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Assessment of amphibian environment through physico chemical analysis of the water hyacinth infested ponds in the Cauvery delta districts of Tamil Nadu

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Abstract

Amphibian declination is mainly due to water pollution. The water may appear clean but there is enormous physico-chemical elements dissolved there which contaminate the water and affect the quality of water and life s. The adult amphibians also remain exposed to water quality. 0-25% of the total utilizable water in India is infested with water hyacinth (*Eichhornia crassipes)*. Numbers of problems are caused due to water hyacinth. The study was carried out in the Cauvery delta region of Nagapattinam, Thiruvarur and Thanjavur districts. Results of the analyses are interpreted using standard statistical procedures. A total of twelve species of frogs and toads were recorded from the study area of three districts which belonged to five families. All the 31 ponds have good diversity of amphibians in which *Euphlyctis cyanophlyctis* was the most commonly encountered species. Among them, the population of *E. cyanophlyctis* was higher in three classified areas of *E. crassipes* ponds than other species. Amphibians were higher in the less colonized *E. crassipes* ponds than the ponds with dense *E. crassipes* . One way ANOVA was used to test amphibian density with response to water quality parameters in water hyacinth infested ponds. The analysis showed that salinity was significantly higher ($P<0.05$) in water hyacinth infested areas ($f = 1.3$, $P = 0.01$) than open water/less infestation areas. Density of amphibian population (13.5/acre) was decreased in the dense *Eichhornia* ponds when compared to less and sparse ponds of water hyacinth. Therefore it could be concluded that the exotic species of water hyacinth might have influenced the amphibian's abundance, diversity and distributional variations in addition to water quality of Cauvery delta ponds. In order to conserve amphibians, effective control of water hyacinths of various ponds of deltaic region is very important.

Keywords: Amphibians diversity, Cauvery delta districts, village ponds, water hyacinth infestations and water quality

INTRODUCTION

IAmphibians are in the midst of an extinction crisis. According to the Global Amphibian Assessment, nearly one-third of all amphibian species are endangered or threatened, making amphibians the most endangered group of animals in the world. The rapid disappearance of amphibian populations in the recent decades has become undoubtedly the most tragic loss of biodiversity, and it is one of the most serious environmental issues. Alteration and destruction of both terrestrial and aquatic habitats are the largest threats. Research of past two decades has proved amphibian declination is mainly due to water pollution. The water may appear clean but there is enormous physico-chemical elements dissolved in it, in which it contaminates water and affect the quality of water and life . The adult amphibians also remain exposed to water quality because of their respiratory skin through which water enters the body continuously and thus remain unprotected to contaminants. The parameters selected for the present research are pH, electrical conductivity, salinity, turbidity, dissolved oxygen, total dissolved solids and temperature. Each physico-chemical parameter performs different functions. Most of the problems associated with *E. crassipes* are due to its rapid growth rate, its ability to successfully compete with other aquatic plants, and its ease of propagation. These characteristics give rise to enormous amounts of biomass that cover the water surface of a great variety of habitats often interfering with the use and management of water resources. Among 140 aquatic weeds, *Eichhornia crassipes*, *Hydrilla vercillata*, *Salvinia* and *Pistia stratiotes* are four primary aquatic weeds of the world. It is, however, estimated that 20-25% of the total utilizable water in India has beeen infested with water hyacinth (*E. crassipes*) (Gopal and Sharma, 1981). More than 70% of these water bodies were infested by water hyacinth in Tamil Nadu rivers, lakes, ponds, canals and irrigation ways (Cherly, 2013). In Tamil Nadu almost 80% of 39,000 tanks were already infested with this weed (Christopher and Sajomon, 2010). Numbers of problems are caused due

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to water hyacinth. Some of the important aspects are that it blocks the irrigation channels and rivers, restricts livestock access to water, destroys natural wetlands, eliminates native aquatic plants, reduces infiltration of sunlight, change the temperature, pH oxygen levels of water surface, increases water loss through transpiration, alters the habitats of aquatic organisms, restricts recreational use of waterways, reduce aesthetic values of waterways, reduces water quality from decomposing plants, snd destroys fences, roads and other infrastructure when large floating rafts become mobile during flood events. Hence, the water hyacinth has become a major ecological and economic problem in the Cauvery delta regions.

MATERIALS AND METHODS

STUDY AREA

The study was carried out in the Cauvery delta areas of Nagapattinam, Thiruvarur and Thanjavur districts. The Nagapattinam district lies between 10°25′ and 11°40′ North Longitude and 76°49′ and 80°01′ East longitude. The general geological formation of the district is plain and coastal. The Thanjavur district lies between 10° 08′ and 11° 12′ North Longitude and 78° 48′ and 79° 38′ East longitude and the Thiruvarur district lies between 10° 20′ and 11° 12′ North Longitude and 78° 48′ and 79° 38′ East longitude. About thirty three ponds were selected for the present study. The water resources from various ponds are mainly used for agriculture and inland aquaculture.

Present investigation was conducted in thirty three permanent amphibian ponds in the village areas of three districts *viz:* Nagapattinam, Thiruvarur and Thanjavur. Each district was studied separately and marked for regular sampling with the help of Global Positioning System (GPS) (Fig.1). The survey was conducted monthly once from 2013-2015. The names

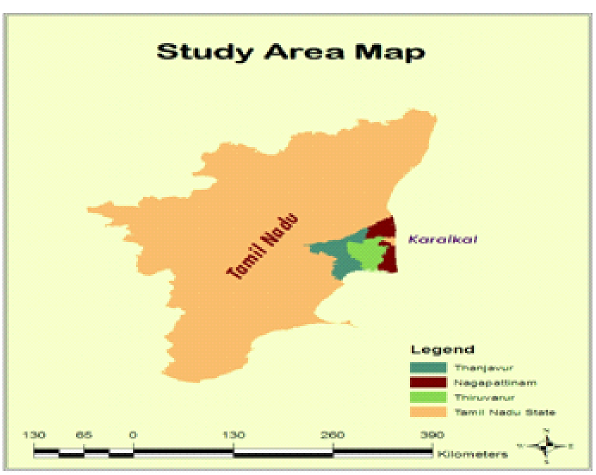

Fig. 1. Study area map of three districts of Nagapattinam, Thiruvarur and Thanjavur, Tamil Nadu

of amphibians encountered in each district are mentioned below:

District of Nagapatinam: *Duttaphrynus melanostictus, Duttaphrynus scaber, Euphlyctis cyanophlyctis, Euphlyctis hexadactylus, Hoplobatrachus tigerinus, Hoplobatrachus crassus, Fejervarya limnocharis, Sphaerotheca breviceps, Microhyla ornate, Microhyla rubra, Ramanella varigata, Polypedates maculates.*

District of Thiruvarur: *R.varigata* was the only one amphibian species which was absent when compared to Nagapattinam district during the study period.

District of Thanjavur: The amphibian species of *H.crassus* and *D.scaber* which was absent during the study period when compared to Nagapattinam district during the study period

The ponds were marked by GPS and GIS Program in Cauvery delta regions of Nagapattinam, Thanjavur and Thiruvarur districts, Tamil Nadu, India, (Fig.1) during May 2013- April 2015. Thirty one ponds were selected on the basis of the degrees of water hyacinth infestations i.e. Dense, Medium or sparse and Low. Water samples were collected once in a month from the above said infestation ponds of three districts. The selected village ponds were regularly monitored for diversity and density of amphibian population. Visual Encounter Survey (VES) method was carried out to estimate the amphibian population (Heyer, *et al.*, 1994) in various ponds and the diversity of frog species was recorded in the morning or evening time. Amphibians were thoroughly searched in the water bodies, edge of the water, grasses, bushes, holes, crevices, stones or under stones and over the surface of the water. Care was taken to see that the amphibians were not disturbed due to the visits of counting. The study period was grouped into four different seasons. The Pre-Monsoon season (PrM) includes the months of July, August and September. The Monsoon season (Mon) includes the months of October, November and December. The Post Monsoon (PoM) includes the months of January, February and March and the summer season (Sum) includes the months of April, May and June (Pandiyan et al., 2006). Collected water samples were brought to the laboratory and the water quality parameters such as pH, temperature, salinity, turbidity, TDS, electrical conductivity and dissolved oxygen were determined by using Water kit analyzer. Species richness was calculated based on the number of amphibians recorded in the pond (Heyer *et al.*, 1994) and the species diversity was calculated by using the Shannon –Wiener Index (H′: Shannon & Wiener, 1949). Individual amphibian density was calculated as number per hectare of the pond in each season. One way ANOVA was used to test the significance of variance between the amphibian densities with water

Table 1. List of amphibian species, belonging to their families with IUCN status encountered in the study area of Nagai, Thiruvarur and Thanjavur, during the study period 2013-2015.

Sl. No	Family	Species Name	Nagai	Thiruvarur	Thanjavur	Total No. of Individual	IUCN Status
1	Bufonidae	*Duttaphrynusmelanstictus*	1	1	1	378	LC
2		*Duttaphrynusscaber*	1	1	0	9	LC
3	Dicroglossidae	*Euphlyctiscyanophlyctis*	1	1	1	2071	LC
4		*Euphlyctishexadactylus*	1	1	1	570	LC
5		*Hoplobatrachustigerinus*	1	1	1	239	LC
6		*Hoplobatrachuscrassus*	1	1	0	27	LC
7		*Fejervaryalimnocharis*	1	1	1	325	LC
8		*Sphaerothecabreviceps*	1	1	1	8	LC
9	Microhylidae	*Microhyla ornate*	1	1	1	97	LC
10		*Microhylarubra*	1	1	1	51	LC
11		*Ramanellavarigata*	1	0	1	2	LC
12	Rhacophoridae	*Polypedates maculates*	1	1	1	26	LC

quality parameters in *Eichhornia* infested ponds. All the statistics were run by using SPSS 16.0. Results of the analyses have been interpreted using standard statistical procedures (Sokal and Rohalf, 1981).

RESULTS AND DISCUSSION

A total of 12 amphibian species were recorded from 31 village ponds during the study period. About 6 species are belonged to the family Dicroglosidae, whereas only three species of *M. ornate, M. rubra* and *R. varigata* aere belonged to the family Microylidae and toads and terrestrial species of *D. melanostictus and D. scaber* were observed assigned to the family Bufonidae. The only one arboreal species *P. maculates* was also encountered which belonged to the family Rhacophoridae. Regarding amphibian diversity, about 12 species were reported from Nagapattinam, 11 species from Thiruvarur and only 10 species from Thanjavure districts (Table 1). The seasonal variation showed that amphibian density was higher in the pre-monsoon season whereas less in summer season (Fig. 2).

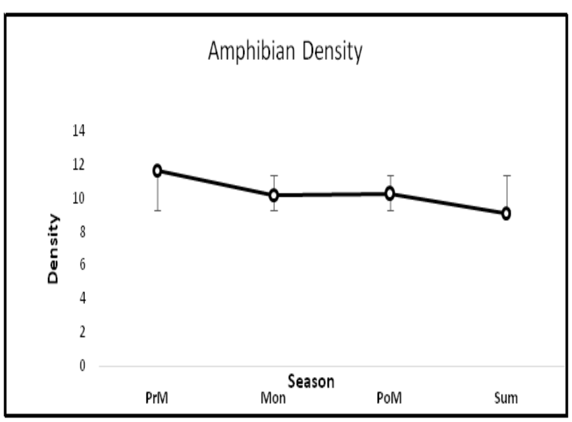

Fig.2. Seasonal variations of amphibian density during the study period of 2013-2015

The results of Shannon Weiner Index clearly showed that the variation is significant at different village ponds i.e., (H = 1.43 (less), 1.6 (Dense) and 1.36 (sparse) in various water hyacinth infested ponds. The diversity indices showed that the amphibian population was higher in dense water hyacinth ponds whereas lower in sparse water hyacinth ponds which were influenced by *E. crassipes* infestations (Table 3). As the infestation of water hyacinth forms a vegetation mat over the surface of water, the amphibians get relatively more microhabitat that could be the reason for the increased diversity of amphibians when compared to the open ponds.

Moreover, this study mainly focused to find out as to how water hyacinth influences the amphibian density and the physico-chemical environment of various pond ecosystems. This complex relationship is likely attributed to several factors associated with the timing of this study. Certain factors such as weather fluctuations, biomass of water hyacinth and water level variations could directly influence the data.

The density of amphibians was estimated with various degrees of *E. crassipes* infested ponds, in which low density of amphibians (13.5/ acre) was found in dense water hyacinth ponds when compared with other infestation ponds of medium (16.19/acre) and less (19.36/acre) infested ponds (Table 3). Among them, the population of *E. cyanophlyctis* was higher (Table 1) in all the three classified areas of *E. crassipes* ponds than other species. The mean and SD value of the amphibian density was lower (6.24±3.37) in dense

Table 2. Pearson correlation between amphibian density and water quality parameters with water hyacinth.

		pH	Tem	EC	TDS	Salin	TURB	DO	Eichhornia
pH	P	1							
	R2								
Temperature (C0)	P	0.394**	1						
	R2	0.000							
Electrical Conductivity µs)	P	0.075	0.279**	1					
	R2	0.055	0.000						
Total Dissolved Solid (ppt)	P	-0.067	0.103**	0.373**	1				
	R2	0.085	0.008	0.000					
Salinity(ppt)	P	0.008	0.125**	0.183**	0.165**	1			
	R2	0.841	0.001	0.000	0.000				
Turbidity(NTU)	P	0.039	-0.036	-0.104**	0.059	-.257**	1		
	R2	0.321	0.363	0.008	0.133	00.000			
Dissolved Oxygen (ppm)	P	-0.009	0.029	-0.087*	-0.062	-0.137**	0.418**	1	
	R2	0.824	0.459	0.026	0.112	0.000	0.000		
Eichhornia	P	0.041	-0.018	-0.014	0.023	0.154**	-0.102**	-0.111**	1
	R2	0.289	0.638	0.723	0.554	0.000	0.009	0.005	

Table 3. Density, diversity and evenness of amphibians on *Eichhornia* infested village ponds of the study area during the study period 2013-15

Diversity/Density	Dense	Sparse	Less
Density/Acre	13.65	16.19	19.36
	6.24±3.37	9.37± 4.73	9.96±6.05
Shannon Weiner H index	1.6	1.36	1.43
Evenness	0.64	0.55	0.57

Table 5. Mean and standard deviation of physic-chemical parameters in the three classified water hyacinth infested ponds.

Parameter	**Dense**	**Sparse**	**Less**
	Mean±SDV	Mean±SDV	Mean±SDV
pH	7.53±0.46	7.52±0.41	7.46±0.37
Temperature (C0)	31.23±1.05	31.30±0.91	31.24±0.88
Electrical Conductivity (µs)	0.95±0.49	0.94±0.42	0.95±0.37
Total Dissolved Solid (ppt)	0.74±0.33	0.67±0.19	0.73±0.26
Salinity (ppt)	1.10±0.57	1.02±0.60	0.92±0.51
Turbidity (NTU)	2.91±2.40	3.32±2.47	3.58±2.73
Dissolved Oxygen (ppm)	13.36±3.10	13.86±2.81	14.10±2.50

Table 4. ANOVA shows a comparison of the amphibian's density with physic- chemical parameters in the study area during the study period of 2013-2015.

Parameter	**SS**	***df***	**MS**	**F**	**P**
Electrical Conductivity (µs)	**59.985**	**240**	**.250**	**1.786**	**.000**
Total Dissolved Solid(ppt)	**26.743**	**240**	**.111**	**1.913**	**.000**
Salinity(ppt)	**84.423**	**240**	**.352**	**1.301**	**.017**
Turbidity (NTU)	**2017.567**	**240**	**8.407**	**1.392**	**.004**
Dissolved Oxygen (ppm)	**2603.743**	**239**	**10.894**	**1.707**	**.000**

Table 6. Season wise physico- chemical parameters during the study period 2013-2015

Parameters	PoM	Summ	PreM	Mon
TDS(ppt)	0.75±0.27	0.78±0.29	0.64±0.24	0.73±0.31
SALIN(ppt)	1.15±0.57	1.00±0.56	0.87±0.48	1.03±0.60
pH	7.43±0.39	7.59±0.39	7.53±0.43	7.46±0.43
EC(µs)	1.03±0.45	1.16±0.49	0.85±0.39	0.80±0.33
Tem(C0)	31.1±0.83	31.5±0.77	31.2±1.0	31.0±1.10

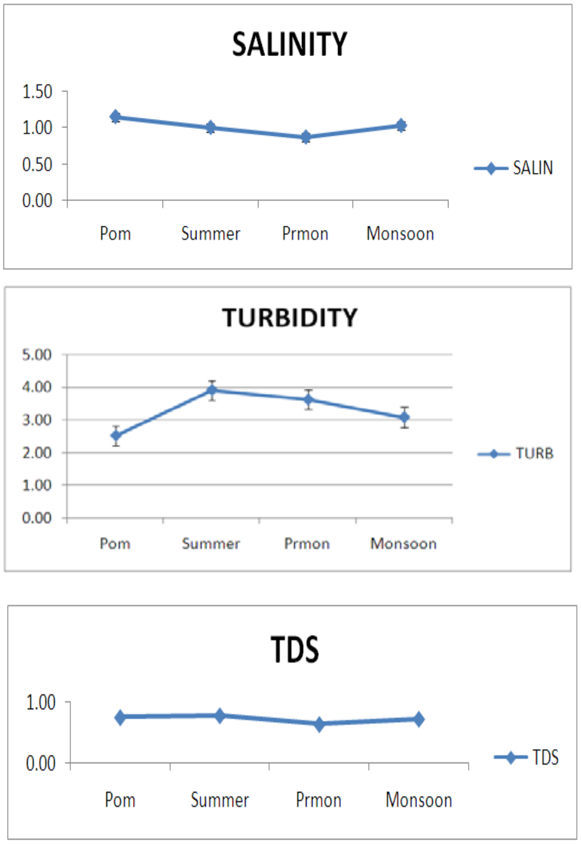

Fig.3. Seasonal variations of physic- chemical parameters during the study period of 2013-2015

infestation ponds whereas higher in medium 9.37± 4.73 and less (9.96±6.05) infestation ponds (Table 3).

One-way *t*-test was carried out to analyze the water chemistry versus amphibian density at village ponds. The different values of acidity (pH), temperature, electrical conductivity, TDS, salinity, turbidity and dissolved oxygen showed that out of seven parameters of the water quality parameters, the electrical conductivity, TDS, salinity, turbidity and dissolved oxygen showed statistically significant ($P < 0.05$). In addition that electrical conductivity, total dissolved solid and turbidity also statistically significant ($P< 0.05$) with amphibian occurrence. Stephen and Robert (1996) reported that amphibian species richness was negatively correlated with conductivity, total hardness, and turbidity. In the present study also physico-chemical parameters such as pH and temperature was not statistically significant ($P>0.05$) with amphibian occurrence (Table 4).

The results of ANOVA showed that salinity was f = 1.3, P= 0.01 (Table 4) statistically significant between water quality parameters and amphibian population. The dissolved oxygen level was found to be higher (14.10±2.50) under the mats of less infested water areas while in dense water hyacinth it was lower (13.36±3.10) Table 5.

The pH, temperature and electrical conductivity were more or less similar in three degrees of infestations of water hyacinth (Table 5). Blaustein *et al*. (1994) and Hayes *et al*. (2002) suggested that the chemical contamination was a factor leading to amphibian decline. Nyananyo (2007) observed in his study that there was just a slight difference between the pH of the water that was underneath the mats of *E. crassipes* and that of the water that was free from *E. crassipes* mats. In the present study also there was no significance between pH and temperature. Gururaja *et al,* (2003) studied that the abiotic environments influenced the efficiency of physiological function of a species; and these factors not only determine quality of habitat but also explain viability of population over a range of habitat components.

EPA (2012) reported that the dissolved solids were also important to aquatic life by keeping cell density balanced. In water with a very high TDS concentration, cells will shrink. These changes can affect an organism's ability to move in a water column, causing it to float or sink beyond its normal range. Wetzel (2001) suggested that high levels of total suspended solids will increase water temperatures and decrease dissolved oxygen (DO) levels. This is because suspended particles absorb more heat from solar radiation than water molecules. This heat is then transferred to the surrounding water by conduction. Hickin (1995) observed that the warmer water cannot hold as much dissolved oxygen as colder water, so DO levels will drop. In addition, the increased surface temperature can cause stratification, or layering, of a body of water. When water stratifies, the upper and lower layers do not mix. As decomposition and respiration often occur in the lower layers, they can become too hypoxic for organisms to survive.

The salinity is usually highest during the periods of low water flows i.e. Post Monsoon (1.15ppt); Monsoon (1.03) and in summer season (1.00 ppt). Salty water conducts electricity more rapidly than pure water. Salinity refers to total concentration of all ions in water. Boyd and Tucker (1998) observed that the fluctuations in the salinity are probably due to fluctuations in total solids. In the present study also, salinity was more in post monsoon season only which was lowest in pre monsoon season when compared to other seasons (Table 6 and Fig.3)

Salam *et al.* (2000) also observed the same fluctuation trend in salinity. In the present study also salinity was more in densely infested ponds where as low in less water hyacinth infested ponds. The most oxygen depletions occurred in the summer months because the warm water holds less dissolved oxygen than cold water. In addition to that treating a heavy infestation of aquatic weeds with an herbicide during the summer could cause oxygen depletion. As the rapid decomposition of a mass of aquatic weeds, it could deplete dissolved oxygen. Due to depletion of dissolved oxygen, the colour of the water was started to change, the whole pond was turned brown. Ultsch (1973) reported that dense mats reduced light to submerged plants, and thus depleting oxygen in aquatic communities. Kasulo (1999) also suggested that most of the vertebrates found in the water hyacinth infested areas were either purely dependent upon aerial respiration like water snakes or were supplemental air breathers such as frogs and air breathing fishes like *Clarias sp.*

Villamagna (2009) also found the same result as dissolved oxygen levels can reach seriously low levels for aquatic diversity when large water hyacinth mats prevent light infiltration or when a relatively large area of plants decompose at the same time . In the present study also DO level showed significant values. Villamagna (2009) observed that the wide spread and fast growth plant is easily occupying the large places of water bodies and absorbs the physico chemicals from the water. So, the optimum water quality changed as abnormal stages from the normal quality level of pH, temperature, electrical conductivity, salinity, turbidity, total dissolved solid and dissolved oxygen, etc.,. Midgley *et al*., (2006) concurred that water hyacinth's impacts on biodiversity in aquatic ecosystems. Moreover, Landiaet al. (2012) also observed, the depth of ponds is one of the key factors for the amphibians, whose limiting factor for survival is sufficient water in the driest months. Gichuki *et al. (* 2012) suggested that the *E. crassipes* infestation is a symptom of broader watershed management and pollution problems to alter aquatic biodiversity. In the present study also, it could be the reason that water quality and environment changes by *E. crassipes* plants in village ponds of the study area.

This research focused on possible impact of water quality indicators and exotic species of water hyacinth on amphibian extinction. The study area encompassed water quality parameters with water hyacinth infested ponds of the Cauvery delta areas. Water quality appears to be an important factor which may limit the occurrence of amphibians. The local environmental factors influence the water qualities of the pond in which the vegetation also determine the quality of the particular ponds. Pearson correlations test was used to investigate the association between water quality parameters with water hyacinth infested ponds.

Thus the amphibian population fluctuation was influenced by various factors like water quality parameters and water hyacinth. This could be the reason for quality and quantity of water. Moreover, physico chemical characteristic features of the pond and characteristic features of exotic species such as water hyacinth and amphibian species etc., (Thenmozhi and Karthik, 2015).

In this report, we first explore our information about water hyacinth on pond water quality. We collected very limited water quality parameters such as pH, TDS, EC, temperature, salinity and turbidity. Total dissolved solids, a measure of the amount of nutrients and other materials in a pond's water could be increased in the increased levels of dissolved calcium, magnesium and potassium ions. There was also a suggestion in the data that TDS increased with greater human development in the surroundings. Temperature data were too scant to allow in-depth analyses. In a nutshell, our initial explorations of water characteristics showed a marked link to the geology of the landscape and, perhaps, at least a partial link to neighbouring land use.

Both the depth of the water and changes in water level are important for the growth of this species. Oki and Ueki (1984) reported that the plants have more roots when they are floating in deep water than in shallow water, while the leaf area, and the summer growth of the plant, are greater in the latter case . In the present study also it showed significant level.

Thus, this study provides information as to how the water hyacinth influences the amphibian density and the physico-chemical environment of various pond ecosystems.

Management and control of the *E. crassipes* infestation

Today there is a global agreement among scientists and managers that there is no totally effective method to eradicate *E. crassipes* indicating the best option is integrated management and control of the weed. Although there has been little attention paid to the integration of chemical and biological control as Center *et al.* (1982) reported in an experimental study weevils were more effective in combination with a growth retardant. Great caution is needed in selecting herbicides to be used together with biological control. At a general level, in countries where *E. crassipes* infestation affects hundreds of thousands of hectares, integrated control may include several different measures. It makes suitable feed for many animals, and can be a source of protein for man. Its use has been recommended in farming as fertilizer and compost for mushroom culture. Environmental awareness measures should also be taken through various communications media.

CONCLUSION

Based on the present study, it is concluded that the water hyacinth (*E. crassipes*) influences the water quality, and amphibian diversity and density in the study area. Several studies have been reported which are similar to our report. Just clearing of the weed is not the best way to solve the socio economic problem of this declining of amphibians as water hyacinth impacting the aquatic biodiversity and affecting the water quality. It was due to the fast regrowth of the water hyacinth. Hence, the best way to solve this problem depends upon the choice of the solution, which lies in the size of the water body, area of *E. crassipes* growth, lifestyle of people living around it, need for employment, etc. As a green manure it can be either ploughed into the ground or used as mulch. It can be converted into compost and used on the land with proper management and technology. Oranic manure can be produced with a small pond with water hyacinth. No investment is required, only labour and time.

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