# Underground Water Quality of Vagdod Taluka, North Gujarat, India

J.D. JOSHI*, J.J. VORA†, SANGITA SHARMA†, N.K. PATEL†, O.K. KOTHARI† and K.N. SALVI†

*Department of Chemistry, Sardar Patel University*
*Vallabhvidyanagar-388 127, India*

Chemical analysis of water samples of 25 borewells from different sites of Vagdod Taluka located in North Gujarat was carried out and the outcome of the results is discussed.

**Key Words: Physico-chemical studies, Borewell water, Vagdod taluka.**

## INTRODUCTION

Vagdod taluka is located in the north of Gujarat, India in Patan district. The people and animals of Vagdod taluka generally use for drinking and domestic purposes, water from bore-wells. They are facing troubles due to increasing use of agricultural fertilizers and pesticides, and also due to increasing depth of bore-wells, varying from 400 to 1200 ft. There was a huge variation in the concentration of different species due to factors like different depths, different land under groundwater conditions, rain conditions, etc.

The movement of salt water into the down wells may cause contamination after the ground level. The groundwater is generally contaminated through shallow aquifers, which have direct or indirect hydraulic continuity[1]. Such degradable water is injurious to human beings; it does not satisfy the prescribed drinking water standards. It is essential, therefore, to demarcate the quality of groundwater zones for implementing necessary remedial measures to prevent the occurrence of adverse conditions.

Water quality depends on chemical, physical and bacterial constituents[2]. The study of hydrogeochemical zones in a few places in India indicates that the chemical composition of groundwater is affected by the use of fertilizers[3] and land use practice. The present paper attempts to evaluate the quality of groundwater in Vagdod taluka and thereby to analyze the various related aspects.

## EXPERIMENTAL

In the present study 25 borewell samples were collected from different sites of Vagdod taluka in brown glass bottles with necessary precautions.

All the chemicals used were of AR grade. All the glasswares used were of A

†Department of Chemistry, Hemchandracharya North Gujarat University, Patan-384 265, India.

class. Double distilled water was used throughout for preparation of reagents and solutions. The water quality parameters considered for the examination in this study are: electrical conductivity by Equiptronics No. EQ-665, pH by Systronics μ pH-meter No. 361, DO and BOD by Winkler's modified method, calcium and magnesium by complexometry method, sodium and potassium by flame photometer Systronics No. 129, aluminum, iron, phosphate, silicate, nitrate by spectrophotometer Spectronics No. 20D+, carbonate and bicarbonate by titrimetric method, sulphate by nephelometry, chloride by argentometry, fluoride by ion selective electrode, COD by dichromate reflux method and TDS by evaporation method at 185°C[4, 5].

## RESULTS AND DISCUSSION

The results indicate that the quality of water has wide variation mainly due to the saline water intrusion which is reflected by the value of electrical conductivity and its chloride, sulphate, calcium, sodium and magnesium etc.

The pH value of drinking water is an important index of acidity or alkalinity. A number of minerals and organic matter interact with one another to give the resultant pH value of the sample. pH below 6.5 starts corroding the pipes, resulting in release of toxic metals. In the present study pH ranged from 7.45 to 8.45 which lies in the range prescribed by ISI[6]. Dissolved oxygen and BOD ranged from 1.65 to 4.09 mg/L and 0.33 to 2.11 mg/L. Depletion of dissolved oxygen in water supplies can encourage microbial reduction of nitrate to nitrite and sulfate to sulfide, giving rise to odour problem.

Taking into account the electrical conductivity (EC) values, the ground water can be considered as good, permissible or bad which is shown in Table-1. The water samples 3, 10, 20, 23 and 24 show a very high value of electrical conductivity, hence quite unfit for drinking purposes. The EC value varies from 0.55 to $5.75 \times 10^{-3}$ mhos/cm. 48% samples have EC values more than or equal to $3.25 \times 10^{-3}$ mhos/cm and are quite unfit for drinking[7].

Drinking water quality is affected by the presence of soluble salts. The level of TDS is one of the characteristics which decide the quality of drinking water. The TDS value of the study area ranges from 346 to 2876 mg/L. The IS (1983) and ICMR (1975) standard for drinking water is 500 mg/L minimum desirable limit and 1500 mg/L maximum permissible limit. The analyzed data show that 64% samples had more than the maximum permissible limits. This decreases palatability and may even cause gastrointestinal irritation[8]. In the present study alkalinity ranged 154–526 mg/L as bicarbonate and 14.10–49.13 mg/L as carbonate.

The chloride content in the samples is 40.7–1223.0 mg/L. Chloride is the most dominant anion in water. According to IS, the maximum permissible limit is 1000 mg/L. In the present study, the values of chlorides in sample no. 3 have been found high, which can cause corrosion and pitting of iron plates or pipes.

TABLE-1

| Sample No. | Name of village | Depth of bore-wells (ft) | Conductance (mhos/cm) | pH | TDS (mg/L) |
|---|---|---|---|---|---|
| 1. | Goliwada | 700 | $1.60 \times 10^{-3}$ | 8.10 | 1011 |
| 2. | Kansa | 900 | $3.20 \times 10^{-3}$ | 7.73 | 1680 |
| 3. | Bhutiyavasna | 900 | $5.75 \times 10^{-3}$ | 7.68 | 2876 |
| 4. | Ajuja | 400 | $1.45 \times 10^{-3}$ | 7.99 | 887 |
| 5. | Muna | 450 | $2.80 \times 10^{-3}$ | 7.73 | 1535 |
| 6. | Bhatsan | 500 | $2.80 \times 10^{-3}$ | 7.45 | 1507 |
| 7. | Khareda | 475 | $2.50 \times 10^{-3}$ | 7.71 | 1497 |
| 8. | Vahana | 500 | $1.20 \times 10^{-3}$ | 7.67 | 760 |
| 9. | Amarpura | 750 | $3.25 \times 10^{-3}$ | 7.92 | 1801 |
| 10. | Khodana | 500 | $3.75 \times 10^{-3}$ | 8.20 | 2070 |
| 11. | Raviyana | 730 | $2.75 \times 10^{-3}$ | 7.68 | 1530 |
| 12. | Koita | 650 | $2.40 \times 10^{-3}$ | 7.66 | 1360 |
| 13. | Haiderpur | 900 | $3.40 \times 10^{-3}$ | 7.61 | 1831 |
| 14. | Jangral | 800 | $3.30 \times 10^{-3}$ | 7.98 | 1786 |
| 15. | Katra | 850 | $0.72 \times 10^{-3}$ | 8.20 | 425 |
| 16. | Mesar | 1200 | $0.55 \times 10^{-3}$ | 8.45 | 346 |
| 17. | Jakha | 830 | $2.50 \times 10^{-3}$ | 8.23 | 1401 |
| 18. | Laxmipura | 850 | $3.60 \times 10^{-3}$ | 7.80 | 1938 |
| 19. | Ablouva | 1000 | $1.30 \times 10^{-3}$ | 8.25 | 753 |
| 20. | Aendla | 700 | $4.00 \times 10^{-3}$ | 7.88 | 2100 |
| 21. | Kanosan | 850 | $3.55 \times 10^{-3}$ | 7.93 | 1924 |
| 22. | Vagdod | 750 | $2.50 \times 10^{-3}$ | 7.78 | 1386 |
| 23. | Bhilvan | 850 | $4.05 \times 10^{-3}$ | 7.65 | 2212 |
| 24. | Vadu | 850 | $3.85 \times 10^{-3}$ | 7.55 | 2051 |
| 25. | Charup | 1000 | $3.25 \times 10^{-3}$ | 7.80 | 1753 |

In the present study sulphate varies from 13.0 to 196.0 mg/L. Maximum permissible limit of IS is 400 mg/L. Excess amount of sulphate causes diorrhoea. All samples are free from sulphate problems.

The nitrogen contaminant in groundwater occurs in the form of nitrates ($NO_3^-$). Nitrogen is one of the major constituents of organisms along with carbon and hydrogen, as amino acids, proteins and organic compounds; it enters the borewell water as $NO_3^-$.[9] In the present study nitrate levels varied in the range 0.0–49.4 mg/L. Excess amount of nitrate causes methemoglobinemia.

The presence of $Ca^{2+}$ in drinking water is due to natural geological sources, mining byproducts and agricultural wastes. Calcium salts are non-toxic except at very high doses (100 mg for 20 days). In human body, hypercalcemia causes coma and death if serum calcium level rises to 160 mg/L. Maximum permissible limit of calcium in drinking water is 100 mg/L as suggested by USPH and WHO[10]; 200 mg/L as suggested by ICMR and IS. Calcium content in all experimental water samples is varying from 10.0 to 134 mg/L, so excepting sample No. 3, all other samples are free from excessive calcium.

Sodium enters in drinking water from natural geological sources, detergents, domestic industrial discharges and mining wastes. It controls intercellular and intracellular osmosis, maintains pH balance of blood within the body and controls the normal activities of muscles and nerves. The maximum permissible limit of sodium in drinking water is 200 mg/L as prescribed by WHO[10], whereas in our experimental water samples it varies from 55 to 730 mg/L. So 84% samples contain excess sodium.

Potassium enters into a drinking water system from natural geological sources, detergents, mining and agricultural wastes. It carries $CO_2$ into the blood system as $KHCO_3$ and also maintains pH balance of blood by controlling Na/K pool system within the body. It supports intercellular and intracellular osmosis and helps to activate various metalloenzymes. In our experimental water samples, the amount of potassium varies from 1.17 to 3.12 mg/L, which is much lower than the maximum permissible limit as prescribe by WHO[10]; so all water samples are free from excessive potassium condition.

Iron in the drinking water may be present as $Fe^{2+}$, $Fe^{3+}$, $Fe(OH)^+$ or $Fe(OH)_2^+$ in suspended or filterable forms. Iron causes staining in clothes and imparts bitter taste. It comes into drinking water from natural geological sources and mining byproducts. Excess amount of Fe (more than 10 mg/L) causes rapid increase in respiration, pulse-rate and coagulation of blood vessels, hypertension and drowsiness. UPHA and WHO[10] recommend the maximum pennissible limit of filterable iron in the drinking water as 0.3 ppm and 1.0 ppm respectively. The iron content in the water samples observed were below the detectable limits, so all the samples are free from iron hazard.

Magnesium enters into the drinking water system from natural geological sources. Too high $Mg^{2+}$ causes nausea, muscular weakness and paralysis in human body when it reaches up to the level of about 400 mg/L[8]. Maximum permissible limit of Mg in drinking water is 150 mg/L as prescribed by WHO[10]. In this area, magnesium concentration ranged from 10.56 to 103.0 mg/L, below the permissible level.

In the present study, phosphate ranges from 5.0 to 48.5 mg/L. The evaluated values of phosphate concentration are higher than the prescribed values[11]. The higher values of phosphate concentration are mainly due to the use of fertilizers and pesticides by the people residing in this area. If phosphate is consumed in excess, phophine gas is produced in the gastrointestinal tract on reaction with gastric juice. This could even lead to the death of the consumer[11].

In the present study, silicate ranged from 11.0 to 28.18 mg/L[12]. COD ranged from 0.0 to 10.0 mg/L.

High levels of fluoride have at times led to dental and/or skeletal fluorosis.

TABLE-2
ANALYSIS DATA OF WATER SAMPLES (ALL THE VALUES IN Mg/L)

| Sample No. | D.O. | BOD | COD | $HCO_3^-$ | $CO_3^{2-}$ | $Cl^-$ | $SO_4^{2-}$ | $NO_3^-$ | $PO_4^{3-}$ | $SiO_3^{2-}$ | $F^-$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $K^+$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 2.21 | 2.11 | 0.00 | 380 | 21.12 | 150 | 96.00 | 6.40 | 27.00 | 17.00 | 2.52 | 10.0 | 10.56 | 290 | 1.17 |
| 2. | 3.02 | 1.11 | 0.00 | 370 | 21.00 | 600 | 96.00 | 10.00 | 17.75 | 27.15 | 2.30 | 37.0 | 66.00 | 435 | 1.17 |
| 3. | 3.55 | 1.52 | 10.00 | 430 | 14.08 | 1223 | 161.00 | 14.00 | 40.50 | 26.25 | 2.61 | 134.0 | 103.00 | 730 | 1.17 |
| 4. | 2.31 | 0.79 | 0.00 | 332 | 24.65 | 148 | 49.95 | 20.70 | 20.52 | 22.83 | 5.30 | 16.8 | 16.80 | 232 | 1.56 |
| 5. | 2.31 | 0.79 | 3.00 | 361 | 25.00 | 410 | 118.00 | 26.50 | 48.50 | 26.50 | 3.95 | 30.0 | 35.00 | 450 | 1.95 |
| 6. | 2.01 | 0.36 | 0.00 | 355 | 31.70 | 445 | 89.00 | 41.90 | 30.50 | 27.72 | 3.63 | 52.8 | 50.00 | 382 | 1.56 |
| 7. | 2.64 | 0.84 | 0.00 | 483 | 24.65 | 322 | 83.25 | 28.20 | 44.15 | 28.02 | 3.64 | 26.4 | 24.16 | 430 | 1.95 |
| 8. | 1.94 | 0.36 | 0.00 | 315 | 15.00 | 112 | 30.00 | 13.00 | 34.20 | 28.18 | 3.08 | 25.0 | 30.00 | 155 | 1.17 |
| 9. | 1.71 | 1.02 | 0.00 | 450 | 36.00 | 480 | 166.00 | 39.20 | 37.93 | 28.02 | 3.52 | 30.4 | 24.00 | 552 | 1.17 |
| 10. | 2.83 | 0.51 | 0.00 | 505 | 45.79 | 632 | 98.00 | 27.10 | 30.50 | 25.00 | 3.97 | 20.0 | 34.08 | 650 | 1.17 |
| 11. | 1.65 | 0.33 | 0.00 | 390 | 22.00 | 405 | 156.00 | 25.00 | 19.28 | 27.10 | 3.08 | 38.0 | 35.00 | 410 | 1.17 |
| 12. | 2.04 | 0.33 | 0.00 | 383 | 21.13 | 325 | 116.00 | 27.80 | 34.82 | 28.02 | 3.72 | 39.4 | 36.70 | 347 | 1.17 |
| 13. | 2.31 | 0.94 | 0.00 | 358 | 17.61 | 576 | 196.00 | 49.40 | 50.00 | 13.28 | 2.27 | 45.6 | 30.50 | 339 | 1.17 |
| 14. | 4.09 | 1.81 | 5.00 | 383 | 28.18 | 587 | 78.00 | 35.40 | 38.00 | 25.00 | 2.76 | 32.0 | 33.60 | 542 | 1.56 |
| 15. | 3.92 | 1.81 | 0.00 | 154 | 14.10 | 78.2 | 13.00 | 2.65 | 15.00 | 12.00 | 1.88 | 32.0 | 10.80 | 90 | 2.73 |
| 16. | 3.87 | 1.91 | 0.00 | 158 | 14.10 | 40.7 | 13.00 | 0.00 | 10.50 | 11.00 | 1.72 | 23.2 | 16.32 | 55 | 3.12 |
| 17. | 2.83 | 1.55 | 0.00 | 376 | 42.26 | 376 | 49.00 | 33.50 | 39.00 | 23.00 | 3.42 | 38.4 | 21.12 | 400 | 1.95 |
| 18. | 2.92 | 0.44 | 0.00 | 430 | 35.22 | 640 | 84.00 | 30.60 | 30.00 | 28.00 | 3.01 | 45.0 | 32.00 | 580 | 1.56 |
| 19. | 2.67 | 0.61 | 0.00 | 225 | 21.13 | 161 | 48.00 | 12.40 | 25.50 | 18.00 | 2.59 | 36.0 | 10.56 | 192 | 3.12 |
| 20. | 2.73 | 1.22 | 0.00 | 383 | 35.22 | 770 | 80.00 | 40.80 | 31.00 | 23.50 | 3.10 | 42.0 | 31.68 | 660 | 1.95 |
| 21. | 2.75 | 0.80 | 0.00 | 455 | 49.31 | 640 | 36.00 | 19.70 | 32.34 | 23.00 | 3.62 | 33.9 | 20.16 | 611 | 1.56 |
| 22. | 2.42 | 0.72 | 2.00 | 372 | 28.20 | 374 | 76.00 | 14.70 | 34.82 | 23.50 | 3.01 | 31.2 | 29.00 | 339 | 1.95 |
| 23. | 2.50 | 1.25 | 0.00 | 526 | 35.22 | 722 | 82.00 | 37.60 | 32.93 | 26.00 | 3.56 | 38.8 | 34.56 | 674 | 1.56 |
| 24. | 2.44 | 0.80 | 0.00 | 451 | 38.74 | 700 | 82.00 | 30.00 | 29.23 | 25.50 | 3.27 | 51.0 | 40.00 | 600 | 1.95 |
| 25. | 2.67 | 0.46 | 2.00 | 403 | 28.20 | 554 | 87.00 | 20.20 | 42.24 | 27.00 | 3.11 | 46.8 | 30.20 | 512 | 1.95 |

The observed value of fluoride content in this area varied from 1.72 to 5.30 mg/L. According to WHO and ISI the maximum permissible limits are 1.5 mg/L, so all samples are contaminated by excess fluoride content.

## Conclusion

The whole Vagdod taluka depends on ground water. Vagdod taluka has all 25 samples having excess fluoride concentration, 16 samples having more than 1500 mg/L of TDS. In all 25 water samples were found to be unsafe for drinking purpose, whereas all samples badly require proper chemical treatment to reduce the toxic levels of fluoride.

## ACKNOWLEDGEMENTS

We are thankful to Dr. D.V. Joshi, Associate Professor, Department of Pathology, Sardar Krushinagar, Dantiwada to help us. We are also thankful to Dr. Shreyas Bhatt, Department of Microbiology, North Gujarat University, Patan for help.

## REFERENCES

1. J. Behnke, A Summary of the Biochemistry of N-Compounds in Ground Water, *J. Hydrol. (AMST)*, **27**, 155 (1975).
2. B.K. Honda, Hydrochemical Zones of India, Proc. Seminar on Ground Water Development, Roorkee, pp. 339–450 (1986).
3. Y.P. Karkar, Groundwater Quality Monitoring in India, *Jal Vigyan Sameeksha*, **13**, 52 (1988).
4. A.I. Vogel, A Text Book of Quantitative Analysis, 5th Edn., ELBS, London (1978).
5. Standard Methods for Examination of Water and Waste Water, 16th Edn., APHA, AWWA and WPCF, Inc., New York (1985).
6. ISI, Indian Standards Tolerance Limits for Inland Surface Water Subject to Pollution, Indian Standards Institution, IS 2296 (1971).
7. R.K. Trivedy and P.K. Goel, Chemical and Biological Methods for Water Pollution Studies, Enviro Media Publication, Karad (1986).
8. M.G. Adak and K.M. Purohit, *Pollu. Res.*, **20**, 575 (2001).
9. D.G. Miller, Nitrate in Drinking Water, Water Research Centre, Medmenham (1981).
11. Andhra Pradesh State Forensic Science Laboratories (APSFSL) Annual Report (1998).
10. WHO, The Guideline for Drinking Water Quality Recommendations, World Health Organization, Geneva., Vol. 1 (1984).
12. K. Park, Park's Textbook of Preventive and Social Medicine (1997).

(*Received*: 5 January 2004; *Accepted*: 6 July 2004) AJC-3500