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Effect of water chemistry on Anuran species diversity in the water hyacinth (*Eichhorniacrassipes*) infested ponds in Cauvery delta regions of Tamil Nadu

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ABSTRACT

Amphibian density is impacted by a multitude of different factors. The potential impact of water hyacinth infestations on the physico-chemical parameters of the aquatic environment, morphology of ponds, density and diversity of amphibians was investigated. Water quality plays a key role in driving the anuran population in aquatic habitat. The water hyacinth significantly affected water quality as well as density of amphibian population in the ponds of Cauvery deltaic regions. Totally 31 ponds were randomly selected using GPS. Water samples were collected once in a month from ponds of three districts. Water quality parameters of the samples such as pH, temperature, salinity, turbidity, TDS, electrical conductivity and dissolved oxygen were determined by standard protocols. Water quality variables from three infestation areas were compared by means of one way analysis of variance (ANOVA). The level of significance was set through Binary Logistic Regression and Multiple ANOVA. The analysis showed that salinity was significantly higher ($P<0.05$) in water hyacinth infested areas (1.00±0.74) than open water/less infestation areas (0.90±0.55). Similarly the pH was significantly higher ($P<0.05$) in water hyacinth dense areas (7.71±0.57) than open water/less infestations (7.48±0.43). The temperature was higher in densely infested areas (31.53±0.95) than open water (31.24±1.06) and medium dense or sparse (31.19±1.38) water hyacinth. Therefore it could be concluded that water hyacinth affected the ecology of Cauvery delta ponds. Effective control of water hyacinths of various ponds of deltaic region is very important, in order to conserve amphibians and prevent both ecological and economic loss due to loss of biodiversity.

Key words: Anurans, *Eichhorniacrassipes*, diversity, ponds, water chemistry

INTRODUCTION

In India, amphibian population is declining day by day. The declining and disappearance of amphibian population in ponds are influenced by several factors such as climatic changes, fertilizers, pesticides, invasion of exotic plants and degradation of microhabitats. Water hyacinth (*Eichhornia crassipes)* creates a major problem for aquatic plants and other aquatic organisms by altering the physico-chemical properties of the water. In India, 342 species of amphibians are classified, in which 161 are still under the data deficient category which indicates the need of elaborative, systematic and coordinated efforts for estimating the population and delimiting the distribution of species. Dinesh *et al*. (2012) reported that the amphibians are the ecological indicator species in the environment. One-third of 6,000 worldwide amphibian species are under threatened category. Besides habitat loss, over exploitation or introduced species, amphibians are affected due to the pollution of surface waters with fertilizers and pesticides (Richard, 2010). Katie Finlinson*et al*. (2002) reported that amphibians are integral components of many ecosystems and serve as excellent bio-indicators of the environment.

Existing agricultural field and village ponds are not suitable habitats for amphibian population in the current trends. Various factors influence the population dynamics of amphibian species in aquatic habitats. These factors could influence the decline of amphibian population in the local areas of our study. Temperature of the water is an important environmental determinant of the prevalence of amphibian, too low temperature or its sudden decrease could cause reduced activity or even death of breeding individuals, and prolong the duration of tadpole stage (Anna *et al*., 2014). It is critical to determine the influence of different factors, including environmental as well as physic-chemical factors of the water on amphibian population (Maciej*et al*., 2014).Similarly land alterations like converting agriculture land to human habitation, uses of pesticides in agriculture field, water contamination in village ponds by using pesticide and chemical fertilizers around the water bodies are some of the causes for decline of amphibian population. Nutrient enrichment is widely regarded as the main contributing factor to the proliferation of water hyacinth. Midgley *et al*. (2006) concluded that water hyacinth's impacts on biodiversity in aquatic ecosystems. Hence, the present article deals with the above said information.

MATERIALS AND METHODS

The ponds were marked by GPS and GIS Program in Cauvery delta regions of Nagapattinam, Thanjavur and Thiruvarur districts, Tamilnadu, India, (Fig.1) during January 2013- December 2013.Thirty one ponds were selected on the basis of the degree of water hyacinth infestations i.e. Dense, Medium and Low. Water samples were collected once in a month from the above said

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infestation pondsof three districts. 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.

Amphibian population

The selected village ponds were monitored monthly once to find out the diversity and density of amphibian population. Visual Encounter Survey Method was carried out to estimate the amphibian population (Heyer, 1994) in various ponds and the diversity of frog species was recorded in the morning or evening time. Amphibianswere 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. The data was collected for required information of frog and its environment. The data were statistically analysed using suitable statistical tools and protocols of the software packages SPSS (Ver-16), Excel (MS office-2007)

RESULTS AND DISCUSSION

A total of nine 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 *Eichhornia* infested ponds than other species. Amphibians were higher in the sparsely *Eichhornia* infested ponds than densely infested ponds (Table 1).

The results of Shannon weiner and Simpson index clearly showed that the variation is significant in different village ponds i.e., (H = 1.88 (less), 1.52 (Dense) and 2.09 (sparse) and Simpson D= 0.00059 (Less), 0.00057 (Dense) and 0.0025 (Sparse) in various water hyacinth infested ponds. Both the diversity indices showed that the amphibian population was higher in less water hyacinth ponds and lower in dense water hyacinth ponds which were influenced by *E. crassipes* infestations (Table 1). As the infestation of water hyacinth forms a vegetation mat over the surface of water, the amphibians get relatively more microhabitat and niches for them, and that could be the reason for the increased population of amphibians when compared to the open ponds.

Monthly samples were made between May2013 to December 2013 from the three classified infestation areas of the ponds to study the effects of water hyacinth infestation on the physic- chemical properties of the ponds. It was found that there was a slight difference in the abiotic parameters of the three categories of Eichhornia infested ponds there was variation in the pH, temperature, dissolved oxygen, electrical conductivity, salinity and turbidity of water in relation to infestation with water hyacinth (Table 2).

Though there were variations in the values of pH such as 7.7±0.57, 7.5±0.42 and 7.48±0.43 in the ponds infested with high, medium and low levels of infestations respectively. It was not statistically significant ($P>0.05$; Table 2&3). Amphibian population was higher in 7.0 to 8.0pH value ponds, which is ideal range for amphibian diversity in *Eichhornia* infested ponds. Thus obviously there was variation in the pH of the ponds due to infestation of water hyacinth. However, the variation were within the optimum range of pH, required for amphibians

Similarly the variations in temperature of the ponds infested with water hyacinth was statisticallysignificant ($P<0.05$; Table 2&3). However, the slight increase in temperature could be due to the pressure of dense mat of water hyacinth over the water surface, which could block the exchange of heat between the pond surface and the atmosphere. At the same time the decaying of organic matter of the water hyacinth results in heat generation which could also be the cause for rise in temperature. The more amphibian population was observed where the optimum range temperature was 30 to 32^{0}C.

The mean dissolved oxygen of the highly infested area (12.71±3.00mg $L^{-1)}$ was lower than the other infested areas and the variation is statistically significant ($P > 0.05$). The relatively low level of DO in the pond could be due to the depletion. Depletion of DO from the water by complexity of metabolic activities of aquatic flora and fauna, which resulted in increased BOD. The green mat of water hyacinth also prevents gaseous exchange between the atmosphere and water. Therefore, the presence of water hyacinth causes continued depletion of dissolved oxygen which adversely affects the biodiversity in the pond.The highest amphibian population was found in optimal range of 14 to 17 ppm of Dissolved Oxygen in *Eichhornia* infested ponds.

The mean value of EC of the highly infested areas was 0.77±0.21µs while the other infested areas showed 0.86±0.46&0.90±0.44 (Table 2). Analysis of variance showed that conductivity values in high water hyacinth infested areas were significantlylesser ($P > 0.05$) than the other infested areas of water hyacinth. Amphibian population was relatively high when the the optimum range was between 0.5 to 1.0ìS of electrical conductivity.

Mean value of turbidity of the less infested areas was 3.8±2.8NTU while the other infested areas showed 2.18±2.02 and 3.38±2.84 (Table 2). Analysis of variance showed that turbidity values in less water hyacinth infested areas were not significantly higher ($P> 0.05$) than the other infested areas of water hyacinth. The

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Table 1. Diversity index of anuran population in water hyacinth ponds of Nagapattinam, Thiruvarur and Thanjavur Districts

Category of water hyacinth pond	Shanon Weiner index for Anurans	Simpson's index for Anurans
	H	D
Less	1.8811	0.00059
Dense	1.5204	0.000574
sparse	*2.0931*	*0.000254*

Table 2. A comparison of the Eichhornia sites with Water chemistry.

Water Quality	Dense Eichhornia Pond	Moderate Eichhornia Pond	Less Eichhornia Pond	Significance
	±SD	±SD	±SD	P – value
pH	7.71±0.57	7.53±0.42	7.48±0.43	0.53
Temperature (^{0}C)	31.53±0.95	31.19±1.38	31.24±1.06	0.58
Electrical Conductivity (ìs)	0.77±0.21	0.86±0.46	0.90±0.44	0.35
Total Dissolved Solids (ppm)	0.56±0.20	0.66±0.33	0.65±0.26	0.41
Salinity (ppt)	1.00±0.74	0.92±0.58	0.90±0.55	0.01
Turbidity (NTU)	2.18±2.02	3.38±2.84	3.80±2.83	0.83
Dissolved Oxygen (ppm)	12.71±3.00	14.24±2.77	13.94±3.02	0.08

Table 3. Binary logistic Regression to compare the Eichhorniawith amphibian presence or absence versus water quality parameters.

Binary Logistic Regression: Site Number versus water Variables in the Equation			
	Score	Df	Sig.
pH	0.37	1	0.53
Temperature (^{0}C)	0.30	1	0.58
Electrical Conductivity (ìs)	0.86	1	0.35
Total Dissolved Solids (ppt)	0.65	1	0.41
Salinity (ppt)	6.18	1	0.01
Turbidity (NTU)	0.04	1	0.83
Dissolved Oxygen (ppm)	1.52	1	0.21
Overall Statistics	12.54	7	0.08

Table 4. Multiple ANOVA shows a comparison of the water physico- chemical parameters versus the sites, which correlate with frog presence or absence

Water Quality Parameters	Type III Sum of Squares	df	Mean Square	F	Sig.
pH	0.07	1	0.07	0.37	0.54
Temperature (^{0}C)	0.42	1	0.42	0.30	0.58
Electrical Conductivity (ìs)	0.15	1	0.15	0.86	0.35
Total Dissolved Solids (ppt)	0.05	1	0.05	0.65	0.42
Salinity (ppt)	2.10	1	2.10	6.32	0.01
Turbidity (NTU)	0.31	1	0.31	0.04	0.84
Dissolved Oxygen (ppm)	13.01	1	13.01	1.51	0.22

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

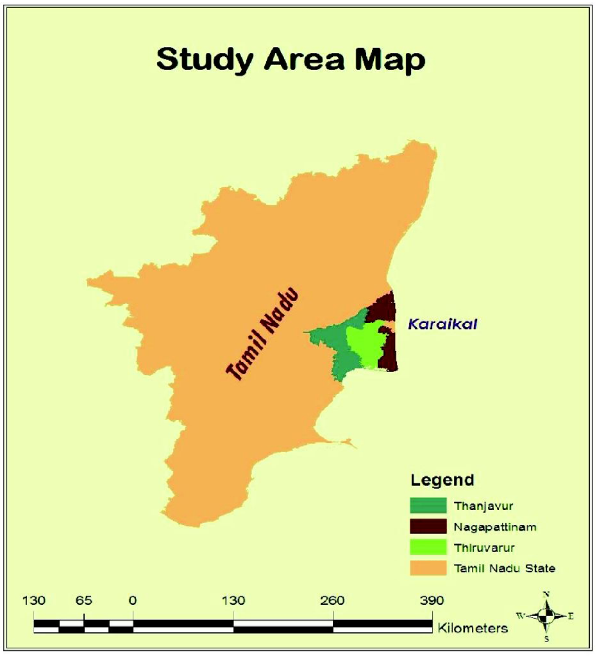
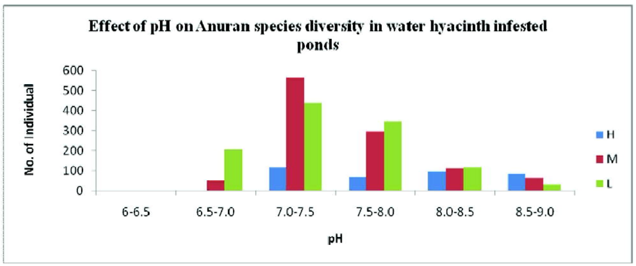
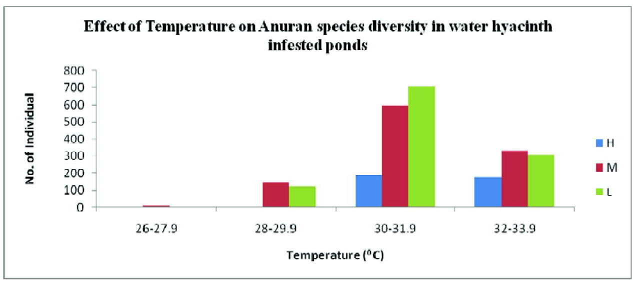


Fig.2. Effect of pH on anuran species diversity in water hyacinth infested (Dense, Sparse and less) ponds



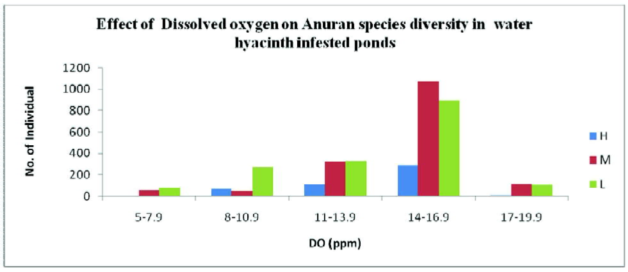
(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI= Class Interval

Fig.3.Effect of Temperature on Anuran species diversity in water hyacinth infested ponds (Dense, Sparse and less)



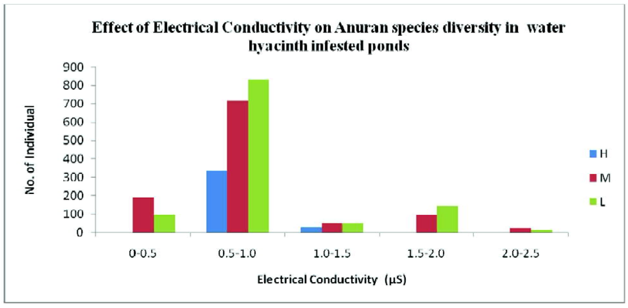
(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI =Class Interval

Fig.4.Effect of Dissolved oxygen on Anuran species diversity in water hyacinth infested ponds (Dense, Sparse and less).



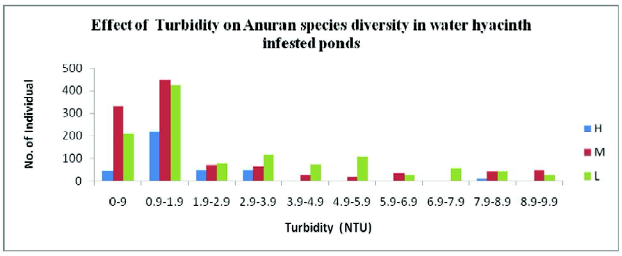
(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI= Class Interval

Fig.5.Effect of Electrical Conductivity on Anuran species diversity in water hyacinthinfested ponds (Dense, Sparse and less).



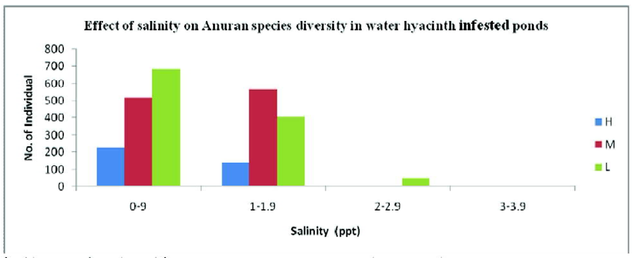
(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI =Class Interval

Fig.6.Effect of Turbidity on Anuran species diversity in water hyacinth infested ponds (Dense, Sparse and less)



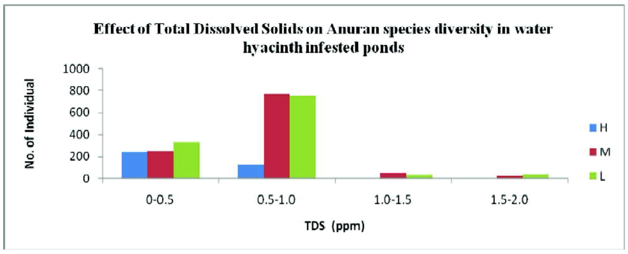
(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI =Class Interval

Fig.7. Effect of salinity on Anuran species diversity in water hyacinth infested ponds (Dense, Sparse and less)



(Eichhornia Infested Ponds)H=Dense, M= Sparse, L=Less; CI=Class Interval

Fig.8.Effect of Total Dissolved Solids on Anuran species diversity in water hyacinth infested ponds (Dense, Sparse and less)



(Eichhornia Infestedponds)H=Dense, M= Sparse, L=Less; CI= Class Interval

highest number of amphibians were recorded where the turbidity range was 0-2 NTU.

Salinity fluctuations were observed in water hyacinth highly infested and other classified water hyacinth areas. Highly Infested areas showed higher salinity (1.00 ± 0.74 ppt) than the other two infestation areas (0.92±0.58 & 0.90±0.55) as shown in Table 2 which was statistically significant (P < 0.05). These results indicate that water hyacinth in various ponds greatly reduce the growth and reproductive success of aquatic macrophytes. The maximum number of amphibians was recorded from 0-0.9 ppm salinity in low Eichhornia infested ponds.

Statistical analyses were made to determine whether there are significant similarities between water chemistry composition of the sites with and without frogs. One-way ANOVA were used to analyze the water chemistry versus the site visited. To correct this and to get accurate statistical information the data were then analyzed for Binary Logistic regression. Binary Logistic Regression were utilized in this study to analyze the different values of acidity (pH), temperature, electrical conductivity, total dissolved solid, salinity, turbidity and dissolved oxygen. When observing the water chemistry, out of seven parameters six parameters were not statistically significant (P>0.05). Salinity variation alone was statistically significant (P< 0.05) (Table 3&4). Maximum number of amphibians was occurred in the range between 0-1.0 ppm of TDS of water in the Eichhornia infested ponds.

All the water quality parameters were statistically analyzed through multiple (ANOVA) variance comparison with physic-chemical parameters versus site numbers which correlate with the anuran presence or absence. Within the seven variables, only salinity showed statistically significant P < 0.05 (Table. 4). Rest of the six parameters of pH, temperature, electrical conductivity, total dissolved solid, turbidity and dissolved oxygen were not statistically significant (P>0.05) with anuran occurrence.

The results obtained from our study showed that the physical parameters of water in the infested ponds had an impact on amphibian density. The analysis revealed that the salinity contribute to decrease the density of each amphibian species in various infested ponds (Table 2 & 3; Fig. 2 to 8).

Salinity is usually highest during periods of low water flows. Salty water conducts electricity more readily than pure water. Salinity refers to total concentration of all ions in water. The fluctuation in the salinity is probably due to fluctuations in total solids [Boyd and Tucker 1998]. Salam *et al.*(2000) also observed the 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.

Navarro and Phiri, (2000) reported that the analysis of variance on the physicochemical parameters revealed that there was no significant difference with respect to temperature between water hyacinth infested and open water areas; however infested area showed high temperature. This slight increase in temperature is a result of dense mats of water hyacinth over the surface, which blocks the exchange of heat between the water column and the atmosphere. Mehra*et al.* (1999) reported also shown that floating water hyacinth mats may have a profound influence on the diurnal temperature fluctuation. In our study also the old leaves of water hyacinth turned brown and gradually started to decay whereas the mat remained intact with entangled root masses and trapped detritus, largely composed of dead hyacinth plants, which caused the temperature increased in the infested ponds.

Kasulo (1999) reported that the 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.* In this study also dissolved oxygen was found to be higher under the mats of less infested water areas while in dense water hyacinth it was fairly lower. The water hyacinth and the physic chemical factors indicate that the maximum number of amphibian species was encountered in sparse *E.crassipes* infestation ponds. It is logically suggested that the frog could benefit from highly fragmented mats of water hyacinth. Such mats had a highest edge-to core ratio, providing some of the benefits of water hyacinth and minimizing the negative effects of dense non-fragmented mats. The less water hyacinth ponds had anuran population which was not rich and not low when compared to the other two types of ponds. The moderate water hyacinth ponds had high amphibian diversity than the rest of two ponds. The effects of water hyacinth on amphibians were complex and difficult to decide. Stephen and Robert (1996) reported that amphibian species richness was negatively correlated with five chemical variables (chloride conductivity, magnesium, total hardness, and turbidity). In the present study also the six physico- chemical parameters namely pH, temperature, electrical conductivity, total dissolved solid, turbidity and dissolved oxygen were not statistically significant (P>0.05) with anuran occurrence (Table 4).

This study aimed to understand as to how water hyacinth influences the amphibian density and the physic-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 may directly influence our collection of data. Pond would be full of water during some months ideally warm and moist, and some were too cold. Originally, each site was supposed to be visited monthly twice. However, some sites were only visited once due to weather limitations, as well as time limitations. During the course of this study water hyacinth availability among the ponds decreased drastically, likely due to herbicide on water hyacinth for control treatments. The physic-chemical parameters like temperature, electrical conductivity and total dissolved solids are significantly related to amphibian population. So the physico- chemical parameters were the response of the amphibian communities on water hyacinth is highly dependent on the physicochemical conditions and water hyacinth density. The combination of these factors makes it very difficult to predict specific effects. From the above results, we came to know that the amphibian population fluctuation was influenced by various factors like water quality parameters and water hyacinth.

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REFERENCE

Anna, J, Brygida. R, Tomasz,&Hetmanski. 2014. Influence of water chemistry and habitat parameters on the abundance of Pond-Breeding Amphibian. *Pol. J. Environ. Stud.*, 23(2), 349-355.

Boyd, C.E. and Tucker, C.S. 1998 "Pond Aquaculture Water Quality Management", Kluwer Academic Publisher, London.

Dinesh. K. P, Radhakrishnan. C, Gururaja. K.V, Deuti . K &Bhatta G., 2012. A Checklist of Amphibia of India with IUCN Red list Status. *Zoological Survey of India.*

Heyer, W.R., Donnelly, M.A., Mcdiarmid, R.W., Hayek, L.C. & Foster. M.S.1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press. Washington, 364.

Kasulo, V. 1999. The impact of invasive species in African Lakes a paper presented at the workshop o n Economics of Invasive species, University of York, U.K.

Maciej A., W³odzimierz C., El¿bieta J & Anna W.2014. Effect of physico-chemical parameters of water reservoirs on amphibian density. *North-Western Journal Of Zoology*, 10 (1), 167-172.

Mehra, A., Farago, M. E., Banerjee, D. K. and Cordes, K. B. 1999 The water hyacinth: An environmental friend or pest? A review. *Resource Environmental Biotechnology* 2, 225 – 281.

Midgley, J. M., Hill, M. P. and Villet, M. H. 2006. The effect of water hyacinth, Eichhornia crassipes (Martius) SolmsLaubach (Pontederiaceae), on benthic biodiversity in two impoundments on the New Year's River, South Africa. African Journal of Aquatic Science 31 , 1 : 25–30.

Navarro, L. and Phiri, G. .2000. Water hyacinth in Africa and the Middle East. A survey of problems and solutions. International Development Research Centre, Canada, 120 pp.

Richard I. 2010. Pesticides reduce biodiversity. *Pesticides News*, 88, 4-7.

Salam, A., Ali, M., Khan, B.A. and Rizvi, S. 2000 "Seasonal changes in physico-chemical parameters of river Chenab MuzaffarGarh, Punjab,Pakistan", *J. Bio. Sci.*, 4, 299-301.

Stephen J. H and Robert T. M. 1996. Amphibian species richness and distribution in relation to pond water chemistry in south-western Ontario, Canada. *Freshwater Biology*, 36, 7–15.

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