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Macrozoobenthic Community as Biological Indicators of Pollution in river Jhelum, Kashmir

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Abstract:

A detailed limnological study of the River Jhelum, Kashmir was conducted during February 2011 to July 2011. Six study sites were selected for the collection of samples. The physico-chemical parameters of water and population density of three phyla viz, Arthropoda, Annelida and Mollusca were determined. The ionic composition of water of the River varied in close relationship with the catchment pattern of the concerned water body. The River Jhelum receiving all sorts of allochthonus material from the catchment had the highest conductivity. The water of the River was well buffered with pH > 7. A total of 21 taxa of macrozoobenthos were recorded from the system. Arthropoda was most dominant group constituting 54.7%, followed by Annelida 28.9% and Mollusca contributed 16.4% of total macrozoobenthos . The hard and stony bottomed sites were dominated by insects belonging to orders Ephemeroptera, Tricoptera and Diptera. Significant changes in macrozoobenthic communities were primarily due to changes in water quality. As elsewhere, macrozoobenthic communities proved to be good indicators of water quality and should be used as bioindicators in long-term monitoring of this river.

Keywords: Bioindicators, Macrozoobenthic community, River Jhelum, Water quality.

1.0 Introduction:

The River Jhelum is one of the main tributaries of the Indus River and is the longest River of Kashmir valley originating from Pir Panjal range of mountains. The water of River Jhelum is used for irrigation, drinking, bathing and also provides food and sport fishing. Human induced hydrological changes, physical disturbances (habitat alteration and urban land use) and point and nonpoint sources of pollution (chemical contamination, surface runoff and intensive agriculture) are examples of processes responsible for a broad-scale deterioration of lotic ecosystems (Chatzinikolaou *et al*., 2006).

Macrozoobenthic invertebrates are a ubiquitous and diverse group of long lived species that react strongly and often predictably to human influences in aquatic ecosystem. The abundance of benthic fauna greatly depends on physical and chemical properties of the substratum. Macrozoobenthic invertebrates can be used as a barometer of overall biodiversity in aquatic ecosystems. Macrozoobenthic invertebrates are an important and integral part of any aquatic ecosystem as they form the basis of the trophic level and any negative effects caused by pollution in the community structure can in turn affect trophic relationships. These can include those that feed on them directly or indirectly such as fish and bird populations, respectively. In addition, aquatic invertebrates have the ability to clean rivers as they utilize the organic and detritus matter. Macrozoobenthic invertebrate populations in streams and rivers can assist in the assessment of the overall health of the stream (Carlisle *et al*., 2007). River Jhelum flowing from south to northeast direction and thus, receives different pollutants. The pouring of wastes contaminates the river and decreases biodiversity. Macrozoobenthic invertebrate communities change in response to changes in physicochemical factors and available habitats (Sharma *et al*., 2011). Realizing their immense importance, several workers have attempted to study the diversity of macrozoobenthic invertebrates in aquatic ecosystem in lotic water bodies of Kashmir (Yousf *et al*., 2006). The present study lays emphasis to find the pollution status of River Jhelum intriguing macrozoobenthic invertebrates inhabiting there, So that the results obtained can make an effective contribution to holistic studies in the riverine management.

1.2 Study Area:

River Jhelum originates from the Pir Panjal Range of mountains. The Jhelum flows through the Valley of

Kashmir in north westerly direction till it falls into the Wular lake near Banyari village in Baramulla District. After its re-emergence from the Wular near Ningli in Sopore, it takes a south westerly direction, leaves the valley through a gorge near Baramulla, then continues its journey. In order to have a true picture about the limnological characteristics of the River Jhelum. Six study sites were selected for the present study. Site I (Verinag spring), Site II (Khanabal), Site III (Wair), Site IV (Chanakha), Site V (Khujabagh), Site VI (Ganantamulla).

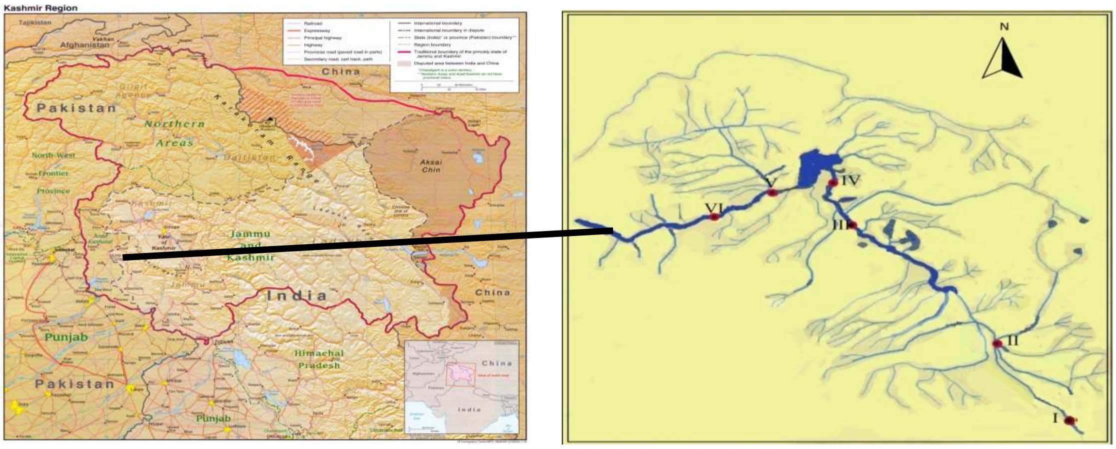

Fig1: Location of sampling zones in the River Jhelum

2.0 Materials and Methods:

2.1 Physico-chemical parameters:

The variation of the Physico-chemical factors of water were studied from February 2011 to July 2011. Monthly samples were collected from the river by dipping one litre polythene bottle just below the surface of water. Water temperature and Air temperature were recorded on the spot by using mercury thermometer. pH of the water was determined by using a portable pH meter. Conductivity was determined by using a conductivity meter. For the estimation of Dissolved oxygen, water samples were collected in glass bottles and fixed at the sampling sites in accordance with Winklers method (A.P.H.A,1998). Free Co_2, hardness, alkalinity and chloride were determined by titrimetric methods (Mackereth, 1978).

2.2 Macrozoobenthos:

For collection of macrozoobenthic invertebrates , sediment samples were collected from six different sampling sites using Ekman dredge having an area of 225cm^2. The sediment sample were sieved and benthic organisms retained in the sieve were picked with the help of forceps and then preserved in 4% formalin. Benthos sampling was done on monthly basis. Preserved samples were then identified according to standard works (Edmondson, 1959, Pennak, 1978, Adoni, 1985 and Tonapi, 1980). The abundance of these organisms was calculated as number per square meter by applying the following formula:

$N = O/A.S \times 10,000$ (Welch,1948)

Where,

N = No. of macrozoobenthic organisms/m^2.

O = No. of organisms counted.

A = Area of sampler in square meter.

S = No. of samples taken at each stations.

3.0 Results and Discussion:

3.1 Physico chemical parameters:

The physico-chemical characteristics of water have a great role over the distribution and abundance of living organisms. Considerable seasonal variations in respect of certain physico-chemical parameters and macrozoobenthic invertebrate population in the river were observed and are represented in (Tables 1, 2, 3, 4 and 5). During the period investigation, the air temperature of the river ranged between a minimum mean value of 21 ^oC (S.D-6.8) at sites I, II,VI and maximum mean value 22 ^oC (S.D-6.9) at sites III, IV and V. The water temperature showed close relationship with the air temperature and ranged between a minimum mean value of 11 ^oC (S.D-1.1) at site I and maximum mean value 17 ^oC (S.D- 5.7) at sites III, IV, V and VI. In general, the seasonal increase or decrease of water temperature is related to the variation in the atmospheric temperature in different seasons of the valley.

The ionic composition of water varied in close relationship with the catchment characteristics of the concerned water body. While the site I recorded the highest conductivity, with a mean value of 360 µS/cm (S.D-71.27). Higher conductivity at site I (Verinag spring) is attributed to the more time for water to interact with the host rock (Jeelani, 2007). The Jhelum receiving all sorts of allocthonus material from the catchment and having diversified catchment had also the highest conductivity mean value 308 µS/cm (S.D- 37.63) at site VI. The increase in the conductivity values at site VI showed a close relationship with the human activity in the catchment of the concerned water bodies. The water of the whole river system was well buffered and pH> 7 was recorded at all the study sites. The mean value of pH calculated for the investigated water body showed on alkaline trend ranging from minimum 7.4mg/l (S.D-0.20) at site I and to maximum 8.3mg/l (S.D- 0.77) at site II and V during the study period. pH is principally a function of amount of Ca, Mg, Carbonate and Co_2 in the water. The lower pH of the River Jhelum clearly indicates that the impact of the domestic sewage on the water as the decomposition of the organic matter results in the decrease in the pH value and increase in the Carbon dioxide and bicarbonate content of the water. The alkalinity of the river Jhelum ranged from a minimum mean value 113.3mg/l (S.D-56.45) at site VI and maximum mean value 165mg/l (S.D-20.43) at site III. Alkalinity was mainly due to bicarbonates of Calcium and Magnesium. Higher alkalinity during summer months at all the sites might possibly be due to dilution owing to huge accumulation of water. Carbon dioxide is an important component of the buffer system in the river. The carbon dioxide ranging from a minimum mean value of 6mg/l (S.D-3.34) at site II and III and maximum mean value 32.1mg/l (S.D-9.17) at site I. Streams rich in carbon dioxide were comparatively less alkaline and a decrease in its concentration resulted in an increase in alkalinity. Large amount of Carbon dioxide in springs is due to exposure of organic matter and bacterial respiration in the soil (Hynes 1979). The Total Hardness of the River Jhelum ranged between a minimum mean value of 67.6mg/l (S.D-14.61) at site I to a maximum mean value of 155mg/l (S.D-62.20) at site v. Fluctuation of Hardness may be due to the addition of domestic sewage which cause sudden change in the values of hardness.The hardness of the water seemed to be influenced by the anthropogenic activity in the catchment area (Yousuf *et al*. 2006). Calcium hardness recorded between a minimum mean value of 38.6mg/l (S.D-14.55) at site I and maximum mean value 57.8mg/l (S.D-25.64) at site V. On the other hand, Magnesium hardness depicted highest mean value of 23.5mg/l (S.D-13.44) at site V and lowest of 7.2mg/l (S.D-0.98) at site I. The Dissolved oxygen in the catchment area ranged between a minimum mean value of 6.8mg/l (S.D-1.15) at site V, and a maximum mean value 9mg/l (S.D-0.89) at site I. Presence of relatively high oxygen seems to be a function of good periphytic algal population liberating oxygen during photosynthesis (Reid,1961 and Hynes 1979).The mean concentration of chloride fluctuated between a minimum 10mg/l (S.D-3.31) at site II and a maximum 14.1mg/l (S.D-1.92) at site IV. A comparison of the physicochemical data represented by earlier workers (Vass,1977, Pandit, 2001 and Yousuf, 2006).

Table 1: Mean and standard deviation of the physico-chemical characteristics of water of river Jhelum

Parameter	Mean and Standard deviation					
	Site I	**Site II**	**Site III**	**Site IV**	**Site V**	**Site VI**
Air temperature °C	21±6.86	21±6.38	22±6.93	22±6.77	22±6.77	21±6.40
Water temperature °C	11±1.16	16±4.63	17±5.78	17±5.04	17±4.72	17±4.26
Conductivity (µS/cm)	360±71.27	170±12.82	186.5±13.75	207±39.11	245±54.09	308±37.63
pH	7.8±0.53	8.3±0.77	7.4±0.20	7.7±0.58	8±1.04	7.7±0.29
FCo_2 (mg/l)	32.1±9.17	6±3.34	6±1.89	6.7±4.57	6.6±4.06	6.6±4.06
DO (mg/l)	9.0±0.89	8.5±0.90	7.7±0.70	7.6±0.96	6.8±1.15	7.6±0.76
Total Hardness (mg/l)	67.6±14.61	119.5±67.77	96.6±42.26	146±46.78	155±62.20	113.3±56.45
Calcium (mg/l)	38.6±14.55	41.7±19.43	47.8±25.98	51.8±26.65	57.8±25.64	39.1±19.36
Magnesium (mg/l)	7.25±0.98	11±5.73	9.25±5.56	22.8±11.26	23.5±13.44	17.9±9.35
Chloride(mg/l)	10±3.31	11.7±3.01	12.6±2.91	14.1±1.92	13.16±1.95	12.6±2.91
Alkalinity (mg/l)	145±12.75	156±32.12	165.8±20.43	155.6±21.51	163.6±28.15	113.3±56.45

Table 2: Population density and percentage of macrozoobenthic invertebrates in river Jhelum during the study period

Groups	Total Macrozoobenthic forms	% Age composition
Arthropoda	35420	54.7%
Annelida	18744	28.9%
Mollusca	10560	16.4%

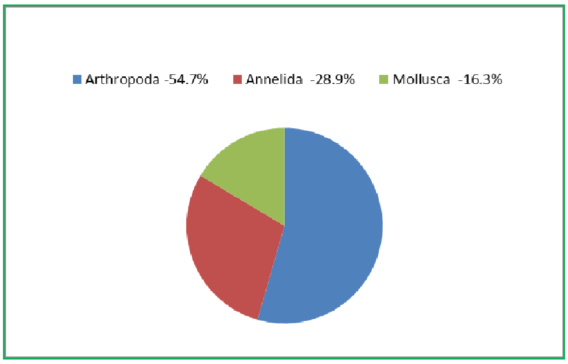

Fig 2: Showing Percent composition of macrozoobenthos inhabiting the River Jhelum during the study period

Table 3: Population density of phylum Arthropoda (ind/m^2) recorded in River Jhelum

S.No.	Species	Site I	Site II	Site III	Site IV	Site V	Site VI
ARTHROPODA							
Order: Ephemeroptera:							
1.	*Baetis sp.*	2684	440	0	0	176	484
2.	*Ecdyonurs sp.*	2068	0	264	264	0	0
3.	*Canis Srinagri*	_	0	17 6	0	264	308
4.	*Epeorus sp.*	308	0	0		264	308
Order: Tricoptera:							
1.	*Hydropsyshae sp.*	352	176	0	0	0	0
2.	*Limnephilus sp.*	1848	0	0	0	0	0
Order: Coleoptera:							
1.	*Elmidae sp.*	352	0	0	0	0	0
Order: Diptera:							
1.	*Simulium sp.*	1100	0	0	484	0	0
2.	*Bezzia sp.*	1496	0	0	0	0	0
3.	*Tiploidy sp.*	132	0	0	0	0	0
4.	*Limnonlli sp.*	880	0	0	0	0	0
5.	*Diamessa sp.*	2552	0	0	0	0	1012
6.	*Chironomous sp.*	_	1144	1012	1716	1012	0
Order: Amphipoda :							
1.	*Gammarus pulex*	3432	1232	1980	1980	1540	1232
Order: Plecoptera:							
1.	*Perilidae sp.*	748	0	0	0	0	0
Total Arthropoda		17952	2992	3432	4444	3256	3344

Table 4: Population density of phylum Annelida (ind/m^2) recorded in River Jhelum

S.NO.	Species	Site I	Site II	Site III	Site IV	Site V	Site VI
ANNELIDA							
Class: Oligochaeta:							
1.	*Tubifex sp.*	176	1540	1848	1232	1540	0
2.	*Limnodrillus sp.*	220	836	1012	528	528	0
Class: Hirudinea:							
3.	*Erpobdella sp.*	1980	1188	1672	1540	1540	1364
Total Annelida		2376	3564	4532	3300	3608	1364

Table 5: Population density of phylum Mollusca (ind/m^2) recorded in River Jhelum

S.NO.	Species	Site I	Site II	Site III	Site IV	Site V	Site VI
MOLLUSCA							
Class: Gastropoda:							
1.	Lymnaea sp.	1452	308	220	792	836	528
Class: Pelecypoda:							
1.	Corbicula sp.	748	176	396	1144	968	484
2.	Promenetus sp.	1056	176	176	1100	0	0
Total Mollusca		3256	660	792	3036	1804	1012
Total macrozoobenthos		**23584**	**7216**	**8756**	**10780**	**8668**	**5720**

3.2 Macrozoobenthos:

A total of 21 species of macrozoobenthos were recorded during the period of present investigation. Arthropoda was the dominant group, comprising 15 species, followed by Annelids with 3 and Mollusca with 3 species. The maximum diversity (19 species) and population density (23584ind/m^2) was recorded at site I and minimum diversity (8 species) and population density (5720 ind/m^2) at site VI (Table 5). In general, the density of macrozoobenthic invertebrates are followed the spatial order as Site I > Site IV > Site III > SiteV > Site II and Site VI . Among these phyla, Arthropoda was the most dominant (54.7%) and was followed by Annelida (28.9%) and mollusca (16.4%) (Table 2) and (Figure 2). At sites where human pressures were present (anthropogenic stress, Municipal sewage and domestic waste) taxa tolerant to pollution, such as Chironomidae, Oligochaeta and Hirudinea increased in abundance, while non-tolerant ones decreased (eg. some Ephemeroptera families).Sensitive Plecoptera taxa were absent from all sites except from site I located on a verinag spring. This change in the benthic composition has already been observed in other river systems, where anthropogenic impacts were most evident. Phylum Arthropoda was represented by class Insecta which was contributed by order Diptera, Tricoptera, Ephemeroptera, Coleoptera, Plecoptera and Amphipoda. The maximum density of insects was (17952ind./m^2) at site I and minimum density was (2992ind./m^2) at site II and at site III, it was (3432ind./m$^{2)}$, at site IV, it was (4444ind./m^2), at site V, it was (3256ind./m^2), at site VI it was (3344ind./m^2) (Table3). Ephemeroptera and Trichoptera do not tolerate organic enrichment (Takeda, 1999). This is confirmed by the present data as the Ephemeroptera and Trichoptera was not present in polluted water but their density was comparatively higher in the upstream as compared to downstream. May fly, Stone fly and Caddis fly in a river is indicative of clean water condition and their absence often denotes a super abundance of organic wastes and low oxygen supply (Gaufin, 1957).

The dipterans in the river Jhelum included *Chironomus sp.* and *Diamessa sp.* Presence of bioindicators and *Chironomous sp.* indicates the effect of pollution. The numerical abundance of *Chironomous sp.* throughout the year indicates the pollution status of the river as chironomids are the common inhabitants of polluted waters, water rich in nutrients and water poor in oxygen (Callisto, 2005, Clemente, 2005, Olomukoro, 2006 and Manoharan, 2006). Phylum Annelida was represented by class Oligochaeta and Hirudinea. The peak oligochaeta was observed at site III due to the presence of numerically abundant *Tubifex sp.* (1848ind/m^2). The maximum density of Annelida was (4532ind/m^2) at site III and minimum density was (1364ind/m^2) at site VI (Table 4). The density of annelids increased in polluted areas. The members of Oligochaeta are usually favored by the organic environment and remain dominant in severally polluted conditions with special emphasis on *Tubifex sp*. which inhabit areas with strong sewage pollution and anoxic waters (Hawkes, 1979). Presence of good organic detritus content contributed the maximum quantity of oligochaetes. Oligochaete communities have been observed in soft depositing substrates rather than stony beds (Bhat *et al.,* 2010). Phylum Mollusca was the minor contribution to the overall population density of macrozoobenthos and was represented by class Gastropoda and class pelecypoda. The maximum density of Mollusca was (3256ind./m$^{2)}$ at site I and minimum density was (660ind./m^2) at site II (Table 5). The occurrence and abundance of mollusca may be due to soft and organically rich bottom, alkaline nature of water and higher concentrations of calcium and bicarbonate alkalinity as has been reported by earlier workers (Aldridge, 2007, Garg *et al*., 2009 and Manoharan, 2006). Amount of sunshine, water quality and amount of aquatic vegetation, depth, temperature, oxygen level and substrate have been suggested to affect the composition and seasonality of macrozoobenthic invertebrates (Dermott, 1985 and Rao, 1985). This all has been found true for all the classes of benthos in a stream as their density showed variation with sites having variation in temperature, Co_2 content, nature of substrate and inorganic and organic load.

4.0 Conclusion:

The river shows 21 species, out of them insects were well dominant at whole study area because of their potency to tolerate the organic pollution. The present study concludes that the presence of some pollution indicator species such as *Tubifex sp. Limnodrilus sp.* among Annelida, *Chironomous sp.* and *Gammarus pulex* among Arhropoda, *Lymnea sp.* and *Corbicula sp*. among Mollusca directly points to the shifting status of the river from non-polluted to polluted. Municipal sewage and domestic waste showed alarming shift or total elimination of sensitive biotic community form the habitat. As the human population continues to grow, it will contribute significantly towards the process of river biodegradation. This bio-survey of the macrozoobenthic invertebrate fauna gives an important insight into the health of the river and appends the knowledge and understanding of the management strategies involving biomonitoring as a significant tool in the river restoration studies.

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