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Heavy Metals In Water, Sediment And In Three Commercially Important Fishes Of Kolavoi Lake, Chengalpet, Tamilnadu, India

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Abstract: The accumulation of Heavy metals in water, Sediment, Cirrhinus mrigala, Labeo rohita and Tilapia mossambica are determined by Atomic Absorption Spectrophotometer in Kolavoi Lake, chengalpet. In Water, the Concentration of Cd, Cu, Cr, Pb, Fe are varied seasonally from BDL -0.004 mg/L, 0.078-0.126mg/L, BDL-0.008mg/L, 0.098-0.142mg/L,7.230-8.076mg/L respectively. Among all the metals analysed in the sediment, Fe was observed to be the highest during summer and Cd, the lowest during pre-monsoon. In the three species of fishes studied, the Concentrations of Cd, Cu, Cr ,Pb and Fe varied seasonally from BDL -0.043 mg /kg, BDL - 2.680mg/Kg, BDL-0.982mg/Kg, BDL-0.842mg/Kg, 0.552-61.240mg/Kg respectively. Of the five metals studied, the Fe concentration was detected to be the highest during Monsoon and in contrast, Cd concentration was found to be minimal throughout the year. Cr and Cu concentrations are assessed to be higher than the recommended values. Which suggests, that the Kolavoi Lake to a certain extent, exhibits toxicity in water, sediment and fishes, making it deleterious to human health.
Key words: Heavy metal, Kolavoi Lake, Accumulation, Atomic Absorption Spectrophotometer, Cirrhinus mrigala, Labeo rohita and Tilapia mossambica.

1. INTRODUCTION

Lakes are inland depressions containing standing water. Lakes are socio economically and bio aesthetically important aquatic ecosystem[1]. The Kolavoi lake is one of the biggest lakes situated about 200m on the north east of Chengalpet and close to Pulipakkam village, running parallel to the national highway. This lake receives water from 12 tanks and the surplus flows into Palar, Neenjal and Madura rivers. It is one of the biggest water bodies with 894 Hectares and a maximum depth of 4.5Metres. Presently 11 villages are benefitting from this lake. It has many species of plants and animals. The total capacity of the tank is 476.69 Mct. with one filling. The Government has permitted M/s Mahindra industrial park Ltd, to draw 0.6Md from Kolavoi Lake. (35 Mct per year).At present approximately 200 Kg of fishes are harvested by fishermen per day. Now the main threat to this lake is due to the pollution by the agricultural wastes, domestic sewage, hospital and Industrial discharges. There is no much investigation so far on the water

Quality parameters and heavy metals' content of this lake. Therefore, the present work has aimed to study these characteristics. Water is one of the most precious gifts of nature, without which no life could survive on the earth. Freshwater present on the earth surface is put to multifarious uses. This water gets polluted with organic and inorganic chemicals pathogens and non-pathogenic organisms. Among these, the metals may react with Biological system to cause adverse effects. These elements enter human body through food chain .Monitoring and assessment of water has become environmental concern due to contamination by Mankind. One of the most important crises of 21st century is the availability of drinking water, a resource basic to our survival and growth. Ever increasing demands for water exceeding its availability due to population explosion, industrial revolution etc, have lead to several other problems.

Besides the drinking purpose, water is also used for fish and aqua culture, irrigation etc...The quality of water is subjected to major physical, chemical and biological changes due to the influx of sediments and dissolved substances from the catchment area with which the water comes to contact with rocks, soils and vegetation during runoff. Since the quality of water affects aquatic lives in many ways, it must be of good quality for healthy survival of organisms. Water quality assessment generally involves analysis of physico-chemical, biological and microbiological parameters and it also reflects on abiotic and biotic status of the eco system. Assessment of water quality in a region is an important aspect for any developmental activity of the region[2].

2. MATERIALS AND METHOD

Kolavoi Lake is subjected to enormous anthropogenic stress, and receives heavy inputs of domestic water and sewage. The lake water is used for drinking purpose of cattle and the local people use it for agriculture, aquaculture and for industrial purposes. Sampling sites are selected by keeping in mind the feeding sources of lake. The study period of one year was divided into four seasons based on the intensity and duration of rainfall as pre-monsoon, monsoon, post-monsoon and summer from September 2010 to August 2011. The water samples after collection were subjected to analysis following the procedures prescribed by APHA (2005)[3].The parameters namely Temperature, pH and Selective heavy metals were analysed at regular intervals. For the heavy metals' analysis the samples were preserved by adding 5 ml of conc.HNO_3 in 1 litre of sample to maintain the pH below 4, following the procedure suggested by Agemian and Chare (1975).The samples were then filtered through the Whatman filter paper No.40 and the filtrate is directly used for analysis in the Atomic Absorption Spectrophotometer. The Sediment was collected by the Vanveen Hydrobios grab. The three different species of fishes such as Cirrhinus mrigala, Labeo rohita and Tilapia mossambica were collected and washed. The weighed fishes were dried in an oven at 105^{o}C for 5 hours until they gained the constant weight. The samples were powdered by mortar and pastel, stored in precleaned plastic bottles and preserved for further analysis. For the quantitative analysis of Cu, Cr, Cd, Pb and Fe, the fish samples were digested. 1 gm of powder was taken in a conical flask then 1 ml of conc. H_2SO_4 and 1ml of Perchloric acid were added to the flask. The samples were heated in a sand bath at 105°C until the solid mass dissolves and then cooled to room temperature. Then the samples were analysed in the AAS with the prepared standard solution.

3. RESULTS AND DISCUSSION

3.1 WATER

The heavy metals of the water sample are listed in Table A and graphs 1 and 34. These metals, in trace amounts might play an important role in the biochemical life process of the fish. However their sublethal concentration becomes lethal on prolonged exposure to these metals. Cd concentration was recorded from BDL to 0.004mg/L, Cr from BDL to 0.008 mg/L, Cu from 0.078 to 0.126mg/L, Pb from 0.098 to 0.142mg/L, Fe from 7.230 to 8.076mg/L and Zn from 0.204 to 0.264mg/L.

The Permitted maximum contamination level's (MCL) for Fe, Zn, Pb, Cd, Cr, Cu is less than 0.3mg/L, 5mg/L. 0.0015mg/L, 0.005mg/L, 0.1mg/L, 3mg/L respectively. The recorded data indicates acceptable levels of Zn, Cd, Cr, Cu whereas Fe and Pb are found to be in higher concentrations thus posing a threat to the quality of water.

Table A- Assessment of Heavy metals concentration in water

SEASONS	Cd	Cr	Cu	Pb	Fe	Zn
POST MONSOON	0.003	0.008	0.126	0.138	7.820	0.232
SUMMER	0.004	0.006	0.078	0.098	8.076	0.264
PRE MONSOON	BDL	0.008	0.100	0.132	7.567	0.218
MONSOON	0.004	BDL	0.122	0.142	7.230	0.204

Measured in mg/L. BDL-Below Detectable Level

3.2 SEDIMENT

The sediment showed the values of heavy metals as Cd - BDL, Cr-0.771mg/kg, Cu-0.471mg/kg, Pb -0.127mg/kg and Fe 241.67mg/kg as listed in Table B.1.

3.3 PLANKTONS

The planktons showed the values of Cd, Cr, Cu, Pb and Fe as 0.026mg/kg, 0.104mg/kg, 0.605mg/kg, 0.316mg/kg and 4.181mg/kg respectively as Table B.2.

Table B.1-Assessment of heavy metals in sediments

SOURCE	Cd	Cr	Cu	Pb	Fe
SEDIMENT	BDL	0.771	0.471	0.127	241.67

Measured in mg/Kg. BDL – Below Detectable Level.

Table B.2-Assessment of heavy metals in Planktons

SOURCE	Cd	Cr	Cu	Pb	Fe
PLANKTON	0.026	0.104	0.605	0.316	4.181

Measured in mg/Kg. BDL – Below Detectable Level.

3.4 FISHES

The heavy metals concentration in the muscle, gills, liver of three fish species of Kolavoi Lake is presented in Table C.1 and kidney in table C.2.Corresponding data are represented in graphs (2-33).

3.4.1 IRON (Fe) The concentration of Fe in fish species studied, varied from 0.552mg/kg to 15.11mg/kg in Rohita, 0.660mg/kg to26.225mg/kg in Tilapia, 2.345mg/kg to 61.240mg/kg in Mrigal. The Mrigal liver showed the highest value of 61.240mg/kg in monsoon period. The Fe **Bio concentration factor** observed between fish and water, based on annual values ranged from 0.007- 2.50 as listed in Table D.

3.4.2 CHROMIUM (Cr) The concentration of **Cr** ranged from BDL to the highest value recorded as 0.982mg/kg in Rohita. And The BCF values ranged from BDL to 77.12. In Rohita Cr’s concentration was found in between BDL-0.982mg/kg, in Tilapia 0.009-0.864mg/kg and in Mrigal 0.036-0.364mg/kg.

3.4.3 COPPER (Cu) The concentration in Rohita was detected in between BDL -1.958mg/Kg, in Tilapia 0.024 -1.764mg/kg, in Mrigal 0.036 -2.680mg/kg. And the BCF value ranged from 0.46 to 12.07.

3.4.4 LEAD (Pb) The concentration in Rohita was observed in the range, BDL -0.842mg/kg, in Tilapia BDL to 0.216mg/kg in Mrigal BDL to 0.362mg/kg.And the BCF value ranged from 0.29 to 1.81.

3.4.5 CADMIUM (Cd) the concentration in Rohita ranged between BDL TO 0.043mg kg, in Tilapia BDL to 0.009mg/kg in Mrigal BDL to 0.009mg/kg. And the BCF value ranged from BDL to 3.

Table C.1- Assessment of Heavy metal concentration in Fishes (Tilapia, rohita, mirigal)

Seasons	Muscle					Gills					Liver					
	FISHES	**Cd**	**Cr**	**cu**	**Pb**	**Fe**	**cd**	**Cr**	**Cu**	**Pb**	**Fe**	**Cd**	**Cr**	**Cu**	**Pb**	**Fe**
Post monsoon	**Tilapia**	0.006	0.371	1.178	0.164	5.220	BDL	0.238	1.387	0.216	8.093	BDL	0.112	0.746	0.193	6.094
	Rohita	0.002	0.045	0.135	BDL	2.089	BDL	0.062	0.452	BDL	3.492	BDL	0.057	1.596	BDL	3.887
	Mrigal	0.002	0.087	0.334	0.094	2.939	BDL	0.264	0.326	0.042	3.664	BDL	0.328	2.680	0.362	58.42
Summer	**Tilapia**	0.009	0.272	0.116	BDL	2.429	BDL	0.097	0.274	0.099	7.097	BDL	0.047	0.662	0.073	11.04
	Rohita	BDL	0.089	0.194	0.069	2.787	BDL	0.130	0.162	BDL	11.19	BDL	0.098	1.958	0.069	15.115
	Mrigal	BDL	0.133	0.215	BDL	3.687	BDL	0.235	0.212	BDL	9.674	BDL	0.236	2.330	0.107	60.30
Pre monsoon	**Tilapia**	BDL	0.142	0.674	0.044	0.660	BDL	0.009	0.040	0.043	11.95	BDL	0.055	1.721	0.084	26.225
	Rohita	0.014	BDL	BDL	0.078	0.552	0.015	0.016	0.022	BDL	2.029	0.039	BDL	0.205	0.158	11.57
	Mrigal	BDL	0.068	0.107	0.034	2.345	BDL	0.173	0.076	BDL	4.360	BDL	0.247	1.435	0.072	21.43
Monsoon	**Tilapia**	0.008	0.374	0.972	0.195	5.326	BDL	0.442	1.015	0.183	12.754	BDL	0.163	1.764	0.103	8.825
	Rohita	0.006	0.053	0.172	0.840	3.126	BDL	0.040	0.972	0.006	3.430	0.043	0.096	1.714	0.016	14.043
	Mrigal	0.008	0.094	0.406	0.128	3.436	0.009	0.274	0.376	0.063	4.432	0.006	0.364	2.642	0.238	61.24

Measured in mg/Kg. BDL-Below Detectable Level

Table C.2- Assessment of Heavy metal concentration in Fishes (Tilapia, rohita, mirigal)

Season	Kidney					
	FISHES	**Cd**	**Cr**	**Cu**	**Pb**	**Fe**
Post Monsoon	**Tilapia**	BDL	0.783	1.641	0.074	3.280
	Rohita	BDL	0.083	0.968	0.163	3.162
	mrigal	BDL	0.068	0.048	0.036	2.834
Summer	**Tilapia**	BDL	0.539	0.094	0.126	3.642
	Rohita	0.006	0.079	1.452	0.070	10.29
	mrigal	0.004	0.036	0.036	0.028	2.364
Pre Monsoon	**Tilapia**	BDL	0.628	0.024	0.178	7.821
	Rohita	BDL	BDL	0.090	0.046	3.951
	mrigal	BDL	0.043	0.037	0.024	2.350
Monsoon	**Tilapia**	BDL	0.864	0.107	0.098	3.972
	Rohita	BDL	0.982	1.648	0.168	3.116
	mrigal	BDL	0.076	0.098	0.062	3.236

Measured in mg/Kg .BDL-Below Detectable Level

Table D- BIO-CONCENTRATION FACTOR (CF)

SEASONS	FISHES	Cd	Cr	Cu	Pb	Fe
Post Monsoon	**Tilapia**	*0.0015/0.003=0.5	*0.371/0.008=46.4	*1.24/0.126=9.84	*0.162/0.138=1.17	*0.056/7.82=0.007
	Rohu	*0.0005/0.003=0.0017	*0.617/0.008=77.12	*0.788/0.126=6.25	*0.041/0.138=0.29	*3.15/7.82=0.40
	Mrigal	*0.0005/0.003=0.0017	*0.186/0.008=23.25	*0.847/0.126=6.7	*0.134/0.138=0.97	*15.46/7.82=1.97
Summer	**Tilapia**	*0.002/0.004=0.5	*0.239/0.006=39.8	*0.287/0.078=3.68	*0.075/0.098=0.76	*6.052/8.07=0.75
	Rohu	*0.002/0.004=0.5	*0.099/0.006=16.5	*0.942/0.078=12.07	*0.052/0.098=0.53	*9.85/8.076=1.21
	Mrigal	*0.001/0.004=0.25	*0.160/0.006=26.67	*0.699/0.098=7.13	*0.034/0.098=0.35	*19/8.096=2.35
Pre Monsoon	**Tilapia**	*BDL/BDL	*0.208/0.008=26	*0.615/100=6.15	*0.087/0.132=0.66	*11.66/7.56=1.54
	Rohu	*0.017/BDL	*0.004/0.008=0.5	*0.079/0.100=0.79	*0.07/0.132=0.59	*4.525/7.56=0.59
	Mrigal	*BDL/BDL	*0.133/0.008=16.63	*0.414/0.100=4.14	*0.033/0.132=0.25	*7.63/7.56=1.009
Monsoon	**Tilapia**	*0.002/0.004=0.5	*0.460/BDL	*0.965/0.122=7.909	*0.145/0.142=1.02	*7.72/7.23=1.06
	Rohu	*0.012/0.004=3	*0.293/BDL	*1.126/0.122=9.22	*0.258/0.142=1.81	*5.93/7.23=0.82
	Mrigal	*0.006/0.004=1.5	*0.202/BDL	*0.880/0.122=7.21	*0.123/0.142=0.86	*18.09/7.23=2.50

BIO-CONCENTRATION FACTOR=MEAN VALUES OF FISH SAMPLES/MEAN VALUE OF WATER SAMPLE

(*Mean values of 4 Samples)

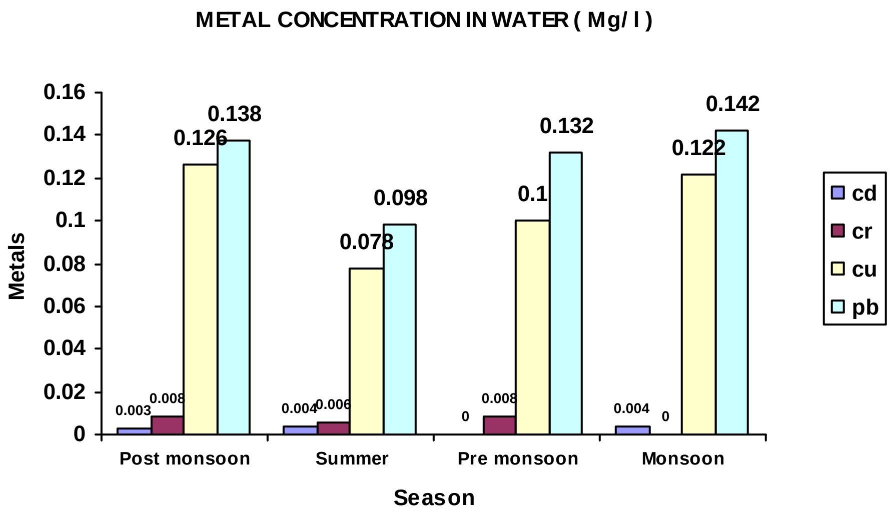
In water the concentration of heavy metals are present in the order of Fe>Zn>Pb>Cu>Cr>Cd .In sediment it is in the order of Fe>Zn>Cr>Cu>Pb>Cd. In planktons Fe< Cu<Pb<Cr <Cd. In fishes it is in the order of Fe>Zn>Cu>Cr>Pb>Cd. In organs it is highly accumulated in liver followed by gills >muscle > kidney.

Fe in the liver was found to be higher than any other metal studied in the fishes and it still falls within the 300mg/kg recommended limits for food fish by WHO (1994)[12] & FEPA[4]. The Pb value obtained in the fishes were below the recommended STD. value limits of 2 mg/kg in food fish. But the observed value was recorded in the report of Daka et al[5], who obtained 0.01 - 0.06mg/kg in fish species and also Kannan and Krishnamoorthy (2006), reported 0.0083mg/kg in Pulicat Lake. The Cr value obtained is higher than the recommended permissible value 0.15mg/kg. So this may create health problems in lungs and kidneys of humans. The recommended permissible value of Cu is 1 -3mg/kg in food fish. Cirrhinus mrigala, Labeo rohita and Tilapia mossambica showed lesser than this value and thus will not create any problem. Cd is non-essential toxic metal whose recommended value according to FAO is 0.5mg/kg (1983)[6]. The studied fishes showed lesser than this value indicating that it will not induce Cd related problems.

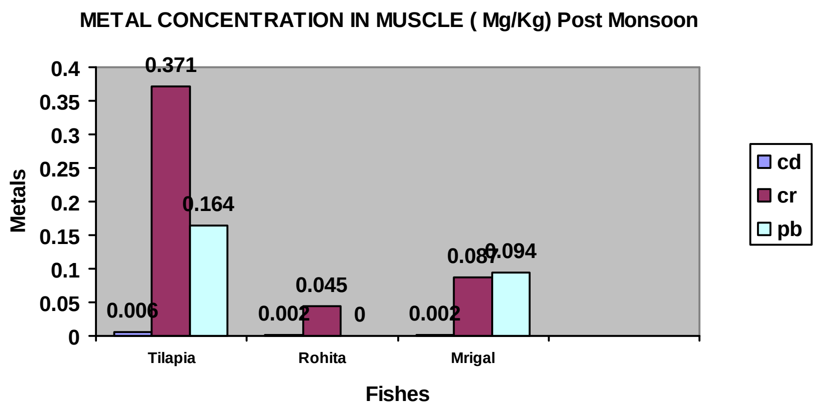
Fish absorbs the metals through gills, skin or through ingestion of contaminated water or food. The concentration of heavy metal is related to several factors such as food habits and foraging behaviour of organisms[7].The gills play an important role in ion regulation, gas exchange, acid balance and excretion, which signifies the key role it plays at the interface with the environment[8]. The higher accumulation of metals in gills and liver than muscle and kidney is due to metallothionein protein. The liver acts as a target organ for heavy metals detoxification. The muscle tissue has lower tendency to accumulate the heavy metals.

Mrigala is a detritivorous fish, which feeds on small organisms and forms an important link in the food web of aquatic eco system in this locality. A high metabolic rate may also induce more feeding sessions, which in turn might result in increased metal levels[9]. Heavy rainy season dilutes the metal concentration. Fishing activities, anthropogenic activities and runoff water might have increased the cadmium level in sediment. The phytoplankton activity can also cause seasonal variation in copper[10].The phytoplankton consumes more copper[11].

Graph 1



Graph 2



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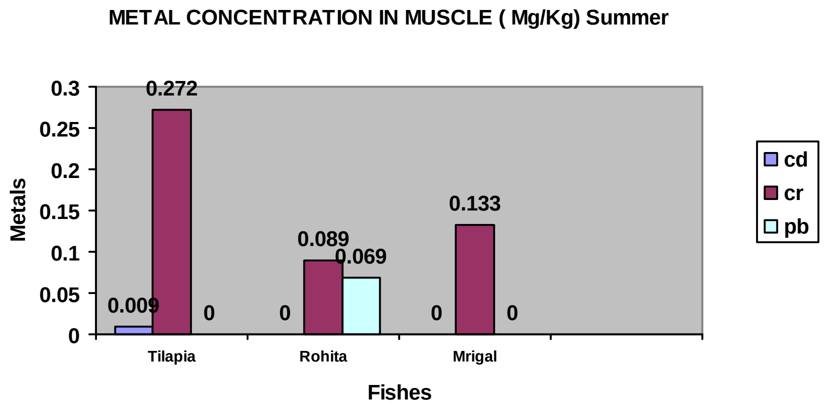

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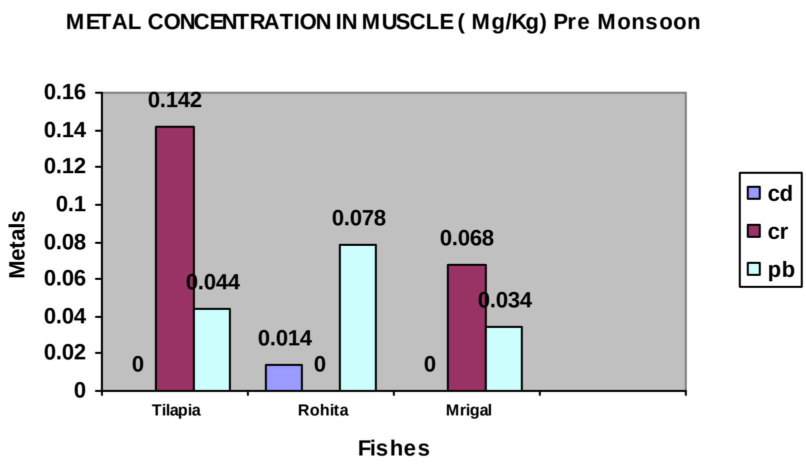

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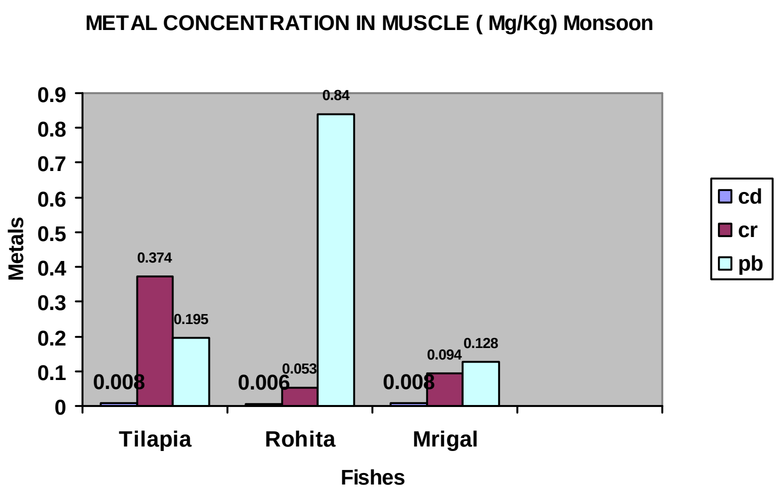

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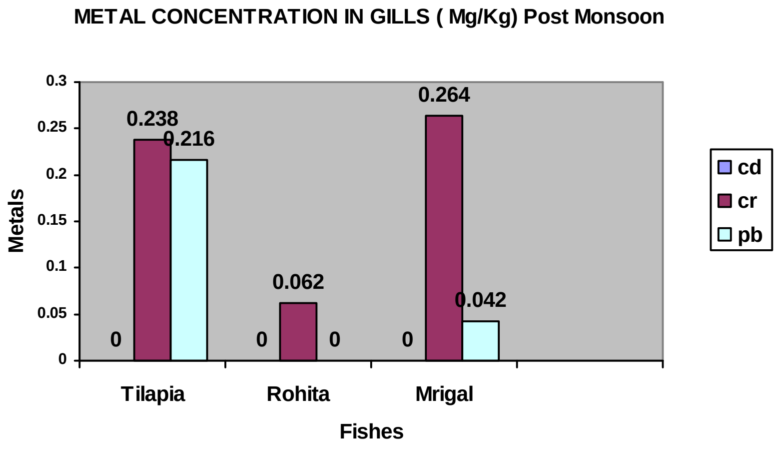

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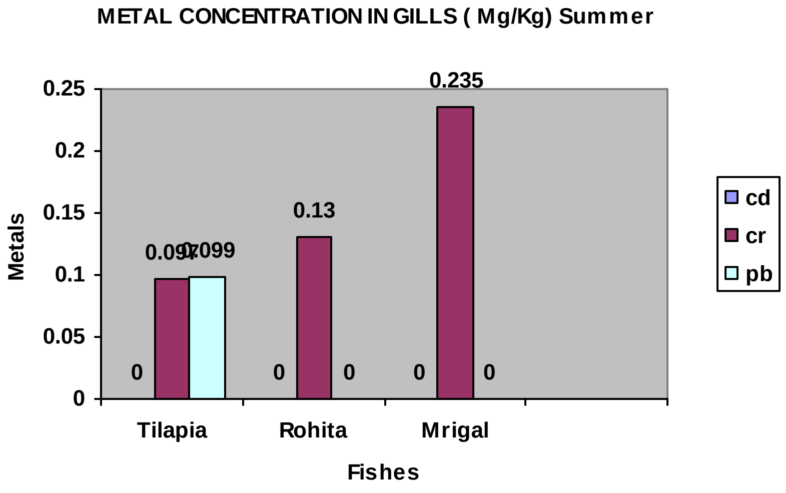

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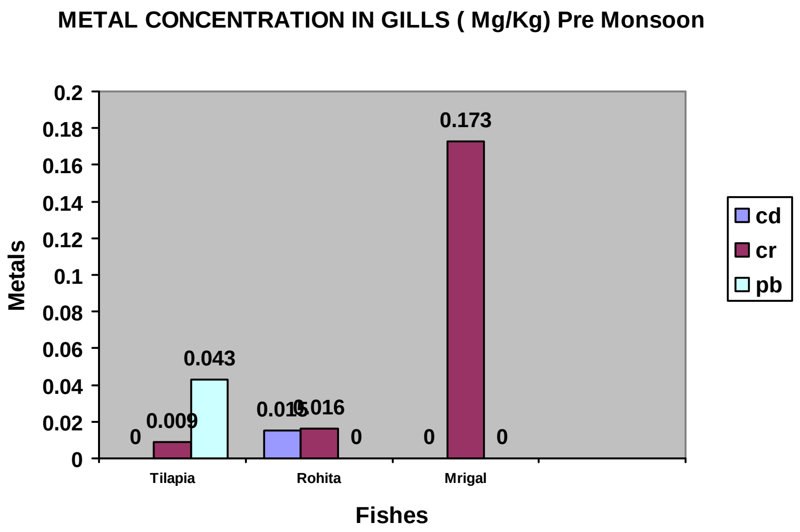

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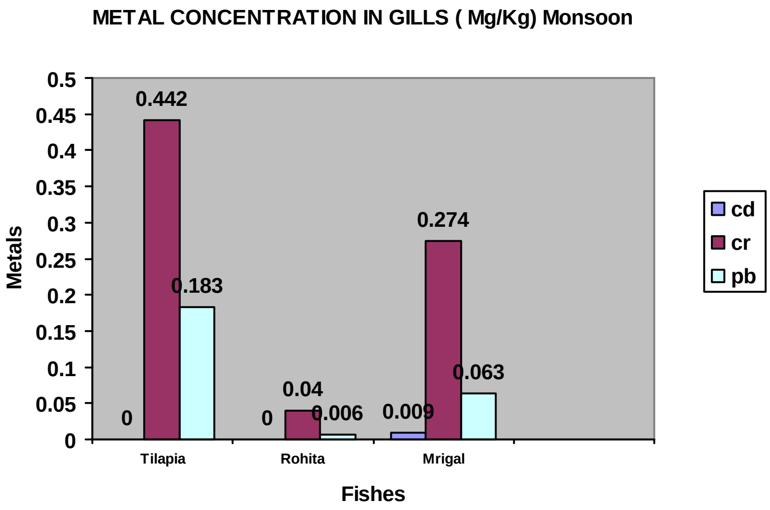

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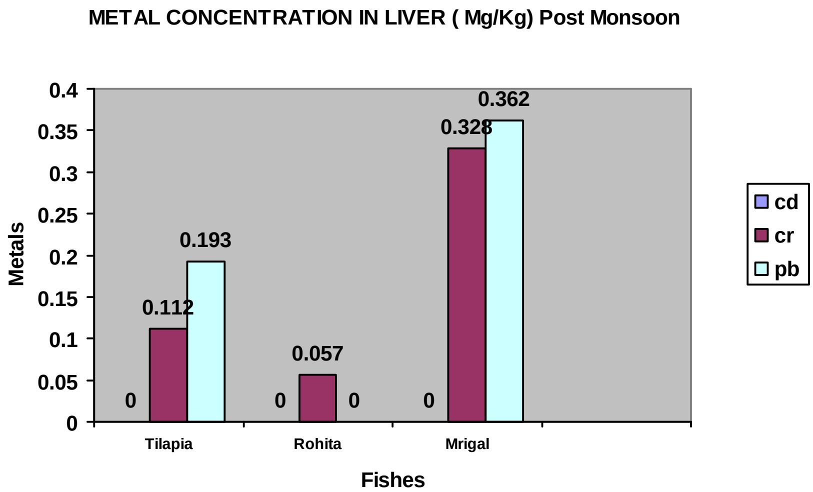

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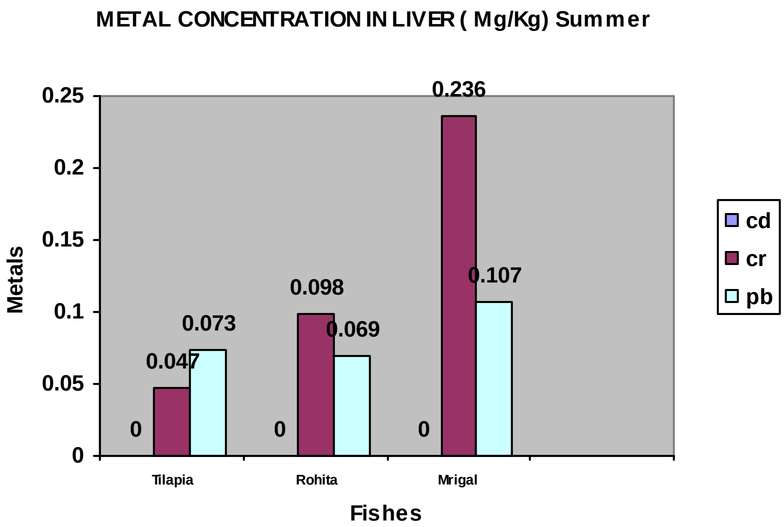

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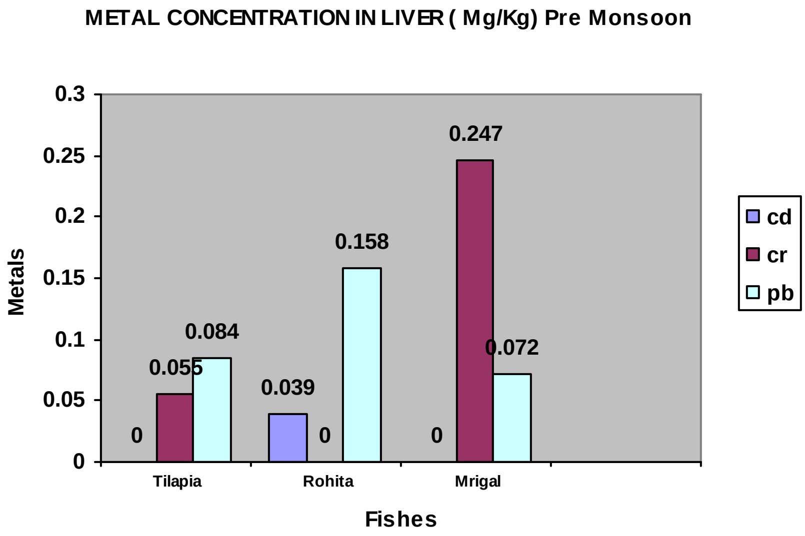

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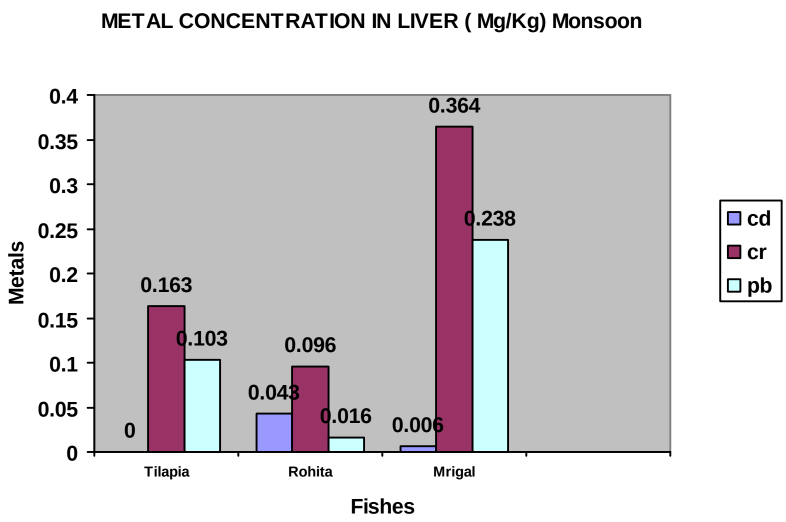

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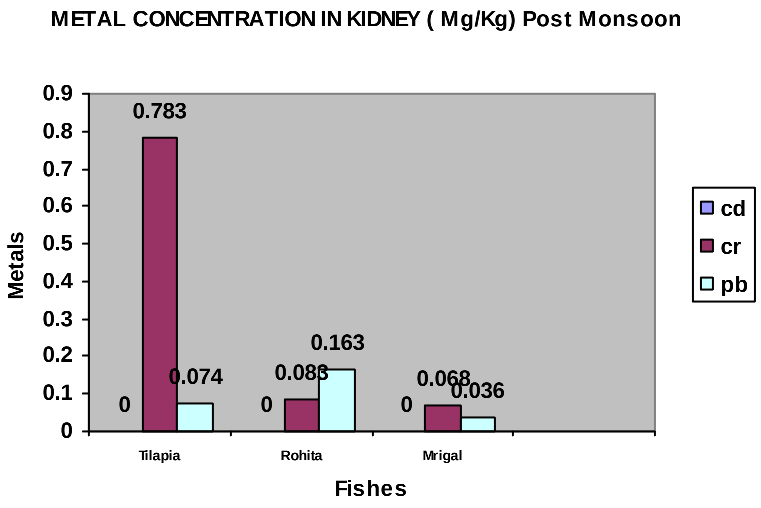

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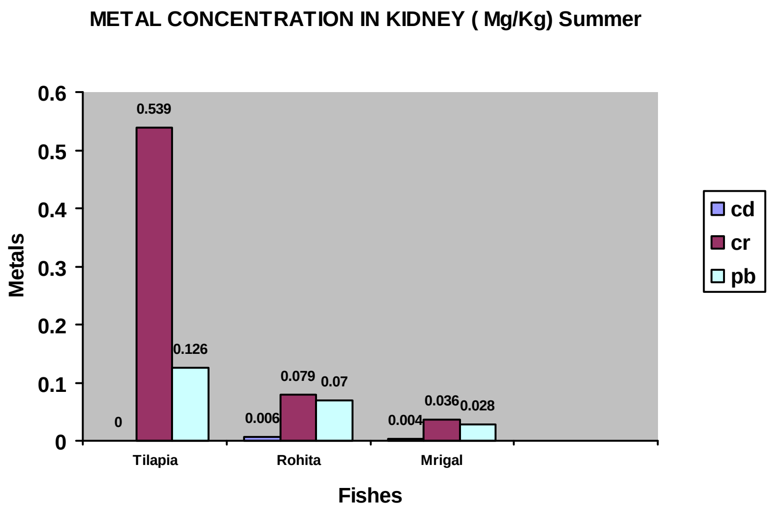

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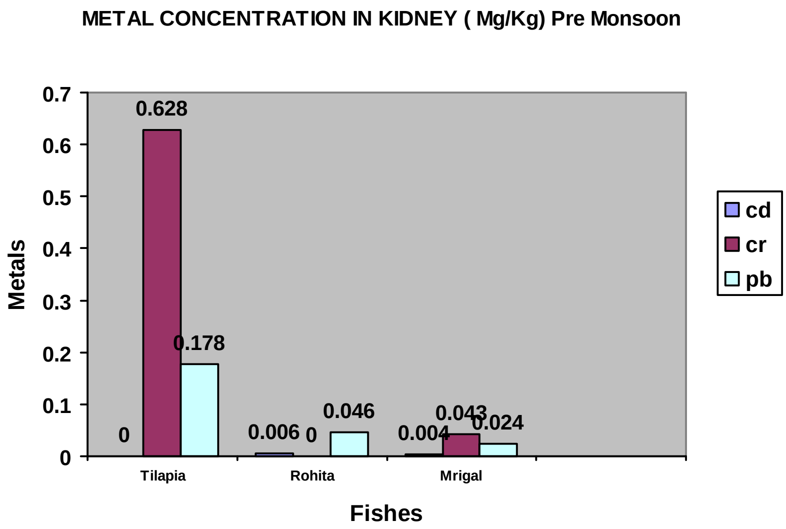

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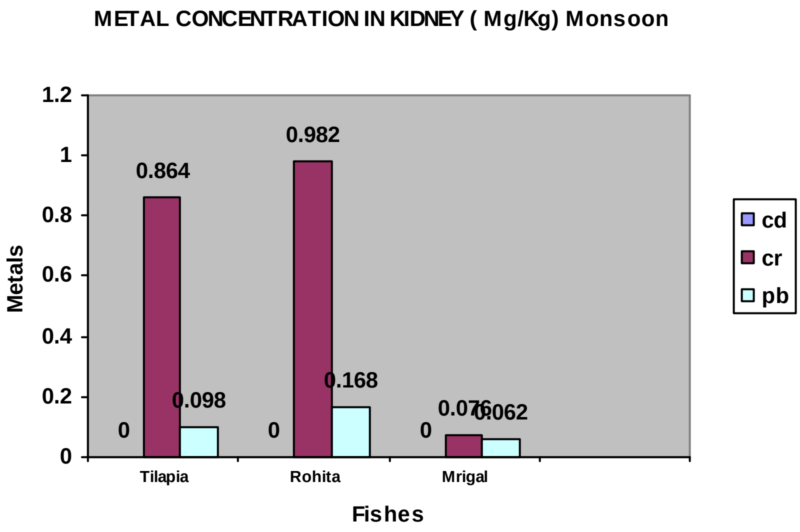

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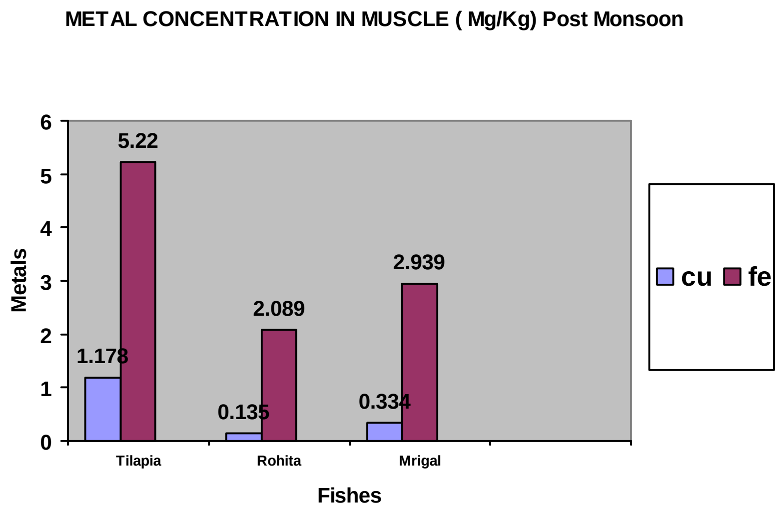

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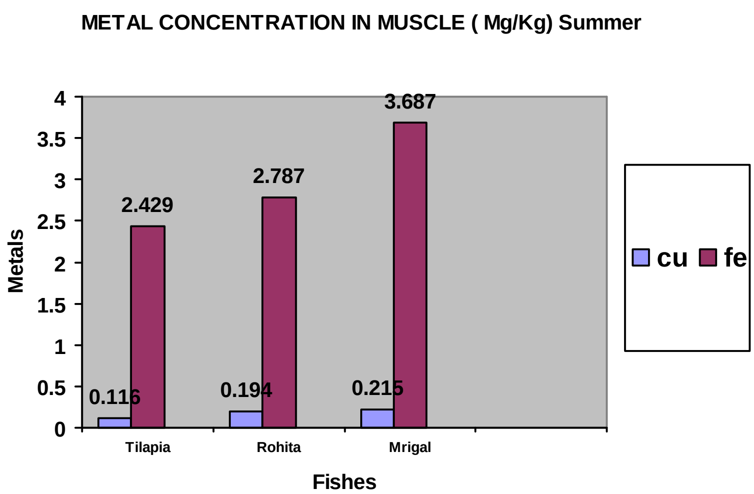

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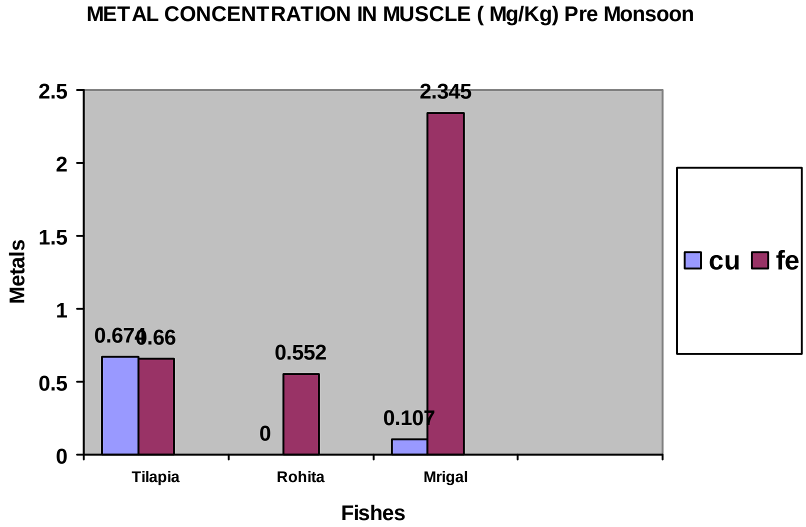

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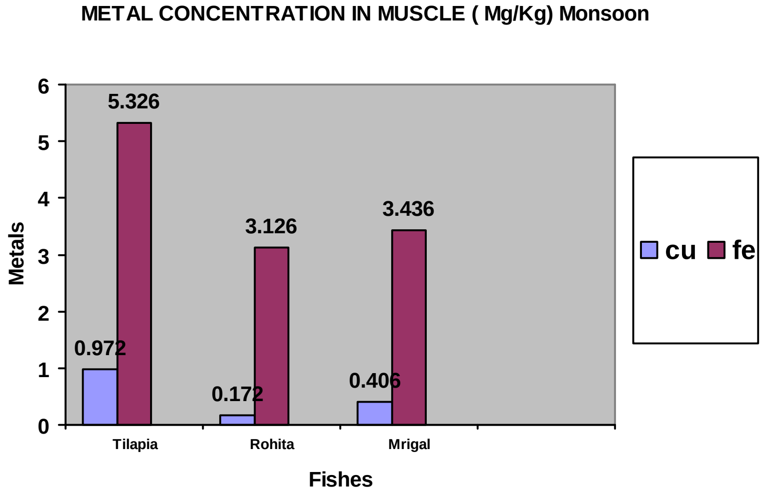

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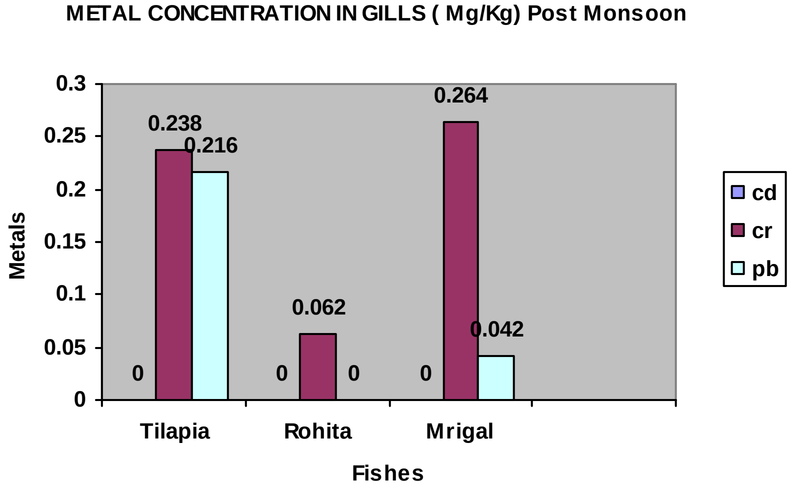

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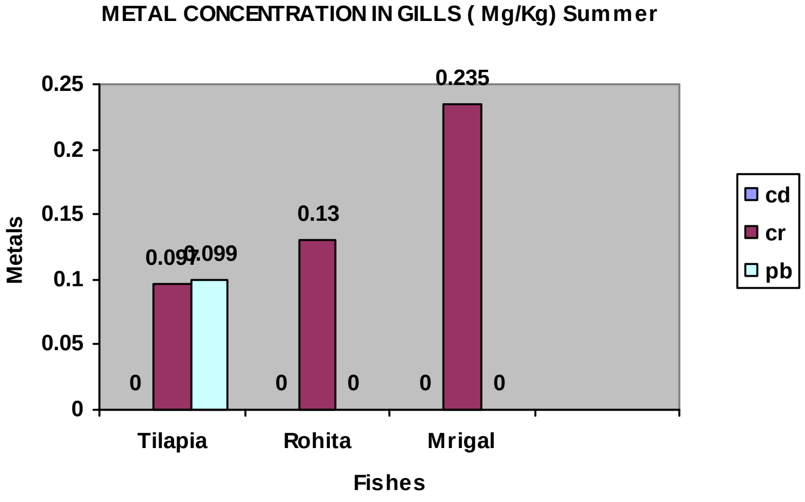
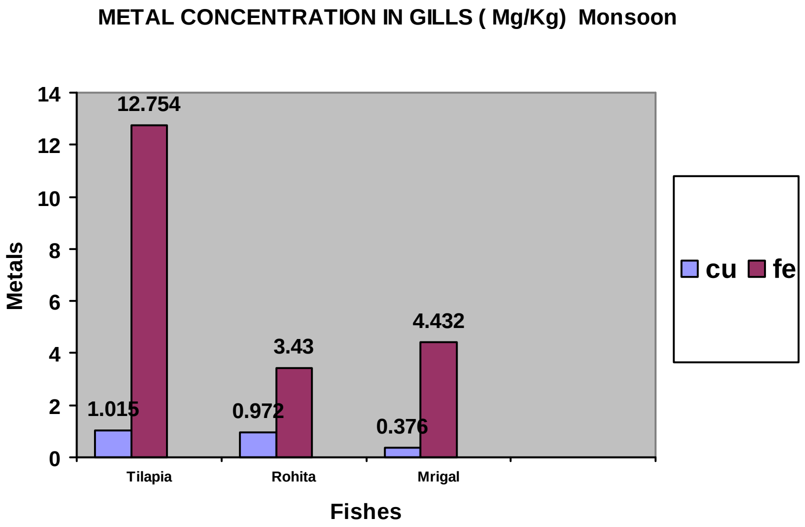
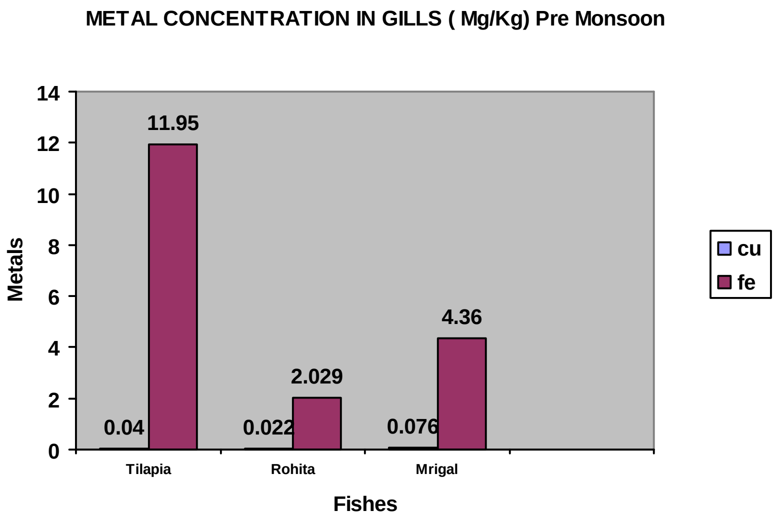


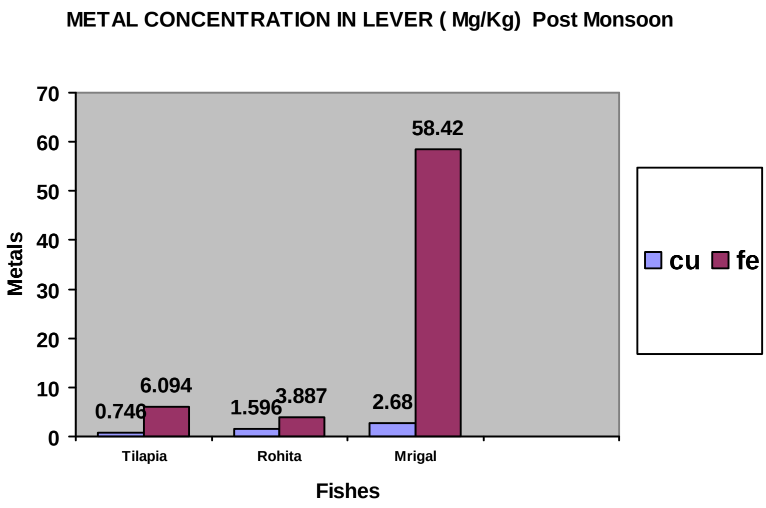
Graph 24



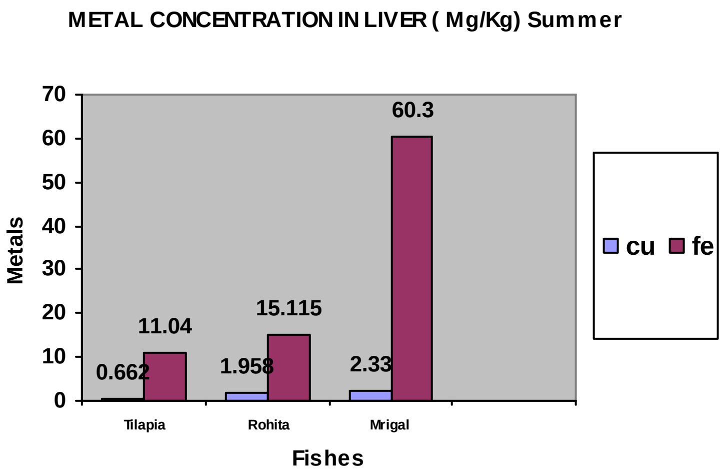
Graph 25



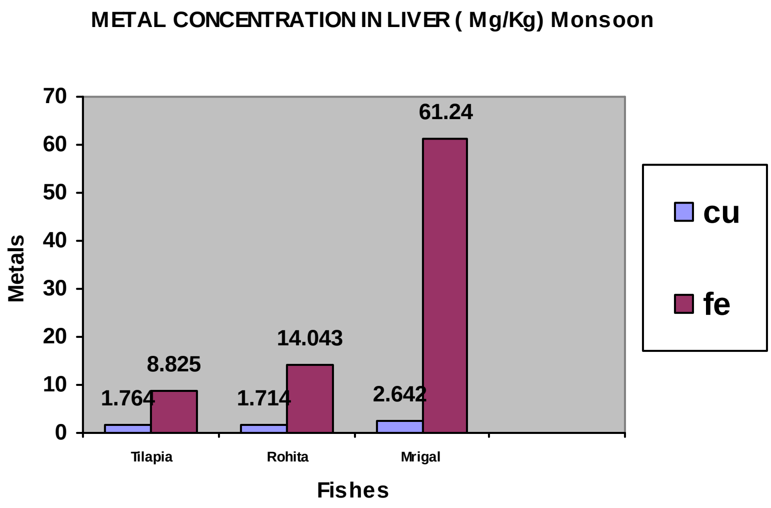
Graph 26



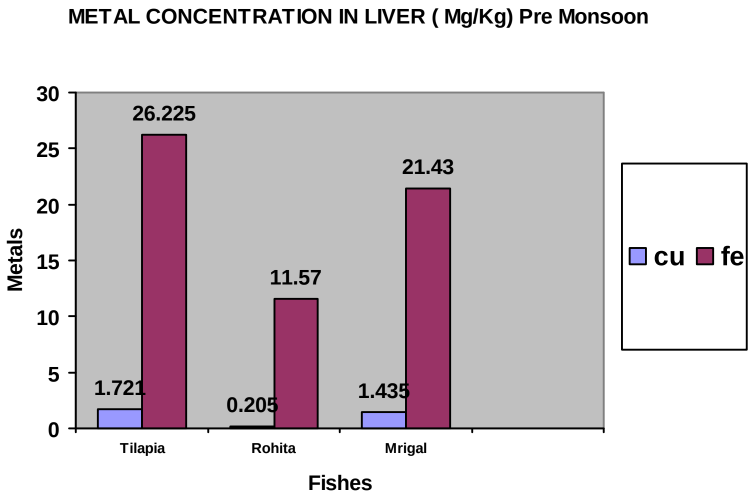
Graph 27



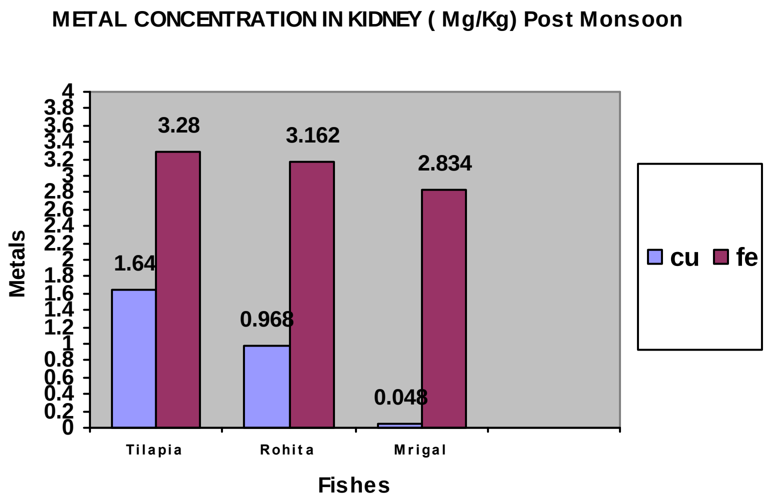
Graph 28



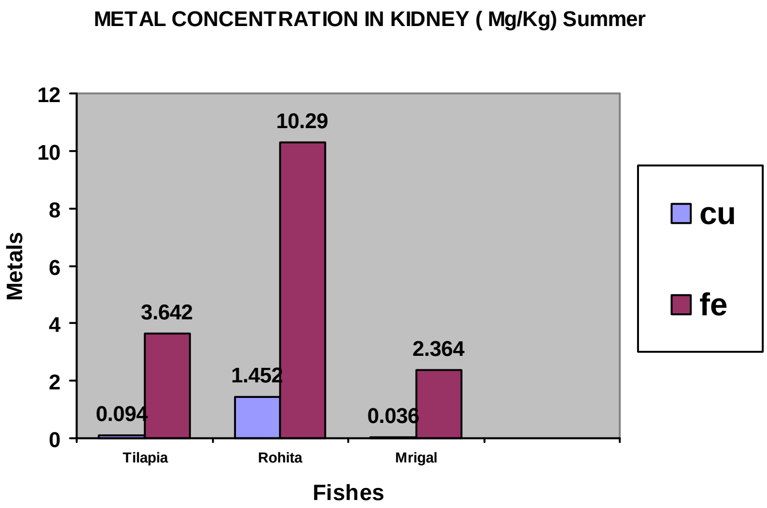
Graph 29



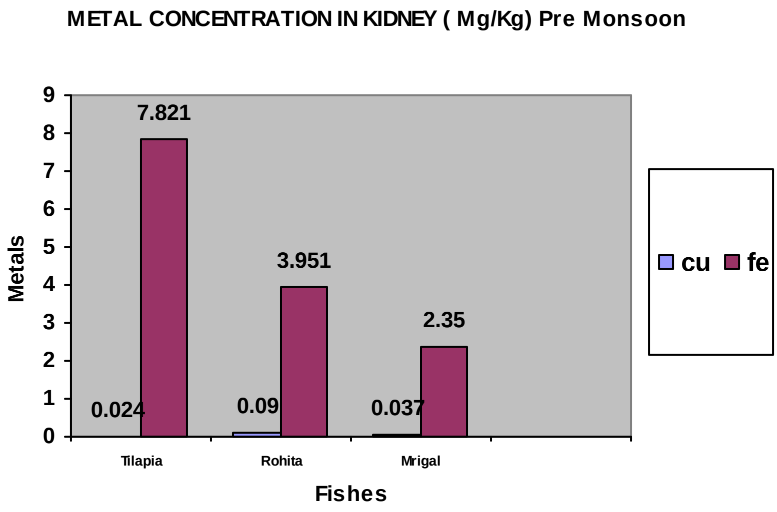
Graph 30



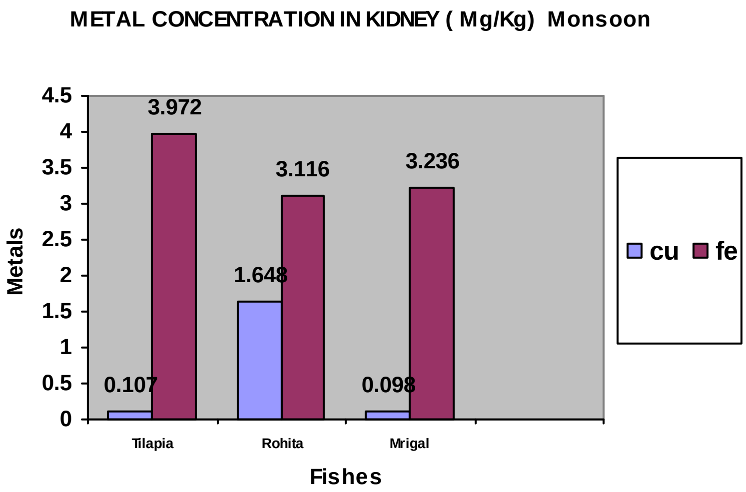
Graph 31



Graph 32



Graph 33



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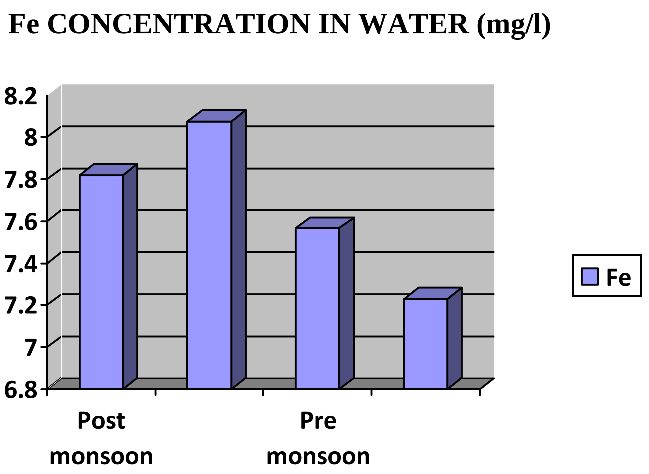

CONCLUSION

In the present investigation, some heavy metals were found to be higher than the safe recommended value, which suggests that Kolavoi Lake is partly heavy metal polluted. The water, Sediment and fishes are not safe for human health and eco system. Gradual development of industries, intensive use of pesticides and untreated domestic sewage may further exacerbate the situation in coming years.

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