Ground Water Assessment in Smart City Region of Bhubaneswar (BMC), Odisha, India.

Susant K. Choudhury[1*], G.Sunpriya Achary[2], V.Madhava Rao[3]

1. PhD Scholar, Department of Civil Engineering, School of Engineering & Technology, GIET University,Gunupur, Odisha;
2. Professor in Chemistry, Department of Basic Science & Humanities, KMBBCET, Bhubaneswar, Odisha, PIN-752056;
3. Research Professor, Department of Civil Engineering, GIET University. Gunupur, Odisha, PIN-765022, India.

ABSTRACT:

The present study monitors the groundwater quality of smart city Bhubaneswar (BMC), Odisha, over a period of one year (2020). Water samples were collected from nine (09) bore wells for both pre-monsoon and post- monsoon seasons and analyzed for physico-chemical parameters; p^H, EC, TDS, TH, Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_3^{2-}, HCO_3^-, Fe, Cl^-, SO_4^{2-}, NO_3, F in accordance with APHA 2005.Water quality index is then calculated to find the suitability of the groundwater for drinking purpose. WQI of groundwater of smart city region of Bhubaneswar (BMC) revealed that the groundwater is overall good for drinking purpose. All the parameters are found below the permissible limits except Iron (Fe) with reference to BIS 10500: 2012 for Drinking Water. TDS, TH, EC &Chloride are found to be highly correlated with each other. The Hill-Piper diagram revels that majority of water samples are Na^+-K^+-Cl^--SO_4^{2-} type in pre-monsoon season but in post monsoon season around half of the samples were found to be Ca^{2+}-Mg^{2+}-Cl^--SO_4^{2-} type and rest were found to be Na^+-K^+-Cl^--SO_4^{2-} type.

Keywords: Groundwater quality, Drinking water suitability, Water Quality Index (WQI), Correlation, Hill-Piper Diagram.

INTRODUCTION

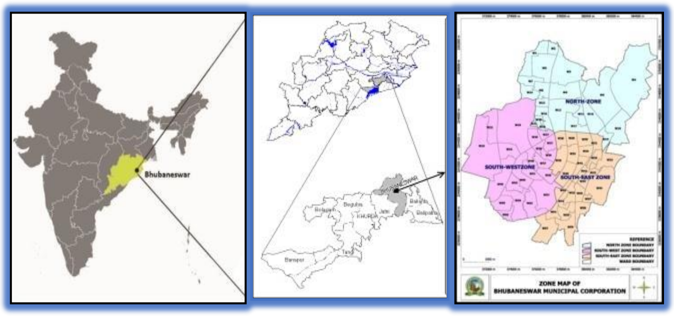
Availability of safe and reliable source of water is an essential prerequisite for sustained population growth and development (Asonye et al.2007) .Ground water is a vital source of water supply for about one-third of the world's population (Nickson et al.2005). Groundwater constitutes nearly 90% of the world's readily available freshwater resources with the remaining 10% from lakes, reservoirs, rivers and wetlands (Boswinkle et al 2000). Comparatively groundwater contamination is not as common as surface water but once contaminated, treatment is often difficult and time consuming (Agbaire and Oyib0 2009). Underground water contamination is one of the main environmental issues today due to improper and indiscriminate disposal of sewage, industrial and chemical waste (Obot and Edi 2012). These sources of contamination may influence important biological, physical and chemical variables of groundwater (Sappa et al 2013).Furthermore , human activities such as land use and the intervention in natural flow patterns are often implicated in groundwater pollution (Schot and Van der Wal 1992). It is therefore critical to first assess the quality of groundwater before it can be exploited for human consumption. Physico-chemical monitoring of water quality quality could serve as a convenient tool for examining potential contamination and to help decision makers in evaluating the effectiveness of regulatory programmes in managing water resources (Pusatli et al 2009; Song and Kim 2009; Sadiq et al.2010) .

Bhubaneswar the capital of Odisha state , India is also known as “Temple City of India” is comforting various challenges including the provision of potable water for its growing population to meet Sustainable Development Goals. Groundwater is an important natural resource that affect the health and wellbeing of many people worldwide. Due to this, the quality of this resource should be given a primary research and quality control attention. The main objective of this study was to evaluate the quality of borehole water in different locations of Bhubaneswar city for drinking purposes..

STUDY AREA:

Bhubaneswar city lies in Bhubaneswar Block of Khurda District, Odisha. It is situated between latitudes of $20^0$12’N to $20^0$25’N and longitudes between $85^0$44’E to $85^0$55’E . Bhubaneswar is an Urban Agglomeration coming under category of Class I UAs/Towns. Bhubaneswar city is governed by Municipal Corporation and is situated in Bhubaneswar Urban Region. Total population of Bhubaneswar UA/Metropolitan region is 886,397. The male population of which is 468,577while female population is 417,820. (Demographic Details: Source: Census, Government of India, 2011). . The location map of Smart City Region Bhubaneswar (BMC) is given in figure-01.

Fig-01: Map of Smart City Region Bhubaneswar (BMC),Odisha.(Source: BMC&CGWB,



Bhubaneswar.)

RESEARCH METHODOLOGY

The study was carried out in nine (09) selected locations covering all the study area of the smart city region of Bhubaneswar (BMC). . A total of eighteen (18) samples were collected between May, 2020 and November, 2020, (Pre- Monsoon & Post-Monsoon) using two sets of polyethylene bottles of one (01) liter capacity for cation and anion analysis and labeled accordingly.The boreholes were allowed to flow for about three (03) minutes before the collection and the samples were collected after the bottles were washed thoroughly and rinsed with the water to be collected into them. Samples collected for the determination of cations were stabilized with diluted hydrochloric acid on collection. All the samples were preserved by refrigeration and analyzed within 24 hours of the collection. The major water quality parameters such as p^H, EC, TDS, TH, Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_3^{2-}, HCO_3^-, Fe, Cl^-, SO_4^{2-}, NO_3, F were analyzed in accordance with APHA 2005.

Spectrophotometric method was used to analyze the cations and anions. The physical parameters p^H and Conductivity were determined on the location itself using p^H meter and Conductivity meter respectively.

WATER QUALITY INDEX (WQI) ANALYSIS

WQI is a scale used to estimate an overall quality of water based on the values of water quality parameters. It is a rating reflecting the composite influences of different water quality parameters. WQI is calculated from the point of view of the suitability of ground water for human consumptions i.e., for drinking purpose. Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index Method. The quality rating scale for each parameter q_i was calculated by using the expression; $\mathbf{q_i = (C_i/S_i)}$.

A quality rating scale **(q_i)** for each parameter is assigned by dividing its concentration **(C_i)** in each water sample by its respective standards **(S_i)**. The normalized or relative weights **(ω_i)** were calculated from the assigned weightages **(w_i)** of different parameters.

i. $\omega_i = [\, W_i / \sum W_i \,]$

Weights for the parameters (pH, TDS, Ca^{2+}, Mg^{2+}, Na^+, K^+, $HCO3^{2-}$, $SO_4{}^{2-}$, Cl^- and NO_3 were adapted from previous studies and for the rest parameters (EC, TH, $CO_3{}^{2-}$, Fe and F) are assigned as per BIS 10500: 2012 for Drinking Water. The weights values range from one (1) to five (5) based on their importance for water quality assessment. Total dissolved solids, Electrical Conductivity, Fluoride and nitrate concentration are given the maximum weight of five (5) because these are important indicators for assessment of the overall water quality, while potassium is given the minimum weight of one (1) because it poses little risk to consumer health. Other chemical parameters are assigned a weight between one and five depending on their importance in determining the water quality. A factor of three (3) is assigned to pH because of the indication of alkalinity and effects on hardness and three (3) to sodium, chloride and sulfate because of their indication of salinity and effects on taste. Calcium, magnesium, Carbonates and bicarbonate are given a weight of two (2) because of their effects on hardness. The overall water quality index (**WQI**) score was calculated by aggregating the quality rating scale **(q_i)** with the relative weights **(ω_i)**.

$$WQI = \sum_{n=1}^{i} \mathbf{q_i \omega_i}$$

WQI=Water quality index Score; **q_i**=Quality rating scale; **ω_i**=relative weights of the i^{th} parameter.

Generally, WQI was discussed for a specific and intended use of water. In this study the WQI for drinking purpose is considered and the permissible WQI for the drinking purpose is taken as 100.

ii. **WQI = [$\sum q_i \omega_i$] X 100]**

RESULTS AND DISCUSSION:

Groundwater Quality Variation:

The pH of the water sample in the study area found in between 5.3 and 7.7. Except three (03) locations almost all samples found within the permissible limit (BIS 10500: 2012). Water with higher TDS was found only in Khandagiri area. No EC & TH were found in any sample both in pre & post-monsoon seasons. The concentration of chloride in most of the area is within the permissible limits except at Khandagiri area which is 261.85 mg/lit. Very little amount of Sodium, Carbonate, Bicarbonate, Sulphate, Nitrate and Fluoride were found to be present in the water samples, but none of them exceeds their respective permissible limits. Samples of Khandagiri & Old Town area were observed Potassium more than the permissible limit.

A higher concentration of Iron was found in the samples almost in all the locations except Khandagiri area. All the stations recorded much higher concentration (value) than the prescribed limit by WHO i.e, 0.3 mg/lit. Higher Iron concentration in the groundwater could result from the interaction between oxidized iron minerals and organic matters or distribution of FeCO3. This type of water is clear when drawn but soon becomes cloudy & then brown in color by precipitation of Fe (OH)3, which is a common problem in some parts of the study area. The other reasons of higher concentration of this element in the groundwater may be removal of dissolved oxygen by organic matters within the sediments leaching to reduced conditions. Under this condition the suitability of iron bearing minerals increases leading to enrichment of the dissolved iron in the groundwater. Presence of clay layers above the aquifers of the study area promotes the development of reducing environment and therefore higher levels of the element in the groundwater. Enrichment of Iron (Fe) in all the seasons indicates the biological cycle and consequent leaching from the topsoil to the groundwater

WATERQUALITY INDEX (WQI):

The computed values of overall WQI of the study area was found to be 79.97 and falls under "Good Quality" category as per Standard water quality classification scheme based on WQI value . Higher value of WQI observed at Khandagiri area is as a result of higher concentration of Iron, TDS, Chloride, EC, and Potassium. 44.45 percent of the water samples found to be "Excellent" for drinking purpose, 22.22 percent of the water samples were falls under "Good" quality category and 33.33 percent falls under "Poor" quality. None of the samples were found to be "Very Poor" or "Unsuitable for drinking purpose" category. Overall, the water of the smart city region of Bhubaneswar (BMC) is found to be suitable for drinking.

CORRELATION FACTOR ANALYSIS:

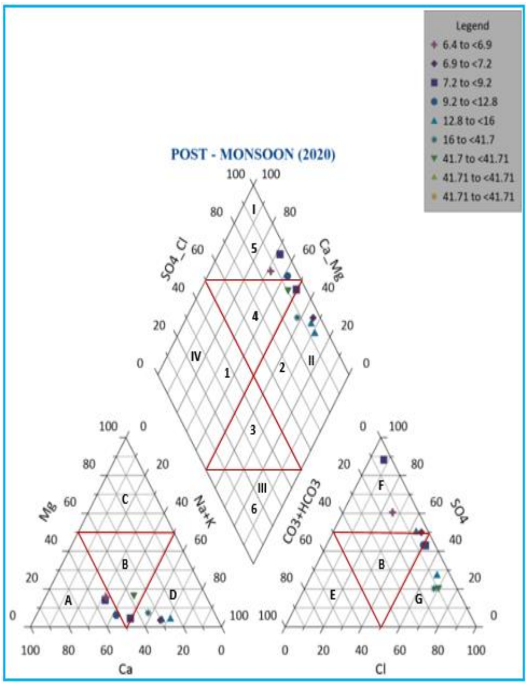
In addition to WQI, factor analysis (FA) of the studied groundwater samples were performed in order to get an overall impression about assembling the samples in a multidimensional space defined by the analyzed parameters. This has emerged as a useful tool for better understanding of the relationship among the variables that are mutually correlated within a data body.

From the analysis it was found that TDS & TH are highly correlated with EC positively. It was also observed that the chloride is positively correlated with EC & TDS. Negative correlation was found between Iron and Fluoride. High EC found in samples of Khandagiri area was due to high concentrations of TDS, TH, and Chlorides present in groundwater of the study area.

WATER QUALITY ANALYSIS BY HILL-PIPER DIAGRAM:

The concentration of 8 major ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, CO_3^{2-}, HCO_3^- and SO_4^{2-}) are represented on the Piper trilinear diagram by grouping the (K^+ with Na^+) and the (CO^{2-} with HCO^-), thus reducing the number of parameters for plotting to 6. On the piper diagram, the relative concentration of the cations and anions are plotted in the lower triangles, and the resulting two points are extended into the central field to represent the total ion concentration.

The Piper Trilinear Diagrams (Piper, 953) for ground water samples (both pre-monsoon & post-monsoon) are presented in fig: - 02 and 03 respectively, which clearly explains the variations of cations & anion concentrations in the ground water of the study area.



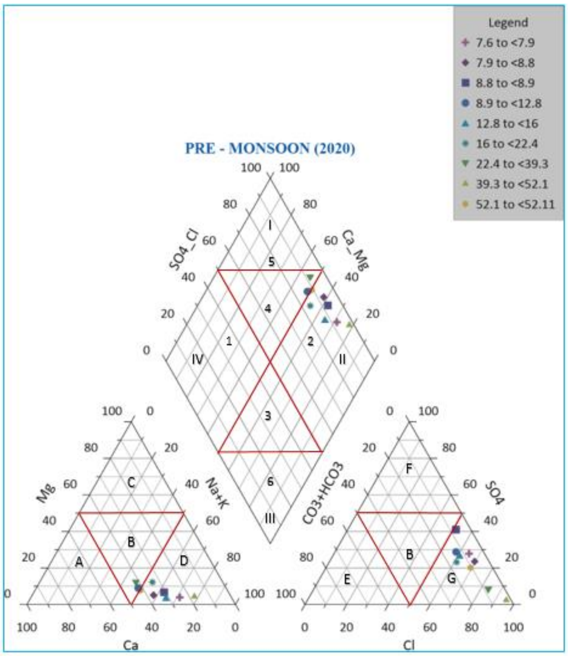


Fig 02: Hill-Piper Diagram (Pre–Monsoon) Fig-03: Hill-Piper Diagram (Post–Monsoon)

A: Clcium Type, B : No Dominant, C : Magnesium Type, D : Sodium &Potassium Type, E: Bicarbonate Type, F :Sulphate Type, G : Chloride Type. I : Ca^{2+} - Mg^{2+} - Cl^{-} - SO_4^{2-} ,

II : Na^{+} - K^{+} - Cl^{-} - SO_4^{2-} , III : Na^{+} - K^{+} - HCO_3^{-}IV : Ca^{2+} - Mg^{2+} -HCO_3^{-} $CaHCO_3$, 2. $NaCl^{-}$,3. Mixed $CaNaHCO_3$,4. Mixed CaMgCl, 5. CaCl, 6. $NaHCO_3$

The diamond shaped field of the piper diagram is further divided into four (04) classes namely, Ca^{2+} - Mg^{2+} - Cl^{-} - SO_4^{2-} , Na^{+} - K^{+} - Cl^{-} - SO_4^{2-}, Na^{+} - K^{+} - HCO_3^{-} , Ca^{2+} - Mg^{2+} - HCO_3^{-}. In the study area majority of the samples falls under Na^{+} - K^{+} - Cl^{-} - SO_4^{2-}(II) type in pre-monsoon period, but for post-monsoon period almost half (50%) of samples is Ca^{2+} - Mg^{2+} - Cl^{-} - SO_4^{2-} (I) type & rest of the samples falls under Na^{+} - K^{+} - Cl^{-} - SO_4^{2-}(II) type.

CONCLUSION:

Water samples collected from different locations of the Smart City Region of Bhubaneswar for the year 2020 (both Pre- Monsoon & Post-Monsoon) indicate almost all physic-chemical parameters except Iron (Fe) are below WHO & BIS water quality standards for drinking purpose.Water at few locations was found to be acidic. Only at Khandagiri area (L1) EC, TDS, Potassium, and Chloride were observed exceeding the permissible limits, but in rest of locations of the study area almost all parameters are well below the respective permissible limits (Except Iron). Human body requires iron but higher concentration of iron in ground water could impart taste, discoloration, deposits and turbidity.The WQI of the study area is found to be 79.97, which indicates the overall groundwater quality of Bhubaneswar City is good for drinking purpose. Higher values of WQI in some locations are resulting from the higher concentration of Iron, TDS, Chlorides, EC, and Potassium. Hiller-Piper diagram suggests that majority of the samples falls under Na^+ - K^+ - Cl^- - SO_4^{2-} type in pre-monsoon period, `but for post-monsoon period almost half (50%) of samples is Ca^{2+} - Mg^{2+} - Cl^- - SO_4^{2-} type & rest of the samples falls under Na^+ - K^+ - Cl^- - SO_4^{2-} type.From the analysis it was also found that, TDS, TH, Chlorides, and EC were highly & positively correlated with each other. Higher value of EC is due to high values of TDS, TH, and Chlorides in the groundwater. Iron was found to be negatively correlated with Fluoride. The overall quality of the groundwater of the smart city Bhubaneswar is found to be “Good” for drinking purpose.

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