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THE SOCIO-ECONOMIC AND ECOLOGICAL IMPACTS OF WATER HYACINTH PROLIFERATION IN WATER BODIES: A CASE FROM GREATER KOCHI AREA IN SOUTH INDIA

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ABSTRACT

Purpose: *The purpose of this study is to critically analyse the socio-ecological impact of water hyacinths on the water bodies passing through 7 wards of the Thrippunithura Municipality in the Ernakulam district of the state of Kerala, India, by checking the quality of water and conducting surveys among the people.*

Research Design: *The study employs a combination of exploratory and descriptive research approaches. Purposive sampling targets individuals directly impacted by water hyacinth proliferation.*

Methodology: *Data collection involved direct surveys using a structured questionnaire, with analysis conducted using Excel and SPSS software. Water samples from selected regions of Thrippunithura Municipality in the Ernakulam district of the state of Kerala, India, were tested for various water quality parameters.*

Results: *The results reveal significant socio-economic ramifications of water hyacinth proliferation, particularly impacting fishing communities. Challenges include job losses, diminished access to fishing grounds, navigational hindrances, reduced catches, and fish scarcity. Ecologically, water quality parameters show notable disparities between heavily-infested and less-infested areas, highlighting the weed's impact on aquatic ecosystems. The phytoremediation potential of water hyacinth was also explored, revealing its ability to accumulate heavy metals such as chromium, cadmium, copper, zinc, lead, iron, and arsenic.*

Originality of Research: *This study records the socio-ecological impact of water hyacinth on the communities and environment, particularly the water bodies, of Greater Cochin. The interest in participating in applications for alternative uses of the otherwise disruptive water hyacinth has also been noted. This research provides valuable insights into managing water hyacinth's negative effects while exploring its potential benefits.*

Keywords: *Water hyacinth, social and ecological effects, alternative uses, heavy metal*

1. INTRODUCTION

The aquatic plant weed known as water hyacinth (*Eichhornia crassipes*) belongs to the family Pontederiaceae, which has been included in the order Commelinales. Eichhornia has eight species that originated in the Amazon basin of South America (DiTomasa et al., 2018). Water hyacinth is often referred to as the "noxious beauty" due to its beautiful purple flower. It is a perennial, free-floating plant in water but rooted in moist mud along the banks of rivers, lakes and impoundments where it can live and produce. It can be considered as the most toxic aquatic weed that is growing in temperate, tropical, and subtropical regions.

The International Union for Conservation of Nature (IUCN) identified water hyacinth as one of the most destructive species in the world due to its capacity for growth and significant socio-economic effect. Water hyacinth has grown to be a serious hazard to rivers around the world. It is considered as the world's worst aquatic weed. Ever since the introduction of water hyacinth outside the Amazon Basin, it has created innumerable problems for communities. The dense mats of water hyacinth interfere with navigation, recreation, irrigation, and power generation (Epstein, 1998). Water hyacinth is characterized by its reproductive capabilities, rapid dispersal and growth which leads to several environmental and socio-economic problems. The weed causes disastrous impact on the economy, health and well-being of communities which depend on water for their livelihood.

The objective of this study is to assess, how the proliferation of water hyacinth affects the livelihood of people residing near water hyacinth-infested water bodies, to examine the impact of water hyacinth on water quality, detect the heavy metal content in water hyacinth for elucidating its bioremediation properties, establish local awareness of the issue as well as to understand the socio-ecological impacts of water hyacinth in the selected wards of Thrippunithura Municipality, Ernakulam district, Kerala.

2. REVIEW OF LITERATURE

Water hyacinth (*Eichhornia crassipes*) is widely recognized for its invasive nature, significantly impacting freshwater ecosystems. Dersseh et al. (2022) highlighted the profound influence of this plant on Lake Tana in Ethiopia, noting a substantial increase in total phosphorus concentrations due to agricultural runoff. This nutrient influx facilitated the rapid proliferation of water hyacinth, exacerbating eutrophication and disrupting local aquatic ecosystems. Considering its environmental and health implications, the pervasive spread of water hyacinth not only affects biodiversity but also poses serious health risks. Endgaw (2021) emphasized that the dense mats of water hyacinth in Lake Tana create breeding grounds for disease vectors such as mosquitoes and snails, leading to increased incidences of malaria and schistosomiasis. The physical obstruction caused by these mats also impedes fishing and transportation, further stressing the socioeconomic stability of local communities.

Maulidyna et al. (2020) explored the economic potential of water hyacinth by documenting its use in crafting various handicrafts in Rawapening Lake, Indonesia. This utilization not only generates economic value but also provides a means of managing the invasive species. Similarly, Ekong et al. (2023) investigated the production of biogas from water hyacinth, highlighting its dual benefits in energy production and invasive species management. Additionally, water hyacinth can be utilized in bioplastic production, handicrafts, and biogas generation, offering alternative economic opportunities (Maulidyna et al., 2020; Pratama et al., 2020).

Effective management of water hyacinth involves a combination of mechanical, chemical, and biological approaches. Gupta and Yadav (2020) argued that manual removal is effective for small areas, despite its labor-intensive nature. They also highlighted the environmental risks associated with chemical herbicides. Biological control, involving the use of weevils and other insects, has shown promise in reducing water hyacinth populations without adverse environmental impacts.

One of the promising applications of water hyacinth is its ability to absorb heavy metals from contaminated water. PN and Madhu demonstrated the plant's efficacy in removing chromium and copper from wastewater, underscoring its potential in phytoremediation. The ability of water hyacinth to accumulate significant amounts of heavy metals in its tissues makes it an effective, low-cost solution for mitigating water pollution.

Water hyacinth represents a complex ecological challenge with significant socioeconomic implications. Addressing its proliferation requires interdisciplinary approaches that balance environmental conservation with sustainable resource management and economic development.

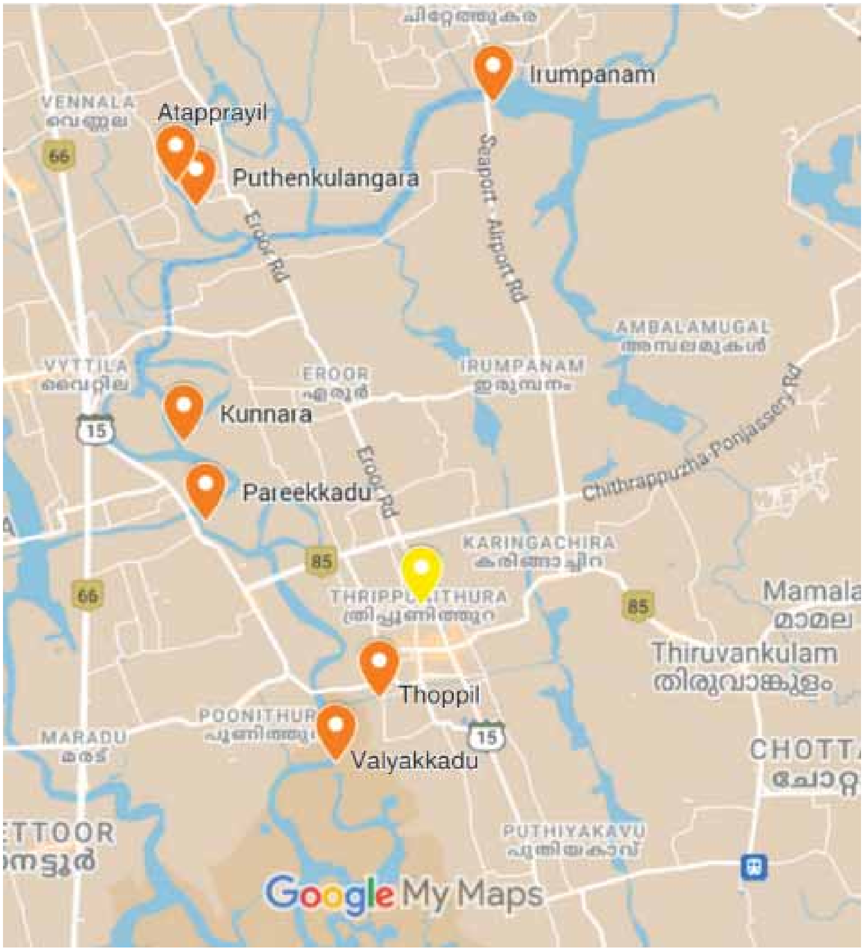
3. RESEARCH METHODOLOGY

The methodology employed in this study comprised a combination of exploratory and descriptive research approaches. Purposive sampling was utilized to target individuals directly impacted by water hyacinth proliferation, particularly in communities residing near Vembanad Lake in Thrippunithura Municipality, Kerala, India. Vembanad Lake occupies the top position on rankings for longest lakes in India as well as one the largest in the state of Kerala spanning over a maximum length of 96.5 km and an area of 230 square kilometers. It is a part of the Vembanad-Kol wetland system which extends from Alappuzha in the south to Azhikode in the north and is approximately 14 kilometers wide at its widest point with a depth of 12m (39 feet). The lake is situated at sea level and is bordered majorly by the Kerala districts of Alappuzha, Kottayam and Ernakulam. The lake is linked to other coastal lakes in the north and south regions by various canals and is fed by 10 rivers flowing into it including the six major rivers of central Kerala. The total area drained by the lake is 15,770 km², which accounts for 40% of the area of Kerala. Its annual surface runoff of 21,900 Mm accounts for almost 30% of the total surface water resource of the state. The 1,252-meter (4,108-foot) long Thanneermukkom saltwater barrier, which was built as part of the Kuttanad Development Scheme to stop tidal action and saltwater intrusion into the Kuttanad lowlands, is one of the lake's distinctive features. The annual recurrence of Eichhornia crassipes infestation in the Cochin backwater, Kerala, India, can be attributed to the opening of Thanneermukkom saltwater barriers during the monsoon season. Because of tidal action, the plants are exposed to different salinities during the process.

The population of the study was confined to people living on the banks of the river in the greater Kochi area. Greater Cochin is the area defined by Greater Cochin Development Authority for town planning. This area consists of the Kochi UA region and its suburbs. The sampling was done from this population in the selected regions. The study employed purposive sampling to select seven wards within the geographical area identified for the study. Water samples were collected from water bodies in these selected wards. Additionally, a survey was conducted among individuals most likely to provide valuable information relevant to the study's objectives. This was done with a sample size comprising of a total of 50 individuals.

Data collection involved a direct survey using a structured questionnaire, with subsequent analysis conducted using Excel and SPSS software. Additionally, water samples were collected from both highly infested and low-infested regions from the area sampled. These samples were analyzed for various parameters, including heavy metals, to assess the extent of water contamination and its implications for the affected communities.

Map showing the 7 selected wards of Thrippunithura Municipality, Kerala, India



Source : Google - My Maps

4. DATA ANALYSIS

The objective of the survey was to assess the impact of water hyacinths on livelihoods and water quality in selected locations. Data was collected from residents using Google Forms and through direct interviews with water metro drivers. SPSS software was used for data analysis. Water and water hyacinth samples were tested in external laboratories for 15 water quality parameters and the presence of heavy metals. The interpretation of this data is provided below :

4.1 Education :

71.7% lack matriculation, limiting adaptability during events like water hyacinth proliferation. Limited higher education reflects historical constraints and ongoing financial challenges.

4.2 Occupation :

56.5% engage in fishing and transportation, facing disruptions from water hyacinth. Younger generations seek alternatives due to unpredictable fishing incomes.

4.3 Major Source Of Income :

46.6% rely on fishing, with limited job options near water bodies. Water hyacinth exacerbates economic strain, disrupting fishing activities and livelihoods.

4.4 Alternative Uses :

Water Hyacinth, typically seen as a nuisance, holds potential for alternative uses. Survey data reveals significant interest (45.7%) among respondents in exploring these options, with some (19.6%) already experimenting, primarily as fertilizer. However, a notable portion (26.1%) remains unaware of such possibilities, suggesting a need for increased awareness efforts. Despite some expressing disinterest (8.7%), there is the promise for utilizing Water Hyacinth in biofuel production, wastewater treatment, and handicrafts, offering economic benefits and aiding environmental conservation.

4.5 Weed management:

The significant spread of water hyacinth in water bodies necessitates weed management. This inquiry aids in determining whether weed management is practiced in the areas under study. 58.7 % people among the respondents said that there was prior weed management in these wards. Irrigation departments, Corporation and Municipality are generally responsible for removal of water hyacinth. However, the execution of this process lacks regularity, as these entities only address the issue upon receiving requests from local residents. Water hyacinth is being removed using JCB and the labor force. It is customary for fishermen to remove water hyacinth themselves when the water bodies fill up with it, otherwise they will not do fishing there.

4.6 Percentage of spread during monsoon :

All the 46 people surveyed said that the presence of water hyacinth is more than 75% during Monsoon season. Increased water level in rivers, lakes and other water bodies due to heavy rainfall facilitates rapid growth of water hyacinth. Water hyacinths thrive in environments that are particularly nutrient-rich, which is created when heavy rainfall dissolves nutrients into the water. Therefore when rain water comes, people find the situation where the water hyacinth spreads vastly.

4.7 Percentage of spread during post-monsoon:

The river influx declines during the Post-Southwest Monsoon and the saline water intrusions from the adjacent Arabian Sea through the Kochi inlet increase salinity downstream of the VLS (Arumpandi et al., 2022). Studies have shown that water hyacinth appears to weaken and reduce their growth at a salinity of oligosaline range (0.5 - 5 ppt). As our study was during the post monsoon period, the proliferation of water hyacinth could not be observed in abundance except in Thoppil. The weed starts to decay as per the salt intrusion into different water bodies.

4.8 Impact of water hyacinth on transportation and fishing activities:

The impact was measured on a 10-point scale, where 1 stands for less impact and 10 stands for extreme impact. Analyzing the impact of water hyacinth on fishing activities in the regions under study during the monsoon season rated a mean of 8.72 ± 1.440, signifying that fishing will be impossible due to the growth of this weed. During the post-monsoon period, the mean value was 4.61 ± 2.362, indicating the possibility of fishing activities as the spread of water hyacinth is reduced.

Analyzing the impact of water hyacinth proliferation on transportation during the monsoon season reveals that dense mats of water hyacinth make transportation very difficult in all wards under study. The impact rating on transportation had a mean of 8.35 ± 1.609, signifying a high impact. With the onset of the post-monsoon period, transportation becomes more manageable as water hyacinth levels decrease in the water, and the mean value was 4.83 ± 2.369.

4.9 Major Challenges Faced by people :

Table 1: Weighted score ranking method

SL. NO.	FACTORS	FREQUENCY					WEIGHTED SCORE					WEIGHTED TOTAL	RANK
		1	2	3	4	5							
1	Stagnation	0	0	0	0	1	0	0	0	0	1	1	10
2	Dereliction of Water Quality	0	1	0	2	6	0	4	0	4	6	14	8
3	Health Hazard	5	0	0	0	3	25	0	0	0	3	28	6
4	Low Tide Inundation	0	0	0	1	1	0	0	0	2	1	3	9
5	Low Water Flow	0	0	0	0	1	0	0	0	0	1	1	10
6	Increased sedimentation	3	3	5	8	18	15	12	15	16	18	76	5
7	Navigational difficulty	2	9	15	9	1	10	36	45	18	1	110	3
8	Loss of jobs related to farming	4	10	13	5	4	20	40	39	10	4	113	1
9	Less fish availability	0	3	0	2	1	0	12	0	4	1	17	7
10	Reduced catch	3	9	8	11	2	15	36	24	22	2	99	4
11	Loss of access to fishing areas	24	7	1	3	4	70	28	3	6	4	111	2
	TOTAL						155	168	126	82	42	573	

Source: Survey data

Weighted ranking method was used to identify the major challenges faced by people living on the banks of the river. Loss of farming and fishing jobs ranked highest, signaling significant socioeconomic impacts. This is followed by loss of access to fishing areas, indicating constraints on fishing activities and potential income reduction. Navigational difficulty emerged as the third-ranked challenge, hindering waterway transportation. Reduced catches ranked fourth, reflecting declining fish availability and economic pressures on fishing communities. Increased sedimentation ranked fifth, highlighting environmental consequences such as water quality degradation. These findings emphasize the complex impacts of water hyacinth, necessitating comprehensive management strategies to address them effectively.

4.10 Water quality analysis: A total of 12 parameters were analyzed to understand the quality of water in weed infested and non infested areas. Physical parameters like Temperature, Total Dissolved Solids and Total Suspended Solids and chemical parameters like Salinity, pH, Alkalinity, Total Hardness, Ammonia, Nitrite, BOD, Dissolved oxygen, Nitrate and Phosphate were tested. The water samples were collected during Post-Monsoon period from seven locations such as Valyakkad, Thoppil, Pareekad, Kunnara, Attapprayil, Irumpanam, Puthenkulangara where water hyacinth was found and one sample from a water hyacinth free area. All the parameters were analyzed using SPSS software. Water hyacinth was highly infested in Thoppil compared to other locations. Due to the salt intrusion in all locations except Thoppil the infestation seemed to be less. So the data were analyzed using a One-sample t-test where the test value of Thoppil was taken. The following tables shows the result:

Table 2: One-Sample Statistics for water quality parameters

Parameters	N	Mean	Std. Deviation	Std. Error Mean	Test Value
Temperature	7	28.1429	1.34519	0.50843	26
pH	7	7.1571	0.09759	0.03689	7.3
Salinity	7	7.5714	4.19750	1.58651	3
Alkalinity	7	83.5714	19.30334	7.29598	160
Total hardness	7	1471.4286	787.32519	297.58095	650
Ammonia	7	0.01343	0.035529	0.013429	0
Nitrite	7	0.07229	0.073920	0.027939	0.472
BOD	7	2.9543	1.03985	0.39303	1.5
Dissolved Oxygen	7	5.5257	2.53200	0.95701	0.35
Phosphate	7	0.12000	0.070666	0.026709	0.089
TDS	7	10.2071	7.05515	2.66660	5.51
TSS	7	0.39829	0.264125	0.099830	0.515

Source: Survey Data

Table 3: One-Sample Test for water quality parameters

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Temperature	4.215	6	0.006	2.14286	0.8988	3.3869
pH	-3.873	6	0.008	-0.14286	-0.2331	-.0526
Salinity	2.881	6	0.028	4.57143	0.6894	8.4535
Alkalinity	-10.475	6	0.000	-76.42857	-94.2812	-58.5760
Total hardness	2.760	6	0.033	821.42857	93.2742	1549.5829
Ammonia	1.000	6	0.356	0.013429	-0.01943	0.04629
Nitrite	-14.307	6	0.000	-0.399714	-0.46808	-0.33135
BOD	3.700	6	0.010	1.45429	0.4926	2.4160
Dissolved Oxygen	5.408	6	0.002	5.17571	2.8340	7.5174
Phosphate	1.161	6	0.290	0.031000	-0.03436	0.09636
TDS	1.761	6	0.129	4.69714	-1.8278	11.2221
TSS	-1.169	6	0.287	-0.116714	-0.36099	0.12756

Source: Data analysis of water samples

The water quality parameters like pH, Salinity, Alkalinity, Total Hardness, Nitrite, BOD, DO, and TDS significantly varied in between the highly infested area and less infested area. The water temperature was recorded from 26 °C to 31 °C. Salinity comes between 2 to 13 ppt, which indicates the entry of salt water into the water bodies. The levels of ammonia, nitrate and sulphate in the water of study areas were found to be below the detectable limit, and the nitrite and phosphate concentration were also minimal. Total hardness recorded in the Thoppil was 650 mg/l which is less than that of the mean total hardness of the less infested areas (1471.42 mg/l). Total hardness is the parameter of water quality used to describe the effect of dissolved minerals like calcium, magnesium etc.

In this study, the highly weed-infested area recorded a DO (Dissolved Oxygen) concentration of 0.35 mg/l, which falls below the desired limit of 4-6 mg/l and the mean tested DO value in the non-infested area was 5.5 mg/l, which is within the desired limit. The least BOD (1.5 mg/l) was reported in the highly infested area, Thoppil and the mean BOD of all other locations was slightly higher (2.95mg/l). Biological Oxygen Demand (BOD) is a measure of the biological activities of a water body. It is an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent. In our study the BOD level was only slightly higher in the low infested area than that of weed highly infested area.Within the comparison areas, the values of TSS and TDS show no significant difference and the concentration of both TDS and TSS were less in all locations.

4.11 Analysis Of Heavy Metals In Water Hyacinth :

The water hyacinth collected from Chithrapuzha river near Irumpanam region was tested for heavy metals: Iron, Copper, Arsenic, Chromium, Zinc, Cadmium, Lead, and Mercury. Different parts of the plant were dried, digested using Concentrated Nitric acid, and analyzed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) System. Except for Mercury, all heavy metals were detected. Iron was represented in percentage, while others were in ppm. The results indicated bioaccumulation and phytoremediation ability, with heavy metal presence: Iron (0.4 %), Copper (60.89 ppm), Arsenic (0.88 ppm), Zinc (74.41 ppm), Cadmium (1.45 ppm), Lead (10.01 ppm), with no Mercury detected.

Table 4: Heavy metals in water hyacinth

SL. No.	SAMPLE NAME	56Fe	63Cu	75As	53Cr	66Zn	114Cd	208Pb	200Hg
1	C3	0.4	60.89	0.88	6.25	74.41	1.45	10.01	NA
UNIT		%	ppm	ppm	ppm	ppm	ppm	ppm	
Detection Limit in ppm		0.10	0.01	0.01	0.01	0.01	0.01	0.01	

Source: Heavy Metal Analysis

5. RESULT AND OBSERVATIONS

5.1 Social Impacts Of Water Hyacinth :

People are directly impacted by the negative consequences of water hyacinth proliferation, particularly during the post-monsoon season, where dense growth obstructs activities like fishing and transportation, reducing water quality and hindering navigation. This adversely affects livelihoods reliant on water-based activities, leading to economic strain and limiting access to fishing grounds. The majority of respondents, primarily fishermen, report adverse effects on their livelihoods due to water hyacinth proliferation, with fishing, transportation, and other water-related activities severely affected, leading to a decline in income by over 50%. Traditional practices like clam harvesting have become unfeasible, with rising living costs exacerbating financial strain. The proliferation of water hyacinths has resulted in significant job losses in farming and fishing. Traditional crafts without advanced technologies are particularly affected due to increased expenses from net breakage, fuel utilization, and boat maintenance. The infestation also clogs boat motors, necessitating frequent repairs and maintenance, which further increases operational costs. Consequently, fishermen lose valuable working days, as time spent fixing nets and motors directly translates to lost income. These problems collectively result in increased financial burdens and reduced productivity for the fishing community. Water hyacinth mats block high fish population regions, especially during the monsoon season, leading to reduced fishing activities and income for fishermen. Local fishermen have also reported decreased fish populations in infested areas, exacerbating employment challenges.

The dense mats prevent easy movement, further restricting access. Waterway transportation is severely impeded, posing hazards for boat operators. Fishermen often have to manually remove water hyacinth mats, resulting in increased physical exertion, loss of time, and reduced catches. Reduced catches are a major issue as well which directly impacts the economic status of local fishing communities. Water hyacinth mats reduce dissolved oxygen and sunlight which are essential for aquatic life. This results in decreased fish populations and hinders fishing activities, especially during and after the monsoon season. Historically abundant species like Pearl Spot, Red Snapper, and Big-sized prawn are notably absent, while Tilapia remains prevalent due to government initiatives. Fishermen report a drastic reduction in income, with earnings plummeting by 50 - 70%, and increased costs for boat maintenance and repairs further strain finances, with daily earnings dropping from ₹1000 (€11.09) to ₹300-₹600 (€3.33-€6.66). Eutrophication and sedimentation, compounded by the 2018 Kerala flood, have reduced water depth, limiting fishing activities and hindering navigation, necessitating dredging and waterway maintenance. Water hyacinth proliferation also promotes mosquito breeding, increasing the risk of diseases like dengue and malaria, with residents reporting itchiness, rashes, allergies, and encounters with dangerous pests like snakes and monitor lizards. Water quality deterioration renders water bodies unsuitable for consumption and domestic use, impacting residents who have relied on them for generations, while hindering Kochi Water Metro operations through blockages, leading to increased maintenance costs and operational challenges. Addressing water hyacinth proliferation requires comprehensive measures to mitigate its impact on livelihoods, health, and transportation infrastructure, ensuring sustainable development in affected regions.

5.2 Ecological impacts of water hyacinth:

The water quality parameters like pH, Salinity, Alkalinity, Calcium, Magnesium, Total Hardness, Nitrite, BOD, DO, and TDS have differences in between the highly infested area and less infested area. Salinity shows a difference due to the salt water intrusion into the water. At the end of North-West Monsoon (October-December) the salt water intrusion begins. Since our study was in the Post-Monsoon period, the water hyacinth started to dry and only patches of mats of water hyacinth can be seen in water bodies. But there is an exceptional case in ward number 35, Thoppil where dense mats of water hyacinth were observed. The water hyacinth starts to dry when salt water gets into the water bodies.

The very low concentration of parameters such as ammonia, nitrite, nitrate and phosphate could be due to the phytoremediation property of water hyacinth. But it is also affected by the nature of water, due to the dynamic nature it possesses. Studies have shown that water hyacinths have excellent capacities in removing N and P from water. Water hyacinth was also effective in significantly lowering the TAN and nitrite of water (Reyes et al., 2019). Total hardness is the parameter of water quality used to describe the effect of dissolved minerals like calcium, magnesium etc. A difference in total hardness was shown by less infested area and Thoppil which is the highly infested area. A study held by Mikhil, 2022 found that the water hyacinth can reduce the hardness of water and he concluded that water hyacinth has phytoremediation properties.

Dissolved Oxygen (DO) concentrations were notably lower in highly infested areas, indicating the impact of dense water hyacinth mats on oxygen transfer. In our study the BOD level was only slightly higher in the low infested area than that of weed highly infested area. The reason for the lack of increase in the BOD level of water in the less infested areas could be the continuous flow of water hyacinth throughout the water. If the weed sinks into the water upon decomposition, it will potentially contribute organic matter to the water. However, since the water hyacinth was continuously flowing, there was minimal organic matter presence, consequently leading to low BOD levels throughout. Total suspended solids (TSS) and total dissolved solids (TDS) showed no significant differences within comparison areas, with concentrations generally lower across all locations. A study conducted by Elizabeth et al., 2020 proved that water hyacinth can be used as a bioaccumulator because it has the ability to absorb substances in the water and makes the water become clearer.

5.3 Heavy Metals :

Water hyacinth, known for its rapid growth and adaptability, offers promise in treating wastewater and purifying polluted water. While it thrives in contaminated environments, it effectively removes organic materials and metals, particularly through its roots, making it a valuable tool for assessing metal pollution levels and phytoremediation. However, heavy metal concentrations vary across its parts, with roots showing the highest accumulation. Notably, metals like copper, chromium, and zinc are detected at concerning levels, emphasizing the need for monitoring and remediation to safeguard the environment and human health in Kerala. Analyzed through Inductively Coupled Plasma Mass Spectrometry (ICPMS), the results highlight diverse heavy metal presence, underscoring water hyacinth's potential as a phytoremediation agent. Continued analysis and adherence to regulatory standards are vital to mitigate associated risks effectively.

6. DISCUSSION

The rapid and uncontrollable proliferation of water hyacinth in the Thrippunithura Municipality significantly affects the local residents, particularly during the monsoon and post-monsoon seasons. During the monsoon, the challenges are heightened, but post-monsoon conditions remain unfavorable for normal activities. The dense growth of water hyacinth forms thick mats on the water surface, severely hampering local activities such as fishing, transportation, and aquaculture. These mats obstruct navigation channels and degrade water quality. Water quality can be affected by water hyacinth. This invasive aquatic plant can impact various parameters such as dissolved oxygen levels, nutrient concentrations (like nitrogen and phosphorus), pH, alkalinity, hardness, TSS, TDS etc. The presence of the weed limits oxygen exchange, creating unfavorable ecological conditions for native aquatic species, which in turn impacts aquatic biodiversity. This reduction in biodiversity directly affects the livelihoods of local fishermen by decreasing the catch rates. Additionally, the proliferation of water hyacinth reduces access to fishing grounds and increases maintenance costs for boats, fuel, and fishing equipment, further exacerbating the economic strain on fishermen. Overall, the infestation leads to significant socio-economic and ecological disruptions, necessitating effective management and remediation strategies to mitigate its adverse impacts.

Education emerges as crucial, with most residents lacking higher education, limiting their adaptability and livelihood options during events like water hyacinth proliferation. To address this, education and training programs are recommended to enhance fishing skills, promote sustainable practices, and diversify employment opportunities. Economically, the spread of water hyacinth poses substantial challenges for communities reliant on water-based activities. The decline in earnings potential, particularly during off-seasons, underscores the vulnerability of these communities, necessitating targeted support measures. Overall, addressing water hyacinth challenges requires comprehensive strategies that prioritize education, infrastructure development, and sustainable resource management. In addition, the analysis reveals that 45.7% of respondents express interest in exploring alternative uses for water hyacinth, with 19.6% having previously utilized it for purposes like fertilizer. However, 26.1% remain unaware of alternative uses, emphasizing the need for education and outreach. Moreover, heavy metal analysis proved that water hyacinth has the ability to absorb different heavy metals, which indicates its phytoremediation property. This underscores the importance of timely removal of water hyacinth to prevent persistent heavy metal accumulation in the environment to avoid reintroduction of pollutants .

7. CONCLUSION

Water hyacinth, known scientifically as *Eichhornia crassipes*, is an invasive aquatic weed causing ecological and socio-economic challenges globally, including in Kerala. Its rapid spread obstructs water flow, disrupts irrigation channels, and reduces sunlight and oxygen levels. Communities near water bodies suffer economic hardships due to decreased access to fishing grounds, especially among those with limited education. Education and training programs are recommended to enhance fishing skills and promote sustainable practices, thereby addressing economic and environmental concerns. While weed management efforts have been made, inconsistent execution highlights the need for coordinated actions by relevant authorities and local communities.

Water hyacinth proliferation peaks during Kerala's monsoon seasons, affecting fishing activities and navigation. Heavy metal contamination in water hyacinth poses risks to the environment and human health, necessitating timely removal to prevent further deterioration of natural conditions. The local communities have expressed their interest in participating in activities of alternative utilisation of the otherwise destructive water hyacinth. Exploring alternative uses for water hyacinth could bring new revenue streams and environmental benefits, but community engagement and capacity-building efforts are essential for success.

The socio-economic impact of water hyacinth infestation is evident in reduced job opportunities, navigational difficulties, and diminished catches, posing significant challenges for affected communities. Breaking the vicious cycle of water hyacinth proliferation requires collaborative actions involving government agencies, local authorities, and community organizations to restore aquatic ecosystems and support impacted communities' resilience and prosperity.

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9. REFERENCE

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