Volume-4, Issue-5, May-2015 • ISSN No 2277 - 8160

Research Paper Engineering

Ground Water Salinity Trend Analysis in Nag and Bhukhi Watersheds, Kachchh District, Gujarat.

Sagar. V. Nimavat	Student, M. E. Water Resources Management, Civil Engineering Department, L. D. College of engineering, Ahmedabad-380015, Gujarat.
Mahendrasingh Gadhavi	Assistant Professor, Civil Engineering Department, L. D. College of engineering, Ahmedabad-380015, Gujarat.
A.K. Sharma	Scientist, Space Application Centre, ISRO, Ahmedabad-380015, Gujarat.

ABSTRACT

Analysis of ground water quality data over a period of 20 years is carried out to understand the trend of salinity variation for Nag and Bhukhi watersheds located in coastal region of Kachchh District, Gujarat. The study is specific reference to Lithology with the use of Remote Sensing (RS) and Geo-graphic Information System (GIS) techniques. The two watersheds were characterized based on observed changes in groundwater levels and salinity by using linear trends fit to well-monitoring data of 1994 to 2013 period for 13 observation wells. Ground water aquifer region having TDS values higher than 2500 ppm is identified as not utilizable for drinking, domestic, industrial and agriculture use. The total area having TDS value more than 2500 ppm is monitored to estimate the percent area extent changes over a period of time in GIS environment. Area above 2500 ppm in 1994 was 13.97% and it increase till 2010 and in 2010 it was 30.40%, but it is decrease to 5.65% in 2013.

KEYWORDS : Total Dissolved Solids (TDS), Water level below ground level, Lithology, Mundra region, Geo-graphic Information System (GIS) and Remote Sensing (RS).

INTRODUCTION

Wa ter is essential and one of the valued natural resources of this planet and groundwater is an important source of water supply throughout the world[1]. Water is a prime need for human survival and industrial development and ground water is also considered as the only source of drinking water in many rural and small communities[2]. Water is a very vital resource on earth gifted by nature and a very essential resource for any type of development worldwide. Water resource is available as surface water and groundwater resources[3]. Groundwater is most sustainable and reliable resource than surface water. Availability of groundwater depends on local hydro-geological condition[4]. Any type of economic development depends on land and water resource potential of the area. Here groundwater as water resource becomes more priority due to easy accessibility. The problems of arid regions' in terms of water resource availability and its potability need special attention[4]. Scanty rain and paucity of resource, water crisis always remain as main natural hazard for the any region. Kachchh located towards western side of Gujarat is an arid region characterized by water crisis and repetitive drought cycles. It has a very low potential of surface and potable groundwater resources. Hydro-geologically, Kachchh is bestowed with huge pile of sedimentary sequence. However, most of the geological formations are deposited in marine environment having inherent salinity. Therefore, availability of potable groundwater is highly restricted. Only Bhuj Formation sandstone of Cretaceous period has been deposited in fluvial environment. Along with this, Kankavati Formation sandstone of Tertiary age also provides good quality groundwater in coastal track of the district. These two aquifers are backbone for drinking and irrigation water supply. The overall resource potential of the region, mainly coastal resources becomes one of the most added attraction and ideal regions for industrial development. The study area had shared the maximum industrial investment amongst other regions of Kachchh. Along with industrialization, population and basic infrastructure have also grown. Resultantly, manifold increase in industrial and domestic water demands have put groundwater resource of the region under tremendous stress and also adversely affected long practiced agricultural industries of the region. Area being coastal region, over exploitation of groundwater has invited the threat of seawater intrusion in the aquifers having considerable environmental implications[10].

LOCATION OF THE STUDY AREA:

The study area is geographically extended from 22^{0}42'00" to 23^{0}12'00" north latitudes and 69^{0}26'46" to 69^{0}57'00" east longitude approximately. The parts of study area watersheds administratively fall in Bhujtaluka in the north, Anjartaluka in the northeast, Mandvitaluka in the west and by the Gulf of Kutch in the south. A system based model study is carried out for ***Nag (5H2B4)*** and ***Bhukhi (5H2B5)*** watershed comprising total 139 micro-watershed, 114 villages and covering 1547.79 km^2 area.

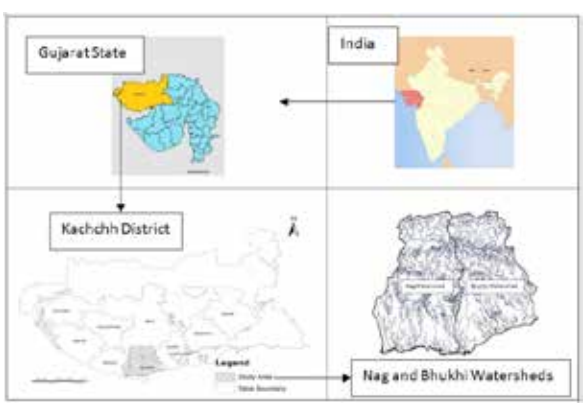


Figure 1: Location of the study area

OBJECTIVE OF THE STUDY:

The main objective of research is to carry out an in-depth study on analysis of ground water salinity trends in coastal region with specific reference to Lithology of Nag and Bhukhi Watersheds, Kachchh District, Gujarat.

SCOPE OF THE STUDY:

- Preparation, collection and compilation of various theme layers like Watershed Map and Lithological Map.
- Watershed characteristics through Analysis of theme layers.
- To study dynamics of Ground-water salinity and ground water levels in the spatial and temporal context with reference to Lithology and Geo-morphology using Remote Sensing and GIS techniques and available models.

DATA USED:

Multi-date remote sensing data corresponding to the Kharif, Rabi and Summer seasons are used for the study. The conventional data collected in the form of published maps, reports, charts, etc. from Central Government Organizations and state Government line Departments is also used for the study.

Satellite Data
IRS and LANDSAT data corresponding to Rabi, Kharif and Summer season for the period 1994 to 2014 is used for the study.

Collateral Data
- Village boundary maps, Taluka / Block maps and Settlement locations from District Administration.
- Watershed boundary map at 1:50,000 scale.
- Hydrological data mainly observation well information on ground water level quality fluctuation from Gujarat Water Resources Development Corporation (GWRDC) from 1994 to 2014.
- Published Geological and geological structures maps from Geological Survey of India and Oil and Natural Gas Commission.

THEME LAYERS PREPARATION
Watershed Map generation
The watershed map is prepared using the information on drainage and slope/elevation (Fig.2). The shape of watershed, area is a significant indicator for understanding the behavior of rainfall runoff and also the nature of geological control on the watershed. For the study purpose, the watersheds have been classified into five levels of hierarchy namely Region, Basin, Catchment, Sub-catchment and Watersheds as per the methodology given by the All India Soil And Land Use Survey (AIS&LUS) in the Watershed Atlas Of India [5].

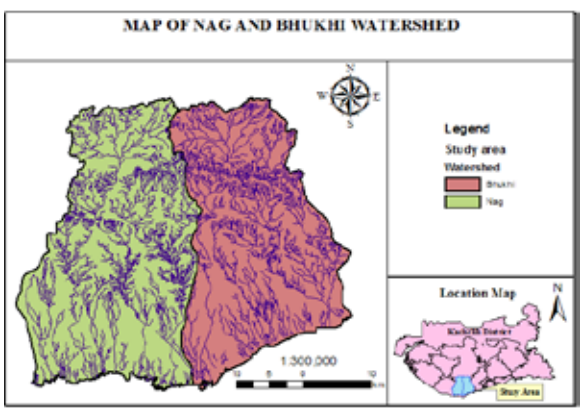


Figure 2: Watershed Map

Lithology Map generation
The lithological map is prepared using satellite data and available maps from Geological Survey of India (GSI) and Oil and Natural Gas Commission (ONGC) (Fig.3). The various litho units have been strati graphically identified with the available published maps and accordingly classified into litho-stratigraphic units. The available litho-stratigraphic boundaries obtained from published maps have been modified as per image signature at the micro level. As per the study, vesicular basalt is a dominant litho-stratigraphic unit occupying 40.16 percent of the study area followed by sand stones which occupy 39.79 percent of the study area. Other litho-stratigraphic unit occurring in the study area are Madh, recent clay, sandy clay occupying 20.05% of the study area.

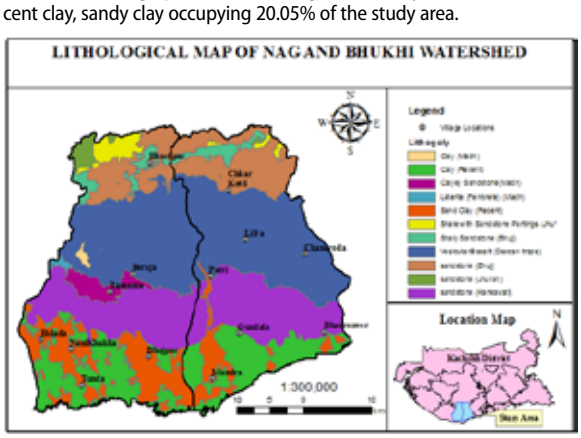


Figure 3: Lithology of the Nag and Bhukhi watershed.

GROUND WATER FLUCTUATION ANALYSIS
Groundwater fluctuation has been analyzed based on historic data collected from GWRDC over a period of 1994-2013. Secular change in water level fluctuation has been analyzed through isobaths map, hydrographs for all 13 locations of observation wells with reference to Lithology at 4 year interval.Average Groundwater levels in the area ranges from 9.9 m to 60.5 m below ground level. It is observed that ground-water level in the study area is declining at an average of about -1 m/yr. The average rate of decline of ground water level in Nag watershed is 15 m/year which is higher as compared to Bhukhi watershed having decline rate of 2.5 m/year.

Ground water level fluctuation hydrograph
- The well hydrographs of Bharapar and Chakar shows gradual increase in water levels. These villages are belong to Bhuj sandstone. It is has been established that the seasonal water level fluctuation is purely rainfall dependent.

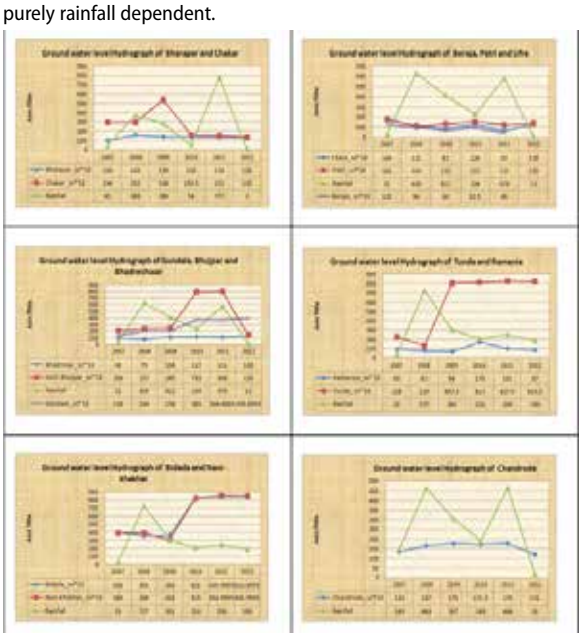


Figure 4: Ground water fluctuation Hydrograph
- The villages of Vesicular Basalt aquifer shows mixed order of fluctuation. Villages like Beraja, Patri and Lifra shows increase in water level on other side, Villages like Ramania and Chandroda shows decrease in first decade but in last decade show increase in water level.
- The hydrographs of Kankavati Sandstone are suggestive of groundwater depletion in spite of area observed high rainfall since year 2006. The observation wells situated in western part of the study area viz, Bhujpar, Tunda represent a case of over exploitation. Whereas, observation wells situated in eastern part like Bhdreshwar village show stability in water levels which, may be attributed to specific and perennial recharge conditions.

Ground water level Isohyets
- Hydro-isobath map (Fig.6) for phase (1994 – 2006) is the period prior to industrial development representing water demand in irrigation and domestic sectors. However this represented 12 years scenario display quite an alarming situation of lowering of water table in the study area. Although approximately 50% of the study area has witnessed rise in water table, remaining 50% study area has suffered from the problem of water table decline. Hydro-isobath map.

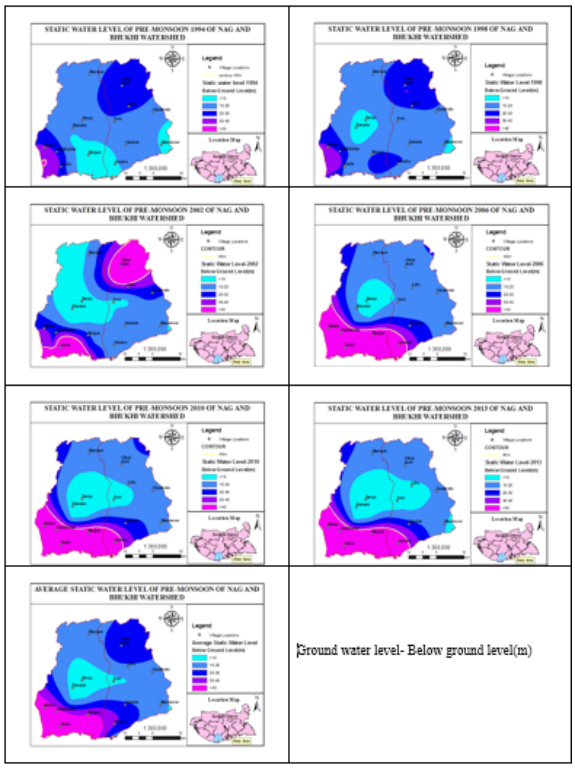


Figure 5: Ground water level Isohyets

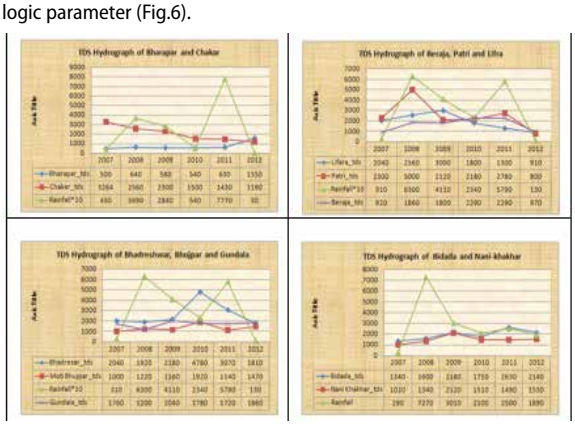
• Representing phase (2006-2013) demonstrate further deteriorating situation of groundwater storage. There has been a perceptible rise in all the categories pointing to lowering of groundwater levels. Even the area showing rise in water table for the period (1995-2005) has reduced significantly. This sharp decline particularly the categories >40 m depletion during 8 years i.e. (2006-2013) may be ascribed to rise in industrial and domestic demands as a part of industrial development in the study area.

GROUND WATER SALINITY ANALYSIS

Salinity trend in ground water has been analyzed based on historic data collected from GWRDC over a period of 1994-2013. Secular change in TDS has been analyzed through isobaths map, hydrographs for all 13 locations of observation wells with reference to Lithology. Ground water salinity in the Nag and Bhukhi Watersheds ranges from 740 ppm to 2740 ppm below ground level. The ground water salinity in the area is increasing on an average of about 27 ppm/year. The average TDS in Nag watershed located at western part is increasing at rate of 313 ppm/year and in Bhukhi watershed average rate of TDS is decreasing at a rate of 157 ppm/year, located at eastern part of the region.

Ground water salinity fluctuation hydrograph

Study through well hydrograph is considered to be the best technique to visualize the change in seasonal patterns of any hydro-geologic parameter (Fig.6).



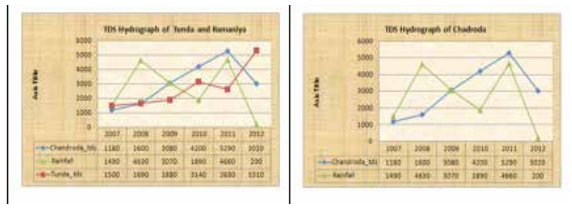


Figure 6: Ground water salinity hydrographs.

- TDS well hydrograph for Bhuj formation sandstone at Bharapar indicate stable to slight increase in TDS over a period of 15 years, but after 2010 it shows increasing trend. Observation wells at Chakar village, TDS concentration show marginal increase after 2006. But later there has been a bit decrease due to continual good rainfall in the study area after year 2010.
- Well hydrographs of basalt indicate high fluctuation in TDS content, but overall it is stable.
- Well hydrographs of kankavati formation sandstone show overall increasing trends. In western part, the observation wells at Tunda and Nani-khakhar villages show gradual increase. In eastern part, the observation wells at Bhadreshwar TDS content show decrease, but overall it is stable to slightly decrease in eastern part.
- Overall secular change in TDS from year 1994 to 2013 show most of the study area has suffered from ground water quality deterioration, where in the TDS has been rise between 740 ppm to 2740 ppm. This simply points to over exploitation of groundwater resources.

Ground water salinity Isohyets

Isobaths map considered to the most illustrative way to represent spatial changes over a large area. TDS Isobath maps for the study area have been prepared for pre monsoon seasons for the year 1994, 1998, 2002, 2006, 2010, 2013 (Fig.8). The hydro-Isobaths show drastic seasonal fluctuation in TDS range in coastal regions of the study area. Based on ground water uses and the relevant quality standards, i.e. drinking water and irrigation; TDS range classes and the respective spatial coverage is categorised.

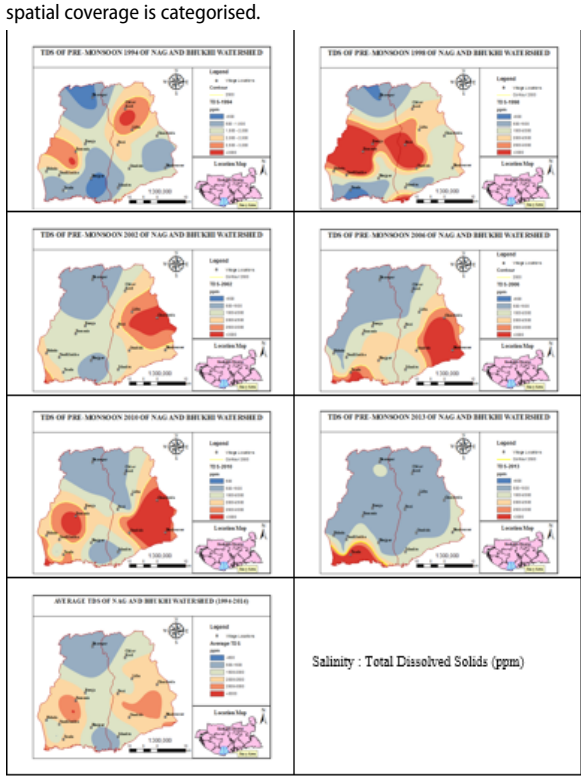


Figure 6: Ground water salinity Isohyets.

Based on derived isobaths patterns, TDS categorization and their specific aerial coverage have been computed. The temporal variation in the total area above and below cut off TDS of 2500 ppm within the study area is estimated using GIS (Table.1).

Table 1:
Area having TDS more than 2500 ppm

Sr.no	Year	% Area(km^2)	
		>2500 ppm	<2500 ppm
1	1994	13.97	86.03
2	1998	25.2	74.8
3	2002	17.93	82.07
4	2006	18.99	81.01
5	2010	30.4	69.6
6	2013	5.65	94.35

CONCLUSION

The average rainfall of the area for past twenty year (1994-2013) is 281 mm/year. The two watersheds were characterized based on observed changes in groundwater levels and salinity by using linear trends fit to well-monitoring data of 1994 to 2013 period for 13 observation wells. Ground water levels in the Nag and Bhukhi watershed, ranges from 9.9 m to 60.5 m below ground level. It is observed that ground-water level in the Nag and Bhukhi watershed is declining at an average of about 1 m/yr. The average rate of decline of ground water level in Nag watershed is 15 m/year which is higher as compared to Bhukhi watershed having decline rate of 2.5 m/year. Ground water salinity in the Nag and Bhukhi watershed, ranges from 740 ppm to 2740 ppm. The ground water salinity in the area is increasing on an average of about 27 ppm/year. The average TDS in Nag watershed is increasing at rate of 313 ppm/year and in Bhukhi watershed average rate of TDS is decreasing at a rate of 157 ppm/year. Total Dissolved Solids (TDS) is the primary indicator of salinity and very basic tool for analysis. Salinity vary with the lithology and Geo-morphology of the area. Behaviour of salinity study area is described as below:

Bhuj Sandstone:

The TDS of Bhuj Sandstone shows inverse correlation with rainfall pattern; with an increase in rainfall, TDS values decreases. By and large area occupied by Bhuj Sandstone show this trend except the Bhrapar, an average TDS is noticed.

Basalt:

The TDS hydrographs of weathered basalt aquifers also show good impact of rainfall input. TDS content show slight increase from year 2006 to 2010, but there has been a reduction in year 2013. Overall, the groundwater shows stable to slight improvement in water quality.

Kankavati Sandstone:

TDS of Kankavati sandstone aquifer have been prepared for northern and southern coastal parts of the study area. As mentioned above, TDS values indicate improvement in quality with the amount of rainfall increased. Hydrographs for observation wells situated in northern part of the aquifer show slight decrease in TDS however, the western most Khakhar village shows increase in TDS concentration. Hydrographs of observation wells situated in coastal region show stable to slight decrease in TDS around Mundra, whereas it show slight increase in western part around Bhujpar village and very much increase around Tunda Village. Villages located in eastern part of the coastal aquifer i.e. Bhadreshwar show a marked decrease in TDS over a period of 05 years.

REFERENCES

[1] Mariappan V., Prabakaran P., Rajan M.R. and Ravichandran A.D., A Systematic study of water quality index among the physico-chemical characterstics of groundwater in and around Thanjavur Town, Ind. J. Env. Protect.,25, 551- 555 (2005). | [2]Jameel, Evaluation of drinking water quality in Thiruchirapalli, Ind. J. Env. prot., 44(2), 108–112 (2002). | [3]Rajmohan N., Elango L., Ramachandran S. and Natarajan, Major ion correlation in groundwater of Kancheepuram region, South India, Ind. J. Env. Health, 45(1), 1-5 (2002). | [4]Sazina. A. Bhimani, Study on ground water salinization and formulation of management strategies for the coastal aquifers of Mundra Region, Kutch District, Gujarat, PhD report,2013. | [5]Anon. All India Soil and Land Use Survey Watershed Atlas of India, Department of Agriculture and Co-operation, IARI Campus, New Delhi.1990. | [6]Adrian D. Werner and Craig T. Simmons, Impact of Sea-Level Rise on Sea Water Intrusion in Coastal Aquifers, Vol. 47, No. 2—GROUND WATER—March–April 2009 (pages 197–204). | [7]Biswas, S.K. and Deshpande, S.V. Basement of the Mesozoic Sediments of Kutch, Western India. Bull. Geol. Min. Met. Soc. India, v.40, pp. 1- 7.1968 | [8]Biswas, S.K. and Despande, S.V. Geological and Tectonic Maps of Kutch. Bull.O.N.G.C.,v.7 (2) pp. 115- 116. 1970 | [9]Biswas, S.K. (1982). Rift Basins in the Western Margin of India and Their Hydrocarbon Prospects. Bull. Am. Assoc. Pet. Geol., v. 66(10), pp. 1497- 1513. | [10]Daniel J. Goode, Lisa A. Senior, Ali Subah, and AymanJaber., Groundwater-Level Trends and Forecasts, and Salinity Trends, in the Azraq, Dead Sea, Hammad, Jordan Side Valleys, Yarmouk, and Zarqa Groundwater Basins, Jordan, Open file report of USGS-2012. | [11]David M. Bjerklie, John R. Mullaney, Janet R. Stone, Brian J. Skinner, and Matthew A. Ramlow, Preliminary Investigation of the Effects of Sea-Level Rise on Groundwater Levels in New Haven, Connecticut. Open file report of USGS-2012. |