Environment Conservation Journal 19 (1&2) 51-58, 2018
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

Water quality changes and winter mortality of major carps (*Cyprinus carpio communis* and *Cyprinus carpio specularis*) in Mansar Lake (a Ramsar Site), Jammu, J&K, India

Sheikh Assadullah and Slathia Deepika ✉

Received: 05.05.2017 **Revised: 12.06.2017** **Accepted: 02.07.2017**

Abstract

Lake Mansar, a subtropical and warm monomictic Ramsar wetland, is an important flyway for various winter migratory birds. During the present study, winter mortality of exotic carps weighing about 50gm to 2kg was observed in the lake during late December 2015 to early February 2016. Mortality was observed more in January as hundreds of small and few large dead fishes weighing >1.5kg were seen on different sites of the lakes during our visits to the lake. Among these, mortality percentage of *Cyprinus carpio communis* and *Cyprinus carpio specularis* was about 90% and 10%, respectively. Water quality analysis revealed low dissolved oxygen and high free $CO_2$and BOD content in the lake water. Several field visits carried out over a period of several weeks, prior to, during, and after mortality, have led us to the conclusion that stress resulted from depletion of dissolved oxygen and increased free CO_2 and was the main cause of sudden fish mortality. Although some fish kill in subtropical lakes during winters is a natural phenomenon but mass fish kills indicate some type of environmental stress and are ecologically unacceptable. As Mansar is a famous tourist destination in J&K, such mass fish kills pose serious threat to the economy of the State and affect the health of the inhabitants who rely on the lake for meeting their water requirements. Comparison of water quality data of winter months(December to February)of three years viz. year before (2014-15), during (2015-16) and after (2016-17) mass fish kill has shown lowest DO and highest free CO_2record during the year of fish kill (2015-16) which further supports the present findings. The study proposes installation of aerators at different locations to aerate the lake water in order to prevent winter kills in future.

Key words:* *Exotic species, lake overturn, Mansar lake, Ramsar site, water quality, winter kill

Introduction

Mass sporadic die offs of fish from various water bodies world over have been assigned varied reasons by numerous workers (excessive water pollution due to release of harmful chemicals and effluents, food shortages, parasitic infestations, toxic algal blooms, environmental stresses, suffocation and injury due to over stocking, diseases, predation pressures, etc.). Ganapati and Alikunhi (1950) ascribed mass fish kill in river Cauvery to the discharge of effluents from Mettur chemical and industrial Corporation Ltd, Mettur Dam, Madras. Arora *et al.,* (1970) attributed heavy fish mortality in Rihand reservoir to high chlorine content (62 ppm) discharged from Kanoria Chemical Industries. Beamish and Harvey (1972) ascribed mass fish mortalities in La Cloche mountain lakes, Ontario to acidification caused by industrial emissions.Winter hypoxia as a factor responsible for mass fish mortality in Gandhi sagar reservoir, Nagpur was reported by Krishnamoorthy and Visweswara (1963) and two-basin Lake in southern Finland during winter (2002–2003) by Ruuhijarvi *et al.,* (2010). Fish kill in Hussain sagar lake was attributed deoxygentaion of water due to discharge of sewage and industrial effluents and choking of gills through fine deposition of pollutants from the effluents affecting the respiratory activity of the fish and hence fish kill by Rao *et al.*, (1989-1990). Dutta *et al.,*(1997) attributed mass mortality of fishes belonging to Cypriniformes, Siluriformes and Ophio cephaliformes in Behlolnullah, Jammu to sudden discharge of large amount of turbid industrial effluents causing imbalance in abiotic characteristics of Behlolnullah. Wanganeo *et al.*,

Author's Address
Department of Environmental Sciences, University of Jammu, Jammu, J&K, India
Email.: *dsenviron2012@gmail.com*

(1994) attributed toxic effects of decomposing *Microcystis* blooms and mixing of bottom and surface water causing oxygen declineto fish mortality in lower lake of Bhopal. Heil *et al.,* (2001) reported the fish kill in Kuwait Bay, Arabian Sea to *Gymnodinium* sp. bloom.Cumulative factors have also been assigned to fish mortality episodes by several workers. Maryland department of Environment (2016) identified a karlotoxin strain as the probable cause of the fish kill in the upper Gunpowder and Bird rivers near Joppatowne (Harford/Baltimore Counties) which killed an estimated 20,553 fishes comprising of about ten species. Mass winter mortality of local trash fish in Lake Mansar, the present area of study, was first reported in February 1997. After this, the lake was stocked with various carp species. Being a religious spot and restriction on fishing in lake, there was tremendous proliferation of carps over a period of time thereby reducing the indigenous fish population of the lake. Although some fish mortality during winter months is usually noticed in this lake but there is no record of any mass fish mortality after 1997. However, during the limnological survey of this lake during the period (2014-2017), high fish mortality was recorded during late December 2015 to early February 2016 and has been described. Comparatively very low fish mortality was noticed during the years (2014-2015) and (2016-2017).

Study Area

Lake Mansar (32^0 48'N and 75^0 23'E)- a designated Ramsar site along with another lake Surinsar, is located in Shivalik belt about 55km east of Jammu City. Situated at an elevation of 664m amsl, Mansar is semi-oval in shape (Fig. 1) with an area of 0.59 km^2, circumference of 3.4 km and depth of 38.25m (Kumar *et al.,* 2006). This warm monomictic, non-drainage type lake is usually rain fed and also receives freshwater from subterranean springs and surface runoff from the catchment. The drinking water is supplied to the adjoining villages through this lake. Lake water is also used for irrigating the fields located in the vicinity.

Material and Methods

Water samples for physicochemical analysis were collected from lake in pre-cleaned, poly-propylene plastic bottles of 1L capacity on monthly basis during the years (2014-2017) with fortnightly sampling during early December to late February (2016). Air and water temperature was recorded on spot by mercury bulb (^0C) thermometer and transparency by Secchi disc while rest of the parameters were determined in the laboratory within 24 hours. For dissolved oxygen, samples were fixed in well stoppered DO bottles of 300 ml capacity and initial fixation was done in the field.

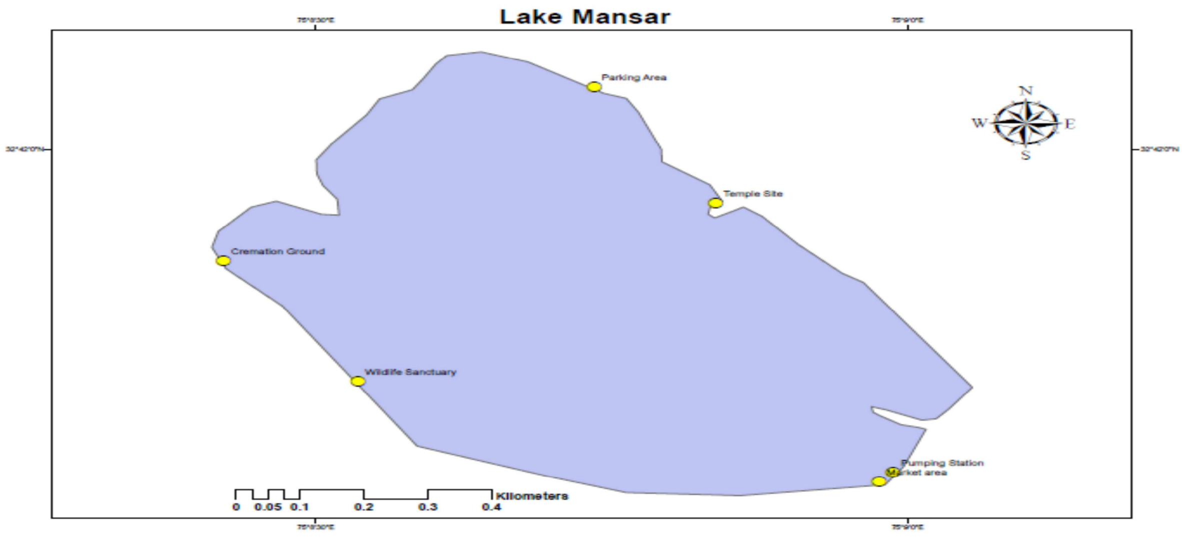

Fig. 1 Map showing Lake Mansar with various points indicating areas of fish kill

Analysis of all water quality parameters was carried out in laboratory following Standard Methods (APHA, 2005). Some dead fish specimen were collected and brought to laboratory for detailed study.

Results and discussion

During the fortnightly visits of Lake Mansar from early December(visit prior to fish mortality), late December to early February(visits during fish mortality) and late February(visit after fish mortality), hundreds of dead fishes were seen floating at various sites of lake Mansar. On careful examination, it was observed that dead specimen were mostly of *Cyprinus carpio communis* and *Cyprinus carpio specularis* both belonging to order Cypriniformes. In the dead specimens, *Cyprinus carpio communis* shared high percentage (90%) than *Cyprinus carpio specularis* (10%). Dead specimen were not restricted to a particular place around the lake but were seen scattered all over the lake in the area along the wildlife sanctuary, cremation ground, near the pumping station, temple site, market side and parking area(Fig.1;2a-d;3a-d). The dead specimen of *Cyprinus carpio communis* and *Cyprinus carpio specularis* varied from 5cm to 15 cm in size andbetween 110g- 2kg and 120-700g in weight, respectively. Visual observations showed that apparently there was nothing wrong with these dead fishes which was further affirmed by microscopic examination of skin and gills of dead fish specimens revealing absence of any ecto-parasite. However, some decomposed specimens were covered with fungus. Fishes during morning hours were seen gulping air at the surface of water especially near the edges, depicting the sign of oxygen stress as reported by Helfrich (2009) (Fig. 4a-d). Results of various water quality parameters investigated prior to fish mortality (early December), during fish mortality (late December to early February) and after fish mortality (late February) have been tabulated in table 1. Water quality analysis revealed sudden fall in water temperature during fish mortality (from late December to early February) which corresponded to the subsequent fall in air temperature. pH and free CO_2showed inverse relationship with each other. High pH (7.4) was observed prior to fish mortality with lowest free CO_2 record (6.60mg/l) and low pH(6.42) was noticed during fish mortality(late January) with highest free CO_2 record(24.20mg/l).DO showed inverse relationship with free CO_2 and observed sudden decline during fish mortality (from late December to early January).The increase in free CO_2concentration and decline in DO in lake water may be due to lake upwelling resulting in mixing of bottom anoxic water with the upper oxygenated layers. Similar increase in free $CO_2$and decrease in DO with lake overturn has been reported by Malhotra *et al.*, (1979); Pandita (2005) and Dutta *et al.,* (2014). Beamish and Harvey (1972) advocated acidification of lakes as a factor responsible for fish mortality from La Cloche mountain lakes, Ontario.The range of DO during fish mortality period (1.22-2.82mg/l) was well below the optimum concentration required for the survival of fish particularly carps(5ppm) (Moore,1942). Less photosynthetic activity due to shorter photoperiod and low temperature during winter reduces the overall production of oxygen in lake (Vasisht and Sekhar, 1979). Fishes overcome this stress by lowering their metabolic rates and oxygen requirements but very less photosynthetic activity and high oxygen demand can further exacerbate oxygen stress which causes fish kill (Holeton, 1980; Hurst, 2007).Diaz and Breitburg (2009) and Small *et al.,* (2014) stated that hypoxia (DO range less than 2-3mg/l in marine water and 5-6mg/l in fresh water) can result in sudden fish kill and is quite evident in the present study also. According to Bickler and Buck (2007), fishes, under severe hypoxia, need to cope with ion disturbance associated with inadequate energy supply and the acidosis associated with anaerobic metabolism. The disturbance of cellular function in fish leads to cellular necrosis eventually leading to death (Richards 2009). Kangur *et al.,* (2016) observed massive fish kill following sudden dip in oxygen (0.49 to 2.8mg/l) from shallow lake of Estonia. An inverse relationship between DO and BOD was also noticed in the present study. The maximum and minimum BOD was recorded during late January (6.0mg/l) and early December (1.8mg/l). Electrical conductivity, TSS and TDS showed a direct relationship and observed sudden increase during the mortality period. However, transparency observed inverse relation with TSS and decreased during the period of fish mortality. Concentration of anions and cations also noticed increase during the mortality period. It was noticed that the fish kill was spontaneous in the area as live fish specimens were also seen swimming among the dead specimens at the time of the observation. Comparison of three years water quality data during the winters (December-February) of year before (2014-15), during (2015-16) and after (2016-17) fish kill has shown lowest record of DO and highest record of free CO_2 during the year of fish kill (Table 2) which further confirms our results. The present findings are also in consonance with the earlier studies of Pandita (2005) and Dutta *et al.,* (2014) who ascribed mass mortality of fishes in lake Surinsar, Jammu to winter lake overturn resulting in sharp decline in oxygen (0.5 mg/l and 3.10 mg/l) causing death of fishes due to suffocation. Strong correlation between fish mortality and dissolved oxygen depletion has been advocated by various workers from India and abroad (Powers, 1938; Ganapati and Alikunhi, 1950; Banerjea *et al*., 1956; Khan and Hussain,1976; Hingorani *et al.,*1977; Bhagat *et al.*, 1979; Holeton, 1980; Sanzi, 1981; Ruparelia *et al.*, 1986; Orietta, 2016).

Fig.2a-d Dead specimen of *Cyprinus carpio communis* and *Cyprinus carpio specularis* scattered all over the lake.

Fig.3a-d Dead specimen along a. cremation ground b. wildlife sanctuary area c. temple site aread. market area

Table-1.Water quality of lake Mansar prior to, during and after fish kill during year (2015-16)

	Units	Prior to fish Mortality	During Fish mortality				After mortality
Parameters		**Early December**	**Late December**	**Early January**	**Late January**	**Early February**	**Late February**
Air Temp	^0C	20.0	14.4	13.10	13.0	13.50	15.80
Water Temp	^0C	17.0	11.70	11.50	10.0	11.75	13.64
EC	mS/cm	0.157	0.287	0.319	0.222	0.231	0.237
TSS	ppm	0.193	0.225	0.281	0.315	0.424	0.372
TDS	ppm	76.45	142.75	154.75	159.5	116.4	118.87
Salinity	ppt	0.10	0.20	0.20	0.30	0.20	0.17
Transp.	cm	160.02	157.42	154.94	147.32	126.68	138.80
pH		7.49	7.05	6.96	6.42	6.80	7.07
Free CO_2	mg/l	6.60	13.20	19.80	24.20	17.60	11.0
DO	mg/l	4.10	3.01	1.60	1.22	2.82	4.15
BOD	mg/l	1.80	3.20	3.80	6.0	5.80	2.24
Bicarbonate	mg/l	95.37	81.9	100.27	102.9	66.15	86.62
Chloride	mg/l	8.56	10.25	13.5	14	15.20	15.37
Calcium	mg/l	59.3	71	85.31	88.28	80.57	79.8
Magnesium	mg/l	15.7	11	7.43	18.12	21.92	23.95
Total Hardness	mg/l	75	82	92.75	100	102.5	103.75

Table-2. Comparison of water quality of Lake Mansar during the winter months (December-February) ofthree year study period (2014-15, 2015-16and 2016-17)

Parameters	Dec (2014)	Jan (2015)	Feb (2015)	Dec (2015)	Jan (2016)	Feb (2016)	Dec (2016)	Jan (2017)	Feb (2017)
Air Temp(^0C)	13	13.5	13.87	17.2	13.05	14.65	14.17	13.75	17
Water Temp (^0C)	11.75	11.25	15.37	14.35	10.75	12.70	11.75	13	13.75
EC(mS/cm)	0.269	0.220	0.237	0.222	0.303	0.274	0.259	0.261	0.259
TSS	-	-	-	0.209	0.298	0.398	-	-	-
TDS(ppm)	150.1	116.37	118.87	109.6	157.13	117.64	131.43	129.3	130.9
Salinity (ppt)	0.35	0.3	0.3	0.15	0.25	0.19	0.27	0.25	0.24
Transp.(cm)	191.12	182.86	188.87	158.72	151.13	132.74	173.72	181.64	183.45
pH	7.22	7.14	7.74	7.27	6.69	6.94	7.45	7.37	7.25
Free CO_2 (mg/l)	8.52	12.1	8.8	9.9	22	14.3	8.10	11.15	10.2
DO(mg/l)	3.65	3.75	4.55	4.43	1.41	3.49	3.85	3.6	4.1
BOD (mg/l)	3.6	3.35	3.05	2.5	4.9	4.02	3.40	4.3	3.7
HCO_3^-(mg/l)	94.4	47.25	86.62	88.64	101.59	76.39	76.36	71.2	72.6
Cl^-(mg/l)	10.25	11.27	11.37	9.41	13.75	15.29	11.83	11.5	12.5
Ca^{2+}(mg/l)	72.09	78.48	75.96	65.15	86.80	80.19	78.75	73.89	77.66
Mg^{2+}(mg/l)	12.69	13.23	13.12	13.35	12.78	22.94	6.80	8.805	7.9
TH(mg/l)	232	250.17	243.45	78.5	96.38	103.13	264.37	272.25	272.05

- **Data not available**

Fig. 4a-d: Fishes gulping air at the surface of water in morning hours

Conclusion

The present study indicated that the winter mass fish kill in 2016 in Lake Mansar was likely caused by a combination of successive and co-occurring extreme phenomena resulting in low water temperature, low pH, low DO, high free CO_2 and low transparency. Sudden fish kills are the first visible sign of environmental stress. Carps, among fishes, though have tolerance for environmental variations but mass deaths are often associated with sudden environmental changes that may affect other animals and plants and may have a direct impact on other users of the water.The sudden fall in water temperature during December resulted in breaking of stratification and mixing of anoxic water from hypolimnion with the oxygen rich water of epilimnion. The dead specimen were collected by State Wildlife Department and locals and buried along the banks of lake but such incidences pose danger of epidemic in the area as the water from lake is used for drinking and other domestic purposes by the inhabitants. Therefore, the study proposes installation of more aerators at different locations of the lake which are considered to be very effective in maintaining oxygen exchange from the atmosphere to water in order to prevent future winter fish kill in the lake.

Acknowledgements

Authors gratefully acknowledge the necessary laboratory facilities provided by Head, Departmentof Environmental Sciences, University of Jammu,Jammu for carrying out the present work. The authors would like to thank Prof. S.P.S. Dutta, Prof. Emeritus for his support during the study. Financial assistance provided by UGC under UGC-SAP programme is highly acknowledged. The authors further declare that they have no conflict ofinterest.

References

APHA. 2005 *Standard Methods for the Examination of water & Wastewater* APHA, 21st Edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.

Arora, H. C., Chattopadhyay, S. N. and Sharma, U. P. 1970 A probable occurrence of fish mortality in Renusagar Renukoot due to chlorine bearing wastes. ***Environ. Hlth***. 12: 260-272.

Banerjea, S. Motwani, M. P. and Karamchandani, S. J. 1956. A case of heavy fish mortality in the River Son a Dehri on sone, Bihar caused by the wastes of the Rohtas Industries Ltd., Dalmianagar. ***Indian J. Fish***, 3: 186-196.

Beamish, R. J. and Harvey, H. H. 1972. Acidification of the La Cloche mountain lakes, Ontario and resulting fish mortality. ***J. Fisheries Resources Board of Canada****,* 29 (8): 1131-143.

Bhagat, M. J., Dwivedi, S. N. and Bohra, O. P. 1979. A note on the fish mortality in Powailake, Bombay. ***Geobios, 5***: 180-181.

Bickler, P. E. and Buck, L. T. 2007. Hypoxia tolerance in reptiles, amphibians, and fishes: life with variable oxygen availability. ***Annual Review of Physiology*** 69, 145– 70.

Diaz, R. J. and Breitburg, D. L. 2009. The Hypoxic Environment. In "***Hypoxia. Fish Physiology. Volume 27***." (Richards, J. G., Farrell, A. P. and Brauner, C. J., Eds.). Elsevier Inc.

Dutta, S. P. S., Slathia, D. and Chandbala 2014. Incidences of winter fish kill in subtropical Surinsar Lake (Ramsar Site) in Shivalik hills of Jammu (J&K). ***Environment Conservation Journal,*** 15(3):35-40

Dutta, S. P. S., Kaul, V., Sharma, J. and Kaur, H. 1997. An incidence of fish kill in Behlolnullah, a tributary of river Tawi, Jammu, J&K. ***J. Env. Biol***. 18(3): 263-266.

Ganapati, S. V. and Alikunhi, K. H. 1950. Factory effluents from the Mettur dam, Madras and their pollution effects on the fisheries of the River Cauvery. ***Proc. Nat. Acad. Sci. India***. 16: 189-200.

Heil, A., Patricia, M., Glibert, Mohammad, A., Al-Sarawi, Faraj, M., Behbehani, M. and Husain, M. 2001. First record of a fish-killing *Gymnodinium* sp. bloom in Kuwait Bay, Arabian Sea: chronology and potential causes Cynthia, ***Marine Ecology Progress Series***, 214: 15–23.

Helfrich, L. A. 2009. Fish Kills: Their Causes and Prevention.Virginia Cooperative Extension, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University. http://www.ext.vt.edu.publication 420-252 pp1-4.

Hingorani, H. G., Rao, K. M. and Rao, R. R. 1977. An attempt to study pollution and fish mortality in HussainSagarreservoir in Hyderabad. ***J. Indian Fish. Assoc***. 4(1&2): 74

Holeton, G. F. 1980. Oxygen as an environmental factor of fishes. In *Environmental Physiology of Fishes* Edited by M. A. Ali (1980). International board of publishers in conjunction with NATO Scientific Affairs Division.pp7-32

Hurst, T. P. 2007. Causes and consequences of winter mortality in fishes. ***Journal of Fish Biology*****,** 71(2): 315–345.

Kangur, K., Ginter, K., Kangur, P., Kangur, A., Nõges, P. and Laas, A. 2016. Changes in water temperature and chemistry preceding a massive kill of bottom-dwelling fish: an analysis of high-frequency buoy data of shallow Lake Võrtsjärv (Estonia). Centre for Limnology, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Rannu, Estonia*,* ***Inland Waters***, 6, pp.535-542

Khan, M. A. and Hussain, M. A. 1976. Preliminary observations on pollution of HussainSagar Lake caused by industrial effluent Indian. ***J. Environ. Health***.18(3): 227-232.

Krishnamoorthy, K. P. and Visweswara, G. 1963. Hydrobiological studies with reference to sudden fish mortality ***Hydrobiologia*****.** 21,(3): 275–303

Kumar, V., Rai, S. P. and Singh, O. 2006. Water Quantity and Quality of Mansar Lake Located in the Himalayan Foothills, India. ***Lake and Reservoir Management***, 22(3):191-198.

Malhotra, Y. R., Jyoti, M. K. and Sehgal, H. 1979. Causes of size and sex restricted kill of *Puntius conchonius* in a subtrophical lake in Jammu***. Ind. J. Exp. Biol***.17 (8): 836-837.

Maryland department of Environment 2017. Gunpowder/Bird River Fish Kill December 18, 2016. *Report published in partnership with Maryland deptt of Natural Resources and Centre for Environmental Science, University of Maryland* on February 14 2017

Moore, W. G. 1942. Field studies on the oxygen requirements of certain fresh water fishes. ***Ecology***, 23:317-329.

Orietta, E. 2016. Thousands of Dead Sardines Found Floating in Chile's Queule River *https://www.ecowatch.com*

Pandita, R. N. 2005. Survey report on fisheries resources of District Udhampur. Department of Fisheries. J and K Govt. 52-60.

Powers, E. B. 1938. Factors involved in the Mortality of fishes. ***Trans. Am. Fish. Soc***., 67: 271-281.

Rao, K. V. R., Pandey, A. K. and Pandey, P. 1989-1990 An instance of major fish kill (*Notopterus notopterus*) in HussainSagar (Lake) on 24th April), 1990. ***Matsya*** ,15 and 16 : 164-167.

Richards, J. G. 2009. Metabolic and *Molecular Responses of Fish to Hypoxia. In "Hypoxia. Fish Physiology. Volume 27*" (Richards, J. G., Farrell, A. P. and Brauner, C. J., Eds.). Elsevier Inc. *PLOS ONE* **9**(4): e94524. https:// doi.org/10.1371/ journal.pone. 0094524

Ruparelia, S. G. ,Verma, Y., Mehta, N. S., Saiyed, S. R. and Ramprasad, T. N. 1986. An episode of massive fish mortality in Lake Kankariya- A case study and follow up surveillance. ***IndianJ. Ecol***. 13: 10-14.

Ruuhijarvi, J., Rask, M., Vesala, S., Westermark, A., Olin, M., Keskitalo, J. and Lehtovaara, A.2010. Recovery of the fish community and changes in the lower trophic levels in a eutropic lake after winter kill of fish. ***Hydrobiologia**,* 645:145-158.

Sanzi, N. 1981. Fish mortality in Bawaria in 1979. ***Fisher Teichwirt***. 32: 136-139.

Small, K., Kopf, R. K., Watts, R. J., Howitt, J. 2014. Hypoxia, Blackwater and Fish Kills: Experimental Lethal Oxygen Thresholds in Juvenile Predatory Lowland River Fishes.

Vasisht, H. S. and Sra, G. S. 1979. The Biological Characteristics of Chandigarh waste waters in relation to Physio-Chemical Factors. ***Proc. Symp. Environ. Biol*.,** 429-440

Wanganeo, A., Pani, S., Nandan, M.J. and Suresh, I. V. 1994. Incidence of fish mortality in lower lake of Bhopal. ***Geobios*,** 21(2):145-146.