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Water Quality Index of Ground Water

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Abstract:
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.

I. INTRODUCTION

1.1 Fresh Groundwater

Freshwater is a vital resource for which there is no substitute. Most of the freshwater on Earth is locked in ice caps, but of the remaining available freshwater more than 90% is below ground. Compared to surface water bodies, groundwater is relatively protected from contamination by overlying soils and geologic sediments. Thus, groundwater resources are ideal for human consumption. India's human population is more than 1 billion with an annual growth rate of approximately 1.9% as per Census of India 2001. The people of India depend upon groundwater resources for survival. Yet, water tables are falling at an alarming pace across India, threatening the future of India's water supply with significant human and ecological impacts already evident. Groundwater is about 25% of the world resource of fresh water and widely used for various purposes. Only about 1% of all of fresh water is available from rivers, ponds, lakes. The quality of water depends upon various chemical constituents and their concentration generated by fertilizers, industrial waste, garbage or domestic waste. The groundwater analysis for physical and chemical properties is very important for Public Health Studies. These studies are also main part of pollution studies in the environment. The groundwater possesses various physical characteristics such as odour, taste and temperature etc. The natural quality of groundwater depends upon the physical environment, the origin, and the movement of water. As the water moves through the hydrological cycle, various chemical, physical and biological processes change its original quality through reactions with soil, rock and organic matter. Natural processes and human activities cause the changes in groundwater quality, directly or indirectly. According to WHO organization, about 80% of all the diseases in human beings are caused by water. It therefore becomes imperative to analyze the water for physiochemical parameters (pH, alkalinity, chloride, hardness, dissolved oxygen, sodium, potassium, fluoride, nitrite, phosphate, total dissolved solids, and electrical conductivity.) by standard methods and to device ways and means to make it safe for potable and other uses. Water quality is analyzed from the point of view of the suitability of groundwater for human consumption.

1.2 Ground Water Scenario in Hadapsar

1.2.1 Hydrogeology: The major part of the hadapsar region is underlain by the basaltic lava flows, which were formed by the intermittent fissure type eruptions during of upper Cretaceous to lower Eocene age. The Deccan Trap has succession of 19 major flows in the elevation range of 420 to 730 m above mean sea level (msl). These flows are 5 characterized by the prominent units of vesicular and massive Basalt. The major part of this region has Alluvium of Recent age which occurs across wide stretch along the course of deposited over the Traps.

1.2.2 Deccan Trap Basal

Deccan Traps occupy about 95% area of the district and it occurs as basaltic lava flows which are normally horizontally disposed over a wide stretch and give rise to table-land type of topography also known as plateau. These flows occur in layered sequence ranging in thickness from 15 to 50 m. Flows are represented by massive portion at bottom and vesicular portion at top and are separated from each other by marker bed known as bole bed. The thickness of weathering varies widely in the district form 5 to 25 mbgl. The weathered and fractured trap occurring in topographic lows form the main aquifer in the district. The ground water occurs under phreatic, semi-confined and confined conditions. Generally the shallower zones down to the depth of 20 mbgl form phreatic aquifer. The water bearing zones occurring between the depths of 20 and 40 m are weathered interflow or shear zones and yield water under semi confined conditions. Deeper semi-confined to confined aquifers occur below the depth of 40 m as the bore wells drilled have shown presence of fractured zones at deeper depths at places. The vesicular portion of different lava flows varies in thickness from 8 to 10 m and forms the potential aquifer zones. However the nature and density of vesicles, their distribution, inter-connection, depth of weathering and topography of the area are the decisive factors for occurrence and movement of ground water in vesicular units. The massive portion of basaltic flows are devoid of water, but when it is weathered, fractured, jointed or contain weaker zones ground water occurs in it. The yield of the dug wells ranges from 2 to 3655 lpm, whereas that of bore wells ranges from 500 lph to about 20000 lph .

1.2.3 Soft Rock Formations

Alluvium:
Alluvium occurs in small areas along banks and flood plains of major and its tributaries. In the Alluvium the coarse grained detritus material like sand and gravel usually occurring as lenses forms good aquifer. The ground water occurs in phreatic

aquifer under water table conditions in flood plain Alluvium deposits near the river banks. Confined conditions are also found wherever the thick clay deposits confine the ground water below it. From CGWB exploration in Alluvium it is observed that the thickness of Alluvium is less than 30 m and the aquifer thickness are limited to 3m. The yield of the dug wells ranges from about 1 to 53 lps, whereas in shallow tube wells it ranges from 0.08 to 7.14 lps

1.3 Ground water resources:
Central Ground Water Board and Ground Water Survey and Development Agency (GSDA) have jointly estimated the ground water resources of the district based on GEC-97 methodology. Ground Water Resources estimation was carried out for 15624.75 sq. km. area out of which 3681.34 sq. km. is under command and 11943.40 sq. km. is non command.

1.4 Adverse effect of impurities in excess of standards in ground water on human health:
pH: pH is a measure of the hydrogen ion concentration in water. The pH of water indicates whether the water is acid or alkaline. The measurement of pH ranges from 1 to 14 with a pH of 7 indicating a neutral condition (neither acid nor alkaline). Numbers lower than 7 indicate acidity; numbers higher than 7 indicate alkalinity. Drinking water with a pH between 6.5 and 8.5 is generally considered satisfactory. Acid waters tend to be corrosive to plumbing and faucets, particularly if the pH is below 6. Alkaline waters are less corrosive. Waters with a pH above 8.5 may tend to have a bitter or soda like taste. Water with a pH of 7.0 to 8.5 will require more chlorine for the destruction of pathogens (disease organisms) than water that is slightly acidic.

Conductivity:
Conductivity is a measure of the conductance of water to an electric current. Conductivity (or E.C.) is commonly reported as Ohms/cm This is an easy measurement to make and relates closely to the total dissolved solids content of water. The total dissolved solids are approximately 70 percent of the conductivity in Ohms/cm.

Total Dissolved Solids:
High concentrations of total dissolved solids (TDS) may cause adverse taste effects. Highly mineralized water may also deteriorate domestic plumbing and appliances. This does not mean water containing more than 500 mg/l TDS is unusable.

Total Hardness:
Hardness is the property which makes water form an insoluble curd with soap and is primarily due to the presence of calcium and magnesium. Waters that are very hard have no known adverse health effects and may be more palatable than soft waters. Hard water is primarily of concern because it requires more soap for effective cleaning, forms scum and curd, causes yellowing of fabrics, toughens vegetables cooked in the water and forms scales in boilers, water heaters, pipes and cooking utensils.

Chloride:
High concentrations of chloride ions may result in an objectionable salty taste to water and the corrosion of plumbing in the hot water system. High chloride waters may also produce a laxative effect. An upper limit of 250 mg/l has been set for the chloride ions, although at this limit few people will notice the taste. Higher concentrations do not appear to cause adverse health effects. .

Alkalinity:
Alkalinity is a measure of the capacity of water to neutralize acids. Water may have a low alkalinity rating but a relatively high pH or vice versa, so alkalinity alone is not of major importance as a measure of water quality. Alkalinity is not considered detrimental to humans but is generally associated with high pH values, hardness and excess dissolved solids. High alkalinity waters may also have a distinctly flat, unpleasant taste.

1.5 Necessity:
The major parts of the Hadapsar area are showing falling ground water level trends mainly in central, northern and eastern parts of the district. The ground water quality is also non-potable at many places as the concentrations of most of the parameters are above desirable limit. The ground water quality is also getting affected due to industrial pollution from sugar and allied industries like Distillery and Paper. The effluent generated from these sugar and allied industries and other industries are causing environmental problems because of its improper storage and disposal without adequate treatment. These areas primarily depends upon the ground water resources like dug wells, bore wells etc. for their various water needs. These areas are facing serious water scarcity in the summer season due to falling ground water table. Due to depleting ground water, the concentration of the various ions increases making the water unsuitable for drinking. Therefore it is imperative to assess the ground water quality status of these areas' ground water resources to frame the policy and management plan for the protecting it from the contamination and further deterioration of water quality. The correlation and regression analysis will help to develop the relationship amongst the various water quality parameters, which can used for developing the regression equation between the highly correlated parameters. These equations will provide the tool for prediction and forecasting the water quality in future without going through the lengthy analysis procedures.

1.2AIM:

- To calculate the water quality index of ground water

1.3 Objectives of the project work:

1. To assess the ground water quality status in Hadapsar area.
2. To carry out correlation and regression analysis of ground water quality parameters.
3. To develop the model for predicting the ground water quality in future.

2.1Materials used and Method of Analysis:
2.1.1 pH:
Apparatus: Digital pH meter.
Reagents:
Electrometric Method:
The pH is determined by measurement electromotive force of a cell comprising an indicator electrode (an electrode responsive to hydrogen ions such as glass electrode) immersed in test solution and a reference electrode (usually a mercury calomel electrode) contact between the test solution and reference electrode is usually achieved by means of liquid junction. This method is the most accurate method for determination of pH. The Colorimetric indicator methods can be used only if approximate pH value is required.

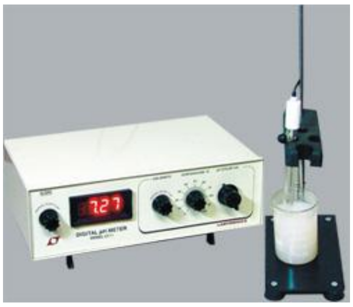


Figure.1. Digital pH Meter

2.1.2 Alkalinity:

Reagents:

1. 0.02N H_2SO_4 solution
2. Phenolphthalein indicator
3. Methyl Orange indicator

Principle:

The alkalinity is measured by titration of samples against standard H_2SO_4 in two stages**.** In the first stage titration is conducted until pH is lowered to 8.3 at which phenolphthalein indicator turns from pink to colorless. End point at pH 8.3 corresponds to the equivalent point for conversion of carbonate into bicarbonate ions. The second stage titration is conducted until the pH is lowered to 4.5.which corresponds to methyl orange indicator turning from yellow to orange red. At this point conversion of bicarbonates into carbonic acid takes place. When the pH is less than 8.3 a single titration is made using methyl orange as indicator. The amount of acid required neutralizing hydroxide: carbonate and bicarbonates represents the total alkalinity indicated by methyl orange end point.

Calculation: Alkalinity of sample in mg/lit =

$$\frac{mlofH2SO4 \times 0.02 \times 50 \times 1000}{mlofsample}$$

2.1.3 Chloride:

Reagents:

1. Standard Silver Nitrate solution(0.0141 N)
2. Standards Sodium Chloride solution(0.0141 N)
3. Potassium Chromate indicator(K_2CrO_4)

Principle:

When $AgNo_3$ is added to the sample, in which both chloride and chromate ions are present than Ag^+ reacts first with Cl^- ions and AgCl precipitate is formed. This is because of the fact that Ag^+ ions have more affinity with Cl^- ions as compared to CrO_4^{-2} ions. When Ag^+ ions have reacted with entire Cl^- ions present in the samples and reddish brown precipitate indicates the arrival of end point and volume of $AgNO_3$ required to precipitate all Cl^- ions is used for the determination of chloride concentration of the sample.

Ag^+ + Cl^- → AgCl

(White Precipitate)

When all Cl^- ions have been precipitate than

$2Ag^+$ + CrO_4^{-2} → $AgCrO_4$

(Reddish brown precipitate)

Calculation: Normality of $AgNO_3$ =

$$\frac{(NormalityofNaCl \times mlofNaCl)}{(mlofAgNO3 - B)}$$

Where B= ml of AgNO3 required for blank

Cl^- in mg/lit = $\dfrac{(A-B) \times 0.0141(N) \times 35.45 \times 1000}{mlofsample}$

2.1.4 Hardness:

Reagents:

1**.** Standards Ethylenediamine Tetra Acetic Acid (EDTA) 0.01 M
2. Erichrome Black T indicator
3. Ammonia buffer solution
4. Standard Calcium solution (0.01M)

Principle:

The dye known as Erichrome Black T serves as an excellent indicator to show when all the hardness causing cat ions have been complexed. When a small amount of Erichrome Black T having a blue colour is added to hard water with a pH of about 10.0.it combines with a few of Ca^{+2} and Mg^{+2} ions to form a weak complex ion, which is wine red in colour.

M^{+2} + E.B.T → [M-E.B.T]

[Divalent cat ions present

Indicator (Blue Colour)

Weak Wine Red complex in water samples]

During the titration with EDTA, all free hardness causing cat ions are complexed according to following equation:

M^{+2} + EDTA → M-EDTA.

Strong complex (stable)

When EDTA has reacted with all free available cat ions, than finally EDTA disputes the red (M-EBT) complex, because it is capable of forming a more stable complex with the hardness ions, this action treats the EBT indicator and the wine red color changes to a distinct blue color, indicating the end of titration. Blue color is formed due to release of EBT, which is blue in colour.

[M –EBT] + EDTA → [M-EDTA]+ EBT

Weak complex wine red colour strong complex Blue colour

Calculation:

C= Molarity of EDTA =

$$\frac{MolarityofCaCO_3 \times mlofCaCO_3}{(mlofEDTArequired - B)}$$

WhereB= ml of EDTA required for blank.

Total Hardness mg/lit as $CaCO_3$ =

$$\frac{(A-B) \times C \times 100 \times 1000}{mlofsample}$$

Where A=ml of EDTA used

2.1.5 D.O.:

Reagents:

1. Manganous sulphate
2. Alkali - iodide Azide solution
3. Concentrated sulphuric acid
4. Starch indicator
5. Sodium thiosulphate (0.025N) Na2S2O3
6. Potassium Dichromate solution (0.025N)

Principle:

When magnese sulphate solution is added to sample followed by strong alkali D.O. rapidly oxidizes an equivalent amount of the dispersed divanltmanganous ions which solution the oxidized manganese reverts back to divalent state with the libretion of iodine equivalent to the original D.O. contents. The iodine is then titrated with thiosulphate of iodine equivalent to the original D.O. contents. The iodine is then titrated with thiosulphate.

Calculation:

D.O. $= (A \times N \times B \times 1000)/(ml\ of\ sample\ taken)$

Where, A= ml of sodium thiosulphate

N= Normality of Sodium thiosulphate

2.1.6 Electrical conductivity and TDS:
Electrical conductivity is the ability of a solution to conduct an electrical current . It can be measured by TDS meter . TDS is total dissolved soliddefined as amount of solids dissolved in a solution. It is also measured by TDS meter . Electrode is immersed into the test sample n TDS meter gives the readings for TDS and Electrical conductivity.

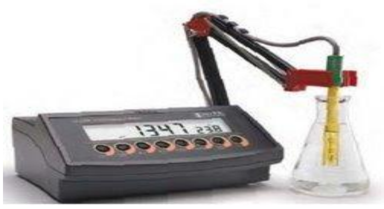


Figure.2. TDS meter

3.2. Water Quality Index
The National Sanitation Foundation developed (1970) the Water Quality Index (NSFWQI), a standardized method for comparing the water quality of various water bodies. The National Sanitation Foundation Water Quality Index (NSFWQI) is the most respected and utilized water quality index in the U.S.

Definition:
Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. Each of the groundwater samples were analyzed for various parameters such as pH, total hardness, calcium, magnesium, bicarbonate, chloride, TDS, fluoride, nitrate, iron, sulphate, manganese, turbidity, total alkalinity, sodium, potassium, electrical conductivity and carbonate.

3.2.1. Review of some important methods of determining WQI
After a detailed literature review and going through all of the different types of water quality indices, the ones which are most commonly used and perceived as important are discussed here in detail.

i. Canadian Council of Ministers of Environment (CCMEWQI)
CCMEWQI compares observations to a benchmark instead of normalizing observed values to subjective rating curves, where the benchmark may be a water quality standard or site specific background concentration [29][30][31]So, this acts as an advantage of the index which can be applied by the water agencies in different countries with little modification. To categorize water quality under this, four categories have been suggested i.e. Excellent, Good, Fair and Poor. Calculating index scores

- Find *F*1: the number of variables whose objectives are not met (scope)

F1= [No. of failed variables /Total no of variables]*100

- *Find F*2: the frequency by which the objectives are not met (frequency)

*F2= [No of failed tests/Total no of tests]*100*

- Find *F*3: the amount by which the objectives are not met (amplitude)

(a) excursion = [Failed test value/Objectives]-1

(b) nse = $\sum_{i=1}^{n} excuersion$ /No of tests

(c) F3= [nse/0.01nse+0.01]

CCMEWQI= [100- $\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}$]

ii. National Sanitation Foundation (NSFWQI)
Brown in 1972 developed a water quality index paying great rigor in selecting parameters, developing a common scale, and assigning weights for which elaborate Delphic exercises were performed. This effort was supported by the National Sanitation Foundation (NSF) and that is why also referred as NSFWQI. This work seems to be the most comprehensive and has been discussed in various papers[32]. Rating curves were developed by asking the experts to attribute values for variation in the level of water quality caused by different levels of each of the selected parameters. Having established the rating curves and associated weights, various methods of computing a water quality index are possible, like

1) Additive index= $\sum_{i=1}^{n} WiQi$

1) I= $\sum_{i=1}^{n} IiWi$

Where, Ii= Sub-index of each parameters, Wi= Weighting factor, n= Number of sub-indices.

iii. British Columbia (BCWQI)
British Columbia water quality index was developed by the Canadian Ministry of Environment in 1995 as increasing index to evaluate water quality. This index is similar to CCMEWQI where water quality parameters are measured and their violation is determined by comparison with a predefined limit. It provides possibility to make a classification on the basis of all existing measurement parameters.
To calculate final index value the following equation is used:

$$BCWQI = \frac{\sqrt{F1^2 + F2^2 + (F3/3)^2}}{1.453}$$

The number 1.453 was selected to give assurance to the scale index number from zero to 100. It is important to note that repeated samplings and increasing stations increase the accuracy of British Columbia index. Disadvantages of this method are that this index does not indicate the water quality trend until it deviates from the standard limit and due to usage of maximum percentage of deviation, it cannot determine the number of withdrawals above the maximum limit of standard.

iv. Oregon (OWQI)
OWQI expresses water quality by integrating measurements of eight water quality variables. It provided the ambient water quality of Oregon's streams for general recreational use and its application to other geographic regions or water body types should be approached with caution. Index developers have benefited from increasing understanding of stream functionality. The original OWQI was modelled after the NSFWQI [33] where the Delphi method was used for variable selection. Both indices used logarithmic transforms to convert water quality variable results into sub index values. Logarithmic transforms take advantage of the fact that a change in magnitude at lower levels of impairment has a greater impact than an equal change in magnitude at higher levels of impairment.

1. The original OWQI used a weighted arithmetic mean function.

$$\text{WQI} = \sum_{i=1}^{n} SIiWi$$

2. The NSF WQI (McClelland, 1974) used a weighted geometric mean function.

$$\text{WQI} = \prod_{i=1}^{n} SI^{wi}$$

The unweighted harmonic square mean formula, as a method to aggregate sub-index results, has been suggested as an improvement over both the weighted arithmetic mean geometric mean formula. This formula allows the most impaired variable to impart the greatest influence on the water quality index and acknowledges that different water quality variables will pose differing significance to overall water quality at different times and locations. The formula is given by:

$$\text{WQI}= \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{SIi^{2}}}}$$

v. Bhargava method

To develop this index, Bhargava (1985) identified 4 groups of parameters. Each group contained sets of one type of parameters. The first group included the concentrations of coliform organisms to represent the bacterial quality of drinking water. The second group included toxicants, heavy metals, etc. The third group included parameters that cause physical effects, such as odor, color, and turbidity. The fourth group included the inorganic and organic nontoxic substances such as chloride, sulfate, etc. The sub-indices were worked out and the simplified model for WQI for a beneficial use is given by:

$$\text{WQI} = \prod_{i=1}^{n} fi(Pi)^{1/n}$$

Where n is the number of variables considered more relevant to the use and fi(Pi) is the sensitivity function of the ith variable which includes the effect of weighting of the ith variable in the use. The index was applied to the raw water quality data at the upstream and downstream of river Yamuna at Delhi, India. [18]

Table.1. An overview of types of indices, their sub-indices, aggregation functions

Index	Sub indices Flaws	Aggregation function
CCME	Formula Harmonic	Square sum
British Columbia	Formula Harmonic	Square sum
NSF Implicit nonlinear Weighted sum Eclipsing Region	Implicit nonlinear	Weighted sum
Oregon	Nonlinear	Weighted product (arithmetic/ geometric) Unweightedarmonic Square Mean
Bhargava	Multiple types	Weighted product

2.2.2. Selection of method for calculating the WQI: After a thorough study of the above mentioned water quality indices, It has been concluded that NSF, Bhargava, Oregon and indices which uses the weighted arithmetic average and the modified weighted sum provided the best results for the indexation of the general water quality. Similarly, the weighted geometrical average has been widely used, especially where there is a great variability among samples. Different countries developed their own water quality indices, so finally, to recognize a unique water quality index for assessing surface water quality of any nation or area with a definitive solution is very difficult. Simplicity in the calculation forms the basis of the selection of NSF WQI method.

2.2.3. NSF WQI :

For computing WQI three steps are followed. In the first step each of the selected parameters has been assigned a weight (*wi*) according to its relative importance in the overall quality of water for drinking purpose. Factors which have higher permissible limits are less harmful because they can harm quality of river water when they are present in very high quantity. So weightage of factor has an inverse relationship with its permissible limits.

The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Magnesium which is given the minimum weight of 1 and magnesium by itself may not be harmful. In second step, the relative weight (*Wi*) is computed from the following equation:

$$Wi = \frac{wi}{\sum_{i=1}^{n} wi} \quad \text{……………………….(1)}$$

Where, *Wi* is the relative weight, *wi* is the weight of each parameter and n is the number of parameters. Calculated relative weight (*Wi*) values of each parameter are also given in Table 1. In the third step, a quality rating scale (*qi*) for each parameter is assigned by dividing its concentration in each water sample by its relative standard according to its guideline laid down by BIS and result multiplied by 100:

$$qi = \frac{Ci}{Si} \times 100 \text{…………………….. (2)}$$

Where *qi*is the quality rating, *Ci* is the concentration of each chemical parameter in each water sample in mg/L, and *Si* is the Indian drinking water Standard for each chemical parameter in mg/L, according to the guidelines of the BIS. For computing the WQI, the *SI* is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation

$$SIi = Wi \times qi \text{ ……………………………….. (3)}$$

$$WQI = \sum_{n} SIi \text{ ………………………………..(4)}$$

SI index is the sub index of i^{th} parameter; qi is the rating based on concentration of i^{th}parameter and n is the number of parameters. The computed WQI values are classified into five types, “excellent water” to “water, unsuitable for drinking” is given in **Table 6**

Table.2. Water Quality Classification based on WQI Values

WQI values	Water Quality
< 50	Excellent
50-100	Good water
100-200	Poor water
200-300	Very poor water
>300	Water unsuitable for drinking

3.1. PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER QUALITY PARAMETERS:

Ground water samples were collected from Hadapsar. The results were found out for following parameters.

3.1.1. p^{H}:

The units for pH is the "Standard pH unit" (Std pH Units) and there is no health related guideline value for pH. However, for aesthetic reasons the range should be within pH 6.5 to pH 8.5. While extreme pH values (<4 and >11) may adversely affect health, there are insufficient data to set a health guideline value. It should be noted that rainwater is always acidic (pH varies between about pH 4.5 to pH 6.5) since moisture (H_2O) in the air absorbs carbon dioxide (CO_2) producing carbonic acid (H_2CO_3). The best way to neutralise the acidity in the water is to suspend a bag of limestone (or marble – calcium carbonate$CaCO_3$) in the centre of the rainwater tank or simply add lime - calcium hydroxide $Ca(OH)_2$. Concrete rainwater tanks will neutralise the acidity in rainwater naturally because concrete is essentially alkaline. Some pH characteristics are as follows:

i) pH< 6.5 may be corrosive

ii) pH = 8 progressively decreases efficiency of chlorination

iii)pH> 8.5 may cause scale and taste problems

It is clear from the table 5.1. that the pH value of water samples were varying from 6.8 to 8.2 and these values are within the limits prescribed by ISI, ICMR and WHO.

3.1.2. Alkalinity:

Alkalinity is a measure of water's ability to neutralize acids, and so is related to pH. It results primarily from carbonate minerals, such as those found in limestone, dissolving in the aquifer. Alkalinity and total hardness are usually nearly equal in concentration when both are reported in mg/L CaCO3 (calcium carbonate), because they come from the same minerals. If alkalinity is much higher than total hardness in an unsoftened sample, consider testing for sodium. If alkalinity is much lower than total hardness, test for chloride, nitrate and sulphate. The lower the alkalinity, the more likely water is to be corrosive. Water with high alkalinity may contribute to scale (lime) build up in plumbing. The acceptable limit at presence of alkalinity like hydroxides, carbonates and bicarbonates should be between 200 to 600 mg/l .The alkalinity values were found between 138 to 414 mg/l.

3.1.3. Chloride:

The desirable value of Chloride content is 250 mg/l .Above taken samples were found concentration of chloride vary from 52-343 mg/l .Obtained range which is slightly higher than permissible limits.

3.1.4. Total Hardness:

Hardness in water is caused by the presence of high levels of calcium (Ca++) and magnesium (Mg++) ions. These ions combine with carbonate (CO3−) dissolved in water to produce scale which is composed of insoluble carbonates (CaCO3 and MgCO3). The scale builds up on plumbing parts, eventually causing blockages to water flow. There is no health related guideline value for total hardness. To minimise undesirable build-up of scale in hot water systems total hardness in drinking water should not exceed 200mg/L as calcium carbonate (CaCO3). Recommendations for hardness are as follows:

i)<150 (mg CaCO3/L) acceptable

ii)200 (mg CaCO3/L) aesthetic guideline NHMRC

iii)>150 <350 (mg CaCO3/L) softening is recommended for laundry dilutions

iv)>350 (mg CaCO3/L) softening is considered necessary for laundry and ablutions

For potable water the TH should be limited upto 300 mg/l & maximum permissible value is 600 mg/l. table 5.1. indicates 364 to 3103 mg/l which has indicated higher values in groundwater.

3.1.5. Dissolved Oxygen:

It is up to 4 mg/l for Survival of aquatic life, From Table 5.1. Samples were found D.O 5 to 6.5mg/l.

4.1.6.Total Dissolved Solids:

The total dissolved solids include silica plus cations plus anions but exclude bicarbonate because bicarbonate is lost when the dissolved material is dried. TDS is calculated as follows:

TDS = SiO_2 (mg/L) + Cations (mg/L) + Anions (mg/L) – (0.5083 x HCO3)

There is an empirical relationship between TDS and the Conductivity known as the I/C ratio. "I" represents total dissolved solids minus silica in mg/L (I = TDS mg/L – Silica mg/L) and "C" is the conductivity in µS/cm.

I/C is calculated as follows and generally ranges in value from about 0.4 to 0.7 (average usually 0.5):

I = (TDS – Silica) mg/L ≈ 0.5

C= Conductivity (µS/cm)

There is no health related guideline value for total dissolved solids. However, for aesthetic reasons (taste) the concentration of total dissolved solids in drinking water should not exceed 500 mg/L. Up to 1000mg/L may be acceptable depending on taste. TDS indicates the salinity behavior of groundwater .TDS of groundwater is mainly due to vegetable decay, evaporation, disposal of effluent and chemical weathering of rocks. In the present investigation the TDS level was found upto 329 to 3558 mg/l (table no. 5.1) which is very higher values than permissible limit. As per Standard greater than 600 mg/l unacceptable for drinking purpose.

3.1.7. Electrical Conductivity:

There is no ADWG value for conductivity. Conductivity is related to the concentrations of ions capable of carrying an electrical current. It is an estimation of the total dissolved solids or salinity in water. Levels upto 800 µS/cm are acceptable in drinking water. Rain water has a conductivity of between 10µS/cm and 20µS/cm while sea water is around 50,000µS/cm.The conductivity of bore waters can vary widely from good quality (<200µS/cm) to very saline (>50,000µ S/cm). In the present investigation the TDS level was found upto 393 S/cm to 1890 S/cm (table no.5.1) it is near to salinity.

3.2. Water Quality Index:

As per the procedure recommended by the NSF for computing WQI, weight assigned and relative weight of all selected parameters are as shown in the following table**.** By following step by step procedure WQI for selected sampling site are computed. Water quality status has been decided by referring the classification chart. Ground water quality statuses at various locations of selected sites are tabulated in the table 5.3.

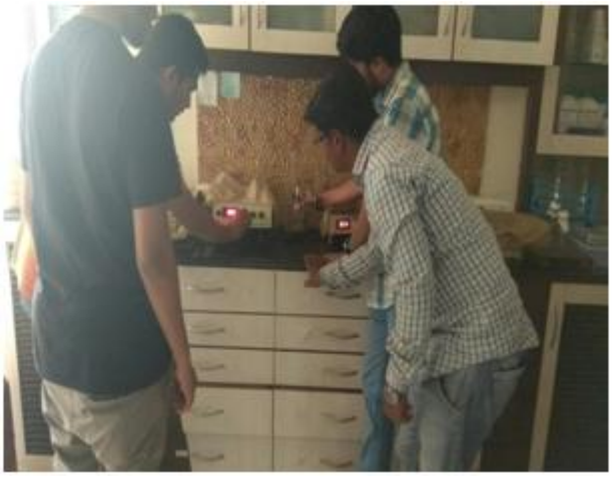
Table No.3. Water Quality Classification based on WQI Values.

Sample no.	Village Name	Location of Samples	WQI of Samples	Water Quality
N_1	Hadapsar	Kumar pebble park	116.601	Poor
N_2	Hadapsar	JSPM Canteen	105.76	Poor
N_3	Hadapsar	Shriram super market	117.604	Poor
E_1	Hadapsar	Sanketvihar	138.423	Poor
E_2	Hadapsar	UruliDevachi	121.53	Poor
E_3	Hadapsar	Bhairavnathnagar	88.06	Good
W_1	Hadapsar	TarawadeWasti	125.79	Poor
W_2	Hadapsar	Wadkar mala	100.17	Poor
W_3	Hadapsar	Vedantvihar	107.87	Poor
S_1	Hadapsar	Navlenagar	80.126	Good
S_2	Hadapsar	Handewadi	178.64	Poor
S_3	Hadapsar	Holkarwadiphata	150.736	Poor

In this study areas, the computed WQI values ranges from 80.126 to 250.08 and therefore can be categorize into five types “excellent water” to “water unsuitable for drinking”. Referring to the table 5.4, the percentage of water samples that under different quality at hadapsar area. About 6.25% of sources fall under very poor category, while 81.25% of sources are under poor category. The high value of WQI at these stations has been found to be mainly from the higher values of hardness in groundwater.

Table.4. Water Quality Classification based on WQI values at hadapsar area

WQI values	Water quality	Percentage of water samples
< 50	Excellent	00
50-100	good water	12.5
100-200	poor water	81.25
200-300	very poor water	6.25
300	water unsuitable for drinking	00



4. SUMMARY:

1. Neem, MoringaOleifera, Vettiver, Nirmali, Luffacylindrica and orange peel are the best herbs for removal of hardness and TDS from water.
2. Plant materials such as Indian gooseberry bark (Phyllanthusemblica), lemon peel (Citrus limon), peanut husk (Arachishypogaea) and vetiver root (Vetiveriazizanoides) proved their effectiveness in reducing the TDS from water.

These indigenous plants are emerging as a low cost effective water treatment option

For rural communities, because of their availability and their ease in application.

5.1 CONCLUSION

Settlement of Hadapsar is near Ssnjaivani Factory. Water in wells, bore wells is completely dry for eight months i.e. pre monsoon period during these period Groundwater level depth gets depleted so following parameters and their concentration of Hardness, Electrical Conductivity and Total dissolved solids increased beyond its permissible limits. Though, analyses were conducted in summer season and Rainy season and most of the sampling stations shown the higher values of the tested parameters. Results of samples collected in pre monsoon and post monsoon were obtained that Ground water quality shown by the Hadapsar were poor categories for drinking purposes. Over all TH,TDS,EC and Chlorine content was beyond the permissible limits. The WQI for pre-monsoon for 16 samples ranges from 80.126 to 250.08 and therefore can be categorize into five types “excellent water” to “water unsuitable for drinking”. Referring to the table 10 , the percentage of water samples that falls under different quality at Hadapsar area. About 6.25% of sources falls under very poor category, while 81.25% of sources are under poor category. The high value of WQI at these stations has been found to be mainly from the higher values of hardness in groundwater. Sample no 6, 10 are good and 14 is very poor. The statistical regression analysis among different water quality parameters having significant correlation with each others, provides a mathematical model which can be effectively used for prediction and forecasting the realistic situation of ground water quality. Here, Correlation Coefficient among all the water quality parameters are calculated from obtained results and are used to develop the mathematical model. Regression Equation is effective for predict and forecast the water quality at particular location and also helpful to evaluate related parameters. The developed model during 2018-2019 from Hadapsar will help us to predict the Water Quality in future and also facilitates to frame the Ground Water Quality Management Plan. Moreover, by using

Low cost herbs treatment stated above can bring groundwater parameters like Total Dissolved Solids, Total Hardness, Chloride content, Electrical Conductivity within permissible limits which make water potable for small community area. Therefore, suitable cost-effective indigenous treatment technologies should be searched out and adopted to soften the hard water in the study area.

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