



E-ISSN: 2320-7078  
P-ISSN: 2349-6800  
JEZS 2014; 2 (3): 231-235  
© 2014 JEZS  
Received: 03-04-2014  
Accepted: 05-05-2014

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## Seasonal variation in biological water quality in ecological segments of river Yamuna.

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### Abstract

A comparative study of biological water quality in ecological segment of River Yamuna the water quality improved from slight pollution to clean in Himalayan segment during 2011. In upper segment the biological water quality of River Yamuna changed from moderate pollution to slight pollution during 2011 and moderate pollution was observed in Delhi segment, Eutrophicated segment and Diluted segment during all season. Arthropods dominated by 87.5% and 12.5% dominated by the Mollusca in Himalayan segment of River Yamuna. Arthropods communities reduced to 62.5% and Mollusca, annelids and Platyhelminthes 12.5% were equally distributed in Upper segment and Eutrophicated segment. As compare to upper and eutrophicated segment Arthropods communities again reduced to 60% and Mollusca and annelids increased to 20% each in Delhi segment of River Yamuna. In Diluted segment, Arthropods community increased 83.3% and Mollusca 16.5% were observed in River Yamuna.

**Keywords:** Benthic macro-invertebrates, Water quality, Ecological segment. River Yamuna.

### 1. Introduction

The River Yamuna is the largest tributary of River Ganga. This river is as prominent and sacred as the great River Ganga itself. The total length of Yamuna River from origin at Saptrishi Kund to its confluence with River Ganga at Allahabad is 1376 km. Deterioration in water quality as a result of discharge of allochthonous and autochthonous sources of pollution into water bodies in increasingly rendering the natural water bodies unsuitable for various beneficial purposes to the mankind, like drinking water source, bathing, navigation, fishing and irrigation. Besides these, the protection and conservation of rare and endangered species in an aquatic ecosystem cannot be overlooked as far as the wholesomeness of water bodies concerned. To restore the wholesomeness of ecosystem, the pollution levels in water bodies are usually detected in term of monitoring physico-chemical parameters, which can reflect and determine the change in chemical characteristics of water bodies. As a result of pollution, the chemical water quality could depict only marginal variation over the year while there is a gradual disappearance of certain sensitive biological life in water. Consequently, a significant number of water bodies have gradually started losing their original biodiversity. In recent past the importance and use of biological monitoring system as a tool has been realized in addition to monitoring of physico-chemical parameter for the prediction and detection of ecological effect and to protect surface water consequences of pollution<sup>[1]</sup>.

Biological Water Quality Criteria (BWQC) has been introduced to assess the actual health of water bodies, for water quality evaluation<sup>[2]</sup>. Biological monitoring provides an effective, easy to understand less time consuming and cost effective method to determine cumulative impact of pollution. The frequent response of a community to pollution is that some species increase in abundance, other (usually the majority) decrease and the population of some species remain stable<sup>[3]</sup>. Among various organisms, benthic macro-invertebrates are more popularly used as bio-indicator for water quality assessment of surface waters<sup>[4]</sup>. The present study gives a biological scenario of River Yamuna from 2009 to 2011 with comparison of biological water quality in ecological segment of River Yamuna.

### 2. Material and methods

Hydrological, Physical and Biological parameters were selected for the study of water quality of River Yamuna. Hydrological parameter such as depth, width, and flow, type of water body, substratum composition, and Physical parameter includes pH, water temperature, and air

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temperature. Biological parameters included diversity score and saprobic score. For biological parameter, benthic macro-invertebrates were the best suitable among the biotic communities in aquatic ecosystem for bio-monitoring of River Yamuna. For biological water quality evaluation the diversity score was compared with the saprobic score with the help of Biological Water Quality Criteria (BWQC), in order to assess the actual health of River Yamuna (Table-1). Sampling locations on River Yamuna were selected for assessment of biological water quality in five ecological segments of River Yamuna. The Yamuna is divided into five distinct segments due to hydrological and ecological characteristic<sup>[5]</sup>.

1. Himalayan segment- From origin to Tajewala barrage (172 km)

2. Upper segment – Tajewala barrage to Wazirabad barrage (224 km)

3. Delhi segment – Wazirabad barrage to Okhla barrage (22 km)

4. Eutrophicated segment – Okhla barrage to Chambal confluence (490 km)

5. Diluted segment – Chambal confluence to Ganga confluence (468 km)

A total of 10 numbers of locations were selected on entire stretch of River Yamuna. The details of sampling location are given in Table 2 and the sampling locations are depicted in Map 1. Sampling was carried out during November 2009, May 2010, and in May 2011.

**Table 1:** Biological Water Quality Criteria (BWQC)

Sl. No	Taxonomic Groups	Range of saprobic score (BMWP)	Range of diversity Score	Water quality characteristic	Water quality class	Indicator Colour
1	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Diptera	7 and more	0.2 - 1	Clean	A	Blue
2	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Planaria, Odonata, Diptera	6 – 7	0.5 - 1	Slight Pollution	B	Light blue
3	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Odonata, Crustacea, Mollusca, Polychaeta, Diptera Hirudinea, Oligochaeta	3 – 6	0.3 - 0.9	Moderate Pollution	C	Green
	Mollusca, Hemiptera, Coleoptera, Diptera, Oligochaeta	2 – 5	0.4 & Less	Heavy Pollution	D	Orange
5	Diptera, Oligochaeta No animals	0 – 2	0 – 0.2	Severe Pollution	E	Red

**Table 2:** Location description of River Yamuna

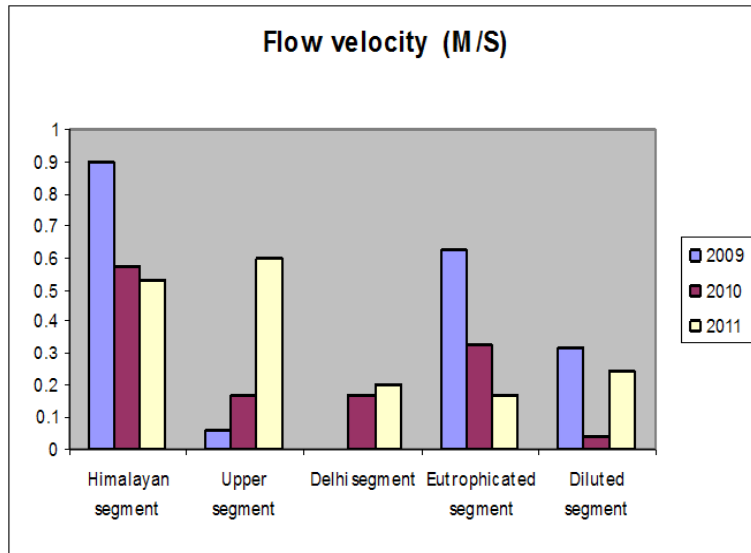
Sl. No.	Name of station (State)	Altitude in meter	Location Distance	Significance of station	Present use of river water
1.	Yamunotri (Uttarakhand)	3291	278 km from Dehradun	Impact of high altitude, reference location.	Drinking and bathing, religious
2.	Hanuman chetti (Uttarakhand)	3256	14 Km from Yamunotri	Impact of high altitude, reference location.	Drinking and bathing, religious
3.	Lakhwar Dam (Uttarakhand)	790	40 Km from Hanumanchetti	Impact of abrupt change in altitude	Drinking and bathing,
4.	Dak Patthar (Uttarakhand)	790	15 Km from Dehradun	Impact of abrupt change in altitude	Drinking and bathing,
5.	Wazirabad (Delhi)	224	25 Km from Palla	Reflects water quality of river water at Haryana -Delhi border and impact of Drain No. 8 (Sonepat)	Drinking water source
6.	Okhla Barrage (Delhi)	213-305	22 Km from Wazirabad	Indicates water quality at Delhi after receiving 14 major drains of city	Propagation of wild life and fisheries
7.	Mathura (Uttar Pradesh)	174	167 from Delhi	Indicates impact of various urban centers Delhi, Haryana and UP	Religious, bathing
8.	Agra (Uttar Pradesh)	169-171	58 Km from Mathura	Indicates river water quality at Taj Mahal.	Tourism, Bathing
9.	Etawah (Uttar Pradesh)	130	119 Km from Agra	Indicates river water quality before confluence to tributaries	Religious, bathing
10.	Allahabad (Uttar Pradesh)	74	357 Km from Etawah	Indicates water quality before confluence to River Ganga	Religious, bathing

**Table 3:** % dominance of taxa of benthic macro-invertebrates in ecological segments of River Yamuna.

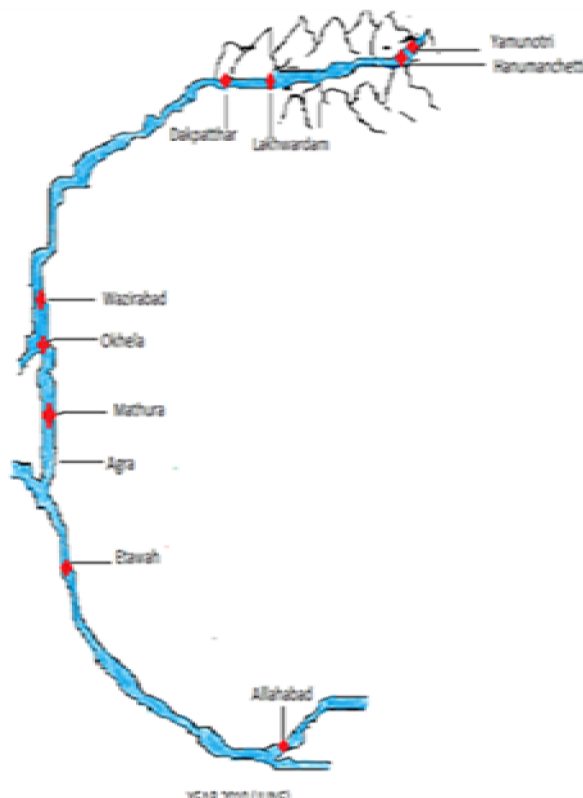
S. No.	Ecological segments of River Yamuna	% Taxonomic composition of groups of benthic Macro-invertebrates			
		Arthropods	Mollusca	Annelids	Platyhelminthes
1.	Himalayan segment	87.5	12.5	0.0	0.0
2.	Upper segment	62.5	12.5	12.5	12.5
3.	Delhi segment	60	20	20	0.0
4.	Eutrophicated segment	62.5	12.5	12.5	12.5
5.	Diluted segment	83.3	16.7	0.0	0.0

**Table 4:** % dominance of order of benthic macro-invertebrates in ecological segment of River Yamuna

Ecological segments of River Yamuna	% Taxonomic composition of order of benthic macro-invertebrates									
	Ephemeroptera	Plecoptera	Tricoptera	Odonat	Hemiptera	Coleoapter	Diptera	Crustacea	Mollusca	Annilida
Himalayan segment	83.3	100	100	19	3.8	15.9	43.4	0.0	9	0.0
Upper segment	3.7	0.0	0.0	14.2	13.4	4.5	13	8.0	13.2	10
Delhi segment	4.76	0.0	0.0	0.0	19.04	28.57	23.80	0.0	19.04	4.76
Eutrophicated segment	7.14	0.0	3.57	14.28	17.85	14.28	14.28	3.57	14.28	7.14
Diluted segment	5	0.0	5	15	15	10	10	10	20	0.0



**Fig 1.**



**Map 1:** Sampling location on River Yamuna

### 3. Result and discussion

Water quality of River Yamuna is mainly attributed to the various uses of Yamuna water which may be grouped into two categories i.e. abstractive uses for domestic water supply, irrigation, and industrial and in stream uses include, hydropower fisheries, navigation, community bathing and washing, cattle bathing and washing. Thus there are two major point sources of pollution i.e. domestic and industrial. Apart from this the diffused sources of pollution originates from the catchments area through movement of water. The agricultural pollution to river is contributed by cattle's, agricultural residues, fertilizer, and pesticide use. About 85% pollution problem in River Yamuna is from the domestic sources. The trend in water quality in River Yamuna with respect to important biological parameter from 2009 to 2011 indicates different water quality in five distinguished segments from origin of River Yamuna, Yamunotri to confluence with River Ganga at Allahabad. Table 3 and 4 show % distribution of biological establishment of taxa, order of benthic macro-invertebrates.

#### 3.1 Himalayan segment

(Length 172 km). The average hydrological water quality of River Yamuna in this segment indicated, water temperature ranging between 4-25 °C and maximum flow velocity 0.9 m/s during 2009 and minimum 0.53 m/s was observed during 2011 (Fig-1). A comparative study on biological water quality in ecological segment of River Yamuna the water quality improved from slight pollution to clean in Himalayan segment during 2011. Clean water quality in Himalayan segment of River Yamuna is suitable for drinking water without conventional treatment but after disinfection. The dominance of taxa of benthic macro-invertebrates was mainly dominated by 87.5% Arthropods' and rest 12.5% by the Mollusca. Orders followed a dominance sequence of Trichoptera>Plecoptera>Ephemeroptera> Diptera> Coleoptera=Odonata= Neuroptera.

#### 3.2 Upper segment

(Length 224) - As compare to Himalayan segment water temperature increased to 16-31 °C. In this stretch the maximum flow velocity 0.6 m/s was observed during 2011 and minimum 0.05 m/s during 2009 (Fig-1). The biological water quality of River Yamuna improved from Class 'C' in 2009, 2010 to Class 'B' in 2011 (Moderate pollution to Slight pollution). Slight pollution in biological water quality (Class 'B') supported Outdoor bathing in upper segment of River Yamuna. Due to Slight pollution dominance sequence of taxa of benthic macro- invertebrates decreased Arthropods communities to 62.5% and Mollusca, Annelids and Platyhelminthes 12.5% were equally distributed in upper segment of River Yamuna. Dominance sequence of order of benthic macro- invertebrates was also changed to Odonata >Hemiptera> Mollusca>Diptera>Annelida> Crurtacea> Coleoptera> Ephemeroptera.

#### 3.3 Delhi segment

(Length 22 km) - The average hydrological water quality of River Yamuna during 2009-2011 indicated, water temperature 23-33 °C. Maximum flow velocity 0.2 m/s was observed during 2011 and there was no flow velocity observed during 2009 (Fig-1). Bio-assessment of water quality was also studied on east and west bank of River Yamuna [6]. With high level of pollution load in Delhi segment, the aquatic life of River Yamuna could sustain biological water quality of moderate

pollution Class 'C' is suitable for Propagation of wildlife and fisheries. As compare to upper segment, Arthropods communities again reduced to 60% and Mollusca and Annelids communities increased to 20% each in Delhi segment of River Yamuna. As compare to Upper and Himalayan segment number of orders decreased in Delhi segment followed a sequence of Coleoptera> Diptera> Mollusca=Hemiptera >Ephemeroptera= Oligochaeta.

#### 3.4 Eutrophicated segment

Average water temperature 15-39 °C was observed in Eutrophicated segment. The maximum flow velocity 0.62 m/s was observed during 2009 and minimum 0.17 m/s during 2011 (Fig-1). There was no change in biological water quality (Class 'C') compare to the Delhi segment. The dominance sequence of taxa of benthic macro-invertebrates was mainly dominated by Arthropods communities 62.5% and Mollusca, Annelids and Platyhelminthes 12.5%. Dominance sequence of order of benthic macro- invertebrates in Eutrophicated segment was Hemiptera>Coleoptera=Diptera=Odonata=Mollusca>Oligochaeta=Ephemeroptera> Crustacea.

#### 3.5 Diluted segment

The average hydrological water quality of River Yamuna in Diluted segment of River Yamuna indicate, water temperature ranging between 19-33 °C and maximum flow velocity 0.32 m/s during 2009 and minimum 0.04 m/s was observed during 2010 (Fig-1). There was also no change in biological water quality (Class 'C') compare to Delhi and Eutrophicated segments. As Compare to Eutrophicated segment Arthropods community was abruptly increase to 83.3% and Mollusca 16.5% was observed in Diluted segment of River Yamuna. The dominance sequence of orders of benthic macro invertebrates followed a sequence of Mollusca> Hemiptera=Odonata>Coleoptera=Diptera=Crustacea> Ephemeroptera= Trichoptera.

### 4. Conclusion

To observe the seasonal variation in biological water quality in ecological segments of River Yamuna, maximum flow velocity of 0.9 m/s was observed in Himalayan segment followed by eutrophicated segment (0.622 m/s) and upper segment (0.6 m/s) and no flow velocity was observed in Delhi segment. River water is black and hardly flows due to barrage in Delhi segment of River Yamuna. Result indicated that water quality of River Yamuna improved from slight pollution to clean in Himalayan segment is suitable for drinking purpose. In upper segment the biological water quality of River Yamuna changed from moderate pollution to slight pollution is suitable for bathing purpose and moderate pollution in Delhi segment, Eutrophicated segment, and Diluted segment support the use of water for wild life and fisheries. Maximum 87.5% of Arthropods was observed in Himalayan segment and minimum 60% was observed in Delhi segment of River Yamuna. Plecoptera and Trichoptera families are very sensitive to pollution was observed only in Himalayan segment. Maximum 20% of Mollusca were observed in Delhi Segment develop much resistance to organic pollution and minimum 12.5% of in Himalayan segment and Upper segment of River Yamuna. Ephemeroptera families' are sensitive to pollution, but some of the tolerant species are also available in other segment of River Yamuna. Coleoptera, Hemiptera, Diptera, and Odonata families indicate moderate pollution was observed from Delhi segment to Diluted Segment of River

Yamuna.

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