Evaluation of water quality of River Malin using Water Quality Index (WQI) at Najibabad, Bijnor (UP) India

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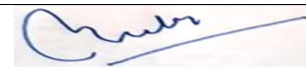
1	**Rakesh Bhutiani**	Supervision, Formal analysis, review editing, and Plagiarism	
2	**Mukesh Ruhela**	Conceptualization, Data curation and investigation	
3	**Faheem Ahamad**	Conceptualization , investigation, original drafts preparation	

Abstract (Maximum 300 words)

Malin river originates from the Kotdwara and merges with Ganga at RavalliGhat in Bijnor. It is an important river of city Najibabad Distt- Bijnor (U.P) because it is the main source of irrigation for agriculture in the most areas of city Najibabad. At some places cloth washing and vegetable washing is the main activity on the Malin River bank. Four sampling sites were established for the collection of water samples during July, 2015 to June, 2016 but in the present study average of all the values of all the four sites was given. Monitoring of water of River Malin includes physico-chemical parameters like temperature, turbidity, total solids, total suspended solids, total dissolved solids, pH, total hardness, calcium hardness, magnesium hardness, total alkalinity, chloride, acidity, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand. TDS, total hardness, calcium hardness and magnesium hardness was found beyond the limit at all the four sampling sites and rest all the parameters were found within the limit. The average values of TDS, BOD, COD and TH were observed 635.1 mg/l±55.31, 12.1±0.54, 35.2±1.01, 341.0±1.84. Further water quality of river Malin has been assessed using water quality index and the quality of river Malin was observed to be bad at all site which may be attributed to untreated and/or partially treated waste inputs of municipal and industrial effluents joining the river.

Key words: BOD, COD, Malin River, Non-perennial, Ravalli Ghat, WQI (in alphabetic order)

Introduction

Rivers form the lifeline of human society and play an important role in the development of Nation and sustenance of life, which are being polluted due to rapid industrialization, urbanization and other developmental activities (Mandal *et al.,* 2012; Aalam and Pathak 2010; Mandal and Das 2011). These are vital freshwater systems of strategic importance across the world, providing main water resources for domestic, industrial, agricultural and recreational purposes. Most of the agriculture area in India receives its water from surface sources like river, reservoir, dam etc. River may be perennial as well as non-perennial. In perennial rivers water flows for all the seasons because such rivers are snow fed. The non-perennial rivers get dried in summer either partially or completely and in monsoon, they are flooded with water. Generally the quantity of water available from non-perennial rivers varies throughout the year. It normally decreases in summer when demand for water is at its maximum.The Malin River under study is also a non- perennial river.

Insufficient capacity of waste water treatment and increasing sewage generation pose big question of disposal of waste water. This huge quantity of waste water is directly and after partial treatment discharged into nearby water bodies mainly in the rivers. The river under study was also heavily polluted due to sewage and industrial discharge (Bhutiani and Ahamad, 2018).

Controlling water pollution is urgent for ecological sustainability of water resources as well as for underlying economic reasons and human health. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know information about different physico-chemical parameters before it is used for different purposes (Kolhe and Shinde, 2014). The term water quality was developed to give an indication of how suitable the water is for human consumption (Vaux, 2001) and is widely used in multiple scientific publications related to the necessities of sustainable water management (Parparov *et al*., 2006).

Therefore a regular monitoring of river water quality not only prevents outbreak of diseases and checks water from further deterioration, but also provides a scope to assess the current investments for pollution prevention and control (Sudevi and Lokesh, 2012).

The WQI was first developed by Horton in the early 1970s. The basic aim of WQI is to give a single value to the water quality of a source on the basis of one or the other system which translates the list of constituents and their concentrations present in a sample in to a single value (Abbasi and Abbasi, 2012). The index result represents the level of water quality in a given water basin, such as lake, river or stream. After Horton a number of workers all over the world developed WQI based on rating of different water quality parameters. For the evaluation of water quality, WQI was applied to the river water (Singh, 1992; Naik and Purohit, 2001; Kumar and Dua, 2009; Kumar *et al.*, 2009; Sharma *et al.,* 2009; Singkran *et al.*, 2010; Gupta *et al.*, 2012). In the present paper, characteristics of different point sources contributing Malin river are discussed and water quality of river Malin is assessed using water quality index.

Material and Methods

Analysis of water was performed according to standard methods as prescribed by APHA (1998), Trivedy and Goel (1986) and Khanna and Bhutiani (2011) for the examination of the water and waste water. In the present study the samples were collected three times in a month in morning hours (7 am-10 am) from July 2015 to June 2016 from Malin River Najibabad Distt Bijnor (UP). Grab water samples from sites were collected in plastic jerry cans from about 15 cm below the surface water by keeping and opening Jerri cans below the surface water. Caps of cans were removed after dipping the can and also closed in the water after filling up of can. Care was taken to avoid bubbling and entry of leaves, twigs or debris into the sampling bottle. Some of the parameters were analysed in the field immediately after collection of samples. Then the water samples were directly taken to the lab and analysed for various physico-chemical parameters. Samples were analysed for following physico-chemical parameters viz. temperature, turbidity, total solids, total dissolved solids, total suspended solids, pH, total hardness (EDTA Titration method), calcium hardness, magnesium hardness, total alkalinity (by simple titration method), chloride acidity, dissolved oxygen (Winkler method), biochemical oxygen demand (5 days incubation method) and chemical oxygen demand (by dichromate titration method).

Study area

The present study was performed on Malin river which is situated in Najibabad district Bijnor Uttar Pradesh. Najibabad is located at 29.63N, 78.33E; it has an elevation of 295 meter (1014 feet). Malin river is the principal source of water for agriculture and other activities. This river is formed by joining of many mountain springs in Garhwal region. It is non-perennial river, get partially dried in summer and it is flooded with water in monsoon. Thus the quantity of water available from river varies throughout the year. It normally decreases in summer when the demand for water is on peak. Malin River covers about 140-150km with a catchment area of about 400 km^2 through 3 district named Pauri Garhwal, Kotdwara and Bijnor. Malin River merges in the Ganga River at the RavalliGhat in the Bijnor city. The main activities responsible for Malin river water pollution are runoff from agricultural fields, domestic waste form the city and villages situated on the bank of river and effluent from Kishan Sahkari Sugar mill. All the sampling sites were shown in table 1 and figure 1.

Calculating of Water Quality Index (WQI)

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters. In current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by (Cude, 2001; Brown *et al.,* 1970). In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean. For assessing the quality of water in this study, firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

Where,

Qi = Quality rating of i^{th} parameter for a total of n water quality parameters

$$Qi = \frac{\left(V_{observed} - V_{ideal}\right)}{\left(V_{standard} - V_{ideal}\right)} x100$$

Vobserved = Actual value of the water quality parameter obtained from laboratory analysis

Videal = Ideal value of that water quality parameter can be obtained from the standard Tables.

Videal for pH = 7 and for other parameters it is equal to zero, but for DO Videal = 14.6 mg/L

Vstandard = Recommended WHO standard of the water quality parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

$$Wi = \frac{\mathrm{K}}{Xi}$$

Where,

• Wi = Relative (unit) weight for nth parameter

• Xi= Standard permissible value for nth parameter

• K= Proportionality constant.

That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

$$WQI = \frac{\Sigma QiWi}{\Sigma Wi}$$

Where,
• Qi = Quality rating
• Wi = Relative weight
In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score.

Results and Discussion

The results of various physico-chemical parameters of River Malin are tabulated in table 3 and 4 and figure 2 and 3 while their WQI values are given in table 5.

Turbidity of water is an important factor that controls the energy relationship at different tropic levels. It is essentially a function of reflection of light from the surface and is influenced by the absorption characteristics of both water and of its dissolved and particulate matter. During the study period the monthly values of turbidity was ranged from 22.7 NTU to 83.3NTU.The minimum monthly average value of turbidity were found 27.2 NTU ±3.53 in the month of June and maximum monthly average value of turbidity were found 70.1 NTU ±16.32 in the month of August (Table-2 and Graph-1). Turbidity values are generally found higher in Monsoon period due to heavy rainfall in mountain areas of Kotdwara region, the origin Point of Malin River. The annual values of turbidity were ranged from 35.7 NTU to 48.9 NTU and annual average was observed 43.9±15.56. A more or less same trend was observed by Khanna *et al.* (2010).

The solids represent the total salts and dirts remain after a particular amount of water sample evaporated. Ecological imbalance in the aquatic ecosystem was caused by technical abrasive action of total solids. During the study period the monthly values of TS was ranged from 808.0 mg/l to 1094.7 mg/l. The minimum monthly average value of TS were found 864.0 mg/l ±58.07 in the month of May and maximum monthly average value of TS were found 1074.1 mg/l ±22.31 in the month of August (Table-2 and Graph-1). TS values are generally found higher in Monsoon period due to heavy rainfall in mountainous areas of Kotdwara region, the origin Point of Malin River. In rainy season when rain fall occurs the river flows with a high velocity and caused soil erosion in nearby areas which increase the total solids in river water. The annual average values of TS were ranged from 939.3 mg/l to 991.4 mg/l and annual average values were observed 963.1±78.64. A more or less same trend was observed by Bhutiani and Khanna (2005).

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter that are dissolved in water. It signifies the inorganic pollution load of water system. During the study period the monthly values of TDS was ranged from 512.0 mg/l to 746.3 mg/l. The minimum monthly average value of total dissolved solid were found 561.7 mg/l ±52.32 in the month of May and maximum monthly average value were observed 714.8 mg/l ±22.12 in the month of August (Table-2 and Graph-1). The annual average values of TDS were ranged from 623.7 mg/l to 642.1 mg/l and annual average were observed 635.1 mg/l ±55.31. A more or less same trend was observed by Khanna *et al.* (2014) and Bhutiani *et al.* (2017).

TSS was previously called non-filterable residue (NFR), but was changed to TSS because of ambiguity in other scientific disciplines. During the study period the monthly values of TSS was ranged from 271.0 mg/l to 391.7 mg/l. The minimum monthly average value of total suspended solid were found 297.0±15.68 mg/l in the month of June and maximum monthly average value were observed 359.3 mg/l ±24.91 in the month of August (Table-2and Graph-1). The annual average values of TSS were ranged from 305.4 mg/l to 350.4 mg/l and annual average were observed 327.9 mg/l ±24.0. A more or less same trend was observed by Khanna *et al.* (2014).

The amount of DO present in surface waters depends on water temperature, turbulence, salinity, and altitude Natural waters in equilibrium with the atmosphere will contain DO concentrations ranging from about 5 to 14.5 mg O2 per liter. The DO concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that, respectively, produce and consume oxygen. DO is the factor that determines whether biological changes are brought by aerobic or anaerobic organisms. Thus, dissolved–oxygen measurement is vital for maintaining aerobic treatment processes intended to purify domestic and industrial wastewaters. A rapid fall in the DO indicates a high organic pollution in the river (Shah and Joshi, 2017**.** During the study period the monthly values of Dissolved Oxygen was ranged from 5.9 mg/l to 9.4 mg/l. The minimum monthly average value of Dissolved Oxygen were found 7.2 mg/l ±1.04 in the month of September and maximum monthly average value were observed 8.0 mg/l ±1.09 in the month of June (Table-3 and Graph-2). The annual average values of Dissolved Oxygen were ranged from 6.3 mg/l to 8.7 mg/l and annual average were observed 7.5 mg/l ±0.27. A more or less same trend was observed by Kumar *et al.* (2012) and Arya and Gupta (2013).

Biological oxygen Demand is a measure of oxygen in the water that is required by the aerobic organisms to decompose the organic matter. During the study period the monthly values of biological oxygen demand (BOD**)** was ranged from 3.7 mg/l to 26.0 mg/l. The minimum monthly average value of biological oxygen demand (BOD) were found 11.2 mg/l ±9.98 in the month of May and maximum monthly average value were observed 13.0 mg/l ±9.97in the month of April (Table-3 and Graph-2). The annual average values of biological oxygen demand (BOD) were ranged from 4.2 mg/l to 22.5 mg/l and annual average were observed 12.1 mg/l ±0.54. COD is an oxygen demand to decompose the biodegradable as well as non-biodegradable organic waste. COD pointing to a deterioration of water quality likely caused by discharge of municipal waste water. During the study period the monthly values of chemical oxygen demand (COD**)** was ranged from 5.3 mg/l to 63.6 mg/l. The minimum monthly average value of chemical oxygen demand (COD) were found 33.2 mg/l ±19.75 in the month of May and maximum monthly average value were observed 36.0 mg/l±24.59 in the month of November (Table-3and Graph-2). An increase in the COD values was found in winter because of sugar mill effluent mixing in the river water. The annual average values of chemical oxygen demand (COD) were ranged from 12.0 mg/l to 61.8 mg/l and annual average value were observed 35.2 mg/l ±1.01. A more or less same trend was observed by Kumar *et al.* (2012) and Arya and Gupta (2013).

Alkalinity is the name given to the quantitative capacity of water to neutralize an acid. During the study period the monthly values of Alkalinity was ranged from 99.1 mg/l to 136.7 mg/l. The minimum monthly average value of Alkalinity were found 118.9 mg/l ±5.55 in the month of November and maximum monthly average value were observed 122.1 mg/l ±5.88 in the month of March (Table-3 and Graph-2). The annual average values of Alkalinity were ranged from 114.0 mg/l to 126.4 mg/l and annual average value were observed 120.6 mg/l ±1.01. A more or less same trend was observed by Ruhela *et al.* (2017) and Bhutiani *et al.,* (2017). During the study period the monthly values of chlorides was ranged from 21.7 mg/l to 38.7 mg/l. The minimum monthly average value of chlorides were found 26.5 mg/l ±4.64 in the month of November and maximum monthly average value were observed 28.9 mg/l ±6.82 in the month of April (Table-3 and Graph-2). The annual average values of chlorides were ranged from 23.2 mg/l to 35.8 mg/l and annual average value were observed 27.9 mg/l ±0.85. A more or less same trend was observed by Khanna *et al.* (2012).

Total hardness (TH) is a parameter of water quality used to describe the effect of dissolved mineral (Ca and Mg), determining solubility of water for domestic, industrial and drinking purpose attributed to presence of bicarbonates, sulphate, chloride and nitrates of Calcium and Magnesium. During the study period the monthly values of total hardness (TH) was ranged from 320.8 mg/l to 351.7 mg/l. The minimum monthly average value of total hardness (TH) were found 337.8 mg/l ±11.81 in the month of March and maximum monthly average value were observed 344.1 mg/l ±5.92 in the month of January (Table-3and Graph-2). The annual average values of total hardness (TH) were ranged from 339.2 mg/l to 343.7 mg/l and annual average value were observed 341.0 mg/l ±1.84. A more or less same trend was observed by Bhutiani *et al.* (2017). The occurrence of calcium hardness (CaH) in water is mainly due to the presence of lime stone, gypsum dolomite and gypsi-ferrous material. During the study period the monthly values of calcium hardness (CaH) was ranged from 106.2 mg/l to 129.3 mg/l. The minimum monthly average value of calcium hardness (CaH) were found 114.0 mg/l ±8.41 in the month of May and maximum monthly average value were observed 119.3 mg/l ±7.32 in the month of March (Table-3 and Graph-2). The annual average values of calcium hardness (CaH) were ranged from 111.0 mg/l to 125.8 mg/l and annual average value were observed 116.2 mg/l ±1.37. Magnesium ranked fourth after sodium in sea water. During the study period the monthly values of calcium hardness (CaH) was ranged from 106.2 mg/l to 129.3 mg/l. The minimum monthly average value of calcium hardness (CaH) were found 114.0 mg/l ±8.41 in the month of May and maximum monthly average value were observed 119.3 mg/l ±7.32 in the month of March (Table-3 and Graph-2). The annual average values of calcium hardness (CaH) were ranged from 111.0 mg/l to 125.8 mg/l and annual average value were observed 116.2 mg/l ±1.37. Approximately similar trend were observed by Arya and Gupta (2013).

Conclusion

The point sources contributing to river Malin have very high organic pollution deteriorating water quality of the river Malin. The river Malin is subjected to varying degree of pollution caused by numerous untreated and/or partially treated waste inputs of municipal and industrial effluents as assessed by water quality index also. Water quality index is an efficient tool to classify the water of the river for their various advantageous uses and give a rapid and precise idea about the pollution load in the river that may be worthwhile for policy makers. On the basis of the present investigation, it was found that the water Malin river is not fit for direct human consumption.

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Conflict of Interest

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Table 1: Showing the sampling sites.

SN	Sampling Site	Co-ordinates
1	Malin River near Shahpur village- (Fig-2)	29.62N, 78.33E
2	Malin River near Basantimata palace- (Fig-3)	29.61N, 78.33E
3	Malin River near Alipura village- (Fig-4)	29.61N, 78.31E
4	Malin River near Kalheri village- (Fig-5)	29.61N, 78.29E

Table 2: Water Quality Index (WQI) and its status according to Chaterjee and Raziuddin (2002).

Water quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Figure 1: Map showing all the four sampling sites.

Figure 2: Showing sampling site-1 Malin River near Shahpur village.

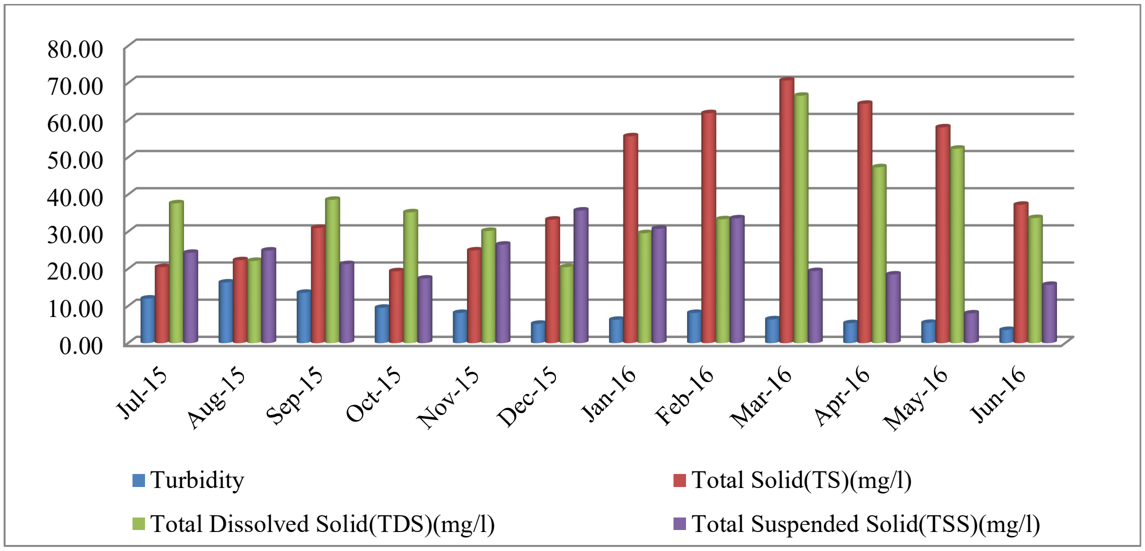

Figure 3: Showing annual variations in different physical parameters of Malin River.