Assessment of Ground Water Quality of Pathardi Region of Nashik, Maharashtra, India

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Abstract: ***In the present study, assessment of suitability of ground water for domestic and agricultural purpose was carried out at Pathardi region of Nashik, Maharashtra, India. The study area covers 10 different locations of Pathardi region near the municipal composting project, Nashik city. The water samples were collected from 10 wells/bore wells during pre-monsoon period (May month). The quality of water depends on a large number of physical, chemical and biological factors. Hence, the parameters such as pH, EC, TDS, TH, HCO_3^-, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, NO_3, Fe, F, Turbidity, Total viable count ,Total coliforms and E.coli were analyzed. The results were compared with IS 10500 standards,2012 (BIS) and it was observed that the groundwater quality at the study site is impaired mainly due to TH, HCO_3^-, Ca^+, Mg^{2+}, Total coliforms and E.coli. This makes the ground water unsuitable for drinking purpose in these areas. Domestic activities, dumping of solid waste at the nearby composting site are the major sources causing pollution in these areas. However, it was found suitable for irrigation/agricultural purposes on the basis of sodium percent and sodium absorption ratio.***

Keywords: water quality, drinking purpose, sodium absorption ratio, hardness, electrical conductivity.

1. Introduction

Ground water is a precious natural resource. It constitutes about 30% of world's total fresh water. It is the major source of water for domestic, agricultural and industrial purposes in many countries. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world's population [1]. In recent years, the increasing threat to ground water quality due to human activities has become a matter of great concern. A vast majority of ground water quality problems present today are caused by contamination and by over-exploitation, or by combination of both.

Generally, the concentrations of dissolved ions in groundwater are governed by lithology, groundwater flow, nature of geochemical reactions, residence time, solubility of salts and human activities[2]. Moreover, the groundwater quality is mostly affected by either natural geochemical processes such as mineral weathering, dissolution/precipitation reactions, ion exchange or various manmade activities such as agriculture, sewage disposal, mining and industrial wastes, etc. The surface runoff from the agricultural field is one of the main sources for nutrients and salinity in the groundwater [3]. Agricultural contamination of groundwater usually results from routine applications of fertilizers on cropped fields and a process that accumulates the nutrients in groundwater.

Several researchers evaluated the suitability of groundwater for irrigation quality [4, 5, 6]. Total dissolved solids (TDS) values are also considered as an important parameter in determining the usage of water and groundwater. Water with high TDS values are not suitable for both irrigation and drinking purposes. Several research groups have discussed in detail on the potential health impact due to poor quality of water. In India and various parts of the world, numerous studies have been carried out to assess the geochemical characteristics of groundwater [7, 8, 9].

In recent decades, attention is being given to study the natural concentration of many ions and metals in groundwater in order to establish the anthropogenic and geogenic sources affecting groundwater quality as well as the reactions that take place within the aquifer. The objective of this study is to determine the groundwater quality of some parts of Nashik city and to delineate regions where groundwater is suitable or unsuitable for drinking and irrigation purpose.

2. Study Area

Nashik is an important and one of the famous ancient cities of Maharashtra. It is a district head quarter located on the banks of River Godavari at a distance of about 565 m above mean sea level. It lies between 19^0-33' and 20^0-53' North latitude and 73^0-16' and 75^0-6' East longitude with an area of 259.13 km^2.

The climate is dry except during south-west monsoon. The average rainfall is 1034 mm, July being the rainiest month. The hottest month is May having mean daily maximum temperature of 41^{o}C and coldest month being December with mean daily temperature of 10.2^{o}C *(Source: Report on Environmental Status of Nashik region, Maharashtra by MPCB).*Nashik district gets its water supply from wells, lakes, rivers and percolation tanks. The Darna, Gangapur, Chanakapur and Waghad lakes have been formed by constructing dams across rivers. The main source of water to Nashik city is Gangapur Dam. Ground water is used as secondary source of water and used to a maximum extent in summers as dam water supply gets depleted. The studied locations fall under Pathardi region near the municipal composting project of Nashik city.

3. Objectives

1. To investigate the ground water quality of Pathardi region, Nashik, Maharashtra, India.
2. Assessment of ground water quality for domestic and irrigation purposes.
3. Effect of composting project at Pathardi region on ground water quality.

4. Materials and Methods

Groundwater samples were collected from 10wells of Pathardi region (Fig. 1) in premonsoon (May) season. The locations which were used for drinking, household and agriculture purposes were identified and mentioned in Table1. The samples were stored in the air tight pre-cleaned bottles. Sterile bottles were used for Microbiological analysis. Collected samples were transported to laboratory within few hours. All the samples were analyzed based on standard methods [10, 11].

Electrical conductivity (EC) and Hydrogen ion concentration (pH) were measured using Chemito make (model 130) and EI make (model 112) instruments respectively. The pH meter was calibrated beforehand using 4.01, 7 and 10.01 buffer solutions and the EC meter was calibrated using 1413µmhos/cm conductivity solution. Groundwater samples collected were transported to the laboratory on the same day. Calcium (Ca^{2+}), magnesium (Mg^{2+}), bicarbonate (HCO_3^-) and chloride (Cl^-) were analyzed by volumetric titration methods, sodium (Na^+) and potassium (K^+) were measured using the flame photometer, sulphate (SO_4^{2-}), nitrate (NO_3^-)and fluoride (F^-) were determined using spectrophotometric technique as per the methods described by the American Public Health Association [10]. The accuracy of the results was checked by calculating the ionic balance errors and it was generally within ±5%.

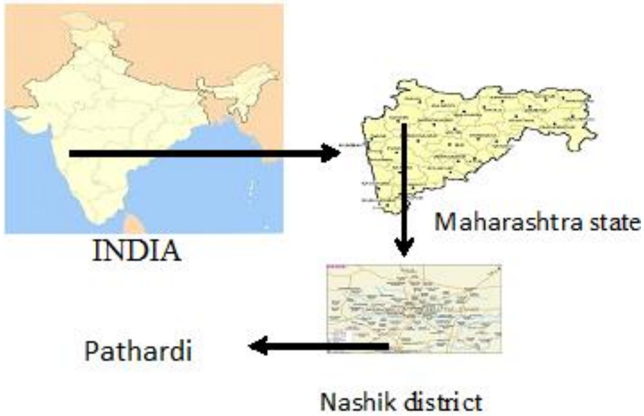

Figure 1: Location map of the study area

Table 1: Details of the studied locations

Location no.	Source	Latitude	Longitude	Use of Water
1.	Well	N19^{0}57.705'	E073^{0}44.079'	Agriculture
2.	Well	N19^{0}55.858'	E073^{0}44.466'	Agriculture
3.	Well	N19^{0}55.935'	E073^{0}44.495'	Agriculture
4.	Hand pump	N19^{0}55.662'	E073^{0}44.572'	Washing & Cleaning
5.	Well	N19^{0}55.733'	E073^{0}44.572'	Agriculture
6.	Well	N19^{0}55.676'	E073^{0}44.586'	Agriculture
7.	Well	N19^{0}55.748'	E073^{0}44.650'	Agriculture, Washing & Cleaning
8.	Well	N19^{0}55.564'	E073^{0}44.723'	Agriculture, Drinking, Washing & Cleaning
9.	Well	N19^{0}55.536'	E073^{0}44.807'	Agriculture
10.	Well	N19^{0}55.637'	E073^{0}44.315'	Agriculture

Table 2: Drinking water specifications of the study area in comparison with BIS 10500 Standards (minimum, maximum and mean ion concentration)

Parameter	pH	TDS mg/l	EC µmhos/cm	HCO^{3-} mg/l	Mg^{2+} mg/l	TH mg/l	Ca^{2+} mg/l	Na^+ mg/l	K^+ mg/l	NO_3 mg/l	Cl^- mg/l	F mg/l	SO_4^{2-} mg/l	PO_4^{3-} mg/l	TVC (35^{0}C, 48 h), (CFU/ ml)	Total Coliforms (MPN Index/ 100ml)	*E .coli* (MPN Index/ 100ml)
Min.	7.15	502	896	146	31.8	379	87	29.2	0.6	0.033	16.4	0.23	50	0.02	1.5 x 10^3	13	94
Max.	8.16	992	1716	874	115	990	207	84.8	5.1	16.1	37.2	0.78	83.4	0.1	7 x 10^5	1600	540
Average	7.67	714	1240	407	77.9	617	119	49.11	1.62	4.2	26.4	0.444	61.69	0.06	-	779	334
Water Quality Standard (max. permissible limit)	6.5-8.5	2000	-	600 (Alkalinity)	100	600	200	-	-	100	1000	1.5	400	-	-	N.D.	N.D.
No. of wells exceeding the permissible limit	NIL	NIL	-	2	3	5	1	-	-	NIL	NIL	NIL	NIL	-	-	10	10

***# where*, BIS *is Bureau of Indian Standards*, N.D. is Not Detectable**

5. Results and Discussion

Evaluation of groundwater quality for domestic use:

a) Hydrogen ion concentration (pH)

In the present study area, the pH value ranged from 7.15-8.16 with an average of 7.7 which indicates the alkaline (>7) character of the ground water samples. These pH values of all the collected samples were within the acceptable limit of 6.5 to 8.5 prescribed for drinking water standards. Normally for domestic uses, water having pH between 6 and 10 generally causes no problem.

b) Total dissolved solids (TDS)

In determining the usage of water, total dissolved solids (TDS) plays an important role. It was found that groundwater with high TDS values is not suitable for both irrigation and drinking purposes. To ascertain the suitability of groundwater for any purposes, it is essential to classify the groundwater depending upon their hydrochemical properties based on their TDS values, which are presented in Table 3. The concentration of the collected samples varies between 502 to 992 mg/l with an average of 714 mg/l (Table 2). Hence, these results indicate that water samples contain high content of soluble salts in groundwater which are above the acceptable limit but within the permissible limit as per IS 10500:2012, Drinking water specification.

c) Total hardness

The total hardness (TH) for drinking water is specified as 300 mg/l. The most desirable limit is 100 mg/l as per the international standard [12]. The water hardness is primarily due to the result of interaction between water and geological formations [13].In the study area, the total hardness varies from 379 to 990 mg/l. Also, the Table 4 shows that all the water samples fall in the category of very hard, in the study area. This may be correlated with the above permissible limits concentration values of Ca^{2+} and HCO_3^- ions in water (Table 2), it results in total hardness and makes the water unsuitable for drinking. There is some suggestive evidence that long term consumption of extremely hard water might lead to an increased incidence of urolithiasis, anecephaly, pre-natal mortality, some types of cancer and cardiovascular disorders [12].

Table 3: Nature of ground water based on TDS

TDS (mg/l)	*Nature of water*	*Percentage of wells*	*Total no. of wells*
<1000	Fresh water	100%	10
1000-10000	Brackish water	Nil	Nil
10000-100000	Saline water	Nil	Nil
>100000	Brine water	Nil	Nil

Table 4: Classification of ground water based on Hardness

Total hardness as $CaCO_3$(mg/l)	**Water class**	**% of samples**	**Total no. of wells**
<75	Soft	Nil	Nil
75-150	Moderately hard	Nil	Nil
150-300	Hard	Nil	Nil
>300	Very hard	100%	10

Table 5: Quality of ground water based on Electrical conductivity

EC (micro mhos/cm)	**Water class**	**% of samples**	**No. of wells**
<250	Excellent	Nil	Nil
250-750	Good	Nil	Nil
750-2000	Permissible	100%	10
2000-3000	Doubtful	Nil	Nil
>3000	Unsuitable	Nil	Nil

d) Biological factors

Presence of excess (more than limit according to BIS standards) of various biological factors i.e. Total coliforms and *E.coli* also indicates that the collected water samples were not safe for drinking (Table 2). Moreover, high total viable count may indicate enhanced microbial activity due to percolation of leachates from composting activity into ground water.

Evaluation of groundwater quality for agricultural use:

The suitability of groundwater for irrigation purposes depends upon the effect of mineral constituents of water on both plants and soils. The general criteria for assessing the irrigation water quality are: total salt concentration as measured by EC, relative proportions of Na^+ as expressed by %Na and SAR as adopted by the United States Salinity Laboratory of the United States Dept. of Agriculture [1]. Water quality criteria can be used as guidelines by farmers for selecting appropriate management practice to overcome potential salinity hazard, if the quality of available water would pose any problem for irrigation to maintain existing soil productivity with the benefit of high crop yield under irrigation[1].

e) Electrical conductivity (EC)

The conductivity measurements provide an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present [14]. In the study area, measured EC values ranged from 896 to 1716 µmhos/cm in which all the 10 water samples are representing permissible category of water classes (Table 5).

f) Salinity (SAR)

While a high salt concentration in water leads to formation of saline soil, a high sodium concentration leads to development of an alkaline soil [15]. The sodium absorption ratio (SAR) parameter evaluates the sodium hazard in relation to calcium and magnesium concentrations. The classification of water samples based on SAR for irrigation purpose is shown in Table 6. SAR can be calculated by the formula (where the concentration of all ions is in meq/l):

$$\mathrm{SAR} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The calculated value of SAR in this area ranges from 0.75 to 2.36 with an average of 1.23 and has been classified as excellently suitable for irrigation. When SAR values are greater than 9, irrigation water may cause permeability problems on shrinking and swelling in clayey soils [16].Higher the SAR values in the water, the greater the risk of Na^+ which leads to the development of an alkaline soil [17], while a high salt concentration in water leads to formation of saline soil.

Table 6: Suitability of groundwater for irrigation based on SAR

SAR	Water Class	% of wells	No. of wells
0-10	Excellent	100%	10
10-18	Good	Nil	Nil
18-26	Fair	Nil	Nil
>26	Poor	Nil	Nil

Table 7: Suitability of ground water for irrigation based on percentage sodium

%Na	Water Class	% of wells	No. of wells
<20	Excellent	20%	2
20-40	Good	70%	7
40-60	Permissible	10%	1
60-80	Doubtful	Nil	Nil
>80	Unsuitable	Nil	Nil

Sodium Hazard

Large amounts of sodium is of special concern as excess sodium in irrigation waters produces the undesirable effects of changing soil properties and reducing soil permeability leading to sodium hazard [18]. Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation. %Na was calculated by using the following formula:

$$\text{Na}\% = \frac{\text{Na x 100}}{\text{Na} + \text{Ca} + \text{Mg} + \text{K}}$$

where the quantities of all cations are expressed in milli equivalents per liter.

The classification of groundwater was grouped according to percentage of sodium as Excellent (<20%), Good (20-40%), Permissible (40- 60%), Doubtful (60-80%) and Unsuitable (>80%). Out of 10 water samples collected in the study area, based on percentage of sodium, 20% of the samples have excellent irrigation water, 70% of the samples have good irrigation water and remaining 10% of the samples have permissible irrigation water quality (Table 7).

6. Conclusions

The results of this study shows that all the water samples have alkaline (>7) character and all the samples fall under fresh water category. The concentrations of major ions in groundwater are within the permissible limit for domestic purpose except for a few locations. TDS values range from 502 to 992 mg/l with an average of 714mg/l. The total hardness exceeded the maximum permissible limit at five sampling points out of ten in the study region. Also, all the ground water samples found under very hard category. Calcium exceeded at one location and Magnesium at two locations. In case of bicarbonates (HCO_3^-), it also exceeded at two locations with a maximum of 874 mg/l at location no.2.As far as EC concentration is concerned, all the samples were representing the permissible category. Presence of Coliforms and *E.coli* makes the water unfit for drinking at all the locations. On the basis of percent sodium and sodium absorption ratio, all the samples were found suitable for irrigation purpose. Hence, the present study concludes that the collected water samples were not suitable for drinking purposes, but can be used for irrigation purpose.

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