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Importance of some physico-chemical characteristics of lotic water bodies in relation to ichthyofaunal diversity of North Bengal: A review

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Abstract: Flowing freshwater environment are called lotic ecosystems for obvious reason of unidirectional water movement along a slope in response to gravity. Currently, rivers are explained as dynamic, three dimensional system dependent upon longitudinal, lateral and vertical transfers of material, energy and biota. People today are under tremendous threat due to undesired changes in the physical, chemical and biological characteristic of air, water and soil. The rivers of North Bengal are glacier-fed, spring-fed and rain-fed, originating from the Himalayas to traverse great alluvial Indo-gangetic plains. Some rivers of this region are Mahananda, Balasan, Teesta, Jaldhaka, Kaljani, Gadadhar etc. River fish which provide a major source of food and recreation is also useful for characterizing environmental condition in streams and rivers. A stream ecosystem i.e. Lotic ecosystem has to have a healthy and diverse fish community. It is necessary to know details about some physico-chemical parameters such as temperature, acidity, total hardness, pH, electrical conductivity, total dissolved solids, turbidity, chloride concentration and dissolved oxygen for the survivability of the ichthyofauna and the aquatic ecosystem; these matters have discussed in this present paper.

Kew words: lotic ecosystems, physico-chemical parameters, ichthyofauna.

Introduction

River is simply defined as a dynamic body of water, which flows from higher ground elevation, like hills and mountains, towards lower levels, like the sea. The physical, chemical and biological processes over a range of time scales (Callow and Petts, 1992). The structure and function of river ecosystem are determined by the interactions between five elements, physical structure, water quality and quantity, condition of riparian zone and flood plain and the diversify and population of plants and animals living in streams (Rutherford et at, 2000). Any change in one of these elements can have significant impact upon other parts of the system.

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Only a miniscule proportion (0.006%) of the world's fresh water is present in streams and rivers at any one time (Shiklomanov, 1993), but this statistic belies the significance of lotic system in human kind and the biosphere.

Rationale of the study

The mountain fluvial ecosystem is unique as well as distinct in all aspect, especially in the topics. Stretch of largest glacier-fed river Teesta in the Derjeeling Himalaya forms a link between Himalaya forms a link between Himalayan mountainous part and flood plains of North Bengal. Thus, it portrays a kind of ecotone, an excellent riverine ecosystem in the eastern Himalayan Hotspot. Diversity of basic food chain that is phytoplankton, zooplankton and ichthyofauna is a good indicator of the health of an aquatic ecosystem. The diversity of species found in the environment is the surest guide to the fight against water pollution (Faurie et al, 2001). Diversity of Plankton and fish fauna in relation to the physico-chemical water quality will be good indicator of the health of the river and its drainage basin.

Lotic Ecosystem:

Flowing fresh water environment are called lotic ecosystem for obvious reason of unidirectional water movements along a slope in response to gravity (Wetzel, 2001). The combination of disciplines with in fresh water science was expressed in the classic monograph on lacleman (Lake Geneva) by swiss Forel (1892-1904). The development of stream ecology or stream limnology as a discipline analogous to take limnology grew out of initiatives that began in this 1950s and 1960s. Hynes 1970 book The Ecology of Running waters is usually regarded as that 1st book on stream ecology. The limnology of running waters was review master fully by Hynes (1970), Wetzel (2001) summarized characteristics of running waters and compare them to those of standing water in his book limnology lake and River ecosystems.

Himalayan Rivers:

"Abode of snow". Himalaya which forms a great mountain wall to the North of India. The Himalaya is often called the "Water Tower of India" as it is the source of the three largest rivers. The glacier-fed rivers originating in the Himalaya Mountain range comprise the largest River run off from any single location in the world (UNEP/GRID-Arendal 2007). The rivers Provide drinking water, food, income, transport, power, and jobs for millions of people; The Ganga-Brahmaputra alone sustains the highest population density in the world (WATCH, 2010).

Physico-Chemical Parameters.

The physico-chemical factors of the medium exert profound influence on the number, abundance, distribution and diversity of its inhabitants. Physical and chemical analysis of water has attained great importance and has been well accepted in recent years for the ecological studies of aquatic habitats.

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Temperature

The air temperature is the resultant affect of several meteorological factors such as solar radiation, humidity, wind etc. And also the latitudinal and altitudinal position of the place under study (Wetzel, 2001). Positive and significant correlation between air and water temperature have been reported by chakraborty et al., (1959), Kant and Anand (1978), Rawat et al, (1995) and Wetzel (2001). Water temperature plays a very important role in some physiological processes like release of stimuli for breeding mechanism in fish, both under natural and artificial conditions (Hora, 1945; chaudhuri, 1964). Lowest temperature observed in the river Kaligkhola (October) but highest tempreture found in the river Torsa and Sankosh (April). Thapa et al., (2010) reported highest temperature 29.6 ^{0} c in Trishuli river in Nepal. Available literature indicated that in the North eastern Himalayan River, water temperature ranged from 5.6^{0}c to 30^{0} c. In the Himalayan River water temperature increased downstream (Singh, 1988; Mathur, 1991, Nautiyal, 2001, 2010).

pH

The pH value characterizes the acidity of river water. By definition, pH of a solution is the logarithm of the inverse of the concentration of hydronium ions (H_{3O+}), produced as a result of dissociation of water (Faurie et al, 2001). Available literature indicated that the range of pH generally varies from 6.5 to 8.7 in north western Himalayan River. Chakraborty et al., (1959) recorded pH more or less constant at 8.0 throughout the year with a shight variation of+,- 0.2 in river Jamuna. Kumar and Bhagat (1978) observed pH range of 7.1 to 7.8 in streams of Kashmir.

Specific Conductance

Conductivity in simply the relative amount of electricity that can be conducted by water (Dodds, 2002). This mostly depends upon the nature of various dissolved ionized substance, the relative concentrations and temperature specific conductance of north western Himalayan river water ranged from 20 to 468.2 umho cm^{-1} and it increased upstream to downstream (Singh, 1988; Mathur, 1991; Nautiyal 2001). Boruah and Biswas (2000) observed range of conductivity was 87-145.7us cm^{-1} in the Brahmaputra River. Bhadra et al., (2003) reported specific conductance of a foothill river Torsa in North Bengal, Varied from 100-280 umho cm^{-1} . The specific conductance of water had significant positive correlation with pH, DO, total alkalinity, total hardness has been recorded by Mariappan and Vasudevan (2002) and Mondal (2009).

Total Alkalinity

Water is said to be alkaline when concentration of the hydroxyl;ions exceeds that of hydrogen ions (Trivedy and Goel, 1984). Most of the alkalinity in Natural water is formed due to dissolution of CO_2 in water. In river and streams of the north western Himalaya total alkalinity ranged from 10 to 221.6 mg L^{-1}. Lowest value observed in the river Ramganga and Bhagirathi (Pathani and Upadhyay 2003) and the

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highest value founed in the stream Chandrabhaga of Garhwal Himalaya (Sharma et al, 2007). Biswas and Boruah (2002) reported range of total alkalinity from 44.3 to 110.8 mg L^{-1} with an average value of 63.4 mg L^{-1} in the river Brahmaputra. Total alkalinity varied in the river in Sikkim from 10-80 mg L^{-1} (Haque et al, 2010). Spring fed river have higher value of total alkalinity than glacier-fed rivers (Sharma and Mishra, 2002).

Total Hardness

The hardness of a water is governed by the content of calcium and magnesium salts, largely combined with bicarbonate and carbonate (temporary hardness) and with sulphate, chlorides and other anions of mineral acids (permanent hardness). The anions responsible for hardness are mainly bicarbonate, carbonate, sulphate, chloride, nitrate and silicates etc. (Trivedy and Goal, 1984). Kumar and Dua (2009). Reported range of Total hardness Varied from 80 to 730 mg L^{-1} in river Ravi. Biswas and Baruah (2002) reported range of total hardness from 53.7 to 106.5 mg L^{-1} with an average value of 67.1 mg L^{-1} in the river Brahmaputra.

Ammonium Witrogen (NH_4–N)

Ammonium ion (NH_4 +) is also brought to natural water by animal and human wastes. The ammonium is either released from proteinaceous organic matter and urea or is synthesized after proteinaceous organic matter and urea or is synthesized after the fixation of atmospheric nitrogen (Train, 1979). It is also produced by fishes and zooplankton, which leads to very repaid development of phytoplankton in water in which this chemical form of nitrogen cannot be detected by chemical analyses (Faurie et al, 2001). The range of NH_4–N concentration western Himalayan rivers varied from traces to 0.644 mg L^{-1} (Semwal and Akolkar, 2006), Jhingran (1991) recorded ammoniacal nitrogen only during January to April in the river Brahmaputra. Barat and Jha (2002), reported value of NH_4–N in the river Mahananda ranged from 0.080 to 0.460 mg L^{-1} . Jana and Barat (1984) observed Significant correlation between DO and NH_4–N.

Dissolved Oxygen

Oxygen is likely the most important chemical constitute of lotic systems, as all aerobic organisms require it for survival. It enters the water mostly via diffusion at the water-air interface. Badola (1979) observed highest value of 18.1 and 16.8 mg L^{-1} of dissolved oxygen in glacier-fed river Alaknanda and spring-fed river Nayar Respectively and Value of DO decreased downstream (Singh, 1988); Mathur, 1991; Nautiyal 1996, 2001). Haque et al. (2010) found range of dissolved oxygen to be 6.8 to 9.89 mg L^{-1} in the river Teesta in Sikkim. In the river of North eastern Himalaya Value of Dissolved oxygen ranged from 3.6 to 15.4 mg L^{-1}. Both values found in the river Brahmaputra (Jhingran, 1991; Biswas and Boruah, 2000) with an average value of 9.4 mg L^{-1}.

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Chloride

Chloride may occur in freshwaters as a result of salt deposits in the soil being dissolved. High chloride content in inland water may been indication of pollution. Maximum chloride content has been correlated with high degree of organic pollution and Eutrophication. Contamination of water from domestic sewage can be monitored by chloride concentration of the concerned water bodies. In Asia mean composition of chloride ion in river water is 8.7 mg L^{-1} , Whereas world average is 7.8 mg L^{-1} (Livingstone, 1963; Benot, 1969), Chloride concentration of Torsha river ranged from 5.8 to 11.1 mg L^{-1} as observed by Bhardra et al (2003. Biswas and Boruah (2000) reported range of chloride concentration from 1.9 to 10.2 mg L^{-1} with and average value of 39.4 mg L^{-1} in the river Mahananda located in the foot hill of Darjeeling Himalaya. Thapa Chhetry and pal (2011 found Positive and significant correlation between chloride and total alkalinity.

Phosphate Phosphorus (PO_4-P)

Phosphorus is found in water in two chemical forms; the orthophosphates (PO_4^{3-}) and organic matter compounds (ATP, NADP etc). Singh et al, (2008) reported range 1.2 to 3.1 mg L^{-1} of PO_4-P in the river Mahananda ranged from 0.060 to 0.0340 mg L^{-1}. Chakraborty (1998b) observed the available phosphorus to Very between 0.005 and 0.008 mg L^{-1}in natural hill streams in Darjeeling.

IchthyoFaunal Diversity

Fishes are cold blooded aquatic vertebrates which breath by means of Pharyngeal gills, propelling and balancing themselves by means of Paired and unpaired fins supported by fin-rays (Jhingran, 1991). There is about 2319 fresh water fish species that have so far been documented, of which about 838 inhabit fresh water fishes in India (Daniels, 2002). Jayaram (1999) Stated that the fish fauna of the India Hill stream is well documented and show perfect adaptations to the living conditions. Greatest diversity in Cypriniformes and siluriformes has been reported by Johal and Rawal (2005) in Western Himalayan Hill stream and by Shrestha (1999) in the Nepal region of the Himalayas. Teesta Low Dam Project reported 26 fish species in Teesta river among which 9 are commercially important and 5 are migratory in nature (Anon, 2002). Jha et al, (2004) studied the fish fauna of Mahananda reservoir, Near Siliguri Town and Identified 49 Species of Fish. Bharat et al (2005) reported 21 species of fishes from Darjeeling uplands, Mukherjee et al, (2011) reported 22 species of endangered/Vulnerable/ threatened fishes from Darjeeling and 8 species from siliguri. Chakraborty and Bhattacharjee (2008) investigated ichthyfaunal resources of south Dinajpur District, Patra et al, (2011) reported ichthyofauna diversity of Karala River in Jalpaiguri, a total of 55 species belonging to 8 orders and 20 families were identified.

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Future Scope

It is clear from the review that the ichthyofunal diversity in fresh water is greatly influenced by some physical and chemical factors. Watershed features land use geochemical features, soil or sed iments also affected ichthyofauna. Research work on these factors are not clearly reported in studies of north Bengal rivers. Most of the discussed case studies are basic and provide necessary information to develop protection and management plans. This review provides a frame work for the improved understanding of research and management strategies in Indian rivers.

Bibliography

Anonymous., 2002. *Environment Impact Assessment, Teesta Low Dam Project, Stage-III, West Bengal (Vol-I),* University of North Bengal, Darjeeling and NHPC Faridabab, Haryana, 8-17.

Badola, S.P., 1979. Ecological studies on the Ichthyofauna of freshwater resources of Garhwal region. H.N.B. Garhwal University, Srinagar Garhwal. (D.Phil. Thesis)*.

Barat, S., Jha, P., 2002. Changes in the water quality and total coliform bacterial load in a streach of River Mahananda at Siliguri city, West Bengal, India. *Asian J. Microbiol. Biotech. Env. Science,* 4(4): 571-575.

Barat, S., Jha, P., Lepcha, P.F., 2005. Bionomics and cultural prospects of Katli, *Neolissocheilus Hexagonolepis* (McClelland) in Darjeeling district of West Bengal. In: *Coldwater fisheries research and development in north-east region of India* (Eds.: B. Tyagi Shyam Sunder and M. Mohan)

Benoit, R. J., 1969. Geochemistry of Eutrophication. *In Eutrophication: causes consequences, Correctives. National Academy of Sciences,* Washington, DC. pp 614-630

Biswas, S. P., Boruah, S. P., 2000. Fisheries ecology of the north-eastern Himalayas with special reference to the Brahmaputra River. *Ecological Engineering*, 16. 39-50.

Boruah, S., Biswas, S.O., 2002. Ecohydrology and fisheries of the upper Brahmaputra basin. *The Environmentalist*, 22. 119-131.

Calow, P., Petts, G. E., 1992. *The rivers handbook*. Blackwell Scientific Publications. London,

Chakrabarty, R.D., Ray, P., Singh, S.B., 1959. A quality study of the plankton and physic-chemical conditions of river Jamuna at Allahabad in 1954-55. *Indian. J. Fish*. 6 (1): 186-203.

Chakraborty, D., 1998a Limnological Studies on Lake Sinchel, a mountain lake in Darjeeling. Environment and Ecology 16 (a): 31-33.

Received: 5 November Revised: 13 November Accepted: 22 November
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Volume 7 Number 12
UGC APPROVED

Chakraborty, T., Bhattacharjee, S., 2008. The Ichthyofaunal Diversity in the Freshwater Rivers of South Dinajpur of West Bengal, India. *Journal of Bombay Natural History Soceity,* 105(3): 292-298.

Chaudhuri, H. 1964. Technique of induced breeding in fishes with special reference to major carps of India. *Proc, Seminar Inland Fish. Div*. U,P. :65-73.

Dodds, W.K., 2002. *"Freshwater Ecology: Concepts and Environmental Applications."* Elsevier India Pvt. Ltd.

Faurie, C., Ferra, C., Medori, P., Devaux, J. 2001. Ecology Science and Practices, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

Forel, F. A. 1882, 1895, 1904. Le lemn: Monographie, Vols. 1-3. Lausanne: F. Rouge.

Haque, N., Toppo, S., Rahaman, H., 2010. Aquatic environment and riverine fish diversity in Sikkim. In: *Cold Water Fisheries Managment,* edited by P.C. Mahanta and D. Sharma. Pp. 141-156.

Hora, S.L., 1945. Fishes of Bengal. Ind. Fmg., Delhi, 6: 163-167.

Hynes, H.B.N.1970. The Ecology of Running Waters. Toronto: University of Toronto Press.

Jana, B. B., Barat, S., 1984 Ammonification as affected by the oxygen level of water. *Limnologis.* 16(1), 67-70.

Jayaram, K.C., 1999. *The Freshwater Fishes of the Indian Region*. Narendra Publishing House, New Delhi, India.

Jha, P., Mandal, A., Barat, S., 2004. Mahananda Reservior, W.B.: Its Ichthyofauna, Fishery and Socio-economic Profile of Fish Production. *Fishing Chimes*, 24 (6): 14-17.

Jhingran, V.G., 1991. *Fish and Fisheries of India*. 3rd Edition. Hindustan Publishing Corporation (India), Delhi.

Johal, M.S., Rawal, Y. K., 2005.Key to the management of the western Himalayan Hill streams in relation to fish species richness and diversity. *Hydrobiologia.* 532: 225-232.

Kant, S., Anand, V.K., 1978 Interrelationship of phytoplankton and physical factors in Ansar Lake, Jammu, India. *J, Ecol*. 5: 134-140.

Kumar, A., Dua, A., 2009. Water Quality Index for Assessment of water Quality of River Ravi at Madhopur (India). *Global Journal of Environmental Science*, Vol. 8 (10). 49-57.

Kumar, K., Bhagat, M. J., 1978. Observations on the ecology of two trout streams in Kashmir and its possible effect on the brown trout. *J. Inland Fish. Soc. India*., 10: 1-8.

Received: 5 November Revised: 13 November Accepted: 22 November
Index in Cosmos
Volume 7 Number 12
UGC APPROVED

Livingstone, D. A. 1963. Chemical composition of rivers and lakes. Chap. G. Data of Geochemisity. 6th Edition Prof. Pap. U>S. Geol Surv, 440-G, 64pp.

Mariappan, P., Vasudevan, T., 2002. Correlation coefficients of some physic-chemical parameters of drinking water ponds in Eastern part of Sivagangi district, Tamil Nadu. *Poll. Res.* 21: 403-407.

Mathur, R.P., 1991. Stretches of the Ganga covered in the study: Trends of physicochemical characteristics of the Ganga water. In: C.R. Krishnamoorti, K. S. Bilgrami, T. M. Das, R. P. Mathur (Eds). *The Ganga-A Scientific Study*, pp. 19-20: 27-38. Northern Book Centre, New Delhi, for the Ganga Project Directorate, New Delhi.

Mondal, D., 2009. Some aspects of Hydrobiological study of Mirik lake of the Darjeeling hills. Ph. D. Thesis. University of North Bengal.

Mukherjee, M., Lepcha, R. F., Chakraborty, C., 2011. *Fish and Fisheries of Himalayan and Terai Region of West Bengal with Ornamental touch.* Deya publishing House. Delhi, pp. 342.

Nautiyal, P., 2010. Food chains of Ganga River ecosystems in the Himalayas. *Aquatic Ecosystem Health & Managment,* 13:4, 362-373.

Nautiyal, P., 2001. Ecology of Mountain strems and rivers in Garhwal Himalaya. In: A. Kumar (Ed.), *Ecology and Conservation of Lakes*, Reservoirs and Rivers. A B D Publishers.

Pathani, S.S., Upadhyay, K.K. 2003. An inventory on zooplankton, zoobenthos and fish funa in the River Ramganga (W) of Uttaranchal India. ENVIS Bulletin Vol. 14(2): Himalayan Ecology.

Patra, A.K., Sengupta, S., Datta, T. 2011. Physico-chemical Properties and Ichthyofauna Diversity in Karala River, a tributary of Teesta River at Jalpaiguri district of West Bengal, India. *International Journal of Applied Biology and Pharmaceutical Technology*. 2(3): 47-58.

Rutherford, M.C., G. F. Midgley, W. J., Bond, L., W., Powrie, R., Reberts, Allosopp. J., 2000. Plant biodiversity. In Kiker, G., Editor, *Climate change impacts in Southern Africa*, Report to National Climate Committee, Department of Environmental Affairs and Tourism Pretoria, South Africa.

Semwal, N., Akolkar, P., 2006. Water quality assessment of sacred Himalayan rivers of Uttaranchal. *Curr. Sci*, 9(4), 486-496.

Sharma, A. P., Mishra, A., 2002. Present status and prospects of mahseer fishery in Garhwal Region of Central Himalaya. In: T. Petr and S.B. Swar (Eds) *Cold water fisheries in the trans-Himalayan countries.* FAO Fisheries Technical Paper, 431, 2560-265.

Sharma, A., Sharma, R.C., Anthwal, A., 207 Monitoring phytoplanktonic diversity in the hill stream chandrabhaga of Garhwal Himalaya. *Life Science Journal*, 4(1). 80-84.

Received: 5 November Revised: 13 November Accepted: 22 November
Index in Cosmos
Volume 7 Number 12
UGC APPROVED

ISSN 2249-3352 (P) 2278-0505 (E)

Shiklomanov, L. A., 1993 World Fresh water Resources. In: Gleick, P. H. (ed). *Water crisis; a guide to world's Freshwater Resources*. Oxford University Press, New York, USA. 13-24.

Shrestha, J., 1999. Coldwater fish and fisheries in Nepal. In: Petr, T. (ed.). *Fish and fisheries at higher altitude-Asia.* FAO Fisheries Technical Paper. No. 385: Rome, FAO. Pp. 13-40.

Singh, H.R., 1988. Pollution study of the Upper Ganga and its tributaries. Final Technical report of Research Project No. J-13013/20/83 RE (EN-1) under Ganga Action Plan, Ministry of Environment and Forests New Delhi. Department of Zoology, Garhwal University, Srinagar-Garhwal India.

Singh, J., Agarwal, D. K., Panwar, S., 2008. Seasonal variation in different physic-chemical characteristics of Yamuna river water quality in proposed lakhwar hydropower project influence area. Intl. J. Appl. Environ. Sci. 3(1), 107-117.

Thapa Chhetry, D., Pal, J., 2011. Physico-chemical Parameters of Koshi River at Kushaha Area of Koshi Tappu Wildlife Reserve. *Our Nature* 9: 156-167.

Thapa, S., Yonzon, P.B., Rai, A.K., 2010. Life of a river in Himalaya: An ecological study of Trisuli River system in Nepal. *Aquaculture Asia Magazine (Genetics and Biodiversity),* Vloume XV No. . 37-40pp.

Train, R. E., 1979. *Quality criteria for water*, Castle House Publications, London.

Trivedy, R.K., Goel, P.K., 1984. *Chemical and Biological Methods for Water Pollution Studies.* Environmental Publications, Karad (India).

UNEP/GRID-ARENDAL. 2007. *Water towers of Asia-glaciers. Water and population in the greater Himalayas-Hindu Kush-Tien Shan-Trbet region.* UNEP/GRID-Arendal Maps and Graphis Library, June 2007. http://maps.grida.no/go/graphis/water-towers-of-asia-glaciers-water-and-population. Accessed on 30 March 2012.

WATCH, 2010. Ganga Brahmaputra River Basin. Water and Golbal Change. Centre for Ecology and Hydrology, at Wallingford, UK.
www.waterandclimatechange.eu/riverbasin/ganges-brahmaputra. Accessed on 30 March 2012.

Wetzel, R.G., 2001. Limnology: Lake and River Ecosystems, (3rd edition). Academic Press, USA.

Received: 5 November Revised: 13 November Accepted: 22 November
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Volume 7 Number 12
UGC APPROVED