International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Assessment of Water Quality of Lungding Stream through Biomonitoring

Nilu Paul[1], A. K. Tamuli[2], R. Teron[3], J. Arjun[4]

[1]Department of Zoology, Lumding College, Lumding, Assam, India

[2]Department of Life Science and Bioinformatics, Assam University Diphu Campus, Diphu, Assam, India

[3]Department of Life Science and Bioinformatics, Assam University Diphu Campus, Diphu, Assam, India

[4]Department of Zoology, Lumding College, Lumding, Assam, India

Abstract: ***Stream ecosystem biomonitoring has been widely used to assess the status of water. It provides information on the health of an ecosystem based on which organisms live in a waterbody. The benthic community is dependent on its surrounding and therefore, it serves as an indicator that reflects the overall condition of the ecosystem. Among the commonly used biomoniting approaches, biotic indices and multimetric approaches are most frequently used to evaluate the environment health of streams and rivers. The macro invertebrate fauna and physico-chemical parameters of Lungding stream of Dima Hasao district were studied seasonally from March 2017 to February 2018. A total of 13 species of benthic invertebrate fauna belonging to three phyla (Annelida, Arthropoda and Mollusca), five classes (Hirudinea, Gastropoda, Bivalvia, Crustacea, Insecta) and thirteen families (Hirudinidae, Physidae, Anomidae, Gammaridae,Panaediae, Baetidae Aeshnidae, Belostometidae, Hydrophilidae, Chaoboridae, Chironomidae) were found in the Lungding stream during the study. Gastropoda was predominant (23.71 %) followed by Crustacea, Bivalvia and Hirudinidae with percentage composition of 19%, 16.59% and 11.42% respectively. Among Insects, Dipteran midges (Chaoboridae) with 8.84% were the dominant group. Macroinvertebrates tolerance values ranged between 4 and10 and family biotic index values between 7.64 and 8.15.***

Keywords: Lungding stream, Macroinvertebrate index, Macroinvertebrate tolerance value, Water quality.

1. Introduction

The "biological monitoring" has been widely used to assess the environmental impact of pollutant discharges. Bio-monitoring is a valuable assessment tool that is receiving increased utility in water quality monitoring programs of all types (Kennish, 1992). In general, out of total land water 1% is available for agriculture, domestic, power generation, industrial consumption, transportation and waste disposal (Mishra *et al*., 2002, Gupta *et al.*, 2007). Although Dima Hasao, a hill district in Assam is relatively free from pollution as there are no major industries in the district, mining activities and organic pollution due to household generated waste materials gradually polluting in certain areas. Lungding stream of Dima Hasao district is a tributary of Diyung river. People living near the river directly pollute the water by taking bath, washing clothes, vehicles and utensils in it. All the domestic sewage, industrial effluents and solid waste find its way to this stream via channels which may affect the quality of water and create health problems, (Raja *et al*., 2002). The physical and biological characteristics of water determine the quality of water (Diersing, *et al*., 2009). Salinity, HCO_3, pH, depth, water temperature are responsible for variations in phytoplankton community (Sharif *et al*., 2017). In eastern Himalayan lotic ecosystem of different environmental factors anthropogenic and other factors may be considered as components of pollution, (Chowdhury *et al*., 2017). There is a direct interrelation between physicochemical and biological parameters (Kaur 2017). Water velocity is also an important factor affecting aquatic fauna, (Singh *et al*., 2017). Macroinvertebrates and water quality are interrelated to each other, as macroinvertebrates are a potential indicator of water quality (Sharma and Rawat, 2009). Such organisms have specific requirements in terms of physical and chemical conditions. Changes in presence/absence, numbers, morphology, physiology or behaviour of these organisms can indicate that the physical and/or chemical conditions are outside their preferred limits (Rosenberg and Resh, 1993). Presence of numerous families of highly tolerant organisms usually indicates poor water quality (Hynes, 1998). Statistical analysis of such variants must play a more important role in biological monitoring because they are capable of explicit statement of confidence in the biological monitoring results. Present study has been conducted to assess the water quality of the selected streams using macroinvertebrates as the biomonitoring agent.

2. Materials and Methods

Study area

The study area is Manderdisha of Dima Hasao district, Assam.

Selected stream is Lungding hill stream.

The area Mandardisa, is a hilly tarain of Dima Hasao district (anciently Mikir Hills), Assam. It is situated adjacent to Lumding (a railway divisional town) of Nowgong district of Assam. The area is situated on the Barail Hill range, Assam at an altitude of about 960 mts. The area covers 20 sq. km. of N.C. Hills. Latitude and Longitude of Lungding stream are 25˚42′26″N 93˚7′23″E respectively.

For study and data collection, Lungding stream segment was divided into two parts-up and down stream with a length of 8 km. The selected parameters viz. air temperature, water temperature , current velocity, transparency, conductivity,

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

pH, Free CO_2 , alkalinity, D.O. were studied on seasonal basis. The stretches were demarcated into five sampling stations viz: S_1, S_2, S_3, S_4 and S_5.

Details of sampling sites

Sampling site	Name of the station	GPS position
S_1	Lunding I	25°42′26″N 93°7′23″E
S_2	Lungding II	25°26′25″N 93°6′20″E
S_3	Lungding III	25°28′35″N 93°9′23″E
S_4	Lungding IV	25°26′30″N 93°8′20″E
S_5	Lungding V	25°30′27″N 93°7′25″E

Figure 1: Sampling sites with GPS Coordinates

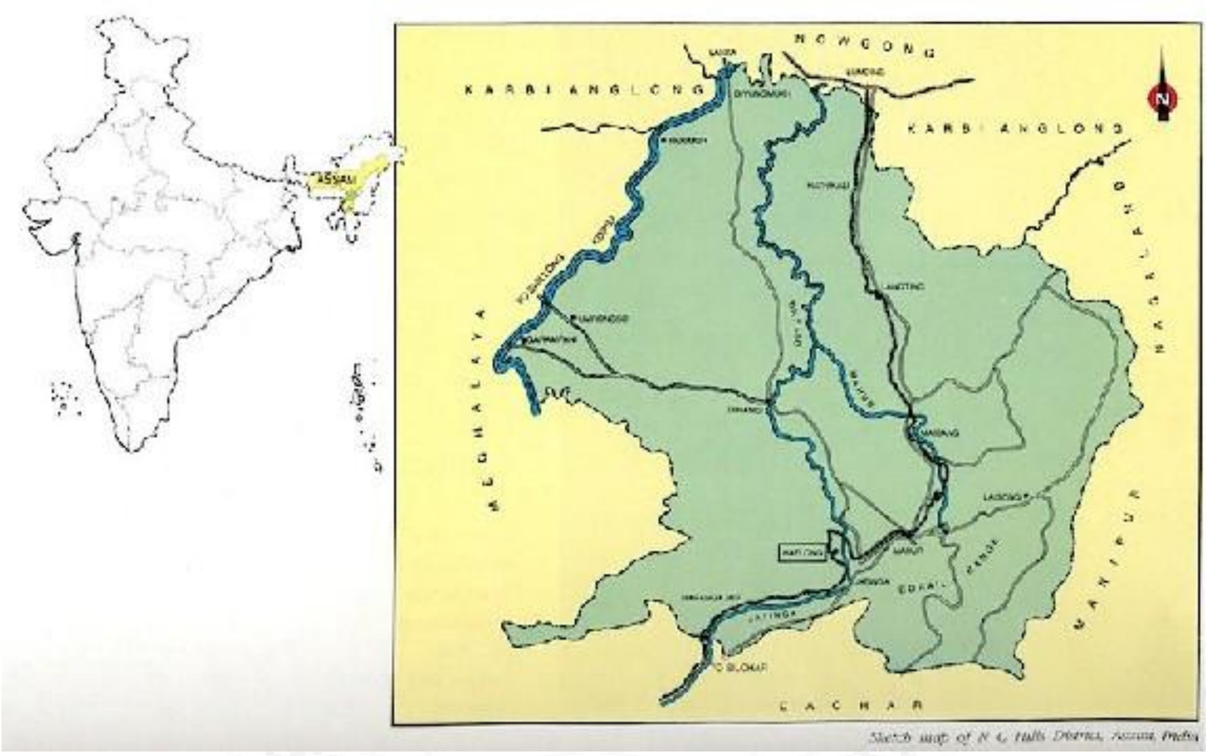

Figure 2: Dima Hasao District map

Figure 3: Location of the sampling sites

Physical features of instream and river banks:

Longitude, latitude of each station was measured with the help of GPS and the geomorphology of the in stream and riparian habitats of the studied sites were recorded (Table-1).

Physico-chemical parameters

Water samples were collected seasonally from March 2017 to February 2018 and certain physicochemical parameters were measured and recorded (some on the spot and some in the laboratory). At each sampling location, composite surface water was collected at the middle of river and stored in clean sampling bottles. Water temperature, pH, depth, transparency, water current, conductivity was determined and recorded in the field, because of their unstable nature. Water temperature was recorded by mercury thermometer, transparency with secchi disc, pH with pen type pH meter (model Hanna; HI96107), conductivity with pen type conductivity meter (Hanna; HI96303) and water current by flow mate. The laboratory analysis of the samples was done using standard methods (APHA, 1998). Alkalinity and free CO_2 was determined by titration method. Dissolved oxygen (DO) was determined by Winkler's modified method.

Macroinvertebrates Assessment:
Benthic macroinvertebrates were collected from each sampling sectors using drag nets and preserved on sites in 70% ethyl alcohol and identified as suggested by Pennak (1989) and Edmondson (1993). The densities of abundant species were analysed for each of the sampling stations using the formula:

D = n/ A, where D= Density; n= total number of macroinvertebrates sampled; A= area of sampling unit. To evaluate the water quality and diversity in the river, biotic index i.e. FBI (Family Biotic Index) was used.

FBI was calculated using the equation: FBI=$\sum xi.t_1$ /n, (Plafkin *et al*., 1989, Barbour *et al*., 1999) where x_i= no. of individuals in the i th taxon ti= tolerance value of the ith taxon and n= total no of organisms in the sample. Tolerance which has been used in the calculation of FBI is a listing of tolerance values that range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant of organic wastes. These values have been taken from standard protocols provided by Hilsenhoff 1987.

3. Result

The geomorphological features of the surveyed stations have been given in Table 1.

Seasonal variations of these factors from different sampling sites have been given in Tables- (2, 3, 4 and 5). The mean physico-chemical values for air temperature (ºC), water temperature (ºC), current velocity (m/s), transparency (cm), conductivity (µs/cm), pH, free CO_2 (mg/l) , alkalinity (mg/l), D.O (mg/l) were found to be 22.8ºC, 21.4ºC, 1.34 m/s, 116.5cm, 111.14µs/cm, 7.48, 3.44mg/l, 55.56mg/l, 10.8mg/l respectively, during Mar-May (pre-monsoon). During Jun-Aug (monsoon), the mean values for the above physicochemical parameters were 31.6ºC, 29.14 ºC , 2.32m/s, 26.6cm, 176.42µs/cm, 7.54, 4.52mg/l, 60.26mg/l, 8.48mg/l respectively, during Sep-Nov (post-monsoon), the values were 26.16ºC, 23.6 ºC, 0.264m/s, 54.66cm, 181.2µs/cm, 7.72, 5.12mg/l, 79.9mg/l, 10.2mg/l respectively and during Dec.-Feb (winter), 9.9ºC, 9.4 ºC, 0.575,m/s, 138.5107.8cm, 107.82µs/cm, 7.7, 2.5875mg/l, 52.7mg/l, 11.18 mg/l respectively.

Macroinvertebrate species collected durimg the study with their densities is shown in Table - 6. A total of thirteen (13) species (*Rhynchobdella* sp, *Physella* sp, *Soletelina* sp, *Gammarus* sp, *Fenneropeneus* sp, *Isotomus* sp, *Caenius* sp, *Gomphus* sp, *Lethocerus* sp, *Hydrophylus* sp, *Chaobarus* sp, *Chironomus* sp) of benthic invertebrates' fauna belonging three (3) phyla (Annelida, Mollusca, Arthropoda), five (5) classes (Hirudenea,Gastropoda, Bivalvia, Crustacea, Insecta.) and thirteen (13) families (Hirudinidae, Physidae, Anomidae, Gammaridae, Panaediae, Isotomidae, Caenidae, Gomphidae, Belostometidae, Nepidae, Hydrophilidae, Chaoboridae, Chironomidae) were found in the study. Table 6 shows the total number of families, species and percentage composition of the macro invertebrate fauna in the study area. In the table, we saw that class - Gastropoda occur predominantly (23.71%) followed by Crustacea, Bivalvia and Hirudinea.

Tolerance and Family biotic index values are summarized in the Table: 6 and Table: 7 respectively. Tolerance values of macroinvertebrates were found between 4 and10. Hirudinea and Collembola showed the highest (10) , followed by Gastropoda, Bivalvia, Decapoda and Diptera (8) and Amphipoda, Odonata, Hemiptera, Coleoptera, (4 and 5 respectively) showed the lowest tolerance values.

Among the taxa the highest community was contributed by pollution tolerant taxa like Gastropods, Bivalvia, Decapoda (prawns) and Diptera (midges). Gastropods were recorded in greater number as shown in Table 6. Sensitive species were reported to be less in all the sectors. The FBI value obtained in the investigation reflects the poor water quality in all the stations of the studied stream.

4. Discussion

Temperature is a vital parameter for growth of organisms and physicochemical behavior of biotic components of aquatic ecosystem. The water temperature showed a declining trend from August to November in different sectors. The seasonal variation showed that the water temperature followed the seasonal pattern of ambient temperature fluctuation. Reduction in transparency in the rainy wet period is due to the addition of eroded soil of riverbank and run off from the catchment areas. The rain water brought large amounts of dissolved and suspended inorganic and organic materials that made water turbid and cause lower transparency in the rainy months (Sawant *et al*.,2010, Timms and Midgley,1970). pH of a water body is very important indicator of water quality (Facayode, 2005). Assessed data on pH of the water of different sectors of the stream was found in between neutral to alkaline range throughout the study period. The pH of an aquatic ecosystem is important because it is closely linked to biological productivity. Although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate good water quality (Baruah and Hazarika, 2011). At the same time, dissolved oxygen (DO) content plays a vital role in supporting aquatic life and is susceptible to slight environment changes. DO has been extensively used as a parameter of delineating water quality and to evaluate the degree of freshness of a river (Fakayode, 2005). Variation in DO values (8.48 – 11.18 mg/lit) is with higher value in winter. Those are unable to withstand in heavy water current during rainy wet season which synthesized and provides oxygen for the aquatic life. The value of free CO_2 was found to be inversely proportional to that of D.O. Free CO_2 value during wet period indicated reduction in photosynthesis resulting in lower oxygen concentration levels and high carbon dioxide levels. The FCO_2 data represents the positive balance between producer and consumer in the river system. Alkalinity of water is a measure of weak acid present in it and of cations balanced against them (Sverdrap et al, 1942). Similarly, total alkalinity of the river ranged between 52.7 and 79.9 mg/l, minimum during dry seasons and maximum during rainy seasons. Tolerance values of macroinvertebrates obtained in the investigation reflects their tolerance limit to their aquatic habitat and it also indicated a strong relationship between the physico-chemical parameters of water and the distribution of organisms in the Lungding stream. This is an indication of the ability of the organisms to survive, adapt, migrate or die under favorable and unfavorable environmental conditions as was also reported by Tyokumbur *et al*., (2002). Similar trends in the correlation between the physico-chemical quality and the distribution of organisms have been reported by many scientists such as Ebele (1981), Ajao and Fagade (1990), Matagi (1996) and Ogbogu (2001). Most of the macroinvertebrates collected during the present study were found to be pollution tolerant species. Thus abundance of such species indicates the introduction of organic pollutants to the stream. Assessment of water quality by using Family biotic index of macroinvertebrate reveals the poor water quality in all the stations of the studied Lungding stream.

Table 1: Geomorphological features of Lungding stream

	Surveyed stations				
Parameters	Station I	Station II	Station III	Station IV	Station V
Width(m)	12	18	20	16	15
Depth(m)	1.8	2.7	3.8	4.2	3.2
Valley reach	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial
Reach type	Riffle	Riffle	Pool	Riffle	Riffle
Substrate	Sandy	Sandy	Sandy	Sandy	Sandy
Bank type	Erosion prone area. U-shaped bank; R-village area L-human habitation	Erosion prone area. U-shaped bank; R-village area L-human habitation	Erosion prone area. U-shaped river bank; R- village area L-Human habitation	Erosion prone area. U-shaped river bank; R- village area L-Human habitation	Erosion prone area. U-shaped river bank; R-village area L-Human habitation.
Riparian vegetation	Grass, trees, plantains	Grass,shrubs, plantains	Grass,shrubs, plantains	Grass, shrubs, trees, bamboo	Bamboo, trees.

Table 2: Physicochemical parameters of the Lungding stream during pre- monsoon (March-May):

Parameters	Surveyed stations					
	Station 1	Station II	Station III	Station IV	Station V	Mean±S.D.
Air temperature (ºC)	20	22	22	24	26	22.8±2.280351
Water temperature (ºC)	22	20	22	20	23	21.4±1.341641
Current velocity (m/s)	1.1	1.2	1.6	1.5	1.3	1.34±0.207364
Transparency (cm)	94	97.2	170.2	100.5	120.6	116.5±31.76177
Conductivity (µs/cm)	110.2	116.3	115.2	109.5	104.5	111.14±4.763717
pH	7.0	7.6	7.8	7.2	7.8	7.48±0.363318
Free CO_2 (mg/l)	3.6	3.4	3.2	3.4	3.6	3.44±0.167332
Alkalinity (mg/l)	57.2	54.3	55.1	54.3	56.9	55.56±1.402854
D.O. (mg/l)	10.2	11.2	11.4	10.5	10.7	10.8±0.494975

Table 3: Physicochemical parameters of the Lungding stream during monsoon (June-August):

Parameters	Surveyed stations					
	Station 1	Station II	Station III	Station IV	Station V	Mean±S.D.
Air temperature (ºC)	30	32	34	30	32	31.6±1.67332
Water temperature (ºC)	28	30	28	30	29.7	29.14±1.04785
Current velocity (m/s)	2.2	2.2	2.3	2.5	2.4	2.32±0.13038
Transparency (cm)	24.9	25.6	27.5	28.2	26.8	26.6±1.35092
Conductivity (µs/cm)	150.5	180.6	186.6	180.2	184.2	176.42±14.7289
pH	7.5	7.2	7.6	7.8	7.6	7.54±0.21908
Free CO_2 (mg/l)	5.8	3.6	3.8	4.2	5.2	4.52±0.94445
Alkalinity (mg/l)	60.1	58.2	61.2	60.4	61.4	60.26±1.27200
D.O. (mg/l)	8.4	8.6	8.3	8.2	8.9	8.48±0.27748

Table 4: Physicochemical parameters of the Lungding stream during post-monsoon (Sept.-Nov):

Parameters	Surveyed stations					
	Station 1	Station II	Station III	Station IV	Station V	Mean±S.D
Air temperature (ºC)	25	25.8	25	29	26	26.16±1.651666
Water temperature (ºC)	24	22	23	24	25	23.6±1.140175
Current velocity (m/s)	0.36	0.23	0.28	0.24	0.21	0.264±0.059414
Transparency (cm)	54.5	54.2	53.6	56.8	54.2	54.66±1.240161
Conductivity (µs/cm)	180	176	178	190	182	181.2±5.403702
pH	7.5	7.8	7.5	7.6	8.2	7.72±0.294958
Free CO_2 (mg/l)	5.5	4.9	5.2	5.1	4.9	5.12±0.248998

Alkalinity (mg/l)	80	80.5	78.2	80.2	80.6	79.9±0.979796
D.O. (mg/l)	9.25	10.60	8.92	11.5	10.8	10.214±1.089716

Table 5: Physicochemical parameters of the Lungding stream during winter (Dec.-Feb.):

Parameters	Surveyed stations					
	Station 1	Station II	Station III	Station IV	Station V	Mean±S.D.
Air temperature (ºC)	8.2	7.7	11	8.5	12.4	9.9±2.180214
Water temperature (ºC)	9.9	8.2	10.5	9.5	10,2	9.4±0.974252
Current velocity (m/s)	0.3	0.6	0.7	0.5	0.5	0.575±0.148324
Transparency (cm)	140	131	135	142	146	138.5±5.890671
Conductivity (µs/cm)	103.6	110.3	106.4	110.1	104.5	107.82±3.10918
pH	7.8	8.2	7.6	7.3	7.7	7.7±0.327109
Free CO_2 (mg/l)	3.5	3.69	2.56	2.4	3.3	2.9875±0.576455
Alkalinity (mg/l)	54.1	50.1	53.3	54.1	53.3	52.7±1.658915
D.O. (mg/l)	12.1	11.55	10.5	12..2	11.5	11.183±0.666302

Table 6: Macroinvertebrate taxa of Lungding stream with their relative densities and tolerance level

Taxa	Class	Family	Species	Density					Tolerance level
				I	II	III	IV	V	
Annelida	Hirudinea	Hirudinidae	*Rhynchobdella* sp.	21	10	5	12	5	10
Mollusca	Gastropoda	Physidae	*Physella* sp.	16	25	24	22	23	8
	Bivalvia	Anomidae	*Soletelina* sp.	7	9	6	10	45	8
Arthropoda	Crustacea	Gammaridae	*Gammarus* sp.	1	4	0	1	0	4
		Penaediae	*Fenneropenae indicus*	20	9	20	22	12	8
	Insecta	Isotomidae	*Isotomurus* sp.	0	1	2	0	0	10
		Caenidae	*Caenis* sp.	0	5	5	2	1	7
		Gomphidae	*Gomphus* sp.	5	7	8	5	5	5
		Belostometidae	*Lethocerus* sp.	2	2	3	4	1	5
		Nepidae	*Ranatra* sp.	0	0	1	0	0	5
		Hydrophilidae	*Hydrophilus* sp.	1	2	2	0	1	5
		Chaoboridae (midges)	*Chaoborus* sp.	15	10	10	5	1	8
		Chironomidae	*Chironomus sp.*	5	10	5	8	1	8

Table 7: Family Biotic Index (FBI) of Lungding stream

Station	FBI Value	Water Quality	Degree of organic pollution
I	8.15	Poor	Very substantial pollution likely
II	7.66	Poor	Very substantial pollution likely
III	7.64	Poor	Very substantial pollution likely
IV	7.90	Poor	Very substantial pollution likely
V	7.87	Poor	Very substantial pollution likely

References

[1] APHA (American Public Health Association), 1998 Standard methods for the examination of water and waste water, 20th ed., American Public Health Association, Washington, DC., USA

[2] Barbour, M. T., J. Gerritsen, B. D. Snyder & J. B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C

[3] Baruah D, Hazarika LP. Present environmental and biodiversity status of the downstream of Subansiri river basin riparian zone and forest: A pre impact assessment of the 2000 MW lower Subansiri dam. FTR (F No33- 137/207(SR)-2008) submitted to, UGC, New Delhi, 2011.

[4] Choudhury, Gangopadhya, Home Choudhury (2017). Understanding maemopoesis or survival strategy in two characteristic fi shes inhabiting hill stream. Journal of Environmental Bullet Vol 10 4 58-67

[5] Clarke, R.T., Furse, M.T., Gunn, R.J.M., Winder, J.M. and Wright, J.F. (2002) Sampling Variation in Macroinvertebrate Data and Implications for River Quality Indices. Freshwater Biology, 47, 1735-1751. http://dx.doi.org/10.1046/j.1365-2427.2002.00885.x

[6] Ebele, S., 1981. Ecological factors affecting the distribution of freshwater snails of medical and veterinary importance in Zaria city, Nigeria. M.Sc. Thesis, Department of Biological Science, Amadu Bello University, Zaria,: 196p.

[7] Edmondson, W.T.: Ward and Whipple's Fresh Water Biology, 2nd Edn. Johan Wily and Sons, New York (1993).

[8] Fakayode S. O., (2005). Impact of industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria, Ajeam-Ragee, 10, 1–13.

[9] Gupta V, Agarwal J, Sharma S (2008). Adsorption Analysis of Mn (VII) from Aqueous Medium by Natural Polymer Chitin and Chitosan, Asian J of Chem 20(8):6195-6198

[10] Hilsenhoff, W.l.1987 An improved biotic index of organic stream pollution, great lakes Entomol, 20: 31-39

[11] Hynes, H.B.N. 1998. Benthic macroinvertebrate diversity and biotic indices for Monitoring of 5 urban and urbanizing lakes within the Halifex Regional Municipality (HRM), Nova Scotia Canada. Soil and water conservation society of matro halifex xiv, 114

[12] Kaur S.(2017). Biodiversity of River Ganaga at Har Ki Pauri, Haridwar. Journal of current trends of science. 9 (2), 273- 278

[13] Kennish, M. J. 1992. Ecology of estuaries, anthropogenic effects. CRC Press Boca Raton

[14] Matagi, S.V., 1996. The effect of pollution on benthic macroinvertebrates in a Ugandan stream. Arch. Hydrobiol., 137: 537-549.

[15] Ogbogu, S.S., 2001. Assessment of water quality and macroinvertebrates abundance in Opa-stream Reservoir system, Ile-Ife. Glob. J. Pure Appl. Sci., 17(3): 517-521.

[16] Pennak, R. W. 1953. Freshwater Invertebrates of United States, John Wiley, NewYork 2nd Edn.

[17] Pennak R.W:1989 Fresh invertebrates of the United states; Protozoa to Mollusca, John Wiley and Sons; INC

[18] Plafkin, J. L., Barbour, M. T., Porter, K. D., Gross, S. K., and Hughes, R. M. 1989. Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates Fish. U.S. Environmental Protection Agency.

[19] Raja, R.E, Sharmila L, Merlin P, Christopher G (2002). Physico-Chemical Analysis of Some Groundwater Samples of Kotputli, Kolahpur, and Maharashtra N Env Pollut. Tech,9(2),273- 278

[20] Rosenberg, D.M. 1998. A National Aquatic Ecosystem Health Program for Canada: We should go against the flow. Bull. Entomol. Soc. Can. 30(4):144-152.

[21] Rosenberg, D. M. and Resh, V. H. (eds.) 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, New York. 488p.

[22] Sawant, R.S.' Telave, A.B., Desai, P.D. and Desai,J.S. 2010: variation hydrobiological characters of Atyal pond in Gadhinglaj Tahsil, Kolahpur, and Maharastra Nat. Env. Pollut. Tech, 9(2), 273-278.

[23] Sharif SM, Islam. S, Haqne N. Bhayan S (2017) Spatial and temporal environmental environmental effect of lower Meghna river and its estuary on Phytoplankton: Int. Journal of fauna and biological studies. (2),273-278

[24] Singh D. Ahmed R Gupta S Bartual. M. Joshi M (2016) Physiological profi le and benthos of River Giri up and down stream Giri Barrage in Renuka Sermour. (HP). Research gate

[25] Sharma, C. and J.S. Rawat: 2009 Monitoring of aquatic macroinvertebrates as bioindicator for assessing the health of wetlands: A case study in the central Himalayas, India. Ecological Indicators, 9, 118-128 .

[26] Singh D. Ahmed R Gupta S Bartual. M. Joshi M (2016) Physiological profi le and benthos of River Giri up and down stream Giri Barrage in Renuka Sermour. (HP). Research gate

[27] Sverdrup, H.H; Johnson,M.W; Fleming,R.H. 1942. The Oceans; their physics, chemistry and general biology. Prentice Hall, New York

[28] Timms,B.V. and Midgley, S.H.1970: The limnology of Bormuda dam. Queensland. Proc. Royal Society of South Africa, 3920:37-42.

[29] Trivedy, R. K., P. K. Goel & C.L. Trisal (1987). Practical Methods in Ecology and Environmental Science.Enviro Media Publication, Karad (India).340 p.

[30] Tyokumbur, E.T., T.G. Okorie and O.A. Ugwumba, 2002. Limnological assessment of the effects of effluents on macroinvertebrates fauna in AWBA stream and Reservoir, Ibadan, Nigeria, The Zoologist, 1(2): 59-69.

[31] Welch, P.S. 1952: Limnology, McGrew Hill Book Company, Inc., New York.