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Water quality assessment of mardi river by using water quality index

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Abstract

The aimed study assesses the water quality of Mardi River applying National Sanitation Foundation (NSF) America developed index called Water Quality Index (WQI). This index is one of effective way to inform about water quality trends to the public and the policy makers for water quality management. As Mardi River is primary source of consumption to Pokhara city and Mardi Watershed entities, the water quality is important for public health and ecological aspects. The study starts with five different sampling stations having total fifteen samples along three (April, May, June) months of the year 2012 were analyzed in water laboratory. After the analysis the weight values and sub index were obtained from the NSFWQI method which results that Mardi River water has **Medium** degraded water quality ranges in **class C** and **NSFWQI** of Mardi river scores as **55.02** and there is high correlation between water quality parameters Nitrogen and Turbidity.

Keywords: Mardi Watershed / River, NSFWQI, Water Quality Index.

1. Introduction

Human civilizations of histories have thrived in part because of their ability to find, transport and deliver potable water to their growing urban populations and agricultural centers. The supply of potable water is a great challenge for the world today as well our country Nepal too. Rivers are large natural stream of water bodies emptying into an ocean, lake, or other bodies of water and usually fed along its course by converging tributaries. Although they contain only about 0.0001% of the total amount of water in the world at any given time, rivers are vital carriers of water and nutrients to areas all around the earth [1].
River water quality is an important issue for each stakeholder as it affects human uses as well as plant and animal life. Traditional approaches to assessing river water quality are based on the comparison of experimentally determined parameter values with the existing local normative. However, it does not provide a global vision on the spatial and temporal trends in the overall water quality. To overcome these difficulties, a water quality index (WQI) was developed. Water quality indices appeared in the literature as early as 1965 (Horton 1965). WQI is a mathematical instrument used to transform large quantities of water quality data into a single number, which provides a simple and understandable tool for managers

and decision makers on the quality and possible uses of a given water body. The evaluation of WQI requires many physical and chemical parameters to be measured [2, 3].

In the early 1970s, the National Sanitation Foundation (NSF), in cooperation with over 100 water quality experts, devised a standard index for measuring water quality. This index is known as the Water Quality Index (WQI), consists of nine tests to determine water quality. These nine tests are: temperature, pH, turbidity, total solids, dissolved oxygen, biochemical oxygen demand, phosphates, nitrate, and fecal coliform. A table or graph for each of the nine tests indicates the water quality value (or Q-value) corresponding to the data obtained. Once the Q-value for a test has been determined, it is multiplied by a weighting factor. Each of the tests is weighted based on its relative importance to overall water quality. The resulting values for all nine tests are total and used to gauge the health of the water source as excellent, good, medium or average, fair, or poor [4].

Study Area: The present study area, the Mardi River / Khola, is located at the northern corner of Pokhara valley of Kaski district. Mardi river situated in the foothills of Annapurna mountain range, the Mardi watershed (83º50'E to 83º 56' E and 28º19'N to 28º29'N; area 144 km2) is representative of mid-hill watersheds of western Nepal.

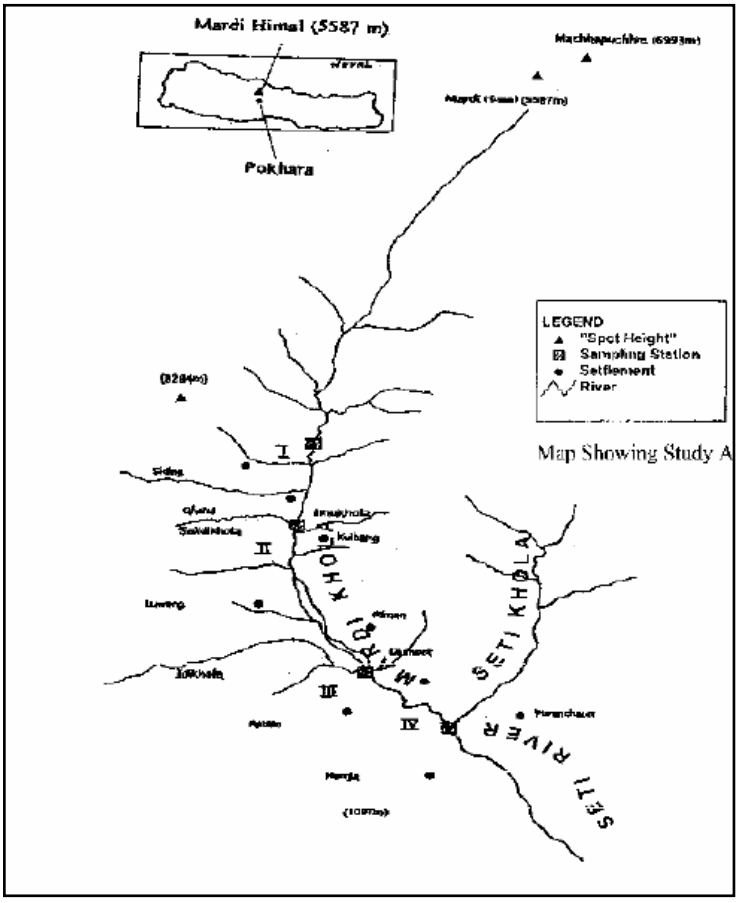

Fig. 1: Map of Study Area (Mardi Khola / River) [5]

The elevation ranges from about 1000 m to 5588 m above mean sea level from valley floor to mountain peaks. The climate of the area varies from warm and humid subtropical to cool and dry alpine along with the elevation variation. The temperature in the study area is the range between 20-30 degrees in the summer and 7-18 degrees in winter Rainfall is monsoonal with average annual rainfall amounting to 4300 mm, of which 80-85% occurs between June and October [6] . So it is very important to study such a diversify area.

2. Material and Methods

Basically, the field visit and sample collections were conducted for their outputs as to carry out research. The research was primarily based on field data supported by secondary data for analyzing, comparison and introduction part. Taking the whole Mardi river as universe, two kilometer apart of the intake point to intake point of water supply scheme were taken as sampling site for having different samples. The sampling points were divided in 500 m interval, which caused to have total five samples from zero to two kilometer of upstream i.e. naming Sample One at Zero meter, Sample Two at 500 meter, Sample Three at 1000 meter, Sample Four at 1500 meter and Sample Five at 2000 meter. All these samples were collected once a month at all intervals in the last week of month from April 2012 to June 2012, which formulated total fifteen samples throughout the sampling.
Structured and standard data collection method were used as per Research Methodology Practice for their outputs as to carry out research work with different tools prescribed (Standard Method for the Examination of Water and Waste Water, (APHA, AWWA, WEF) 19th Edition 1995) and ENPHO test kit procedures. The field collected samples were tested by using following particular methods and instruments as mentioned in Table 1. The data obtained from the field observation were categorized, tabulated, processed and analyzed using NSF WQI methods. The parameters of NSF WQI were tested by using following Instruments and Test Kits with following particular testing methods.

Table 1: The test methods used for Parameters [7]

S.N.	Testing Parameters	Testing Methods / Instruments	Remarks
1	PH	Hanna Calibrated Electrode Probe PH Meter	
2	Temperature	Mercury Thermameter	
3	Turbidity	Turbidity Meter	ENPHO Kit
4	Total Solids	Gravimetric	
5	Nitrate	Reagent 1,Reagent 2,Colour Chart	ENPHO Kit
6	Total Phosphate	Reagent 1,Reagent 2,Colour Chart	ENPHO Kit
7	E- Coli	Elevated Temperature Fermentation	
8	Dissolved Oxygen	Winkler Method	
9	BOD	Winkler Method	

Finally the collected water samples were tested in Regional Water Supply Monitoring and Supervision Office Pokhara and Nepal Water Supply Corporation Pokhara Branch as per respective standard guidelines. The analysis of the data was accomplished and presented using tools like MS Word, Excel and SPSS v. 16 as required.

3. Theory / Calculation

There are lots of efforts made to know the water quality of different water bodies like lakes and rivers around the world. Several organizations in the United States and around the world have adopted the WQI concept for expressing the water quality for their water resources. Among them some widely accepted WQI are NSF WQI, Canadian Council of Ministers of the Environment (CCME) WQI, Alberta Agricultural Water Quality Index (AAWQI), British Columbia WQI etc. In case of Nepal little studies found on the WQI. Hence the NSF WQI method has been chosen to study the Mardi river water quality as it is economical and easy. Essentially, a WQI is a compilation of a number of parameters that can be used to determine the overall quality of a river. To measure the water quality, a standard index called the National Sanitation Foundation Water Quality Index (NSFWQI) is used. The ***National Sanitation Foundation*** WQI consists of Dissolved Oxygen, Fecal Coliform, pH, Biological Oxygen Demand, Temperature, Total Phosphate, Nitrate, Turbidity and Total Solids parameters. The results of the tests are transferred to a weighting curve chart where their numerical values are obtained. These numerical values are multiplied by a "weighting factor" and then added – an overall Water Quality Index is obtained as of Table no 2 and 3.

Table 2: Water Quality Weight Factor of NSF – WQI [8]

Water Quality Weight Factor	
Factors	Weight
Dissolved Oxygen	0.17
Fecal Coliform	0.16
PH	0.11
BOD	0.11
Temperature	0.10
Total Phosphate	0.10
Nitrates	0.10
Turbudity	0.08
Total Solids	0.07

The mathematical expression for **NSF WQI** is given by

$$\textbf{NSF WQI} = \sum_{i=1}^{p} \textbf{Wi Ii}$$

where

Ii - is the sub-index for i th water quality parameters.
Wi - is the weight (in terms of importance) associated with i th water quality parameters.
P - is the number of water quality parameters.

The NSF WQI is an excellent management and general administrative tool in communicating water quality information. The table of classification criteria is very clear that according to the NSF value ranges the descriptor and category denotes the water quality information. This index has been widely tested in field and applied to data from a number of different geographical areas all over the world.

Table 3: Table of Classification Criteria Standards Based on NSF – WQI [8]

NSF – WQI	Descriptor	Category
90 – 100	Excellent	A
70 – 90	Good	B
50 – 70	Medium	C
25 – 50	Bad	D
0 – 25	Very Bad	E

4. Results

All the collected samples result were analyzed and presented as follows

Table 4: Statistics of observed NSFWQI parameters

Parameters	Min	Max	Average ± S.E.
Do	74.00	105.00	87.33 ± 2.29
Fecalcoliform	27.00	50.00	38.13 ± 2.00
pH	6.80	7.80	7.43 ± 0.082
BOD	18.00	42.00	32.20 ± 1.94
Temperature	22.00	26.00	24.26 ± 0.34
Total Phosphate	0.20	1.00	0.62 ± 0.07
Nitrate	25.00	75.00	46.66 ± 5.38
Turbidity	15.00	40.00	24.40 ± 2.13
TotalSolids	130.00	250.00	169.67 ± 12.06

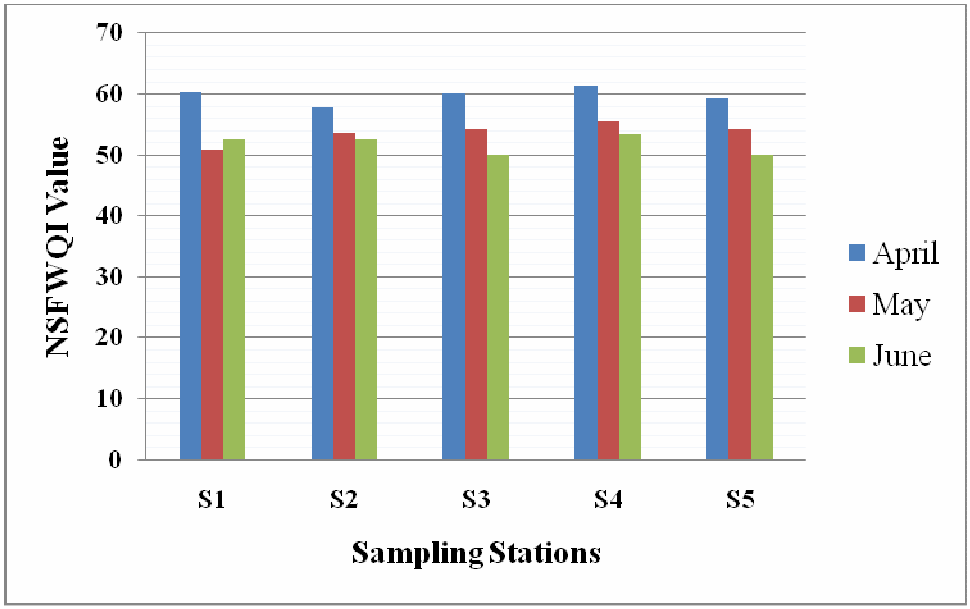

Fig. 2: WQI in Different Months along the Different Stations

According to above WQI values of different stations there is general progressive decline in WQI values which indicated that as the rainy season commence the quality of water get started to degrade. This is also supported by the given below of monthly variation of WQI graph.

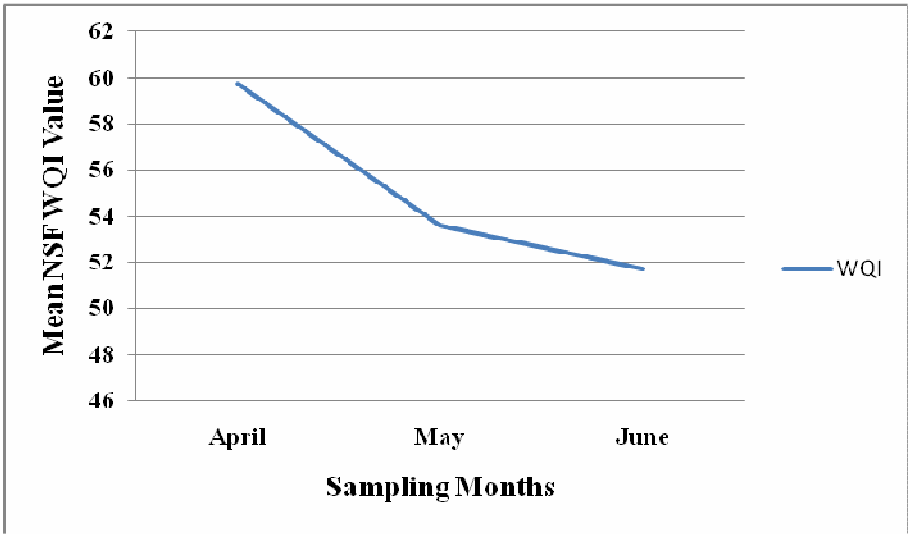

Fig. 3: Monthly Varation of WQI

Table 5: Correlation Coefficient matrix of Water Quality Parameters

Parameters	DO	Fecal Coliform	PH	BOD	Temperature	Total Phosphate	Nitrate	Turbidity	Total Solids
DO	1.000								
Fecal Coliform	0.855**	1.000							
PH	0.561*	0.636*	1.000						
BOD	0.772**	0.936**	0.435	1.000					
Temperature	(-0.832**)	(-0.727**)	(-0.611*)	(-0.654*)	1.000				
Total Phosphate	0.591*	0.627*	0.122	0.744**	(-0.524*)	1.000			
Nitrate	0.853**	0.918**	0.634*	0.814**	(-0.672**)	0.667**	1.000		
Turbidity	0.851**	0.864**	0.536*	0.797**	(-0.776**)	0.715**	0.891**	1.000	
Total Solids	0.876**	0.789**	0.602*	0.674**	(-0.786**)	0.542*	0.857**	0.895**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

5. Discussion

The correlation matrix shows that there is high correlation in parameters Nitrate and Turbidity with the water quality of Mardi River. These two parameters are highly correlated and responsible for degradation of water quality of Mardi. So for having corrections in water quality, we should think

about the controlling mechanism of Nitrate and Turbidity. The analysis shows that if we have to give the priority between Nitrate and Turbidity then Nitrate becomes the first parameter, which should be minimized to make less effective role in degradation of Mardi's River water quality.

Excess amount of Nitrogen content in water causes the algae growth, which finally seriously affects the aquatic life as the algal blooms are formed. The eutrophication will be the major problem of water due to excess Nitrogen content in water. The long term use of Nitrogen contained water cause the blue baby disease which is also known as methemoglobinemia. Other health problems like headache, dizziness, weakness or difficulty in breathing also can be caused.

Turbidity becomes the secondary one which is highly affecting the water quality of Mardi River. Turbidity is the life span shortening factor of water bodies as it get deposited in the bed and at bank the streams get narrow down. Turbidity blocks the natural photosynthesis process which is important part of the life cycle of water bodies. Excess turbidity could cause lack of dissolved oxygen which is the most essential thing for survival of aquatic life. So these factors are prime causes of Mardi water quality degradation which should be taken in account.

6. Conclusion

Although the study reveals Mardi has degraded water quality and it lies in medium level pollution and denoted by C. Though it still can be used for agriculture, fishery and for drinking application after proper treatment. Rainfall increases the runoff carrying chemical fertilizers, manure and soil particles which get washed away towards the Mardi River .This plays vital role for increasing the value of Nitrate and Turbidity concentration.

River water pollution is not only an aesthetic problem, but a serious economic, public health problem and sustaining aquatic life as well. So regular monitoring of the water quality is thus required to assess the condition of river water. WQI is helpful in saving the river from further degradation and maintain the standard of sustaining aquatic life.

Recommendation

Based on assumption that the taken stretch of Mardi River represents the whole Mardi Watershed's Mardi River, it clearly shows that there is an urgent need to control the further deterioration of Mardi river water quality. The following measures are recommended based on the study:

1. Best management practices for fertilizer use can reduce nitrate concentration in the soil. following practices in planning of fertilizer use are recommended:

- Use soil and water analysis to determine exact nitrogen needs of crop and consider all the potential sources of nitrogen.
- Set a realistic yield goal for each field.

2. Upstream villages should be rewarded through PES mechanism to decrease the contamination to the river by different activities such as helping to construct public toilets, lowering the manure application, public awareness campaigns etc.

3. Best practices of watershed management already applied in Nepal should be used in this Mardi watershed area like:

i. Terrace Improvement and On-farm Conservation

ii. Cascades of Conservation Ponds

iii. Water Supply focused Activity of Watershed Management

iv. Community Based Management

v. Bioengineering Measures

4. Anthropogenic actions like open defecation and wastewater discharge, cattle washing and funeral rituals in and near vicinity of Mardi River should be stopped.

5. Adequate water treatment plant (Sedimentation) for Mardi Water Supply Scheme should be planned and implemented.

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