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CHANGES IN WATER QUALITY AND BIOTA OF STREAM BAN GANGA, KATRA (J&K) OVER THE PERIOD OF 22 YEARS (1994-2015).

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ABSTRACT

The present studies were undertaken to analyse the changes in the water quality of Ban Ganga stream over the period of 22 years (1994-2015) with special reference to its physico-chemical parameters and macrobenthic invertebrate fauna. Some of the physico-chemical parameters such as pH, chlorides, FCO_2, bicarbonates, calcium, magnesium and nitrates showed significant increment in their values with the passage of time whereas decrease in the values of DO, speed and sulphates have been recorded. Station wise composition, distribution and numerical abundance of macrobenthic invertebrates clearly reflect that the pollution load in this stream has increased to a greater extent which is the direct outcome of increased pilgrimage load. Thus, the tourism activities must be regulated for the restoration and conservation of this religiously celebrated stream.

KEYWORDS: abundance, composition, macrobenthic invertebrates.

INTRODUCTION

Water is such an indispensible commodity of life without which the existence of life can even not be imagined. Aquatic ecosystems are fascinating as well as complex, comprising of community of organisms that are interdependent on one another and also on their environment. But the deterioration of water quality has become a major concern these days. The various anthropogenic impacts have severely altered the physico-chemical environment of the water which has ultimately affected the biotic fauna to a greater extent. One such religiously celebrated stream that is also facing the problem of its existence is the Ban Ganga stream.

Ban Ganga stream originates from Trikuta Hills which are the abode of "Mata Vaishno Devi Shrine" and flows in District Reasi of Jammu division of J&K. It has strong presence within the Hindu religion as it is considered as sacred and water of this stream is used for performing various religious activities by pilgrims visiting the shrine. They take holy dip in it to wash away their sins and to attain salvation. But the irony is that like most of the sacred water bodies, this too is struggling under the anthropogenic stress. The pilgrimage load that tremendously increased from 44,000 (2013-14) to more than 1,04,95,209 (2013-2015) has severely deteriorated the water quality of this stream. Keeping this in view, the present study has been designed out to investigate the changes in water quality with special reference to the physico-chemical parameters and macrobenthic invertebrate fauna from 1994-2015.

MATERIAL AND METHODS

I. Study Area

The stream Ban Ganga is an important tributary of river Chenab and flows through the Katra town of Jammu and Kashmir. To analyse the abiotic and biotic (macrobenthic invertebrates) components, four stations were selected along the longitudinal profile of the stream.

Station I: where the stream Ban Ganga shows its appearance.

Station II: influenced by religious activities (offering flour balls, bathing activities and performing Mundan ceremonies) and also receives waste from nearby shops and dhabas.

Station III: located near pony stable, receives pony dung waste and huge amounts of kitchen waste from Gulshan Langar.

Station-IV: located downstream, receives a lot of waste from upstream sections and effluents from the dumped waste along its sides.

II. METHODOLOGY

1) Physico-chemical Parameters

Water samples were collected monthly from different stations. Estimation of some physico-chemical parameters like air temperature, water temperature, pH, dissolved oxygen, free carbon dioxide, carbonates, bicarbonates, calcium, magnesium and chloride was done on the spot, while for sulphates, nitrates and phosphates samples were stored in glass bottles and brought to laboratory for analysis. These parameters were analysed by following standard methods.[1]

2) Macro-benthic invertebrates: The bottom samples were collected from all the four stations by using appropriate sampler. The collected sample were washed through sieve no. 40 (256 meshes/ cm^2) and macrobenthic invertebrates thus segregated were transferred to tubes and preserved in 5% formalin for subsequent identification.[2,3&4] The total number of macro-benthic invertebrates / m^2 was computed using the following formula.

$$\text{Individual} / m^2 = \frac{N}{A} \times 10000$$

Where N = Average number of microscopic organisms per sample
a = Area of sampler (cm^2)

RESULTS AND DISCUSSIONS

Summary of the values measured for physico-chemical parameters during the two study periods has been given in Table I. A close observance of Table I clearly shows the fluctuations in various physico-chemical parameters over the period of time i:e 1994-2015. Air temperature shows a slight increase as the mean value of air temperature varied from a minimum of 14.3°C to a maximum of 32.58°C (1994-1996) whereas it ranged from 14.13°C to 34.78°C (2013-2015). Such an increase of 0.10- 0.30 ◦C over a period of 22 years can be ascribed to the global warming and this can be authenticated with the report submitted by National Statistical Analysis on Climate, India (2015).

The velocity of the stream that showed a decline clearly shows that it has been decreased from mean values of 0.124 -0.24 m/s (1994-1996) to 0.048- 0.095 m/s (2013-2015), which may be related with the dying up of the sources (Samkal Spring) to some extent and moreover, due to more pilgrimage pressure on Katra Town, the requirement of water has increased and as a result majority of water is supplied to them. Another point of observation worth mentioning about the stream is that increase in the average value of depth (46.88cm, 2013-2015) from 15.74-38.8cm (1994-1996) has been recorded. The pounding done by Shrine Board at some stretches of the stream resulted in the increased depth.

The tremendously increasing pilgrimage pressure (mass bathing activities, other religious ceremonies, sewage from Gulshan Langar) over the period of time has resulted in the increase in organic pollution, thus causing reduction in the values of DO.[5] Sinha et al. (1991) has also held bathing activity as responsible factor for low DO contents in Ganga river. Also, similar decline due to sewage content has also been reported by[6] Pathak and Bhatt (1990) and[7] Sharma (2013). Increase in CO_2 concentration over the period can be ascribed to increased decomposition activity with increased temperature and increased sewage load.[8] Joshi et al. (1992) also observed that addition of sewage was the main casual factor for increase in FCO_2 in their water bodies. Release of salts during microbial decomposition of organic matter in Ban Ganga stream seem to be the contributing factor for the heavy increase in the values of bicarbonates during the study period[9&10] and moreover, conversion of insoluble marls (present in effluents) into soluble form by FCO_2 may account for higher record of bicarbonates.[11] Mathur et al. (1991) proposed that bathing activities increase the bicarbonates level in water while studying physico-chemical parameters of Chambal river.

Table I: Comparative analysis of physico chemical parameters during two study periods.

Parameters	1994-1996	2013-2015
	Range	**Range**
Air Temperature(◦C)	14.3-32.58	14.13-34.78
Water Temperature(◦C)	14.96-29.3	12.57-26.03
Speed (m/s)	0.124-0.24	0.048-0.095
Depth (cm)	15.74-38.8	22.8-46.88
pH	7.58-8.16	6.96-8.32
Dissolved Oxygen(mg/l)	2.51-8.09	1.2-8.0
Free Carbon Dioxide(mg/l)	4.25-9.55	0-12.5
Carbonates (mg/l)	0	0-19.6
Bicarbonates (mg/l)	41.27-95.4	168.34-388.83
Chlorides (mg/l)	7.84-13.98	14.45-36.83
Calcium (mg/l)	29.94-73.28	26.18-52.10
Magnesium (mg/l)	31.63-73.35	31.81-76.41
Nitrates (mg/l)	0.81-2.87	1.16-3.12
Sulphates (mg/l)	0.72-1.85	0.03-0.35

The high concentration of chlorides is the outcome of increasing pilgrimage due to which there is continuous addition of domestic sewage from Langar.[12] Kumar et al. (2011) also reported the organic matter as the factor responsible for increase in the content of chlorides. A significant rise in the values of nitrates has also been recorded over the period of time that appears to be the outcome of influx of decaying organic matter and faecal matter, crematoria waste and excessive bathing activity. An interesting finding with regard to the decrease in the values of sulphates (0.72-1.85 mg/l, 1994-1996 to 0.03-

0.35 mg/l, 2013-2015) was noticed as the use of soaps and detergents in the stream water is strictly banned now.

Macrobenthic Invertebrates

Macrobenthic invertebrate fauna form an integral part of an aquatic environment as they play a significant role in maintaining the interaction between community and environment.[13] Qualitative analysis of benthos during the two study periods has been depicted in Table II. Persual of this table clearly depicts that during the first study period (1994-1996), taxonomically Phylum Arthropoda was the most diverse (represented by 2 sps. of Coleopterans, 1 sps. of Trichopterans, 5 sps. of Ephemeropterans, 5 sps. of Dipterans and 1 sps. of Odonates) whereas in current scenario (2013-2015) Annelida (10sps.) represents the most diverse group followed by Arthropoda (9sps.) and Mollusca (3 sps.).

Comparative account on different benthic groups along the longitudinal profile from 1994-1996 to 2013-2015 clearly shows the absence of all the Oligochaetes and Hirudinea except Erpobdella sps. and presence of few Ephemeropterans and Molluscs at Station I, which clearly reveals the pollution free status of this station. Oligochaetes require soft bottom for burrowing but construction of cemented bathing ghats has completely eliminated their habitats and thus absence of suitable substratum may serve as the plausible reasons for the absence of most of the above mentioned macrobenthic invertebrates. Also, the current data recorded shows the absence of Trichopterans, Coleopterans and Odonates from Stations II, III and IV whereas Oligochaetes, Hirudinea and Diptera recorded their abundance at these stations.[14] Marshall and Winterbour (1979 and[15] Bazzanti and Seminara (1987) too found Oligochaeta to contribute the major share to the total macrobenthic fauna in their respective water bodies.

TableII: Distribution of macrobenthic invertebrates during the study period (1994-1996).

Species	Station-I		Station-II		Station-III		Station-IV	
Oligochaeta								
Tubifex sps.	-	-	+	+	+	+	+	+
Limnodrilus sps.	+	-	+	+	+	+	+	+
Lumbriculus sps.	+	-	+	+	+	+	+	+
Nais sps	-	-	+	-	+	-	+	-
**Allosoma* sps.	-	-	-	+	-	+	-	+
**Dero digitata*	-	-	-	+	-	+	-	+
**Eisenia fetida*	-	-	-	+	-	+	-	+
**Branchiura* sps.	-	-	-	+	-	+	-	+
Hirudinea								
Leech	-	-	-	-	+	+	+	+
**Piscicola* sps.	-	-	-	+	-	+	-	+
Erpobdella sps.	-	+	-	+	-	+	-	+
Coleoptera								
Psephenus sps.	+	-	+	-	-	-	-	-
Ectopria sps	+	-	+	-	-	-	+	-
Berosus sps.	+	-	-	-		+	+	+
Trichoptera								
Hydropsyche sps.	+	-	+	-	-	-	-	-
Ephemeroptera								
Centroptilum sps.	+	-	+	-	-	-	+	-
Cinygmule sps.	+	-	+	-	-	-	+	-
Ephemerella sps.	+	-	+	-	+	-	+	-
Heptagenia sps.	+	-	-	-	-	-	+	-
Leptophlebia sps.	+	-	-	-	-	-	-	-
Baetis sps.	-	-	-	+	-	-	-	+
Callibaetis sps.	-	+	-	+	-	+	-	+
Cingyma sps.	-	-	-	+	-	+	-	+
Caenis sps.	-	-		-	-	-	-	+
Odonata								
Anax sps.	+	-	+	-	+	+	+	+
Diptera								
Chironomus sps.	-	-	+	+	+	+	+	+
Pentaneura sps.	+	-	+	+	+	+	+	+
Psychode sps.	+	-	+	-	-	-	+	-
Simulum sps	+	-	+	-	-	-	+	-
Tabanus sps.	-	-	+	+	+	+	+	+
Culicoides sps.	-	-	-	+	-	+	-	+
Limnophila sps.	-	-	-	+	-	+	-	+
Gastropoda								
Gyralus sps.	+	+	+	+	+	+	+	+
Lymnea sps.	-	+	-	+	-	+	-	+
Physa sps.	-	+	-	+	-	+	-	+

Overall numerical abundance of macrobenthic invertebrates shows the dominance of Annelids followed by Arthropoda and Mollusca (Table-III: Fig. I, II & III) whereas Sharma (1994-1996) recorded the dominance of Arthropoda followed by Annelida and Mollusca. A look at the percentage of Annelids at different stations along the longitudinal profile (Table III) shows that the downstream stations i:e Station III and Station IV were dominated by Annelids. Their overall as well as dominance at downstream stations may be attributed to the high content of organic detritus[16&17], increase in temperature, low water depth[18] and high content of nitrates.

Table III: Abundance of different macrobenthic invertebrate groups during the two study periods.

Stations	Year	Annelids		Arthropoda		Molluscs	
St-I	1994-1996	726	28.76%	1586	62.84%	212	8.40%
	2013-2015	125	22.45%	68	12.24%	364	65.3%
St-II	1994-1996	1805	82.96%	1282	58.92%	24	1.10%
	2013-2015	2592	32.97%	1718	21.86%	3551	45.17%
St-III	1994-1996	3021	60.37%	1553	22.90%	837	16.73%
	2013-2015	11930	55.31%	8717	40.41%	922	42.73%
St-IV	1994-1996	1503	41.97%	1847	51.58%	231	6.45%
	2013-2015	16541	50.99%	13929	42.91%	1969	6.06%

During the study period (1994-1996), only one sps. of Hirudinea was recorded. However, currently, Hirudinea has recorded its great abundance both qualitatively as well as quantitatively. The increase in pilgrimage load that has contributed to the maximal anthropogenic activity along the other factors such as decline in speed of water and appearance of muddy bottom.[19] King (1983) also reported their high abundance at sewage outfall simply confirms the present results.

The dipterans (*Chironomous, Pentaneura, Culicoides and Tabanus*) have also shown tremendous increase in their number over the period of time. Similar abundance of Chironomoids has also been reported by[20] Aura et al. (2011) and [17]Sharma et al. (2011). Persual of the Table IV reveals that molluscs have registered their numerical abundance at Station II which may be linked with the high concentration of calcium and bicarbonates (Table-I) at these stations[21&17] New species of molluscs and their high number has also been recorded at the polluted sites (2013-2015) depicting their pollution tolerant nature and polluted status of the stream. The organisms like *Gyralus, Physa* and *Lymnea* have already been identified as pollution indicator genera by workers such as[22] Saksena and Kulkarni (1982) and [7]Sharma (2013).

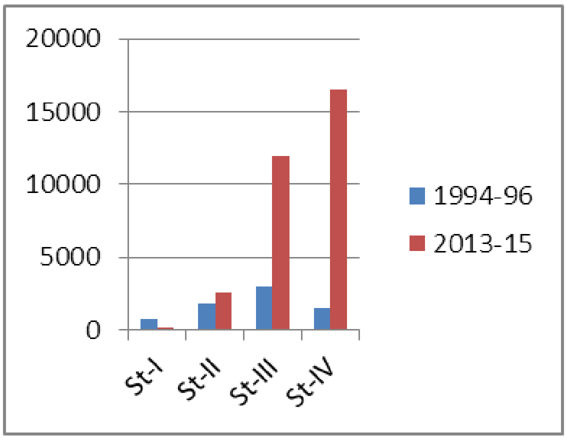

Fig. I (Annelida)

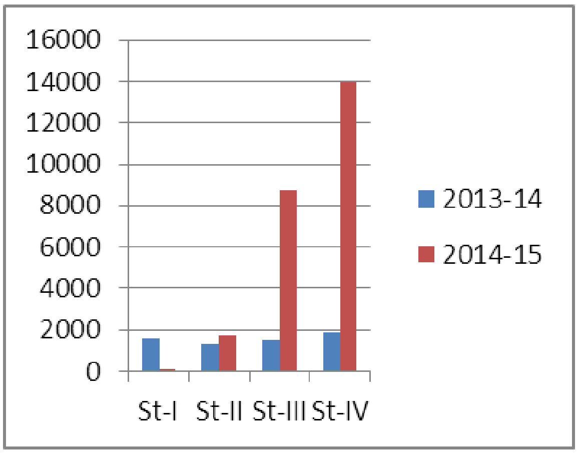

Fig. II (Arthropoda)

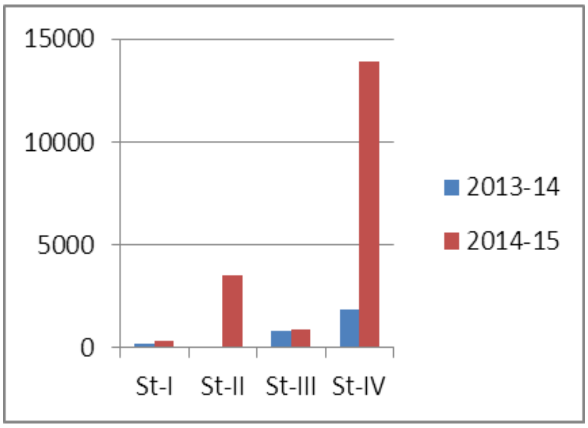

Fig.III (Mollusca)

Figures I, II &III showing numerical abundance of various macrobenthic invertebrate groups during the two study periods.

CONCLUSION

Thus overall comparative study during the period of 22 years, it was observed that due to tremendous rise in pilgrimage pressure from (1994-1996) during 2000 to 1,04,95,269 in 2013 to Shri Mata Vaishno Devi Shrine, there is continuous stress on this stream in the form of increasing waste from increased number of dhabas, hotels, pony waste, ashes from crematorium grounds, kitchen run off from Gulshan Langer (that caters foods to the pilgrims). In addition to this, the population of the Katra Town is also increasing because of hike in business opportunities related to tourism.

Demand for drinking water is also increasing and that is compensated by drawing more water from this stream and has led to the decline in water volume beyond this point. Sewage of the Katra town has also put stress on this aquatic ecosystem.

Moreover, global warming over the period of time has also resulted in significant increase in both air and water temperature.

An increment in the concentration of FCO_2, bicarbonates, chlorides, calcium, magnesium and nitrates indicates the polluted status of the stream.

Decrease in the value of DO and increase in the value of BOD further indicates the presence of organic load.

As a consequence of all these the biota of the stream is severely affected and can be witnessed by the absence of some Ephemeropterans, Trichopterans and Coleopterans (pollution sensitive species) which were present earlier and dominance of some pollution tolerant genera.

Thus, the results drawn from this comparative study give an important insight into the changing trophic status, which suggests that it is rapidly shifting towards eutrophic conditions, thus, requires immediate attention and action for its conservation as well as management.

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