International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

A Study on the Catastrophic Impact of Unscientific Fishing Practice over the Fish Wealth of Kuthiyathodu Region of Pamba River, Kerala, India

Rani S. Dharan[1], Dr. Sherly Williams .E[2]

Environmental sciences, Aquaculture and Fish biotechnology lab, PG and Research Department of Zoology, Fatima mata National College (Autonomous), Kollam. 691001, India

Abstract: ***The catastrophic impact of unscientific fishing practice in Kuthiyathodu region of Pampa River Kerala, India was studied. The study brought out the unscientific practices prevailed in this area. Massive death of fish species was noticed during the study. Water quality analysis was done to prove the unsafe concentration of copper, chromium, lead and cadmium in the Pamba River due to water poisoning. Ulcerative syndrome due to over exposure to pesticide was also observed during the study. So steps to curb the unscientific fishing practices and proper awareness is necessary to sustain the existing fish fauna of this area.***

Keywords: Unscientific fishing, catastrophic impact, Kuthiyathodu, Pampa River, Ulcerative syndrome

1. Introduction

The holy river Pamba is the third longest river in the South Indian State of Kerala after Periyar and Bharathapuzha. The Pulachimalai hill in the Peerumedu plateau of Western Ghats marks the origin of Pamba river. It feeds and fosters Pathanamthitta and Alapuzha districts in Kerala. The northern boundary of Pamba river is confluence with Manimala River and the sourthern boundary with the Achenkovil River. The Pamba River is a repository of great biodiversity. All living systems have the capacity to react to the variations in the environment, which in turn is influenced by its biodiversity. Biodiversity have a major role in providing the resources from the ecosystem. Beyond to its intrinsic value biodiversity have aesthetic value also. Being a part of biodiversity, icthyofaunal diversity also plays a pivotal role in maintaining the balance of ecosystem [18]. Of the world's total fresh water fisheries 94% is contributed by developing countries [14]. The Pamba River host wide variety of fish species by providing suitable habitat conditions. In a study done by Radhakrishnan,[31] among the 175 fish species collected from various rivers of Kerala,55 were from the Pamba River. In another work done by Renjithkumar [32] revealed 76 fish species from the Pamba River system.

The water quality in the ecosystem where the fish thrive is important to sustain this marvelous creature. Any stress in the river ecosystem is reflected in its icthyofaunal diversity. At the same time it exhibits wide range of tolerance to any environmental fluctuations [21].When compared to simpler organisms the hydro morphological changes that the fish species exhibit in response to variations in water quality is more obvious. The water quality parameters in the habitat like dissolved oxygen, p^H, temperature and water velocity have a primary role in determining the distribution and assemblage of fish species than their inter specific interactions [23];[29].

As fish is rich in proteins it accounts 6 % of yearly animal protein supplies for humans [13].Now a days, fishing turns out the common extractive tool of wildlife in the world. On considering both aquaculture and wild capture, the figure rounded up to 149 million tons [14]. Fishing provides life bread for thousands of world's population in lowest sector, while remains as a commodity of intense export value, recreation and tourism. Recently the irrational popularity of various unscientific means of fishing is uprooting this immense source of protein, making it forbidden for the coming generation. The common unscientific methods of fishing prevailed are electric fishing, dynamiting and river poisoning. The objective of this paper is to unravel the various impacts that happened to Kuthiyathodu stretch of Pamba River, Alapuzha, Kerala.

Study area

The area selected for the present study was Kuthiyathodu, Kerala,India (Fig- 1). Kuthiyathodu is a rustic place in Alappuzha district with a latitude of 9.338 and a longitude of 76.5773.

Figure 1: Location of Study area

2. Literature Survey

Ecosystem and its conservation is a widely discussed topic worldwide. So many surveys are conducting in a regular basis to evaluate the threat status of various biota in various ecosystems. Such studies are significant in maintaining the stability of ecosystems. Manik and Sudip [26] studied the impact of fishing methods and gears used on fish faunal diversity in spring–fed torrential river Relli in Darjeeling hill area of West Bengal and found that improper fishing practices will affect the water quality of rivers. IUCN [20] conducted a survey in the Mekong River and identified 116 fish species and report a decline in fish wealth due to over fishing. In Uttarakhad Himalayas local people were using powder prepared from woody shrub for fishing, which was destroying the reverine ecosystem [28]. There were few studies about the exploitation of fish wealth in the Kuthiyathodu stretch of Pamba River due to unscientific fishing practice. So the present study is significant.

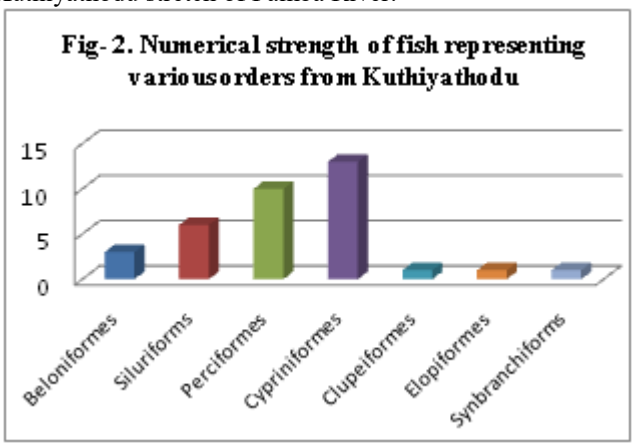
3. Materials and Methods

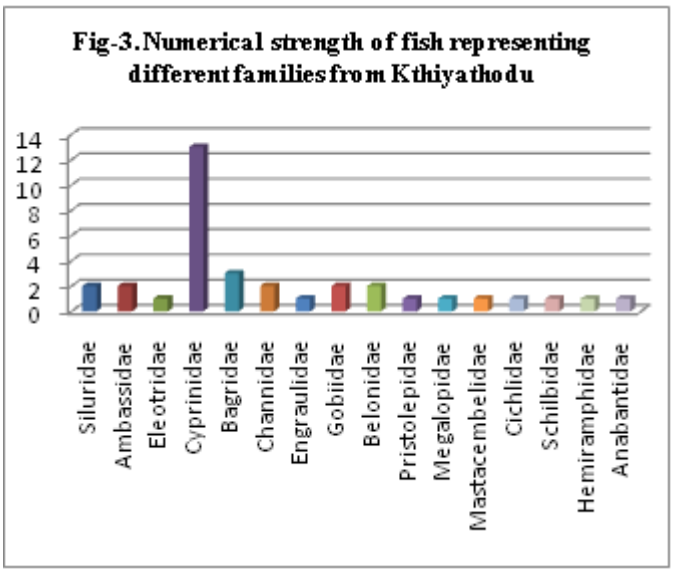
Water sample was collected from this area once in every 30 days from September 2012 to August 2013 to analyze water related issues with respect to pre monsoon, monsoon and post monsoon seasons. Water sample was taken in good quality glass bottle kept in ice box to bring to the laboratory. Materials and methods adopted for the study was given in table-2. The parameters that have to be tested in spot like temperature, P^H and DO were done at the site itself. Parameters were compared as per the standard methods of APHA [1].

Fish samples also collected once in every month of the above said time period to study the variations in the availability and abundance in the three seasons. Local fisher men helped to collect fish using different types of nets like gillnets, castnets and dragnets. The collected fish were preserved in 10% formaline before taking to the laboratory. Fish identification was done based on the reference from Day[10], Jayram [22] and Talwar and Jhingran [35].

4. Results and Discussion

During the study period 35 fish species belonging to 7 orders and 16 families were collected from Kuthiyathodu (Table-1). Among the 8 different orders, the order Cypriniforms topped the list with 13 fish species followed by Perciforms with 10 species, Siluriforms with 6 species, Beloniformes with 3 species and one each was contributed by other orders like Clupeiformes, Elopiformes and Synbranchiforms (Fig-2). In the 16 families, family Cyprinidae representes 13 fish species, followed by Bagridae with 3 species, two each by Siluridae, Ambassidae, Channidae, gobiidae and Belonidae, one each by Eleotridae, Engraulidae, Pristolepidae, Megalopidae, Mastacembellidae, Cichilidae, Schilbidae, Hemiramphidae and Anabantidae(Fig-3) On comparing the fish faunal diversity with the previous studies in the Pamba River by Renjithkumar [32], which draws out the existence of 76 species, in spite of the confinement of the concerned study area, the list is very short. Many fish species like *Wallago attu, Channa diplogramma, Nandus nandus, Channa striata, Megalops cyprinoides, Mastacembelus armatus, Hyporhamphus xanthopterus, Ombok malabaricus, Puntius bimaculatu and Horabagrus nigricollaris* were being depleted fast from the area. Many other species like *Sinocrossocheilus guizhouensis, Etroplus suratensis,Heteropneustes fossilis, Channa micropeltes, and Anguilla bengalensis* were completely disappeared from the Kuthiyathodu stretch of Pamba River.





Water quality analysis results are as below(table- 3)

pH

The average value of pH varied from 7.34 to 8.48. According to ISI and CPCB the desirable limit for pH ranges from 6.5- 8.5.Albiet for most biological life the pH range is very narrow ranges from 6 to 9 [15]. High pH value was

noted during pre monsoon. This may be due to high precipitation [2] or due to more sulfate content in water during pre monsoon as sulfate showed a slight positive correlation with pH.

DO

Average value of DO ranged from 1.31 to 6.98.The standard value set by CPCB [9] prescribes that for supporting wild life and fisheries the DO should be 4mg/l or more. Low DO during pre monsoon may be mainly due to high temperature and increased salinity [5].

Temperature

The average temperature recorded from this site ranged from 26.25 to 28.63.Aquatic life is greatly influenced by its temperature as it determines the species that to be flourished and diminished. The poikilotherms could thrive well in habitats with optimum temperature range.

Table 1: Systamatics pertaining to fish species from Kuthiyathodu during sept- 2012 to Aug- 2013

Sl No	*Order*	*Family*	*Genus*	*Species*
1	Siluriforms	Siluridae	*Wallago*	*attu*
2	Perciformes	Ambassidae	*Ambassis*	*gymnocephalus*
3	Perciformes	Eleotridae	*Eleotris*	*melanosoma*
4	Cypriniformes	Cyprinidae	*Amblypharyngodon*	*melettinus*
5	Cypriniformes	Cyprinidae	*Hypselobarbus*	*curmuca*
6	Cypriniformes	Cyprinidae	*Puntius*	*mahecola*
7	Siluriforms	Bagridae	*Horabagrus*	*brachysoma*
8	Perciformes	Channidae	*Channa*	*diplogramma*
9	Clupeiformes	Engraulidae	*Stolephorus*	*commersonnii*
10	Cypriniformes	Cyprinidae	*Labeo*	*dussumieri*
11	Cypriniformes	Cyprinidae	*Puntius*	*sarana*
12	Perciformes	Gobiidae	*Glossogobius*	*giuris*
13	Beloniformes	Belonidae	*Xenentodon*	*cancila*
14	Beloniformes	Belonidae	*Xenentodon*	*cancila*
15	Perciformes	Pristolepidae	*Pristolepis*	*marginata*
16	Perciformes	Channidae	*Channa*	*striata*
17	Elopiformes	Megalopidae	*Megalops*	*cyprinoides*
18	Siluriforms	Bagridae	*Mystus*	*armatus*
19	Synbranchiforms	Mastacembelidae	*Mastacembelus*	*armatus*
20	Perciformes	Cichlidae	*Etroplus*	*maculatus*
21	Cypriniformes	Cyprinidae	*Tor*	*khudree*
22	Cypriniformes	Cyprinidae	*Catla*	*catla*
23	Siluriforms	Schilbidae	*Clupisoma*	*taakree*
24	Cypriniformes	Cyprinidae	*Salmophasia*	*acinaces*
25	Beloniformes	Hemiramphidae	*Hyporhamphus*	*xanthopterus*
26	Cypriniformes	Cyprinidae	*Puntius*	*chola*
27	Perciformes	Anabantidae	*Anabas*	*testudineus*
28	Siluriforms	Siluridae	*Ombok*	*malabaricus*
29	Cypriniformes	Cyprinidae	*Puntius*	*filamentosus*
30	Cypriniformes	Cyprinidae	*Rasbora*	*daniconius*
31	Perciformes	Ambassidae	*Parambassis*	*dayi*
32	Cypriniformes	Cyprinidae	*Puntius*	*punctatus*
33	Cypriniformes	Cyprinidae	*Puntius*	*bimaculatus*
34	Siluriforms	Bagridae	*Horabagrus*	*nigricollaris*
35	Perciformes	Gobiidae	*Sicyopterus*	*Griseus*

TDS

Water sample from this area have an average TDS ranged from 20.21 ppm to 27.42.The desirable limit set by BIS [19] for TDS in potable water is 500mg/l. The standard permissible limit set by WHO [38] for TDS is 1000 mg/l. TDS pose a threat to ecosystem when its component ions exceeds the limit, there by shift the ecosystem type results in the lock out of certain species [37].

Table 1: Methods / instruments used for water physcico chemical analysis

Sl No	Physico- chemical Parameters	Method/Instrument
1	PH	Eutech (Model- S- 660)
2	DO (mg/l)	Eutech (Model- S- 660)
3	Temperature(^{0}C)	Digital Thermometer
4	TDS (ppm)	Eutech (Model- S- 660)
5	Conductivity(µs)	Eutech (Model- S- 660)
6	Salinity (ppm)	Eutech (Model- S- 660)
7	Copper (water)	IS 3025 (part 42)
8	Zinc (water)	IS 3025 (part 49)
9	Lead (water)	IS 3025 (part 47)
10	Cadmium (water)	IS 3025 (part 41)
11	Chromium (water)	Annex j of IS 13428: 2005
12	Copper (soil)	AAS
13	Zinc (soil)	AAS
14	Lead (soil)	AAS
15	Cadmium (soil)	AAS
15	Chromium (soil)	AAS

Conductivity

The electric current conductivity of water is called its conductivity. This ability is determined by the dissolved ions present in the water. This include calcium (Ca+2), sodium (Na+), potassium (K+), bicarbonate (HCO3-) and carbonate (CO3-2) ions. Even phosphates (PO4-3) and nitrates (NO3-2) also contribute to conductivity, but in a less extend, that itself is biologically significant. Average value of conductivity ranged from 33.72 µs to 43.16 µs at this area. Fresh water stream with conductivity ranged from 150 to 500 µS/cm is ideal for diverse aquatic life [11].

Salinity

Table 2: Analysis of water quality parameters

Parameters	*Average value in pre monsoon*	*Average value in monsoon*	*Average value in post monsoon*
PH	8.48	7.8	7.34
DO (mg/l)	1.31	6.98	3.15
Temperature(^{0} C)	28.63	26.25	28.8
TDS (ppm)	20.21	27.42	26.18
Conductivity(µs)	33.72	41.98	43.16
Salinity (ppm)	24.16	28.77	28.52
Cu(S) (mg/kg)	2.53	9.03	1.83
Cu (W) (mg/l)	0.05	0.09	0.02
Zn (S) (mg/kg)	3.8	13.13	2.63
Zn (W)(mg/l)	0.05	0.18	0.06
Cr (S) (mg/kg)	2.8	15.93	4.89
Cr(W) (mg/l)	0.01	0.16	0
Pb(S) (mg/kg)	3.03	6.95	2.49
Pb(W) (mg/l)	0.02	0.27	0.03
Cd(S)(mg/kg)	0.33	2.5	0.23
Cd(W) (mg/l)	0	0.05	0

In the considered area the average salinity value ranged from 24.16 to 28.77. For many fish species important development processes like fertilization, incubation, development of yolk sac, and inflation of swim bladder are governed by the ambient salinity. Role of salinity in determining the intake and conversion of food and its complex reaction with temperature also proved [3]. According to World Health organization the desirable limit of salinity for drinking water is 0.8 deci-siemens per meter ie, 0.8 x 640 = 512 ppm. (1000 EC (µS/cm) = 1dS/m = 1mS/cm = 1mmho/cm = 640 ppm; ("Measuring units", 2016)). So the salinity value recorded from this site does not pose any threat to the ecosystem.

Copper in sediment and water sample

In the sediment sample the average value of copper ranged from 1.83mg/kg to 9.03 mg/kg, while in the water sample the value ranged from 0.02 mg/l to 0.09 mg/l. According to Canadian Sediment Quality Guidelines [6] copper in sediment above 18.1 mg/kg is not desirable and according to Persaud et al [30], when the amount is above 16µg/g (1 µg/g = 1mg/kg), it can impact the aquatic life. Since the value obtained from this area was below this level, it is assumed to be in a safe zone. In the case of water sample the desirable limit is below 0.05mg/l [19], but in the study area the value had exceeded this prescribed limit. So it has to be admitted as undesirable for the aquatic life. Copper is used in a range of products like Electroplating, Pesticides, fungicide, as wood preservers and in animal feeds. If the copper level in water rises it can impair the olfactory ability of fish especially salmonoids. If this ability is impaired the fish cannot recognize its predators, mates and kins, which is fatal [7] .

Zn in sediment and water sample

In the sediment sample the average value of Zn ranged from 2.63 mg/kg to 13.13 mg/kg and that of water the value ranged from 0.05 mg/l to 0.18 mg/l. For Zn in sediment, according to Persaud et al [30], when the value out run 120 µg/g, it will be harm to the ecosystem. According to Canadian Sediment Quality Guidelines for the Protection of Aquatic Life [6], the threshold effect level for Zn in sediment is 124mg/kg. So the value for Zn in sediment from the study area was not posing any threat to the ecosystem. With respect to the value obtained for the water sample, when compared with the desirable limit set by Indian Standard for Drinking Water,[19] that is 5 mg/l, was not a vex to the ecosystem. Zn can reach any water media from leaching out from galvanized pipes, paints, dyes and from other natural deposits.

Chromium in sediment and water sample

In the study area the sediment sample had an average chromium load ranged from 2.8 to 15.93 mg/kg. According to Persaud et al [30], the ecosystem is affected when the amount of chromium in the sediment was above 26 µg/g. The Canadian Sediment Quality Guidelines for the Protection of Aquatic Life[6] stated the threshold effect level for cadmium in sediment is 52.3. The present study assured the safe status of sediment in this area so far. The water samples from this area contain average chromium ranged from 0 to 0.16 mg/l. According to Indian Standard for Drinking Water,(2010) [19] , amount of chromium above 0.05mg/l is not desirable. So the study is a credential for the unsafe condition of the water. Main sources of chromium are over flow from septic tanks, industrial discharge, mines, fertilizers derived from tanning process [9] and in wood preservatives.

Lead in sediment and water sample

In the sediment and in the water sample the average amount of lead ranged from 2.49 to 6.95mg/kg and 0.02 to 0.27 mg/l respectively. According to Canadian Sediment Quality Guidelines for the Protection of Aquatic Life [6] the threshold effect level for lead in sediment is 30.2mg/kg. Conceding with the work of Persaud et al [30], above 31 µg/g of lead in sediment can affect the ecosystem. Since the value obtained for lead in sediment from this study area lay below this level, it is not a matter to concern. In the case of water sample, 0.05 mg/l is the desirable limit for lead according to the guidelines of Indian Standard for Drinking Water,[19]. In the considered study area, the amount of lead in water had exceeded this limit, so it has to take on account the deleterious effect it can pose on the ecosystem. There are several sources that play major role in bringing lead to the water media like paint, discarded batteries, natural deposits, fertilizers produced from steel industry waste recycle [12].

Cadmium in sediment and water sample

Sediment sample from the study area had an average cadmium content ranged from 0.23 to 2.5 mg/kg. According

to Canadian Sediment Quality Guidelines for the Protection of Aquatic Life [6], sediment sample with cadmium above 0.7 mg/kg could affect the balance of ecosystem. Persaud et al [30] also stated that if cadmium in the sediment is above 0.6 µg/g, it will affect the ecosystem. As the cadmium content in the sediment of the study area was above the prescribed margin, it was not a green signal for the ecosystem. In the case of water sample the average cadmium content ranged from 0 to 0.05mg/l. According to Indian Standard for Drinking Water,[19] cadmium content above 0.01mg/l is highly toxic. So the water sample from this study area also carries a significant cadmium load, harmful to aquatic life.

Figure 4: Ulcerative Syndrome noticed in Channa diplogramma

Fishing mediated threats to icthyofaunal sustenance

During the study, indiscriminate poisoning of river using pesticides for fish capture was noticed. Majority of these pesticides contain many heavy metals, which is dangerous to the aquatic life. Common pesticides used in this area were parathion, furudan and paramer. Heavy metal content of inorganic fertilizers and pesticides are well proven. A fertilizer called super phosphate was experimentally proved to contain high concentrations of Cd, Co,Cu and Zn as impurities. Some pesticides also proved to carry high load of cadmium as impurity [16] .The study unraveled the unhealthy condition of water by pointing the exceeded limits of copper, chromium, lead and cadmium in water and also the critical level of cadmium in sediment sample. Even at low concentration cadmium is toxic to all life forms including humans. It can cause cancer, mutations and birth defects. In a study conducted by Borgmann et al, [4], cadmium was proved to be more toxic when compared with other 63 heavy metals. With a rise in temperature, the toxicity of cadmium to Bull trout and rainbow trout was experimentally proved [17]. The pH in water play a significant role in determining the toxicity of cadmium to fishes, but the exact relation is not known [34] . Albeit there were some proofs for the protective nature of low pH to fish against cadmium toxicity [34]..Higher levels of copper can impair the olfactory function of salmanoid fishes, which is fatal. High copper level is detrimental for the fish immune system and migration also [7] .Water with high lead content is fatal to fish species. In a study done by Martinez et al, [26] it was proved that high lead content can make serious histopathological lesions like epithelial lifting, lamellar aneurism and hyperplasia. High pesticide content in water may be a reason behind the coming back of ulcerative syndrome among fish that was previously noticed in various regions of Pamba River.

Figure 5: River poisoning for fishing caused massive death of fish species.

5. Conclusion

The present study had found the catastrophic impact of unscientific fishing practice on the existing fish fauna in the Kuthiyathodu region of Pamba River.Water quality analysis brought out the critical contition of water carrying excess loads of chromium, copper ,cadmium and lead.The existing water conditions had been causing massive death among fish species in the Kuthiyathodu region despite the steps taken by the State Fisheries Board to overcome the situation. So immediate steps have to be taken to enlighten the local fishermen about the backlashes of this unscientific fishing practice upon the existing fish fauna of this region and also take stringent action against this unscientific methods.

6. Future Scope

For the sustanence of the existing fauna in the Kuthiyathodu segment of Pamba River proper enlightenment of lay men should be done after detailed studies of the effect of various poison on the fish fauna.The poison that is applying to the water can hamber the health of man kind also.

7. Acknoledgment

The authors are grateful to the University Grand Commission, New Delhi for granting F.I.P for doing the research work. I also thanks for the local fisher men and laymen of Kuthiyathode for their extended support.

References

[1] APHA (2012). Retrieved June 26, 2016, from http://www.phf.org/events/Pages/American_Public_Health_Association_2012_Annual_Meeting_Expo.aspx
[2] Ashok ,K.Y. and Praveen, K.,2013. A Comparative Study of Premonsoon and Postmonsoon Status of Different Physical and Chemical Parameters of Water

Samples Collected from the Various Sources of Water in Todaraisingh Tehsil of Tonk (Rajasthan) India. *Journal of Science Frontier Research* .13(2): p 4

[3] Bœuf, G., & Payan, P. (2001). How should salinity influence fish growth? *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 130*(4), 411-423. doi:10.1016/s1532-0456(01)00268-x

[4] Borgmann, U., Couillard, Y., Doyle, P., and Dixon, D.G., 2005, Toxicity of sixty-three metals and metalloids to Hyalella azteca at two levels of water hardness: Environmental Toxicology and Chemistry, v. 24, no. 3, p. 641–652.

[5] Campbell, G. and S. Wildberger. 1992. The Monitor's Handbook . #1507. LaMotte Company, Chestertown,MD, pp. 30-32,36-39

[6] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. (n.d.). Retrieved April 26, 2016, from https://www.pla.co.uk/Environment/Canadian-Sediment-Quality-Guidelines-for-the-Protection-of-Aquatic-Life

[7] Carol, A. W. (2007). Copper: Effects on Freshwater Food Chains and Salmon A literature review. Retrieved April 26, 2016, from https://www.renewableresourcescoalition.org/sites/www.renewableresourcescoalition.org/files/Woody_Copper_Effects.pdf

[8] Ciavatta, C. (2012). Chromium-Containing Organic Fertilizers from Tanned Hides and Skins: A Review on Chemical, Environmental, Agronomical and Legislative Aspects. *Journal of Environmental Protection JEP, 03*(11), 1532-1541. doi:10.4236/jep.2012.311169

[9] CPCB. (2015). Water Quality Requirement for Different Uses. Retrieved April 21, 2016, from http://www.nih.ernet.in/rbis/india_information/water quality standards.htm

[10] Day, F. (1958). *The fishes of India*. London: Dawson.

[11] Definition of Water Quality Parameters. (2015). Retrieved April 22, 2016, from http://www.fosc.org/WQDataOrig/WQParameters.htm

[12] Duff, W. (1997, July 3). Fear In The Fields -- How Hazardous Wastes Become Fertilizer -- Spreading Heavy Metals On Farmland Is Perfectly Legal, But Little Research Has Been Done To Find Out Whether It's Safe. *Seattle Times*. Retrieved May 3, 2016.

[13] FAO. (2007). Retrieved April 08, 2016, from http://www.fao.org/docrep/009/A0699e/A0699E00.htm

[14] FAO. 2012. *The State of World Fisheries and Aquaculture 2012*. Food and Agriculture Organization of the United Nations. Fisheries and Aquaculture Department. Rome, Italy

[15] Firozia, N. J. and Sanalkumar, M.G., 2012. Hydrology and water quality assessment of Achenkovil River in relation to pilgrimage season. *J. International Journal of Scientific and Research Publications.* 2(12): p 2

[16] Gimeno-García, E., Andreu, V., & Boluda, R. (1996). Incidence of heavy metals in the application of inorganic fertilizers to rice farming soils (Valencia, Spain). *Fertilizers and Environment,* 491-493. doi:10.1007/978-94-009-1586-2_85

[17] Hansen, J. A., Welsh, P. G., Lipton, J., Cacela, D., & Dailey, A. D. (2002). Relative Sensitivity Of Bull Trout (Salvelinus Confluentus) And Rainbow Trout (Oncorhynchus Mykiss) To Acute Exposures Of Cadmium And Zinc. *Environmental Toxicology and Chemistry Environ Toxicol Chem, 21*(1), 67. doi:10.1897/1551-5028(2002)0212.0.co;2

[18] Hiddink, J., Mackenzie, B., Rijnsdorp, A., Dulvy, N., Nielsen, E., Bekkevold, D., Ojaveer, H. (2008). Importance of fish biodiversity for the management of fisheries and ecosystems. *Fisheries Research, 90*(1-3), 6-8. doi:10.1016/j.fishres.2007.11.025

[19] Indian Standard for Drinking Water as Per BIS Specifications_2010. (2010). Retrieved April 26, 2016, from https://www.scribd.com/doc/35309468/Indian-Standard-for-Drinking-Water-as-Per-BIS-Specifications-2010

[20] IUCN (2013). Ecological Survey of the Mekong River between Louangphabang and Vientiane Cities, Lao PDR, 2011-2012. Vientiane, Lao PDR: IUCN. 241 pp.

[21] Irigolen, X., Huisman, J., & Harris, R. (2004). Global biodiversity patterns of marine phytoplankton and zooplankton. *Nature, 429*(4), 863-866.

[22] Jayaram, K. C. (1999). *The freshwater fishes of the Indian region*. Delhi: Narendra Pub. House.

[23] Khanna, D., & Fouzia, I. (2013). Impact of water quality attributes and comparative study of icthyofaunal diversity of Asan lake and River Asan. *Journal of Applied and Natural Science, 5*(1), 200-206.

[24] Khawaja, M. A., Asma, R., Sumera, M., Muddasir, A. H., & Syed, A. S. (2012). Carbofuran Degrading Bacteria Isolated From Different Areas Of Punjab As Potentila Bioremediator Of Agricultural Soil. *Science International, 24*(3), 273-280.

[25] Manik, L. A., & Sudip, B. (2010). Impact of fishing methods on conservation of ichthyofauna of river Relli in Darjeeling Himalaya of West Bengal. *Journal of Environmental Biology, 31*(3), 431-434.

[26] Martinez, C. B., Nagae, M. Y., Zaia, C. T., & Zaia, D. A. (2004). Acute morphological and physiological effects of lead in the neotropical fish Prochilodus lineatus. *Braz. J. Biol. Brazilian Journal of Biology, 64*(4), 797-807. doi:10.1590/s1519-69842004000500009

[27] Measuring units. (2016). Retrieved April 24, 2016, from http://www.environment.nsw.gov.au/salinity/basics/units.htm

[28] Muruganandam, M., Pande, R. K., Sharda, V. N., Mishra, P. K., & Raizada, A. (2014). Myths, perceptions and knowledgeof farmers on basics of fishes and fish farming in western Himalayas:A review of realities. Indian Journal of Traditional Knowledge, 13(1), 70-86.

[29] Peres-Neto, P. (2004). Patterns in the co-occurrence of stream fish metacommunties: The role of site suitability, morphology and phylogeny versus species interactions. *Oecologia,* 140(2), 352–360.

[30] Persaud, D., Jaagumagi, R., & Hayton, A. (1993). *Guidelines for the protection and management of aquatic sediment quality in Ontario: Report*. Toronto: Water Resources Branch, Ontario Ministry of the Environment.

[31] Radhakrishnan, K. (2006). *Systematics, germplasm evaluation and patterns of distribution and abundance of freshwater fishes of Kerala* (Ph.D Thesis).Cochin Univerisity of Science and Technology, 305
[32] Renjithkumar, C. R. (2014). *Fish Germplasm Resources And Exploited Fisheries Of The Rivers Of Kerala And Bionomics Of 'Red Canarese Barb', Hypselobarbus Thomassi (DAY 1874)* (Unpublished master's thesis). Cochin University Of Science And Technology.
[33] Risk Assessment. (n.d.). Retrieved May 04, 2016, from http://www.health.state.mn.us/divs/eh/risk/studies/metals.html
[34] Som Niyogi, Rebecca Kent, and Chris M. Wood, 2008. Effects of water chemistry variables on gill binding and acute toxicity of cadmium in rainbow trout (Oncorhynchus mykiss): A biotic ligand model. Comparative Biochemistry and Physiology, Part C 148 (2008) 305–314.
[35] Talwar, P. K., & Jhingran, A. G. (1991). *Inland fishes of India and adjacent countries*. New Delhi: Oxford & IBH Pub.
[36] Water Temperature Effects on Fish and Aquatic Life. (2016). Retrieved April 22, 2016, from http://sciencefairwater.com/physical-water-quality-parameters/water-temperature/water-temperature-effects-on-fish-and-aquatic-life/
[37] Weber-Scan, P. K., & Duffy, L. K. (2007). Effects of Total Dissolved Solids on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. *American Journal of Environmental Sciences American J. of Environmental Sciences, 3*(1), 1-6. doi:10.3844/ajessp.2007.1.6
[38] World Health Organization. (1993). Guidelines for Drinking –Water Quality, 2nd edition. Geneva.

Author Profile

Rani.S.Dharan , Assistant Professor (HoD), Department of Zoology, St . Gregorios College Kottarakara, Kerala, India.

Dr. Sherly Williams E, Associate Professor, Environmental Science, Aquaculture & Fish Biotechnology Lab, Department of Zoology, Fatima Mata National College, Kollam 691003, Ph: 0474 - 2743387,