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Analysis of Ground Water Quality Parameters: A Review

Devendra Dohare[1], Shriram Deshpande[2] and Atul Kotiya[3]
[1]CE-AMD, S.G.S.I.T.S. College, Indore, INDIA
[2]S.G.S.I.T.S.College, Indore, INDIA
[3]Regional Lab, M.P.P.C.B., Indore, INDIA

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Abstract

Due to human and industrial activities the ground water is contaminated. This is the serious problem now a day. Thus the analysis of the water quality is very important to preserve and prefect the natural eco system. The assessment of the ground water quality was carried out in the different wards of Indore City. The present work is aimed at assessing the water quality index (WQI) for the ground water of Indore City and its industrial area .The ground water samples of all the selected stations from the wards were collected for a physiochemical analysis. For calculating present water quality status by statistical evaluation and water quality index, following 27 parameters have been considered Viz. pH, color, total dissolved solids. electrical conductivity, total alkalinity, total hardness, calcium, chromium, zinc, manganese, nickel. The obtained results are compared with Indian Standard Drinking Water specification IS: 10500-2012. The study of physico-chemical and biological characteristics of this ground water sample suggests that the evaluation of water quality parameters as well as water quality management practices should be carried out periodically to protect the water resources.

Keywords: Ground water, water quality standards, physico-chemical, Water Quality Index.

Introduction

Water is the most important in shaping the land and regulating the climate. It is one of the most important compounds that profoundly influence life[1].Groundwater is used for domestic and industrial water supply and also for irrigation purposes in all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. According to WHO organization, about 80% of all the diseases in human beings are caused by water[2]. Once the groundwater is contaminated, its quality cannot be restored back easily and to device ways and means to protect it. Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of groundwater. The greater part of the soluble constituents in ground water comes from soluble minerals in soils and sedimentary rocks. The more common soluble constituents include calcium, sodium, bicarbonate and sulphate ions. Another common constituent is chloride ion derived from intruded sea water, connate water, and evapotranspiration concentrating salts, and sewage wastes for example. Nitrate can be a natural constituent but high concentrations often suggest a source of pollution. Water quality standards are needed to determine whether ground water of a certain quality is suitable for its intended use. Guidelines for Drinking Water Quality have been published by IS: 10500-2012**.** For Drinking water, quality is commonly expressed by classes of relative Suitability, although most classification systems include units on specific conductance, sodium content and boron concentration.

Table-1
List of substances found naturally in some ground waters which can cause problems in operating wells

Substance	Types of problems
Iron(Fe^{+2},Fe^{+3})	Encrustation, staining of laundry and toilet fixtures
Manganese (Mn^{-2})	Encrustation, staining of laundry and toilet fixtures
Silica (SiO_2)	Encrustation
Chloride (Cl^-)	Portability, Corrosiveness
Fluoride (F^-)	Fluorosis
Nitrate (NO_3^-)	Methemoglobenemia
Sulphate (So_4^{-2})	Portability
Dissolved Gases	Corrosiveness
Dissolved Oxygen	Corrosiveness
Hydrogen Sulphide (H_2S)	Corrosiveness
Carbon dioxide (CO_2)	Corrosiveness
Radio Nuclides	Portability
Miner Constituents	Portability, Health aspects
Calcium and Magnesium (Ca^{2+}, Mg^{2+})	Encrustation

WQI is an important technique for demarcating groundwater quality and its suitability for drinking purpose. It is computed to reduce the large amount of water quality data to a mere numerical value that expresses the overall water quality at a certain location and time based on several water quality parameters. In this index

a mathematical equation used to transform large number of water quality data into a single number which is simple and easy to understandable for decision makers about quality and possible uses of any water body. It serves as the understanding of water quality for the possible uses by integrating complex data and generating a score that describes water quality status.

Literature Review

General: I referred various technical research papers on assessment of ground water quality for bore wells of different cities and countries, which are presented in Dissertation Phase-1. Reported work on assessment of ground water quality index is summarized below.

Shweta Tyagi, Bhavtosh Sharma, Prashant Singh, Rajendra Dobhal[3] carried out Water quality assessment in terms of Water Quality Index at Uttarakhand (India). The study states that Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. However, WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers. In spite of absence of a globally accepted composite index of water quality, some countries have used and are using aggregated water quality data in the development of water quality indices. Attempts have been made to review the WQI criteria for the appropriateness of drinking water sources. Besides, the present article also highlights and draws attention towards the development of a new and globally accepted "Water Quality Index" in a simplified format, which may be used at large and could represent the reliable picture of water quality. Initially, WQI selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries.

Manjesh Kumar and Ramesh Kumar[4] Carried out experimental work on Physico-Chemical Properties of Ground Water of U.P., (India). The study deals with evaluation of granite mines situated in jhansi (Goramachia) for their status about physicochemical contamination of ground water. Six different sites are selected for sample testing collected from mines and urban area. Three samples have been taken at various distances on the site. This location is 10Km above from Jhansi city. The physic-chemical parameters such as pH, D.O., E.C., T.D.S., alkalinity, turbidity, Ca (calcium) and Mg (magnesium) hardness, total hardness, NO_3 (nitrate), F (fluoride), Fe^{+3} (iron) and Cl^- (chloride) have been tested. It has been found that parameters are not in limit when compared with W.H.O. standards.

Shivasharanappa, Padaki Srinivas and Mallikarjun S Huggi[5] carried out research work on Bidar city (Karnataka) for their characteristics of ground water and Water quality index (W.Q.I.). This research work deals with revaluation of W.Q.I. for ground water for the residential and industrial area of bidar. In the city there are 35 wards, samples collected from all wards and tested for 17 parameters. The parameters are pH, total hardness, Ca (Calcium), Mg (magnesium), chloride (Cl), NO_3 (Nitrate), SO_4 (sulphate), T.D.S., Fe^{+3} (Iron), F (Fluoride), sodium (Na), potassium (K), alkalinity, manganese (Mn), D.O., total solids and Zinc (Zn). Tested results were used for suggest the models for water quality analysis.

J Sirajudeen, S Arul Manikandan and V Manivel (2013)[6] Carried out the work on ground water for evaluating the W.Q.I. Samples collected an Ampikapuram area near Uyyakondan channel Tiruchirappalli district. For Evolution of water quality index following parameters are examined: pH, E.C., T.D.S**.**, Total hardness, D.O., C.O.D., B.O.D., Cl^-, NO_3 and Mg .The WQI for these samples ranged between is 244 to 383.8.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.

Cristina Rosu, Ioana Pistea, Mihaela Calugar, Ildiko Martonos, A.Ozunu[7], carried out work on quality of ground water by W.Q.I. method in Tureni Village, Cluj County. The rural population from Romania is dealing even today with the absence of access to a sure drinking water source. Therefore in 2002 only 65% of the Romanian population had access to drinking water, distributed in 90% from the urban environment and 33% from the rural one. This work presents a case study referring to a 3 month (April-May-June 2011) monitoring of weekly samples of the quality of well water (10 samples) from Tureni village, Cluj County. A portable multi parameter model WTW 720 Germany was used to measure the pH, total dissolved solids (TDS), electrical conductivity (EC), temperature, oxidation-reduction potential and salinity of the collected water samples (these tests were done on site). In laboratory, using the photometric method (RQ Flex instrument, Merck) we determined: Ca2+, Mg2+, SO42-, Cl- and NO3-.

Dr. N.C. Gupta, Ms. Shikha Bisht and Mr. B.A. Patra[8] carried out Physico-Chemical analysis of drinking water quality from 32 locations in Delhi. Delhi is an old town, which has gradually grown into a popular city. It is one of the important business centers of India and thickly populated as well (Gupta et al). Since the last decade, drinking water problem has created havoc in the city. In this study, we collected 32 drinking water samples throughout Delhi. Different parameters were examined using Indian Standards to find out their suitability for drinking purposes. During this examination mainly the physic chemical parameters were taken into consideration.

G. Achuthan Nair et al[9] carried out ground water quality status by water quality index at North –East Libya The quality of groundwater was assessed to their suitability for drinking at six places of north-east Libya viz. El-Marj Albayda, Shahat, Susa, Ras al-Hilal and Derna, during November, 2003 to March, 2004, by determining their physicochemical parameters (17 parameters)

and water quality index (15 parameters). Peoples of Libya are aware for ground water quality and purity level and present study will be use full for maintaining the desired levels.

RAMKRISHNA Ch.[10] carried out studies on ground water status by water quality index at Visakhapattanam (India) Commensurate with the growth of industrial and allied activities in and around Visakhapatnam city; its area grew from 30 km2 in 1960 to over 80 km2 to date. The city's population according to 2001 census is about 1.33 million. Water supply has always been inadequate in this city with the crisis growing along with the cities progress. Today's water requirement is 360 million gallons per day. The existing Thatipudi, Gossthani, Meghadrigadda and Mudasarlova can hardly meet 50 % of the need. Rajwada water scheme can add a little more, therefore the supply capacity needs to be augmented. The only viable solution is to transport water from Godavari. Apart from the municipal supply the population also depends upon the ground water reservoirs.Groundwater quality of southern India is strongly dependent on bedrock geology and climate but may also be impacted in parts by pollution, particularly from agricultural and industrial sources.

Amaliya N.K. and Sugirtha P. Kumar[11] carried out ground water quality status by water quality index method at Kanyakumari (INDIA), that the Quality Index assessment method is used to monitor the pollution status of water samples by integrating the water quality variables. The aim of this work is to monitor the pollution level of ground water samples from different places of Kanyakumari district. For calculating the Quality Index the following18 water quality variables such as EC, TDS, DO, TH, pH, alkalinity, calcium, sodium, magnesium, sulphate, phosphate, potassium, chloride, fluoride, manganese and nitrate Have been considered. The different ground water samples of Kanyakumari district have quality index values ranging from8.45 to 162.3. In this present work the status of water quality is found to be good for consumption and other purposes except Kalkulam bore well water sample.

Rajankar P. N. et. al (2013)[12] carried out evaluation of tube well water quality using W.Q.I. in Wardha (India). Using W.Q.I. Some tehsile of district Wardha were evaluated. It is calculated by parameters, such as pH, turbidity, Temp., D.O., B.O.D. in the residential, commercial and agricultural area. Some Other physico-chemical parameters are E.C., Total hardness, calcium hardness (as $CaCO_3$), SO_4 (sulphate), chlorides (as Cl^-), Na^+ (sodium) and K^+ (potassium) etc. Final parameters are compared with B.I.S. (Bureau of Indian Standard).

K. Elangovan (2010)[13] carried out characteristics of tube well water for district Erode (India) states that ground water quality of 60 locations in Erode district during pre- monsoon and post-monsoon seasons. Ground water samples were tested for 11 physico-chemical parameters following the standard methods and procedures. World Health Organization (WHO) standards were adopted for calculation of water quality index (WQI) by using the methods proposed by Horton and modified by Tiwari and Mishra.

Neeraj D. Sharma, J.N. Patel carried out evaluation of ground water quality index of the Urban segments of Surat city (INDIA) states that the development of urban regions in developing country needs the multifaceted study of qualitative and quantitative stresses n available natural resources there within. Under this study the various seasonal ground water samples were collected for some consecutive years and the respective physico-chemical analysis was carried out for particularly five groundwater quality parameters pH, TDS, Chlorides, Hardness and Electrical Conductivity (EC) suggested and essentially responsible for groundwater quality degradation in the said area. The ground water quality Index for each sample location was determined by imparting the relative and proportionate weightage.

Sriniwas Kushtagi and Padaki Sriniwas(2011)[14] carried out studies on water quality index of Groundwater of Aland taluka, Gulbarga(INDIA)states that main aim of the current work is to evaluate the quality of well water for rural and urban population based on W.Q.I. results, groundwater characteristics and quality assessment .Ten villages of Aland taluka are selected and at each village water samples at three places were collected using standard procedural methods and analyzed for pH, TH, Ca, Mg, CL, TDS, Fe, F, NO_3,SO_4 . BIS-10500-1991 standards were adopted for calculation of water quality index.

Assessment of water quality

General: Due to increasing urbanization, surface water is getting over contaminated and more stringent treatments would be required to make surface water potable. Therefore, it is required to additional sources for fulfill the requirement of water. Because the ground water sources are safe and potable for drinking and other useful purposes of human being. Hence studies of physic-chemical characteristics of underground water to find out whether it is fit for drinking or some other beneficial uses.

Parameters to be analyzed: For the assessment of ground water quality of the bore well of the Indore city, Taking in view the following drinking water parameters are analyzed (1) pH (2)Turbidity (3) Total Dissolved Solids (4) Elec. Conductivity (5)Total hardness(6) Calcium(7) Magnesium,(8)Sulphate(9) Nitrate (10)M.P.N.(11) Total alkalinity (12)Chloride(13) Fluoride,(14)Boron(15) Phosphate (16) C.O.D.(17) Iron(18) Cadmium(19) Chromium(20) Nickel(21) Zinc(22)Manganese (23) Sodium and(24) Temperature.

Parameters included in water quality assessment: Monitoring of bore wells at Indore city requires many different parameters to be sampled. The parameters analyzed in this assessment include:

pH[15]: pH of solution is taken as –ive logarithm of H_2 ions for many practical practices. Value range of pH from 7 t0 14 is alkaline, from 0 to 7 is acidic and 7 is neutral. Mainly drinking water pH lies from 4.4 to 8.5. The pH scale commonly ranges from 0 to 14.

Turbidity[15]: Suspension of particles in water interfering with passage of light is called turbidity. Turbidity is caused by wide variety of Suspended particles. Turbidity can be measured either by its effect on the transmission of light which is termed as Turbiditymetry or by its effect on the scattering of light which is termed as Nephelometry. As per IS: 10500-2012 the acceptable and permissible limits are 1 and 5 NTU respectively.

T.D.S[15]: Difference of total solids and suspended solids is used to determine the filterable solids by the help of filtrate and following the procedure as above. In water sample it can also be estimated from conductivity measurement. The acceptable and permissible limits As per IS: 10500-2012 is 500 and 2000 mg/l respectively.

Elec.Conductivity[16]: Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions the solution contains. In contrast, the conductivity of distilled water is less than 1umhos/cm. This conductivity depends on the presence of ions their total concentration, mobility, valence and relative concentration and on the temperature of the liquid .Solutions of most inorganic acids, bases, and salts are relatively good conductors.

Total hardness[16]: As per IS: 10500-2012 Desirable limit and Permissible limit for hardness is lies between 200 to 600 mg/l respectively. The effect of hardness is Scale in utensils and hot water system in boilers etc. soap scum's Sources are Dissolved calcium and magnesium from soil and aquifer minerals containing limestone or dolomite. The Treatment of hard Water is Softener Ion Exchanger and Reverse Osmosis process. The degree of hardness of drinking water has been classified in terms of the equivalent $CaCO_3$ concentration as follows: Soft - 0-60mg/l, Medium - 60-120 mg/l, Hard - 120-180 mg/l, Very hard - >180 mg/l.

Sulphate: Natural water contains sulphate ions and most of these ions are also soluble in water. Many sulphate ions are produce by oxidation process of their ores, they also present in industrial wastes. The method to measure quantity of sulphate is by UV Spectrophotometer. As per IS: 10500-2012 Desirable limit for Sulphate is 200 and 400 mg/l in Permissible limit

Nitrate: Nitrate is present in raw water and mainly it is a form of N_2 compound (of its oxidizing state). Nitrate is produced from chemical and fertilizer factories, matters of animals, decline vegetables, domestic and industrial discharge. The method to measure quantity of nitrate is by UV Spectrophotometer. As per IS: 10500-2012 Desirable limit for nitrate is max.45 and no relaxation in permissible limit.

Total alkalinity[16]: Alkalinity is the sum total of components in the water that tend to elevate the pH to the alkaline side of neutrality. It is measured by titration with standardized acid to a pH value of 4.5 and is expressed commonly as milligrams per liter as calcium carbonate (mg/l as $CaCo_3$).Commonly occurring materials in water that increase alkalinity are carbonate, phosphates and hydroxides. Limestone bedrock and thick deposits of glacial till are good sources of carbonate buffering.

Chloride[16]: All type of natural and raw water contains chlorides. It comes from activities carried out in agricultural area, Industrial activities and from chloride stones. Its concentration is high because of human activities. As per IS: 10500-2012 Desirable limit for chloride is 250 and 1000 mg/l in Permissible limit.

Fluoride: Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals etc, in nature. Among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock minerals assemblage through which the ground water is circulating. As per IS: 10500-2012 Desirable limit for fluoride is 1 and 1.5 mg/l in Permissible limit.

Boron: Boron naturally occurs as boric acid and boric acid salts. It is released from rocks and soils through weathering, and subsequently ends up in water. It also gets added to soil and ground water through domestic landfills, when these are inadequately sealed .It serves as a typical indicator compound that indicates the presence of other hazardous substances. As per IS: 10500-2012 Desirable limit for Boron is .5 and 1 mg/l in Permissible limit.

Phosphate[17]: Phosphorus is an essential plant nutrient and most often controls aquatic plant growth in fresh water. Normally ground water contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate.

Chemical Oxygen Demand (COD)[17]: COD is a measure of the oxygen required for the chemical oxidation of organic matter with the help of strong chemical oxidant. High COD may cause oxygen depletion on account of decomposition of microbes to a level detrimental to aquatic life. COD determination has an advantage over BOD determination in that the result can be obtained in about 5 hours as compared to 5 days required for BOD test.

Zinc: Zinc is present approx 0.05 g/kg in the earth crust. Its main common mineral is sphalerite (ZnS) which is usually united with the other sulfide elements. Symptoms of zinc toxicity in human include vomiting, dehydration, electrolyte imbalance, abdominal pain. Acute renel failure caused by zinc chloride has been reported.

Table-2
Physical and chemical properties of tube well water as per IS 10500-2012[18]

S.No.	Parameter	Unit	Accept. Limit	Permi. Limit
1	Colour	Hazen Unit	5	15
2	Odour		Agreeable	Agreeable
3	pH		6.5-8.5	No relaxation
4	Turbidity	NTU	1	5
5	Total Dissolved Solids	mg/l	500	2000
6	Ammonia	mg/l	0.5	No relaxation
7	Boron	mg/l	0.5	1
8	Calcium	mg/l	75	200
9	Chloride	mg/l	250	1000
10	Fluoride	mg/l	1	1.5
11	Magnesium	mg/l	30	100
12	Nitrate	mg/l	45	No relaxation
15	Total Alkalinity	mg/l	200	600
16	Sulphate	mg/l	200	400
17	Total Hardness	mg/l	200	600
18	Temperature	^{o}C	-	
19	Sodium	mg/l	-	
21	Iron	mg/l	0.3	No relaxation
22	Cadmium	mg/l	0.003	No relaxation
23	Chromium	mg/l	0.05	No relaxation
24	Zinc	mg/l	5	15
25	Manganese	mg/l	0.1	0.3
26	Nickel	mg/l	0.02	No relaxation

Water Quality Index (WQI) [19]: There are two basically different types of Water Quality Index.
Additive Water Quality Index, in the form $WQI_a = \sum_i^n w_i q_i$
Multiplicative water quality index, in the form $WQI_m = \sum_{i=1}^n q_i^{w_i}$

Where, q_i = quality rating for the parameter $\sum_{i=1}^n w_i = 1$, w_i = weight to the i^{th} parameter, Such that, n = Number of parameters.

Canadian council has invented Canadian Water Quality Index (CWQI) which is based on W.Q.I. of british Columbia. Parameters used by CWQI are: temp, conductivity, color, turbidity, D.O., pH, alkalinity (total alkalinity), calcium (Ca). sodium (Na), magnesium (Mg), potassium (K) sulphate (SO_4^{2-}), chloride (Cl^-), fluoride (F^-), dissolved organic carbon (DOC), phosphorus (P), nitrate, nitrite (NO_3^-, NO_2^-), nitrogen (N), silicon dioxide (SiO_2), aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), lithium (Li), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), strontium (Sr), vanadium (V), zinc (Z).

Canadian Water Quality Index is based on three attributes of water quality that relate to water quality objectives: i.Scope -F_1, ii. Frequency-F_2, iii. Amplitude-F_3

$$CWQI = 100 - \left(\frac{F_1^2 + F_2^2 + F_3^2}{1.732} \right)$$

Quality index defines ranges for each CWQI: Bed (0–44), Marginal (45–64), Good (65–79), Very Good (80–94), Excellent (95–100)

Conclusion

Water quality is dependent on the type of the pollutant added and the nature of mineral found at particular zone of bore well. Monitoring of the water quality of ground water is done by collecting representative water samples and analysis of physico-chemical characteristics of water samples at different locations of Indore City. Estimation of water quality index through formulation of appropriate using method and evaluate the quality of tube well water by statistical analysis for post and pre monsoon seasons i.e. from nov. to feb. and march to may. Result of water quality assessment showed that most of the water quality parameters slightly higher in the wet season than

in the dry season[1]. Correlations the physico-chemical characteristics water pollutants by appropriate statistical method[20].

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