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Development of Water Quality Index(WQI) for Groundwater Covering the Parts of Padmanabhanagar, Bangalore Urban District

Sheetal D
Research Scholar
Department of Civil Engineering& CTM
Acharya Institute of Technology, Bangalore, Karnataka, India

Dr. N Balasubramanya
Professor & Dean
Department of Civil Engineering & CTM
Acharya Institute of Technology, Bangalore, Karnataka, India

Abstract

Water is a crucial constituent to sustain life on earth. For millions of rural and urban areas, the tube well water is the source for domestic use. According to one of the surveys, ground water accounts for the 50% of urban water requirement. The present study evaluates the ground water quality of the water samples collected from 15 bore wells in the study area which is situated in Rangappa Layout which is located in the Ittamadgu Village of Uttarahalli Hobli which falls in the Bangalore South taluk of the Bangalore Urban district. Water Quality Index is developed for all the samples considering various parameters like pH, Temperature, Total Suspended Solids, Turbidity, Total Dissolved Solids, Total Hardness, Electrical Conductivity, Sodium, Potassium, Ca, Mg, Cl, HCO3, CO3, NO3, F, SO4, PO4, Cr+6, Fe, Cu, Pb, Ni, Zn. The quality of water found is excellent and suitable for drinking purpose.
Keywords: Physico-Chemical Characteristics, Water Quality Index (WQI)

I. INTRODUCTION

Water is the most essential and one of the prime necessities of life. Every one of us knows how important and precious the water is. Whenever there is no water in our taps, we become helpless. Unplanned urban development has posed gigantic problems of environmental pollution. Due to this, water of natural bodies is getting polluted at an alarming rate. Quality of water is an important criterion for evaluating the suitability of water for irrigation and drinking. The study of underground contamination will be of immense help to researchers and environmental regulators to evolve and initiate mitigative measures. Long and sustained industrial activity in any given area can often lead to soil and ground water contamination. Improper waste disposal practices might contaminate the soils and gradually the entire ground water in the area, impairing ground water quality for many applications including drinking. The present investigation involves the analysis of water quality by developing Water Quality Index in relation to physico- chemical parameters.

II. STUDY AREA

In order to study the ground water development and the quality of the ground water, a sample study area (Fig. 1) the Rangappa Layout which is located in the Ittamadgu Village of Uttarahalli Hobli which falls in the Bangalore South taluk of the Bangalore Urban district has been chosen. It falls between Longitude 77° 32’ 53” & 77° 32’ 58” and Latitude 12° 55’ 28” & 12° 55’ 32”. The area is spread approximately less than square kilometer which houses residential flats. The people in the layout depend mainly on bore well for their day to day water need. It is a Rocky upland Plateau and predominant geology is Granitic Gneisses. The Bangalore south taluk is categorized as Over Exploited with stage of development 175 % as on March 2011.

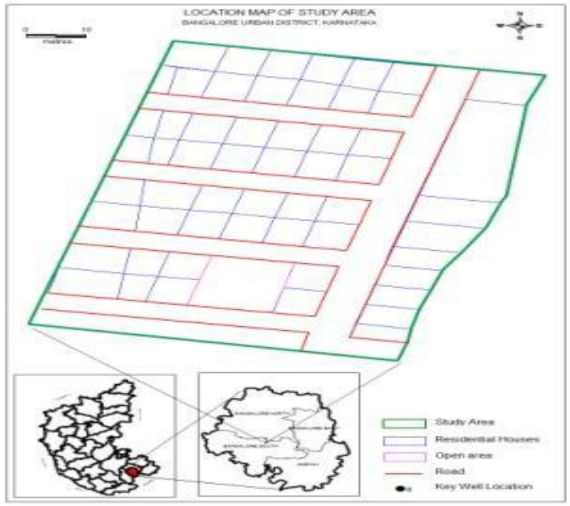

Fig. 1: Location of the Study Area

III. METHODOLOGY

Water samples are collected for basic parameter analysis from 15 Bore wells for the purpose of computing the Water Quality Index from the results of the water quality analysis.

A. Depth of Well:

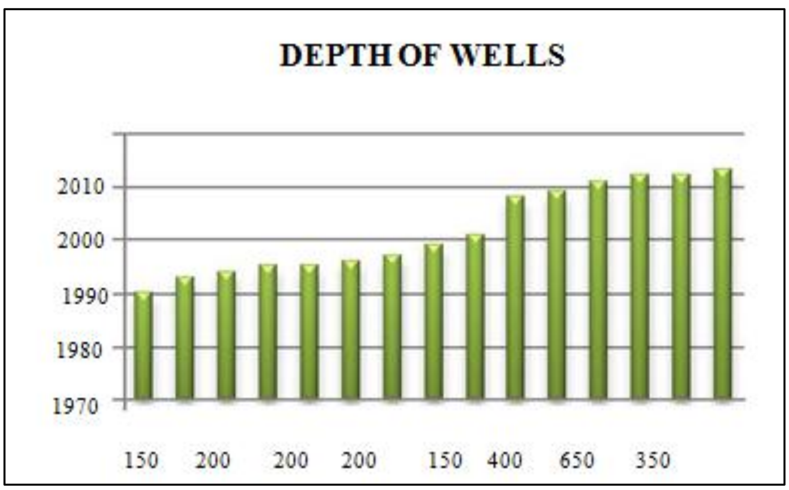

Fig. 2: Depth of Well

The above bar graph represents the depth of the wells drilled in the study area from 1990 – 2014 (Fig 2). The water availability in the ground has decreased which has resulted in increase in the depth of the wells. This indicates the decrease in the level of water table. In the recent past artificial recharge is introduced compulsory. It is expected artificial recharge scheme is enhances the level of water table in future scenario.

B. Water Quality Index (WQI):

Accurate and timely information on the quality of water is necessary to shape a sound public policy and to implement the water quality improvement programs efficiently. One of the most effective ways to communicate information on water quality trends are with indices. Water quality index (WQI) is commonly used for the detection and evaluation of water pollution and may be defined as "a rating, reflecting the composite influence of different quality parameters on the overall quality of water."

WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values. The factors include pH, Turbidity, TDS, Electrical Conductivity, Sodium, Potassium, Calcium, Magnesium, Total hardness, Chloride, Carbonate, Bi-carbonate, Fluoride, Nitrate, Phosphate, Sulphates, Iron and Zinc. The WQI takes the complex scientific information of these variables and synthesizes into a single number.

C. Interpreting WQI and Its Advantages:

The WQI synthesizes complex reality of multiple water quality parameters into a single value that can be appreciated and understood by common man. The single WQI number ranges between zero and 100. It expresses water quality where a lower number indicates better water quality.

IV. CALCULATION OF WQI

For the purpose of present investigation, eighteen water quality parameters have been selected. These eighteen parameters are pH, Turbidity, TDS, Electrical Conductivity, Sodium, Potassium, Calcium, Magnesium, Total hardness, Chloride, Carbonate, Bi-carbonate, Fluoride, Nitrate, Phosphate, Sulphates, Iron and Zinc.

Table – 1:

Water Quality Parameter	Standards	Unit Weights (W_i)
pH	6.5-8.5	0.219
Turbidity	5	0.2
TDS	500	0.002
Electrical Conductivity	750	0.00133
Sodium (Na)	200	0.005
Potassium (K)	30	0.03333
Calcium (Ca)	75	0.01333
Magnesium (Mg)	30	0.0333
Total hardness	300	0.00333
Chlorides (Cl)	250	0.004
Carbonate (CO_3)	100	0.01
Bi-Carbonate (HCO_3)	300	0.0033
Fluoride (F)	1	1
Nitrates (NO_3)	45	0.0222
Potassium (PO_4)	0.05	20
Sulphate (SO_4)	150	0.00667
Iron (Fe)	0.3	3.333
Zinc (Zn)	5	0.2

The quality rating q_i for the i_{th} water quality parameters (i = 1, 2, 3-------------12) was obtained from the relation

$$q_i = 100\ (v_i / S_i) \text{ --------------------(1)}$$

Where,

V_i = value of the ith parameter at a given sampling station

S_i = Standard permissible value of ith parameter.

This equation ensures that $q_i = 0$ when a pollutant (the i_{th} parameter) is absent in the water, while q_i = 100 if the value of this parameter is just equal to its permissible value for drinking water. Thus the larger the value of q_i the more polluted is the water with the ith pollutant.

However, quality ratings for pH require special handling. The permissible range of pH for the drinking water is 6.5 to 8.5. Therefore, the quality rating for Ph may be

$$= 100 \left[\left(- 6.5 \right) \quad \left(8.5 - 6.5 \right) \right] \quad q_{pH} \quad v_{pH} \text{ ------------ (2)}$$

Where v_{pH} = value of pH ~ 6.5, it means the numerical difference between v_{pH} and 6.5, ignoring algebraic sign. Equation (2) ensures the $q_{pH} = 0$ for pH = 6.5

The more harmful a given pollutant is, the smaller is its permissible value for drinking water. So the 'weights' for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters i.e, $ii\ S$

$W = k$ --------------------- (4)

Where W_i = unit weight for the ith parameter (i = 1, 2, 3 ----------------12),

k = constant of proportionality which is determined from the condition and k =1 for sake of simplicity.

Σ12

i 1

W_i = 1 -------------------- (5)

The unit weights W_i calculated from equation (4) and (5) are listed in Table 1.

To calculate the Water Quality Index, first the sub index $(SI)_i$ corresponding the ith parameter was calculated. These are given by the product of the quality rating q_i and the unit weight W_i of the ith parameter i.e.

$(SI)i = qiWi$ ---(6)

The overall Water Quality Index was then calculated by aggregating these sub-indices (SI) linearly. Thus Water Quality Index could be written as

$$WQI = [\sum_{i\,1} q_i W_i / \sum_{i\,1} W_i]$$

$$WQI = \sum_{i\,1}^{12} q\, i\, Wi \text{ ----------------------------- } (7)$$

This gives,

$$WQI = \Sigma_{i1}^{12}\, qiWi \text{ -- } (8)$$

Since $\Sigma W i = 1$.

Table – 2:
Water Quality of Index Data

Sl. No	*Depth of Well*	*WQI*
1	*200*	*18.95583*
2	*200*	*19.0235*
3	*400*	*19.65235*
4	*190*	*18.91689*
5	*150*	*19.9695*
6	*430*	*18.38386*
7	*150*	*18.94791*
8	*350*	*19.06847*
9	*170*	*19.428*
10	*600*	*18.8192*
11	*200*	*19.74086*
12	*650*	*19.07411*
13	*300*	*19.24603*
14	*200*	*3.112479*
15	*500*	*19.29751*

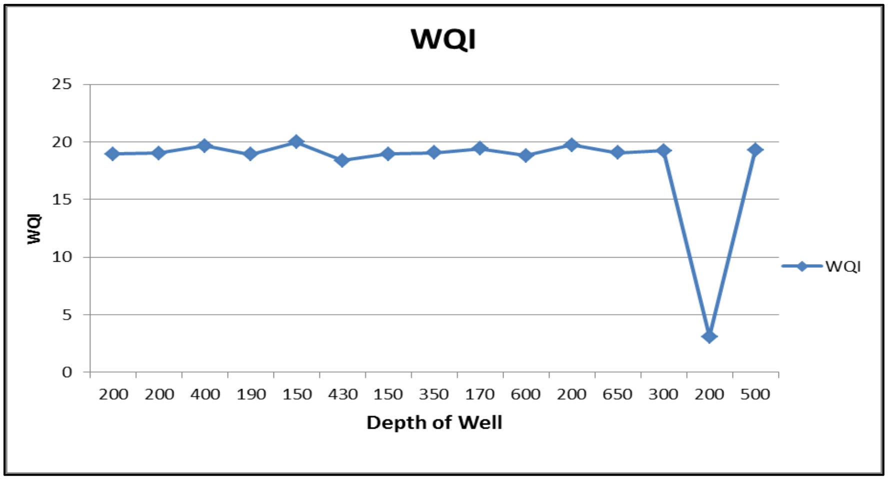

Fig. 3: Water Quality Index

The single WQI number ranges between zero and 100. It expresses water quality where a lower number indicates better water quality.

Table – 3
Classification of Quality of Water based on WQI

Excellent	*0 - 25*
Good	*26 - 50*
Poor	*51 – 75*
Very poor	*76 – 100*
Unsuitable for drinking	*100 and above*

V. Conclusion

The chemical analysis data of the 15 water samples collected was considered. The Water Quality Index (WQI) is calculated considering the parameters such as pH, Turbidity, TDS, Electrical Conductivity, Sodium, Potassium, Calcium, Magnesium, Total hardness, Chloride, Carbonate, Bi-carbonate, Fluoride, Nitrate, Phosphate, Sulphates, Iron and Zinc. The WQI of all the 15 samples are found to be well within the limit according to the ISI classification and is found to be Excellent for the purpose of drinking.

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