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Original Research Paper

Appraisal of Groundwater Quality Around two International Tourism Destinations, Kovalam and Vizhinjam, Thiruvananthapuram, Kerala, India

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ABSTRACT

The current groundwater state of Kovalam and Vizhinjam area was swot up in detail. The importance of these two places fetches much emphasis for the present study. Vizhinjam is the place where an international port is intended to come up and the pilot activities have already been set off. The Kovalam is the second spot which is an international tourism destination where owing to the invasion of hefty scale buoyant population, both the quality and quantity of groundwater, is being pretentious. While analysing the water quality, problems identified include the acidic water content, incident due to the low pH in the open wells and the microbiological contamination at multiple locations posturing peril to the locale. Imperative parameters, which have commanding influence were projected into a geospatial platform and primed various thematic maps. By integrating the thematic maps by assigning weighted parameter rating (WPR), a groundwater quality zonation map was also prepared. This map is ready to lend a hand to locate zones where good quality water is accessible. Apart from the anthropogenic blemish, the doable sources of geogenic contamination were also considered.

INTRODUCTION

Hydrology is the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas (Fetter 1990). Knowledge of hydrology is of basic importance in all problems that involve the use and supply of water. The quality of groundwater is usually determined by measuring the values of its physical, chemical and bacteriological characteristics. The quality of groundwater is controlled by several factors like climate, soil, circulation of groundwater through rock and saline water intrusion. The microbiological examination of water enjoys a special status in pollution studies, as it is a direct measurement of deleterious effects of pollution on human health. The microbiological examination is routinely conducted to ensure the safety of drinking water and also to evaluate forthcoming water resources for consumption purpose. The area investigated is located (Fig. 1) along the coastal stretch of Kovalam and Vizhinjam area of Thiruvananthapuram district bordering the capital city. Vizhinjam is the place where the international port is proposed and activities on the first phase have already commenced. Vizhinjam is unique as a navigational channel, since this is the place where the deepest natural channel is in close proximity with the coast, which makes the port attractive. Kovalam is a famous international tourism destination where thousands of foreigners visit every year. It lies between parallels of North latitude 8°22' and 8°25' and East longitude 76°57' and 77°1' in the Survey of India toposheet numbers: 58D/15NE and 58 H/3NW in 1:25,000 scales. The study area administratively falls in Neyyatinkara taluk of Thiruvananthapuram district. The major locations of the study area include Vizhinjam, Kovalam, Panathura, Venganur, Kaladichanmula and Muttakad. The study area is exceptionally populated, dug wells are the chief abstraction structures and very few tube wells were also found at certain locations. In most of the regions groundwater is primarily used for drinking and other domestic purposes.

The aim of the present study is to get on hydrogeochemical and microbiological analysis of groundwater to comprehend the quality of water and also to figure out the geology of areas and its influence on the water quality. Various physico-chemical parameters were analysed (APHA 1995) and results have been summarized in Table 1. To measure the suitability of groundwater, the hydrogeochemical parameters were compared with the guideline values recommended by the Bureau of Indian Standards (BIS 1991). A water quality zonation map was prepared to depict the general nature of water for drinking purpose.

MATERIALS AND METHODS

For the determination of the quality of the water for the drinking and domestic purposes, water samples were collected from 49 open wells and one bore well. For microbiological analysis, water samples were collected from five open wells. The analytical methods used for the present study include the spot measurement of groundwater pH using a spot digital pH tester, followed by titration, flame photometry and spectrophotometry. For microbiological analysis also, the

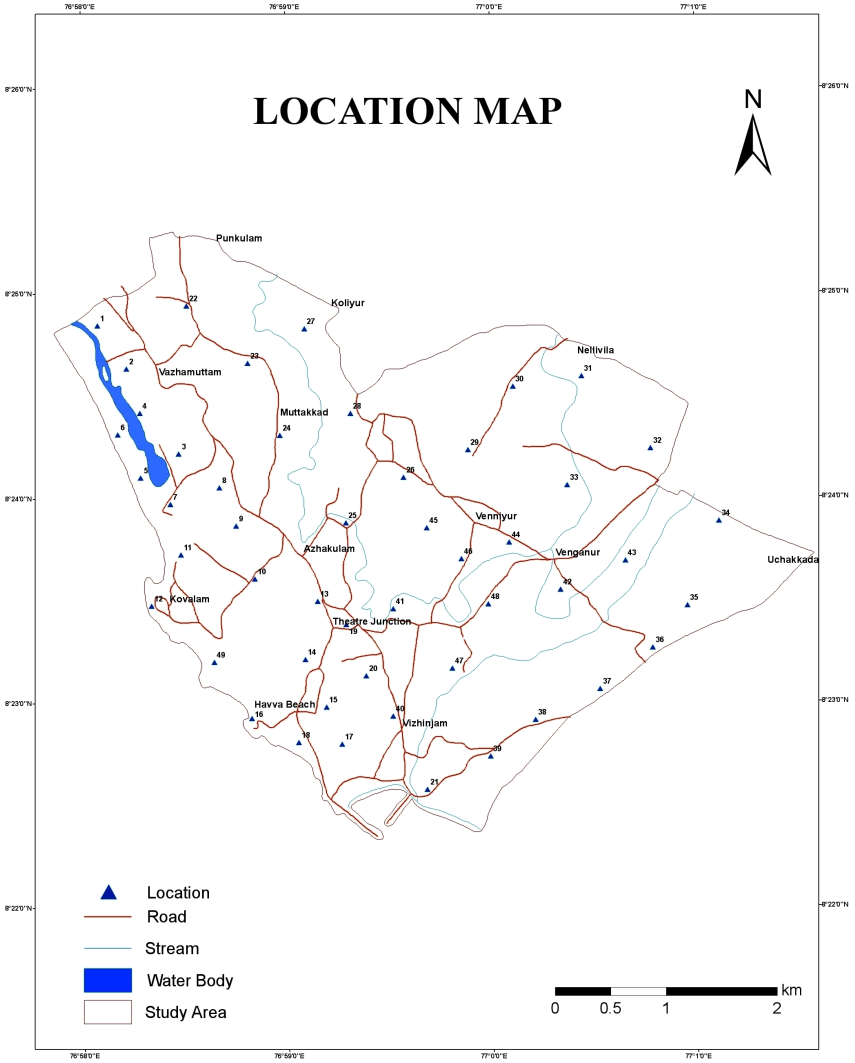

Fig. 1: Location map of the study area and sampling stations.

standard procedures were adopted. Groundwater quality zonation map was prepared in GIS platform using Arc GIS 9.1 software by overlaying individual layers (Fig. 2).

RESULTS AND DISCUSSION

Geologically, the area is covered by coastal alluvium, below which Paleogene sequence is observed (CGWB 2003). Laterite exposures are common in the area. Major rock type is massive Charnockite. Anomalous pH values were observed in multiple locations and the variation is from 4.1 to 7.4 with a mean of 5.85 indicating an idiosyncratic acidic trend. Lowest pH value of 4.1 was obtained from Muttakad and highest pH value of 7.4 from Panathura. The presence of shallow laterite aquifer (Binoj & Divya 2012) in the area is the prime culprit for the creation of acidic groundwater (Anseena & Binoj 2011) in the region. The bore well (BW) water from Vattavila gives a value of 6.9 demonstrating that the deep aquifers are not affected by the acidic pH dilemma. From this, it is palpable that the open well water is mediocre in quality, while the other water bodies are not indicating much intimidation. However, most of the people residing in Vizhinjam and Kovalam are habitually depending upon open wells to meet up their drinking demands without knowing the quality worsening and this may pose a serious menace.

Electrical conductivity show slight variations, i.e. from 100 µS/cm at Venganur to 6810 µS/cm at Panathura, with a mean value 837.714 µS/cm. This shows that the water quality varies from excellent to permissible in character with respect to BIS standards. The highest EC may be due to ex-

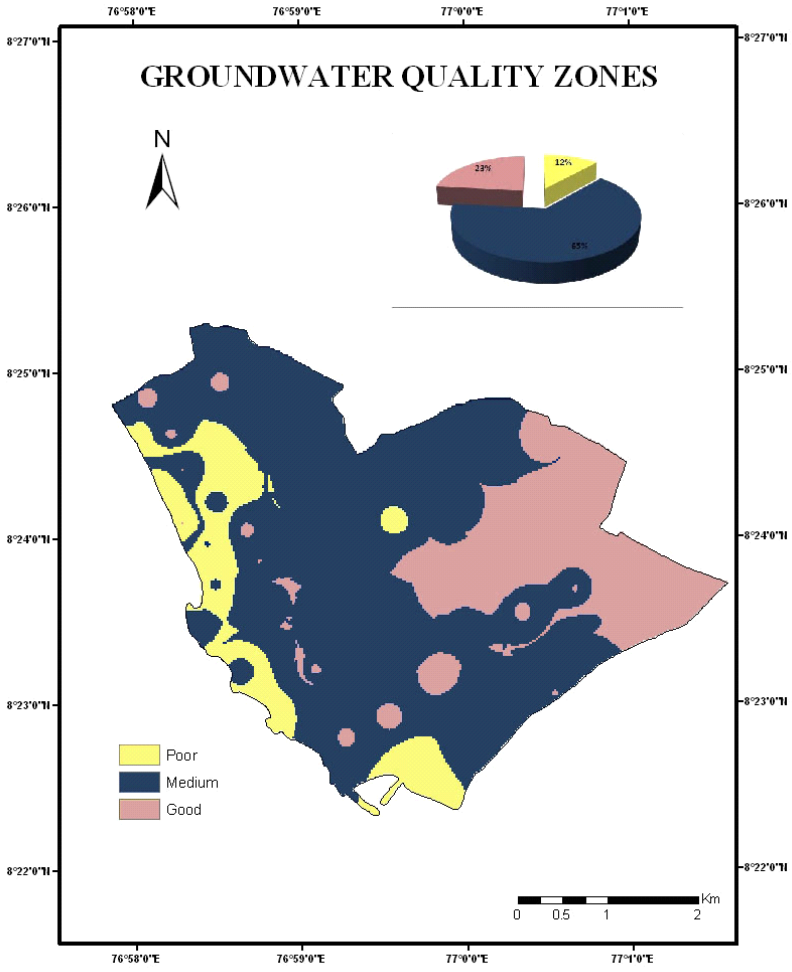

Fig. 2: Groundwater quality zones.

cess of dissolved salt by means of salt water ingress. TDS varies from 50.8 mg/L to 3470 mg/L with a mean value of 424.808 mg/L. The lowest value of TDS is 50.8 mg/L, which is obtained from Venganur and highest value of TDS 3470 mg/L was obtained from Panathura. Bore well water collected from Vattavila gives a value of 295mg/L. In the present work the hardness ranges between 10 mg/Lto 320 mg/L with a mean value of 92.347 mg/L. The lowest value of total hardness 10 mg/L is obtained from Venganur and higher value of 320 mg/L from Vizhinjam, while values measured of bore well water sample at Vattavila shows a total hardness of 90 mg/L.

The salinity values of open well water samples range from 0.06 ppt to 2.07 ppt with a mean value of 0.4083 ppt. The lowest value of salinity 0.06ppt is obtained from Venganur, and the 2.07ppt from Panathura. Chloride ion concentration ranges from 21.3 mg/L to 1793.5 mg/L with a mean value of 158.86 mg/L. Lesser chloride value 21.3 mg/L is obtained from Kidarakuzhi and higher value 1793.5 mg/L from Panathura. All the values fall within the BIS limit (250-1000), except Panathura. The bore well water sample from Muttakad shows 85.2 mg/L of chloride. The chief sources of sulphate are sulphur minerals. Sulphide of heavy metals occurs in the igneous and metamorphic rocks and gypsum and anhydrite found in some sedimentary rocks. Also the oxidation and hydrolysis of pyrite produce sulphuric acid and soluble sulphate. Apart from these natural sources, sulphates can be introduced through the application of sulphatic soil conditioners. Climate has an important bearing on the accumulation of sulphate in the soil and

Table 1: Water quality analytical data of Vizinjam and Kovalam Area.

Parameter		Groundwater	Bore well water	BIS standard	
				Highest desirable	Maximum permissible
pH	Range	3.7-6.1	4.8-5.3		
	Mean	4.63	5.82	6.5-8.5	6.5-8.5
EC (µS)	Range	47.8-797	87.8-388		
	Mean	210.19	247.66		100
TDS (mg/L)	Range	24.6-403	43.9-197		
	Mean	108.47	125.57	500	2000
Salinity (ppt)	Range	0.02-0.8	0.04-0.19		
	Mean	0.15	0.12		
Hardness (mg/L)	Range	5-125	30-105		
	Mean	30.93	69.29	300	600
Bicarbonate (mg/L)	Range	10-125	15-40		
	Mean	28.56	25.71	300	600
Na (mg/L)	Range	5-58	4-26		
	Mean	23.87	15.43	50	200
K (mg/L)	Range	0-16	1-4		
	Mean	3.29	2.14		
Ca (mg/L)	Range	0-40.08	0-20.04		
	Mean	7.52	11.45	75	200
Mg(mg/L)	Range	1.19-21.85	1.2-25.51		
	Mean	4.09	10.75	30	60
Cl (mg/L)	Range	7-99.4	31.95-81.65		
	Mean	42.28	49.7	250	1000
NO_3 (mg/L)	Range	0-11.05	0-5.47		
	Mean	3.49	1.92	45	100
SO_4 (mg/L)	Range	3.1-18.74	3.24-4.81		
	Mean	3.67	3.71	200	400
PO_4 (mg/L)	Range	0	0	-	-
	Mean	0	0	-	-

groundwater. In humid regions, the sulphate may be removed with the runoff, whereas in arid and semi-arid regions the sulphates may accumulate in the surface and in groundwater due to low precipitation and inadequate drainage. Here, the amount of sulphate varies from 3.15 mg/L to 111.3 mg/L with a mean value of 24.753 mg/L in the case of open well water samples. The lower value 3.15 mg/L was obtained from Nellivila and higher value 111.3 mg/L from Kovalam beach. On the other hand the bore well water obtained from Vattavila shows only 48.78 mg/L.

The presence of carbonic acid is indicated if the pH is less than 4.5, bicarbonate if the pH is between 4.5 and 8.2 and carbonate if the pH is above 8.2. No trace of carbonate was found in any of the samples collected from the study area. Whereas bicarbonate values of open well water range from 0.1 mg/L to 3.4 mg/L with a mean value 0.684 mg/L. The lowest value of total alkalinity 0.1 mg/L was obtained from Kovalam beach. The highest value 3.4 mg/L was obtained from Panathura, while bore well water collected from Vattavila shows considerable bicarbonate value of 0.6 mg/L. Phosphate concentration in open well water samples ranges from 0 to 0.53 mg/L with mean value of 0.0155 mg/L. Phosphate is detected in places such as Vattapara and Vizhinjam and higher value 0.53 mg/L is obtained from Vizhinjam. Nitrate concentration of open well water samples varies from 0 mg/L to 17.913 mg/L with a mean value of 6.57 mg/L. The lower value 0 mg/L is obtained from Panathura and higher value 17.913 mg/L is obtained from Ambalkulam. At Vattavila the bore well water shows 0.225 mg/L of nitrate. It is worth to note that a value above 15 mg/L should be viewed with care because it can lead to contamination in the near future.

Calcium concentration of open well water samples vary from 0 mg/L to 72.14 mg/L with a mean value of 15.767 mg/L. The highest value was obtained from Vizhinjam. At Vattavila the bore well water shows 16.032 mg/L of calcium. Foremost minerals bearing magnesium are olivine, augite, biotite, hornblende, serpentine and talc. Even though in igneous and metamorphic rocks magnesium occurs in the form of insoluble silicates, weathering breaks them down into more soluble carbonates, clay minerals and silica. Hence, the magnesium content in groundwater achieves abundant range. Magnesium concentration of the open well water in the study area ranges from 1.2 to 54.66 mg/L with a mean

value of 13.78 mg/L. Higher value of magnesium at 54.66 mg/L was perceived in Panathura. At Vattavila, the bore well water sample shows a value of 12.13 mg/L. Momentous magnitude of sodium is found in natural waters. Virtually all sodium salts are highly soluble in water and once leached from rocks and soil they hang about in solution. Foremost source of Na^+ in groundwater is plagioclase feldspars, feldspathoids and clay minerals. Sodium has a propensity to get absorbed on the clay particles but may efficiently be exchanged by Ca^{2+} and Mg^{2+}. Sodium concentration varies from 4 mg/L to 185 mg/L with mean value of 42.08 mg/L in the case of open well water samples. The lower value 4 mg/L was obtained from Venganur and higher value of 185 mg/L from Panathura. At Vattavila, the bore well water sample show 49 mg/L of sodium. The frequent source of potassium is the silicate minerals orthoclase, microcline, nepheline, leucite and biotite in igneous and metamorphic rocks. Though potassium is nearly as copious as sodium in igneous and metamorphic rocks, its concentration in groundwater is one-tenth to even one-hundredth that of sodium. Resistance of potassium minerals to decomposition and fixation of potassium in clay minerals are the reasons for the slighter amount of potassium. The results obtained show that potassium concentration varies from 0 to 29 mg/L with a mean value of 4.224 mg/L. Higher value of 29 mg/L was obtained from Vizhinjam. The concentration of potassium varies from 1 mg/L or 10 mg/L to 15 mg/L in potable water (Karanth 1987). Here, the values of potassium are considerably higher in areas including Vizhinjam and Panathura. At Vattavila the bore well water sample contains 0.4 mg/L of potassium.

Microbiological analysis of groundwater shows sizeable presence of coliform bacteria. This may be due to leakage from septic tanks, sewages or offal holes from nearby areas, and also due to the pervasiveness of open defecation at certain settings (Binoj & Anet 2012). Microbial analysis was done for five groundwater samples, in which four show the presence of *E. coli*. Number of *E. coli* varies from 0 to 183 per 100mL. Highest concentration was noticed from the sample collected from Vattapara. The biological pollution is predominantly owed to the nearness of the unscientifically constructed septic tanks to the dug wells and open defecation practice which is pretty frequent in coastal belt. Distance between the septic tanks and wells is minimal and being an alluvial area, migration of these bio-pollutants are expected in these areas. Local people are consuming this water without knowing this biological pollution. Diarrhoea and related diseases are common in some portions of the study area especially during rainy season. *E. coli* contamination in shallow groundwater is observed in the samples collected from Kuzhivilakam (1), Vattapara (183), Panathura (6) and Kovalam Palace (126). The present sampling was done in summer season and the degree of pollution will amplify many folds during rainy season. Highest concentration of coliforms is obtained from Vattapara (183 colonies) which is located near a septic tank. *E. coli* reported from the well in Kovalam palace (126 colonies) is located adjacent to the coastal side. Hotel wastes are dumped near to this well from which leakage occurs and pollute the groundwater nearby.

Based on the analytical data, a groundwater quality zonation map was prepared by assigning suitable rank and weightages by following weighted parameter rating (WPR) method (Binoj & Divya 2013), to relevant water quality parameters, which do have explicit control on the quality of the water in the region. The pH values exceeded the highest desirable limit of BIS at many places and hence this is taken as the key parameter for the preparation of groundwater quality zone map. Zonation map was prepared in GIS platform using Arc GIS 9.1 Software by overlaying individual layers (Fig. 2). The groundwater zonation maps were prepared by means of GIS tool for various parameters like pH, EC, TDS, Mg and Cl. The maps reveal that 65% of the study area lies in moderate category, 23% in good category, and 12% in poor category.

CONCLUSION

As the two areas considered are of towering connotation, the quality of water in this province needs a great deal of care. The study make obvious that groundwater in copious parts of the area is by now polluted. The pH problem stands eminent posturing peril of gastrointestinal exertion for the people within this sector. Similarly, there is an intimidation of saline water infringement by the side of the coast. An additional foremost problem is the microbiological contamination of groundwater. This dilemma desires to be attended prudently in the early hours. Effectual water managing tactics necessitated to be espoused for this province altogether for the wellbeing of people.

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