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Physicochemical Water Quality Assessment of Hanumante River, Bhaktapur, Nepal

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Abstract: This study was done to determine the current water quality of the Hanumante River, Bhaktapur by analyzing the physicochemical characteristics of water samples. Multiple water quality parameters such as temperature, pH, Turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total hardness, Total alkalinity, ammonia, phosphate, Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD) were examined by collecting samples from six locations along the river course. The findings suggest that the river is heavily polluted after reaching urban areas. Sewage discharge into river, dumping of solid wastes, and industrial effluent are the reasons of water quality degradation in Hanumante. There is a paramount necessity for appropriate wastewater management and effective pollution control to recover the ecological integrity and cultural heritage of Hanumante River.

Keywords: Hanumante River, physicochemical assessment, river pollution, water quality.

Introduction

The confinement of facilities, services, infrastructures and employment opportunities forced people to migrate into the Kathmandu Valley in search of better livelihoods. The migration of people from different region to Kathmandu amplified the unmanaged urbanization, leading to rapid increment in population, change in land use activity, and river encroachment-all of which contributed to degradation of river systems across the valley. The Bagmati river, primary river flowing through Kathmandu, is polluted due to the release of wastewater from its tributaries- originating from various parts of the valley. The major contributors to the heavy discharge of wastewater into the Bagmati are its tributaries: the Bishnumati (Kathmandu), Nakkhu (Lalitpur), Balkhu (Lalitpur and Kathmandu), Manohara (Kathmandu and Bhaktapur), and Hanumante (Bhaktapur). The inadequate sewage treatment systems, poor solid waste management, and chaotic settlements of squatters in slums along the river banks has further amplified the contamination leading to adverse effect in the river's water condition and aquatic animals' health.

Hanumante, the main river of Bhaktapur District, has cultural, religious, and geographical significance. It displays the heritage and essence of Bhaktapur's civilization. It is considered a holy river with many culturally important sites such as Brahmayani Ghat, Hanuman Ghat, Mangal Tirtha, and numerous temples located along its banks. This river originates from Mahadev Pokhari in Nagarkot in the east and flows through Bhaktapur, Suryabinayak, and Thimi municipalities before merging with the Manohara River at Narephant, Kathmandu. It covers a length of 23.5 km and drains a catchment area of 143 km², with 100 km² in Bhaktapur and 43 km² in Lalitpur (Sada, 2012). Kasan and Godavari are its major tributaries, joining the river at Sallaghari and Lokanthali respectively.

There is a progressive declination in Hanumante River water quality, once it enters urban areas. The increase in population within urban areas has contributed to polluted environments alongside riverbank. The population growth in Bhaktapur district is 3.35% annually, with a density of 3,631 individuals per square kilometer (National Statistics Office, 2021). The population growth contributes to ongoing deterioration of the river's condition alongside increasing urbanization (Sada, 2014). One can observe the rising trend in proliferation of human settlement along the riverbank in recent years. The primary cause of increased housing along the riverbank is the growing trend of migration to the river banks from core areas in Bhaktapur and Suryabinayak municipalities, combined with uncontrolled settlements in other downstream sections of the river.

The upsurge in population results in increase of solid waste and domestic sewage. Concurrently, the rising number of industries contributes to increase in industrial effluent. Domestic and industrial wastewater sewer lines have been directly discharged into the river, causing severe pollution and pungent odors along the riverside. The river water is being used for irrigation in urban areas and the water containing sewage, industrial effluents, microorganisms is likely to gather on crops, potentially posing risk to human health. Man-made pollution has not only harmed people but have also posed a serious risk to the survival of aquatic life. In present, the Hanumante River is clogged and polluted with waste and sewage, turning into a small dirty stream. Despite the river being polluted, people still take holy baths on several important ceremonies. There are various ongoing efforts for the treatment of sewage before it enters the river course, with initiation from the Government of Nepal. The construction of wastewater treatment plants in Sallaghari and Hanumanghat,

along with interceptor sewers at two locations in Bhaktapur, is still ongoing (GON and ADB, 2022).

Climate change, alongside anthropogenic factors like rapid urbanization, agricultural runoff and industrialization is deteriorating river water quality across many developing countries (Bhardwaj 2005; Rana et al., 2017). The study of physicochemical parameter of river water tells the degree of pollution and aids in understanding its impact on aquatic life and human health (Shah & Chaturvedi, 2019). Various studies have been conducted to assess river water quality around the globe, such as Woldeamanuale (2017) in Ethiopia; Chandra et al. (2011), Matta et al. (2020), and Mishra & Kumar (2021) in India; Nahar et al. (2016) and Mobin et al. (2014) in Bangladesh to name few.

River pollution is a common problem in densely populated cities of Nepal. Several researchers (Shah & Pant, 2012; Shrestha & Basnet, 2018; Singh, Kayastha, & Pandey, 2021) have studied the physical and chemical quality parameters of rivers, using different techniques at various locations in Nepal. Similarly, Bagmati being a major river system of Kathmandu valley, many water quality research have been carried out in the past. Previous research (Kannel et al., 2007, Paudyal et al., 2016, Adhikari, Neupane, & Kafle, 2019, Pal et al., 2019, Poudel et al., 2021, Kunwar et al., 2022) have studied physical, chemical, and microbial parameters of Bagmati and its tributaries to determine their water quality. Shrestha (2010), Sada (2014), Bohara (2016), and Bajracharya et al. (2020) analyzed different physical, chemical, biological wastes parameters to assess pollution of the Hanumante River and its tributaries and provided detailed insights into its water quality. In the recent time, there is very few study on physicochemical parameters of Hanumante, except for Bhatta et al. (2024), and Prajapati et al. (2025), who checked microplastics assessment and heavy metals removal techniques.

We aim to assess the physicochemical characteristics of the Hanumante River water to present an overview of its quality, helping to set a baseline for upcoming policy interventions and water quality monitoring. The data of this study would be useful for relevant government and non-government agencies to understand the status of pollution, design its mitigation measures, and formulate productive water resource management plans. For educational purpose, it also serves as local scientific literature on river pollution study in Nepal, where there is a lack of data. This study also provides basis for designing waste water treatment plants and development of sustainable urban infrastructures.

Materials and methods

The workflow of our study includes fixing the study points, data collection and sampling, physicochemical testing at lab, and analysis of the data.

Study area

To conduct the study, water samples were collected from six distinct sites, (H1-H6), along the course of Hanumante River (Figure 1). The first sample was taken from Sudal, Bhaktapur, H1 near the origin of the river. Rest of the samples were collected from different locations based on major sewage discharge point and river confluences. One sample from each location was taken for the study. The details of study points are shown in Table 1.

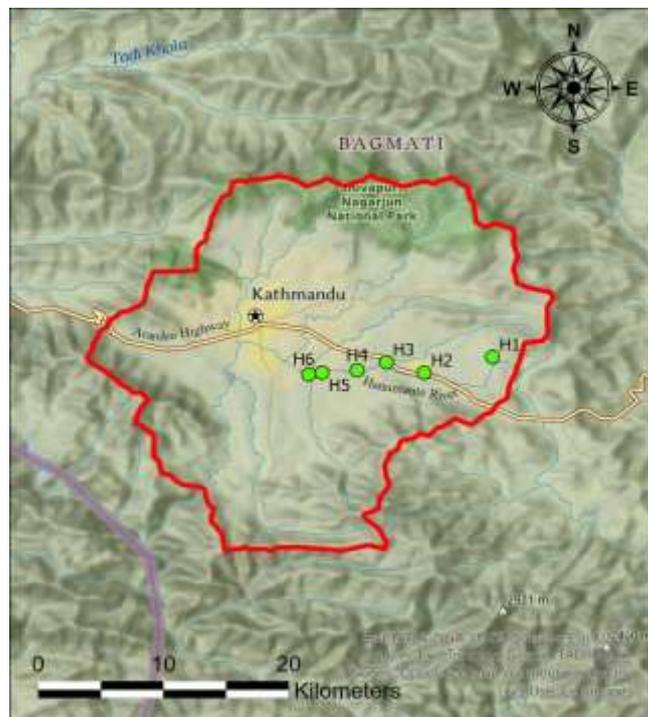


Figure 1. Locations of study area.

Table 1. Study locations of Hanumante River and their details.

S. N	Study sites	Coordinates	Location	Remarks
1.	H1	27°40'52"N, 85°28'59"E	Sudal, Bhaktapur	Without pollution load from city
2.	H2	27°40'09"N, 85°26'03"E	Hanumanghat, Bhaktapur	With domestic sewage, solid waste, and industrial effluents
3.	H3	27°40'37.7"N, 85°24'24.9"E	Shrijananagar, Confluence with Kasan River	With domestic sewage, solid waste, and industrial effluents

4.	H4	27°40'15.8"N, 85°23'9.7"E	Thimi, Beside Seabird International College	With domestic sewage, solid waste, and industrial effluents
5.	H5	27°40'8.8"N, 85°21'37.8"E	Kaushaltar, Confluence with Godavari River	With domestic sewage, solid waste, and industrial effluents
6.	H6	27°40'5.2"N, 85°21'04"E	Jadibuti, Confluence with Manohara River	With domestic sewage, solid waste, and industrial effluents

Sampling

For the collection of water sample, one liter plastic water bottles were used. The bottles were labeled and thoroughly cleaned before taking to the sampling site. Upon arrival at each site, the labeled bottle was rinsed three times with the river water before the water sample was taken. Water samples were collected by dipping each bottle 5-15 cm deep below the normal water level, placing bottle mouth against the flow of river. Sampling was done in the morning between 6:30 AM and 8:00 AM. The collected samples were then brought to laboratory within 30 minutes for analysis. All the parameters were analyzed in the laboratory.



Figure 2. Water condition at H3 during sampling.

Physicochemical analysis

The collected water samples were analyzed in the laboratory of Khwopa Engineering College. A total of 12 different physicochemical parameters were tested for this study. All the parameters were tested according to APHA (1998) standards. The temperature, pH, EC, and TDS were measured using thermometer, pH meter, EC meter, and TDS meter respectively, where all the instruments' measuring ends were dipped in samples and digital values were noted. A turbidity meter (range: 0–1000 NTU) was used to assess the turbidity levels of the collected water samples. TSS analysis was performed using standard gravimetric procedures. Total hardness was measured by EDTA titration method with Eriochrome Black T as indicator. Total alkalinity was measured by titrating against phenolphthalein and methyl orange as indicators. Ammonia and phosphate concentrations in water samples were measured using spectrophotometric methods. Colorimetric reactions specific to each sample were developed, and transmittance was determined using a UV-Vis spectrophotometer at their respective wavelengths. COD was measured by using the closed reflux method with potassium dichromate digestion followed by titration with ferrous ammonium sulphate. BOD₅ was determined by incubating water samples for 5 days at 20°C and measuring dissolved oxygen before and after incubation using the Winkler iodometric titration method.

Results and Discussion

The physicochemical parameters of river water samples collected from the six sites were examined to assess their environmental quality. The analysis revealed considerable variation in parameters of the samples, particularly in those associated with organic and nutrient pollution. The results of physical and chemical parameters of the six different sites observed in present study are shown in Table 2.

Table 2. Characterization of Hanumante River water based on physicochemical parameters.

Parameters	Study Sites					
	H1	H2	H3	H4	H5	H6
Physical parameters						
Appearance	Clear	Turbid	Turbid	Turbid	Turbid	Turbid
Temperature* (°C)	16.1	17.1	19.6	19.4	16.6	18.9
pH	7.7	7	6.4	6.7	6.7	7
Turbidity (NTU)	0	101	94	65	62	94
EC (µS/cm)	270	910	820	890	830	500
Chemical parameters						
TDS (mg/l)	156	528	501	560	583	276
TSS (mg/l)	8	320	380	320	240	280
Total Hardness (mg/l)	90	228	232	182	174	128
Total Alkalinity (mg/l)	14.6	58.2	43.6	43.7	48.5	29.1
Ammonia (mg/l)	0	2.1	1.9	1	1.3	1
Phosphate (mg/l)	0.02	7.7	7.3	10.1	7.1	11.8
COD (mg/l)	60	540	532	380	465	224
BOD (mg/l)	2.4	46.1	197.6	212.8	228	48.6

*Temperature during measurement

Physical parameters assessment

Temperature: The temperature of wastewater samples varied from 16.1 °C to 19.4 °C, with Sudal recording the minimum and Shrijananagar the maximum. The low water temperature at all sites can be attributed to testing being performed at morning hours. Nevertheless, the temperature at the time of sampling cannot be used as the sole parameter in water quality assessment, as it varies with time and external conditions.

pH: The pH of 6.4 to 7.7 was observed across the wastewater samples. The drop from 7.7 to 6.4 indicates that wastewater discharge is introducing acidic substances, probably due to organic waste decomposition producing carbonic acid and lack of adequate buffering capacity in the river. All the pH values are within WHO guidelines for irrigation; it was found that people were using the river water for irrigation.

Turbidity: The value of turbidity ranged from 0 NTU to 101 NTU. NWQS (2079) suggests maximum limit for Drinking water turbidity values to less than 5 NTU. The elevated turbidity level of Hanumante River water makes it unfit for drinking. Such pronounced turbidity level indicates heavy pollution and high concentration of suspended particles, which can harbor pathogens and reduce treatment effectiveness (Kannel et al., 2007).

Electrical conductivity (EC): The EC values in the water samples ranged from 270 $\mu\text{S}/\text{cm}$ at the site H1 to a maximum of 910 $\mu\text{S}/\text{cm}$ at site H2. This significant increase indicates high ionic enrichment probably due to anthropogenic pollution sources such as domestic sewage, industrial effluents, and urban runoff (Sawyer et al., 2003). Water sample from site H6, located at the confluence, exhibited a comparatively lower EC value. This reduction may be due to dilution from less polluted tributaries or natural self-purification processes.

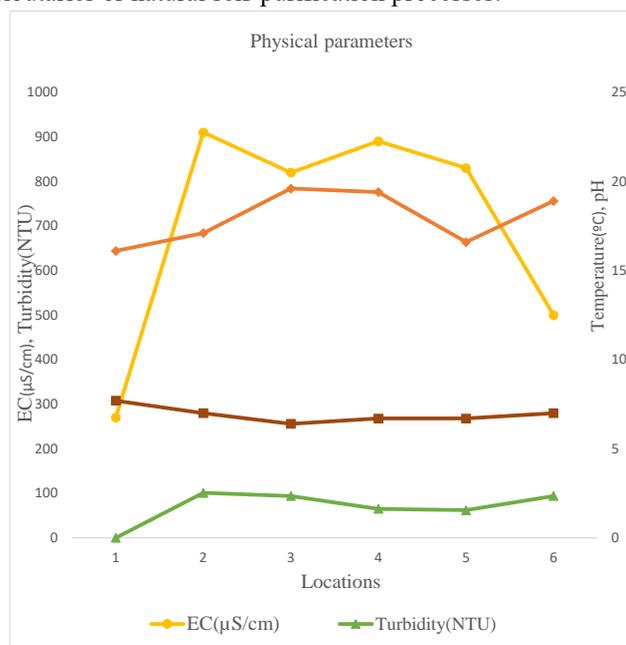


Figure 3. Variation of physical parameters along Hanumante River course.

Chemical parameters assessment

Total dissolved solids (TDS): TDS values in the water samples were found to range from 156 mg/l to 583 mg/l. TDS values at H1 reflects clean, less mineralized water. TDS in water primarily consist of bicarbonates, carbonates, chlorides, nitrates, and phosphates of elements such as calcium, manganese, magnesium, potassium, and sodium, along with organic matter, salts, and various other particles (Mahananda et al., 2010). The increased TDS levels at various points are detrimental to water quality, compromising its appropriateness for potable use (Vasanthavigar et al., 2010) and posing ecological risks to aquatic biota. TDS concentration at H6 indicated a drop, probably due to dilution at a confluence.

Total suspended Solids (TSS): TSS in wastewater samples ranged between 8 mg/l to 720 mg/l. CPCB (2019) suggested water with TSS greater than 100 mg/l as polluted water, indicating samples except at H1 to be severely polluted. TSS values exceeding 200 mg/L, except at H1, are indicative of polluted water, particularly in river systems influenced by urbanization and anthropogenic activities.

Total Hardness: Hardness concentrations in the Hanumante River was in range of 90 mg/l to 232 mg/l. This signifies that the water varied from moderately hard to hard. This increase in hardness is likely linked to human activities-based pollution, which contributes significant quantities of calcium and magnesium ions to the aquatic environment.

Total Alkalinity: Total alkalinity at the sites varied from 14.6 mg/l to 58.2 mg/l. The value of alkalinity differed at various sampling sites. Alkalinity values indicated low to moderate buffering capacity of river.

Ammonia: Ammonia concentrations ranged from 0 to 2.1 mg/L, with multiple sites exceeding ecotoxic thresholds. Ammonia value of more than 1.2 mg/l indicates water unsuitable for aquatic life (CPCB, 2019). High concentration of ammonia represents high organic pollution, oxygen depletion, and threat to aquatic biota.

Phosphate: The phosphate value was found from 0.02 mg/l to 11.8 mg/l. The lowest value observed at H1 was within accepted value for unpolluted surface water. The values at remaining sites were excessive, indicating high phosphorus pollution. High concentrations of phosphate can reflect the occurrence of contamination, poses ecological stress, and are mainly responsible for eutrophic conditions (WHO, 2011).

Chemical Oxygen Demand (COD): The COD of water samples ranged from 60 mg/l to 540 mg/l. The lowest value observed upstream (H1) suggests a considerably unpolluted river course prior to the river entering urban areas. High COD concentration implies depletion of dissolved oxygen in water, representing area with severe organic pollution. Water with COD values above 300 mg/L typically require advanced treatment stages beyond primary settling for reducing the organic load to acceptable discharge limits (Tchobanoglous et al., 2014).

Biological Oxygen Demand (BOD): BOD values varied widely across the sampling sites, ranging as low as 2.4 mg/l at H1 to as high as 228 mg/l at H5. These fluctuating values show varying degree of organic pollution across the sampling sites. The value of BOD has direct relation with rate of oxygen depletion across river course. All results from samples collected in urban settlements indicate a decline in dissolved oxygen (DO) levels along the river course. BOD standard for aquatic life, outdoor bathing, and irrigation is less than 4mg/l, less than 6 mg/l and less than 10 mg/l respectively (GON,2008). Only sample from Site H1 fit into this stated category, whereas rest can be considered heavily polluted.

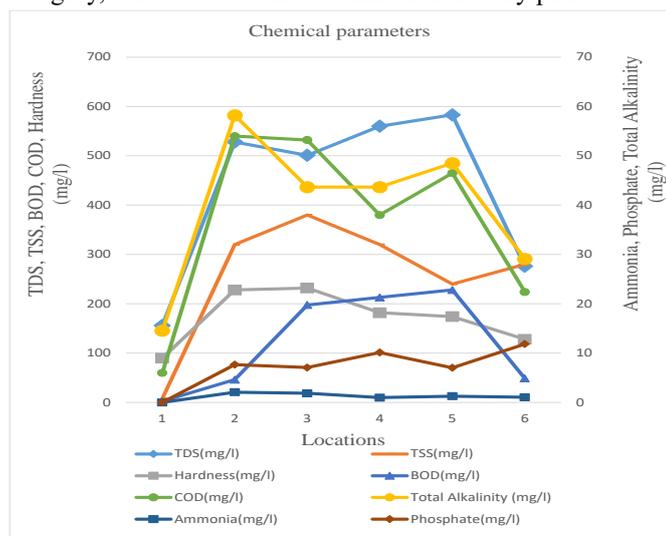


Figure 4. Variation of chemical parameters along Hanumante River course.

Conclusions

The physicochemical parameters of Hanumante River water were assessed by collecting samples at six different locations along the river course. The study shows degradation of water quality in urban areas. The primary cause for this is anthropogenic factors such as direct mixing of domestic sewage to the river, industrial effluent, and dumping of solid waste. None of the study locations, except H1, can be considered suitable for recreation and the aquatic ecosystem; the remaining locations are heavily polluted. The results highlight an urgent need for effective wastewater management and pollution control in the Hanumante River. The completion of wastewater treatment plants in Sallaghari and Hanumanghat, along with interceptor sewerage across other locations, is expected to upgrade river water quality in the coming years.

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Authors Contribution

NB, UB, and NHL conceptualized the study, performed the experiments and data analysis, and drafted the manuscript. RG supervised the study. All authors have read, reviewed, and endorsed the manuscript.

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