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Research Article

ASSESSMENT OF SOME ECOLOGICAL PARAMETERS FOR GADARIA STREAM- A TRIBUTARY OF RIVER NARMADA IN THE CENTRAL ZONE, INDIA

Ankit Kumar[1]., Anjali Chaurasia[1]., Tabassum Bashir[1]., Seema Pandey[1]., Sajjad Ahmad War[1]., Rachna Deo Golwalkar[2] and Vipin Vyas[3]*

[1]Department of Environmental Science and Limnology, Barkatullah University, Bhopal
[2]Department of Zoology and Applied Aquaculture, Barkatullah University, Bhopal
[3]Department of Bioscience, Barkatullah University, Bhopal

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ABSTRACT

Ecology is lifeline of any stream or river ecosystem and it cannot be ignored. Life is dependent on ecological factors as abiotic and biotic component. So study on ecological parameters is very much important nowadays because tremendous pressure has been created on ecosystem through human interventions. Present study is an example of ecological investigation of Gadaria stream which is a tributary of River Narmada in the central zone. Here physical habitat assessment, status of riparian buffer zone, visual observation of substrate characterization, physico-chemical analysis and diversity of macrozoobenthos has been chosen as ecological parameters. After investigation of these ecological parameters results suggested that human interference is playing a key role in degradation of ecosystem and it needs proper attention for conservation and management of the stream.

INTRODUCTION

Streams and rivers play vital role in biogeochemical cycle so that they are an integral part of biosphere. They provide habitat, food and shelter for variety of organisms and plants. Humans are also dependant for various activities on them as streams and rivers are the main sources of water for domestic uses, agriculture, industries, transport, power production, recreation etc. These human interventions may induce changes in sensitive stream ecosystems and ecological conditions of many streams and rivers in developing countries are deteriorating as a result of human population explosions, change in land use, intensified agricultural practices and increased industrialization are affecting natural conditions of streams [1]. Therefore, ecological parameters of any stream or river should be studied and is necessary for future to evaluate ecological conditions. At present, assessment of ecological parameters to evaluate ecological condition of Gadaria stream is designed and this study is a small step towards the assessment of ecological status of Gadaria stream which is a tributary of River Narmada in the central zone.

MATERIALS AND METHOD

Study Area

Gadaria is a seasonal tributary (stream) of River Narmada which originates from the Vindhyan hilly ranges in the central zone. Basin of this stream falls in Sehore and Raisen districts of Madhya Pradesh (Figure- 1).

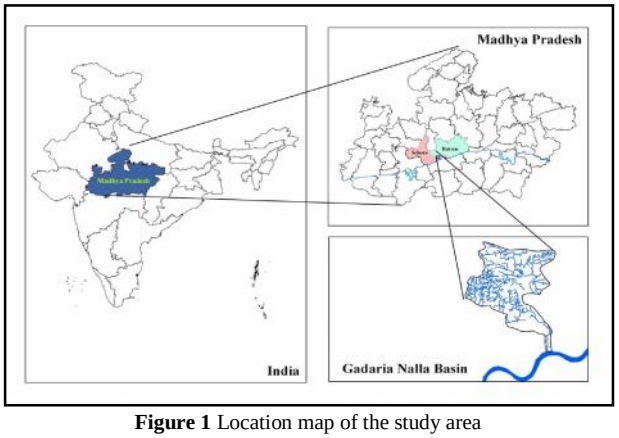

Figure 1 Location map of the study area

Corresponding author:* **Vipin Vyas
Department of Bioscience, Barkatullah University, Bhopal

After covering a total length of 34.58 kms this stream joins the river from right bank between Jamuniya and Budhni village (Figure- 2).

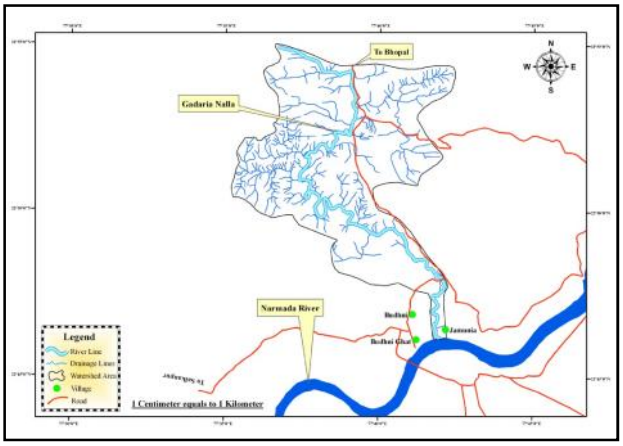

Figure 2 Base map of the study area

Maximum watershed area falls under dense forest cover only few areas are dominated with agricultural land use near confluence with River Narmada. Since headwaters of the stream is in thick forest and at high elevation so it was not possible during this rapid survey to cover the entire stream, hence two sampling stations were chosen along the all-weather road (Figure- 3). Details of chosen sampling stations are given in Table- 1.

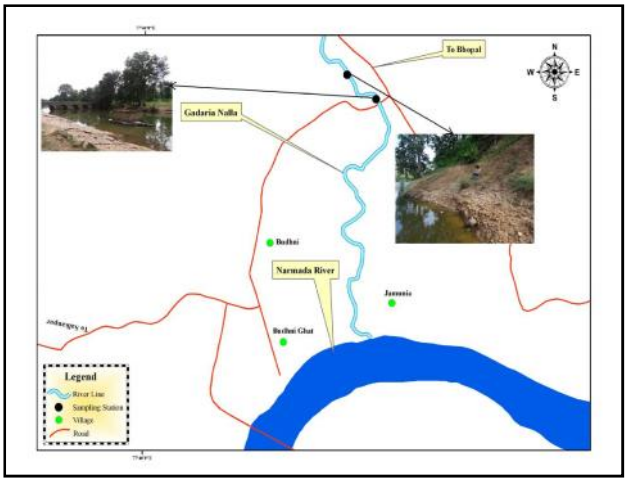

Figure 3 Sampling stations of the study area

Table 1 Details of sampling stations

2	**Gadaria stream**	**First**	**GD- 1**	**77º42'2.7" E**	**22º48'0.7" N**
		Second	GD- 2	77º41'47.01" E	22º48'11.29" N

Parameters selected for ecological assessment of the stream

Physical habitat assessment- Physical habitat of any stream or river is important for maintaining the aquatic life. There are several habitat parameters which indicate the primary ecological condition of any stream. For present study physical habitat assessment was done using protocol of the Rapid Bioassessment Protocols, USEPA [2] and ten habitat parameters were scored and categorized under four conditions i.e. optimal, suboptimal, marginal, poor according to the existing conditions (Table- 2).

Table 2 Integrated scores of physical habitat assessment

S. No.	Condition categories	Total scoring
1.	Optimal	154-200
2.	Suboptimal	101-153
3.	Marginal	48-100
4.	Poor	0-47

Substrate categorization- Substrate is a stage which plays an essential role for aquatic life in stream or river ecosystem. Different kinds of substrate supports various types of aquatic life, therefore observation of substrate is an essential part of ecological assessment. In present study, major classification of substrate was done visually according to the Wentworth scale (1922) [3] and data sheets were filled accordingly for each sampling station.

Riparian Buffer Zone (RBZ) - Riparian zones are the important interfaces between terrestrial and aquatic ecosystems which play an important role for balancing several abiotic and biotic factors. It provides a number of ecosystem services such as reducing the sediment run off, temperature control and many more [4]. Thus survey of riparian buffer zone is an important ecological parameter which was taken into consideration for this study. On foot rapid survey of riparian buffer zone was carried out at both sampling stations, where six parameters were chosen for this study and data sheets were filled separately (Table- 3).

Table 3 Parameters of riparian buffer zone

S. No.	Parameters Analyzed
1.	Agricultural land
2.	Forest land
3.	Barren land
4.	Pasture land
5.	Vegetation
6.	Settlements
7.	Soil erosion

Physico-chemical parameters- The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physico-chemical parameters and biological characteristics. These characteristics can identify certain condition for the ecology of living organisms [5]. Therefore physico-chemical analysis acts as an important ecological parameter, so during present study some physico-chemical parameters were chosen for ecological assessment of the stream (Table- 4) [6].

Table 4 List of physico-chemical parameters

S. No.	Parameters	S. No.	Parameters
1.	Depth (in meters)	9.	Total Dissolved Solids (mg/l)
2.	Air Temperature (ºC)	10.	Dissolved Oxygen (mg/l)
3.	Water Temperature (ºC)	11.	Alkalinity (mg/l)
4.	Water Flow (cm/sec)	12.	Chloride (mg/l)
5.	Transparency (cm)	13.	Total Hardness (mg/l)
6.	Turbidity (NTU)	14.	Ca- Hardness (mg/l)
7.	Conductivity (µs/cm)	15.	Nitrate (mg/l)
8.	pH	16.	Orthophosphate (mg/l)

Macrozoobenthos- Macrozoobenthos are organisms in the aquatic environment without backbone that can be seen with the naked eye and are those organisms often retained by mesh sizes of 0.05 m^2 although the early stages of many macrobenthic invertebrates species are smaller than this size.

These animals can be found on rocks, logs, sediment, debris and aquatic plants during some period in their life. Though these animals are an important ecological indicator of aquatic ecosystem so they are considered for the study [7] [8].

Collection, preservation and identification of macrozoobenthos
Samples of macrozoobenthos were collected from D- frame net from the identified stations. Stones and pebbles were also washed to collect attached fauna. Sieving was done using 0.5 mm mesh size brass sieve and organisms were collected using forceps and brushes. Collected organisms were kept safely in reagent grade wide mouth plastic screw cap bottle with 4 % formaldehyde solution used as preservative on field. After completion of field procedure samples were transferred to the laboratory carefully.

Identification of macrozoobenthos was done with the help of stereomicroscope and hand lens with 6x zoom capacity to observe the finest details about the organisms. Available keys and monographs were used to identify fauna upto their lower taxonomic levels [9] [10] [11] [12] [13].

RESULTS AND DISCUSSION

Physical habitat assessment- In the present study, ten parameters of physical habitat assessment were scored for both stations and it was found that sampling station GD-1 falls under suboptimal condition category which evidences that this station supports biodiversity fairly, whereas station GD- 2 falls under optimal condition category shows that physical habitat condition is the highest supporter for aquatic life (Table- 5). Physical habitat assessment of Kaliyadeh stream also reported that out of two sampling stations one falls under suboptimal and another is under optimal condition category (Pandey *et al.*, 2015) [1]. In Denwa River out of six sampling reaches one was ranked under poor category, one was under suboptimal category, three were categorized under marginal and one was found under optimal condition category according to the scores of habitat assessment [14].

Table 5 Scoring of physical habitat assessment

S. No.	Habitat Parameters	Gadaria Stream			
		GD- 1		GD- 2	
1	Epifaunal Substrate/available cover	8		14	
2	Pool substrate characterization	8		11	
3	Pool variability	11		10	
4	Sediment deposition	20		20	
5	Channel flow status	19		20	
6	Channel alteration	20		20	
7	Channel sinuosity	11		9	
	Total	97		104	
		Left bank	Right bank	Left bank	Right bank
8	Bank stability	10	10	10	8
9	Vegetative protection	10	10	10	8
10	Riparian vegetative zone width	9	5	8	10
	Total out of 200	151		158	

Substrate categorization- It was observed that at station GD- 1 pan rock was dominant followed by bed rock, sheet rock, clay and sand, while at GD- 2 boulders was dominant followed by soil (Table- 6). Presence of rocks and boulders shows natural substrate condition because this stream flows from hilly ranges and also substrate was not found heterogeneous which affects the diversity of flora and fauna. At two stations of Kaliyadeh stream dominance of rock and boulders in substrate was also reported by Pandey *et al.*, (2015) [1].

Table 6 Major substrate types in the study area

Stream	Station	Substrate
Gadaria Stream	GD - 1	Pan Rock > Bed Rock > Sheet Rock > Sand > Soil > Clay
	GD - 2	Boulders > Soil

Riparian buffer zone- At both sampling stations riparian buffer zone was dominated with forest cover (Table- 7) but on the left bank of station GD- 1 some human interventions such as bathing, flow of domestic sewage etc. were noticed which is being affected negatively to the stream. Domination of forest cover in the riparian buffer zone was noticed at one station of Kaliyadeh stream [1], at some areas of Chandni stream [4] and also few forested areas were reported in the selected reach of River Narmada [15].

Table 7 Riparian buffer zone status at different sampling stations

Stream	Station	Bank Side	Status
Gadaria Stream	GD - 1	Left Bank	Forest Land > Vegetation > Settlement > Soil Erosion
		Right Bank	Forest Land > Vegetation > Soil Erosion
	GD - 2	Left Bank	Forest Land > Vegetation > Soil Erosion
		Right Bank	Forest Land > Vegetation > Soil Erosion

Physicochemical parameters- In the present study sixteen physico-chemical parameters were analyzed for ecological assessment. Minimum and maximum values of those parameters are given in Table- 8.

Table 8 Minimum and maximum values of physico-chemical parameters

S. No.	Parameters	Min	Max
1	Depth (m)	0.43	0.72
2	Air Temperature (^{0}C)	20.5	33
3	Water Temperature (^{0}C)	25	31.5
4	Water Flow (cms/sec)	3	12
5	Transparency (cm)	43	99
6	Turbidity (NTU)	0.1	10.5
7	Conductivity (µs)	200	290
8	pH	6.5	7.1
9	Total Dissolved Solids (mg/l)	14	19
10	Dissolved Oxygen (mg/l)	7.2	9.6
11	Alkalinity (mg/l)	60	142
12	Chloride (mg/l)	20.97	34.96
13	Total Hardness (mg/l)	134	358
14	Ca- Hardness (mg/l)	111.3	161.7
15	Nitrate (mg/l)	1.2	1.6
16	Orthophosphate (mg/l)	0.5	0.9

Depth is responsible for many ecological activities like solar radiation in the water, movement of particles, resident to organisms, its productivity etc. During the present investigation rang of depth varied from 0.43 m to 0.72 m. Pandey *et al.*, (2015) [1] observed 0.23m - 0.84m depth in Kaliyadeh stream. Temperature plays an important role in dissolution of gases, distribution of organism etc. During the study, range of air temperature fluctuated from 20.5 °C to 33 °C, temperature of water recorded between 25 °C to 31.5 °C which shows ideal condition. Similar observations were recorded at Bhagner stream [16], at Mouri River of Bangladesh [17], at Brahmani River of Rourkela [18] and at Chandni stream a tributary of

River Narmada [5]. Flow is the major architect of the physical habitat in streams and rivers. It influence the particle size and nature of the substrate and channel morphology, the supply of dissolved oxygen, affect the distribution and turnover of food and other resources, and create direct physical forces within the water column and on the substrate. In Gadaria stream range of water flow was recorded between 3 cm/sec to 12 cm/sec. Range of flow in Kaliyadeh stream was observed between 37 cm/sec to 62 cm/sec [1]. Transparency is also one the major factor to define health of any aquatic ecosystem and is directly affected by the level of suspended particles (mainly algae, sediment) and dissolved materials in the water. The range of transparency fluctuated between 43 cm to 99 cm in the present study. Similar observation was recorded at Kaliyadeh stream [1]. In the water, turbidity is determined by colloidal matter, silica of diatomaceous earth, clay, silt, non-living organic particulate, plankton and other microscopic organisms, in addition to suspended organic or inorganic matter [19].

Table 9 List of macrozoobenthos found during the study

S. No.	Taxa	Gadaria Stream	
		GD - 1	GD - 2
Phylum	Mollusca		
Class	Gastropoda		
Order	Mesogastropoda		
Family	Viviparidae		
1	Bellamya *bengalensis*	+	+
2	Bellamya *dissimilis*	-	+
Family	Thiaridae		
3	Thiara (Melanoides) *tuberculata*(Muller)	-	+
4	Tarebia *lineata* (Gray)	+	+
Phylum	Arthropoda		
Class	Insecta		
Order	Odonata		
Family	Corduliidae		
5	Neurocordulia *sp.*	+	-
Family	Gomphidae		
6	Gomphus *sp.*	-	+
Order	Hemiptera		
Family	Nepidae		
7	Nepa *sp.*	+	+
Family	Corixidae		
8	Sigara *sp.*	+	-
Order	Diptera		
Family	Chironomidae		
9	Chironomus *sp.*	+	+
Family	Culicidae		
10	Culex *sp.*	-	+
Order	Ephemeroptera		
Family	Ephemerellidae		
11	Ephemerella *sp.*	+	+
Family	Caenidae		
12	Caenis *sp.*	+	+
Order	Coleoptera		
Family	Elmidae		
13	Stenelmis *sp.*	+	-
Family	Gyrinidae		
14	Dineutus *sp.*	-	+
Order	Plecoptera		
Family	Perlidae		
15	Acroneuria *sp.*	-	+
Phylum	Annelida		
Class	Oligochaeta		
Order	Lumbriculida		
Family	Lumbricullidae		
16	Lumbriculus *sp.*	-	+
	Total	9	13

The range of turbidity was varied between 0.1 NTU to 14.6 NTU in the study area. Range of turbidity in the Bhagner stream was 4.8 NTU - 20 NTU [16], in Chandni stream 65 NTU - 115 NTU [5], in Kaliyadeh stream it was between 10 NTU to 14.6 NTU [1] and in Mouri River of Khulna Bangladesh it was recorded between 16.5 NTU to 21.5 NTU [17]. The ability of water to conduct an electric current is known as conductivity or specific conductance and depends on the concentration of ions in solution which is almost temperature dependent. In the present study range of conductivity varied between 200 µs/cm to 290 µs/cm. In Bhagner stream it ranged from 380 µs/cm to 570 µs/cm [16], in Chandni stream 520 µs/cm – 580 µs/cm [5], in Kaliyadeh stream between 370 µs/cm to 460 µs/cm [1] and in Bertam River of Cameron Highlands, Malaysia it was found between 38 µs/cm to 80 µs/cm [20]. pH is concentration of hydrogen ion and is an important factor which is linked with the chemical changes, species composition and life process of plant and animal communities inhabiting in them. During the present study, range of pH varied from 6.5 to 7.1 shows slight acidic and alkaline condition. Similar observation was found in Chandni stream [5], in Bhagner stream [16], in Kaliyadeh stream [1] and in Jhelum River of Kashmir [21]. Dissolved solids elevate the density of water, influences osmoregulation of freshwater organisms and reduce solubility of gases (like oxygen) and utility of water for drinking, irrigational, and industrial purposes. In the present study range of TDS fluctuated between 14 mg/l to 19 mg/l which is normal. In Kaliyadeh stream TDS ranged between 10.2 mg/l and 28 mg/l [1], while in Chandni nalla range of TDS was observed from 32 mg/l to 40 mg/l [5], in Bhagner stream it was between 18 mg/l to 38 mg/l [16] and in Bertam river of Cameron Highlands, Malaysia it was found between 28 mg/l to 52 mg/l [20]. Dissolved oxygen is the most significant parameter in any aquatic system which was found between 7.2 mg/l to 9.6 mg/l in the present study. In Kaliyadeh stream it ranged from 6 mg/l to 7.6 mg/l [1], in Chandni stream between 6.4 mg/l to 7.2 mg/l [5], in Bhagner stream from 5.6 mg/l to 11.6 mg/l [16] and in Belgirinalla of Chhattisgarh from 6 mg/l to 8.9 mg/l [23]. During the present investigation the range of alkalinity was fluctuated between 60 mg/l to 142 mg/l. Similar finding was recorded in Kaliyadeh stream [1], in Bhagner stream [16] and in Chandni stream [5]. Chloride is one of the important ions found in abundance in the natural water. Its sources in water include natural from leaching of rocks, soils etc., while the anthropogenic sources include human and animal wastes. The excess chloride in water increases salinity of the water, thereby rendering it unsuitable for particular life forms. The range of chloride in the study area varied from 20.97 mg/l to 34.96 mg/l. Similar range of chloride was recorded in Chandni stream [5], in Kaliyadeh stream [1], in Bhagner stream [16] and in Jhelum River of Kashmir [21]. Hardness in the water depends on the concentration of calcium and magnesium. The range of total hardness was observed between 134 mg/l to 358 mg/l, whereas the values of calcium hardness varied from 111.3 mg/l to 161.7 mg/l in the present study. Range of total hardness and calcium hardness was found similar in Kaliyadeh stream [1], in Bhagner stream [16], in Chandni stream [5] and in Jhelum River of Kashmir [21]. Nitrate, the highest oxidation state of nitrogen is one of the most important plant nutrients in aquatic ecosystems. Excessive nitrate in water also causes toxicity in water. Therefore, nitrate

is one of the most important water quality indicating parameters in aquatic resources. Range of nitrate was fluctuated between 1.2 mg/l to 1.6 mg/l in the present study. Minimum range of nitrate was noticed in Bhagner, Kaliyadeh and Chandni streams tributaries of River Narmada [16] [1] [5]. Orthophosphate is the readily available form of phosphorus, the most important limiting factor in freshwater ecosystems. The excess range of phosphate in water can increase the growth rate of blue green algae causing unsuitable for bathing [22]. During the present study, range of orthophosphate was recorded from 0.5 mg/l to 0.9 mg/l within the permissible limit according to the guidelines of WHO and ISI [23].

Macrozoobenthos- At Gadaria stream 16 taxa of macrozoobenthos was recorded from two sampling stations of three phylum i.e. mollusca, arthropoda and annelida (Table- 9). Percent composition of major taxonomic groups is shown in Figure- 4.

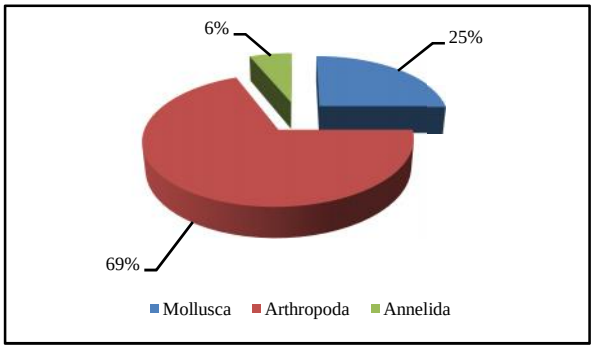

Figure 4 Percent composition of major taxonomic groups

Phylum mollusca is represented by one class i.e. gastropoda with one order, two families and four species. Among those four species *Bellamya bengalensis* and *Tarebia lineata* (Grey) were present at both stations, while *Bellamya dissimilis* and *Thiara* (Melanoides) *tuberculata* (Muller) were found only at station GD- 2. Arthropoda phylum is also represented by only one class i.e. insecta with six orders, eleven families and 11 taxa. Among them four were recorded from station GD- 1 and another four were recorded from station GD- 2, while three were recorded from both stations. Phylum annelida is represented by one class, one order, one family and one genus.

Results of the present study revealed that phylum arthropoda was dominant than mollusca and annelida respectively. Similar findings were reported in four tributaries of River Narmada [24], in Kaliyadeh stream [1], in Bhagner stream [16], in Chandni stream [5], in River Narmada [7] [25], in Morand river [26] and in Ganjal river [27]. During the investigation it was found that maximum diversity of macrozoobenthos was recorded from station GD- 2. Here out of 16 taxa 13 were present. This observation is supported by other ecological assessment parameters which were considered for present study. At station GD- 2 physical habitat was found under optimal condition, visual observation of substrate shows mixture of boulders and soil, riparian buffer zone was dominated with forest cover and vegetation which produced favorable condition for diversity of macrozoobenthic fauna here. On the other hand at station GD- 1 minimum diversity was recorded. Here physical habitat assessment was categorized under suboptimal condition, substrate was mixture of rock, boulders, sand, soil and clay, riparian buffer zone was dominated by forest cover and vegetation but instead of these favorable conditions less macrozoobenthic fauna was found and the only reason noticed during study was human interferences in the environment. At this station human interventions like bathing, washing clothes, cleaning their vehicles and flow of sewage was noticed which was playing a key role for slow degradation of stream habitat.

CONCLUSION

In concluding remarks it can be stated that ecological condition of Gadaria stream looks good but introduction of human interventions is not good for ecology of stream. Therefore, activities which can be easily controlled should be controlled and continuous monitoring is required as well as if action will not be taken in near future condition of stream will be threatened.

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