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Water quality of Bishnumati River in the Kathmandu valley

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Abstract
The condition of the rivers in the Kathmandu Valley has been rapidly degrading. Several governmental and nongovernmental institutions, civil society organizations and other stakeholders are working to improve the environmental conditions of these rivers. Thus the main purpose of this study was to see whether water quality of Bishnumati River was suitable for aquatic lives. Seven stations; Panimuhan, Tokha, Jalbinayak, Gongabu, Shobhabhagawati, Teku before-mixing in Bagmati and Teku after-mixing in Bagmati River were selected for sampling. Water sampling was performed in March 2016 for analyzing eleven physicochemical and biochemical parameters such as Temperature, pH, Total solid, Total hardness, Alkalinity, Chloride, Turbidity, Ammonia, DO, BOD and COD methods. The pH of all sites was found to be neutral. The pH of river water ranged from 7.0 to 7.4 in this study indicating potable for organisms.The turbidity of Jalbinayak was maximum 469 NTU and that of Panimuhan was minimum indicating less particles in initial point. The alkalinity of Teku after-mixing Bagmati was the highest and Panimuhan showed lowest alkalinity. Panimuhan had the lowest amount of chloride. Shobhabhagawati and Teku after-mixing with Bagmati site had higher amount of chloride. Total Hardness of Panimuhan and Tokha were found to be 1.48 and 1.68 mg/l respectively indicating the water of those stations were soft. Shobhabhagawati had the highest total hardness of 3.28 mg/l. The DO of Tokha, Jalbinayak and Gongabu was decreasing as moving down-streams whereas the BOD was increasing on moving down-streams.

Keywords: Water Pollution, pH, temperature, BOD, COD, DO

Introduction

Bishnumati is one of the very important rivers of the Kathmandu Valley, Nepal. It serves for drinking water, cultivating agriculture and uses of rituals purpose of the local citizen. It has got rich ritual cultural values in the valley beauties. The river originates at Tokha on Sivapuri Mountain, north of Kathmandu and flows through the western part of old Kathmandu city. It is a holy river for both Hindu and Buddhist people. Literally, Bishnumati means the beloved river of Lord Vishnu. But from last 35 years it has been using for dumping site for all types. Encroachment of the river with diversion of the river has been carried out by the people and it is having from the river to drain so it should be stopped. For that surrounding environment should be improved. That is the river side improvement and demand of greenery development by bioengineering system to be needed today.

Bishnumati River receives tributaries such as the Lupan Khola the Sanla Khola and the Mahadev Khola which supply debris from the Shivapuri range composed of the Sheopuri Injection Gneiss Zone. The river flows between the altitudes of 2,481 m (the origin in the Shivapuri hills) and 1,289 m (confluence with the Bagmati River at Teku).The stretch of the river ranges from 65m to 100 m in width. The recorded mean monthly flow of this river at Teku is 0.72 m.3/sec in March (minimum) and 16.62 m.3/sec in August (maximum). The total catchment area of this river about 80 sq km. The banks of the Bishnumati River have become provisional landfill sites, where dumping of solid waste from Kathmandu was started in 1994. The dumping zone extends from Balaju in the northwestern part of the metropolis to Teku, at the confluence with the Bagmati River [1]. Bishnumati receive raw sewage from the metropolitan area, untreated effluents from industrial estates, hospital wastes, toxic chemicals and acid from carpet washing plants, pesticides and chemical fertilizers washed by rainwater from the field, and the detritus of cremation. Around 68 industries and nearly 2 million people pour industrial effluent and human waste directly into the holy river, which is the backbone of the civilization of the Kathmandu cities and not just a river of religious, cultural and social importance [2]. As suitable river management in urban areas is not well known and adopt in Nepal. Despite of their fundamental role since ancient times as the first place of urbanization, riverside areas are frequently afflicted by tremendous problems of overcrowding, conflicting uses, and pollution, often due to the absolute lack of planning and management.

Now days, people are aware of water quality and safe drinking water is everyone's prime concern. Quality of water here relates to the inorganic and organic substances including the composition and status of water body. In Nepal, we do have largest natural water resources. The major sources of water are glaciers, snow-melt from the Himalayas, rainfall and ground water. Of these, river water is the most significant in terms of potential development. The rivers alone cover about 54 percent of the total water coverage area in the country [3]. Human activities such as deforestation, agriculture, disposal of industrial and domestic waste has been responsible for surface water pollution [4]. In Kathmandu, the main source of water pollution is domestic sewage system, which pollutes important source of drinking water such as well and rivers. It is estimated that Kathmandu produces 150 tons of waste each day, nearly half of which is dumped into the river. More than 40 million liters a day of wastewater is generated in Kathmandu and a whopping over 80 percent of this is generated by households [2]. Degradation and loss of freshwater biodiversity can be attributed to adverse changes to environmental water quality, mainly as a result of pollution of anthropogenic origin [5]. In many developing countries approximately 90% of wastewaters are discharged into rivers and streams with partial or no treatment [6], thus resulting in most of the freshwaters from polluted ecosystems being regarded as unfit even for industrial activities requiring poor quality water [7].

Many rivers of the world receive a heavy flux of sewage, industrial effluents, domestic and agricultural wastes that consist of substances varying from simple nutrient to highly toxic hazardous chemicals. Pollutants in any industrial discharge are of different types, such as oxygen demanding wastes, disease causing agents, synthetic organic compounds, plant nutrients, inorganic chemicals and minerals, sediments, thermal discharges, oil and grease. In this country, like in most of the other developing countries, the current practice is still to discharge mostly untreated industrial wastewater and sewage directly into the local streams and rivers. As a result, the quality of most of the streams and rivers in the vicinity of industries has been degraded to the point where the water is harmful to the aquatic life and human health [8]. Therefore, the present study was carried out to study the status of water quality parameters of Bishnumati River.

2. Materials and Methods

2.1. Study Area

The study area was Bishnumati River within the ring road and main city of Kathmandu Valley.

2.2. Sampling sites/stations

Altogether seven sampling sites of Bishnumati River namely Panimuhan (S1), Tokha (S2), Jalbinayek (S3), Gongabu (S4), Shobhabhagawati (S5), Teku before mixing in Bagmati (S6) and Teku after mixing in Bagmati River (S7) were selected as sampling sites. The samples were collected in the month of March to September. A GPS tracking was done to determine and track its precise location of sampling station. The detail information on sampling sites is given in Table 1.

Table 1: Sampling sites and their GPS locations

SN	Sampling Site	Location	Name
1	S1	27°45'19.5"N 85°18'35.4"E	Panimuhan
2	S2	27°45'12.5"N 85°19'31.9"E	Tokha
3	S3	27°45'19.5"N 85°18'35.4"E	Jalbinayek
4	S4	27°44'9.2"N 85°18'26.7"E	Gongabu
5	S5	27°42'53.5"N 85°18'6.7"E	Sobhabhagabati
6	S6	27°41'30.6"N 85°18'7.2"E	Teku (*before mixing Bagmati*)
7	S7	27°41'27.4"N 85°18'7.8"E	Teku (*after mixing Bagmati*)

2.3. Methods

The physicochemical parameters were analyzed by using standard methods [9] to find out the quality of river water. Temperature measurement was made by immersing the thermometer into water sample for a sufficient period of time till the reading stabilizes and expressed as °C. The pH was determined on site with the help of pH meter. To measure total solid in water sample, a known volume of sample was evaporated in a pre-weighed dish and dried in an oven at 103-105^{o} C. A constant weight was obtained by repeating heating, cooling and weighing. Total hardness of water was determined by titrimetric method. Here 50 ml of the sample was taken in a conical flask, to which 1ml. of ammonium buffer and 2-3 drops of Eriochrome black -T indicator were added. The mixture was titrated against standard 0.01M EDTA (Ethylene diamine tetraacetic acid) until the wine red color of the solution turned pale blue at the end point. In the same way, the alkalinity of water was also determined by titrating with standard sulphuric acid and methyl orange was used as indicator. At the end point dark orange color was seen. Similarly, chloride was tested by argentometric titration. In this process, a known volume of filtered sample was taken in a conical flask, to which about 0.5 ml. of potassium chromate indicator was added and titrated against standard silver nitrate till brick red silver dichromate ($AgCrO_4$) precipitated out. Turbidity of water sample was determined by using Nephelometer.

Likewise, ammonia content was analysed by Nesselar's method. In this method, 100 ml. of sample was taken and Nessler's reagent was added and a distinct yellow coloration was observed. The concentration of ammonia was then estimated with the help of UV spectrophotometer. Dissolved Oxygen (DO) was determined by Winkler's iodometric method in which liberated iodine was titrated with sodium thiosulphate ($Na_2\ S_2\ O_3$) where starch was used as an indicator. At the end point, blue color of indicator disappeared. The difference in oxygen concentration of the sample before and after 5 days of incubation at 20 °C was obtained to calculate biological oxygen demand (BOD) of the water sample to investigate pollution.

Similarly, chemical oxygen demand (COD) was estimated by open air reflux method in which sample was refluxed with

0.025 M potassium dichromate and concentrated sulphuric acid with little amount of mercuric sulphate. The excess amount of potassium dichromate was titrated against 0.025 M ferrous ammonium sulphate using ferroin indicator. The amount of ferrous ammonium sulphate consumed was used to calculate.

All the reagents were of analar grade and were obtained from Merck Company. Distilled water had been used throughout the experiment. Chemto Ltd Company's UV-Vis spectrophotometer was used in this experiment for ammonia.

3. Results and Discussion

Table 2: The results obtained from all the above tests are summarized in the following table:

Parameters		S1	S2	S3	S4	S5	S6	S7	#NSV
Temperature (ºC)		17.3	22.8	21.9	23	22	21.4	21.5	6 - 32
pH		7.2	7.3	7.2	7.0	7.2	7.4	7.1	6.5 - 9.0
Total solid, (mg/L)		60	228	342	262	480	482	608	< 2000
Total hardness, (mg/L)		1.48	1.68	2.54	2.00	3.28	3.00	3.00	20 - 100
Alkalinity, (mg/L)		55	168	198	199	368	388	391	20 ~ 100
Chloride, (mg/L)		10.0	40.0	63.0	52.9	108.1	102.1	110.8	< 100
Turbidity, (NTU)		7	126	469	173	312	218	280	< 50
Ammonia, (mg/L)	Concentration	1.452	3.724	5.601	5.333	6.792	5.088	8.682	1.5*
	Absorbance	0.188	0.472	0.717	0.682	0.873	0.650	1.119	
DO, (mg/L)		12.2	1.34	1.02	0.36	0.00	0.00	0.00	6 - 9
BOD, (mg/L)		1.17	61.75	465	112.9	528.6	307.9	247.6	< 15
COD, (mg/L)		11	180	640	340	670	450	240	< 40

Note: # NSV= Nepal Standard value/Reference Value: The result obtained in this study was compared with this reference value: #Environment Statistics of Nepal 2008, Government of Nepal, National Planning Commission Secretariat, central Bureau of Statistics, Kathmandu, Nepal, Annex 8: Nepal Water Quality Guidelines [10].

* It indicates the value of NDWQS (Nepal Drinking Water Quality Standards).

Out of seven sampling sites of Bishnumati River, the temperature of Gongabu, Tokha and Shobhabhagawati was found to be slightly high. It may be due to the intensity of sunlight. According to NWQGA (Nepal Water Quality Guidelines for Aquaculture, 2065), the adaptable temperature ranges from 4 ºC to18 ºC for cold water species,6 ºC to 32 ºC for intermediate species and 24 ºC to 30 ºC for warm water species. The pH of all sites was found to be neutral. The pH 6.5-9.0 is optimal thus the water of all stations is potable for organisms. The total solids of all the samples from seven sites were presented in Fig. 1. From the diagram one can clearly see the increasing trend of total solid when moving to downstream from Panimuhan to Teku. It may be due to agricultural and residential runoff, leaching of soil, water discharged from industrial areas and sewage mixing.

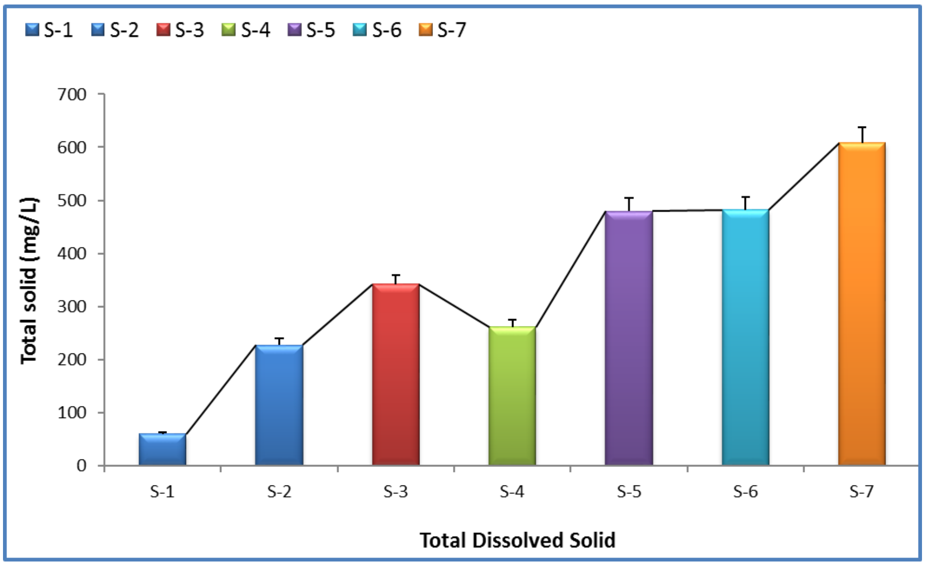

Fig 1: A bar diagram indicating the total dissolved solid in different sites in the Bishnumati River.

The turbidity values also indicated increasing trend. The turbidity of Jalbinayak was maximum 469 NTU. It is due to excess sand, silts, bacteria, germs, chemical precipitates, particles and coloured materials in water. The turbidity of Panimuhan is minimum indicating less particles in initial point. NTU value greater than 50 is considered harmful for aquatic organisms.

Correspondingly, the results showed that alkalinity of Teku after mixing Bagmati was found to be the highest. This result is due to the presence of bicarbonates and carbonates and hydroxides of calcium, magnesium and sodium. Many of the chemicals used in water treatment such as alum, chlorine, or lime, also supposed to be cause of alkalinity. Lowest alkalinity of Panimuhan indicated the softness of water in Panimuhan and also it was less corrosive. The acceptable range for most fish is 20-100 mg/L. The Shobhabhagawati, Teku before mixing with Bagmati and Teku after mixing with Bagmati sites showed greater value than acceptable range which was unfit for aquatic life.

Similarly, water sample of Panimuhan had the lowest amount of chlorides. Shobhabhagawati and Teku after mixing with Bagmati site had higher amount of chlorides.

Total Hardness of water sample of Panimuhan and Tokha were 1.48 and 1.68 mg/l respectively which indicated that the water of those stations was soft. Shobhabhagawati site had the highest total hardness of 3.28 mg/L. The increase in total hardness was caused due to the increase in the concentrations of carbonates, bicarbonates, sulphates, mainly, Ca and Mg in the river water. The hardness affects the ability of water to support aquatic life resulting in oligotrophic condition.

The ammonia concentration was very high in Shobhabhagawati site indicating elevated fresh contamination.

The DO (dissolved oxygen) of Panimuhan was the highest (12.2 mg/L) whereas the DO of Tokha, Jalbinayak and Gongabu was decreasing as moving to down streams. The DO of Shobhabhagawati, Teku before mixing with Bagmati and Teku after mixing with Bagmati sites were completely null which indicates the presence of maximum amount of organic wastes in those areas. Panimuhan site showed sufficient DO that can support aquatic lives but Shobhabhagawati, Teku before mixing with Bagmati and Teku after mixing with Bagmati sites stations had no DO signifying risks to aquatic lives with maximum pollution.

Likewise, the BOD (biological oxygen demand) value was increased on moving down streams. At Shobhabhagawati station, BOD was 670 mg/L.

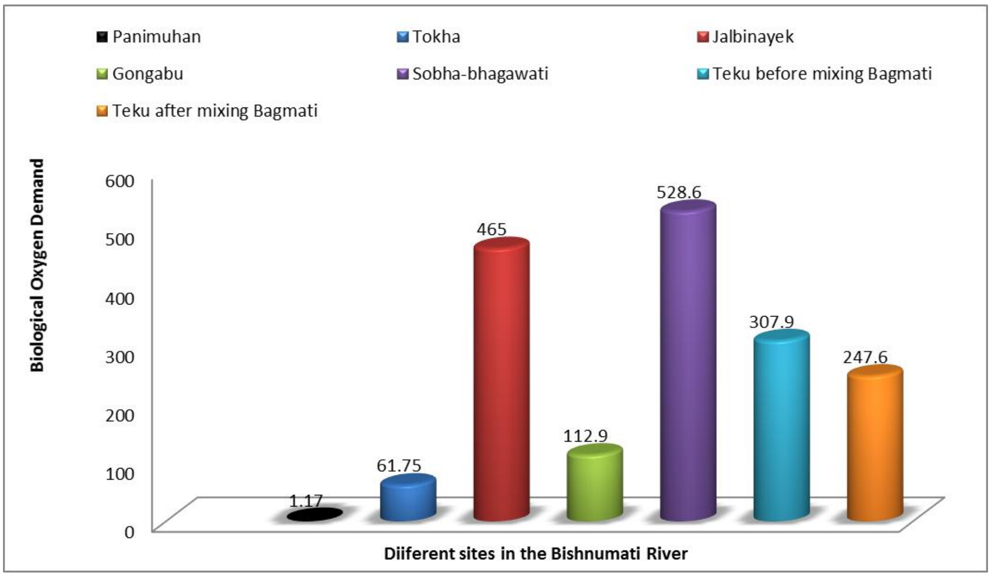

Fig 2: Bar graph showing the BOD values in different sites in the Bishnumati River.

This high value indicated the contamination of higher amount of wastes such as pharmaceuticals, food processing chemicals, commercial cleansing, disinfectant, fertilizers, and sanitary wares directly discharged in river which is responsible for lowering of dissolved oxygen. Such high values of BOD suppress the microbial activity and hence it creates a higher demand of oxygen. As recommended by BBWMSIP (Baghmati Basin Water Management Strategy and Investment Program 1994, the desirable BOD level for drinking and aquatic life is 4mg/L and bathing and agriculture is 10mg/L. In addition to this, the COD (chemical oxygen demand) value of water from Shobhabhagawati contained maximum amount of organic matters as well as chemicals in comparison to initial point Panimuhan. The overall results indicated that water of Panimuhan was found to be in acceptable limit.

Regarding the physico-chemical parameters of the Bishnumati river of Kathmandu valley [11] had conducted a study and found that Bishnumati River was polluted by different chemicals and effluents from the various anthropogenic sources such as industrial effluents, domestic sewages, unburned fossil fuels. Most of the parameters were above the level of WHO standard and he also concluded that the pollution load was found increasing slowly from upstream sites of the river to downstream [11].

4. Conclusion

The present study disclosed the physicochemical contamination level in water at different stations of Bishnumati River. The results obtained were compared with the standard of water quality guidelines of aquaculture which indicated that the contamination level gradually increased as moving to downstream except the places where another tributary river was passing through crowded and industrial areas. Jalbinayak to Teku dovan was highly polluted in comparison to other sites. The increase of pollution level in downstream may be due to increase in urbanization and industrialization activities that made the water unfit for aquatic life. The water quality at Panimuhan was not found polluted. As the study revealed that the Bishnumati River being highly polluted, the following corrective measures are to be taken to check and control the present pollution level: (a) proper and strong policies from government level to be taken towards discharge of water effluents from industrial setups, (b) Necessary guidelines to be made mandatory for treatment of waste water before discharging in the river, (c) stopping illegal squatter settlement on river bank, (d) ownership of sewerage system to be given to locals and (e) basic and necessary awareness programs to be conducted in due course of time so as to make people aware towards pollution level and health hazards.

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