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Quality Assessment of Bagmati River Water, Kathmandu, Nepal

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ABSTRACT

Water pollution, one of the serious environmental issues of the world, results from contaminants being introduced into the natural environment. In the present study physiochemical and total coliform count of water sample collected from various location of the Bagmati river were determined. In physicochemical assessment temperature, pH, TSS, DO, BOD, COD, total nitrogen, phosphorus, Nitrate, metals like Cu, Pb, Zn, Cd, Cr and Hg were analyzed. The study was carried out in the two season vz January to June, 2020-21 and July to December, 2020-21. Results showed that TSS range was found (113-mg/l to 444mg/m) (4-444mg/l), DO (9.2mg/l)Maximum value, BOD (201mg/l to 394mg/l) (1.5-394mg/l) and COD (514mg/L to 950mg/l) (6-950mg/l) which is very above the World health organization and Nepal Standard guideline in few water sample of Bagmati river in January to June period, where as in July to December it was TSS range was found (68-mg/l to 523mg/l) (3-513mg/l), DO (1.5mg/l) (8.2mg/l) Maximum value, BOD (106mg/l to 325mg/l) (1.5-392.8mg/l) and COD (280mg/l to 870mg/l) (5-896mg/l). The coliform count in January to June was 0.2 x10^2 to 72.2 x 10^2(0.18 x102 – 148.6 x102 W6 water sample)) whereas from July to December it was 0.24 x 10^2 to 64 x 10^2 (0.2 x102 – 126 x102). High value of TSS, DO, COD and BOD in the lower belts of river was due to large inputs of wastewater and organic loads caused by anthropogenic activities. High value of Coliform in all the samples indicates bacterial contamination in river water. The comparative study for the water quality variables in the summer and winter season showed that the main rivers and its tributaries were equally polluted.

Key words: *Physicochemical analysis, coliform count, Bagmati River and Nepal*

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INTRODUCTION

The Bagmati River, which has both religious and geographic significance, is the pride of the Kathmandu Valley civilization and is revered as a holy river by the Hindu and Buddhist communities. On the bank of the river are numerous significant holy sites, including Gokarneshwor, Pashupatinath, Guhyeshwari, Teku Dovan, and others (1). Urbanization and civilization in Nepal are credited to the Bagmati River. It is a river that originates from Baghdwar and Shivapuri hill at a height of 2650m, in contrast to the other huge snow-fed rivers of the Himalayas. The Kathmandu valley river system's main river is the Bagmati River (2). The Bagmati River, an important water resource of Nepal, is currently facing biological, chemical, and other ecological challenges (3). Due to a lack of water resources, many residents use this river's untreated water for a variety of uses, including irrigation, cleaning recently produced agricultural items, and residential consumption. In addition, unplanned development and unchecked population growth have caused most of the sewage and solid waste from metropolitan areas to discharge straight into rivers. The Bagmati River's and its tributaries' quality has been gradually deteriorating. Large amounts of untreated sewage are present, and the river is highly polluted due mostly to the dense population in the area. Many people in the Kathmandu valley throw their trash and other debris into the river (4). Therefore, the presence of diverse groups of waterborne pathogens in this river water is likely high. The characterization and quantification of waterborne pathogens in the Bagmati River are essential to identify the sources and potential risks from contamination. Due to insufficient research in molecular level, human enteric pathogens are not commonly diagnosed from environmental and clinical samples at the national level, in Nepal. Although several studies have assessed the water quality of the Bagmati River, few have analyzed the microbiological aspect of water quality with respect to the presence of enteric viruses, protozoa, and bacteria (5, 6).

Therefore, the present study was undertaken to assess the physiochemical and bacteriological quality of water and to evaluate the heavy metal concentration of the water of Bagmati river.

MATERIALS AND METHODS

Sampling site and collection ofSample: Seven major points were selected for the collection of samples, which include,

1. **Sundarijal:** upper portion of the river, just outside the Shivapuri national park, minimum human influence,
2. **Gokarna:** mixing of seasonal rivers and some sewage pipe, dense human settlement,
3. **Guheshwari:** protected area on oneside and dense human settlelment on the other side,
4. **Suvidanagar:** before joining of Manohara river
5. **Sankhamul:** after joining of Manohara and Hanumante river
6. **Teku:** lower stretch of the river before joining of the Bishnumati River
7. **Chovar:** lower stretch of the river after joining of Balkhu River

Physicochemical and Bacteriological analysis of samples: Physico-chemical analysis of water samples as temperature, pH, TSS, DO, BOD, COD, total nitrogen, phosphorus, Nitrate, metals like Cu, Pb, Zn, Cd, Cr, Hg and total coliform count were analyzedby standard methods mentioned in APHA, 2005 guideline 23rd edition.

RESULTS AND DISCUSSION

The results show that there was considerable variation among the analyzed sample with respect to their physiochemical and bacteriological parameters. Which lies above the maximum permissible levels of Nepal standard and WHO standard (7). This result shows that the heavy metal concentration of water in the study area do not pose any health or environmental issues however one sample shows the high mercury concentration (W7 sample1.9) than the Nepal standard and WHO standard (8).

The assessment of water sample indicates that the Bagmati River Water is highly polluted as chemically and bacteriologically.

Table 1: Physiochemical Parameters Of Water Sample Analyzed During January To June2020

Parameters	Units	Generic std	WHO Std	NDWQS	W1	W2	W3	W4	W5	W6	W7
Temp	°C		25		18.0	18.5	19.1	19.0	19.0	19.5	19.5
pH			6.5-8.5	6.5-8.5	6.8	7.0	7.1	7.2	7.2	7.2	7.3
TSS	mg/l	50	50		5.0	113.0	30.0	416	322.0	444.0	408.0
DO	mg/l		6		9.2	0.9	0.8	0.07	<0.1	<0.1	<0.1
BOD	mg/l	32-100	4		1.5	38.5	59.2	275.6	201.4	316.8	394.8
COD	mg/l	250	10		6.0	100.0	160.0	712.0	514.8	772.2	950.4
Total nitrogen	mg/l				1.75	10.5	17.5	84.0	68.3	85.7	87.5
Total phosphorus	mg/l				0.14	2.3	3.7	24.6	19.2	25.4	28.7
Ammonical Nitrogen	mg/l	50	0.01		0.19	6.8	10.5	47.6	51.2	53.9	58.4
Nitrate	mg/l		50	50	0.59	1.4	0.4	4.9	0.87	1.3	1.6
Copper	mg/l	3	2.0	1.0	<0.01	0.12	0.02	0.12	0.06	0.13	0.16
Lead	mg/l	0.1	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	0.05
Zinc	mg/l	5		3.0	0.09	0.18	0.08	0.37	0.32	0.5	0.38
Cadmium	mg/l	2			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Chromium	mg/l	0.1	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.01	0.001	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.9

Table 2: Physiochemical Parameters of Water Sample Analyzed During July To Dec 2020

Parameters	Units	Generic std	WHO std	NDWQS	S1	S2	S3	S4	S5	S6	S7
Temp	°C		25		20	21.1	21.4	22.2	22.2	22.2	21.5
pH			6.5-8.5	6.5-8.5	7.8	7.8	7.8	7.8	7.7	7.6	7.5
TSS	mg/l	50	50		3.0	89.0	68.0	432.0	322.0	440.0	513.0
DO	mg/l		6		8.2	2.1	1.5	0.5	0.4	0.5	0.5
BOD	mg/l	32-100	4		2	21.0	106.0	112.0	106.0	144.0	325.0
COD	mg/l	250	10		5	50.0	280.0	490.0	320.0	470.0	870.0
Total kjeldahl nitrogen	mg/l				1.75	10.5	23.75	48.25	33.5	67.75	77.0
Total phosphorus	mg/l				0.12	2.0	2.9	22.6	18.1	22.2	24.9

Ammonical Nitrogen	mg/l	50	0.01		0.19	6.6	11.5	26.5	30.6	33.2	46.4
Nitrate	mg/l		50	50	0.54	0.9	0.4	3.8	0.68	1.2	1.4
Copper	mg/l	3	2.0	1.0	<0.01	0.10	0.12	0.12	0.05	0.12	0.14
Lead	mg/l	0.1	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/l	5		3.0	0.08	0.16	0.06	0.28	0.24	0.3	0.4
Cadmium	mg/l	2			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Chromium	mg/l	0.1	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.01	0.001	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table no: 3 Physiochemical Parameters of Water Sample Analyzed During January To June 2021

Parameters	**Units**	**Generic std**	**WHO Std**	**NDWQS**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
Temp	°C		25		24.0	24.5	25.0	25.0	25.0	26.0	26.0
pH			6.5-8.5	6.5-8.5	6.8	7.0	7.0	7.2	7.3	7.4	7.4
TSS	mg/l	50	50		4.0	108.0	26.0	398.0	297.0	422.0	374.0
DO	mg/l		6.0		7.0	0.9	0.8	0.3	<0.1	0.2	0.3
BOD	mg/l	32-100	4.0		1.5	36.5	58.2	257.6	198.4	316.8	392.8
COD	mg/l	250	10		5.0	98.0	158.0	692.0	508.0	722.0	940.0
Total nitrogen	mg/l				1.55	8.5	15.5	42.0	44.3	70.7	80.7
Total phosphorus	mg/l				0.10	2.4	3.8	26.0	29.6	31.4	32.0
Ammoniacal Nitrogen	mg/l	50	0.01		0.21	7.2	14.2	54.6	61.6	66.8	68.0
Nitrate(as NO3-N	mg/l		50	50	0.69	1.8	0.6	5.3	0.97	2.1	2.3
Copper	mg/l	3	2.0	1.0	<0.01	0.12	0.02	0.12	0.06	0.13	0.16
Lead	mg/l	0.1	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	0.05
Zinc	mg/l	5		3.0	0.09	0.18	0.08	0.37	0.32	0.5	0.38
Cadmium	mg/l	2			<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Chromium	mg/l	0.1	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.01	0.001	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4: Physiochemical Parameters of Water Sample Analyzed During July to December 2021

Parameters	Units	Generic std	WHO std	NDWQS	S8	S 9	S 10	S 11	S 12	S 13	S 14
Temp	°C		25		13.0	14.0	14.0	15.0	15.0	15.0	16.0
pH			6.5-8.5	6.5-8.5	6.5	6.8	6.8	6.9	7.0	7.3	7.3
TSS	mg/l	50	50		5.0	108.0	33.0	392.0	317.0	405.0	396.0
DO	mg/l		6.0		8.0	1.0	0.9	0.08	<0.1	<0.1	<0.1
BOD	mg/l	32-100	4.0		1.5	32.5	54.2	271.6	198.4	298.8	374.6
COD	mg/l	250	10		6.0	96.0	154.0	672.0	498.0	698.0	896.0
Total Kjeldahl nitrogen	mg/l				1.7	9.5	10.5	81.0	63.7	83.5	85.7
Total phosphorus	mg/l				0.16	2.6	3.9	26.6	22.0	23.6	27.8
Ammoniacal Nitrogen	mg/l	50	0.01		0.17	5.9	9.8	42.7	50.2	54.8	59.7
Nitrate(as NO3-N	mg/l		50	50	0.44	1.3	0.3	4.7	0.82	1.4	1.8
Copper	mg/l	3	2.0	1.0	<0.01	0.14	0.03	0.17	0.08	0.18	0.19
Lead	mg/l	0.1	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	0.08
Zinc	mg/l	5		3.0	0.12	0.18	0.08	0.47	0.42	0.50	0.42
Cadmium	mg/l	2			<0.00	<0.00	<0.00	<0.00	<0.00	<0.00	<0.00

					3	3	3	3	3	3	3
Chromium	mg/l	0.1	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.01	0.001	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Generic Standard: Standard Guideline of Department of Environment, Government of Nepal WHO: world health Organization NDWQS: Nepal drinking water quality standard											

Bacteriological analysis of water sample

Table 5: Total Coliform count of water samples of Bagmati river (January to June, 2020)

Sampling site	Sundarijal	Gokarna barrage	Guheshwari	Subidhanagar	Sankhmul	Teku	Chovar
Sample Code	W1	W2	W3	W4	W5	W6	W7
Cfu/ml	0.20×10^2	1.5×10^2	5.20×10^2	17.3×10^2	35.6×10^2	148.6×10^2	72.2×10^2

Table 6: Total Coliform Count of Water Samples of Bagmati River (July to December, 2020)

Sampling site	Sundarijal	Gokarna barrage	Guheshwari	Subidhanagar	Sankhmul	Teku	Chovar
Sample Code	S8	S9	S10	S11	S12	S13	S14
Cfu/ml	0.24×10^2	1.46×10^2	5.80×10^2	15.3×10^2	30.6×10^2	126.6×10^2	64.2×10^2

Table 7: Total Coliform Count of Water Samples of Bagmati river by Pour plate technique (January to June 2021

Sampling site	Sundarijal	Gokarna barrage	Guheshwari	Subidhanagar	Sankhmul	Teku	Chovar
Sample Code	W8	W9	W10	W11	W12	W13	W14
Cfu/ml	0.18×10^2	1.64×10^2	4.90×10^2	16.7×10^2	32.6×10^2	138.6×10^2	65.2×10^2

Table no 8: Total Coliform Count of Water Samples of Bagmati river by Pour plate technique (July to December, 2021)

Sampling site	**Sundasrijal**	**Gokarna barrage**	**Guheshwari**	**Subidhanagar**	**Sankhmul**	**Teku**	**Chovar**
Sample Code	S1	S2	S3	S4	S5	S6	S7
Cfu/ml	0.2×10^2	0.54×10^2	3.10×10^2	9.9×10^2	21.6×10^2	103.6×10^2	45.2×10^2

Results of physicochemical analysis of water samples from Bagmati river, Kathmandu Nepal, from January to June 2020, showed that Temperature range (18 ^oC to 19.5 ^oC) , pH (6.8 to 7.3), TSS range was found (113-mg/ml to 444mg/ml)(5-444), DO (0.1mg/l to 9.2mg/l) (less than .1 -9.2), BOD (201mg/l to 394mg/l) (1.5 -393) and COD (514mg/L to 950mg/l) (6-950), Total Nitrogen (1.75) (1.75-87.5), Total Phosphorous (0.14mg/l to28.7mg/l), Ammoniacal Nitrogen (0.19mg/l to 58.7mg/l), and Nitrate (0.4mg/l to 4.9mg.l), which is very among them TSS, COD, BOD, TN, TP, etc. was very high in range as compared to the World health organization and Nepal Standard guideline in few water sample (W4, W5, W6, and W7) (the mentioned data are not matched with the water sample no of observation table) of Bagmati river in January to June 2020 period, where as in July to December, 2020 it was TSS range was found (68-mg/l to 523mg/l) (3-513), DO (1.5mg/l) (8.2 -0.4), BOD (106mg/l to 325mg/l) (2-325) and COD (280mg/l to 870mg/l) (5-870) for (W4, W5, W, and W7) (sample no must be S1-S7) water sample. The coliform count in January to June was 0.2 $x10^2$ to 72.2 x 10^2.(0.2-148.6)whereas from July to December it was 0.24 x 10^2 to 64 x 10^2(0.24-126.6)were very high for water sampling site i.e S4, S5, S6, and S7, which are Subidhanagar, Sankhmul, Teku and Chovar of Bagmati River, Kathmandu.

Results of physicochemical analysis of water samples from Bagmati river, Kathmandu Nepal, from January to June 2021, showed that Temperature range (24 ^oC to 26 ^oC) , pH (6.8 to 7.4), TSS range was found (4-mg/ml to 442mg/ml) (4-422), DO (0.1mg/l to 7.0mg/l), BOD (1.5mg/l to 392mg/l) and COD (5mg/L to 940mg/l), Total Nitrogen (1.5mg/l to 80.7mg/l), Total Phosphorous (0.10mg/l to 32.0mg/l), Ammoniacal Nitrogen (0.21mg/l to 68.0mg/l), and Nitrate (0.6mg/l to 5.3mg.l) (0.69-2.3), among them TSS, COD, BOD, TN, TP, etc. was very high in range as compared to the World health organization and Nepal Standard guideline in few water sample (W11, W12, W13, and W14) of Bagmati river in January to June period, 2021, where as in July to December 2021, it was TSS range was found (5-mg/l to 405mg/l),

DO (0.9mg/l to 8.0mg/l) (0.1-8.0), BOD (1.5mg/l to 374.mg/l) and COD (6mg/l to 896mg/l) for (S11, S12, S13, and S14) water sample. (Results of other parameters like TN,TP,AN and nitrate were missing????) The coliform count in January to June was 0.18 $x10^2$ to65.2 x 10^2 (.18- 138). whereas from July to December, 2021 it was 0.24 x 10^2 to 45 x 10^2(.2 – 103.6)were very high for water sampling site i.e W11, W12, W13, and W14, which are Subidhanagar, Sankhmul, Teku and Chovar of Bagmati River, Kathmandu. The metal contamination range was observed negligible and during January to June 2020-2021, but significant during July to December 2020-2021???

In the previous study, the ammonia concentration for Sundarijal was only 0.2 mg/L which was limit for surface water recommended by WHO (9). But the concentration of ammonia for other samples was a lot higher than the recommended value which might be due to more amount of municipal waste dumping in the river of Kathmandu valley. Highest ammonia concentration was from Balkhu sample, 90 mg/L, and Tukucha sample, 80 mg/L. Similar results reported by (10), also had a higher value of ammonia in Balkhu River indicating that it was more polluted than other rivers.

Previous study (11), presented a similar result being Teku and Sundarighat as most contaminated sites considering Tukucha River and Balkhu River joins on Bagmati in Teku and Sundarighat respectively. High chloride concentration in river is toxic to aquatic life and increases the potential corrosivity of water (12).

Nitrate was recorded highest in Tukucha and Hanumantei (5.7mg/l) which is higher than the data previously recorded (11), 3.95mg/l. Both studies showed similarity in the increment of nitrate content from upstream to downstream. Excess levels of nitrates can be considered to be a contaminant of river waters. Most sources of excess nitrates come from human activity. The source of excess nitrates can usually be traced to agricultural activities, human wastes, or industrial pollution. Rainwater can wash nitrates in the fertilizer into streams and rivers (13).

Highest phosphate value was 3.5 mg/l in Tukucha. Sundarijal sample phosphate value was 0.0 mg/L and that of Chobar 2.5 mg/l which are low compared to that of the data of similar research, 0.24 mg/L at Sundarijal and 12.3 mg/l at Chobar. Significant increase was seen in the level of phosphate as the river enters an urban core area, which is from manmade sources such as septic systems, fertilizer runoff, and improperly treated wastewater. (our's findings should be mentioned here to compaired to previous finding????) I think so

At Sundarijal, BOD level was found to be within the guideline by BBWMSIP. However, the level of BOD increases with the increase in the organic waste in the river. BOD indicated the pollution of organic waste resulting low level of dissolved oxygen. Previous study showed a low level of BOD in Sundarijal but an increment in the level of BOD towards downstream.

Dissolved oxygen concentrations in the core urban areas were significantly lower than that of Sundarijal showing that the water is anoxic. As the river flows downstream, the dissolved oxygen gets more reduced. Bacterial decomposition of incorporated organic matter was most likely for low level of dissolved oxygen similar research also observed low level of DO in Bagmati River (4).

In this study, coliform was present in the entire river water sample. The presence of a high amount of coliform might be due to the fact; samples were taken from the river before it was subjected to a treatment of disinfection. Previous studies on the river water from Kathmandu valley showed the presence of various viruses, Human Enteric Viruses, Protozoa, and Indicators of Pathogens except in the sample of Sundarijal. The water is contaminated by various anthropogenic activities as it flows downstream (14)

All seven water samples were analyzed for coliform detection and the study indicates the fecal contamination of human origin in Bagmati River and its tributaries. Although there was a low detection rate of pathogen in Sundarijal during a previous study but the detection of coliform from the Sundarijal suggest the contamination of water even upstream of the Bagmati River, which cannot be neglected.

CONCLUSION

The study showed the variation in water quality of the Bagmati River and its tributaries. The quality of water is worse in the urban core areas compared to that of upstream. The presence of high level of physicochemical like TSS, DO, BOD, COD, metals like Cu, Pb, Cr, Cd and Hg, and fecal coliform in river water is the prime indication of a possible source of an outbreak for waterborne diseases and water is not suitable for drinking purposes without proper treatment. Immediate action is needed to prevent further deterioration of the river and amplify efforts to slow the emergence and spread of resistance.

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