



RESEARCH ARTICLE

A floristic checklist of wetland and aquatic vascular plants of Telangana, India

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Abstract

The present study was carried out to explore the wetland and aquatic vascular plant diversity in Telangana State, India during 2015 to 2024. The field-based study notifies 352 plant taxa pertaining to 198 genera and 76 families of vascular wetland and aquatic plants. Among these, Cyperaceae family tops the list with 80 species followed by Poaceae with 45 species, Asteraceae (21 spp.), Fabaceae (15) and Lythraceae, Rubiaceae and Scrophulariaceae (11 spp. each). The most frequent genera are *Cyperus*, *Eichhornia*, *Typha*, *Ipomoea*, *Pistia* and *Alternanthera* in wetlands of Telangana. The genus *Cyperus* dominates the diversity by having 23 species, where *Fimbristylis* and *Schoenoplectus* possess 10 species each, *Eriocaulon* and *Rotala* have 8 species, *Eleocharis* with 7, *Pycnus* with 6 taxa and *Commelina*, *Scleria* and *Utricularia* consist of 5 spp. each and 137 plant genera holds a single species each. The present study reveals that wetland and aquatic plant diversity in Telangana is extremely uneven with high diversity seen in northern Telangana region while less diversity found in southern Telangana and most of the aquatic and wetlands were found highly polluted in Greater Hyderabad compared to other districts due to industrial effluents, urbanization and habitat fragmentation. The current research study is the first catalogue to encounter 352 wetland and aquatic plant taxa and provides insights to understand the aquatic plant diversity and measures to protect the aquatic ecosystems from anthropogenic pressure and calls for prioritizing conservation activities and to know the impact of aquatic invasive species on native plant diversity.

Keywords: floristic inventory; habitat; macrophytes; plant species diversity; Telangana; wetlands

Introduction

The aquatic ecosystems consist of diversified plant wealth which add beauty and other services to humankind. Wetland and aquatic vascular plants play a wide range of roles in ecosystem services in aquatic conditions with immense value for the well-being of living organisms. The term 'aquatic vascular plants' is used to refer to Pteridophytes (ferns and fern allies) and Spermatophytes (seed bearing plants) which exist permanently or partially in aquatic bodies or float on the water surface and the plant taxa that commonly grow in water. Wetlands are defined as 'a place where 80 % or more of the plants grow in wetlands or is a place where inundation must occur for at least 2 weeks and saturation for at least 2 consecutive months' (1). Aquatic plants provide many ecosystem services including maintenance of low mud, soil erosion, nutrients, etc. Aquatic vegetation meets various needs of living beings like production of food, provision of shelter for aquatic fauna, improving the water quality, purification of water, reduce water fowl, fodder for livestock,

supply of oxygen, improves plankton diversity, recreation, aesthetic value and regulates carbon dioxide, mineral salts, nature of substratum, temperature, high turbidity and remediates the contaminated aquatic ecosystems (2).

Wetland and aquatic vascular plants play a crucial role in the structure, functions and maintain the health of aquatic ecosystems with earlier workers having carried out floristic studies related to aquatic ecosystems at global level (2-6). Wetlands are the most productive ecosystems on the planet earth and sometimes called as 'Kidneys of the Earth' as they perform different biogeochemical cycles, these are very essential to meet some of United Nations 17 Sustainable Development Goals (SDGs) which are associated with poverty, hunger, good health, clean water, energy, consumption, life below water and on land, and climate change (<https://sdgs.un.org/goals>) (7). India is the home of a rich diversity and largest number of wetlands in South Asia, and these wetlands usually have a cultural religious significance. In India, there are a total of 231195 wetlands which is

around 4.86 % (15.98 Mha) of the total geographical area of the country of which 85 Ramsar sites and 113 significant wetlands and play an important role in maintaining ecological balance, supporting biological diversity and essential in managing the impact of floods, cyclones, droughts and mitigate extreme weather effects (<https://moef.gov.in/national-wetlands-inventory-assessment>) and they also play a vital role as a provider of natural resources. Cook wrote 'Aquatic and Wetland Plants of India' which can be utilized as a handbook for identification of aquatic vascular plants found in permanent or seasonal freshwater bodies in India (1). Telangana has a large number of wetlands that possess high diversified biota and claims to be a 'State of Lakes' despite of a wetland coverage of 5.67 lakh ha, it doesn't receive the Ramsar tag even with the establishment of a State Wetland Authority (SWA) in 2019, not even a single aquatic body in the state has been mentioned under the National Plan for Conservation of Aquatic Ecosystems (NPCA) of the country. Telangana state has a large scope to utilize its wetland vegetation for different purposes. Most of the floristic inventory profiling being focused on terrestrial plants, there is a lack of information regarding the diversity of aquatic plants which needs urgent attention (8).

Comprehensive studies on the diversity of wetland and aquatic vascular plants in Telangana state are meager with no detailed research work and documentation of wetland plant taxa has not been undertaken by earlier workers in the study area (9-12). It is also keenly observed that the shrinking of aquatic habitats by filling up most of the water bodies and extinction of plant species diversity is due to anthropogenic activities such as irrigation, agrochemical exposure, biological invasion by non-native species, urbanization, habitat degradation, fragmentation,

industrialization, construction of buildings, dams and pollution as well as lack of studies to explore the effect of the mentioned activities on the concerned ecosystem and proper scientific documentation of aquatic vegetation in the state (13).

The main aim of the present study is to provide a comprehensive list of wetland and aquatic vascular plant species growing in wetland habitats of Telangana and to provide students, scholars, biologists and wetland managers with a means of identifying wetland and aquatic vascular plants encountered in the aquatic habitats of the state, and calls for further more research work on long term changes in the species composition, diversity and impact of invasive species in aquatic habitats to maintain healthy wetland ecosystems.

Study area

Telangana is the 29th and youngest state of Indian Union and lies between latitudes 15°48'32" to 19°55'46"N and longitudes 77°09'02" to 81°18'51"E. It is bounded east by Odisha, west by Karnataka, north-east by Chattisgarh, north and north-west by Maharashtra and south by Andhra Pradesh (Fig. 1). The state covers an area of 112122.44 sq km (43291 sq mi) which is 3.41 % of total geographical area of India and the total forest cover is 21214 sq km of which very dense, moderately dense and open forests are 1545 sq km, 8521 sq km and 8390 sq km, respectively that is about 16.46 % of geographical area of the state and the elevation ranges between 30 to 900 m above sea level (14). In Telangana, different forest vegetation types like tropical moist deciduous, tropical dry deciduous, tropical thorn, tropical riparian fringing, scrub and savanna forests are present (15). The main soil types are loamy, black cotton, coarse sandy, clayey, red, alluvial where iron ores, lime stones, laterite, coal, building stones

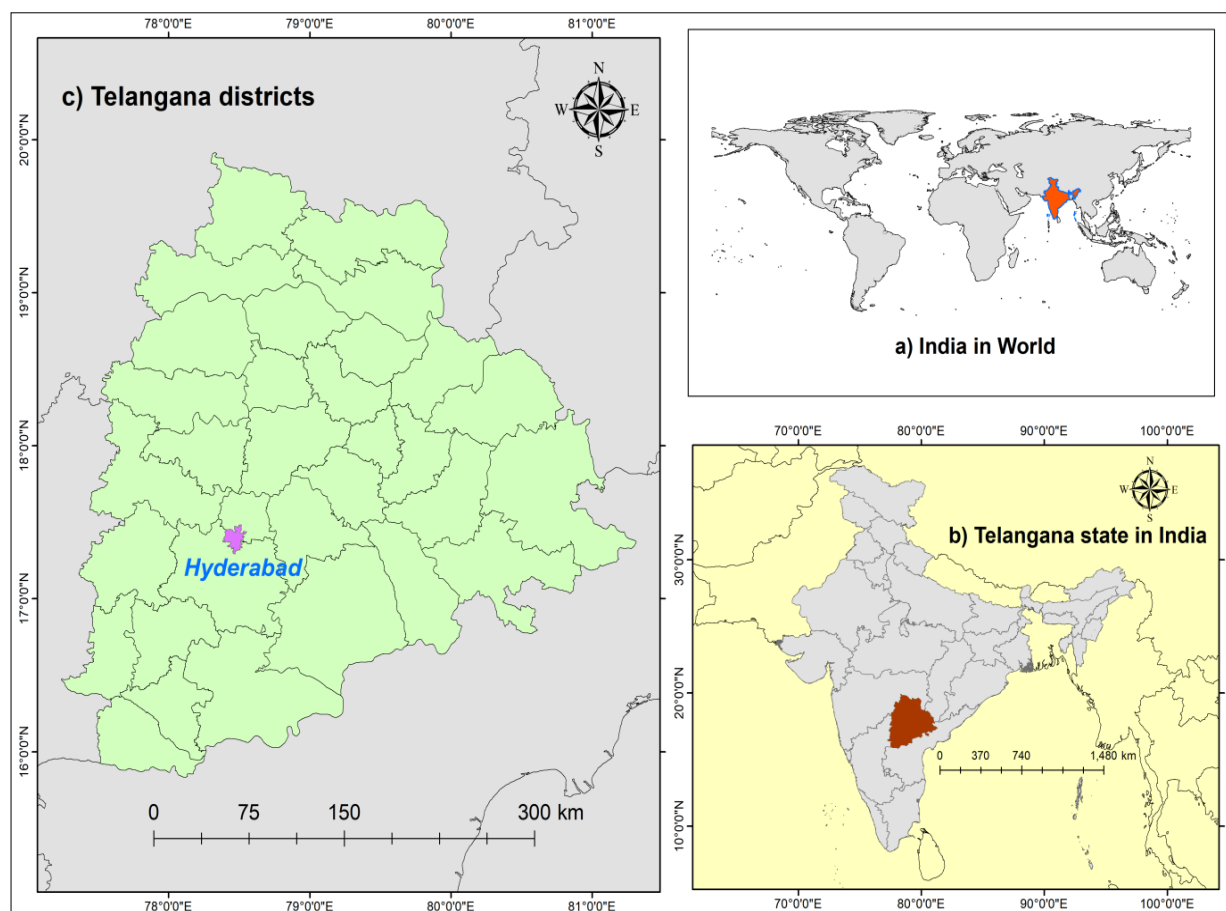


Fig. 1. Location of study area: a) World; b) India; c) Telangana state with 33 districts. (Source: NRSC, Hyderabad)

are the major mineral deposits in the state. The annual rainfall ranges between 800 - 1200 mm and 80 - 85 % of precipitation is usually from June to September (south-west monsoon). Extreme summer season with temperature reaching up to 50 °C in some areas and the coldest months are December and January, where the temperature sometimes drops up to 4 °C during winter (16). The state is drained mainly by Godavari and Krishna along with artificial lakes such as Nizam sagar, Pocharam, Ramappa, Laknavaram, Ghanpur (Mulug), Pakhal, Kinnerasani, Jurala, Nagarjuna sagar, etc., where the wetland area distribution is 566680 ha and does not have any coastal habitat in the area (17, 18).

Materials and Methods

The extensive field investigations were conducted during 2015 to 2024 for the collection of ground level data on wetlands and aquatic plant taxa found in Telangana. The present study has covered 33 districts of the state and major lakes, ponds and streams in towns, villages and forest areas. The study was concentrated on the data gathering from both primary and secondary sources. Detailed literature survey was accumulated on wetland and aquatic ecosystems for the present study on geographic locations, habitats, grazing, degradation, fragmentation, encroachment of aquatic bodies for different purposes, contaminated ponds, grazing and conversion of aquatic bodies into settlements and establishment industries were keenly observed in the natural ecosystems (19). The taxonomic identification of the collected plant specimens was done and collected data was compared to that of the Flora of Telangana State, India by the research team and taxonomic details, and the scientific names of plants were updated based on <http://www.theplantlist.org> and www.worldfloraonline.org (15). All the aquatic vascular plants were tabulated in a MS excel spreadsheet in alphabetical order for data analysis.

Results and Discussion

The present study was conducted in 33 districts of the state and in each district 15 sites were selected as a unit (total 495 sites). The

study region enjoys rich flora and finds 4 types of growth forms, herbs, shrubs, trees and climbers. The study explores a good number of the wetland and aquatic vascular plants in the region and common habitats are ponds, rivers, marshy areas, canals, streams, ditches, lakes and even contaminated areas in metropolitan cities like Greater Hyderabad and Greater Warangal. The taxonomic exploration study encountered 352 plant taxa under 198 genera and 76 families which consist of different growth-forms, and were recorded and dominated by 341 herbaceous, shrubs and climbers were 4 species of each, and 3 species were pertaining to trees (Supp Table 1).

There was a huge difference in the number, diversity and richness of the plant taxa recorded in northern part of the state than the southern part due to the more wetland area occupied in the region. The most frequent genera in the study region are *Cyperus*, *Eichhornia*, *Typha*, *Ipomoea*, *Pistia* and *Alternanthera*. The genus *Cyperus* dominates the diversity by having 23 species, where *Fimbristylis* and *Schoenoplectus* possess 10 species each, *Eriocaulon* and *Rotala* have 8 species, *Eleocharis* with 7, *Pycnus* with 6 taxa and *Commelina*, *Scleria* and *Utricularia* consist 5 spp. each where 137 plant genera hold single species each, accounting for 39 % of the total genera documented in the study area (Table 1).

The most dominant and diversified family of wetland and aquatic plants is Cyperaceae with 80 plant species and contributing 37.04 % of total plant count, followed by Poaceae with 45 species (20.83 %), Asteraceae with 21 taxa (9.72 %), there are 32 families were with only one species (0.46 % of each family) accounting for around 14.72 % of the overall family composition in the study area where Nymphaeaceae shared highest species richness (9 spp.), subsequently followed by Alismataceae (6 spp.), Pontederiaceae and Salviniaceae (4 spp. each), Convolvulaceae, Cyperaceae, Hydrocharitaceae, Lythraceae, Menyanthaceae and Onagraceae with 3 species each (20). The members of Cyperaceae and Poaceae (35.5 %) reproduce quickly during rainy season and dominate the habitat, some of them are perennials and establish monocot ridge mats that encourage the next successional processes (21, 22). The present study results were like the different exploration studies from Northwest China, Zhob district of Pakistan, Bikaner district of Rajasthan and Siddipet of Telangana as the Cyperaceae tops the list

Table 1. List of genera and number of species under each genus

No. of genera	Name of the genus	No. of spp.
137	<i>Abelmoschus</i> , <i>Abildgaardia</i> , <i>Acrocephalus</i> , <i>Ageratum</i> , <i>Amorphophallus</i> , <i>Anagallis</i> , <i>Anodendron</i> , <i>Anosporum</i> , <i>Arundo</i> , <i>Azolla</i> , <i>Bacopa</i> , <i>Barringtonia</i> , <i>Basilium</i> , <i>Blainvillea</i> , <i>Blumea</i> , <i>Brachiaria</i> , <i>Bulbostylis</i> , <i>Caesulia</i> , <i>Calamus</i> , <i>Canna</i> , <i>Cenchrus</i> , <i>Centaurium</i> , <i>Centella</i> , <i>Ceratophyllum</i> , <i>Ceratopteris</i> , <i>Cleome</i> , <i>Coelachyrum</i> , <i>Coldenia</i> , <i>Colocasia</i> , <i>Crassocephalum</i> , <i>Curcuma</i> , <i>Cyrtococcum</i> , <i>Dentella</i> , <i>Digera</i> , <i>Diplachne</i> , <i>Diplacrum</i> , <i>Dopatrium</i> , <i>Eclipta</i> , <i>Eichhornia</i> , <i>Elytrophorus</i> , <i>Emilia</i> , <i>Enicostema</i> , <i>Epaltis</i> , <i>Equisetum</i> , <i>Eriochloa</i> , <i>Evolvulus</i> , <i>Exacum</i> , <i>Flaveria</i> , <i>Flemingia</i> , <i>Galinsoga</i> , <i>Glinus</i> , <i>Gomphrena</i> , <i>Grangea</i> , <i>Habenaria</i> , <i>Hellenia</i> , <i>hoppea</i> , <i>Hydrilla</i> , <i>Hydrolea</i> , <i>Impatiens</i> , <i>Imperata</i> , <i>Ischaemum</i> , <i>Isoetes</i> , <i>Knoxia</i> , <i>Kyllinga</i> , <i>Lagarosiphon</i> , <i>Lippia</i> , <i>Limnophyton</i> , <i>Mecardonia</i> , <i>Melastoma</i> , <i>Melilotus</i> , <i>Melochia</i> , <i>Memecylon</i> , <i>Merremia</i> , <i>Mucuna</i> , <i>Murdannia</i> , <i>Naravelia</i> , <i>Neanotis</i> , <i>Nelsonia</i> , <i>Nelumbo</i> , <i>Nothosaerva</i> , <i>Oldelandia</i> , <i>Ophiuros</i> , <i>Oryza</i> , <i>Osbeckia</i> , <i>Ottelia</i> , <i>Oxystelma</i> , <i>Paederia</i> , <i>Pandanus</i> , <i>Paspalum</i> , <i>Pentapetes</i> , <i>Peperomia</i> , <i>Phragmites</i> , <i>Phyla</i> , <i>Physalis</i> , <i>Pistia</i> , <i>Polycarpon</i> , <i>Pseudoraphis</i> , <i>Pulicaria</i> , <i>Rhyncospora</i> , <i>Rikliella</i> , <i>Rorippa</i> , <i>Rottboellia</i> , <i>Rotula</i> , <i>Ruellia</i> , <i>Rungia</i> , <i>Saccharum</i> , <i>Salomonina</i> , <i>Scirpus</i> , <i>Senna</i> , <i>Sesbania</i> , <i>Smithia</i> , <i>Solanum</i> , <i>Sphaeranthus</i> , <i>Sphagneticola</i> , <i>Sphenoclea</i> , <i>Spirodela</i> , <i>Stemodia</i> , <i>Synedrella</i> , <i>Tamilnadia</i> , <i>Tenagocharis</i> , <i>Terminalia</i> , <i>Thecagonum</i> , <i>Themeda</i> , <i>Tonningia</i> , <i>Trapa</i> , <i>Trichilia</i> , <i>Typha</i> , <i>Vahlia</i> , <i>Vallisneria</i> , <i>Vernonia</i> , <i>Wolffia</i> , <i>Xanthium</i> and <i>Zingiber</i>	1
35	<i>Acalypha</i> , <i>Ammannia</i> , <i>Aponogeton</i> , <i>Arthraxon</i> , <i>Bergia</i> , <i>Blyxa</i> , <i>Chrysopogon</i> , <i>Clematis</i> , <i>Corchorus</i> , <i>Crinum</i> , <i>Cyanotis</i> , <i>Desmodium</i> , <i>Drosera</i> , <i>Elatine</i> , <i>Gnaphalium</i> , <i>Hedyotis</i> , <i>Hygrophila</i> , <i>Indigofera</i> , <i>Ipomoea</i> , <i>Limnophila</i> , <i>Mariscus</i> , <i>Marsilea</i> , <i>Monochoria</i> , <i>Najas</i> , <i>Neptunia</i> , <i>Nymphaea</i> , <i>Nymphoides</i> , <i>Oxalis</i> , <i>Paspalidium</i> , <i>Sacciolepis</i> , <i>Sagittaria</i> , <i>Setaria</i> , <i>Sporobolus</i> , <i>Syzygium</i> and <i>Tamarix</i>	2
10	<i>Aeschynomene</i> , <i>Canscora</i> , <i>Coix</i> , <i>Echinochloa</i> , <i>Eragrostis</i> , <i>Euphorbia</i> , <i>Fuirena</i> , <i>Heliotropium</i> , <i>Juncellus</i> and <i>Spilanthes</i>	3
7	<i>Alternanthera</i> , <i>Lindernia</i> , <i>Lipocarpa</i> , <i>Ludwigia</i> , <i>Panicum</i> , <i>Polygonum</i> and <i>Potamogeton</i>	4
3	<i>Commelina</i> , <i>Scleria</i> and <i>Utricularia</i>	5
1	<i>Pycnus</i>	6
1	<i>Eleocharis</i>	7
2	<i>Eriocaulon</i> and <i>Rotala</i>	8
2	<i>Fimbristylis</i> and <i>Schoenoplectus</i>	10
1	<i>Cyperus</i>	23

(2, 12, 23, 24). There are 3 families (Lythraceae, Rubiaceae, Scrophulariaceae) with 10 species each, 2 (Amaranthaceae, Gentianaceae) with 7 species, 3 families (Acanthaceae, Euphorbiaceae, Lentibulariaceae) with 5 species, and 7 families with 4 taxa each, 6 families with 3 plant species and 16 families were with 2 species each and contributing the share about 14.88 % among the total families, and the percent distribution of each family is mentioned in Table 2. In a previous study, the distribution and diversity of macrophytes from Nagaram tank of Warangal, Telangana were documented (25). A limited study on aquatic and wetland plants of Pocharam lake, Medak reported 110 species of hydrophytes pertaining to 80 genera and 37 families of angiosperms. Another survey from Karimnagar district enumerated 80 species of aquatic and semi-aquatic ornamental plants belonging to 65 genera and 38 families, while a study from Singabhupalem in Kothagudem Bhadradi district documented 61 species representing 52 genera and 34 families of aquatic macrophytes (11).

Table 3 represents the flowering and non-flowering aquatic vascular plants, in which Pteridophytes (non-flowering) consist of 6 taxa under 5 genera and families while Dicotyledons (Magnoliopsida) spread 168 taxa, 114 genera and 52 families which is little lesser than Monocotyledons (Liliopsida) that has 178 species, 79 genera under 19 families (Table 3, Fig. 2). Pteridophytes were documented in the lowest numbers with 6 plant species belonging to 5 genera as well as families. The largest and most diversified families of Liliopsida are Cyperaceae and Poaceae with 80 and 45 plant taxa, respectively and these 2 families contributed about 35.5 % collectively among all 76 families encountered. Among Magnoliopsida members, Asteraceae tops the list with 21

species, followed by Fabaceae (15 species) and Lythraceae, Rubiaceae and Scrophulariaceae with 10 plant taxa each. The top 5 dominant dicotyledons families were Asteraceae, followed by Fabaceae, Lythraceae, Rubiaceae and Scrophulariaceae, Amaranthaceae and Gentianaceae, Acanthaceae, Euphorbiaceae and Lentibulariaceae while Cyperaceae, Poaceae, Commelinaceae, Eriocaulaceae and Hydrocharitaceae were fell under the 5 major monocotyledon families (Table 2 & 3). Wetland and aquatic plant species play a crucial role in provisional services to living beings like food, shelter, improves water quality, purification, fodder, serve as primary producers of oxygen through photosynthesis, aesthetic value and regulates the carbon dioxide, mineral salts, nature of substratum, depth of water, temperature, high turbidity and remediates the contaminated aquatic ecosystems by acting as natural filters effectively (26). Many economically helpful aquatic and wetland plants were documented from Andhra Pradesh for different uses like fish feed, compost, animal feed, proteins, carotenes and paper pulp along with their habit, phenology, habitat condition, etc. (27). Nevertheless, some of the aquatic vegetation such as water cabbage, water hyacinth, cattail, bush morning glory, duckweed pose a threat to aquatic ecosystems due to their fast spreading and obstruct the canals, waterways, barriers for navigation and kill fish by deoxygenating the water (20). There is urgent need to minimize runoff from industries effluents, intensification of agricultural activities, habitat fragmentation, fishing practices, and regular monitoring of aquatic bodies from harmful industrial and domestic pollutants, spatial expansion for settlements and industries establishments or other purposes to maintain ecological balance and conserve the aquatic ecosystems from different sources of

Table 2. Distribution of species familywise

No. of spp.	% of a family	Name of the Family	No. of families
80	37.04	Cyperaceae	1
45	20.83	Poaceae	1
21	09.72	Asteraceae	1
15	06.94	Fabaceae	1
10	04.63	Lythraceae, Rubiaceae, Scrophulariaceae	3
9	04.17	Comelinaceae	1
8	03.70	Eriocaulaceae	1
7	03.24	Amaranthaceae, Gentianaceae	2
6	02.78	Hydrocharitaceae	1
5	02.31	Acanthaceae, Euphorbiaceae, Lentibulariaceae	3
4	01.85	Araceae, Boraginaceae, Convolvulaceae, Elatinaceae, Onagraceae, Polygonaceae, Potamogetonaceae	7
3	01.39	Alismataceae, Lemnaceae, Malvaceae, Melastomataceae, Pontederiaceae, Ranunculaceae	6
2	00.93	Amaryllidaceae, Apocynaceae, Aponogetonaceae, Droseraceae, Lamiaceae, Marsileaceae, Menyanthaceae, Myrtaceae, Najadaceae, Nymphaeaceae, Oxalidaceae, Solanaceae, Apiceae, Arecaceae, Balsaminaceae, Barringtoniaceae, Brassicaceae, Butomaceae, Campanulaceae, Cannaceae, Caryophyllaceae, Ceratophyllaceae, Cleomaceae, Combretaceae, Cordiaceae, Costaceae, Equisetaceae, Hydrophyllaceae, Isoetaceae, Meliaceae, Molluginaceae, Nelumbonaceae, Orchidaceae, Pandanaceae, Piperaceae, Plantaginaceae, Polygalaceae, Primulaceae, Pteridaceae, Salviniaceae, Sphenocleaceae, Trapaceae, Typhaceae, Vahlciaceae	16
1	00.46		32

Table 3. Strength of flowering and non-flowering aquatic vascular plants recorded from Telangana State, India

Category	No. of species	No. of genera	No. of families
Pteridophytes	06	05	05
Dicotyledons	168	114	52
Monocotyledons	178	79	19
Total	352	198	76

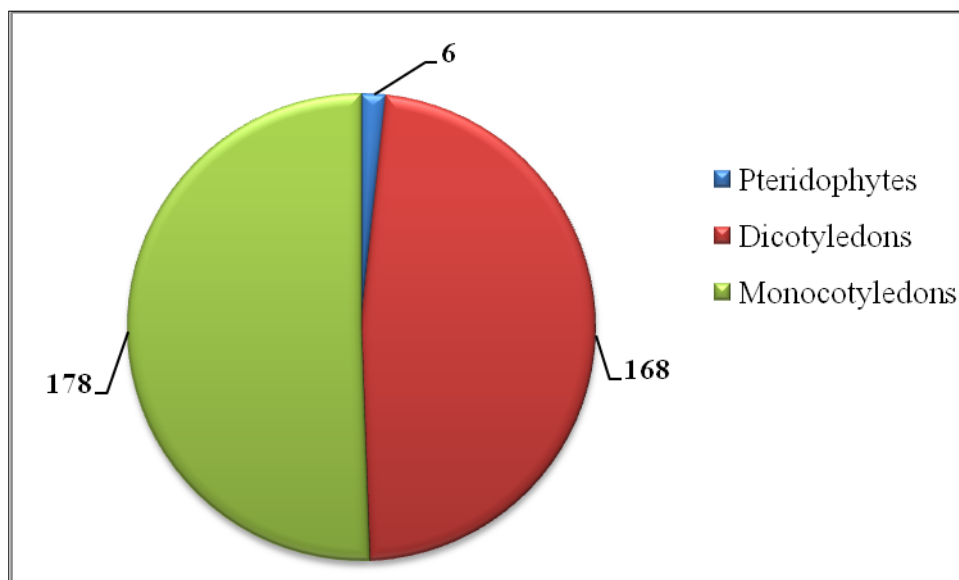


Fig. 2. Representation of wetland and aquatic pteridophytes, dicotyledons and monocotyledons in Telangana. disturbance (28).

Conclusion

The present study is an outcome of a decadal comprehensive survey and surveillance of wetland and aquatic areas of Telangana state. The study reports 352 species of wetland and aquatic vascular plants pertaining to 198 genera and 76 families. The most varied family is Cyperaceae with 80 taxa followed by Poaceae with 45 species, Asteraceae (21), Fabaceae (15) and Lythraceae, Rubiaceae and Scrophulariaceae (11 species each). The most frequent genera in the area are *Cyperus*, *Eichhornia*, *Typha*, *Ipomoea*, *Pistia* and *Alternanthera*. The genus *Cyperus* tops the list recorded with 23 species, *Fimbristylis* and *Schoenoplectus* consist of 10 species each, *Eriocaulon* and *Rotala* with 8 species, *Eleocharis* with 7, *Pycnus* with 6 taxa and *Commelina*, *Scleria* and *Utricularia* consist of 5 spp. each where 137 plant genera hold a single species each. The difference in the distribution of aquatic vegetation was observed in northern and southern parts of Telangana and 4 types of growth forms herbs, shrubs, trees and climbers were observed where herbaceous layer predominantly distributed in the study area. Anthropogenic pressure is ever increasing by filling up water bodies for different purposes and aquatic habitats are under severe threat which leads to a gradual loss of hydrophytic species diversity. The current research study is the first catalogue to encounter 352 wetland and aquatic plant species in the state and provides insights to understand the aquatic plant diversity and measures to protect the aquatic ecosystems in Telangana from anthropogenic pressure for the benefit of all the living beings and calls for prioritizing conservation activities and to know the impact of aquatic invasive species on native plant diversity.

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Authors' contributions

SS carried out the exploration of wetland and aquatic vascular plants of Telangana for a decade; designed and drafted the manuscript. OK contributed to the execution and design of the work and participated in the field work for the collection of data. GSR assisted in the base line data collection during field. MM provided support with statistical analysis. KE was actively involved in the exploration of wetland plants and formatted the reference section. SN helped in the field and reviewed the manuscript and gave suitable recommendations for the improvement of the article. All the authors have gone through the manuscript critically and approved the final manuscript for the submission.

Compliance with ethical standards

Conflict of interest: The authors declare that there is no conflict of interest in publication of the present article.

Ethical issues: None

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