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Effect of Water Quality on Benthic Macro Invertebrates in Dikhu River, Nagaland, India

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ABSTRACT

Background: Water quality monitoring is vital for the sustainable conservation of water resources. Benthic macro invertebrates have been documented as the best indicators of water quality serving as a vital link in the aquatic food web. The present work was carried out at Dikhu River, Mokokchung, Nagaland.

Methods: The analysis of water samples was done by adopting standard methods and compared against the W.H.O. 1995 drinking quality standards of water. The macroinvertebrates were collected with the help of the Surber and preserved in 5% formalin and examined using inverted microscope. Pearson's correlation analysis were performed by IBM SPSS package 16.0.

Result: All water parameters were within the permissible limit of drinking quality standards except for alkalinity. A total of 646 individual benthic macro invertebrates belonging to three taxa (Annelida, Arthropoda and Mollusca) were recorded during the study. The study depicts the present status of macrobenthic structure of Dikhu River of Nagaland and aims to lay the foundation for further effective work as future prospect.

Key words: Benthic macro invertebrates, Dikhu river, Water quality, Water health.

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INTRODUCTION

Water is essential for life. However there are reports of increased eutrophication in water bodies due to anthropogenic activities ultimately affecting its quality (Temjen and Singh, 2018). The effect of land use on water bodies can be understood by studying the water quality status (Hakamata *et al*., 1992). Water quality monitoring is therefore vital for the sustainable conservation of water resources and involves the regular and continued monitoring of physico-chemical parameters of water bodies. Variations in the quality of water are mirrored within the biotic community with certain sensitive species acting as indicators of water quality (Barbour *et al*., 1999). Biological agents that are utilised as indicators provide an exact measures of anthropogenic effects on aquatic ecosystems (Camargo *et al*., 2004). Benthic macro invertebrates have been documented as the best indicators of water quality in urban fauna stream (Mutonkole, 2015). Such composition of the benthic fauna are considered as a good indicator of water quality as they form relatively stable communities persistently and reflect characteristics of both sediments and upper water layer (El-Shabrawy and Khalil, 2003). This community serve as a vital link in the aquatic food web (Siraj *et al*., 2010). Therefore, keeping in view the importance of benthic macro invertebrates as biological indicators and the subsequent lack of data in the region, the present investigation attempts to report physico-chemical properties of water and various benthic macro invertebrates in the Dikhu River, Nalagand, India.

MATERIALS AND METHODS

Study area

Dikhu is one of the most prominent rivers of Nagaland, North East India. It has a total length of about 160 km. It originates from Nuroto Hill area in Zunheboto district. The river flows across Mokokchung and Longleng districts in Nagaland. The main tributaries of River Dikhu are Yangyu of Tuensang district and Nanung in the Langpangkong range in Mokokchung district. For the present investigation, two sampling sites were selected on the basis of accessibility and vegetation. Sampling site 1: Longmisa Noksen (N 26° 31' 30.953" E 94°41' 13.429") is located upstream and has a stretch of 2.18km and width varying from 9.56 to 40.29 m. The human settlement nearest to this site is Changtongya Town, Mokokchung, Nagaland. Sampling site 2: Longmisa-Chuchu (N 36°32' 4.68" E 94°41' 46.027") has a stretch of 898.87 m and width varying from 12.56 to 32.29 m. Both sites are adjacent to agricultural farmland and plantations during the study period. This water body is vital for the population living in the district of Mokokchung, Nagaland. The water body is utilised for domestic purposes such as irrigation for the adjacent farmland areas and also for domestic purposes. The water, however, is under the effect of a several anthropogenic factors such as sewage, chemical runoff and fishing activities.

Sampling procedures and analysis of water

Physico-chemical characteristics of water were investigated on a seasonal basis. The seasons included winter (Nov 2015-Jan 2016), spring (Feb-April 2016), summer (May-July 2016) and autumn (Aug-Oct 2016). Water temperature was recorded on the sampling sites. The water samples were collected from the sampling sites by dipping one litre polyethylene bottle just below the surface of water. For estimation of dissolved oxygen, samples were fixed at the sampling site in accordance with modified Winkler method (ISO, 1983). The analysis of water samples was done by adopting standard methods (Adoni *et al*., 1985; APHA, 1985; Trivedy and Goel, 1986). Water sample for other physico-chemical parameters were stored and carried to the laboratory for analysis. Turbidity was measured using an electronic turbidity meter (submersible turbidimeters, USGS, 2013). pH was measured with the help of portable digital pH meter (OAKTON). The water quality was also compared against the drinking quality standards of water (WHO, 1995).

Sampling for benthic macro invertebrates

The macroinvertebrates colonizing the substrate and surface were collected with the help of the Surber sampler (0.50 mm mesh net) and by hand-picking from beneath the stones and macrophytes. The macroinvertebrates were preserved in 5% formalin at the sampling sites and were examined using inverted microscope for identification up to genus level with the help of standard monographs and identification keys.

Statistical analysis

Pearson's correlation analysis was performed to determine the statistical relationships between the different water parameters and also examine the effect of water parameters on benthic macro invertebrates at the sampling stations. All statistical operations were performed by using IBM SPSS package 16.0.

RESULTS AND DISCUSSION

Physico-chemical parameters of water

Table 1 shows the seasonal variation in physico-chemical parameters of water at sites 1 and 2. The water temperature (°C) ranged between a minimum of 10.61°C -27.5°C at site 1 and 10.01°C to 28.8°C at site 2 during the study period. Water temperature has been observed to follow the general atmospheric temperature. Temperature constrains the various processes in aquatic ecosystems differently and therefore, a general warming of the water column will change trophic interactions and ecosystem functioning (Alheit *et al*., 2005). Water Turbidity ranged from 9.97-77.56 NTU at site 1 and 10.42-78.92 NTU at site 2. The water turbidity levels were found to increase with the onset of the rainy season. Verma and Shukla (1969) believed that the pH would prove to be an ecological factor of major importance in controlling the activities and distribution of aquatic flora and fauna. During the study, pH ranged from 7.72-8.23 at site 1 and 7.59-8.21 at site 2. Dissolved oxygen is essential for the respiratory metabolism of organisms. The dissolved oxygen ranged between 8.33-12.45 mg/L at site 1 and 8.39-12.06 mg/L at site 2. The effects of waste discharge in the water body are largely determined by the oxygen balance of the system (Trivedy and Goel, 1986). It directly affects the survival and distribution of fauna and flora in an ecosystem (Vijaykumar *et al*., 1999). Higher values of dissolved oxygen were found during the winter season at both sites which may be due to decreased algal bloom as compared to that in summer season (Temjen and Singh, 2018). The carbon dioxide ranged between 5.33-9.33mg/L at site 1 and 5.25-9.21 mg/L at site 2. The primary source of inorganic carbon for photosynthesis and the organic substances in an aquatic ecosystem are largely in the form of dissolved carbon dioxide and bicarbonates (Wetzel, 2001). Water velocity values ranged from 0.196-0.518 m^3/s at site 1 and 0.192- 0.520 m^3/s at site 2. Alikunhi (1957) considered alkalinity as a measure of productivity. In present study, the values ranged from 72.95-134.55 mg/L at site 1 and 73.50-135.65 mg/L at site 2. The concentration of alkalinity in water bodies shift the pH levels of water bodies to the alkaline side (Wetzel, 1983). The higher values of alkalinity at both sites during the spring season in the present study might be attributed to higher rate of decomposition of nutrients by microbes and subsequent increase in temperature. Cole (1975) recorded calcium and magnesium to account for most of the hardness. Total hardness of water in present study ranged from 14.20-38.5 mg/L at site 1 and 14.35-39.6 mg/L at site 2. A trend of lower values in rainy season and maximum during winter was observed. Similar observations have been reported by Temjen and Singh (2018) who worked on Milak River at Mokokchung district, Nagaland. During the study, it is recorded that all the water quality parameters were within the permissible limit of WHO (1995) except for alkalinity which had a value of 134.55 mg/L at site 1 and 135.65 mg/L at site 2. The increased alkalinity might be attributed to anthropogenic forces such as improper sewage disposal and run offs from the adjacent farmlands near the water body.

Diversity of macro invertebrates

During the study, a total of 19 species of benthic macroinvertebrates belonging to 3 taxa were identified at site 1 (Table 2). The species were identified only at generic level. Under Annelida, four species found were *Enchytraeidae sp, Haplotaxida* sp, *Lumbriculida* spand *Tubificidae* sp. 9 Arthropod species were *Astacidae* sp, *Baetidae* sp, *Caenidae* sp, *Chaoboridae* sp, *Chironomini* sp, *Coenagrionidae* sp, *Ephemerellidae* sp, *Heptageniidae* spand *Leptohyphidae* sp. A total of 6 species identified under Mollusca were *Bothynidae* sp, *Corbiculidae* sp, *Lymnaeidae* sp, *Physidae* sp, *Pleuroceridae* spand

Table 1: Seasonal variation in physico-chemical parameters of water collected from Dikhu River at site 1 and site 2.

	Sites	Average ± SD	Winter Av	Spring Av	Summer Av	Autumn Av	W.H.O (1995)
Water temperature (^{0}C)	Site 1	18.75±1.52	10.61	23.50	27.5	24.22	NA
	Site 2	19.30±2.02	10.01	22.90	28.8	23.70	
Turbidity (NTU)	Site 1	47.10±8.5	9.97	57.21	77.56	24.71	NA
	Site 2	48.02±10.2	10.42	60.24	78.92	25.65	
pH	Site 1	7.94±1.55	8.20	7.72	7.68	8.23	6.5-8.5
	Site 2	7.97±1.38	7.92	7.75	7.59	8.21	
Dissolved oxygen (mg/L)	Site 1	10.3±1.48	12.45	8.53	8.33	9.37	5-7
	Site 2	10.2±1.60	12.06	9.03	8.39	9.35	
Carbon dioxide (mg/L)	Site 1	7.39±1.27	5.33	6.22	6.27	9.33	NA
	Site 2	7.37±0.98	5.25	6.18	6.32	9.21	
Water velocity (m^3/s)	Site 1	0.356±0.01	0.196	0.42	0.518	0.287	NA
	Site 2	0.360±0.10	0.192	0.45	0.520	0.292	
Alkalinity (mg/L)	Site 1	104.0±65.2	89.31	134.55	72.95	77.00	120
	Site 2	104.4±59.9	90.12	135.65	73.50	75.65	
Total hardness (mg/L)	Site 1	27.17±2.2	38.5	22.86	14.20	19.83	300
	Site 2	27.40±3.2	39.6	23.15	14.35	20.01	

Table 2: Population of benthic macroinvertebrates collected from Dihku River at site 1 and site 2.

Annelida	Site 1	Site 2
Enchytraeidae sp	+	-
Haplotaxida sp	+	+
Lumbriculida sp	+	+
Tubificidae sp	+	+
Arthropoda		
Astacidae sp	+	+
Baetidae sp	+	+
Caenidae sp	+	+
Chaoboridae sp	+	+
Chironomini sp	+	+
Coenagrionidae sp	+	+
Ephemerellidae sp	+	-
Heptageniidae sp	+	-
Leptohyphidae sp	+	-
Lesidae sp	-	+
Psephenidae sp	-	+
Tanypodinae sp	-	+
Mollusca		
Bothynidae sp	+	-
Corbiculidae sp	+	-
Lymnaeidae sp	+	+
Physidae sp	+	+
Pleuroceridae sp	+	+
Sphaeriidae sp	+	+
Valvatidae sp	-	+
Viviparidae sp	-	+

+= present, -= absent.

Sphaeriidae sp. It was observed that the Athropoda had the maximum diversity followed by Mollusca and Annelida (Fig 1). At site 2, a total of 18 species belonging to 3 taxa of macro inverteberates were recorded (Table 2). The species were identified only at generic level. Only 3 species were observed under Annelida namely, *Haplotaxida* sp, *Lumbriculida* spand *Tubificidae* sp. 9 species found under taxa Arthropoda, were *Astacidae* sp, *Baetidae* sp, *Caenidae* sp, *Chaoboridae* sp, *Chironomini* sp, *Coenagrionidae* sp, *Lesidae* sp, *Psephenidae* sp *and Tanypodinae*sp. Lastly, 6 species under Mollusca, namely *Lymnaeidae* sp, *Physidae* sp, *Pleuroceridae* sp, *Sphaeriidae* sp, *Valvatidae* sp and *Viviparidae* sp were recorded. Site 2 also possessed maximum diversity of Arthopoda, followed by that of Mollusca and Annelida (Fig 2). Fig 3 displays the seasonal variation of macro benthic invertebrate composition at site 1 and 2. We observe that summer had the highest number of taxa for all the 3 genera while winter had the lowest number of taxa at both the study sites.

Pearson's test for correlation showed that at site 1 (Table 4), dissolved oxygen was negatively correlated with water temperature(r=-.973, p=0.027). At site 2 (Table 5) a similar trend was observed between dissolved oxygen and temperature (r=-.988, p=0.022). We observe that with the increase in temperature, there is a significant decrease in the levels of dissolved oxygen present in the water body. This can be attributed to increased metabolic activities of biota consuming increased levels of dissolved oxygen due to increased temperature (Uehlinger *et al*., 2000). Water velocity was positively correlated with turbidity at both sites (r=998, p=0.002) and (r=.996, p=0.004) for site 1 and site 2 respectively. The increased influx of water during the rainy season, may increase the turbidity in the water body. Total hardness was negatively correlated with water temperature at both site 1 and 2, (r=-.992, p=0.008) and (r=-.997, p=0.003), respectively. The higher value of total hardness during winter seasons may be due a number of factor. Firstly, a decreased water level increases the ratio of calcium and magnesium salts concentration in water as compared to other season. Secondly, with the lower water volume during winter, anthropogenic activities such as fishing, washing of clothes and domestic sewage which contribute calcium and magnesium salts, further increases value of hardness of water. Meanwhile, the lower value of total hardness during the warmer seasons may be due to increased water levels due to precipitation. Similar observation have been reported by (Singh and Gupta, 2009; Temjen and Singh, 2018).

Arthropoda was found to be positively correlated with water temperature (r=.960, *p*=0.040). Water temperature controls both the supply of oxygen and metabolism of invertebrates (Ekau *et al*., 2010). Therefore the increase in the water temperature during the warmer season may favour the population of Arthopoda. Meanwhile, Arthropoda was found to be negatively correlated with total hardness (r=-979**,** *p*= 0.021). This indicate that the increased levels of water hardness at site 1 negatively impacts the population and diversity of Arthropoda. This may indicate the susceptibility of arthropod species to the increased levels of water hardness. No statistical correlation of macro benthic invertebrates with water parameters were observed at site 2.

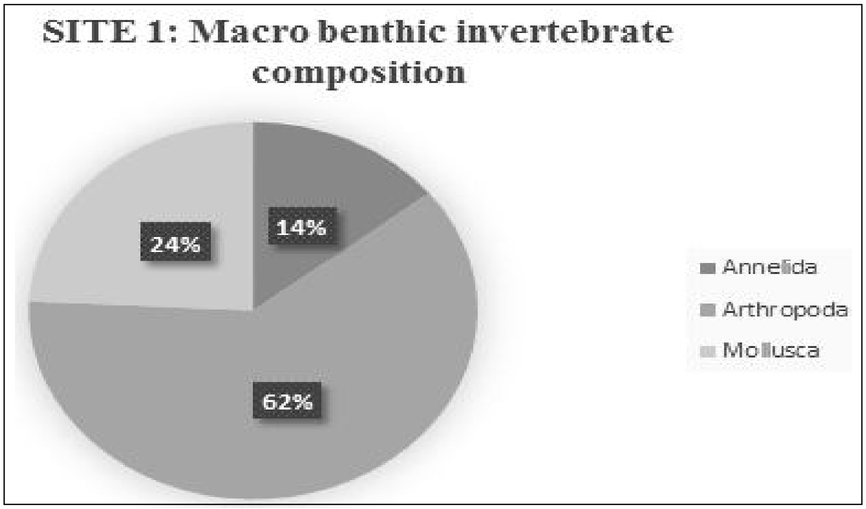

Fig 1: Macro benthic invertebrate composition at site 1.

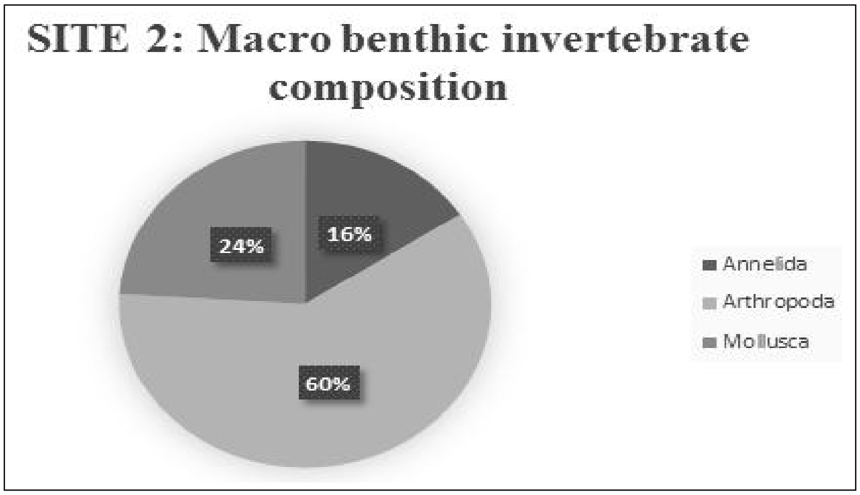

Fig 2: Macro benthic invertebrate composition at site 2.

Table 3: Seasonal variation of benthic macroinvertebrates collected from Dikhu River at Site 1 and Site 2.

Taxa		Winter	Spring	Summer	Autumn
Annelida	Site 1	14	19	4	11
	Site 2	11	16	9	13
Arthropoda	Site 1	32	52	68	53
	Site 2	23	44	74	47
Mollusca	Site 1	17	26	21	17
	Site 2	18	20	18	19

Table 4: Pearson correlation matrix at site 1.

	Water Temperature	Turbidity	pH	Dissolved oxygen	Carbon dioxide	Water Velocity	Total Alkalinity	Total Hardness	Arthropoda	Mollusca	Annelids
Water temperature	1										
Turbidity	.797	1									
pH	-.607	-.947	1								
Dissolved oxygen	**-.973***	-.848	.724	1							
Carbon dioxide	.475	-.151	.395	-.347	1						
Water velocity	.836	**.998****	-.926	-.877	-.084	1					
Total alkalinity	-.064	.120	-.378	-.160	-.327	.092	1				
Total hardness	**-.992****	-.792	.577	.940	-.476	-.832	.184	1			
Arthropoda	**.960***	.878	-.683	-.915	.302	.907	-.209	**-.979***	1		
Mollusca	.446	.698	-.850	-.639	-.320	.677	.795	-.356	.390		
Annelids	-.418	-.390	.137	.240	-.161	-.411	.865	.529	-.608	.386	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5: Pearson correlation matrix at site 2.

	Water Temperature	Turbidity	pH	Dissolved oxygen	Carbon dioxide	Water Velocity	Total Alkalinity	Total Hardness	Arthropoda	Mollusca	Annelids
Water temperature	1										
Turbidity	.828	1									
pH	-.321	-.788	1								
Dissolved oxygen	**-.988***	-.851	.347	1							
Carbon dioxide	.455	-.118	.697	-.415	1						
Water velocity	.861	**.996****	-.735	-.889	-.046	1					
Total alkalinity	-.126	.157	-.248	-.027	-.365	.184	1				
Total hardness	**-.997****	-.786	.259	.977*	-.512	-.820	.187	1			
Arthropoda	.933	.864	-.505	-.886	.243	.865	-.323	-.929	1		
Mollusca	.237	.163	.141	-.368	.274	.237	.792	-.209	-.100	1	
Annelids	-.034	-.087	.275	-.101	.194	-.018	.826	.058	-.368	.926	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

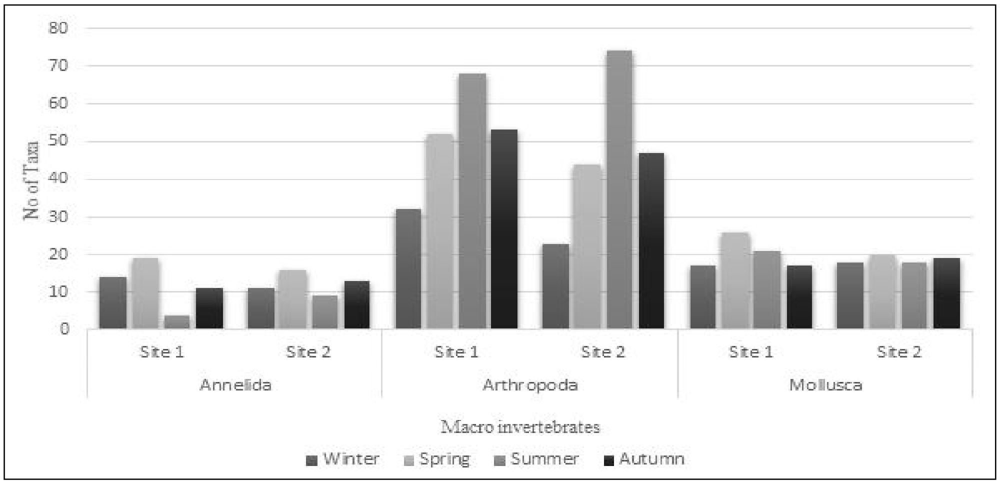

Fig 3: Seasonal variation of Macro benthic invertebrate composition at site 1 and 2.

CONCLUSION

Biodiversity is one of the most significant attributes of sustainable development and represents the biological wealth of a given nation. Flora and fauna are becoming extinct at an alarming rate because of habitat loss, overexploitation and global climate changes. The present study highlights the status of macro benthic invertebrate structure of Dikhu River of Nagaland. Further, we conclude that the water quality parameters were within the limits of WHO (1995) except for alkalinity. The sensitivity of Arthropoda to water hardness may indicate that it is a source of bio indicator. Future large scale work on inventorying of macro benthic fauna can shed more light on the effect of water quality on macro benthic invertebrates while also enabling workers to inventory the rich biodiversity of the region.

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Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Adoni, A.D., Joshi, G., Ghosh,K., Chourasia, S.K., Vaishya, A.K., Yadav, M. and Verma, H.G. (1985). Work book on Limnology. Dr. Harishingh Gour Vishwa Vidyalyay, Sagar Publication.

Alheit, J., Mollmann, C., Dutz, J., Kornilovs, G., Loewe, P., Mohrholz, V. and Wasmund, N. (2005). Synchronous ecological regime shifts in the central Baltic and the North Sea in the late 1980s. ICES Journal of Marine Science. 62: 1205-1215.

Alikunhi, K.H. (1957). Fish culture in India. Bulletin of Indian Council of Agricultural Research. 20: 1-150.

APHA. (1985). Standard Methods for Examination of Water and Wastewater, 20th Edition, American Public Health Association, Washington D.C.

Barbour, M.T., Gerristen, j., Synder, B.D. and Stribbling, J.B. (1999). Rapid Bioassessment protocols for use in streams and wadeable rivers. Periphyton, Benthic Macroinvertebrates and Fish, Second edition EPA 842-B-99-002 USEPA, office of water, Washington D.C.

Camargo, J.A., Alonso, A. and De La Puente, M. (2004). Multimetric assessment of nutrient enrichment in impounded rivers based on benthic macroinvertebrates. Environmental Monitoring and Assessment. 96: 233-249.

Cole, G.A. (1975). Text book of limnology. Saint Louis: The C.V. Mosby Company.

Ekau, W., Auel, H., Pörtner, H.-O. and Gilbert, D. Impacts of hypoxia on the structure and processes in pelagic communities (zooplankton, macro-invertebrates and fish), Biogeosciences. 7: 1669-1699.

El-Shabrawy, G.M. and Khalil, M.T. (2003). Macrobenthos of Lake Bardawil and Zaranik Lagoon. A report presented to Nature Conservation Sector, EEAA Med Wet Coast Project, conservation of wetland and coastal ecosystems in the Mediterranean Region, ecological survey of Zaranik Nature Protectorate, GEF, pp. 30.

Hakamata, T., Hirata, T. and Muraoka, K. (1992). Evaluation of land use and river water quality of the Tsukuba Mountains ecosystem, Japan. Catena. 19: 427-439.

ISO, Water quality (1983). Determination of dissolved oxygen, Iodometric method (ISO 5813).

Mutonkole, S.P. (2015). Benthic macroinvertebrates as indicators of water quality: a case-study of urban Funa Stream (in Kinshasa, Democratic Republic of Congo). Open Journal of Water Pollution and Treatment. 2(1): 8-24.

Singh, M.R. and Gupta, A. (2009). Seasonal Variations in certain Physico-Chemical Parameters of Imphal, Iril and Thoubal Rivers from Manipur River System, India. Ecology, Environment and Conservation. 16(2): 197-207.

Siraj, S., Yousuf, A.R., Bhat, F.A. and Parveen, M. (2010). The ecology of macrozoobenthos in Shallabugh wetland of Kashmir Himalaya, India. Journal of Ecology and The Natural Environment. 2(5): 84-91.

Temjen, W. and Singh, M.R. (2018). Analysis of some selected physico-chemical properties of water from milak river, Mokokchung, Nagaland. Pollution Research. 37(1): 197-204.

Trivedy, R.K. and Goel, P.K. (1986). Chemical and biological methods for water pollution studies, Environmental Publication, Karad, Maharashtra.

Uehlinger, U., König, C. and Reichert, P. (2000). Variability of photosynthesis irradiance curves and ecosystem respiration in a small river. Freshwater Biology. 44(3): 493-507.

Verma, S.R. and Shukla, G.R. (1969) Pollution in a perennial stream, Khala Laksar, Shaharanpur, India. Environmental Health. 11: 145-162.

Vijaykumar, K., Holkar, D. and Kaur, K. (1999). Limnological Studies on Chandrampalli Reservoir, Gulbarga. In: Freshwater Ecosystems of India (Ed. K. Vijayakumar). Delhi: Daya Publishing House. pp. 59-108.

Wetzel, R.G. (1983). Limnology, 2nd Ed. New York: Saunders College Publishing Co. pp. 767.

Wetzel, R.G. (2001) Limnology-Lake and River Ecosystems. San Diego: Academic Press. pp.1006.

World Health Organization (WHO) (1998). Guidelines for drinking water quality. 2nd Ed. Geneva. ISBN 9241545143:36.