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# Assessment and Management of Groundwater Resource of Gandhinagar District using Geo-Informatics

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***Abstract*** **- Groundwater is one of the most valuable natural resources requiring systematic study for the development of the area. Gandhinagar has been selected as study area as it is fast developing city and also one of the proposed smart cities. The area is occupied mainly by alluvial plain and having coarse sandy loamy soil. Various thematic maps have been prepared and integrated with geo-hydrological and hydrological data using GIS technology to understand surface hydrology and ground water occurrence and behavior of aquifer. For present study assessment of groundwater data for the period 1995-2015 has been done.**

**Multiple aquifers are occurring in the area. Water table level fluctuations of confined and unconfined aquifers have been evaluated taluka wise in GIS environment for assessing the behavior of water table and for ascertaining the quality of sub surface water. With the availability of surface water from the Narmada canal the ground water table has improved in the command area falling in the Gandhinagar District. Locally quality of sub surface water has also improved. However, it has no impact on the confined aquifers as they might be having recharge zones much away from the command area of canal.**

## I.INTRODUCTION

Water is our most valuable natural resource. Ground water, which is the source for more than 85 percent of India's rural domestic water requirements, 50 percent of its urban water requirements and more than 50 percent of its irrigation requirements is depleting fast in many areas due to its large scale withdrawal for various reasons. Groundwater is the only alternative option for even the urban centers like Gandhinagar having well planned, designed and executed water supply systems, during the periods of water scarcity due to shortfall of rain. Now a day the groundwater potential and its quality level in major cities and urban centre is getting deteriorated due to the population explosion, urbanization, industrialization and also due to the failure of monsoon and improper management of rain water. Gandhinagar is the capital city of Gujarat. Sabarmati River is flowing through the Gandhinagar district. Water supply in the Gandhinagar district is not sufficient for drinking and irrigation purpose. Therefore major part of the Gandhinagar is dependent on the groundwater resources. Drinking water and water for irrigation has now been partly supplied by Narmada canal.

In the present study groundwater condition of Gandhinagar district has been evaluated in GIS environment for proper management of ground water resources.

## II.STUDY AREA

Gandhinagar district lies between 72.3' – 72.7' East (Longitude) to 23.0' – 23.6' North (Latitude), it is having 2,163, 48 sq.km area with average elevation of 81 meters (266 feet). The Sabarmati River flows through Gandhinagar District. It is Non-perennial River which dries in the summer, with only a small stream of water as per riparian law from Dharoi dam in the upstream. Gandhinagar has a tropical wet and dry climate. The average maximum temperature is around 29 °C (84 °F), the average minimum is 14 °C (57 °F), and the climate is extremely dry. In summer temperature goes upto 44 to 45 degree. The average annual rainfall is around 803.4 mm (31.63 in). Topographically the area is generally flat dissected by ravines along the banks of Sabarmati River and local nalas.

### *A. Drainage*

The entire district is a part of North Gujarat Alluvial plain. The Sabarmati, The Khari and the Meshwo are most important rivers of the district. The Sabarmati River, which flows through the district in south direction is the principal river of the district. The Sabarmati flows through the central part of Gandhinagar taluka. Recently water from Narmada canal is being used in Gandhinagar for irrigation and drinking purpose.

## III.METHODOLOGY

Various thematic maps such as Soil map , Land use map, Geological map, DEM ( Digital Elevation Map), Slope Map, Drainage pattern Map, Geo-hydrological maps have been developed from imageries and topographical , hydrological and geo-hydrological data using remote sensing and geo-informatics technology.

Synthesis of Spatial and non spatial data has been done for the assessment of groundwater condition and for groundwater management in GIS environment.

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## IV.THEMATIC MAPS OF THE AREA

### *A. Landuse Map*

Land use can be defined as the use of land by humans, usually with emphasis on the functional role of land in economic activities. 90% of the total area is agricultural.

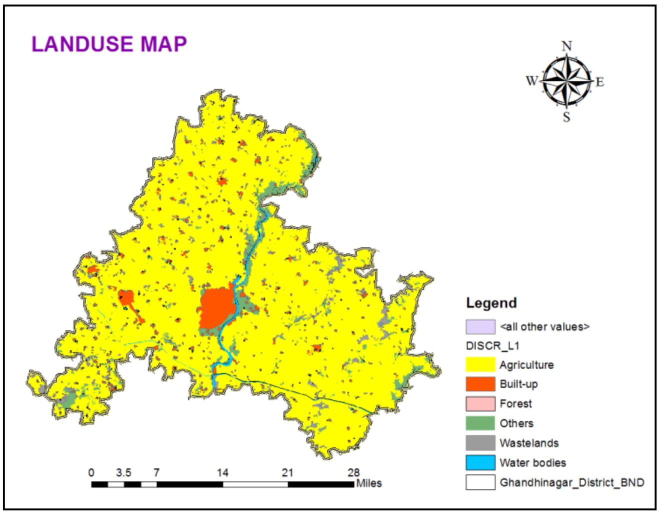


Fig.1 Land Use Map

### *B. Soil Map*

Many types of soils are present in Gandhinagar district. It contains mainly coarse loamy and fine loamy. In very little part fine soil is also present. The soil in the district is generally sandy loam type with grey to brown colour , 70% of total area is coarse loamy.

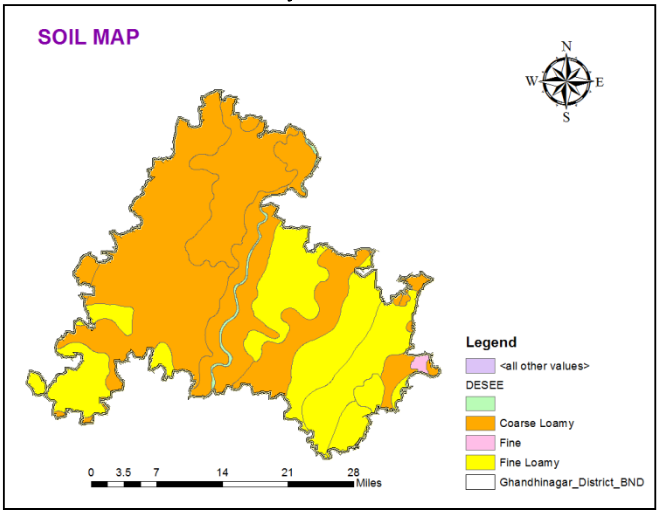


Fig.2 Soil Map

### C. *Geological Map*

A geological map is a special purpose map made to show geological features.

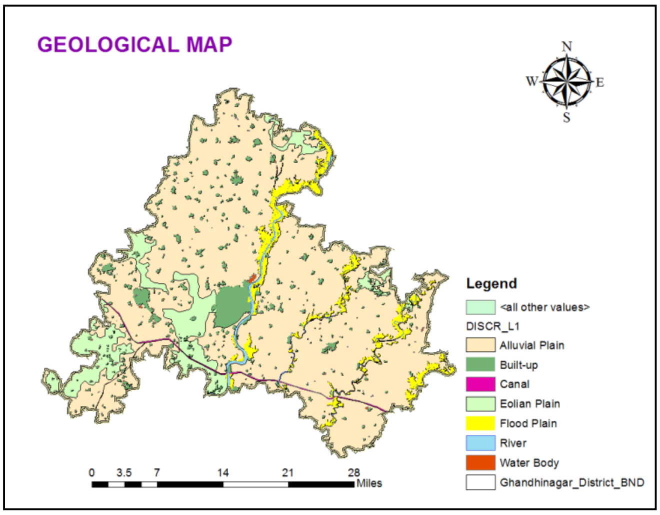


Fig.3 Geological Map

Rock unit or geological structures shown by color or symbols to indicate where they are exposed on surface. Geological maps represent distribution of different types of surface deposits, as well as location of geologic structures. In Gandhinagar district most of the land contain alluvial plain and some of Eolian plain. The built up area and flood plain is also shown in the map.

### *D. Digital Elevation Map (DEM)*

The Digital Elevation Model (DEM) is a digital representation of the height of a terrain over a given area, usually at a regularly spaced grid.

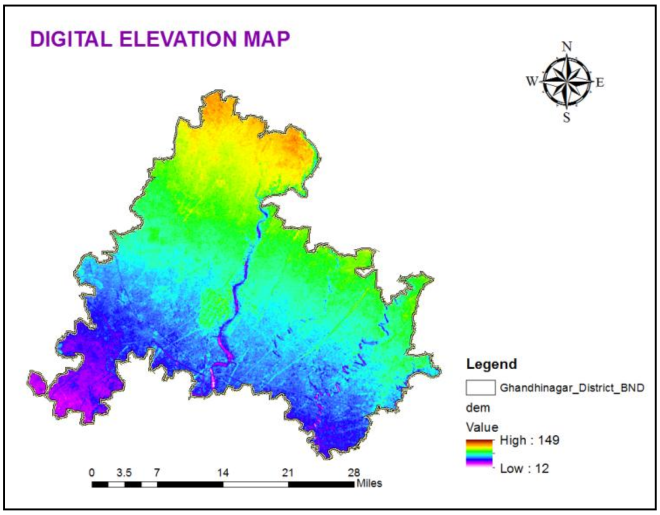


Fig.4 Digital Elevation Map

### *E. Slope Map*

Slope map has been prepared from DEM and analysis has been done to find out various categories of slopes and their percentage.

In the present study area it has been observed that about 99% of land is having 0-1 % slope and remaining land is having 1-3 % slope. Slope is the measure of change in surface value over distance and can be expressed in decimal or in percentage (%).

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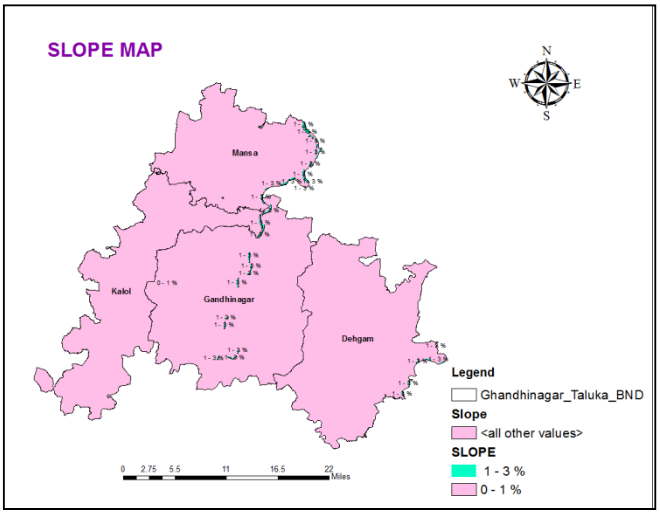



Fig.5 Slope Map

*F. Drainage Pattern Map*

The drainage area is defined as the land area where precipitation falls off into creeks, streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line along the highest elevation between two areas on a map, often a ridge.

In Gandhinagar most of the area is flat land and the drainage pattern lines are as shown in the figure

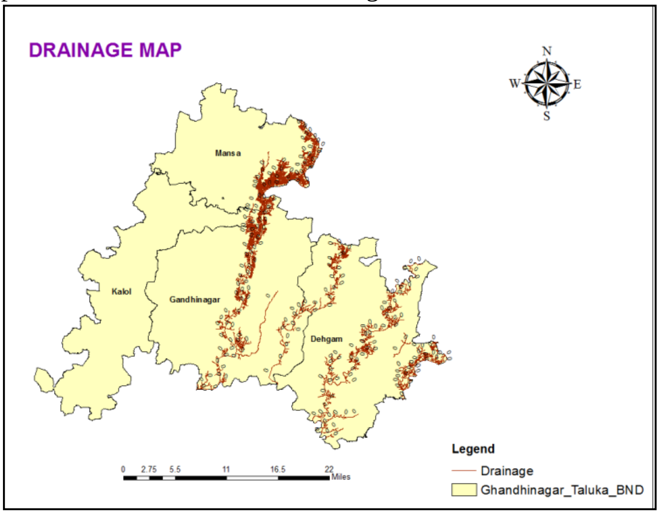
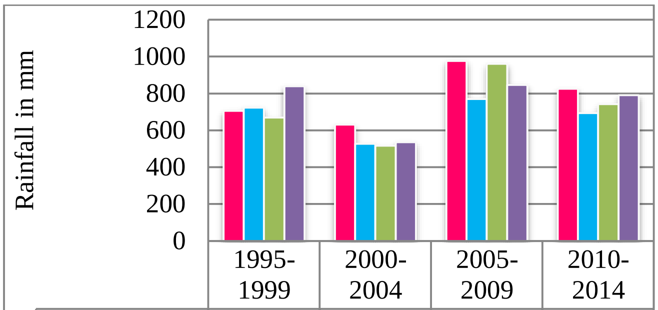



Fig.6 Drainage Pattern Map

## V.DATA ANALYSIS

A. *Rainfall Analysis*

Gandhinagar has a tropical wet and dry climate, and the average annual rainfall is around 803.4 mm (31.63 in). Gandhinagar is having 4 talukas. The annual rainfall for Gandhinagar, Mansa, Kalol and Dehgam can be seen from graphs given below.




| | 1995-1999 | 2000-2004 | 2005-2009 | 2010-2014 |
|---|---|---|---|---|
| Gandhinagar | 706 | 631 | 976 | 826 |
| Kalol | 723 | 526 | 770 | 693 |
| Dehgam | 670 | 517 | 961 | 742 |
| Mansa | 839 | 536 | 847 | 791 |

Fig.7 5 Year Annual Rainfall Chart For Each Taluka

The annual rainfall in Gandhinagar district varies from 517 mm to 976 mm with average number of 45-50 rainy days. Comparing 5-5 year annual rainfall data of 4 talukas of Gandhinagar district it can be seen that from 2005 to 2009 the rainfall conditions were good compared to past 10 years. Gandhinagar taluka is having the good rainfall conditions other than Mansa, Kalol and Dehgam.

*B. Water Level Analysis for Unconfined Aquifer*

Available unconfined water level data has been synthesized for the period of 1995 to 2015. Unconfined aquifer water level maps have been made using GIS environment with interpolation technique. Using IDW (Inverse Distance Weighted) spatial interpolation technique, groundwater level depth maps were prepared and compared for analysis.

Water level in unconfined aquifer depends mainly on rainfall conditions in that area and other factors which affect the water level in unconfined aquifer are infiltration capacity, porosity, and type of soil and land use pattern of the area. Groundwater level data was available in the form of pre-monsoon and post monsoon water level depth. In India, May month represents pre-monsoon and October month represents post-monsoon.

Unconfined aquifer water level depth for Gandhinagar taluka was 16 m in year 1995, which decreased by 3 m and been 13 m in 1998. From 1998 to 2005 groundwater level depth was around 17 m. In 2008 groundwater level depth has decreased and water level depth was 11m. After 2010 groundwater level depth for Gandhinagar taluka is around 18m. Water level depth for Mansa taluka was 35m in 1998 which has increased to 39 m in 2010 and after 2010 to 2015 groundwater level depth is around 37 m. For Kalol taluka, water level depth was 42m in 2012, which was decreased to 36m in 2014. For Dehgam taluka water level depth was 10 m in 1995 which has increased to 13m in 2005. From 2008-2015 water level depth is around 14m.

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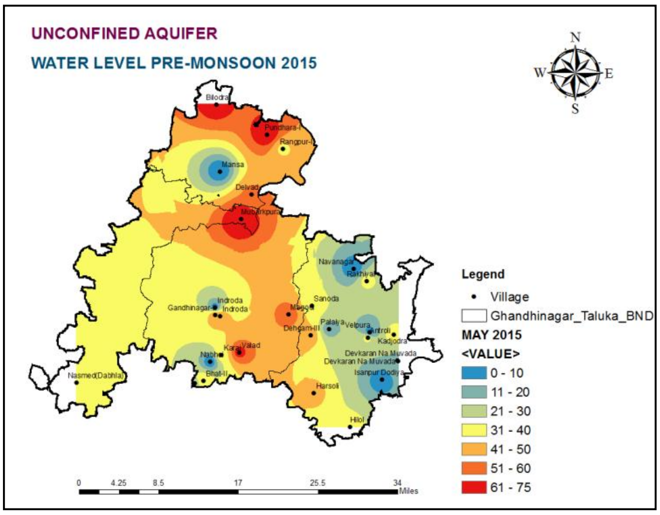


Fig.8 Unconfined Aquifer: Pre-Monsoon Water Level Map 2015

For the duration 2010-2014 there was an increase in rainfall, so as groundwater level has increased from 2010-2014. If the water level is not correlating with rainfall than, there must be some other factors like infiltration capacity, type of soil etc which are affecting the groundwater.

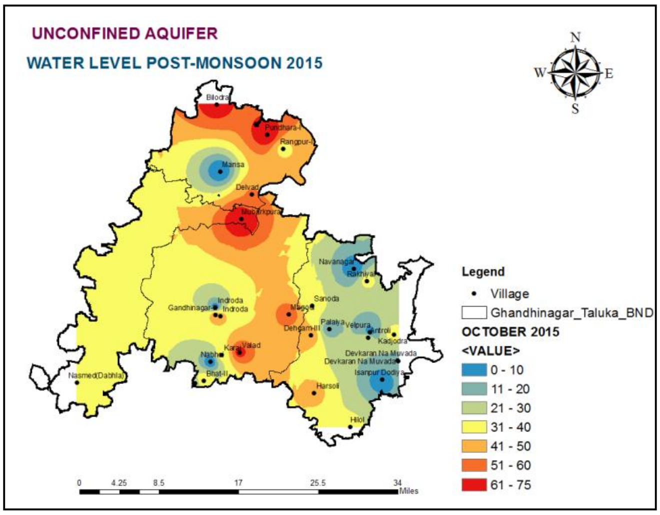


Fig.9 Unconfined Aquifer: Post Monsoon water level map 2015

It can be seen from graphs of water level depth, that there is no continuous decrease or increase in groundwater level, but from 1995-2003 groundwater level has gone down and after 2008 there is an increased water level and which is maintained till now.

In above chart how the pre monsoon and post monsoon water level varying according to the rainfall can be seen.

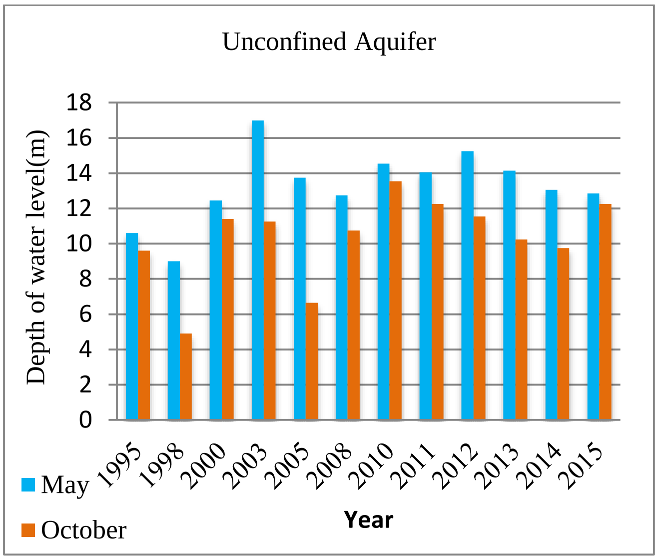


Fig.10 Depth of Water Level for Gandhinagar District

Sub surface geological C/S has been prepared based on the available groundwater level data.

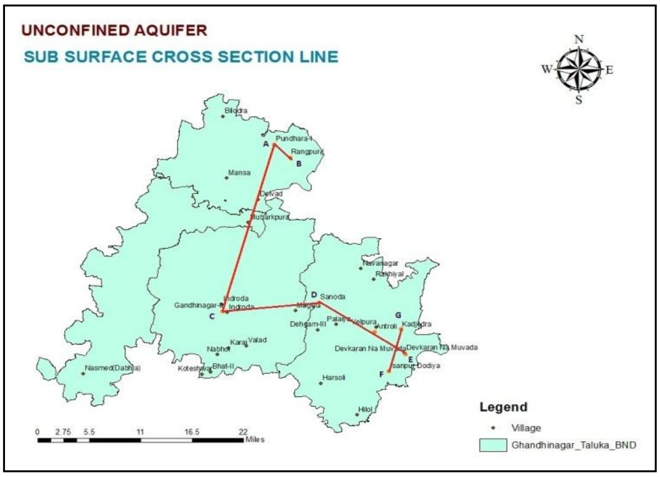


Fig.11 Unconfined aquifer : C/S Lines

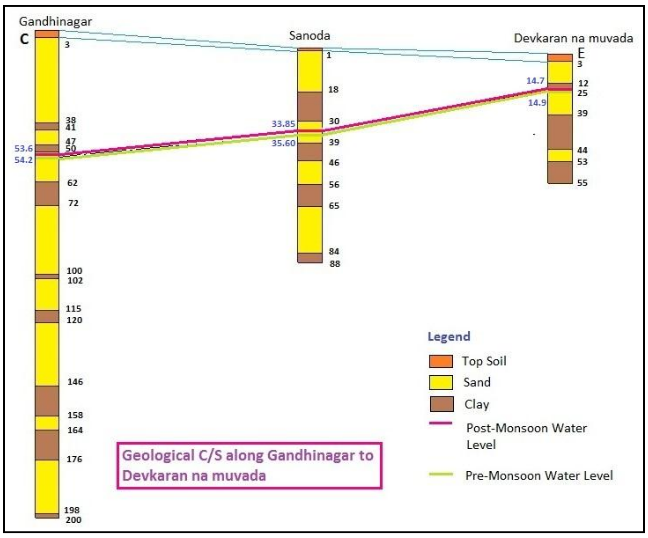


Fig.12 Geological C/S for line

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### *C. Water Level Analysis for Confined Aquifer*

Available confined water level data has been synthesized for the period of 1995 to 2015. Confined aquifer water level maps have been made using GIS environment with interpolation technique.

Confined aquifer is confined under pressure greater than atmospheric by over lying relatively impermeable strata. Rises and falls of water in wells penetrating confined aquifers result primarily from changes in pressure rather than storage. Confined aquifer is not directly dependent on rainfall conditions of the area. So most of the time there will not be any drastic change in confined aquifer water level and if the change is there it would be very less.

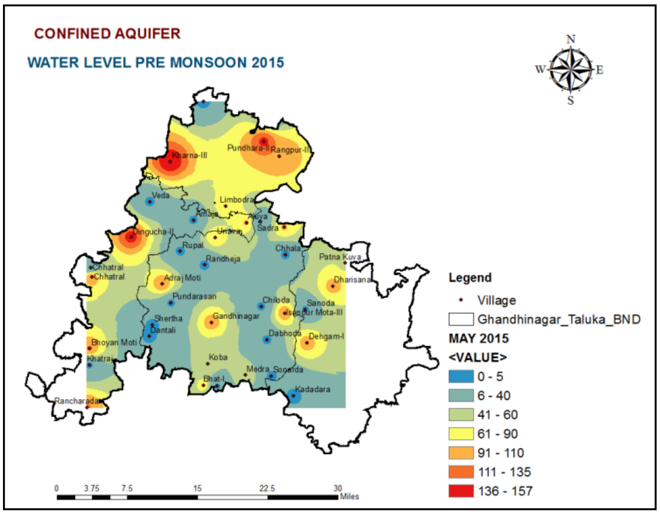


Fig.13 Confined Aquifer Water Level 2015

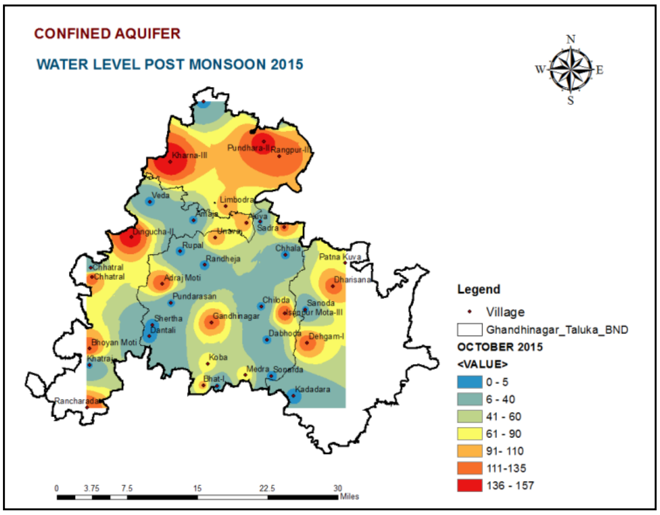


Fig.14 Confined Aquifer Water Level 2015

For, Confined aquifer water level in year 2010 had gone better than 2003. In years of 2010 and 2011 water level depth is almost same and there is say no change. From 2011 to 2015 the confined water level depth is having very little increase and decreasing trend, no drastic changes are there.

Confined aquifer water level depth chart is shown in fig.15, in which it can be seen that pre and post monsoon water level depth is almost same so rainfall is not directly affecting confined aquifer water level.

C/S for confined aquifer is given in fig.17. Where water is confined under pressure, so two impermeable clay layers are there. Village name indicate the present tube well in the village and according to RL C/S is shown.

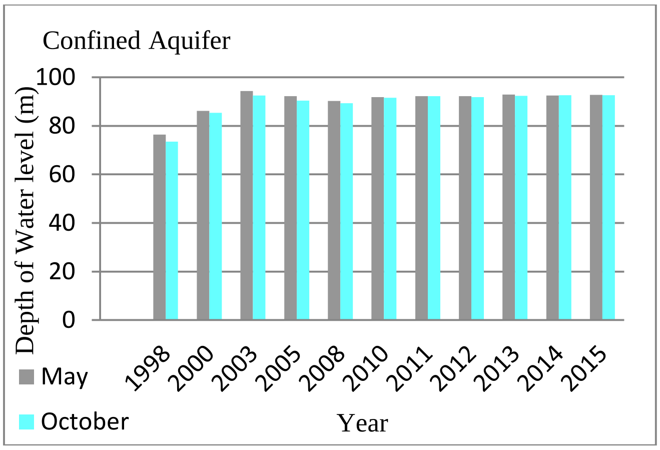


Fig.15 Water level depth chart for Confined aquifer

Confined aquifer geological C/S is shown below.

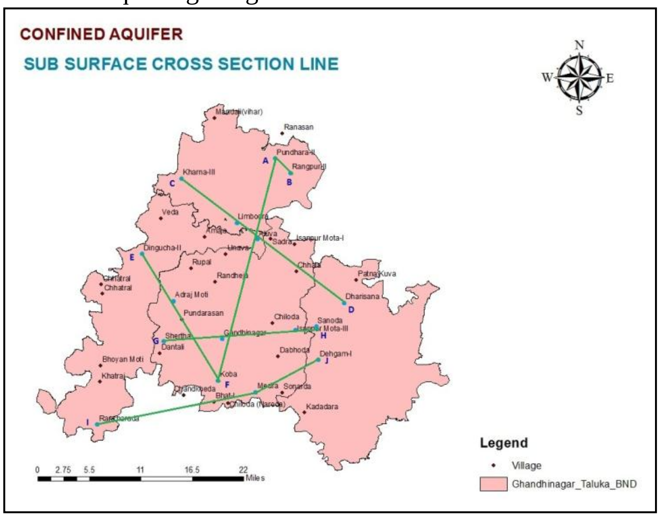


Fig.16 Confined Aquifer Sub Surface C/S Lines

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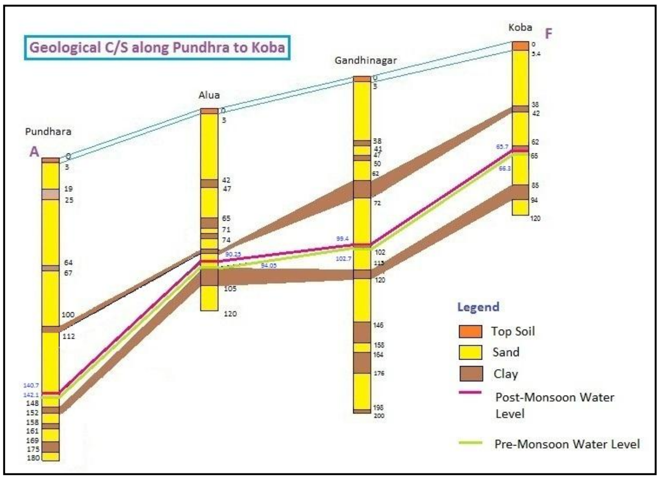


Fig.17 Geological C/S of line AF

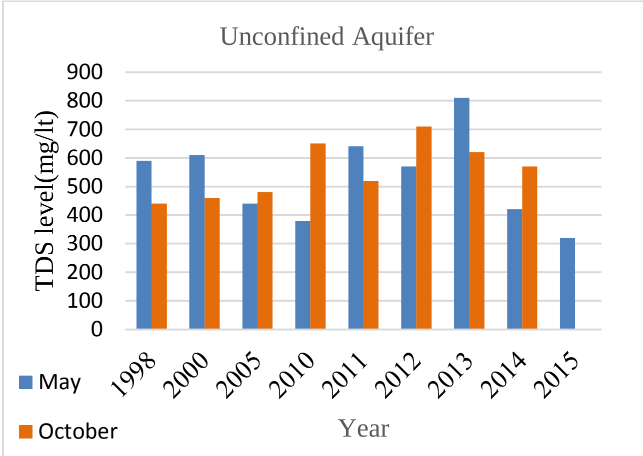


Fig.18 TDS Level Chart For Unconfined Aquifer

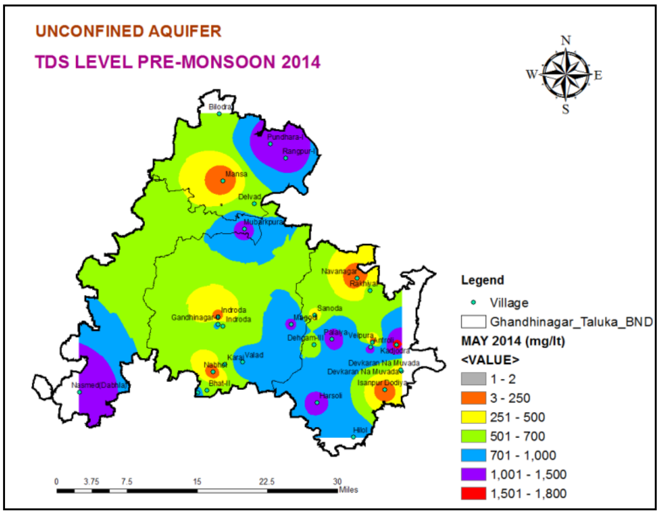


Fig.19 Unconfined aquifer: TDS level pre monsoon 2014

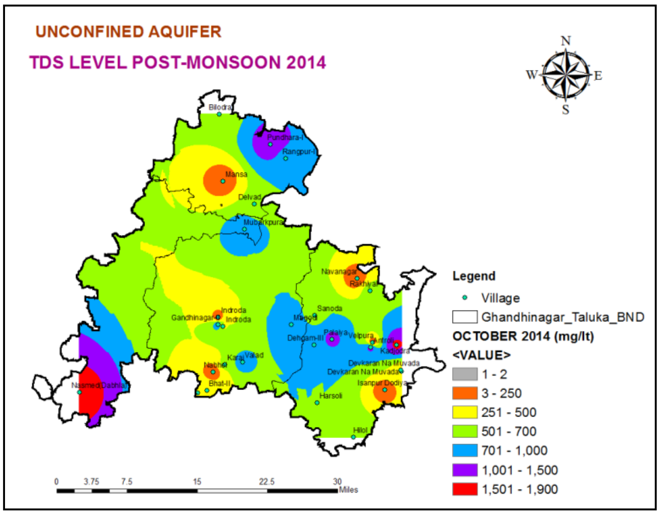


Fig.20 Unconfined aquifer: TDS level post monsoon 2014

*D. Water Quality (TDS) Analysis*

TDS (Total Dissolved Solids) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular , ionized or micro-granular suspended form. Total dissolved solids are normally discussed only for fresh water systems, as salinity induces some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes. TDS is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

If rainfall will be more than, TDS will not get concentrated and, if the rainfall will be less than, TDS will get concentrated and its level will get higher. Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants.

Table I. Classification of Quality of Water

| Zone | TDS(mg/lit) | Classification |
|---|---|---|
| I | <500 | Desirable |
| II | 2000 | Permissible |
| III | >2000 | Rejected |

*(1) Quality Analysis for Unconfined aquifer*

From the charts, it can be seen that in 1995 TDS level was more than 2000. Till 2013 TDS level was increasing but after 2013 TDS level has gone down.

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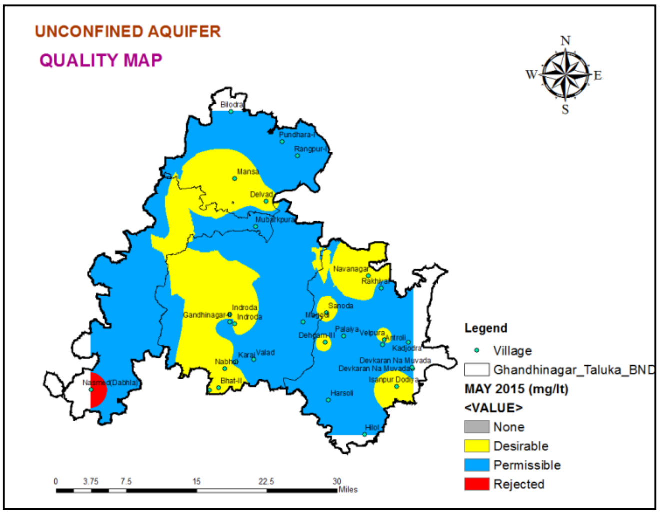


Fig.21 Quality Map For Unconfined Aquifer

TDS level from the year 2000 to 2010 was almost same around, but in year 2013 and 2014 TDS level has increased. In 2015, Mansa taluka TDS level is 900mg/lit, Dehgam and Kalol taluka are having TDS level around 800mg/lit and Gandhinagar taluka TDS level is 700mg/lit. Gandhinagar taluka is having better groundwater quality conditions then other 3 talukas. Here, quality map for Gandhinagar is shown, in which most of the water available in unconfined aquifer is within permissible limit, so groundwater quality of Gandhinagar district is good, and it should be maintained properly.

(2) Quality Analysis for Confined Aquifer

TDS analysis for confined aquifer is done with GIS and following results have obtained.

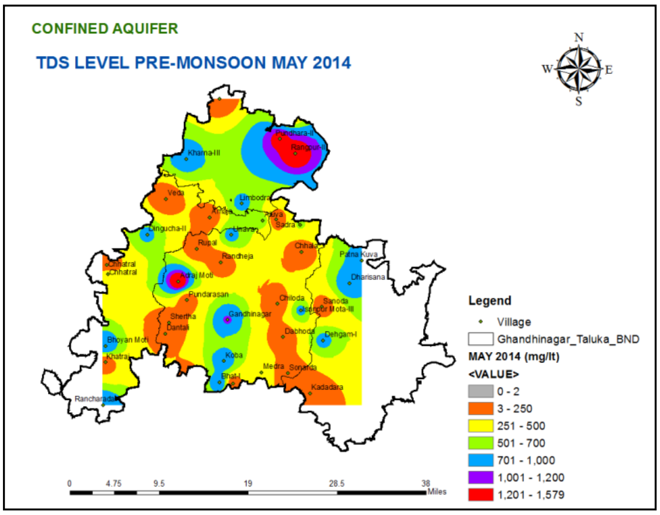


Fig.22 Confined aquifer: TDS level pre monsoon 2014

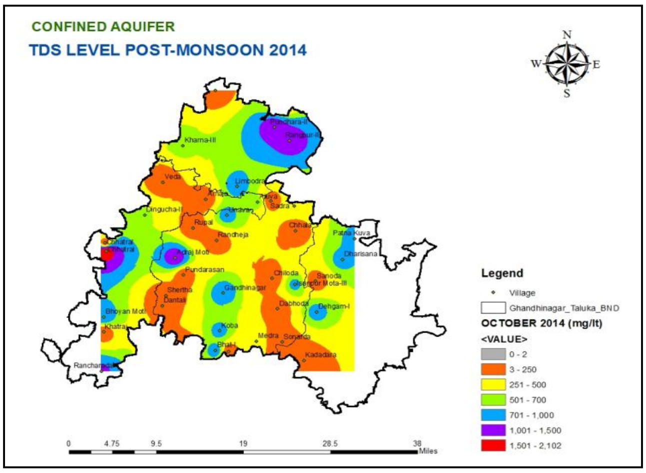


Fig.23 Confined Aquifer: TDS Level Post Monsoon 2014

Confined aquifer water is having variations in TDS level place by place, as the confined aquifer water does not directly depends on rainfall, then reason for these variations can be different. For Dehgam taluka TDS level was 1000mg/lit in 2000 , which has decreased to 800 in 2015. Kalol taluka , TDS level in 2015 was 600mg/lit. Gandhinagar taluka , TDS level in year 2015 was 400mg/lit.

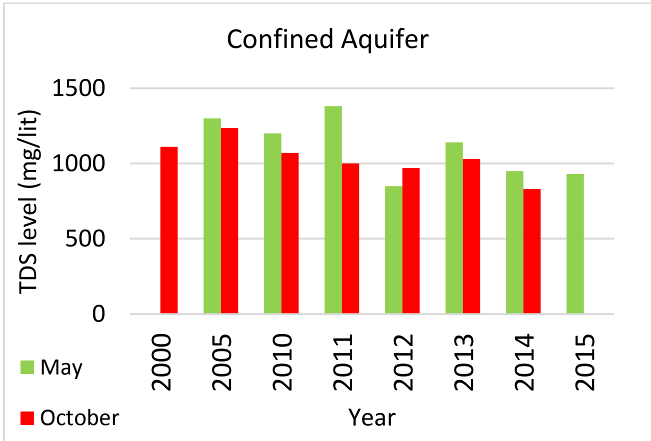


Fig.24 TDS level Chart for duration 1995-2015

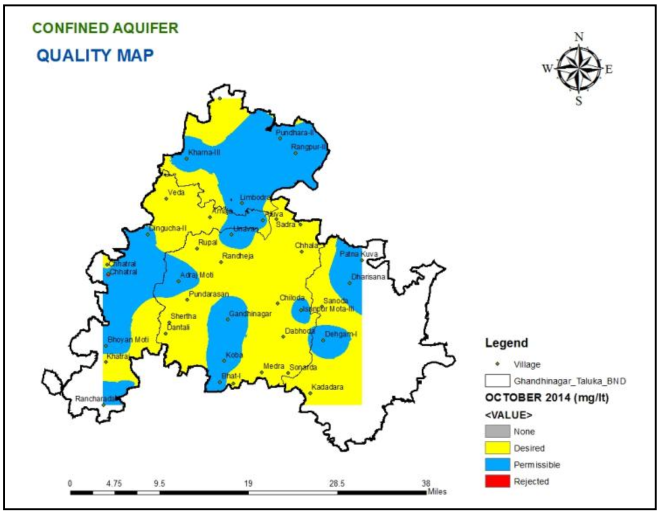


Fig.25 Quality Map for Confined Aquifer

*E. Management Measures Suggested To Maintain Groundwater Level*

Table II. Artificial Recharge Structure

| Taluka | Formation | Suitable Artificial Recharge Structure |
|---|---|---|
| Dehgam | Soft Rock | Percolation Tanks/Ponds, Recharge Wells, Recharge Shafts |
| Gandhinagar | | |
| Mansa | | |
| Kalol | | |

(1) Artificial Recharge Techniques

A. Direct Surface Techniques

- Flooding
- Basins Or Percolation Tanks
- Stream Channel Method
- Ditch And Furrow Method
- Over Irrigation

*B. Direct Sub Surface Techniques*

- Injection Wells
- Recharge Pits And Shafts
- Dug Well Recharge

*C. Combined Surface-Sub Surface Techniques*

- Basin Or Percolation Tanks With Pit Shafts Or Wells

*D. Indirect Techniques*

- Induced Recharge From Surface Water Source
- Aquifer Modification

(2) Rain Water Harvesting

In build up areas, the roof top rain water can be conserved and can be used for recharge of groundwater. In method requires connecting the outlet pipe from roof top to divert the water to either existing wells or tube wells or specially designed wells. The urban house hold complexes and institutional buildings have large roof top area and it can be utilized for rain water harvesting for recharge of aquifer.

## VI. DISCUSSIONS AND CONCLUSIONS

The area is occupied mainly by alluvial plain consisting of sandy loamy soil. In this area multiple aquifer are occurring at different depths depending on local geology. Unconfined and confined aquifers are generally having potable water. Various thematic layers have been prepared and integrated with geo-hydrological and hydrological data using GIS technology to understand surface hydrology and ground water occurrence and behavior of aquifer.

Assessment of groundwater occurrence and quality in the Gandhinagar District has been carried out for four talukas namely Dehgam, Mansa, Kalol and Gandhinagar.

Unconfined water level depth for Gandhinagar and Kalol taluka is varying from 70 to 90 m for duration of 1995-2015, for Dehgam it is 55 to 75 m and for Mansa it is 100 to 150m.

For confined aquifer, water level depth varies from 70 to 90m for Gandhinagar and Kalol, it is 100 to 90 m for Mansa and for Dehgam it is 55 to 75m.

The Narmada canal based water supply system has reduced dependability on groundwater for drinking purpose. Therefore after 2008 there have been improvements in groundwater level depth. It has salutary effect on groundwater. For confined aquifer the groundwater level is almost same for past 10 years and there are no drastic changes in the water level. This may be due to the fact that recharge zone of the confined aquifer is away from the command area of Narmada canal.

TDS level varies from 400-800 mg/lit for duration 2000-2005. In 2015, TDS level for Mansa was 900mg/lit, Dehgam and Kalol were having TDS level around 800mg/lit and TDS level for Gandhinagar was 700mg/lit. Gandhinagar taluka is having better groundwater quality conditions then other 3 talukas. In current situation, TDS level in Gandhinagar district is within permissible limits, so groundwater quality conditions are good in almost all parts of Gandhinagar district.

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## ACKNOWLEDGMENT

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[12] Helmut E. Kobus "GROUNDWATER POLLUTION CONTROL -A CHALLENGE TO HYDRAULIC RESEARCH "
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