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Seasonal Variations of Ground Water Quality in and around Gulf of Mannar Coastal Aquifers

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ABSTRACT

The present study is aimed to assess coastal aquifer system along the sea shore area of Gulf of Mannar. An effort has been undertaken for a detailed survey of ground waters, twenty five ground water samples collected during three different seasons namely pre-monsoon, monsoon and post-monsoon. Nineteen physico, chemical and biological parameters like temperature, pH, TDS, total hardness (TH), temporary hardness (THA), permanent hardness (PHA), total alkalinity (TA), Cl⁻, SO₄²⁻, CO₃²⁻, HCO₃⁻, Ca²⁺, Mg²⁺, Na⁺, K⁺, DO, BOD and COD were analyzed for collected ground water samples. The experimental results were compared with standard values as prescribed by Bureau of Indian standard (BIS) and World Health Organization (WHO). The results showed that, some of ground water samples have high hardness, EC, TDS, sodium, calcium, chloride, DO, BOD, COD content. From this study, it is observed that, some of water samples unfit for drinking purposes due to high salt concentration. These high dissolved solids may be due to salt water intrusion. The influence of seasonal changes (Pre-monsoon, monsoon and post-monsoon) on the physico-chemical properties of the water of Gulf of Mannar shore area also investigated. This study showed that the salt concentration is found to be very high during pre-monsoon compared to other seasons, it may be due to water evaporation during pre-monsoon season.

1. Introduction

Water is an essential input not only for the human existence, but also for all developments. Demand of ground water has increased tremendously in recent years due to the industrialization, urbanization, population increase and intense agricultural activities [1]. Ground water aquifers naturally contain mineral ions dissolved from soil particles, sediments and rocks [2]. Factors like climate, slope, drainage condition, seepage of industrial effluents, salt water intrusion and residence time are the additions, which leads to the degradation of ground water quality *i.e* ground water pollution [3]. Ground water pollution is a challenging global problem, particularly people, who are living nearer to coastal areas, are facing a struggle to have safe drinking water. Coastal regions are having both spatial and temporal variations in the ground water characteristics [4]. Seasonal change in a water quality and its aquifer with the passage of time has hydrological significance which may be due to weathering of parent rocks and anthropogenic activities [5]. Regular monitoring of the quality of ground water should be undertaken temporarily and spatially to identify the sources of force contaminants and other inhibitory compounds that affect the potability of water [6].

The Gulf of Mannar which is the first marine Biosphere Reserves established in India, lies between India and Srilanka and covers an area of about 10,500 sq.km. The Gulf of Mannar (GoM) is one of the coral reefs rich regions in India. The Gulf of Mannar is considered as “Biologists Paradise” for it has 3600 species of flora and fauna. The GoM is heavily threatened by the discharge of sewage from human settlements, salt pan and effluents from industries [7]. The profiles of study area and the sampling location were well detailed in the previous paper [8]. The water quality assessment may give clear information about the sub surface geologic environments in which the water presents. The objective of the study is to evaluate ground water aquifer system to assess the suitability of ground water for drinking and irrigation purposes, by measuring nineteen water quality parameters (WQPs).

2. Experimental Methods

Water samples were collected in one litre polythene bottle from 25 different stations (bore well, Hand Pump and Pond) in Gulf of Mannar sea shore starts from Rameshwaram to Tuticorin. Samples were collected in three seasons like pre monsoon (May 2009), monsoon (September 2009) and post monsoon (January 2010). Before collecting the water samples, bottles were thoroughly cleaned by dilute HNO₃ followed by repeated washing with deionised water. The samples were collected for physico – chemical analysis, BOD measurements and heavy metal analysis separately by using the standard procedure [9]. Temperature of the samples were noted at sampling point itself. The pH of the water samples were determined in the field at the time of the sample collection by using digital pH meter (Model No. L1613 Elico digital pH meter). The collected samples were properly transferred to the laboratory and stored in the refrigerator at 4 °C till the analysis was over. These samples were analyzed chemically for major anion, cation and other water quality parameters using the standard methods [10].

3. Results and Discussion

The ground water samples were analyzed for physico chemical parameters and the experimental results were compared with standard values as prescribed by Bureau of Indian standard (BIS) and World Health Organization (WHO). The results showed that, some of ground water samples have high hardness, EC, TDS, sodium, calcium, chloride, DO, BOD, COD content. From this study, it was observed some of water samples unfit for drinking purposes due to high salt concentration. These high dissolved solids may be due to salt water intrusion. These studies also focus on the impact of climatic condition on the physico chemical parameters of ground water in Gulf of Mannar coastal aquifers.

3.1 Seasonal Variations

Water temperature of the study samples were varied from 27.0 °C to 29.2 °C at different sampling locations of Gulf of Mannar. Water temperature affects the ability of water to hold oxygen and dissolution of minerals in water [11]. The pH serves as index to denote the extent of pollution by acidic or alkaline wastes [12]. Water pH values were found in the range of 7.2 to 9.3 and high pH values were recorded during pre-

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monsoon season. All the sampling sites showed lower pH than the WHO permissible limits. Electrical conductivity values were found in the range from 300 to 7700 $\mu\text{mhos/cm}$ at Gulf of Mannar. Most of the water samples in this study area were found to be high EC values than the prescribed limits.

The hardness values were obtained in the range from 45 mg/L to 2235 mg/L at Gulf of Mannar and the maximum hardness found during pre-monsoon and minimum during post monsoon season. High hardness values which may due to the presence of carbonate and non-carbonate hardness. Generally hardness are not harmful to health however, these hardness may play some role in heart disease and formation of kidney stone [13]. TDS values of water samples were found in the range from 192 mg/L to 4928 mg/L at Gulf of Mannar. Seasonal changes on TDS values showed, maximum during pre-monsoon season and minimum during post monsoon season. In this study, most of the sampling sites showed TDS values above the WHO limits. The sea water intrusion may be the reason for high TDS in and around the coastal areas.

Alkalinity around 150 mg/L regularly conducive to higher productivity of water bodies [14]. Alkalinity values registered in the range from 10 to 510 mg/L at Gulf of Mannar coastal aquifers. Chloride ions concentrations in the range from 15 to 5053 mg/L were found in the sampling sites. In this study, it is confirmed that the chloride pollution in coastal aquifers which may due to the discharges from desalination plants and salt pans located in this area. In this study, sulphate ion variations with seasons accounted remarkably, i.e. 11.0 to 346 mg/L at Gulf of Mannar coastal area.

The results of Calcium and Magnesium ions and their findings in the study area, may be explained on the basis of ion exchange mechanism in the hydrogeo chemistry, duly exchanged with Na^+ and K^+ ions and reflected in the concentration of Na^+ and K^+ in ground water samples. Very few sampling sites showed zero level calcium which may due to the shallow aquifers on the sea beds stone of water, almost drinking water quality. Sampling sites such as GoM9, GoM13, GoM15 and GoM21 in Gulf of Mannar showed calcium ion levels much higher than the prescribed limits (Fig. 1). (> 500 ppm WHO), which may due to dissolution of rock components in the coastal aquifer. Further, the sites identified with high population density, over usage of ground water as the domestic and fertilizer industries may be the reasons for high calcium and magnesium contents in water.

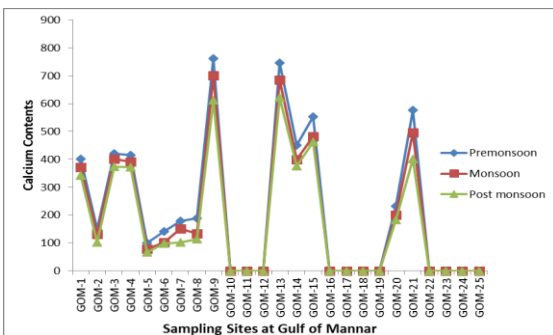


Fig. 1 Seasonal variations of Calcium at Gulf of Mannar Sea shore area

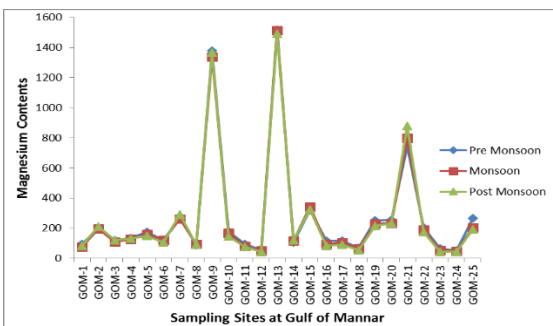


Fig. 2 Seasonal variations of Magnesium at Gulf of Mannar Sea shore area

Magnesium ions concentration were observed in the range from 45 to 1519 mg/L at Gulf of Mannar sea shore study area, among which all the study sampling sites Mg^{2+} ions higher than their recommended limits. In Gulf of Mannar, the sampling sites GoM9 and GoM13 were found above 1000 ppm of magnesium (Fig. 2) which indicates saline intrusion and mixing with coastal aquifers [15].

Sodium ions concentrations were found in the range from 17 to 917 mg/L at Gulf of Mannar coastal aquifers. Most of the water samples showed high sodium ions content due to the sampling sites are located

nearby sea [16]. The seasonal variations of sodium ions concentration were recorded maximum during pre-monsoon and minimum during post monsoon (Fig. 3). High sodium concentration in irrigation water results in absorption of Na^+ ion by clay particle resulting in reduced permeability of the soil and poor internal drainage. Such soils become hard when dry [17].

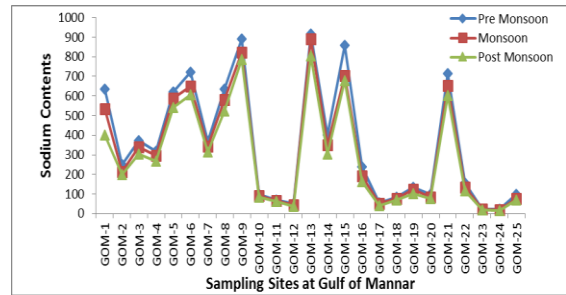


Fig. 3 Seasonal variations of Sodium at Gulf of Mannar Sea shore area

Potassium is an essential nutrition element for human, but in excessive amounts it acts as cathartic [18]. The major source of potassium ions in natural fresh water is due to weathering of rocks but the quantity increase, in the polluted water is due to the disposal of waste water [19]. Potassium ions are very similar to sodium ions in many physical and chemical properties. Potassium ions content in the water samples undertaken for this study area were found in the range from 1 to 400 mg/L at Gulf of Mannar coaster aquifers.

Potassium ions reported in most of the water samples higher than their limits. The seasonal variations of potassium concentration were recorded maximum during pre-monsoon and minimum during post monsoon (Fig. 4). Similar observations have been made at Dindigul Town, Tamilnadu, India by Mohamed Hanipha et al [20].

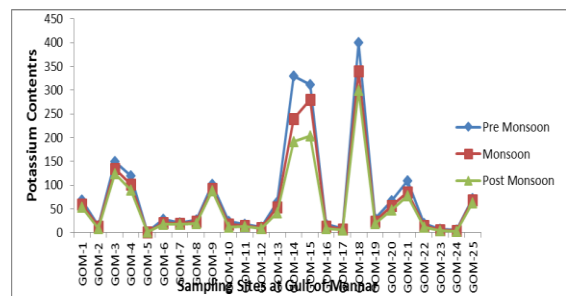


Fig. 4 Seasonal variations of Potassium at Gulf of Mannar Sea shore area

The amount of oxygen that can be dissolved in water is function of temperature and therefore dissolved oxygen content in water may vary from place to place and time to time. The percentage of DO is suitable for survival of aquatic life [21]. Dissolved oxygen content found in the range from 5.2 to 9.5 mg/L at Gulf of Mannar coastal aquifers.

Biological Oxygen Demand (BOD) is a value of presence of organic materials in water which can support life [22]. The BOD depends on variable of dissolved oxygen and oxidizable organic matter. The BOD values were observed in the range from 8.8 to 16.8 mg/L at Gulf of Mannar shore area.

The sampling locations where BOD exceeds 3 mg/L, the water becomes unfit for regular consumption and requires some treatment for microbiological bacteria contamination. The maximum permissible COD limit is 10 mg/L for drinking water [23]. The chemical oxygen demand (COD) values were found to be fluctuated between the stations as well as seasons. The COD values obtained in the range from 4.2 mg/L to 10.2 mg/L at Gulf of Mannar lower than their limits.

4. Conclusion

Seventy five (25×3) ground water samples were collected from Gulf of Mannar sea shore area during pre-monsoon, monsoon and post monsoon seasons. The ground water samples were analyzed for physico chemical parameters and the experimental results were compared with standard values as prescribed by Bureau of Indian standard (BIS) and World Health Organization (WHO). The results showed that, some of ground water samples have high hardness, EC, TDS, sodium, calcium, chloride, DO, BOD, COD content. From this study, it was observed some of water samples unfit for drinking purposes due to high salt concentration. These high dissolved solids may be due to salt water intrusion. The influence of seasonal

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