Groundwater Quality of Open Wells and Tube Wells around Amalner Town of Jalgaon District, Maharashtra, India

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Abstract: Groundwater samples (Three open wells, three tube wells) were collected from six different locations around Amalner town and analyzed during November 2007-February 2008. Fifteen physicochemical parameters were analyzed and the results were compared with water quality standards prescribed by WHO and ISI 10500-91. In the present study, two water samples (one open well, one tube well) showed high EC, TDS, TA, TH values indicating poor water quality. The correlation coefficients were calculated. The significance of the results is further discussed.

Keywords: Groundwater, Physicochemical parameters, Correlation analysis.

Introduction

Water is a vital source of life which is extremely essential for survival of all living organisms. Life is not possible on this planet without water. About 97.2% of water on earth is salty and only 2.8% is present as fresh water from which about 20% constitutes groundwater¹. Groundwater serves as a major source for drinking, irrigation and industry. Groundwater is generally considered to be much cleaner than surface water. However, several factors such as discharge of industrial, agricultural and domestic wastes, land use practices, geological formation, rainfall patterns and infiltration rate affects the groundwater quality and once contamination of groundwater in aquifers occurs, it persists for hundreds of years because of very slow movement in them². Water gets polluted due to contamination by foreign matter such as microorganism, chemicals, industrial or other wastes or sewage. These matters deteriorate the quality of the water and render it unfit for its intended uses. Water pollution is the introduction into fresh or ocean waters of chemical, physical or biological material that degrades the water quality and affects the organisms living in it³. Ingestion of polluted water can result various health problems. Disposal of sewage water into

fresh water aquifers is the main cause of groundwater pollution. Hence determination of groundwater quality is important to observe the suitability of water for particular use. Groundwater monitoring of open wells and tube wells is one of the important tool for evaluating groundwater quality. Considering these aspects of groundwater pollution the present study of groundwater monitoring was undertaken to investigate physicochemical characteristics of some groundwater samples around Amalner town.

Experimental

Study area

Amalner town (latitude $21^{\circ}2'30''\text{N}$ and longitude $75^{\circ}4'\text{E}$) in Jalgaon District lies at Northern region of Maharashtra state with an expected population of about 1 lakh by the end of 10th five year plan. The present study was planned by selecting six different sites around Amalner area which included three sites from villages Mangrul, Nandgaon and Dhar. The literature survey showed that no groundwater studies were made in these regions so far. Hence the present study was undertaken.

Collection of water samples

The groundwater samples were collected in plastic canes of three litre capacity as per standard procedure. Water samples from six sampling points situated at different places were collected during a post monsoon period of four months (November 2007 to February 2008). The samples were kept in refrigerator maintained at 4°C . The sampling points are given in Table 1.

Table 1. Sampling points

S. No.	Sampling points	Source
1	Galwade area (S_1)	Open well
2	Mangrul (S_2)	Open well
3	Deoli Road (S_3)	Open well
4	Railway Crossing (S_4)	Tube well
5	Nandgaon (S_5)	Tube well
6	Dhar (S_6)	Tube well

Analysis of water samples

The physicochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity (Turb), dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), chloride (Cl^-), nitrate (NO_3^-), sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}) were determined using standard methods⁴⁻⁶. AR grade reagents were used for the analysis and double distilled water was used for preparation of solutions. The methods used for estimation of various physicochemical parameters are tabulated in Table 2.

Table 2. Methods used for estimation of physicochemical parameters

S.No.	Parameters	Method
1	pH	pH Metry
2	Electrical Conductivity	Conductometry
3	Total Dissolved Solids	Filtration method
4	Turbidity	Nephelometric method
5	Dissolved Oxygen	Iodometric method
6	Total alkalinity	Titration method

Contd..

7	Total hardness	EDTA titration
8	Calcium	EDTA titration
9	Magnesium	EDTA titration
10.	Sodium	Flame Photometric method
11.	Potassium	Flame Photometric method
12.	Chloride	Silver Nitrate method
13.	Sulphate	Turbidimetric method
14.	Nitrate	Brucine method
15.	Phosphate	Stannous Chloride method

A simple linear correlation analysis has been carried out to find out correlation between any two tested parameters. The significance of correlation was studied.

Results and Discussion

The average results of the physicochemical parameters for water samples are presented in Table 3.

Table 3. Average results of the physicochemical parameters

S.No.	Parameter	Sampling points						ISI 10500-91
		S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	
1	pH	7.5	7.3	7.7	7.3	7.1	7.5	6.5-8.5
2	EC	813.5	1516	491.8	591.6	1846	997.1	1400*
3	TDS	320	680	400	360	1280	480	500
4	Turbidity	0.4	0.2	0.1	0.1	3.1	1.7	5.0
5	DO	7.0	7.6	5.6	2.0	4.0	4.0	5.0*
6	TA	272	200.9	227.7	263.4	300	292	200
7	TH	386	714	274	282	716	456	300
8	Ca ²⁺	80.16	141.9	58.52	60.12	152.3	100.2	75
9	Mg ²⁺	45.32	87.71	31.19	32.16	81.87	50.19	30
10	Na ⁺	77.09	78.98	46.07	59.23	195.6	81.79	200*
11	K ⁺	0.603	0.402	0.603	0.804	2.011	0.603	---
12	Cl ⁻	74.66	222.6	21.13	43.67	333.8	100.01	250
13	NO ₃ ⁻	0.451	1.202	0.437	0.178	0.901	0.669	45
14	SO ₄ ²⁻	29.21	61.79	21.35	15.73	40.45	50.56	200
15	PO ₄ ³⁻	0.078	0.233	0.155	0.078	0.233	0.155	----

(All parameters are in mg/l except pH, EC and Turbidity. EC in micromhos / cm, Turbidity in NTU),

*WHO

pH

pH is a measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. pH value below 4 produces sour taste and a higher value above 8.5 give alkaline taste⁵. In the present study, the pH values of water samples varied between 7.1 to 7.7 (Table 3) and were found within the limit prescribed by ISI 10500-91.

Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts⁷. EC values were observed in the range of 491.8 micromhos/cm to 1846 micromhos/cm. EC values were found within WHO limit except sampling sites S₂ (Open well) and S₅ (Tube well) indicating the presence of high amount of dissolved inorganic substances in ionized form.

Total dissolved solids (TDS)

High concentrations of total dissolved solids may cause adverse taste effects. TDS values varied from 320 mg/L to 1280 mg/L. The sampling points S_2 and S_5 showed higher TDS values than the prescribed limit given by ISI 10500-91.

Turbidity

Turbidity makes water unfit for domestic purposes, food and beverage industries and many other industrial uses. In the present analysis, turbidity values varied between 0.1 to 3.1 NTU and found within the limits prescribed by WHO and ISI 10500-91.

Dissolved oxygen (DO)

Dissolved oxygen reflects the physical and biological processes prevailing in the water. The DO values indicate the degree of pollution in water bodies. In the present analysis of water samples, DO value varied from 2.0 to 7.6. The sampling points S_4 , S_5 and S_6 showed low DO values indicating heavy contamination by organic matter.

Alkalinity

Alkalinity is a total measure of substance in water that has "acid-neutralizing" ability. The main sources of natural alkalinity are rocks which contain carbonate, bicarbonate and hydroxide compounds; borates, silicates and phosphates may also contribute to alkalinity³. Total alkalinity values for all the investigated samples were found to be greater than the value prescribed by ISI 10500-91.

Total hardness (TH)

Hardness in water is due to the natural accumulation of salts from contact with soil and geological formations or it may enter from direct pollution by industrial effluents. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both⁸. In the present study, total hardness varied from 274 mg/L to 716 mg/L. The values for open well sample from point S_1 , S_2 and tube well sample from point S_5 , S_6 were higher than the prescribed limit.

Calcium and magnesium (Ca^{2+} , Mg^{2+})

Water with high calcium content is undesirable for household uses such as washing, bathing and laundering because of consumption of more soap and other cleaning agents. In the present investigation, calcium concentration ranged from 58.52 mg/L to 152.3 mg/L and found higher than prescribed ISI 10500-91 limits except open well sample (S_3) and tube well sample (S_4).

At high concentrations, magnesium salts have a laxative effect particularly when present as magnesium sulphate. Magnesium content in the investigated water samples was varied from 31.19 mg/L to 87.71 mg/L and found above prescribed limit.

Sodium (Na^+)

Excessive amount of sodium in drinking water is harmful to persons suffering from cardiac, renal and circulatory diseases. Sodium concentrations in the present analysis were found from 46.07 mg/L to 195.6 mg/L and were within the prescribed limit.

Potassium (K^+)

Potassium is an essential nutrition element but in excessive amounts, it act as cathartic. Potassium content in the water samples varied from 0.402 mg/L to 2.011 mg/L.

Chloride (Cl^-)

The most important source of chlorides in the waters is the discharge of domestic sewage. People accustomed to higher chloride in water are subjected to laxative effects⁷. In the present analysis, chloride concentration was found in the range of 21.13 mg/L to 333.8 mg/L. The values are within the limit except water sample collected from point S_5 .

Higher chloride concentration in sample from point S_5 may be due to discharge of sewage near the sampling site.

Nitrate (NO_3^-)

Groundwater can also be contaminated by sewage and other wastes rich in nitrates. In excessive amounts, nitrate may cause methemoglobinemia in infants, a disease characterized by blood changes⁶. The nitrate content in the study area varied in the range 0.178 mg/L to 1.202 mg/L and found within the prescribed limit.

Sulphate (SO_4^{2-})

Discharge of industrial wastes and domestic sewage tends to increase sulphate concentration. Sulphate as magnesium sulphate causes laxative effects. In the present analysis, sulphate concentration varied between 15.73 mg/L and 61.79 mg/L and found within the prescribed limit.

Phosphate (PO_4^{3-})

Phosphate occurs in groundwater as a result of domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. The phosphate content in the study was found in the range of 0.078 mg/L to 0.233 mg/L.

Statistical analysis

Correlation is the mutual relationship between two variables. Direct correlation exists when increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of other parameter⁹. The correlation coefficients (r) among various quality parameters were calculated and the values are given in Table 4.

Table 4. Correlation matrix for different water quality parameters

Parameter	pH	EC	TDS	Turb.	DO	TA	TH	Ca ²⁺
pH	1							
EC	-0.777	1						
TDS	-0.757	0.899	1					
Turb	-0.561	0.707	0.828	1				
DO	0.281	0.184	-0.081	-0.303	1			
TA	-0.292	0.158	0.301	0.736	-0.575	1		
TH	-0.704	0.980*	0.815	0.577	0.323	-0.009	1	
Ca ²⁺	-0.714	0.991*	0.848	0.650	0.262	0.075	0.995*	1
Mg ²⁺	-0.687	0.961*	0.774	0.498	0.380	-0.093	0.995*	0.982*
Na ⁺	-0.761	0.844	0.942*	0.913*	-0.152	0.563	0.723	0.771
K ⁺	-0.684	0.600	0.854	0.841	-0.417	0.620	0.436	0.494
Cl ⁻	-0.811	0.989*	0.946*	0.732	0.117	0.185	0.949*	0.963*
NO ₃ ⁻	-0.429	0.852	0.635	0.369	0.532	-0.272	0.932*	0.912*
SO ₄ ²⁻	-0.296	0.716	0.407	0.319	0.464	-0.164	0.813	0.801
PO ₄ ³⁻	-0.429	0.819	0.790	0.511	0.277	-0.202	0.851	0.852
Parameter	Mg ²⁺	Na ⁺	K ⁺	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	PO ₄ ³⁻	
Mg ²⁺	1							
Na ⁺	0.669	1						
K ⁺	0.375	0.918*	1					
Cl ⁻	0.928*	0.889	0.694	1				
NO ₃ ⁻	0.944*	0.474	0.149	0.795	1			
SO ₄ ²⁻	0.817	0.299	-0.071	0.613	0.913*	1		
PO ₄ ³⁻	0.843	0.578	0.383	0.810	0.898	0.724	1	

* Highly positive correlation

EC showed highly significant positive correlation with TDS, TH, Ca^{2+} , Mg^{2+} , Cl^- , NO_3^- and PO_4^{3-} . TDS showed highly significant positive correlation with Turb, TH, Ca^{2+} , Na^+ , K^+ and Cl^- . This suggests that electrical conductivity depends on dissolved solids which depend on salts¹⁰ such as NaCl, CaCl_2 . Total hardness showed significant correlation with Ca^{2+} , Mg^{2+} , Cl^- , NO_3^- , SO_4^{2-} and PO_4^{3-} . So it may be suggested that total hardness of the experimental water samples may be due to presence of salts of these ions.

Some weak correlation is observed between TA and Ca^{2+} ($r = 0.075$) so that alkalinity is weakly depend on Ca^{2+} . pH showed negative correlation with most of the parameters.

Conclusion

In the current study, the groundwater samples showed deviations from water quality standards indicating groundwater contamination. The open well sample from point S_2 and tube well water sample from point S_5 showed high EC, TDS, TA, TH than the prescribed limits given by water quality standards indicating poor water quality and water from these sites is unfit for drinking purpose. The open well water samples from point S_1 , S_3 and tube well water samples from point S_4 , S_6 showed most of the parameters within the limits of water quality standards showing good water quality and the water from these sampling points is fit for drinking purpose.

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References

1. Jameel A and Sirajudeen J, *Environ. Monit. Assess.* 2006, **123**, 299.
2. Jayalakshmi Devi O and Belagali S L, *Nature, Environment and pollution Technology*. 2006, **5(4)**, 553.
3. Garg D, Kaur R, Chand D, Mehla S and Singh R, *Rasayan J Chem.*, 2008, **1(4)**, 743.
4. American Public Health Association: Standard Methods for the examination of water and waste water, 17th Ed., Washington, DC. 1989.
5. Trivedy R K and Goel P K Chemical and Biological methods for water pollution studies Environmental Publication, Karad, 1986.
6. Manivaskam N, Physicochemical examination of water sewage and industrial effluent. 5th ed. Pragati Prakashan Meerut, 2005.
7. Sudhir Dahiya and Amarjeet Kaur, *J Environ Pollut.*, 1999, **6(4)**, 281.
8. Shrinivasa Rao B and Venkateswarlu P, *Indian J Environ Prot.*, 2000, **20(3)**, 161.
9. Karunakaran K, Thamilarasu P and Sharmila R, *E-J Chem.* 2009, **6(3)**, 909.
10. Shah M C, Shilpkar P, and Sharma S, *Asian J Chem.* 2007, **19(5)**, 3449.