Turkish Online Journal of Qualitative Inquiry (TOJQI)

Volume 11, Issue 4, December 2020: 1784-1799

# Hydrochemical Analysis of river Wainganga with special reference to Bhandara and Suburbans

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**Abstract:**

The main aim of the study was to hydro chemical analysis of river Wainganga in Bhandara and sub-urbans. The sampling sites denotes W1, W2, W3, W4. In the present work, an attempt made to analyze various water parameters quantitatively and to establish a mathematical relation between them. For that, correlation coefficient was calculated to understand the nature of correlation between physico-chemical parameters and established a regression equation to calculate the water parameters. The Weighted Arithmetic Index has been adopted to assess the status of existing water quality. Great care was taken in the collection of water samples. The test which has to be conducted at sites like water temperature, pH and EC were immediately done at site by using a digital thermometer, pH meter and conductivity meter respectively. For testing rest of the parameters, collected water samples were kept in an ice box and were brought to the laboratory for analysis. All parameters were analyzed as per the standard methods of American Public Health Association. All the samples were analyzed for the following seventeen physico-chemical parameters like water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH),calcium hardness (CaH), magnesium

hardness (MgH), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), iron ($Fe^{2+}$), chloride ($Cl^-$), fluoride ($F^-$), nitrate ($NO_3^-$), sulphate ($SO_4^{--}$), and phosphate ($PO_4^{3-}$). Then data analysis and interpretation were done and chronicled the results, discussion and conclusion of the research.

**Keywords**: Hydrochemical, Wainganga, Bhandara

## INTRODUCTION:

The water quality evaluation may be complicated practice in compound parameters causing numerous anxieties in general quality of water. It is not easy to assess water quality for huge samples containing concentrations for many parameters. The Conventional methods for evaluating quality of water are based on the comparison of experimentally determined parameter values with the existing guidelines. So, water quality indices are such approaches which minimises the data volume to the great extent and simplifies the expression of water quality status. A WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner [1-5]. The objectives of the research are in the following with special focus on Bhandara and sub-urbans:

- To examine and evaluate the water quality of Wainganga river based on the physico - chemical characteristics.
- To find out the variations if any in the quality of water at different sites of Wainganga river.
- To monitor seasonal variations of physico-chemical parameters in the Wainganga river.
- To do the comparison of all the examined water quality parameters with water quality standards and guidelines given by WHO.
- To evaluate the statistical relationship among water quality parameters using correlation and regression analysis.

- To assess the water quality data by using water quality indices (WQI).

- To identify the point sources of discharged pollutant in to the stream in order to aware and envisage the local authority toward careful management of water resources.

- To suggest the preventive majors if required to the concerned authority.

## RESEARCH METHODOLOGY:

### Study Area:

The study area of the research was Bhandara and sub-urbans. The river is Wainganga.

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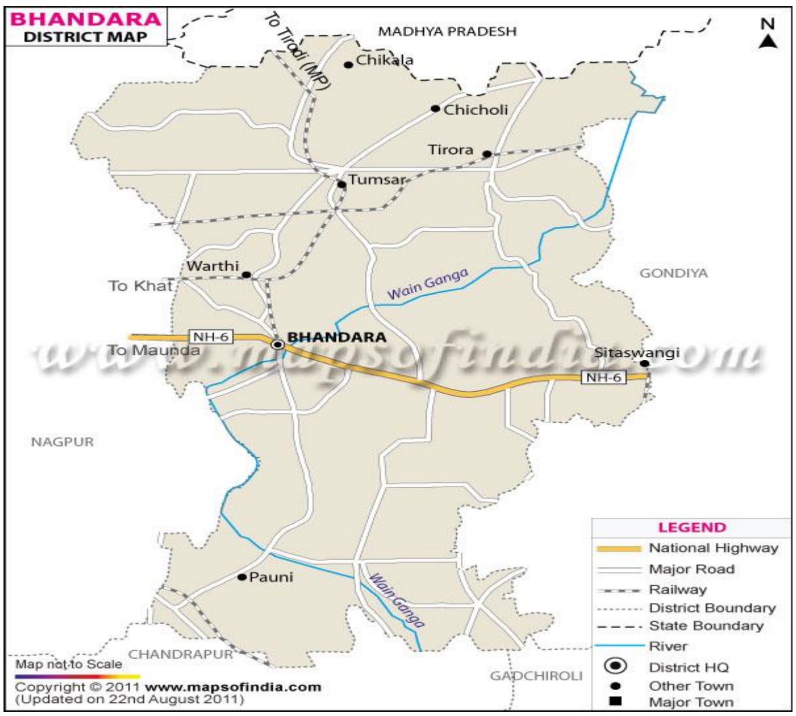


**Figure 1: Bhandara District Map (Source: www.mapsofindia.com)**

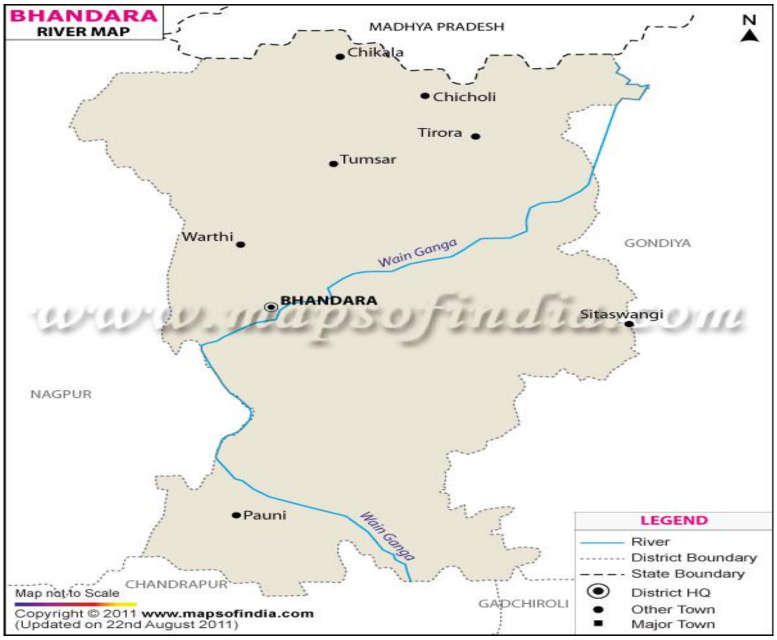


**Figure 2. Bhandara River Map (Source: www.mapsofindia.com)**

## Sampling sites:

The sampling sites denotes $W_1$, $W_2$, $W_3$, $W_4$

**$W_1$:** This site is at the border of Bhandara.

**$W_2$:** This site is 523 meters away from the sampling site $W_1$.

**$W_3$:** This site is 2026 meters away from sampling site $W_2$.

**$W_4$:** This site is 2089 meters away from sampling site $W_3$.

## Materials and Methods:

An initial approach in any study is to define a problem, once the problem is identified then only satisfactory solution can be sought out.  In this regard, the chapter deals with materials used and methods adopted to probe the actual status of water quality of Wainganga river at Bhandara and sub-urbans. Statistical methods related to the assessment and interpretation of observed water quality data and methods employed in evaluation of water quality indices.

**Sampling:**

Appropriate sampling is a precondition for good analysis. The composition of the sample should be the same as the average composition of the material to be analysed.

The sampling can be classified under two heads such as "Composite sampling" and "Grab sampling." composite sampling is necessary in the case of industrial wastes when the wastes of a particular composition are discharged for a fixed time interval of day. Grab sampling includes the collection of a single sample or measurement at a specific time or over as short period as feasible. This is most common type of sampling technique and used in most laboratories. In present study Grab sampling technique was used.

**Sample collection:**

With the objective in view the present work was planned to assess the quality of water from four different sites *i*.e. $W_1$, $W_2$, $W_3$ and $W_4$ of Wainganga river in Bhandara and sub urbans for physico-chemical parameters and the results are compared with the standards given by WHO to determine the extent of pollution.

Water samples were collected in the polythene containers of about two litres capacity in the first week of each month (generally on the first day), once in the month, from the four selected sites of river Wainganga for analysing the water quality parameters for a period of 24 months, from July 2019 to June 2021. The bottles thoroughly cleaned in soap solution first, soaked in 10 % hydrochloric acid (HCl) solution for 24hrs, and then rinsed with distilled water. The bottles further rinsed three times with sample water, immersed about 20 cm below the water surface and filled up to the top with the mouth facing slightly upward in the direction of the current. The container was properly labelled; the samples were transported to the laboratory in an ice box to avoid unpredictable changes in physico-chemical and biological characteristics.

The samples were collected in morning hours between 9.00 am to 11.00 am from each sampling sites and brought to the laboratory in ice boxes for the analysis of various physico- chemical parameters. The portion of the water samples for metal analysis were treated with 2.0 ml of hydrochloric acid (HCl) in 100.0 ml sample to arrest the microbial activities. The water temperature, pH and EC were recorded on the spot and remaining parameters were analysed in the laboratory. The samples were preserved by refrigeration at $4^0$C, which is most generally accepted method. The recorded data was segregated into the following three seasons:

- Rainy season period (July to October)
- Winter season period (November to February)
- Summer season period (March to June)

In the present work, an attempt made to analyse various water parameters quantitatively and to establish a mathematical relation between them. For that, correlation coefficient was calculated to understand the nature of correlation between physico-chemical parameters and established a regression equation to calculate the water parameters. And also, the Weighted Arithmetic Index has been adopted to assess the status of existing water quality.

**Methodology:**

Great care was taken in the collection of water samples. The test which has to be conducted at sites like water temperature, pH and EC were immediately done at site by using a digital thermometer, pH meter and conductivity meter respectively. For testing rest of the parameters, collected water samples were kept in an ice box and were brought to the laboratory for analysis. All parameters are analysed as per the standard methods of American Public Health Association APHA (2005).

**Physico-chemical Analysis:**

Samples were analysed in laboratory by using standard methods of analysis APHA, (2005).

**The Glassware's:**

The glassware's used for the analysis of water were of Borosil. This included burettes, pipettes, standard flasks, measuring cylinders, conical flasks etc.

**Chemicals and Reagents:**

High purity analytical research (AR) grade chemicals and double distilled water were used for preparing standard solutions for analysis. The chemicals were weighed by using an electronic balance.

**Methods:**

All the samples were analysed for the following seventeen physico-chemical parameters like water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), calcium hardness (CaH), magnesium hardness (MgH), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), iron ($Fe^{2+}$), chloride ($Cl^{-}$), fluoride ($F^{-}$), nitrate ($NO_3^{-}$), sulphate ($SO_4^{--}$), and phosphate ($PO_4^{3-}$).

**Water Temperature:**

Water temperature was recorded by using digital thermometer (Lutron TM 917). A portion of the water sample about 2 liter was taken and digital thermometer was immersed in it for a sufficient period of time till the reading get stabilized. The temperature reading was expressed in degree Celsius ($^{0}$C).

**pH:**

The pH of water samples from sampling site was recorded with the help of Digital water analysis kit (Hanna instruments, HI 98128) by using pH electrode. The calibration was carried out following the manufacturer's calibration procedure. The electrode was dipped into the sample and the reading was noted.

**Electrical Conductivity (EC):**

The instrument used for measurement of electrical conductivity (EC) was portable water analysis kit (Hanna instruments, HI 98304) and the procedure was followed as per the instructions given in operational manual.  Conductivity cell was washed with distilled water and placed in potassium chloride solution (0.01M) after rinsing.  The reading was adjusted to 1413 µSiemens/cm.  This was the standardization of the EC meter.  Then the sample was taken in a 100 ml beaker and specific conductivity was measured after washing the cell with distilled water and rinsing with the sample.  The EC meter directly measures the electrical conductivity.

The value of conductivity was expressed in µSiemens/cm. (APHA, 2005).

**Total Dissolved Solids (TDS):**

Total dissolved solids (TDS) was estimated by Gravimetric method (APHA, 2005). Water samples collected from different sampling sites were filtered through Whatman filter paper no.1.  100.0 ml of filtrate was taken in an evaporating porceilin dish of known weight (A).  The filtrate was evaporated to dryness on steam bath and dried in hot air oven at 180 0C followed by cooling in desiccators and weighing again (B).  From the difference between initial and final weights, the amount of total dissolved solids were calculated using the formula.

Where

A = Weight of  empty dish.

B = Weight of  dried residue + dish.

V =  ml of filtrate used.

**Total Alkalinity (TA):**

The total alkalinity (TA) of water sample was estimated by simple Acidimetric titration method with standard sulphuric acid at room temperature using phenolphthalein and methyl orange as an indicator (APHA, 2005).

**Total Hardness (TH):**

Total Hardness (TH) is defined as, the characteristics of water that mainly represents the total concentration of Ca and Mg ions expressed as mg/L of Calcium carbonates. The total hardness of water sample was determined by EDTA titrimetric method by titrating it against standard EDTA (0.01M) titrant using Eriochrome BlackT (EBT) as an indicator (APHA, 2005).

**Calcium Hardness (CaH):**

The presence of calcium in water is due to over deposit of lime stones, dolomite, gypsum and some other calcium bearing rocks and it is measured by EDTA titrimetric method (APHA, 2005). Take 50.0 ml sample, add 1.0 ml of NaOH and mix well. Add a pinch of Murexide indicator and titrated against 0.01 M EDTA solution until the pink colour changed to blue, that was the end point. Reading of EDTA required was recorded (A').

**Magnesium Hardness (MgH):**

Magnesium hardness can be calculated from the determined total hardness and calcium hardness.

**Dissolve Oxygen (DO):**

The dissolved oxygen (DO) was determined by adopting Winkler method with azide modification (APHA, 2005). The surface water samples were collected in a narrow mouth, glass stoppered BOD bottles of 300 ml capacity with proper care, to avoid entrapping or dissolving atmospheric oxygen.

**Chemical Oxygen Demand (COD):**

Chemical oxygen demand was determined by adopting the Dichromate Reflux method, using ferroin indicator (APHA, 2005).

**Biochemical Oxygen Demand (BOD):**

Biochemical oxygen demand (BOD) is defined as, the quantity of oxygen required by bacteria and other microorganisms in the biochemical degradations and transformation of organic matter under aerobic condition at $20^0$C over a period of 5 days. The sample collected from respective sampling sites were brought to laboratory and immediately processed for BOD test, keeping in mind the organic waste input in the river under study. BOD was determined by using method given by APHA, 2005.

**Iron:**

Iron was determined by phenanthroline method (APHA, 2005, Caldwell and Adams, 1946).

**Chloride:**

Chloride in the form of Cl- ion is one of the major inorganic anion in water and waste water. The amount of chloride ions in the water sample was estimated by Argentometric method (APHA, 2005), by titrating with silver nitrate solution using potassium chromate as an indicator.

**Fluoride:**

Fluoride ion was determined by SPANDS method (APHA,2005).

**Nitrate:**

The nitrate was determined by Brucine method (APHA, 1998). Nitrates ion reacts with Brucine in strong sulphuric acid solution to form a yellow colour which is measured spectrophotometrically (Equip-Tronics model EQ-822).

**Sulphate:**

The sulphate was determined by Turbidimetric method (APHA, 2005).

**Phosphate:**

The total phosphate was determined by Stannous chloride method (APHA2005).

**DATA ANALYSIS AND INTERPRETATION:**

The analysis and interpretation was evaluated under the following tables:

- Monthly variation in physico-chemical parameters of sampling site W1 of Wainganga river water at Bhandara & Suburban's from July 2019 to June 2020

- Monthly variation in physico-chemical parameters of sampling site W1 of Wainganga river water at Bhandara & Suburban's from July 2020 to June 2021
- Seasonal variation in physico-chemical parameters of sampling site W1 of Wainganga river water at Bhandara & Suburban's from July 2019 to June 2021
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W1 of Wainganga river at Bhandara & Suburban's for 2019-21(Annual)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W1 of Wainganga river at Bhandara & Suburban's for 2019-20 (Seasonal variations)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W1 of Wainganga river at Bhandara & Suburban's for 2020-21 (Seasonal variations)
- Monthly variation in physico-chemical parameters of sampling site W2 of Wainganga river water at Bhandara & Suburban's from July 2019 to June 2020
- Monthly variation in physico-chemical parameters of sampling site W2 of Wainganga river water at Bhandara & Suburban's from July 2020 to June 2021
- Seasonal variation in physico-chemical parameters of sampling site W2 of Wainganga river water at Bhandara & Suburban's from July 2019 to June 2021
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W2 of Wainganga river at Bhandara & Suburban's for 2019-21 (Annual)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W2 of Wainganga river at Bhandara & Suburban's for 2019-20 (Seasonal variations)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W2 of Wainganga river at Bhandara & Suburban's for 2020-21 (Seasonal variations)
- Monthly variation in physico-chemical parameters of sampling site W3 of Wainganga river water at Bhandara & Suburban's from July 2019 to June 2020
- Monthly variation in physico-chemical parameters of sampling site W3 of Wainganga river water at Bhandara & Suburban's from July 2020 to June 2021

- Seasonal variation in physico-chemical parameters of sampling site W3 of Wainganga river water at Bhandara & Suburban’s from July 2019 to June 2021
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W3 of Wainganga river at Bhandara & Suburban’s for 2019-21 (Annual)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W3 of Wainganga river at Bhandara & Suburban’s for 2019-20 (Seasonal variations)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W3 of Wainganga river at Bhandara & Suburban’s for 2020-21 (Seasonal variations)
- Monthly variation in physico-chemical parameters of sampling site W4 of Wainganga river water at Bhandara & Suburban’s from July 2019 to June 2020
- Monthly variation in physico-chemical parameters of sampling site W4 of Wainganga river water at Bhandara & Suburban’s from July 2020 to June 2021
- Seasonal variation in physico-chemical parameters of sampling site W4 of Wainganga river water at Bhandara & Suburban’s from July 2019 to June 2021
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W4 of Wainganga river at Bhandara & Suburban’s for 2019-21(Annual)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W4 of Wainganga river at Bhandara & Suburban’s for 2019-20 (Seasonal variations)
- Determination of water quality index (WQI) of physico- chemical parameters of sampling site W4 of Wainganga river at Bhandara & Suburban’s for 2020-21 (Seasonal variations)
- Monthly mean value of physico-chemical parameters of Wainganga river water at Bhandara & Suburban’s from July 2019 to June 2020
- Correlation coefficient (r) among the mean values of studied physico chemical parameters of Wainganga river at Bhandara & Suburban’s (2019-2020)
- Monthly mean value of physico-chemical parameters of Wainganga river water at Bhandara & Suburban’s from July 2020 to June 2021

- Correlation coefficient (r) among the mean values of studied physico chemical parameters of Wainganga river at Bhandara & Suburban's (2020-2021)
- WQI value for all the sampling sites of Wainganga river at Bhandara & Suburban's
- Regression equation for pairs of parameters having highly positive significant correlation coefficients ($0.9 < r < 1.0$) for year 2019-20
- Regression equation for pairs of parameters having highly positive significant correlation coefficients ($0.9 < r < 1.0$) for year 2020-21
- Regression equation for pairs of parameters having highly negative significant correlation coefficients ($-0.9 < r < -1.0$) for year 2019-2021

## DISCUSSION AND CONCLUSION:

The maintenance of a healthy aquatic ecosystem is dependent on the physicochemical properties of water and the biological diversity. Now-a-days, the aquatic ecology is under stressed condition due to fast pace of development, deforestation, cultural practices and agriculture. The study of physical and chemical characteristics of water provides a considerable insight into the quality of water present in Wainganga river.

Wainganga river water is used for drinking, fishing, irrigation and other domestic purposes. This study would help the water quality monitoring and management in order to improve the quality of water with maintaining better sustainable management. In this context, the present study mainly deals to assess water quality and biodiversity of the Wainganga river site $W_1$ to $W_4$ at the Bhandara and sub-urbans.

1. The results obtained from the present investigation, show that there were significant variations in the physico-chemical parameters at all sampling sites of Wainganga river.
2. A glimpse of observations on the physico-chemical parameters indicate that, site $W_4$ is unpolluted as it does not receive any appreciable source of pollutants. The site $W_3$ is slightly polluted as the values of studied parameters are slightly higher than the values at site $W_4$. Site $W_2$ is moderately polluted, as this site is nearer to temple, the garlands, flowers and other temple waste materials are thrown at this site. Moreover, community activities such as bathing, cloth washing,

cattle washing, etc. has been carried out at this site. Site $W_1$ is very near to crematorium where after burning the dead bodies, ashes of pyres and other wastes are thrown into water and also site $W_1$ receives the domestic as well as industrial effluents by small scale paper mill. The waste water from the said paper mill is released in the temporary sedimentation ponds, and overflowing water, outflows and is stored in some pools for a greater part of the year. During rainy season when the pools are flooded, the effluent laden water is carried and poured at site $W_1$.

3. On the basis of data collected from the present investigation, it was concluded that, each parameter shows the monthly, seasonal, annual and spatial variations in their concentrations. On the basis of various parameters studied, Wainganga river water during study period showed variations from good to bad water quality. At site $W_1$ and $W_2$, some parameters like pH, total alkalinity, calcium hardness and phosphate were recorded just little beyond the permissible limits when compared with that of WHO standards and revealed that these sites are slightly more polluted than site $W_3$ and $W_4$ but still those were fit for fish culture and irrigation. The sources of pollutants were village sewage, domestic wastes and waste from religious activities performed by the locality on the bank of river such as cloth and cattle washing, discharge of temple wastes, cremated ashes and pollutants from river basin agriculture.

4. The results from the present study clearly pointed out that river water were comparatively more polluted at the downstream site when compared to that of the other three sites. Thus, the study shows that the river water has been polluted which should be dealt with utmost care. The study provides an informative data and helps to understand the contamination of water in the Wainganga river due to discharge of effluents from industries nearby. The correlation coefficient shows the extent of association exists between two variables. The greater the value of coefficient indicates a good relationship between two parameters. A systematic correlation study showed that there was a significant linear relationship among different pairs of water quality parameters. The linear correlation was very useful to get fairly accurate idea of quality of the river water by determining physico –chemical parameters experimentally. Both the correlated variables might have influenced by one or more other variables. This study proved beyond doubt that all the physicochemical parameters of drinking water in study area were more or less correlated with each other.

5. From present investigation, it can be concluded that maximum parameters were correlated with each other. Some were negatively correlated and some were positively correlated with each other

indicating their direct or inverse relations. From the present study, it was cleared that DO was negatively correlated with all the parameters which implies the effect of increase or decrease of values of various parameters on DO.

6. The linear regression analysis was carried out for the water quality parameters having highly significant correlation coefficients ($0.9<r<1.0$) and found to have better and higher level of significance with their correlation coefficients. Calculated $R^2$ values suggest that dependent variables can be well predicted from the independent variables. Adjusted $R^2$ values are close to estimated $R^2$ values supporting the adequate predictive ability for dependent variables, also the relevancy and utility of regression model. The statistical significance of the applied regression model is indicated in significance column, p-values less than or equal to 0.05 indicates that the model applied is significantly good enough in predictive the dependent variables. Whereas p-values greater than 0.05 suggest that the variables are not related to a significant level of 0.05.

7. A systematic correlation and linear regression analysis in this study showed that there was a significant linear relationship among different pairs of water quality parameters. The linear correlation was very useful to get fairly accurate idea of quality of the river water by determining physico-chemical parameters experimentally. It can be concluded that EC, TDS, TA and TH were the important physico-chemical parameters of drinking water quality because they are correlated with most of the water parameters. This study showed or proved that maximum physico-chemical parameters of drinking water in study area were more or less correlated with each other.

8. The suitability of Wainganga river in the study area for drinking purpose has also been assessed by evaluating the Water Quality Index (WQI) using weighted arithmetic index method. WQI was calculated yearly and seasonally at four sampling sites in order to assess the suitability of Wainganga river water body for different purposes by comparing the several values with WHO standard. From the results, it was concluded that the water of Wainganga river during the study period is moderately polluted, except at site $W_4$ which was less polluted, whereas the site $W_1$ was very much polluted. Based on WQI values, it could be inferred that the water quality at the sampling sites were good, poor, very poor and can only be used for drinking after convential treatment and disinfection mostly during rainy and summer season. On the basis of data collected, from the present investigation, it was concluded that the water quality was better during first year than second year of investigation.

9. From the results, it has been concluded that the water of Wainganga river during the study period was showing the variations from good quality to poor quality and the pollution increases as we go towards the downstream from the site $W_4$ to $W_3$, site $W_3$ to $W_2$ and site $W_2$ to $W_1$. Water quality of Wainganga river was comparatively poor during rainy and summer season than winter season, where the water quality was good.

10. WQI evaluation will not only be helpful for understanding the annual and seasonal quality of water but also has advantages for government agencies and institutions, where regular water quality data is required. Present investigation might be regarded as a pioneer attempt for water quality indices in Bhandara and sub-urbans.

11. The above analysis is very useful, cost effective and time saving method to get accurate idea of quality of Wainganga river water. The analysis gives us tool to predict the level of pollution by investigating the water parameters and take preventive measures prior to the detailed pollution monitoring of river Wainganga.

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