



Research Paper

SALT WATER INTRUSION IMPACTS AND QUALITY OF GROUND WATER ALONG COASTAL AREA FROM THALAPADY TO KUMBALA, KASARAGOD DISTRICT, KERALA, INDIA

Cheruvathoor Vannathan Gopalan^{1*} and Krishnaiah Chikkamadaiah²

*Corresponding Author: **Cheruvathoor Vannathan Gopalan** ✉ cvgopalan72@gmail.com

Pre- and post-monsoon water samples collected from open well and bore wells at specified intervals from coastal areas of Thalapady, Kannuathethertha, Manjeshwar, Banthiyod and Kumbala, Kasaragod district shows that Electrical Conductivity (EC) of pre- and post-monsoon water samples varies drastically. This may be attributed to saline water intrusion during pre-monsoon season due to excessive usage of water from these wells. At Thalapady, EC of pre-monsoon sample is 1080 ($\mu\text{S}/\text{cm}$) and EC of post monsoon sample is 260 ($\mu\text{S}/\text{cm}$). Similarly all other samples also shows variations in EC including both open and bore well samples. The decrease may be due to decrease of Total Dissolved Solids (TDS) during monsoon season due to mixing of groundwater with rainwater and increase in EC is due to enrichment of TDS during summer season due to saline water intrusion. The EC of pre-monsoon samples here varies from 260 to 1630 ($\mu\text{S}/\text{cm}$) and that of post monsoon samples varies from 120 ($\mu\text{S}/\text{cm}$) to 770 ($\mu\text{S}/\text{cm}$). The pH of the samples varies from 6.5 to 8. At 500 m west of Banthiyod, the water sample from bore well is having smell of H_2S and a fine layer of oil is noticed. It is 150 feet depth and EC during post-monsoon records 770 ($\mu\text{S}/\text{cm}$). The open well in the same location is having potable water with EC of 110 ($\mu\text{S}/\text{cm}$) during post-monsoon. Bore well water sample from Devinagar, Kumbala is characterized by the presence of mucous precipitate and color of the water is yellowish green. The open well water sample from Kannuathethertha is rich in ferruginous materials and the coconut plants here is developed brown coloration. Open well water sample at Uppala is characterized by high Cu content (600 ppb) and the water here is having sour taste.

Keywords: Electrical Conductivity, Water sample, Total Dissolved Solids, Saline water and pH

INTRODUCTION

Groundwater is an important resource of people living on the coastal areas for drinking, agricultural and other purposes. One of the major concerns most commonly encountered in coastal aquifers

is the induced flow of saltwater into freshwater aquifers caused by over-pumping of groundwater and is called saline water intrusion (Lanmbo Liu, 2006). Groundwater is easily the most important component and constitutes about two thirds of

¹ Senior Geologist, Geological Survey of India, Mangalore, Karnataka, India.

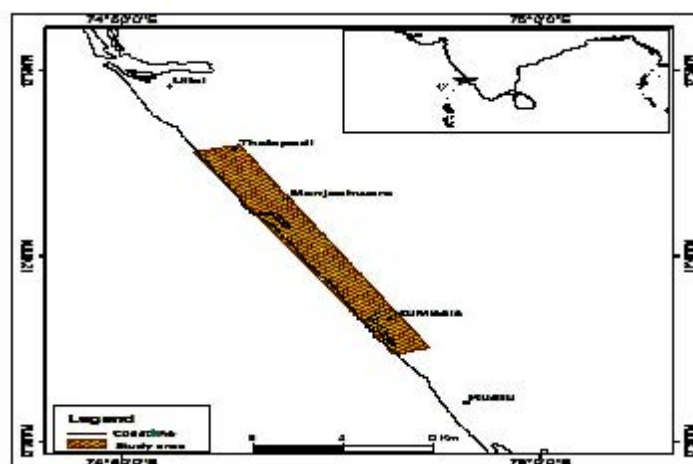
² Professor, Dept. of Marine Geology, Mangalore University, Mangalagangothri-574199, Mangalore, Karnataka, India.

the freshwater resources of the world and, if the polar ice caps and glaciers are not considered, groundwater accounts for nearly all usable freshwater (Chapman,1992). Two thirds of world population living in the coastal areas and extracts ground water at an alarming rate which causes the degradation of groundwater by saline water intrusion into the aquifer systems through fracture and fault zones that exist on the coastal areas. Rocky beaches are more vulnerable to intrusion than sandy beaches. Even 2% of sea water in ground water is enough to make it unsuitable for drinking (Philippa Aitchison-Earl *et al.*, 2003).

Quality of ground water is as important as its quantity. The adverse effects on ground water quality are the results of man’s activity at ground surface, unintentionally by agriculture, domestic and industrial effluents, unexpectedly by sub-surface or surface disposal of sewage and industrial wastes (CPCB, Delhi, 2008). Once polluted, a groundwater body could remain so for decades, or even for hundreds of years, because the natural processes of through-flushing are so slow (Chapman,1992).

The natural quality of groundwater is, therefore, controlled by the geochemistry of the lithosphere, the solid portion of the earth, and the hydrochemistry of the hydrosphere and the aqueous portion of the earth (Chapman, 1992). Any abnormal content of trace elements, heavy metals, pH, turbidity, microorganisms, etc., in water more than prescribed limit may cause serious health hazards to people who consume it. WHO publishes the drinking water standards every year and one should strictly adhere to these values for the safety of health. The ground water from bore wells should be definitely analyzed as it comes from deep metamorphic rock and some hazardous minerals like apatite which contains fluoride in the rocks react with the water and make it unfit for drinking. The pesticides used in agriculture purposes in due course percolate with ground water and will be dissolved and make it unsafe for drinking purpose. Ground water in coastal areas are prone to saline water intrusion during summer period when excess water is being consumed.

Figure 1: Map Showing the Study Area



A study has been conducted along the coastal areas of Kasaragod district between Kumble and Thalapady for a distance of 30 km to evaluate the impact of saline water intrusion and quality of ground water by monitoring few open wells and bore wells at definite intervals in different seasons like pre-monsoon, post-monsoon and monsoon.

STUDY AREA

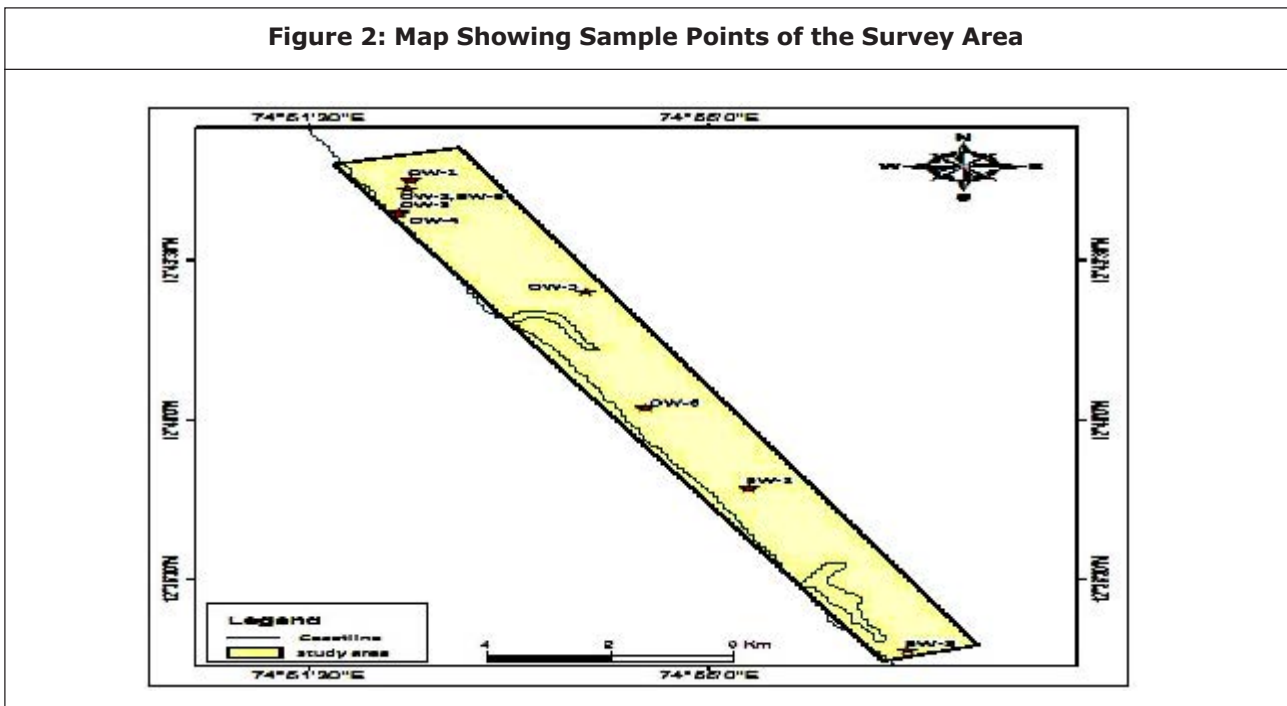
The study area includes the coastal stretch of about 30 km between Kumbala and Thalapady of Kasaragod district, Kerala state (Figure 1) bounded by latitudes and longitudes (1) Longitude 74.8613° and 74.9554°; (2) Latitude 12.5784° and 12.7663°. The area is an agricultural land consists of abundant coconut trees, mango trees, arecanut trees, cashew plants, bushes, herbs, etc. It is highly populated area. The lithology of the area is mainly quaternary formations and laterites with few outcrops of charnockites and gneisses. The area is well connected with

highway NH-17 which is passing nearby connecting Mangalore and Kasaragod. The major towns in study area include Manjeshwar, Uppala, Banthiyod, Hosangadi and Kumbala. The area enjoys a tropical climate with temperatures varies from 27°C to 40°C. The maximum temperature is experienced in the month of May and minimum in the month of July. The SW monsoon starts from June and ends in September and North West monsoon in October. The average annual rainfall of the area is about 2500 mm.

MATERIALS AND METHODS

Water samples at 7 locations from the study area are collected during pre-monsoon & post monsoon season (Figure 2). These wells include (1) Thalapady- open well (OW); (2) Kannuathiertha – 2 wells (one- open well and one bore sell); (3) Kannuathiertha beach – 2 open wells; (4) Manjeshwar – one open well; (5) Uppala open well; (6) Banthiyod (Bore well); and (7)

Figure 2: Map Showing Sample Points of the Survey Area



Kumbala (Bore well). The open well at first location – Thalapady – is 75 feet deep and is about 1 km east from beach and 30 m towards west from highway, the well is almost dried during summer. The waters of the well is used for domestic purposes and hotels. The two wells at Kannuatheertha is about 200 m west from N.H-17 and is in a laterite basin the waters of the wells are being used for agricultural activity. One open well is about 20 feet in deep and water is highly muddy, ferruginous and thin brown film is observed at the surface. The bore well at this point is about 60 feet deep. The wells at Kannuatheertha beach is 15 feet deep and one open well is being used for drinking purpose and is a clear water and water table is about 2 m from ground surface.

The other open well here is 20 m apart from the first one and water is brownish in color. The coconut plants irrigated by this water shows brown coating on the stem. The open well at Manjeshwar is about 200 m west from NH and near to canal. The well is 15 feet deep and water level is 2 m from ground surface and is very clear water and used for drinking purpose. The open well at Uppala is 50 feet deep and water level is 45 feet below the ground surface. It is about 300 m west from Uppala town. The water here is with sour taste which may be due to high Cu content and is not used for drinking purpose. The borewell at Banthiyod is 250 feet deep and have some H₂S smell. The bore well at Kumbala is 260 feet and the water is yellowish in color.

The pH and conductivity of the water samples were measured on the spot by digital pH tester pHep of Hanna Instruments and digital

conductivity meter of Aquapro. Trace elements and cations were detected in chemical laboratory, Geological Survey of India (GSI), Mangalore, by Atomic Absorption Spectroscopy (AAS).

RESULTS AND DISCUSSION

In any area, groundwater has unique chemistry due to several processes like soil/rock–water interaction during recharge and groundwater flow, prolonged storage in the aquifer, dissolution of mineral species, etc. (Hem, 1985). Moreover, detailed knowledge about geochemical process regulates groundwater chemistry is necessary to overcome the groundwater-related issues. (Subrahmani *et al.*, 2010)

Water containing more than 1,000 mg/L TDS is characterized principally by sodium and chloride ions, 500 mg/L to 1,000 mg/L displays a mixed composition, typically a calcium-bicarbonate or calcium/sodium-bicarbonate/chloride character, less than 500 mg/L TDS shows the broadest range of chemical composition, collectively a calcium-bicarbonate/sulfate to calcium-bicarbonate to sodium-bicarbonate character (Eric, Rechar *et al.*, 2003). When a well begins to draw in seawater, the concentrations of all dissolved ions increase, and chloride and sodium concentrations increase relative to bicarbonate and calcium concentrations, respectively and the water becomes unpleasant to drink, or even unpotable, and it may become unsuitable for irrigation or other uses as well (Philippa Aitchison-Earl *et al.*, 2003). Groundwaters of the India are mostly of calcium bicarbonate (Ca-HCO₃) type when the

total salinity of water is below 500 mg/L (corresponding to electrical conductance of 750 mS/cm. at 25°C). They are of mixed cations and mixed anion type when the electrical conductance is between 750 and 3000 mS/cm and waters with electrical conductance above 3000 mS/cm are of sodium chloride (Na-Cl) type (Jha, CGWB, 2010). BIS has recommended a drinking water standard for total dissolved solids a limit of 500 mg/L (corresponding to about EC of 750 mS/cm at 25°C)

The Electrical Conductivity (EC) of Pre- and post-monsoon water samples for the study area shows that it varies drastically (Table 1) e.g., at Thalapady, EC of pre-monsoon sample is 1080 μ S/cm and post-monsoon sample measures 260 (μ S/cm). A higher TDS/EC of water means there are cations and anions in the water (Thomas Harter, 2003). Waters with more than 500 mg/L TDS is not recommended for drinking purpose (US Environmental Protection Agency Guidelines). The high EC during pre-monsoon may be due to salt water influx in the aquifer due

to excessive usage of ground water during that period. The EC value decrease in post monsoon time due to dissolution of total dissolved solids with excessive rain water. The EC of post-monsoon samples varies from 120 (μ S/cm) to 770 (μ S/cm) (Table 2) and pre-monsoon water samples varies from 260 to 1630 μ S/cm. The pH of water samples varies from 6.5 to 8. At 500 m west of Banthiyod, the borewell water is having the smell of H₂S and a fine film of oil is found on water surface. EC of this sample is 770 μ S/cm in post-monsoon where is the open well water from the same area is having EC of 110 μ S/cm and is for drinking purpose. This shows that the ground water in the hard rock area is affected with slight incursion of seawater where surface open well water is not affected. Borewell water at Devinagar, Kumbala is characterized by presence of yellow precipitate and the color of the water is yellowish green. The open well waters at Kannuathiertha (near Thalapady) and one well at Kannuathiertha beach are characterized by reddish brown color. At Kannuathiertha beach,

Table 1: Physical Parameters Of Water Samples Collected During Pre-monsoon (May, 2010)

| S. No. | Sample No | Location | LAT | LONG | EC(μ S/cm) | TDS(mg/l) | PH |
|--------|-----------|----------------------|-------------|-------------|-----------------|-----------|-----|
| 1 | OW-1 | Thalappady | 12° 45' 15" | 74° 52' 24" | 1080 | 723 | 6.5 |
| 2 | BW-1 | Kannuathiertha | 12° 45' 04" | 74° 52' 22" | 1630 | 1092 | 8.0 |
| 3 | OW-2 | Kannuathiertha | 12° 45' 04" | 74° 52' 22" | 1510 | 1011 | 8.0 |
| 4 | OW-3 | Kannuathiertha Beach | 12° 44' 33" | 74° 52' 18" | 260 | 174 | 6.5 |
| 5 | OW-4 | Kannuathiertha Beach | 12° 44' 31" | 74° 52' 18" | 1080 | 723 | 6.5 |
| 6 | OW-5 | Manjeshwar | 12° 42' 48" | 74° 53' 56" | 550 | 368 | 6.5 |
| 7 | OW-6 | Uppala | 12° 40' 15" | 74° 54' 27" | 820 | 549 | 8.2 |
| 8 | BW-2 | Kumbala | | | 620 | 415 | 6.2 |

Table 2: Physical Parameters Of Water Samples Collected During Post-monsoon. November, 2010

| S. No. | Sample No | Location | LAT | LONG | EC(μ S/cm) | TDS(mg/l) | PH |
|--------|-----------|----------------------|---------------|-------------|-----------------|-----------|-----|
| 1 | OW-1A | Thalapady | 12° 45' 15" | 74° 52' 24" | 260 | 174 | 6.5 |
| 2 | BW-1 | Kannuatheertha | 12° 45' 04" | 74° 52' 22" | 300 | 201 | 6.5 |
| 3 | OW-2 | Kannuatheertha | 12° 45' 04" | 74° 52' 22" | 230 | 154 | 6.5 |
| 4 | OW-3 | Kannuatheertha Beach | 12° 44' 33" | 74° 52' 18" | 350 | 234 | 6.5 |
| 5 | OW-4 | Kannuatheertha Beach | 12° 44' 31" | 74° 52' 18" | 130 | 87 | 6.5 |
| 6 | OW-5 | Manjeshwar | 12° 42' 48" | 74° 53' 56" | 120 | 80 | 6.5 |
| 7 | OW-6 | Uppala | 12° 40' 15" | 74° 54' 27" | 300 | 201 | 6.5 |
| 8 | BW-2 | Kumbala | 12° 34' 56.9" | 74° 56' 44" | 250 | 167 | 7.5 |

coconut plants irrigated with this water becomes reddish in color. The open well water at Uppala is characterized by high Cu (600 ppb) and Ni (190 ppb) content (Table 3) and the trace elements of the all pre-monsoon water samples are (<5ppb) and Ca and Mg are well within the prescribed limit of drinking water standard (WHO, 2006), (Ca varies from 5 to 25 and Mg varies from 5 to 10 ppm). The EC values of water samples of pre-monsoon, it is inferred that open well waters

from Kannuatheertha (Near beach), Manjeshwar and Kumbala are below 600 μ S/cm and are good quality drinking water and there is no salt water influx. Whereas the open well and borewell waters from Thalapady (1080 μ S/cm), Kannuatheertha (1080 μ S/cm), Uppala 820 μ S/cm are affected with slight sea water incursion. Whereas the post-monsoon water samples of the study area are well within the drinking water limit (110 to 770 μ S/cm (BIS-Drinking water standard, 2012)

Table 3: Trace Elements and Cations Of Pre-monsoon Water Samples (May, 2010)

| S. No. | Sample No | Location | Cu(ppb) | Pb(ppb) | Zn(ppb) | Ni(ppb) | Co(ppb) | Cd(ppb) | Ca(ppm) | Mg(ppm) |
|--------|-----------|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 | OW-1A | Thalapady | <5 | <5 | <5 | 25 | <5 | <5 | 5 | <5 |
| 2 | BW-1 | Kannuatheertha | <5 | <5 | <5 | <5 | <5 | <5 | 6 | <5 |
| 3 | OW-2 | Kannuatheertha | <5 | <5 | <5 | <5 | <5 | <5 | 5 | <5 |
| 4 | OW-3 | Kannuatheertha Beach | <5 | <5 | <5 | <5 | <5 | <5 | 15 | <5 |
| 5 | OW-4 | Kannuatheertha Beach | <5 | <5 | <5 | <5 | <5 | <5 | 20 | <5 |
| 6 | OW-5 | Manjeshwar | <5 | <5 | <5 | <5 | <5 | <5 | 6 | <5 |
| 7 | OW-6 | Uppala | 600 | <5 | <5 | 190 | <5 | <5 | 5 | <5 |
| 8 | BW-2 | Kumbala | <5 | <5 | <5 | <5 | <5 | <5 | 25 | 10 |

CONCLUSION

Four pre-monsoon water samples (OW-1, OW-2, BW-1 and OW-3) from the study area are unsuitable for drinking purpose as the EC of these water samples crosses 1000 $\mu\text{S}/\text{cm}$ (BIS, 2012) whereas the water samples of post-monsoon are good for drinking purpose as the EC drastically comes down to below 300 $\mu\text{S}/\text{cm}$. It can be assumed that there is slight seawater intrusion during peak summer in the months of April and May and during monsoon the water is diluted with mixing of rainwater and the dissolved solids is minimized which is indicated by the low Electrical Conductivity in the post-monsoon water samples. One open well water at Uppala is characterized by high Cu and Ni (600 ppb and 190 ppb) content which may be due to industrial waste dumping in the nearby areas. Some of the heavy metals are extremely essential to humans, for example, cobalt, copper, etc., but large quantities of them may cause physiological disorders (CPCB, Delhi, 2008).

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