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A study of physico-chemical characteristics of lakes around Jaipur, India

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Abstract: *Annual survey of Jalmahal, Amer, Nevta and Ramgarh lakes, has been conducted for one calendar year, to determine physico-chemical characteristics of water and the levels of zinc (heavy metal) and endosulfan (an organochlorine pesticide). These lakes are situated on the outskirts of Jaipur city. Changes in pollutants correlated well with the physico-chemical characteristics of water bodies. Results reveal that the levels of endosulfan and zinc are highest in Jalmahal lake (1.324 and 0.197 mg l^{-1} respectively) and lowest in Ramgarh lake (0.020 and 0.120 mg l^{-1} respectively). Anthropogenic sources and cultivation in the dried up area of these lakes seem to contribute largely to pollution.*

Key words: *Physico-chemical characteristics, Endosulfan, Zinc*
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Introduction

Contamination of water bodies is a serious problem being faced by water stressed areas, such as Rajasthan. It is well established that domestic sewage and industrial effluents falling into natural water bodies change the water quality and lead to eutrophication (Shaw *et al*.,1991). Characteristics of water bodies influence the quality of water individually and in combination with various pollutants, thereby, influencing the biota therein (Srivastava *et al*., 2003; Hoo *et al.,* 2004; Smitha *et al.,* 2007).

Non-degradable metals and organic pollutants tend to accumulate in various vital organs of fishes and lead to long term toxic effects (Gupta and Srivastava, 2006; Kumar and Riyazuddin, 2006; Tilak *et al.,* 2007; Karthikeyan *et al*., 2007; Singh *et al.,* 2008). They also induce structural and functional abnormalities in different organs of fishes (Gupta and Srivastava, 2006; Dorval *et al.,* 2003).

Zinc is an essential trace element in living organisms, being involved in nucliec acid synthesis and occuring in many enzymes, but, it can be toxic when present in excess amount (Carpene *et al.,* 1990; Agrawal and Srivastava, 2003; Gupta and Srivastava, 2006). Endosulfan is an organochlorine pesticide which is generally discharged into aquatic environment from agricultural runoff and industrial discharge. It is widely used for insect and pest control by the local people (Bakore *et al.*, 2003).

This study has significance because fish from these water bodies are consumed by people in the city; apparently healthy fishes may, infact, be carriers of pollutants which will biomagnify in man (Harit and Srivastava, 2007; Srivastava and Srivastava, 2008). This study will therefore, increase public awareness about toxicity levels of water bodies and would result in stringent government regulations. Physico-chemical parameters of water affect water quality individually and in combination with zinc and endosulfan. Variations of physico-chemical parameters also have a direct bearing on the structure and functions of various organs (Khillare and Dovane, 1998; Dhanapakian *et al*., 1998). Hence monitoring of zinc, endosulfan and evaluation of physico-chemical parameters and zinc concentration of water bodies around jaipur. Their impact on physiological functions will subsequently be studied.

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Materials and Methods

Some studies on physico- chemical characteristics of water bodies of Rajasthan have been estimated by (APHA, 2005) but an annual survey, correlating the changes in pollutants to physico-chemical variations has not been conducted. It was, therefore, decided to survey four water bodies, located on the outskirts of Jaipur city (Table 1) as fish catch from these is consumed by people of the city. Physico-chemical variations in lakes have been correlated to changes in levels of zinc and endosulfan (as common pollutants).

Water samples were collected (30 cm depth) for a period of 12 months (from February 05 to January 06), from Jalmahal lake, Amer lake, Nevta lake and Ramgarh lake. Atmospheric and water temperatures were measured in knee deep water (30 cm depth) at the site of collection; photoperiods were simultaneously recorded. For estimation of dissolved oxygen, water samples were fixed at the site in BOD bottles. Other physico-chemical parameters *i.e.,* hardness, alkalinity, pH and free CO_2 were estimated in samples brought to the laboratory. For estimating zinc concentration, water samples were preserved by adding HNO_3 and filtered through a milipore filtering unit. Filtered samples were evaporated to dryness and digested with HNO_3-$HClO_4$ mixture. The digested samples were made up to the required volume and then analyzed by GBC 902, double beam Atomic Absorption Spectrophotometer (AAS). Method prescribed by APHA, 1995 with some modifications (Bakore *et al.,* 2003) was used

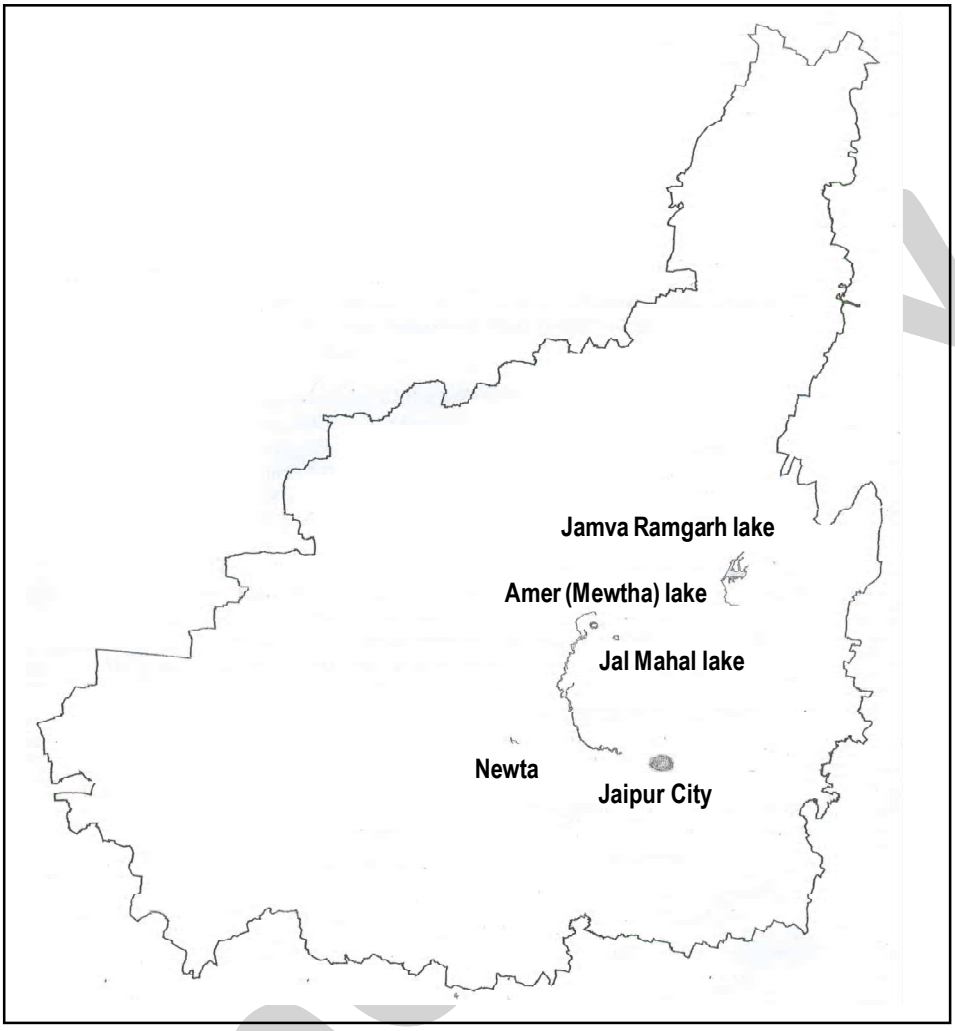

Fig. 1: Map of the study area

for the extraction for endosulfan residue from the water samples. Procedure is as follows - water samples > treated with hexane+Nacl solution>clean up of extract with anhydrous sodium sulfate>evaporated to dryness using rotatory vacuum evaporator>dried extract dissolved in hexane for GC analysis. Above mentioned parameters were chosen for study since physico-chemical parameters of water affect water quality individually and in combination with various pollutants.

Results and Discussion

Temperature and photoperiod are important factors which control the behaviour, physiology and distribution of organisms. During the present study, the atmospheric and water temperatures ranged from 24.8 to 40.7°C and 14.0 to 34.1°C respectively. Water temperature was highest at Jalmahal and lowest at Ramgarh lake for the entire period of study, similar to an earlier report (Srivastava *et al.*, 2003).

In the majority of studies conducted on water bodies, the pH value is generally reported between 6 to 9. The pH range which is not directly lethal to fish is 5 to 9; however, the toxicity of several common pollutants is markedly affected by pH changes within this range, and increasing acidity or alkalinity may make these poisons more toxic (Lloyd, 1960). In the present study, pH ranges between 7.0 to 9.2; pH range of 7 to 8 has been considered good for fish culture (Jhingran, 1997). This range has been observed in Ramgarh and Nevta lakes in the present study. Accordingly, the level observed in Jalmahal lake during the entire period of study and Amer lake for most of the months; is not suitable for fish living therein (Table 2-4).

Total alkalinity showed lowest values of 250.0 mg l^{-1} in months of August and October at Ramgarh lake and highest of 440 mg l^{-1} at Jalmahal lake in May. Alkalinity values noted in months of February to June in all four lakes are higher than the values noted in July (Table 1-4). Trivedi and Goel (1992) pointed out that dilution plays an important role in lowering alkalinity of water. Lower values of alkalinity in all four lakes may be related to rainfall during the months of July, August and September, confirming this view, it is noted to rise after Oct. Throughout the period of study, alkalinity values of Jalmahal and Amer lakes were higher than those of Ramgarh and Nevta

Table - 1: Physico-chemical properties and estimation of zinc and endosulfan in water of Jalmahal lake (2005-2006)

Months	Photoperiod		Atmospheric	Water temp.	pH	Total alkalinity	Free CO_2	Dissolved	Hardness	Zinc	Endosulfan
	Hrs.	Min.	temp. (°C)	(°C)		(mg l^{-1})	(mg l^{-1})	oxygen (mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})
Feb.	11	2	24.8-15.6	16.1	9.0	425±55.68	25.0±14.68	3.92±0.36	182.0±2.66	0.161±0.03	0.285±0.04
Mar.	11	37	28.6-19.0	24.0	8.5	428±69.44	28.0±11.08	3.70±0.01	320.0±8.79	0.168±0.03	0.307±0.01
Apr.	12	32	39.4-23.8	31.0	8.8	430±55.74	32.0±3.88	3.64±0.70	416.7±4.67	0.174±0.01	0.313±0.02
May.	13	14	39.7-26.4	32.0	8.7	440±46.20	27.0±1.47	3.51±0.48	404.7±5.21	0.177±0.02	0.325±0.01
Jun.	13	45	40.7-28.6	31.0	8.4	420±12.03	24.0±3.89	4.20±1.02	398.7±2.90	0.182±0.01	0.356±0.05
Jul.	13	35	33.4-23.8	30.0	8.6	400±23.12	24.20±10.29	5.50±1.48	350.0±7.06	0.183±0.03	0.574±0.07
Aug.	13	6	36.0-26.0	32.0	9.0	275±3.31	24.93±1.47	5.80±0.13	358.0±8.00	0.186±0.02	0.611±0.01
Sep.	12	15	40.0-24.8	34.1	9.2	350±11.06	27.86±1.46	6.21±1.13	366.0±6.11	0.187±0.04	0.642±0.01
Oct.	11	30	35.2-20.9	32.0	9.0	348±12.01	29.33±1.46	5.94±0.13	377.3±1.76	0.187±0.03	0.876±0.05
Nov.	10	45	27.3-11.6	28.4	9.2	358±23.12	21.27±1.47	5.80±0.14	379.3±2.40	0.196±0.02	1.199±0.01
Dec.	10	31	24.6-4.8	24.3	9.1	358±40.20	20.40±2.54	6.34±0.13	380.7±1.67	0.197±0.01	1.271±0.02
Jan.	10	25	21.5-3.8	19.6	9.0	380±12.67	20.33±1.46	6.61±0.14	382.0±1.16	0.197±0.03	1.324±0.05

Values are mean ± 5 samples in each month

Table - 2: Physico-chemical properties and estimation of zinc and endosulfan in water of Amer lake (2005-2006)

Months	Photoperiod		Atmospheric	Water temp.	pH	Total alkalinity	Free CO_2	Dissolved	Hardness	Zinc	Endosulfan
	Hrs.	Min.	temp. (°C)	(°C)		(mg l^{-1})	(mg l^{-1})	oxygen (mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})
Feb.	11	2	24.8-15.6	16.5	8.5	200±8.83	22.20±1.47	4.86±0.23	170.0±3.05	0.141±0.03	0.149±0.01
Mar.	11	37	28.6-19.0	23.0	7.5	205±8.80	20.20±1.47	5.00±0.13	204.0±2.31	0.147±0.01	0.151±.0.05
Apr.	12	32	39.4-23.8	30.5	7.6	208±3.33	20.53±2.93	4.99±0.14	182.7±10.48	0.143±0.02	0.165±0.07
May.	13	14	39.7-26.4	31.1	7.6	210±3.34	20.0±2.93	5.40±0.13	192.0±4.90	0.143±0.03	0.212±0.01
Jun.	13	45	40.7-28.6	31.0	7.5	206±3.34	20.0±2.54	5.81±0.14	182.7±1.76	0.147±0.02	0.276±0.02
Jul.	13	35	33.4-23.8	30.0	8.0	200±3.33	20.40±2.54	5.70±0.14	155.3±1.33	0.152±0.02	0.278±0.01
Aug.	13	6	36.0-26.0	31.0	8.3	200±0.33	20.53±1.47	5.53±0.13	163.3±3.33	0.155±0.02	0.381±0.05
Sep.	12	15	40.0-24.8	33.0	8.5	202±0.34	23.46±2.93	5.67±0.23	176.7±3.71	0.158±0.04	0.483±0.03
Oct.	11	30	35.2-20.9	32.4	8.5	202±0.33	23.46±1.46	5.54±0.27	180.0±3.05	0.158±0.03	0.514±0.01
Nov.	10	45	27.3-11.6	24.6	8.7	206±0.34	29.33±1.47	5.40±0.13	182.0±2.00	0.164±0.03	0.742±0.02
Dec.	10	31	24.6-4.8	22.0	8.6	200±3.34	19.07±1.47	6.34±0.13	156.7±1.67	0.167±0.03	1.161±0.07
Jan.	10	25	21.5-3.8	17.2	8.4	200±0.67	16.13±1.46	7.15±0.13	157.3±1.67	0.167±0.04	1.176±0.02

Values are mean ± 5 samples in each month

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Table - 3: Physico-chemical properties and estimation of zinc and endosulfan in water of Mevtal lake (2005-2006)

Months	Photoperiod		Atmospheric	Water temp.	pH	Total alkalinity	Free CO_2	Dissolved	Hardness	Zinc	Endosulfan
	Hrs.	Min.	temp. (°C)	(°C)		(mg l^{-1})	(mg l^{-1})	oxygen (mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})
Feb.	11	2	24.8-15.6	14.1	8.0	350±52.07	19.50±1.46	5.67±0.23	162.0±1.17	0.132±0.04	0.111±0.05
Mar.	11	37	28.6-19.0	22.4	7.0	355±62.57	20.0±1.47	5.50±0.16	250.0±7.69	0.136±0.03	0.115±0.02
Apr.	12	32	39.4-23.8	28.4	7.3	360±12.16	20.50±2.54	5.40±0.13	158±4.17	0.136±0.03	0.116±0.02
May.	13	14	39.7-26.4	28.4	7.3	362±23.18	20.50±1.47	5.40±0.35	148±5.78	0.139±0.02	0.117±0.01
Jun.	13	45	40.7-28.6	30.2	7.3	360±12.09	18.50±2.93	5.54±0.59	144.7±1.76	0.140±0.01	0.117±0.03
Jul.	13	35	33.4-23.8	29.3	7.0	350±8.89	18.0±2.94	6.21±0.13	139.3±1.67	0.142±0.04	0.118±0.01
Aug.	13	6	36.0-26.0	30.0	7.6	348±18.6	19.06±1.4	5.94±0.14	146.7±3.33	0.146±0.04	0.118±0.06
Sep.	12	15	40.0-24.8	31.1	8.0	330±12.16	23.46±1.46	6.61±0.14	155.3±1.66	0.146±0.02	0.120±0.05
Oct.	11	30	35.2-20.9	30.2	8.1	345±18.6	24.93±1.46	6.21±0.13	156.7±1.33	0.148±0.03	0.130±0.01
Nov.	10	45	27.3-11.6	22.6	8.2	350±13.34	27.86±1.47	6.08±0.13	156.0±1.15	0.148±0.04	0.155±0.02
Dec.	10	31	24.6-4.8	18.7	8.1	345±12.16	20.53±1.47	6.61±1.13	156.7±1.67	0.152±0.04	0.186±0.08
Jan.	10	25	21.5-3.8	15.2	8.0	320±12.09	14.67±2.54	7.29±0.23	158.7±1.67	0.156±0.02	0.198±0.01

Values are mean ± 5 samples in each month

Table - 4: Physico-chemical properties and estimation of zinc and endosulfan in water of Ramgarh lake (2005-2006)

Months	Photoperiod		Atmospheric	Water temp.	pH	Total alkalinity	Free CO_2	Dissolved	Hardness	Zinc	Endosulfan
	Hrs.	Min.	temp. (°C)	(°C)		(mg l^{-1})	(mg l^{-1})	oxygen (mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})
Feb.	11	2	24.8-15.6	14.0	7.5	320±3.37	Nil	6.62±0.27	156.7±1.67	0.120±0.02	0.020±0.01
Mar.	11	37	28.6-19.0	22.0	7.0	315±8.95	Nil	6.76±0.13	156.7±2.91	0.123±0.01	0.028±0.05
Apr.	12	32	39.4-23.8	28.4	7.1	300±8.88	Nil	7.02±0.13	131.3±11.10	0.123±0.04	0.029±0.03
May.	13	14	39.7-26.4	28.2	7.1	298±5.78	Nil	7.29±0.23	110.7±6.96	0.127±0.03	0.036±0.08
Jun.	13	45	40.7-28.6	30.0	7.0	290±6.57	Nil	7.57±0.36	96.7±3.53	0.127±0.04	0.037±0.06
Jul.	13	35	33.4-23.8	29.0	7.0	275±5.89	Nil	7.97±0.27	91.3±2.91	0.133±0.02	0.038±0.01
Aug.	13	6	36.0-26.0	30.0	7.5	250±3.33	Nil	8.10±0.23	94.0±2.0	0.133±0.01	0.045±0.05
Sep.	12	15	40.0-24.8	30.1	7.5	254±3.37	Nil	8.51±0.47	96.7±1.66	0.136±0.03	0.046±0.07
Oct.	11	30	35.2-20.9	30.0	7.2	250±3.36	Nil	8.10±0.23	95.3±1.66	0.138±0.01	0.047±0.01
Nov.	10	45	27.3-11.6	22.0	7.2	275±4.08	Nil	8.23±0.13	96.7±1.67	0.138±0.02	0.048±0.02
Dec.	10	31	24.6-4.8	18.0	7.1	275±6.57	Nil	8.64±0.13	95.3±1.67	0.139±0.01	0.049±0.01
Jan.	10	25	21.5-3.8	14.6	7.1	270±3.33	Nil	8.64±0.01	94.7±1.34	0.142±0.02	0.050±0.07

Values are mean ± 5 samples in each month

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lakes. In an earlier study, also higher total alkalinity has been reported in Jalmahal and Amer lakes (Srivastava *et al.*, 2003)

In the present investigation, value of CO_2 varied from 14.67 to 32.0 mg l^{-1} (Table 1-4). CO_2 in Ramgarh lake was found to be almost nil and in other lakes it showed slight variations throughout the year. Mathew (1978), observed an inverse relationship between CO_2 and DO in Govind Sagar lake. A similar relationship is observed in the present study where DO is highest at Ramgarh lake while CO_2 is nil during the entire period of study. This inverse pattern is also observed in Jalmahal and Amer lakes, whereas in Nevta lake the inverse relationship of CO_2 and DO is clearly observed only during winters.

Dissolved oxygen values range from 8.64 mg l^{-1} (Tables 1-4,) to 3.51 mg l^{-1}. The values tend to show a very gradual decline from winters to summers in all the four lakes studied substantiating the generally accepted view that dissolved oxygen is inversely proportional to temperature. Jain *et al. (*1996) have also observed a sharp decline in dissolved oxygen values from winters to summers in Halali reservoir at Vidisha. Dissolved oxygen is essential and in some cases even limiting factor for maintaining aquatic life; its depletion in water is probably the most frequent result of certain forms of water pollution.

In the present survey, hardness ranges from 91.33 mg l^{-1} to 416.7 mg l^{-1}. Observations reveal that the values of hardness are in decreasing order from Jalmahal > Amer > Nevta > Ramgarh. The same pattern has been reported in an earlier study (Srivastava *et al*., 2003). High levels of hardness increase toxicity of zinc to fish (Lloyd, 1960). The level of zinc is recorded to be highest at Jalmahal in the present study. Zinc coupled with hardness and high pH in this lake definitely makes the environment toxic for fish.

The safe levels of discharge of zinc, on inland surface water as given by ISI (1982) is 5 mg l^{-1}. Results of the present investigation reveal that the values of zinc concentration in Jalmahal, Amer, Nevta and Ramgarh lakes are within safe levels. According to Landner, (1976) infinitely low levels of heavy metals are regarded as potential pollutants in aquatic eco-systems because of their absorption in bottom sediments even at low concentrations, environmental persistence, toxicity at low concentrations and their ability to be incorporated into food chain and concentrate in aquatic organisms. Thus, the levels of zinc (less than 0.197 mg l^{-1}) observed in this study can also be considered as potential toxicants.

Present annual survey shows that the value of endosulfan is highest in Jalmahal lake and lowest in Ramgarh lake (Tables 1 and 4). All the lakes show a high level of endosulfan in the months of October, November, December and January as compared to summer months. According to Nash,1983 organochlorine pesticides are volatilized despite their low vapour pressures. Higher temperature enhances volatile losses by a direct effect on vapour pressure, which shows positive relationship with temperature (Spencer and Cliath, 1970). Influence of heat and wind, which are characteristics of summer season, are very low during winter season, therefore, dissipation does not takes place. This together with lower temperature reduces volatilization during winter season (Samuel *et al.*, 1988). (Bakore *et al.*, 2003) have also recorded higher organochlorine pesticide residues in rainy and winter seasons from drinking water samples of Ramgarh lake, Jaipur. Shukla *et al.* (2006) detected endosulfan in the range of 0.12 to 2.14 ppm in domestic well supplies of Hyderabad city and concluded that these concentrations are above the acceptable daily intake (ADI) values *i.e.* 0.008 mg kg^{-1} body wt. for humans (FAO, WHO, 1993). Ramgarh lake water is used for the domestic supplies in Jaipur city. The endosulfan concentration in Ramgarh lake varies from 0.02 to 0.050 ppm which is within ADI values, whereas the levels recorded in all the other lakes are not within ADI values (Table 1-3). The level of endosulfan is highest in Jalmahal lake because waste waters from certain areas of Jaipur city drain into the Jalmahal lake, making it a highly polluted lake, not siutable for human use. Water from this lake is being used for cultivating vegetables, when peripheral areas of the lake dry up during summers. This practice needs to be stopped immediately considering the harmful effects it may have on the city's population.

From the present annual survey, it emerges that Jalmahal lake is most polluted having high alkalinity, free CO_2, hardness and pH but a low level of DO endosulfan and zinc contents in Jalmahal lake are also high, thus making it unsuitable for biota and fish and Contrarily, Ramgarh lake shows high DO, low alkalinity, free CO_2, hardness pH, endosulfan and zinc concentrations are relatively low throughout the year. Thus, water of Ramgarh lake is least polluted and most suitable for survival of fishes amongst all the lakes studied.

Data from the Fisheries' Department, Government of Rajasthan, substantiate these observations, since the variety observed in fish fauna and percentage catch of *Catla catla* of Jalmahal lake is low in comparison to Ramgarh lake. Pollution is taking its toll. Some species (*Cyrinus mrigila, Clarius batrachus, etc.*) netted three years back in Ramgarh lake are now practically missing from the catch (F.D., Govt. of Rajasthan) It is time for public awareness and stringent government regulations.

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References

Agrawal, M. and N. Srivastava: Effect of chronic zinc exposure on the thyroid gland activity of a fresh water fish *Channa punctatus* (Bloch). *J. Ecophysio. Occup. Hlth.*, **3**, 273-278 (2003).

APHA: Standard methods for examination of water and waste, 19th Edn. Washington, DC (1995).

Bakore, N., P.J. John and P. Bhatnagar: Organochlorine pesticide residues in wheat and drinking water samples from Jaipur, Rajasthan, India. *Environ. Monit. Asset.,* **98**, 381-389 (2003).

Carpene, E., O. Cattani, G.P. Serrazanetti, G. Fedrizzi and P. Cortesi: Zinc and copper in fish from natural waters and rearing ponds in Northern Italy. *J. Fish. Biol.,* **37**, 293-299 (1990).

Dhanapakiam, P., V.K. Ramasamy and Sampoorani: A study on the hestopathological changes in gills of *Channa punctatus* in Vauvery river water. *J. Environ. Biol*., **19**, 265-269 (1998).

Dorval, J., V.S. Leblond and A. Hentela: Oxidative stress and loss of cortisol secretion in adrenocortical cells of rainbow trout (*Oncorhynchus mykiss*) exposed *in vitro* to endosulfan, an organochlorine pesticide. *Aquat. Toxicol.,* **63**, 229-241 (2003).

FAO and WHO: Endosulfan. *In*: 1982 evaluations of some pesticide residue in food, Rome, Food and Agriculture Organization of the United Nation (1983).

Gupta, P. and N. Srivastava: Effects of sub- lethal concentrations of zinc on histological changes and bioaccumulation of zinc by kidney of fish *Channa punctatus* (Bloch). *J. Environ. Biol.,* **27**, 211-215 (2006).

Harit, G. and N. Srivastava: Endosulfan untake and biochemical profile of the musle in a fresh water murrel. *Channa punctatus*. *Bull. Pure Appl. Sci.,* **26**, 23-27 (2007).

Hoo, L.S., A. Samat and M.R. Othman: The level of selected Heavy metals (Cd, Cu, Fe, Pb, Mn and Zn) at Residential Area nearby Labu river system Riverbank, Malaysia. *Res. J. Chem. Environ.,* **8**, 24-29 (2004).

ISI: Draft Indian Standard Specification for Drinking Water. DOC : CDC 26 : 8626, New Delhi (1982).

Jain, S.M., M. Sharma and R. Thakur: Seasonal variations in physico-chemical parameters of Halali reservoir of Vidisha district, India. *J. Ecobiol.,* **8**, 181-188(1996).

Jhingran, A.G.: Optical appearance and interpretation of annuli on scales of *Gadusia chapra* (Ham.). *J. Inland. Fish Soc. India,* **91**, 138-153 (1997).

Karthikeyan, S., P.L.R.M. Palaniappan and Selvi Sabhanayakam: Influence of pH and water hardness upon nickel accumulation in edible fish *Cirrhinus mrigala*. *J. Environ. Biol.,* **28**, 489-492 (2007).

Khillare, V.K. and P.M. Davane: Chronic effect of water variables on development of gill and supporting cells in early life stage of fish, Puntius stigma. *J. Environ. Biol*., **19**, 125-129 (1998).

Kumar, A.R. and P. Riyazuddin: Chemical Speciation of Trace metals in aquatic environment - An overview. *Res. Chem. Environ.,* **10**, 93-103 (2006).

Landner, L.: Fourth FAO/SIDA Training Course on Aquatic Pollution in Relation to Protection of Living Resources, Bioassay and Toxicity Testing, Held at Lysekil, Sweden (1976).

Lloyd, R.: The toxicity of Zinc sulfate to rainbow trout. *Ann. Appl. Biol.,* **48**, 84-94 (1960).

Mathew, P.M.: Limnological investigations on the plankton of Govind Garh lake and its correlation with physico-chemical factors. Proc. Semi. Econ. *Fish Freshwater Reserv.*, 37-46 (1978).

Nash, R.G.: Comparative volatilization and dissipation rates of several pesticides from soil. *J. Agric. Food Chem.* **31**, 210-217 (1983).

Samuel, T., H.C. Agarwal and M.K.K. Pillai: Persistence and binding of DDT and gamma HCH in a sandy loam soil under field conditions in Delhi, India. *Pestic Sci.,* **22**, 15 (1988).

Shaw, B.P., A. Sahu and A.K. Panigrahi: Water quality of the Rushikulya river estuary in relation to waste water discharge from a chlor-aikali plant. *Pollut. Res*., **10**, 139-149 (1991).

Shukla, G., A. Kumar, M. Bhanti, P.E. Joseph and A. Taneja: Organochlorine pesticide contamination of ground water in the city of Hydrabad. *Environ. Int.,* **32**, 244-247 (2006).

Singh, Dharam, Kamlesh Nath, S.P. Trivedi and Y.K. Sharma: Impact of copper on haematological profile of freshwater fish, *Channa punctatus*. *J. Environ. Biol.,* **29**, 253-257 (2008).

Smitha, P.G., K. Byrappa and S.N. Ramaswamy: Physico-chemical characteristics of water samples of Bantwal Taluk, south-western Karnataka, India. *J. Environ. Biol.,* **28**, 591-595 (2007).

Spencer, W.F. and M.M. Cliath: Vapour density of pesticides (Tech. Grade) for agriculture. Pesticide Information XXVIII (2), 52-54 (1970).

Srivastava, N., M. Agarwal and A. Tyagi: Study of physico-chemical characteristics of water bodies around Jaipur. *J. Environ. Biol.,* **24**, 177-180 (2003).

Srivastava, Rama and Neera Srivastava: Changes in nutritive value of fish, *Channa punctatus* after chronic exposure to zinc. *J. Environ. Biol.,* **29**, 299-302 (2008).

Tilak, K.S., K. Veeraiah and J. Milton Prema Raju: Effects of ammonia, nitrite and nitrate on hemoglobin content and oxygen consumption of freshwater fish, *Cyprinus carpio* (Linnaeus). *J. Environ. Biol.,* **28**, 45-47 (2007).

Trivedi, R.K. and P.K. Goel: Chemical and Biological Methods for Water Pollution Studies. Environ. Publ., Karad (1992).

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