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Water Quality Assessment Using Water Quality Index (WQI): A Case Study of Karmanasha River, Lalitpur, Nepal

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Abstract

The research analyzes the water quality of Karmanasha River which functions as a primary water source for domestic and agriculture needs in Lalitpur area. This investigation examines the environmental well-being of the river through the analysis of measurements for pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Iron Content, Turbidity (NTU), and Total Coliform Count which were analyzed and then aggregated in the form of WQI. The BOD and COD levels demonstrate substantial human-caused polluting factors. This research highlights the Water Quality Index to indicate the quality of water in the Study area.

Keywords: Kodku Khola, Karmanasha River, Water Quality index.

1. Introduction

The WQI serves as a widespread tool to group different water quality ratings into "excellent" through "poor" to "unsuitable" levels for multiple applications. The Water Quality Index functions as a powerful assessment method that simplifies the presentation of water body quality assessment results. A single numerical value derived from several water quality parameters represents water quality assessment data extending, and the scale shows improved water quality through higher numbers (Ashwani Kumar, 2009).

The area has experienced a decrease in water quality due to urban expansion, industrial development, and rising population. The objective of this study was to determine the water quality of the Karmanasha River by analyzing its major physicochemical parameters. These are vital factors that must be analyzed mandatorily for a sustainable approach and superior management strategies. As this part of karmanasha river deliver the water tank services to the many houses of Kathmandu valley without the water quality mention. The paper documents the deteriorating water quality of the river which stems from urbanization alongside industrial growth and increasing population density throughout its course.

2. Study Area

The research is conducted in the Kodku Khola River basin, commonly referred to as Karmanasha, as shown in Figure 1. The Guindaha section of Badikhel village is the starting point of this river situated in the Godawari Municipality within the Lalitpur District (Shrestha, 1988). The Kodku Khola falls under a sinuous river with an average slope of 2.58. (Naresh kazi Tamrakar, 2012). The river system is the only waterway flowing north to south across its drainage area. The river flows through Godawari, then Hattiban, and finally Gwarko, before reaching its terminus at the Balkumari Manohara River in Kathmandu. The study area incorporates the territories located above the Hattiban Bridge. The researchers have selected a combination of research methods to evaluate the Karmanasha River's water condition. Water sampling and survey contribute to quantitative data collection, while stakeholder interviews provide qualitative information in this research. The upstream section of Karmanasha River experiences a discharge flow between 17.35 m^3/s to 56.94 m^3/s. (Acharya *et al.,* 2020). The Khumaltar Station recorded an average annual rainfall of 1238 mm over ten years,

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while the Godawari Station measured 1494 mm during the same period, indicating a significant contribution of rainfall to seasonal river (Laxmi Devi Maharjan, 2007).

Figure 1. Study Area and Sample Location

3. Methods

3.1. Sample Location and Collection.

The sampling was taken in January (dry season) when the flow of river is low and the water is more polluted than other season, upstream of Hattiban Bridge (around 2km). Four water samples, labeled L1, L2, L3, and L4, were selected for physical, chemical, and microbiological analysis. The site was selected due to the presence of a sewage intake channel and the significant environmental changes in the river, which is severely polluted. The Mountain View housing serves as point L3 for sewage discharge and Merocity apartment operates as point L4 for sewage disposal. Location L2 serves as a water intake for tank water services to distribute water throughout the valley through tankers.

Table 1 Location Coordinates

Location	Coordinates
L1	27°38'06"N |85°20'04"E
L2	27°38'24"N |85°20'06"E
L3	27°38'37"N |85°20'04"E
L4	27°38'50"N |85°20'08"E

The samples were collected in 2L plastic bottles from all locations.These are taken to NAST (Nepal Academy of Science & Technology) for water analysis report.

Figure 3. Sampling Location

Figure 4. Sample testing

3.2. National Sanitation Foundation's Water Quality Index (NSF-WQI)

The Water Quality Index (WQI) was calculated by NSF-WQI method developed by (Robert M Brown, 1970) this index result in 0-100 point scale by the result of nine parameter.

Table 2. Weight scores NSF-WQI parameters

Parameters	Weighted Mean
pH	0.11
DO, mg/L	0.17
EC	0.16
Temp	0.1
Ammonia	0.1
Phosphate	0.1
Turbudity	0.08
BOD	0.11
TDS	0.07

The national sanitation foundation's water quality index (NSF-WQI) is given by:

$$NSFWQI = \sum_{i=1}^{n} SliWi \qquad \text{(Equation 1)}$$

Where, "Wi" is weight score, "Sli" is sub index value of parameter.

Table 3. Water Quality Range according to NSF-WQI

WOI	General criteria
85-100	Uncontaminated
70-84	Acceptable
50-69	Little Contaminated
30-49	Contaminated
0-29	Highly contaminated

3.3. Weighted Arithmetic Water Quality Index (WA-WQI)

Assign weight (W_i) to each parameter based on their relative importance in overall water quality.
Calculation of relative weight:

$$WAWQI = \sum \frac{QnWi}{Wi} \quad \text{(Equation 1)}$$

…where, "Qn" is the quality rating scale for each parameter, "w_i" is the weight of each parameter, and "n" is the number of parameters.
Calculation of quality rating scale:

$$Qn = \frac{Vn - Vo}{Sn - Vo} \times 100 \quad \text{(Equation 2)}$$

…where, "Vn" is the observed value, "Vo" is the concentration of each parameter, and "Sn" is the standard value by NDWQS.
Determination of Wi:

$$W_i = \frac{1}{Sn} \quad \text{(Equation 3)}$$

The water quality of the river falls into five categories—Excellent, Good, Poor, Very Poor, and Unfit for drinking water—according to the WQI rating ranges (I.A Kalagbor, 2019) Table 4.

Table 4. Water Quality Range according to WA-WQI

WQI	General Criteria	Grade
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very Poor	D
Above 100	Unfit	E

4. Result

The water samples collected at four locations (L1, L2, L3, L4) upstream of the Hattiban Bridge yielded the results shown below.

Table 5. Water Quality Parameter Report

S. N	Parameters	L 1	L 2	L 3	L 4	NDWQS
1	pH	6.06	5.95	6.03	6.11	6.5-8.5
2	Conductivity(µS/cm)	414	335	306	376	<1500
3	Turbidity (NTU)	68.8	28.8	38.8	27	<5
4	Total Hardness(mg/L)	130	140	150	140	120-180mg/L
5	Chloride Content(mg/L)	25.56	28.4	31.24	34.08	<250mg/L
6	Iron Content(mg/L)	1.97	0.59	0.63	0.59	<0.3mg/L
7	Ammonia(mg/L)	0.1	0.7	0.3	3	1.5gm/L
8	TDS(Mg/l)	227.38	224.45	204.02	251.92	<1000gm/L
9	TSS(mg/L)	172	72	97	67.5	<12.5
10	Dissolved Oxygen (DO)(mg/L)	8.16	8.03	7.24	5.63	>5mg/L
11	Biological Oxygen Demand (BOD)(mg/L)	11.86	12.12	14.13	27.46	<12mg/L
12	Chemical Oxygen Demand (COD)(mg/L)	155.33	172	35.33	68.66	<10mg/L
13	Total Coliform Count	>300	>300	>300	>300	0-100 mL

4.1 Water Quality Score and graph

The analysis implemented NSF-WQI and WA-WQI as dual assessment tools to reveal additional information about the quality decline in Karmanasha River's waters. Both evaluation systems demonstrated diminished water quality along the watercourse, yet their pollutant detection abilities and calculation procedures led to unique results during assessment.

Table 6. Water Quality Score (WA-WQI)

Sn	Location	WA-WQI	
1	L1	83	Very Poor
2	L2	72	Poor
3	L3	91	Very Poor
4	L4	118	Unfit

Table 7. Water Quality Score (NSF-WQI)

SN	Location	WQI	
1	L1	79	Acceptable
2	L2	71	Acceptable
3	L3	56	Little Contaminated
4	L4	52	Little Contaminated

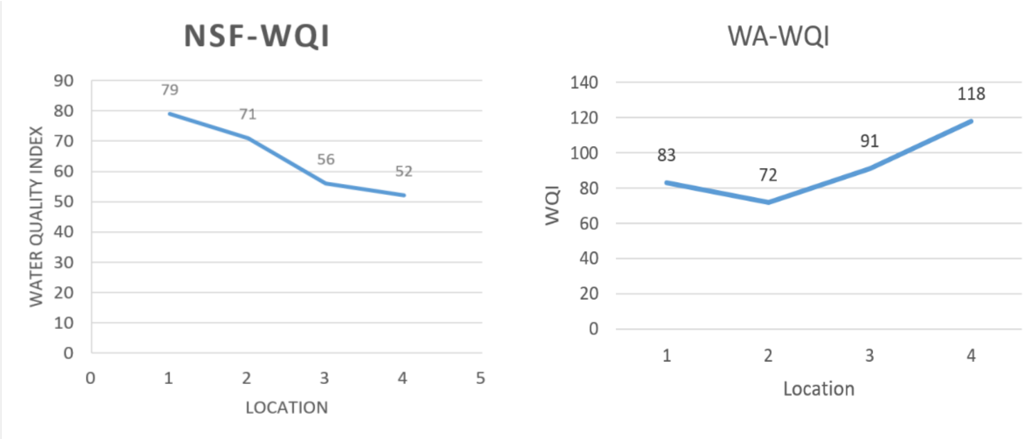

Figure 4. Water Quality Index Graph

5. Conclusion

The dual-index methodology showed that clean water conditions prevail in the upper parts of the Karmanasha River but pollution caused by urbanization produces severe contamination throughout its lower stretches. NSF-WQI assigned a "Poor" rating to L4 while WA-WQI classified this point as "Unsuitable" thus emphasizing the immediate need for wastewater treatment systems and measures to control soil erosion along with public awareness initiatives.

The research conducted on the water quality of the Karmanasha River in Lalitpur, Nepal, demonstrates that the WQI values clearly indicate a deterioration in water quality from the upstream location, L1, to the downstream location, L4. The water quality meets WHO standards at all sampling locations, with all pH measurements falling within the approved parameters for aquatic life. The river water contains minimal minerals since its TDS readings do not exceed NSWQS standards. The decrease in dissolved oxygen (DO) occurs slightly downstream of the measurement point but remains above the necessary threshold, which supports the aquatic ecosystem. The downstream water quality showed deteriorating organic pollution status.

Data reveals that turbidity exceeds NSWQS standards from L3 onwards because of suspected pollutants and elevated sediment loads in the area. The analysis reveals E. coli is absent at all sampling points, while the microbial numbers rise downstream, which indicates fecal pollution and potential health threats. The water quality remains good in upstream areas yet turns fair as the river flows downstream, thus demanding specific measures for improvement.

The research demonstrates that urbanization practices and human activities have created water contamination problems in the Karmanasha River.

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This case study stands as a testament to the synergy of collective effort, intellectual innovation, and shared commitment to advancing sustainable environmental practices. We hope it serves as a meaningful contribution to this field.

This study faces limitations as it was conducted during a single dry-season period while sample contamination risks arose from transportation procedures and has restricted its research area to the sector above Hattiban Bridge and did not investigate either future research directions or management strategies.

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Author Contribution

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