Assessment of Groundwater Quality for Drinking and Irrigation Purpose: A Review

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ABSTRACT: ***With the increase of development and other activities the problems related to the quality of water is also increasing. Among all the available water resources, groundwater is an essential and vital component of any life support system in a country like INDIA. It is not only the basic need for human existence but also a vital input for all development activities. Therefore, it becomes necessary to assess the groundwater. The quality of water is determined by its physical, chemical and biological characteristics. This paper aims to assess the groundwater for drinking and irrigation purpose through various physico-chemical parameters and calculating Water Quality Index (WQI). An Indian standard (IS: 10500-2012 and IS: 11624-1986) has given the specification for drinking and irrigation purpose from which some parameters are discussed in this paper.***

Keywords: *Groundwater, physico-chemical, Water Quality Index (WQI)*

I. INTRODUCTION

The safe, portable water is absolutely essential for healthy living. Fresh water makes up a very small fraction of all water on the planet. Surface and groundwater are two major sources of fresh water available easily. Surface water is the water that is available above the ground and it is naturally replenished by precipitation. Surface water includes the water, which is available in form of rivers, lakes, ponds, streams, etc., whereas groundwater is the water which is available beneath the surface of the earth. The water that seeps below the surface of the earth is stored or holds in the cracks and spaces that are formed in soil and rocks. Of the total available freshwater estimated to be present on the earth, about 22 % exists as groundwater, which constitutes about 97 % of all liquid freshwater potentially available for human use (Foster 1998). In the developing country like India the importance of ground water increases where the surface water is not sufficient to fulfil the needs of all. The various activities in India like, irrigation, washing clothes/cars/floors, bathing, drinking, gardening, etc. are performed by the use of the ground water in urban as well as in rural areas, among which irrigation activities use ground water widely. The characteristic of water changes through region to region mainly based on geology and climate. There may also be change in the water characteristics on a local level depending on whether the source is from surface water bodies (rivers and ponds) or from groundwater aquifers with varying geology, and whether the water has been chemically treated. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (M.S. Islam et. al, 2009). Quality of water can also vary, depending on the type and quantity of dissolved salts. The excess amount of salts present in the water used for irrigation can be hazardous to the crops. Salts are originated from dissolution or weathering of rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These substances are carried with the water to wherever it is used (UCCC, 1974; Tanji, 1990). The main objective is to assess the groundwater for drinking and irrigation purpose through various physico-chemical parameters and calculating Water Quality Index (WQI). An Indian standard (IS: 10500-2012 and IS: 11624-1986) has given the specification for drinking and irrigation purpose from which some parameters are discussed in this paper.

II. LITERATURE REVIEW

Janardhana Raju (2007) have been studied the management of water resources, quality of water is just as important as its quantity. In order to know the quality and/or suitability of groundwater for domestic and irrigation in upper Gunjanaeru River basin, 51 water samples in post-monsoon and 46 in pre-monsoon seasons were collected and analyzed for various parameters. Geological units are alluvium, shale and quartzite. Based on the analytical results, chemical indices like percent sodium, sodium adsorption ratio, residual sodium carbonate, permeability index (PI) and chloroalkaline indices were calculated. The pre-monsoon waters have low sodium hazard as compared to post-monsoon season. Residual sodium carbonate values revealed that one sample is not suitable in both the seasons for irrigation purposes due the occurrence of alkaline white patches and low permeability of the soil. The overall quality of groundwater in post-monsoon season in all chemical constituents is on the higher side due to dissolution of surface pollutants during the infiltration and percolation of rainwater and at few places due to agricultural and domestic activities.

Shah Mayur C et.al. (2008) is studied that present communication deals with study of physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), calcium hardness (CaH), magnesium hardness (MgH), total hardness (TH), chloride (Cl^-), fluoride (F^-), sodium (Na^+), potassium (K^+), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and sulphate (SO_4^{2-}) of water samples of bore wells of forty villages of Gandhinagar taluka of Gujarat state, India. The experimental values of water samples were compared with standard values given by World Health Organization (WHO) and United State Salinity Laboratory for drinking and irrigation purposes respectively. Water Quality Index (WQI) was also calculated to know the overall quality of water samples. The statistical analysis like mean, standard deviation (SD), coefficient of variance (% CV), analysis of variance (ANOVA), t -test, coefficient of correlation (r) and regression analysis of obtained data were carried out. The results show that the quality of water is poor and quite good for drinking and irrigation purposes respectively. The variance was found significant at 1% level of significance in case of sodium and potassium content and at 5% in case of total alkalinity and dissolved oxygen among the four regions (North, South, East and West) of Gandhinagar. The linear relation also established for each pair of water quality parameters of studied water samples.

Omoleomo Olutoyin Omo-Irabor et.al. (2008) investigates the natural and anthropogenic processes that influence the chemistry of surface and groundwater within the western Niger Delta region using multivariate statistical techniques. A total of 137 surface and groundwater samples were collected between 2003 and 2007 during the rainy and dry seasons, from 15 sites and analysed for their physico-chemical constituents. The chemical data set generated were subjected to Principal Component Analysis (PCA)/Factor Analysis (FA) and Hierarchic Cluster Analysis (HCA). PCA is a procedure for reducing data redundancy, while FA establishes the general relationship among variables. CA is used to detect spatial similarity among sampling sites. The results indicate five dominant processes or factors for surface water that explained 77.11% of the variance in the data set. In groundwater, the factors account for 80.55% of the total variance. Cluster analysis revealed a random spatial distribution of the chemical components investigated. This is consistent with the multipurpose nature of land use in the study area. The multiple natural and anthropogenic sources indicated by this study, and their unsystematic distribution show that proper land use planning and firm implementation of existing environmental laws is imperative in this oil producing region, in order to have effective surface water and groundwater resource management.

Mishra Deepti et.al. (2009) In this paper ground water quality of Bhavnagar region was assess for determining its suitability for drinking purposes. Ground water samples, collected from 12 different locations of Bhavnagar region from various ground water sources for winter, summer and post monsoon seasons, were analyzed for physico-chemical parameters (pH, conductivity, turbidity, total dissolved solids, suspended solids, chloride, alkalinity, sulphate, hardness, nitrate, fluoride, sodium, potassium and heavy metals) using standard methods. It was found that pH of all samples was neutral to slight alkaline. Turbidity of all samples was within permissible limit. Total dissolved solids, total hardness, fluoride, chloride and chromium were beyond permissible limit in some samples.

Ramakrishnaiah C. R. et.al. (2009) has been aimed at assessing the water quality index (WQI) for the groundwater of Tumkur taluk. This has been determined by collecting groundwater samples and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following 12 parameters have been considered: pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, total dissolved solids, iron, manganese and fluorides. The WQI for these samples ranges from 89.21 to 660.56. The high value of WQI has been found to be mainly from the higher values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate and manganese in the groundwater. The results of analyses have been used to suggest models for predicting water quality. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

Prasanth Sarath et.al. (2012) The present hydro-geochemical study was confined to the coastal belt of Alappuzha district, which lies in the coastal lowland division of Kerala. Groundwater quality and its suitability for irrigation and domestic purpose were examined by various physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, and chloride. These parameters were used to assess the suitability of groundwater for domestic purpose by comparing with the WHO and Indian standards. TDS, sodium adsorption ratio (SAR), and permeability index were used for irrigation suitability assessment. The sample analysis reveals that the groundwater is not entirely fit for drinking with respect to pH, EC, Ca^{2+},Mg^{2+},Na^{2+}, and Cl^{-}. In some of the collected samples, the concentrations of these parameters exceed the permissible limits of WHO and ISI standards. Based on TDS and SAR almost all samples are suitable for irrigation purpose except a few locations, which show values beyond the permissible limits.

Singh et.al. (2016) has studied the water quality index (WQI) is an important parameter for determining the drinking water quality for the end users. The study for the same has been carried on the groundwater by collecting 47 groundwater samples from 25 blocks of Greater Noida city, India. In order to develop WQI the samples were subjected to a comprehensive physicochemical and biological analysis of 11 parameters such as pH, calcium, magnesium, chloride, nitrate, sulphate, total dissolved solids, fluorides, bicarbonate, sodium and potassium. Geographical information system has been used to map the sampling area. The WQI index for the same has been calculated and the values ranged from 53.69 to 267.85 which indicate the very poor quality water in the area dominated by industrial (Ministry of water resources), Roorkee (IIT Campus).

Chaurasia Abhishek Kumar et.al. (2018) In the present study, sixteen groundwater samples were collected from the southern portion of the Varanasi district, Uttar Pradesh, India, during the pre monsoon period of May, 2015. The twenty two water quality parameters have been considered for the calculation of water quality index viz. pH, electrical conductivity (EC), total hardness (TH), total dissolved solid (TDS), alkalinity, sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{2+}), magnesium (Mg^{2+}), nitrates (NO^{3+}), bicarbonate (HCO^{3-}), chlorides (Cl^{-}), sulphates ($SO4\ ^{-}$), fluorides (F^{-}), chromium (Cr), zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), nickel (Ni), lead (Pb) and cadmium (Cd). The Bureau of Indian Standard (BIS, 2012) has been considered to assess the suitability of groundwater for drinking purposes and for the calculation of WQI. Correlation study between various physicochemical properties also reveals significant negative relationships. The current study shows that ~20% area is falling under the non suitable for drinking water category and rest is falling under good, moderate, poor, very poor as per the WQI classification. The present study is helpful in proper planning and management of available water resource for drinking purpose.

III. ASSESSMENT OF WATER QUALITY

The quality required of a groundwater supply depends on its purpose of use. The parameters required for the analysis of groundwater for drinking and irrigation purpose mainly include as mention below:

3.1 pH

pH is used to specify how acidic or basic a water-based solution is. The pH scale ranges from 0 to 14. The solutions having lower pH represent an acidic and higher pH represents basic solutions. It is defined as the logarithmic of the reciprocal of the hydrogen ion.

3.2 Electric Conductivity (EC)

Electric conductivity measures the water's capability to pass electrical flow.

3.3 Total dissolved solids (TDS)

TDS is a measure of the solids that are dissolved in water. Conductivity is directly proportional to to the concentration of the dissolved ionized solids in the water.

3.4 Alkalinity:

Alkalinity of water is its acid-neutralizing capacity and is the sum of all titrable bases. The measured value may vary significantly with the endpoint pH used. Alkalinity is significantly used in the interpretation and control of water and wastewater treatment processes. Alkalinity is in excess of alkaline earth metal concentrations, and thus it is significant in determining the suitability of a water for irrigation. The measured values also may include contributions from borates, phosphates, silicates or other bases if these are present.

3.5 Total hardness

Hardness was used to measure the capacity of water to precipitate soap. Soap is precipitated chiefly by the calcium and magnesium ions present. Other polyvalent cations also may precipitate soap with organic constituents which are in complex forms. Total hardness is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in milligrams per liter. When hardness numerically is greater than the sum of carbonate and bicarbonate alkalinity, that amount of hardness equivalent to the total alkalinity is called "carbonate hardness" the amount of hardness in excess of this is called "noncarbonated hardness". When hardness numerically is greater than the sum of carbonate and bicarbonate alkalinity, all hardness is carbonate hardness and noncarbonated hardness is absent.

3.6 Chloride

Chloride is the one of the major inorganic anionic in water. The chloride concentration can add the salty taste to the water depending on the chemical composition of water. The high chloride content may harm metallic pipes and structures as well as growing plants.

3.7 Nitrate

Nitrate is the form of nitrogen and is the component of the nitrogen cycle. The higher concentration of nitrate can be found in groundwater and contribute to cause illness known as methamoglobinemia in infants. Also, nitrate is an essential nutrient for many autographs hence it can provide growth.

3.8 Fluoride

Fluoride can be present in water either naturally or by adding it. A fluoride having approximately 1.0 mg/L concentration in water is helpful in reducing dental problems without any harmful effects on health. But the higher concentration of fluoride, beyond the permissible limits can cause florosis and it need to be defloridated.

3.9 Sodium (Na)

Sodium in groundwater can be found due to saline intrusion, sewage effluent, mineral deposits, etc.

3.10 Potassium (K)

Potassium is essential element for humans but excess presence of potassium in water can dysfunction kidney or other diseases.

IV. WATER QUALITY INDEX (WQI)

The water quality index (WQI) is a mathematical instrument used to transform large quantities of water quality data into a single number which represents the water quality level (Saeedi Mohesn et.al. 2010). The WQI measures the scope, frequency, and amplitude of water quality exceeds and then combines the three measures into one score. In simple terms, Water Quality Index (WQI) measures the quality of drinking water supplied. Water Quality Indices are calculated in two steps:

1. First is analysis of raw data for selected water quality parameters, having dissimilar units of measurement and are converted into unit less sub index value.
2. Next is to calculate sub-indices and then the aggregation of sub-indices using some type of mathematical function to calculate a WQI value (Ponsadai Lakshmi et. al).

The Water quality index has been applied for evaluation of water quality in a particular area. There are many methods from which water quality can be determined. The many indices are often based on the varying number and types of water quality parameter as compared with respective standards of a particular region. Water quality indices are accredited to demonstrate annual cycles, spatial and temporal variations in water quality and trends in water quality even at low concentration in an efficient and timely manner. These indices have many variation and limitation based on number of water quality variables used and not accepted worldwide. Following are the methods for the evaluation of water quality index.

1. The National Sanitation Foundation Water Quality Index (NSFWQI)
2. Canadian Council of Ministers of the Environment Water Quality Index(CCME WQI)
3. Oregon Water Quality Index (OWQI)
4. Weighted Arithmetic Water Quality Index Method

III. CONCLUSION

1. The overall quality of groundwater in post-monsoon season in chemical constituents is on the higher side due to dissolution of surface pollutants during the infiltration and percolation of rainwater and at few places due to agricultural and domestic activities.
2. The result of the water quality status has proved that the geometric DWQI is optimistic which also reflects the real condition of water quality.

IV. REFERENCES

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