Environment Conservation Journal 19 (1&2) 191-201 , 2018
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

# Evaluation of water quality of River Malin using water quality index (WQI) at Najibabad, Bijnor (UP) India

**Bhutiani R., Ahamad Faheem ✉ Tyagi Varun and Ram Khushi**

**Received: 25.11.2017** **Revised: 28.01.2018** **Accepted: 14.02.2018**

## Abstract

**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: Malin River, Non-perennial, RavalliGhat, WQI,***

## 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

**Author's Address**
Limnology and Ecological Modelling Laboratory, Department of Zoology and Environmental Science, Gurukula Kangri Vishwavidyalaya, Haridwar-249404
**E-mail.:** *faheem.ahamad170390@gmail.com*

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

### 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 figure 1.

| 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 |


**Figure 1. Showing Malin River and all the four sampling sites**

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).

**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

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

**$V_{observed}$**= Actual value of the water quality parameter obtained from laboratory analysis

**$V_{ideal}$**= Ideal value of that water quality parameter can be obtained from the standard Tables.

**$V_{ideal}$** for pH = 7 and for other parameters it is equal to zero, but for DO Videal = 14.6 mg/L

**$V_{standard}$** = 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;

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

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.

**Table 1: 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 |

## Results and discussion

The results of various physico-chemical parameters of River Malin analysed during the study period (Average results of all the four sites from July 2015 to June 2016) are tabulated in table 2 and 3 and Graph 1 and 2 while their WQI values are given in table 4.

**Turbidity (NTU):** It 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; Bhutiani *et al.,* 2015.

**Total Solids (mg/l):** 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.

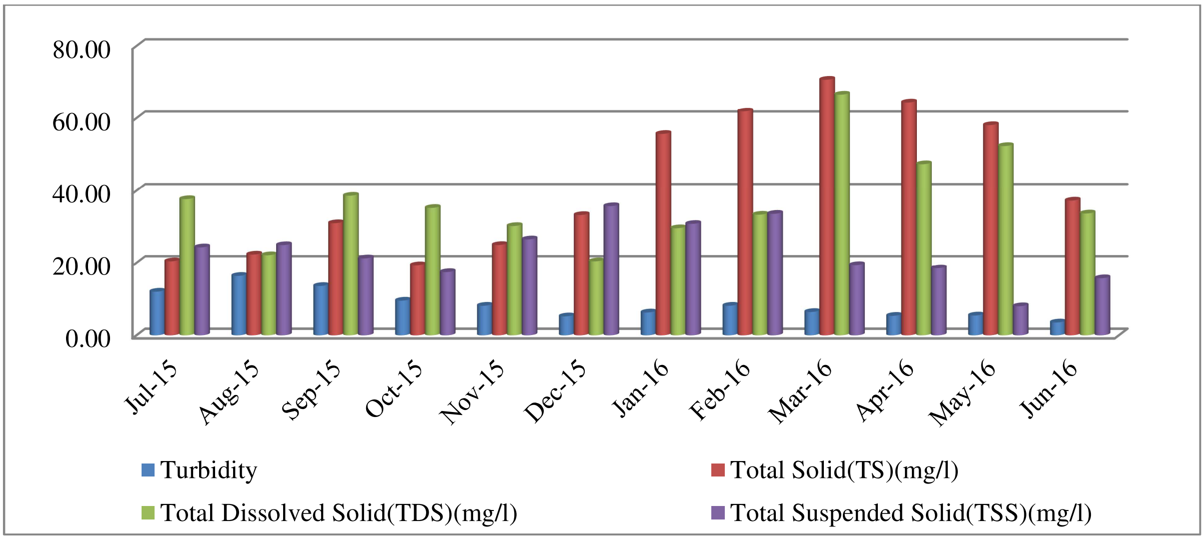
**Total Dissolved Solid (mg/l):** Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter that are dissolved in water. It signifies the inorganic pollution load of water 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.

**Total suspended Solids (mg/l):** 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; Bhutiani *et al.,* 2018..

**pH:** The increase in pH is associated with increasing use of alkaline detergents in residual areas and alkaline material from waste water in industrial process. During the study period the monthly values of pH was ranged from 6.2 to 7.6. The minimum monthly average value of pH was found 6.9±0.38 in the month of June and maximum monthly average value was observed 7.3±0.17 in the month of July (Table-3 and Graph-2). The decrese in the pH values in summer season was found due to sugar mill effluent mixing. The annual average values of pH were ranged from 6.7 to 7.4 and annual average were observed 7.1±0.10. A more or less same trend was observed by Sharma and Kansal, 2011; Yadav and Mishra 2014; Shah and Joshi, 2017 and Bhutiani and Khanna ,2007.

Table 2. Monthly average value of different Physical parameter at different sampling sites.

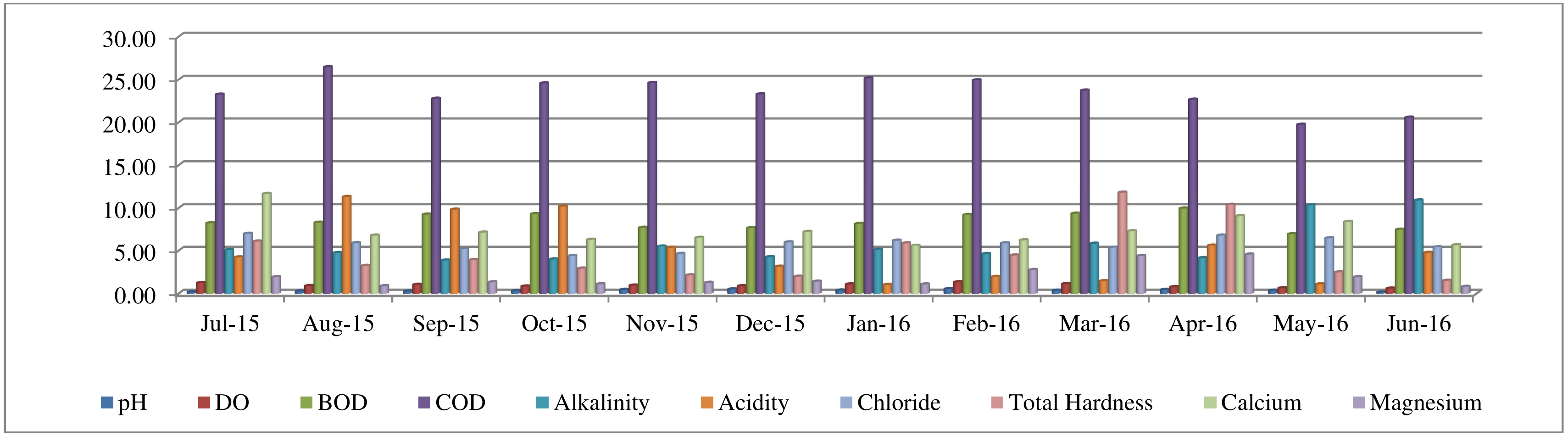
| Date/ Parameter | Turbidity (NTU) | Total Solid(TS)(mg/l) | Total Dissolved Solid(TDS)(mg/l) | Total Suspended Solid(TSS)(mg/l) |
|---|---|---|---|---|
| **July-15** | 64.5±11.99 (47.7-76)* | 1038.3±20.44 (1012.7-1062.7)* | 679.3±37.63 (646.0-729.7)* | 359.0±24.30 (333.0-391.7)* |
| **August-15** | 70.1±16.32 (47.3-83.3)* | 1074.1±22.31 (1042.7-1094.7)* | 714.8±22.12 (696.7-746.3)* | 359.3±24.91 (329.3-380.3)* |
| **September-15** | 61.5±13.55 (45.7-75.7)* | 1047.8±30.98 (1011.7-1078.0)* | 693.9±38.57 (641.0-733.0)* | 354.4±21.25 (335.7-374.7)* |
| **October-15** | 56.2±9.52 (43.3-66.0)* | 1020±19.34 (995.7-1043.0)* | 674.8±35.20 (636.7-719.3)* | 345.3±17.37 (323.7-359.7)* |
| **November-15** | 47.7±8.12 (40.3-59.3)* | 1019.5±24.95 (990.0-1040.7)* | 677.0±30.20 (637.0-700.7)* | 342.5±26.50 (307.7-370.3)* |
| **December-15** | 42.1±5.20 (39.3-47.7)* | 997.7±33.23 (971.7-1044.7)* | 658.5±20.44 (629.3-675.3)* | 338.5±35.68 (299.0-384.7)* |
| **January-16** | 34.9±6.28 (26.7-37.0)* | 947.9±55.66 (875.0-1010.0)* | 632.9±29.59 (604.0-670.3)* | 315.0±30.78 (271.0-339.7)* |
| **February-16** | 33.2±8.12 (27.7-45)* | 923.7±61.89 (847.7-996.0)* | 610.6±33.33 (566.7-637.3)* | 313.0±33.58 (281.0-360.3)* |
| **March-16** | 30.4±6.41 (25.3-39.7)* | 889.2±70.69 (817.3-962.7)* | 588.5±66.57 (523.3-658.7)* | 304.8±19.39 (291.3-333.3)* |
| **April-16** | 30.7±5.36 (24.7-36.0)* | 869.7±64.40 (809.0-935.0)* | 565.4±47.33 (516.7-607.3)* | 304.3±18.47 (287.0-327.7)* |
| **May-16** | 28.4±5.45 (22.7-35.3)* | 864.0±58.07 (808.0-918.7)* | 561.7±52.32 (512.0-609.0)* | 302.3±7.99 (296.0-314.0)* |
| **June-16** | 27.2±3.53 (24.3-32.3)* | 865.9±37.23 (835.0-913.7)* | 564.4±33.67 (522.3-594.0)* | 297.0±15.68 (285.3-319.7)* |
| **Average± SD** | 43.9±15.56 (35.7-48.9)* | 963.1±78.64 (939.3-991.4)* | 635.1±55.31 (623.7-642.1)* | 327.9±24.07 (305.4-350.4)* |




**Graph-1. Showing annual variations in different physical parameters of Malin River.**

**Table 3. Monthly average value of different chemical parameter at different sampling sites (* Range).**

| Date/ Parameter | pH | DO | BOD | COD | Alkalinity | Chloride | Total Hardness | Calcium Hardness | Magnesium Hardness |
|---|---|---|---|---|---|---|---|---|---|
| **July-15** | 7.3±0.17 (7.0-7.4)* | 7.6±1.25 (6.1-9.1)* | 12.4±8.25 (4.8-22.3)* | 37.1±23.24 (14.9-63.4)* | 121.2±5.10 (116.5-127.0)* | 27.3±7.02 (21.7-37.0)* | 342.2±6.14 (336.9-348.4)* | 116.8±11.66 (109.6-113.6)* | 55.0±1.93 (52.3-56.9)* |
| **August-15** | 7.2±0.27 (6.8-7.4)* | 7.3±0.91 (6.2-8.3)* | 12.4±8.31 (4.9-22.7)* | 34.8±26.48 (5.3-63.4)* | 119.7±4.74 (112.6-122.6)* | 27.7±5.95 (22.3-35.4)* | 343.4±3.24 (340.5-347.9)* | 116.7±6.83 (108.7-125.1)* | 55.3±0.88 (54.4-56.5)* |
| **September-15** | 7.1±0.26 (6.7-7.3)* | 7.2±1.04 (5.9-8.2)* | 12.8±9.26 (4.3-24.5)* | 35.9±22.76 (13.1-60.8)* | 120.2±3.87 (115.2-124.6)* | 26.9±5.22 (22.5-33.4)* | 341.4±3.93 (339.2-347.1)* | 116.0±7.17 (108.9-124.3)* | 55.0±1.34 (53.4-56.2)* |
| **October-15** | 7.1±0.32 (6.7-7.4)* | 7.2±0.85 (6.1-7.9)* | 12.5±9.31 (4.1-24.1)* | 35.8±24.54 (13.0-62.7)* | 120.6±4.00 (115.3-124.8)* | 27.0±4.40 (23.2-32.4)* | 340.2±2.93 (336.3-343.4)* | 116.4±6.34 (110.5-122.6)* | 54.7±1.11 (53.6-56.0)* |
| **November-15** | 7.0±0.46 (6.5-7.6)* | 7.4±0.95 (6.4-8.4)* | 11.5±7.73 (3.8-19.9)* | 36.0±24.59 (11.0-62.6)* | 118.9±5.55 (110.9-123.6)* | 26.5±4.64 (22.3-32.2)* | 341.3±2.14 (339.2-344.3)* | 116.0±6.56 (108.8-123.9)* | 55.0±1.27 (53.8-56.2)* |
| **December-15** | 7.0±0.52 (6.4-7.6)* | 7.6±0.89 (6.7-8.5)* | 12.0±7.69 (3.9-20.7)* | 35.9±23.27 (11.6-61.6)* | 120.5±4.27 (114.9-125.0)* | 27.6±6.04 (22.6-35.9)* | 341.5±1.99 (340.5-344.5)* | 116.8±7.25 (109.3-125.6)* | 54.8±1.41 (53.4-56.4)* |
| **January-16** | 6.9±0.38 (6.4-7.3)* | 8.0±1.09 (6.9-9.4)* | 11.7±8.18 (3.8-21.0)* | 35.2±25.19 (10.4-62.3)* | 119.9±5.13 (112.6-124.5)* | 28.6±6.23 (24.3-37.7)* | 344.1±5.92 (339.3-351.7)* | 117.3±5.63 (110.6-123.8)* | 55.8±1.08 (54.2-56.7)* |
| **February-16** | 7.0±0.54 (6.2-7.4)* | 7.9±1.34 (6.7-9.7)* | 12.1±9.21 (3.7-23.7)* | 34.9±24.95 (11.4-64.1)* | 119.3±4.62 (114.6-123.8)* | 28.9±5.93 (23.9-37.0)* | 338.7±4.46 (332.2-342.3)* | 115.3±6.27 (111.8-124.7)* | 54.7±2.77 (50.9-56.5)* |
| **March-16** | 7.1±0.36 (6.8-7.6)* | 7.8±1.13 (7.0-9.4)* | 12.4±9.37 (4.0-24.7)* | 34.5±23.71 (11.6-63.6)* | 122.1±5.88 (113.4-126.2)* | 28.4±5.38 (24.4-36.0)* | 337.8±11.81 (320.8-347.3)* | 119.3±7.32 (112.1-129.3)* | 53.3±4.40 (46.7-55.6)* |
| **April-16** | 7.1±0.45 (6.5-7.6)* | 7.4±0.78 (6.8-8.5)* | 13.0±9.97 (4.1-26.0)* | 35.5±22.65 (13.8-61.2)* | 121.0±4.15 (117.3-125.6)* | 28.9±6.82 (22.9-38.7)* | 339.2±10.39 (324.1-346.9)* | 114.5±9.08 (106.2-127.0)* | 54.8±4.57 (48.1-58.3)* |
| **May-16** | 7.2±0.36 (6.7-7.5)* | 7.5±0.64 (6.9-8.4)* | 11.2±9.98 (4.8-19.6)* | 33.2±19.75 (13.8-56.1)* | 121.8±10.35 (99.1-136.7)* | 28.3±6.52 (23.6-37.9)* | 341.0±2.49 (338.4-343.9)* | 114.0±8.41 (112.4-125.7)* | 55.4±1.93 (52.8-57.1)* |
| **June-16** | 7.0±0.15 (6.9-7.2)* | 7.3±0.61 (6.6-8.2)* | 11.6±7.50 (4.3-20.6)* | 34.3±20.57 (14.6-59.2)* | 121.6±10.90 (111.8-136.3)* | 28.7±5.46 (24.0-36.5)* | 341.6±1.51 (339.5-343.0)* | 115.8±5.71 (110.9-123.1)* | 55.4±0.81 (54.8-56.3)* |
| **Average± SD** | 7.1±0.10 (6.7-7.4)* | 7.5±0.27 (6.3-8.7)* | 12.1±0.54 (4.2-22.5)* | 35.2±1.01 (12.0-61.8)* | 120.6±1.01 (114.0-126.4)* | 27.9±0.85 (23.2-35.8)* | 341.0±1.84 (339.2-343.7)* | 116.2±1.37 (111.0-125.8)* | 54.9±0.61 (52.5-56.2)* |




**Graph-2. Showing annual variations in different Chemical parameters of Malin River.**

**Table 4. Showing Calculation of WQI of Malin River water samples**

| Parameters | Observed value (Vo) | Standard Value (Sn) | Ideal value (Vi) | Unit Weight (Wi) | Quality Rating (Qi) | WiQi |
|---|---|---|---|---|---|---|
| **Total Solid(TS)(mg/l)** | 963.1 | 2100 | 0 | 0.0008 | 45.86 | 0.0367 |
| **Total Dissolved Solid(TDS)(mg/l)** | 635.1 | 500 | 0 | 0.0035 | 127.02 | 0.4446 |
| **Total Suspended Solid(TSS)(mg/l)** | 327.9 | 100 | 0 | 0.0177 | 327.90 | 5.8038 |
| **pH** | 7.1 | 7.5 | 7 | 0.2354 | 20.00 | 4.7080 |
| **DO** | 7.5 | 6 | 14.6 | 0.2941 | 82.56 | 24.2809 |
| **BOD** | 12.1 | 5 | 0 | 0.3532 | 242.00 | 85.4744 |
| **COD** | 35.2 | 250 | 0 | 0.0071 | 14.08 | 0.0999 |
| **Alkalinity** | 120.6 | 200 | 0 | 0.0088 | 60.30 | 0.5570 |
| **Chloride** | 27.9 | 250 | 0 | 0.0071 | 11.16 | 0.0792 |
| **Total Hardness** | 341.0 | 300 | 0 | 0.0059 | 113.67 | 0.6707 |
| **Calcium Hardness** | 116.2 | 75 | 0 | 0.0236 | 154.93 | 3.6564 |
| **Magnesium Hardness** | 54.9 | 30 | 0 | 0.0589 | 183.00 | 10.7787 |
| | | | | ΣWi=1.0161 | ΣWi=1382.4800 | ΣWi=136.5903 |
| **WQI=134.4260** | | | | | | |

**Dissolved Oxygen (mg/l):** 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; Arya and Gupta 2013; Bhutiani *et al.,* 2018.

**Biological Oxygen Demand (mg/l):** 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. A more or less same trend was observed by Kumar *et al.,* 2012 and Sharma *et al.,* 2014.

**Chemical Oxygen Demand (mg/l):** 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 (mg/l):** 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 Bhutiani *et al.,* 2017 and Khanna and Bhutiani, 2003.

**Chlorides (mg/l):** 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, and approximately similar trend were observed by Bhutiani *et al.,* 2017, Tyagi and Malik, 2018 and Arya and Gupta 2013.

**Total Hardness (mg/l):** 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.

**Calcium Hardness (mg/l):-** 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. Approximately similar trend were observed by Arya and Gupta 2013: Bhutiani *et al.,* 2016.

**Magnesium Hardness (mg/l):** 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; Bhutiani *et al.,* 2018..

## Water quality index

Water Quality Index allows for a general analysis of water quality on many levels that affect a stream's ability to host life and whether the overall quality of water bodies poses a potential threat to various uses of water (Akkaraboyina and Raju 2012). From Table 4, the WQI of the Malin river Water was calculated as 134.4260 which indicate(Table 1) that river water was seriously polluted during the study period. Similar water quality index (57-290) were observed by Chandra *et al.,* 2017 for the water quality parameters of Vijayawada, Krishna district of Andhra Pradesh.

## 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. Most of the parameters was found above the standard limit of WHO and BIS. The annual values of Some parameters such as chloride, COD and BOD was found under the limit but at some sites these parameters was found above the limits. On the basis WQI the river water was also found not only unsuitable for drinking purpose but was found seriously polluted.

## References


Abbasi Tasneem and Abbasi S. A., 2012. *Water Quality Indices*. ***Elsevier Publication.***:4

Alam M., Pathak J.K., 2010. Rapid Assessment of Water Quality Index of Ramganga River, Western Uttar Pradesh (India) Using a Computer Programme. ***Nature and Science,*** 8(11): 1-8.

APHA, AWWA, WPCF, 1998. Standard methods for examination of water and waste water, 20th Eds. American Pub lie HealthAssociation; 1015, Fifteen Street, New Washington, 15: 1-1134.

Akkaraboyina M, Raju B 2012. A Comparative Study of Water Quality Indices of River Godavari. Int J Eng Res Dev 2(3):29–34

Arya Sandeep and Gupta Richa 2013. Water Quality Evaluation of Ganga River from Up to Downstream Area at Kanpur City. ***J.Chem. &Cheml. Sci.*** 3 (2):54-63.

Bhutiani R.,Ruhela Mukesh and Ahamad Faheem 2017. Limnological Characterisation of Hindon River at NCR (Uttar Pradesh) India. ***Environ. Cons. Jour.*** 18(1&2):219-229.

Bhutiani Rakesh and Ahamad Faheem 2018. Efficiency assessment of Sand Intermittent Filtration Technology for waste water Treatment. ***International Journal of advance research in science and engineering (IJARSE),*** 7(03): 503-512.

Bhutiani Rakesh and Khanna D. R. 2007.Ecological study of river Suswa: modeling DO and BOD. ***EnvironMonit Assess*** 125:183–195.

Bhutiani R., Khanna D.R., Ram Khushi, Ahamad Faheem and Tyagi Varun 2016: Quality assessment of Ganga River at Haridwar with reference to various physico-chemical parameters. ***Biotech. Int.*** 9(1):17-24.

Bhutiani R., Khanna D.R., Tyagi Varun, Ahamad Faheem, 2015. Removal of Turbidity in Dairy Waste Water Through Aquatic Macrophytes.International Journal of Research Grantahlayah, 3 (9):1-3.

Bhutiani R., Khanna D.R., Ahamad Faheem, Tyagi Varun, 2018. Asesement of water quality status of Malin River at Najibabad, Bijnor (UP), ***Water biology, Discovery Publishing Housepvt ltd, New Delhi, India:*****281-307.**

Bhutiani R., Khanna D.R., Malik Rahul, Ahamad Faheem, Tyagi Varun, 2018. Physico-chemical characterization of River Ganga at Haridwar, Uttarakhand, ***Water biology, Discovery Publishing Housepvt ltd, New Delhi, India:*****143-159.**

Brown, R.M., McClelland, N.I., Deininger, R.A., Tozer, R.G., 1970. A water quality index-do we dare? ***Water sewage works,*** 117:339-343.

Chaterjee C. and Raziuddin M., 2002. Determination of water quality index (WQI) of a degraded river in Asanol Industrial area, Raniganj, Burdwan, West Bengal. ***Nature Environment and Pollution Technology*** 2: 181-189.

ChandraSatish, AsadiSS. and Raju M.V.S. 2017. Estimation of water quality index by weighted arithmetic water quality Index method: A model study. ***International Journal of Civil Engineering and Technology (IJCIET),***8(4):1215-1222.

Cude, C. 2001. Oregon water quality index: A tool for evaluating water quality management effectiveness. Journal of the American ***Water Resources Association,*** 37:125–137.

Gupta, R. C., Gupta, A. K. and Shrivastava, R. K., 2012. "Assessment of water quality status of holy river Kshipra using water quality index", ***J. Indian Water Resources Society,*** 32(1-2):33-39.

Khanna D. R., Bhutiani R., Matta Gagan, Kumar Dheeraj, Singh Vikas and Neeraj 2010. Ecology of the river Ganga at foothills of Grahwal Himalaya(Uttarakhand ), ***J. Exp. Zool. India.*** 13(1) 115-119.

Khanna D.R., and Bhutiani R., 2005. Benthic fauna and its ecology of river Ganga from Rishikesh to Haridwar (Uttarakhand) India. ***Environment Conservation Journal*** 6(1):33-40.

Khanna D.R., Bhutiani R., Matta Gagan, Singh Vikas and Ishaq Fouzia 2012. Seasonal variation in physico-chemical characteristic status of River Yamunain Doon Valley of Uttarakhand. ***Environ. Cons. Jour.,*** 13(1&2):119-124.

Khanna D.R., Bhutiani Rakesh, Tyagi Varun and Ahamad Faheem 2014. Impact of Sugar mill Effluent on Physico-chemical properties of Malin River in Najibabad. ***Indian J. Sci. Res. Spl. Ed. NSESIR*** :5-10

Khanna, D. R. and Bhutiani, R. (2011), "Water analysis at a glance"Third edition, Action for sustainable efficacious development and awareness publication Rishikesh.

Khanna D.R., Bhutiani R., 2008. Laboratory manual of water and Waste water Analysis. Daya Publishing House New Delhi -110002.

Khanna, D.R., Bhutiani R., 2003. Limnological characteristics of river Ganga at Haridwar (Uttaranchal), ***U.P. J. Zool.*** 23(3): 179-183.

Kolhe Bharati G. and Shinde Satish M.(2014). Study of Some Physico-Chemical Parameters of Godavari River Water at Ramkund, Nashik With Reference to Correlation Study. ***Indian Journal of research***,3(5):1-3.

Kumar Ravi Gangwar, KharePuneet, Singh Jaspal and Singh A. P. 2012. Assessment of physico-chemical properties of water: River Ramganga at Bareilly, U.P. ***Journal of Chemical and Pharmaceutical Research,*** 4(9):4231-4234.

Kumar, A. and Dua, A., 2009. "Water quality index for assessment of water quality of River Ravi at Madhopur", ***Global Journal of Environmental Sciences,*** 8(1):49-57.

Kumar, R. N., Rajal, Solanki and Kumar, J. I. N., 2009."An assessment of seasonal variation and water quality index of Sabarmati river and Kharicut canal at Allahabad, Gujarat", ***Electronic Journal of Environmental, Agricultural and Food Chemistry,*** 10(8):2771-2782.

Mandal H.S. and Das Amrita, Nanda Ashis Kumar 2012. Study of Some Physicochemical Water Quality Parameters of Karola River, West Bengal - An Attempt to Estimate Pollution Status. ***International Journal of Environmental Protection.*** 2(8):16-22.

Mandal H.S. and Das Amrita, 2011. Assessment of seasonal variation in physico-chemical characteristics and quality of Torsha river water for irrigation used in Cooch Behar and

Jalpaiguri districts of West Bengal, India, ***J. Chem. Pharm. Res.,*** 3(6):265-270.

Naik, S. and Purohit, K. M., 2001. "Studies on water quality of river Brahmani in Sundargarh district, Orissa", ***Indian J. Environmental and Eco-planning,*** 5(2):397-402.

Parparov, A., Hambright, K. D., Hakanson, L. and Ostapenia, A. 2006. "Water Quality Quantification: Basics and Implementation," ***Hydrobiologia*****,** 560(1):1227-237.

Ruhela Mukesh, Bhutiani Rakesh, Ahamad Faheem, 2017. Pollution Status of River Hindon from Ghaziabad to Noida with Special Reference to Heavy Metals**. *International Journal of Advance Engineering and Research Development ,*** 4( 8):540-548.

Shah Kosha A. and Joshi Geeta S., 2017. Evaluation of water quality index for River Sabarmati, Gujarat,India. ***Appl Water Sci***. 7:1349–1358, DOI 10.1007/s13201-015-0318-7

Sharma Deepshikha and Kansal Arun 2011. Water quality analysis of River Yamuna using water quality indexin the national capital territory, India (2000–2009).***Appl Water Sci.*** 1:147–157.

Sharma M. K., Jain C. K. and Singh Omkar , 2014. Characterization of Point Sources and Water Quality Assessment of River Hindon Using Water Quality Index. ***Journal of Indian Water Resources Society,*** 34(1):53-64.

Sharma, M. P., Patra, S. and Singal, S. K., 2009. Water quality management of Damodar river*,* ***J. Indian Water Resources Society,*** 29(2):23-31.

Singh, D. F., 1992. "Studies on the water quality index of some major rivers of Pune, Maharashtra", ***Proceedings of the Academy of Environmental Biology,*** 1(1): 61-66.

Singkran, N., Yenpien, A. and Sasitorn, P., 2010. "Determining water conditions in the Northeastern rivers of Thailand using time series and water quality Index models", ***Journal of Sustainable Energy and Environment,*** 1(2):47-58.

Sudevi Basu and Lokesh K.S 2012. "Evaluation of Cauvery River Water Quality at Srirangapatna in Karnataka using Principal Component Analysis". ***International Journal of Engineering and Science*** 1(4):6-12.

Trivedy, R.K. and Goel, P.K. 1986. Chemical and Biological methods for water pollution studies. ***Environment Publication, Karad.***

Tyagi Divya and Malik D.S., 2018. Assessment of Physico-Chemical parameters and Water Quality Index of Ram-Ganga Reservoir At Kalagarh (Uttarakhand). ***International Journal of Current Research in Life Sciences,*** 7(03) :1234-1239,

Yadav Surendra Kumar and Mishra Govind Chandra 2014. "Analysis of Water Quality Parameters of River Hindon Entering in Saharanpur (UP, India)".***International Journal of Environmental Research and Development*** 4(3):269-274.

W.H.O. 1993. Guidelines for drinking water quality (vol.2): Recommendations. ***World Health Organization, Geneva***

World Health Organization (W.H.O.) 1998. Guideline for drinking water quality. ***Health criteria and other supportingInformation*** (2ndedn.) Geneva, 2: 231 -270.

World Health Organization (WHO), 2004. "Guidelines for Drinking-Water Quality," 3rd Edition, World ***HealthOrganization (WHO),*** Geneva,