nativity of invasive aquatic plants in the study area

SI. No.	Botanical Name	Family	Nativity	References
1	*Nymphaea pubescens* Willd.	Nymphaceae	Tropical & subtropical asia	Emily *et al.*, 2017
2	*Cabomba furcata* Schult. & Schult.f.	Cabombaceae	South America	Biju *et al.*, 2023
3	*Melochia corchorifolia* L.	Sterculiaceae	Tropical America	Prameela *et al.*, 2023
4	*Ludwigia peruviana* (L.) H. Hara	Onagraceae	South America	Prameela *et al.*, 2023
5	*Mikania micrantha* Kunth.	Asteraceae	Central & S. America	Prameela *et al.*, 2023
6	*Sphagneticola trilobata* (L.) Prusk.	Asteraceae	Central America	Prameela *et al.*, 2023
7	*Ipomoea aquatica* Forssk.	Convolvulaceae	China	Prameela *et al.*, 2023
8	*Utricularia aurea* Lour.	Lentibulariaceae	Asia & Australia	Pandit *et al.*, 2005
9	*Alternanthera sessilis* (L) .DC.	Amaranthaceae	Tropical America	Sahoo & Nayak, 2022
10	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae	Asia & North Australia	Prameela *et al.*, 2023
11	*Vallisneria spiralis* L.	Hydrocharitaceae	S. Europe, N. Africa & S.W. Asia	Prameela *et al.*, 2023
12	*Pontederia crassipes* Mart.	Pontederiaceae	South America	Biju *et al.*, 2023
13	*Pontederia vaginales* Burm.f.	Pontederiaceae	Tropical America	Raj *et al* ., 2018
14	*Commelina benghalensis* L.	Commelinaceae	Tropical Gerontia	Sahoo & Nayak, 2022
15	*Colocasia esculenta* (L.) Schott	Araceae	Tropical Asia	Sahoo & Nayak ,2022
16	*Pistia stratiotes* L.	Araceae	Pantropical	Biju *et al.*, 2023
17	*Lemna perpusilla* Torr.	Lemnaceae	Canada & U.S.A	Jayan &

				Sathyanathan, 2012
18	*Potamogeton nodosus* Poir.	Potamogetonaceae	Europe	Kak, 1984
19	*Cyperus rotundus* L.	Cyperaceae	Europe	Raj *et al*., 2018
20	*Leersia hexandra* Sw.	Poaceae	Pantropical	Odelu, 2014
21	*Saccharum spontaneum* L.	Poaceae	Trop. W. Asia	Sahoo & Nayak, 2022
22	*Azolla pinnata* R. Br.	Azollaceae	Africa & Asia	Pandit *et al*., 2005
23	*Salvinia molesta* D.S. Mitch.	Salviniaceae	South eastern Brazil	Biju *et al*., 2023

3.3. Economic potentialities of documented plants

Out of the 23 invasive aquatic plants that have been reported, 21 are deemed to be economically significant. These include 2 of them are ornamentals, 11are of medicinals, and a few others with various miscellaneous purposes.

3.3.1. Medicinal potentialities of invasive aquatic plants

The present study revealed, among the 23 invasive plants documented, 11 species are known to have medicinal properties (**Table-4**). These species contain a variety of chemical compounds, such as flavonoids, phenols and alkaloids, which give them their therapeutic effects. Various parts of non-native plants are employed as therapeutic herbs.

A study was conducted on the uses of the invasive species by Semenya *et al.* (2012). According to them, many of exotic species are extensively exploited in Africa. In fact, some of these species have become used for edible purposes in the daily lives of residents of Africa and also used for various traditional medicinal practices.

The whole plant extracts from *Hydrilla verticillata* rich in flavonoids, which have antimicrobial and astringent properties that help with wound healing. (Mary Kensa *et al*., 2014). Roots of *saccharum spontaneum* are used to treat gynecological problems, respiratory problems, constipation and piles and the aerial parts are used to treat burning sensation (Deepak *et al*., 2023).

The methanol extract of the root, stem, leaves and flowers of *Sphaeticola trilobata* was found to be significant against the following three bacteria: *Pseudomonas aeruginosa, Staphylococcus aureus* and *Salmonella typhi*. *S. trilobata* (Hoang Thanh Chi *et al*., 2021).

Other species including *Ludwigia peruviana, Mikania micrantha, Melochia corchorifolia, Alternanțasessilis, Colacasia esculenta, Leersia hexandra* and *pistia stratiotes* are also reported with the various medicinal properties like antioxidant, antibacterial and anti-inflammatory properties.

Table-4: List of invasive aquatic plants with various medicinal properties

SI No.	Botanical Name	Family	Medico- potentialities	References
1	*Melochia corchorifolia* L.	Sterculiaceae	Medicinal uses, including treating urinary disorders, abdominal swelling, dysentery, and snakebite	Mamatha *et al*., 2018
2	*Ludwigia peruviana* (L.) H. Hara	Onangaracea	Used for treating Hepatic pain, diuretic and kidney problems	Armijos *et al*., 2018

3	*Mikania micrantha* Kunth.	Asteraceae	Anti-inflammatory attributes, Antidiabetic characteristics, Cytotoxic and anticancer potencies, Antioxidant properties, Wound healing aspects and antimicrobial activity.	Moinuddin *et al.,* 2020
4	*Sphagneticola trilobata* (L.) Pruski	Asteraceae	Antidiabetic potential activity, hypoglycemic effect, antioxidant activities. *S.trilobata* methanol extract inhibited the growth of the human megakaryoblastic leukemia cell line.	Hoang Thanh Chi*et al.,* 2021
5	*Alternanthera sessilis* (L) .DC	Amaranthaceae	Relieve pain, wound healing, dysentery, asthma and hypertension,	Chia Shing *et al.,* 2022
6	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae	provide complete nutrition, improve digestion and gastrointestinal function, circulation, neurological health, blood sugar control, to strengthen immunity and increase endurance	Prabha *et al.,* 2019
7.	*Commelina benghalensis* L.	Commelinaceae	remedy for hypertension, infertility in women, sore throats and eyes, burns, rashes, leprosy, dysentery, infant's thrush, opthalmia, burns, sore throats, sore feet, wound healing, urethral pain, demulcent, emollient, depressant, bitter, refrigerant, laxative, and for the treatment of Malaria.	Fibrich et al., 2020
8	*Colocasia esculenta* (L.) Schott	Araceae	Improved blood sugar levels, better skin care, helps to reduce obesity. anti-hepatotoxic , hepatoprotective activity, anti-inflammatory activity, neuropharmacological activity, anti-fungal activity and anti-metastatic activity.	Khush *et al.,* 2023
9	*Pistia stratiotes* L.	Araceae	The root is laxative, emollient, and diuretic. Leaves infusions used for dropsy, bladder complaints, kidney afflictions, hematuria, dysentery, and anemia.	Tripathi *et al.,* 2010
10	*Leersia hexandra* Sw.	Poaceae	Treatment of muscular tiredness, treatment of hemoptysis and hypertension	Danielle *et al.,* 2019
11	*Saccharum spontaneum* L.	Poaceae	Anti-diarrhoeal activity, anti-inflammatory activity , Anti-oxidant activity , Anti-psychotic	Deepak *et al.,* 2023

			activity, Cytotoxic activity, Anti-urolithiasis activity, anti-obesity activity & CNS depressant activity	

3.3.2. Plants used for Miscellaneous purposes

In addition to medical use, these non-native plants have a variety of other miscellaneous purposes, such as food, decorative, biofertilizer, biological control agent, etc. Plants like *Azolla* are used as a biofertilizer. Different parts of other plants like *Nymphaea pubscence, Melochia corchorifolia, Ipomoea aquatica, Colacasia esculenta* are edible and used for traditional food preparation by natives (**Table-5**).

Azolla's high nitrogen content that helps rice crops to grow better, especially in submerged paddy fields. It can be used as a protein and fiber supplement in livestock feed, also used as the substrate for producing low-cost biofuel.The nitrogen-rich water from *Azolla* that used to fertilize algal growth too (Gamachis Korsa *et al*., 2024)

Plants like *Utricularia aurea* and *Azolla pinnata* are used to control mosquitoes. *Pistia stratiotes*, which is known to be an ornamental plant also have phytoremediation property to remove toxins from polluted water, remove heavy metals from polluted water and it also can break down pollutants through its own metabolism (Adamu Yunusa *et al*., 2015).

Table-5: List of invasive aquatic plants with different Miscellaneous uses

SI No.	Botanical Name	Used as	Use	Reference
1.	*Nymphaea pubescence* Willd.	Food, Ornamental plant	Seed flour can be used to make cookies and other baked goods.	Nizam *et al.* 2016
2.	*Cabomba furcata* Schultes & Schultes f.	Ornamental plant	Popular aquarium plant that adds color and life to a tank.	Siti *et al.*, 2010
3.	*Melochia corchorifolia* L.	Food	Fresh leaves of *M. corchorifolia* are consumed as a portherb and cooked leaves as slimy side-dish in West Africa and Malai respectively.	Dhanu *et al.*, 2024
4.	*Ipomoea aquatica* Forssk.	Food	The leaves are good source of minerals andvitamins especially carotene and is considered a possible source of	Dubey *et al.*, 2021

			food protein	
5.	*Utricularia aurea* Lour.	Biological control agent	It is the carnivorous aquatic plant that can be used to control mosquito larvae.	Ajeet *et al.,* 2024
6.	*Commelina benghalensis* L.	Food	It is used for animal fodder or is eaten as a vegetable, such as spinach.	Fibrich*et al.,* 2020
7.	*Pistia stratiotes* L.	Phytoremediation agent	It can be used to remove toxins from polluted water. It can be used to treat water resources contaminated by herbicides	Dandara *et al.,* 2019
8.	*Lemna perpusilla* Torr.	Food	The protein production of duckweeds per harvested area was higher than that of soybean, rice, and corn; thus, it could solve the problem of farmland shortage to produce food or animal feed	GahYoung*et al.,* 2021
9.	*Azolla pinnata* R. Br.	biofertilizer	*Azolla* by dual cropping decreased CH_4 emission by ~ 40% and also stimulated CH_4 oxidation compost. It alsoIncreases water holding capacity, organic carbon, ammonium nitrate $(NH^4)2\ NO_3$ and it also absob various minerals like P, K, Ca, Mg etc.	Mahipal *et al.,* 2017
10	*Salvinia molesta* D.S. Mitch.	Ornamental	*Salvinia* species used as cultivated ornamentals in aquariums.	Simpson *et al.,* 2010

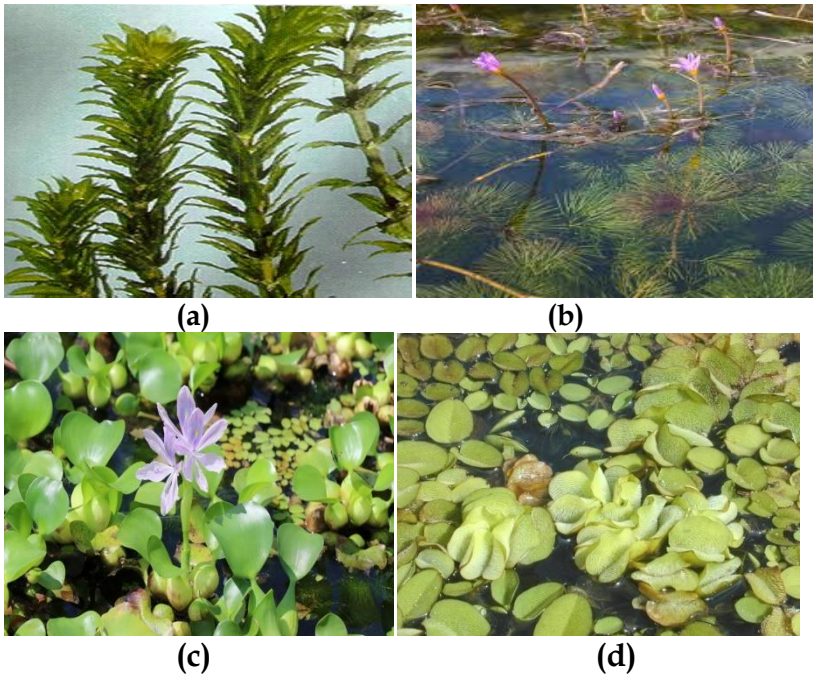
3.3.3. Weedy Invasive Aquatic plants

Even if many of the invasive aquatic plants are significant, many of them have turned to be aggressive weeds and it may affect the native flora of the area. It is observed that *Hydrilla verticillata* [**Fig.2 (a)**], *Cabomba furcata* [**Fig.2 (b)**], *Pontederia vaginales* [**Fig.2 (c)**] and *Salvinia molesta* [**Fig.3 (d)**], are the major invasive weeds which have grown to an extensive level to cause various impacts on ecological balance in the study area. *Leersia hexandra* and *Colocasia esculenta* are also present in high frequency.

Purple nutsedge, or *Cyperus rotundus*, an aggressive weed and detrimental to agriculture's bottom line. It is regarded as one of the worst weeds in the world. It may face competition from crops for space, light and nutrients. Once it established, eradication might be challenging.It has the ability to infiltrate other places including native vegetation (Rojas & Acevedo, 2022).

According to (Oyedeji *et al.*, 2012) Aquatic plants have adapted to living in or on aquatic environments and constitute a problem in culture fisheries. They block navigational channels on the waterways and easily choke the propellers of boats.

Fig.3: Weedy invasive aquatic plants of study area



(a) *Hydrilla verticillata* **(b)** *Cabomba furcata* **(c)** *Pontederia vaginales* **(d)** *Salviniamolesta*

4. Conclusion

From the above investigation, 23 invasive plants are reported from the study area. They were introduced from various regions. These plants have different economic benefits and they were also used as medicines,food, ornaments etc. They migrate from their native places and establish themselves in different aquatic habitats due to favorable conditions. This leads to interference with native plant growth, resulting in competition and loss of native aquatic biodiversity.

The introduction of invasive species has dramatically altered native floristic distributions. To combat this, a multi-faceted approach is crucial. This entails preventing invasive species introduction through regulated trade and transport, public education, location-specific research on invasive species and early detection monitoring. Rapid response teams should be formed to swiftly to address invasive species sightings and measures such as eradication, biological control and habitat restoration should be implemented.

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