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# Physicochemical characteristics and statistical study of groundwater of some places of Vadgam taluka in Banaskantha district of Gujarat state (India)

**Kiran V. Mehta**

*Department of Chemistry, R. R. Mehta College of Science and C. L. Parikh College of Commerce, PALANPUR, Banaskantha, Gujarat(India)*

**ABSTRACT**

*The demand of water is continuously increasing in today's world due to massive increase in population and human activities. As a complementary resource to surface water, groundwater is a valuable natural resource for drinking water. Like the other natural resources, it should be monitored periodically and natives should be made aware of the quality of drinking water. For the present study, different samples of groundwater were collected from the locations of Vadgam taluka of Gujarat state of India and analysed for their physicochemical parameters like temperature, colour, odour, turbidity, electrical conductance (E.C.), pH, total dissolved solids (TDS), total alkalinity, chemical oxygen demand (COD) and concentrations of ions like chloride, fluoride, calcium and magnesium. Its quality was compared with drinking water standards of ICMR and EU (1998). For the statistical analysis, values of mean, standard deviations and correlation co-efficients (r) were also calculated for these water quality characteristics.*

**Key words:** Physicochemical characteristics, correlation co-efficient, quality.

## INTRODUCTION

Water and life are two sides of the same coin. Life starts and grows in the lap of water. Water is very crucial to all the forms of life : from very small living creatures to very complex systems of animals and human being. The purity of water varies from place to place in nature. Rain water, if not contaminated by atmospheric pollutants, is highly pure while the sea water contains large amount of salt. Water for a variety of uses can be obtained from the sources like precipitation in the form of rain, snow and hail while surface water in the form of glaciers, streams, rivers and

sea water. Besides these sources of water, there is also a natural rich source of water in the form of groundwater which is complementary to the surface water.

Groundwater occurs as a part of the hydrological transformations of permeable structured zones of the rocks, gravel and sand [1]. Groundwater can be obtained from aquifers and hypopheric zones. Fractured crystalline bedrocks are good sources of potable water in many parts of the world [2]. Ground water satisfies the domestic, agricultural and industrial need of the society. In today's world, the demand of water is rapidly increasing due to massive increase in population, industrialisation and urbanisation. This demand is fulfilled by surface water and groundwater. Both the water resources largely depend on ice melting and rainfall. In this scenario, to provide safe drinking water is a very big responsibility for the governments. Today, almost 1.2 billion people on the earth do not have safe water to drink [3]. Easily and regularly available clean drinking water is still a tough task to achieve not only in deserts but also in most of the mega cities and small towns.

In rural arid and semi arid regions, where well managed water transportation system and related infrastructures are not available, ground water serves as prime source of drinking water. Groundwater is an excellent reservoir of water but as rivers, lakes and streams are influenced by natural and human factors, groundwater is also facing the same situation around the world. Human activities, hydrological aspects and characteristics of recharged water affect the quality of groundwater. As groundwater is used in high extent, some troubles are created such as water logging, land subsidence, lowering of water table, sea water intrusion in coastal aquifers and deterioration in water quality [4]. Groundwater quality is a very sensitive issue which transcends national boundaries [5]. Similar to other countries, issue of groundwater has become an issue of importance for the development of India [6]. Unrestricted exploration of groundwater and excessive use of fertilizers and pesticides make possible the infiltration of detrimental constituents to the groundwater. Domestic and industrial waste also defile groundwater [7,8]. As a result, groundwater becomes unhygienic [9-15].

Groundwater is a valuable asset for any country of the world. In India, as groundwater is ultimate and key water resource, people use groundwater for drinking purpose. In addition to this, groundwater is also used in agricultural and industrial fields.

If the groundwater used for drinking and other domestic activities is contaminated, it creates intimidation to the health of the people. Hence, periodical evaluation of water quality requires serious attention. Water quality assessment is pre-requisite to the water quality management. To protect and manage quality and quantity of groundwater is necessary for the healthy growth of the nation.

## EXPERIMENTAL SECTION

The present study is related to the groundwater quality of some places of the Vadgam Taluka which is situated in Banaskantha district of Gujarat state of India. In this taluka, agriculture and dairy production are the major monetary activities. Wheat, Bajara, Juwar, Maize and Groundnuts are generally the crops which are cultivated here. From this taluka, groundwater samples of bore wells were collected in November-December, 2008. The samples were collected from the different places like : (a) Sabalpur, (b) Hatavad, (c) Kodram, (d) Moriya, (e) Joita, (f) Memadpur, (g) Vadgam, (h) Bvalchudi, (i) Ghodiyal, (j) Dharevada. These samples were collected, preserved and analysed for physicochemical characteristics such as temperature, colour, odour, turbidity, electrical conductance, pH, total dissolved solids, total alkalinity,

chemical oxygen demand and concentrations of ions like chloride, fluoride, calcium and magnesium by the standard methods which are described in the literature [16-24].

## RESULTS AND DISCUSSION

Values of different physicochemical characteristics are shown in Table-1. Quality of these water samples is compared with Indian Council of Medical Research (ICMR: 1975) specifications for drinking water and standards suggested by the European Union (EU: 1998) for water. The European Union drew up directives which adopted on 3rd November, 1998, for the purity of water intended for human consumption.

Temperatures of these samples were in the range of 26°C to 30°C. By direct observation, all the water samples were found clear. Similarly, direct inspection of the samples for odour was done and found that samples were odourless. According to EU, clarity and odour of water should be acceptable to consumers and there must not be abnormal changes in these characteristics of water.

Turbidity is a measure of murkiness of water. It is an important factor for characterisation of water [25]. Turbidity is the condition which results due to the suspension of solid particles in water. High value of turbidity indicates presence of many suspended particles in it. Clear water contains low turbidity level while muddy water contains high turbidity level. For all the water samples, turbidity was in the range of 1 to 2 NTU (Nephelometric Turbidity Unit). It indicates absence of suspended and colloidal matters like decomposed vegetation, sewage, sediments in the samples.

**Table-1: Values of physicochemical parameters**

| Parameter | a | b | c | d | e | f | g | h | i | j | Mean | S. D. | ICMR Standards | | EU Standards |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | DL | MPL | |
| **Temp $^0$c** | 30 | 27 | 30 | 28 | 26 | 26 | 27 | 28 | 29 | 27 | 27.80 | 1.48 | - | - | - |
| **Colour** | Cl | Cl | Cl | Cl | Cl | Cl | Cl | Cl | Cl | Cl | - | - | - | - | * |
| **Odour** | Ol | Ol | Ol | Ol | Ol | Ol | Ol | Ol | Ol | Ol | - | - | - | - | * |
| **Turbidity(NTU)** | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1.40 | 0.52 | - | - | * |
| **E.C.(ms cm$^{-1}$)** | 0.67 | 0.85 | 1.45 | 1.33 | 0.92 | 1.53 | 0.89 | 1.20 | 0.78 | 0.94 | 1.06 | .30 | - | - | 2.5 |
| **pH** | 8.59 | 8.40 | 8.70 | 7.84 | 8.10 | 7.60 | 8.17 | 8.00 | 8.34 | 8.96 | 8.27 | 0.41 | 7.0-8.5 | 6.5-9.2 | ≥6.5 and ≤ 9.5 |
| **TDS(mg/l)** | 410 | 480 | 850 | 815 | 650 | 880 | 605 | 820 | 595 | 760 | 686.50 | 163.08 | 500 | 1500-3000 | - |
| **Cl$^{1-}$(mg/l)** | 80 | 98 | 111 | 105 | 96 | 124 | 79 | 146 | 90 | 120 | 104.90 | 20.97 | 200 | 1000 | 250 |
| **Total Alkalinity(mg/l)** | 277 | 305 | 360 | 297 | 310 | 348 | 330 | 315 | 284 | 300 | 312.60 | 26.58 | - | - | - |
| **F$^{1-}$ (mg/l)** | 0.78 | 0.89 | 0.95 | 0.80 | 0.87 | 0.81 | 0.77 | 0.92 | 0.85 | 0.93 | 0.86 | 6.52 | 1 | 1.5 | 1.5 |
| **Ca$^{2+}$ (mg/l)** | 86 | 105 | 119 | 78 | 108 | 102 | 155 | 94 | 85 | 68 | 100.00 | 24.60 | 75 | 200 | - |
| **Mg$^{2+}$ (mg/l)** | 37 | 14 | 52 | 34 | 25 | 40 | 33 | 37 | 41 | 27 | 33.90 | 10.13 | 50 | - | - |
| **COD (mg/l)** | 11 | 16 | 13 | 24 | 17 | 12 | 21 | 18 | 19 | 15 | 16.60 | 4.09 | - | - | - |

***Cl :*** *Clear,* ***Ol :*** *Odourless,* ***S.D.*** *: Standard Deviation,* ***DL*** *: Desirable Limit,* ***MPL*** *: Maximum Permissible Limit,* ******* *: Acceptable to consumers and no abnormal changes.*

High values of electrical conductivity exhibits large amount of salts dissolved in water. This kind of property is not desired because it makes water inappropriate for drinking purpose. Electrical conductivity of these water samples varied from 0.67 to 1.45 ms $cm^{-1}$.

pH is a measure of hydrogen ion concentration. The pH value of water is indication of how acidic or basic the water is on the scale of 0 to 14. Generally, pH values of groundwater are fluctuating in the range of 3 to 10 [26]. pH values of water samples were found in the range of 7.60 to 8.96 having mean value 8.27 and standard deviation 0.41. pH values ( >7 ) are indicative of alkaline nature of water. Three samples (a, c, j) were beyond the desirable limit of pH suggested by ICMR, while all the samples were in maximum permissible limit of pH (ICMR). All the samples were also well within the EU standards for pH.

As water is very good solvent, it picks up many impurities. Total dissolved solids in water originates from various factors like minerals, sewage, natural sources, the nature of piping which is used to convey the water, agricultural runoff, etc. The value of TDS describes the general quality of water. TDS values for the samples varied from 410 to 880 mg/l. For TDS, ICMR suggests 500 mg/l as the desirable limit while 1500-3000 mg/l as the maximum permissible limit in the absence of alternate source. Here, eight samples (c to j) showed TDS values which were exceeding the desirable limit. High TDS decrease the quality and affect the taste of water [27]. If TDS value is more than 500 mg/l, it may cause gastro intestinal irritation.

Domestic sewage, agrochemicals and chlorine rich effluents can contribute for high chlorine content in water. Chloride content in water may be due to the minerals like mica, apatite and from the liquid inclusions through the igneous rocks [28]. The high chloride content in the presence of magnesium can create corrosion of utensils used for domestic purposes [29]. In drinking water, high chloride content may lead to laxative effects [30-31]. High chloride content also alters the taste of water. The chloride contents of these samples lie in the range of 79 to 146 mg/l. According to ICMR, desirable limit of chloride is 200 mg/l while according to EU, it is 250 mg/l. All the samples were inside the desirable limit of chloride content.

Excessive alkalinity may cause eye irritation in human and chlrosis in plants [32]. If alkalinity value in drinking water is higher than 200 mg/l, the taste of the water becomes unpleasant. In the water samples, total alkalinity was from 277 to 360 mg/l having mean value 312.60 and standard deviation 26.58.

In water resources, concentration of fluoride is increasing due to geochemical dissolution of fluoride containing minerals, rapid urbanization and modern industrialization. The amount of fluoride in ground water varies greatly in the same region i.e. vertically and horizontally, fluoride is distributed in groundwater in uneven manner [33]. Presence of large amount of fluoride (> 1.5 mg/l) is associated with dental and skeletal fluorosis [34-35], while inadequate amount of fluoride (<1.0 mg/l) is associated with dental carries. Large population in India is also affected by fluorosis [36-37]. In groundwater, fluoride is found in different concentrations [38-43]. The $F^{1-}$ concentration in samples was from 0.77 to 0.95 mg/l having mean value 0.86 which is not violating permissible limit (1.0-1.5 mg/l) indicated by ICMR and EU.

Calcium is a chief constituent of different types of rocks. It is a cause for hardness in water. Similarly, magnesium is also responsible for hardness of water. With an increase in hardness of water, its suitability decreases for cooking, cleaning and laundry jobs and if the concentration of magnesium is more than 300 mg/l, it is toxic [44]. In the samples, $Ca^{2+}$ concentration ranged

from 68 to 155 mg/l, while $Mg^{2+}$ content was found from 14 to 52 mg/l. so, the amount of $Ca^{2+}$ present in the sample was well within the maximum permissible limit indicated by ICMR.

The COD values of the samples varied from 11 to 24 mg/l having mean value 16.60 and standard deviation 4.09. Hence, the observed values were not too high.

**Statistical Analysis**

**Table - 2: Correlation matrix**

| Parameter | Temp. $^0$c | Turb. (NTU) | E.C. (ms cm$^{-1}$) | pH | TDS (mg/l) | $Cl^{1-}$ (mg/l) | T.A. (mg/l) | $F^{1-}$ (mg/l) | $Ca^{2+}$ (mg/l) | $Mg^{2+}$ (mg/l) | COD (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temp $^0$c** | 1.000 | | | | | | | | | | |
| **Turb. (NTU)** | 0.117 | 1.000 | | | | | | | | | |
| **E.C. (ms cm$^{-1}$)** | -0.114 | 0.250 | 1.000 | | | | | | | | |
| **pH** | 0.462 | -0.047 | -0.461 | 1.000 | | | | | | | |
| **TDS (mg/l)** | -0.193 | 0.058 | 0.902** | -0.342 | 1.000 | | | | | | |
| **$Cl^{1-}$ (mg/l)** | -0.198 | -0.088 | 0.647* | -0.215 | 0.761* | 1.000 | | | | | |
| **T. A. (mg/l)** | -0.192 | 0.361 | 0.753* | -0.219 | 0.633* | 0.361 | 1.000 | | | | |
| **$F^{1-}$ (mg/l)** | 0.086 | -0.059 | 0.214 | 0.475 | 0.359 | 0.592 | 0.257 | 1.000 | | | |
| **$Ca^{2+}$ (mg/l)** | -0.162 | 0.131 | 0.054 | -0.174 | -0.084 | -0.331 | 0.600 | -0.216 | 1.000 | | |
| **$Mg^{2+}$ (mg/l)** | 0.601 | 0.370 | 0.485 | -0.050 | 0.464 | 0.157 | 0.398 | 0.001 | 0.075 | 1.000 | |
| **COD (mg/l)** | -0.180 | -0.705* | -0.036 | -0.352 | 0.104 | -0.111 | -0.219 | -0.230 | 0.096 | -0.186 | 1.000 |

***Turb. :*** *Turbidity,* ***T.A. :*** *Total Alkalinity,* ******* *Correlation is significant at the 0.05 level (2-tailed).*
******** *Correlation is significant at the 0.01 level (2-tailed).*

For the values of physicochemical parameters, mean and standard deviation are calculated and are shown in **Table-1**.

In statistics, correlation is a broad class of statistical relationship between two or more variables. Hence, it can be considered as a normalized measurement of covariance. The correlation study is useful to find a predictable relationship which can be exploited in practice. It is used for the measurement of the strength and statistical significance of the relation between two or more water quality parameters. Hence, it is a helpful tool for the promotion of research [45-50]. It can put forward possible causal or mechanistic relationships [51-52]. The correlation coefficients(r) were calculated and correlation matrix was obtained [53-61]. Here, r is a dimensionless index which is in the range of -1.0 to +1.0 inclusive and exhibits the extent of a relation between variables. The values of correlation coefficients are listed in **Table-2.** High positive correlation was found between E.C. and TDS, total alkalinity and E.C., $Cl^{1-}$ and TDS while moderately high negative correlation was observed between COD and turbidity. Very poor positive correlation was observed between turbidity and temperature, $F^{1-}$ and temperature, TDS and turbidity, $Ca^{2+}$ and turbidity, $Ca^{2+}$ and E.C., COD and $Ca^{2+}$, while there is almost no correlation was found between $F^{1-}$ and $Mg^{2+}$.

## CONCLUSION

Water is indispensable not only for the existence of the mankind but also for human development and healthy functioning of the eco-system. The present study has led to conclude that the quality of water samples studied were acceptable from the majority of the physicochemical parameters but as TDS values of most of the samples were violating the desirable limit suggested by ICMR, the water should be treated properly before its usage as drinking water to avoid possible adverse effects. Therefore, public should be made aware of drinking water quality and careful management of precious natural resources. Water quality also should be monitored continuously for the welfare of the people.

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