Marine Pollution Bulletin 78 (2014) 118–129

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Source speciation resolving hydrochemical complexity of coastal aquifers

Sahebrao Sonkamble *, Subash Chandra, Shakeel Ahmed, R. Rangarajan

Indo-French Centre for Groundwater Research, CSIR-National Geophysical Research Institute, Hyderabad 500 007, India

ARTICLE INFO

Keywords:
Hydrochemical complexity
Seawater mixing percentage
Industrial effluent
Source speciation
Coastal aquifers
Southern India

ABSTRACT

There is a growing concern of seawater intrusion to freshwater aquifers due to groundwater overexploitation in the eastern coastal belt of Southern India. The problem becomes complex in the regions where industrial effluents are also contaminating the freshwater aquifers. In order to understand the hydrochemical complexity of the system, topographic elevation, static water level measurements, major ion chemistry, ionic cross plots, water type contours and factor analysis were applied for 144 groundwater samples of shallow and deep sources from Quaternary and Tertiary coastal aquifers, located within the industrial zone of 25 km^2 area near Cuddalore, Southern India. The ionic cross plots indicates dissolution of halite minerals from marine sources and seawater mixing into inland aquifers up to the level of 9.3%. The factor analysis explains three significant factors totaling 86.3% of cumulative sample variance which includes varying contribution from marine, industrial effluent and freshwater sources.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

The increasing population, expansion of irrigation activities and growing industrialization are causing severe stress to groundwater regime particularly in the coastal belts. Acute shortage in freshwater supply led 40% increase of groundwater usage in domestic sector on worldwide where roughly half of the world's population dwells within 50 km of the coastline (Alexander and Driss, 2003; Hodges et al., 1993; Von and Turner, 2001). The coastal aquifers are fragile, experiences great stresses and depleting due to overexploitation of groundwater resources (Khair et al., 1994); causing salinization from diverse sources (Falgas et al., 2009); halite dissolution (Hidalgo and Cruz-Sanjulian, 2001); seawater intrusion (Sanford and Pope, 2010); industries and other anthropogenic contamination (Westbrook et al., 2005; Sankaran et al., 2010, 2012; Sonkamble, 2012; Sonkamble et al., 2013a, 2013b, 2013e) etc. Among these, seawater intrusion is the common problem in coastal areas that force the abandonment of drinking water wells in many instances (Giordana and Montginoul, 2006). The coastal aquifers being highly porous in nature, are more vulnerable to the rapid spread of the contaminants in case of heavy pumping (Rezaei et al., 2005; Dyer and Behnke, 1968; Kafri and Arad, 1979; Appelo and Willemsen, 1987; Dixon and Chiswell, 1992; Iribar et al., 1997; Milnes and Renard, 2004; Jorgensen et al., 2008; Datta et al., 2009; Gattacceca et al., 2009; Post and Abarca, 2010; Zhang et al., 2011; Nguyen et al., 2012).

Many industries settled in the coastal belts on worldwide for the reasons such as inexpensive availability of water resources, proximity of coast for ocean dumping of effluents, and ease of transportation through sea ways. The lack of effluent treatment plants (ETP), nonfunctioning ETP, and open dumping of wastes by industrial units in many instances drives chemical pollution of shallow aquifers, especially in developing countries like India. Chemical pollution, particularly gypsum in phreatic aquifers of coastal areas had been studied by Ogden and Collar (1989), Tellam (1994), Mitchel et al. (2000), Sharif et al. (2008), Wang and Jiao (2012). However, the combined effect of seawater intrusion and industrial pollution in coastal aquifers are rarely studied. Identifying the point sources of pollutants within the complex hydrochemistry is imperative and become acute environmental issue to be addressed for coastal aquifer management. Geophysical applications to determine the point sources of pollution in homogeneous aquifers were found failure in many instances due to poor contrast in geophysical anomaly (Sonkamble et al., 2013c, 2013d). However, chemical scanning using major ion chemistry can be adapted to determine the sources of pollutants such as Na^+ and Cl^- (seawater intrusion) and Ca^{2+} and SO_4^{2-} (gypsum contamination).

Shallow and moderate depth groundwater resources up to 100 m depth in coastal belt of Tamil Nadu state, India are being utilized for drinking and irrigational needs. Several industrial activities are in operation near the long east coastline of this state. State Industries Promotion Corporation of Tamil Nadu (SIPCOT) is a civic body oriented to provide infrastructure for the industrial units. Some of the closed industries in the recent past have continuously dumped scrap and chemicals like gypsum, sulfuric acid,

* Corresponding author. Tel.: +91 9441455291; fax: +91 40 23434651.
E-mail address: sahebrao.ngri@gmail.com (S. Sonkamble).

0025-326X/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.marpolbul.2013.10.052

sulfur, lime, pesticides and other raw materials, which were the prime sources of subsurface pollution in the Cuddalore SIPCOT area. Seven out of nine industries proposed for SIPCOT are under "Red" category securing its place in the dubious club of 'Global Toxic Hotspots' owing to the area's high levels of pollution (Palaniswamy, 2002). The effluent generation in this industrial area from all the functioning industries is around 800 kilo liters per day (Jonathan et al., 2008). Many sewerages and industrial wastes are discharged directly into the Uppanar River, which flows parallel to the coast line. There are exploitation pressure on this limited groundwater resources and growing concern of deterioration of groundwater quality due to anthropogenic activities such as unplanned disposal of industrial effluents, sewerage, etc. The increase in groundwater extraction from wells have caused deep water table condition and has generated hydrodynamic imbalance between fresh and saline water resources, inducing salt water intrusion into fresh aquifers in the Cuddalore area (Kalimas and Gregorauskas, 2002; Sherif and Singh, 2002).

The source speciation and hydrochemical zonation is mandatory in coastal aquifer system partly affected by industrial pollution. This study will stand as decision support tool to pollution control authorities for coastal aquifer management and to resolve issues on social conflicts. This paper dealt with hydrochemical zonation and source speciation through micro-level integrated study at an industrial complex area in the coastal belt of Cuddalore district, Southern India.

2. Study area

The study area (Latitudes 11.62° to 11.70° N and longitudes 79.72° to 79.78° E, 25 km^2) falls in East Coastal belt, located within the industrial complex area of SIPCOT, Cuddalore in the state of Tamil Nadu, India. It is 25 km south of Pondicherry, 8 km south of Cuddalore town and 1–2 km from the coast line (Fig. 1). The average annual rainfall of the area based on long term data (for 33 years from 1975 to 2008) is 1200 mm. The area experiences both southwest (August to October) and northeast (November to January) monsoons contributing 59% and 29%, respectively. Uppanar River flows from south to north has high salinity (mean Total Dissolved Solid: 28,870 mg/l) due to back waters from Bay of Bengal as well as discharge of industrial and domestic effluents. Geomorphologically, the area is classified as the coastal landforms, consisting of sand dunes, beach ridges and coastal plain. The alluvial soil is mainly sand with admixtures of fine silt and clay. Geologically, the area is covered by Quaternary (Recent alluvium) formations such as beach sands, clay, silts, gravel, pebbles (0–100 m depth), underlain by Tertiary sediments (100–300 m depth). The Tertiary formations are Cuddalore Sandstone of Mio-Pliocene age, having fluvial to brackish deposits of clay, sand, gravel, pebbles and lignite. Groundwater occurs as shallow unconfined to semi confined conditions in alluvium aquifers and confined conditions in Tertiary formations. The shallow sandy unconfined aquifer occurs from 3 to 35 m bgl. It is highly permeable, gets adequately recharged during the monsoon season.

3. Material and approach

A systematic integrated study encompassing topographic survey, water table monitoring, and major ions chemistry of surface and subsurface water samples with dense data coverage were carried out. Static water level measurements were taken during pre-monsoon (June 2008) and post-monsoon (January 2009). A total of 143 key wells (bore wells, tube wells and hand pumps) were established in and around the SIPCOT area (Fig. 2a). The GPS (Garmin 72 channel) used for geo-referencing and reduced level survey was carried out at 150 locations with grid size of 0.167 km^2 for more precise measurement of surface elevation using Differential Global Positioning System (DGPS, Trimble R3). Total 166 groundwater samples collected from 144 shallow (max 35 m depth) and 16 deep (max 300 m depth) wells, and 6 surface water (Uppanar River) samples to characterize the chemical status of the groundwater during pre- and post-monsoon period (Fig. 2b). The samples

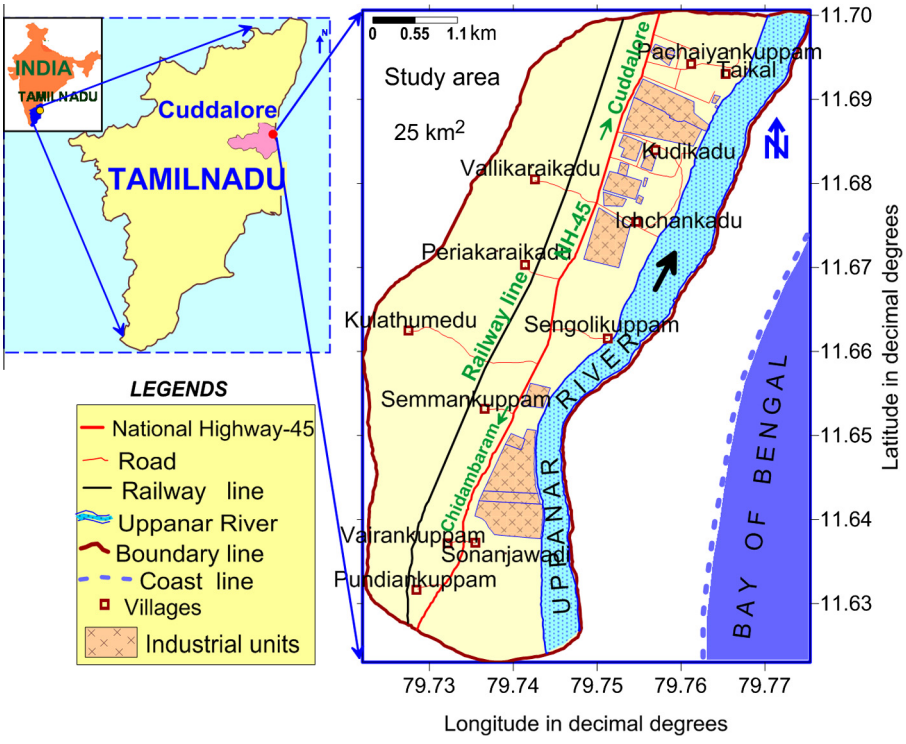

Fig. 1. Location map of the study area, SIPCOT Cuddalore, Southern India.

Download English Version:

https://daneshyari.com/en/article/6359213

Download Persian Version:

https://daneshyari.com/article/6359213

Daneshyari.com