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GIS BASED SPATIAL DISTRIBUTION MAPPING EVALUATION OF GROUNDWATER QUALITY FOR INDUSTRIAL, DOMESTIC AND AGRICULTURAL PURPOSE IN SATARA DISTRICT

Pratibha Prakash Jadhav* and S. M. Bhosale

Department of Technology, Shivaji University, Kolhapur.

***Corresponding Author: Pratibha Prakash Jadhav**
Department of Technology, Shivaji University, Kolhapur.
Email ID: ppjadhav013@gmail.com

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ABSTRACT

Water is one of the most essential components on earth. The main problem is the availability of water in right place at right time and in right form. Almost 71% of earth's surface is covered with water. Ground water is of only 0.63%. Remaining 0.02% of water is further divided into 0.005% of soil water, 0.009% of freshwater lakes, 0.001% in atmosphere, 0.001% in streams and 0.008% of saline lakes and inland seas. The cycle describes the method of transport of water in the hydrosphere. This water cycle includes water beneath the Earth's surface and in rocks, the water in plants and animal (Biosphere), the water covering the surface of planet in liquid and solid forms, and water in the atmosphere in the form of water vapour, clouds and precipitation. The combination of waters temperature and salinity determines whether it rises to the surface, sinks to the bottom, or stays at some intermediate depth. The water table has been falling rapidly in many areas of the country in recent decades. This is largely due to withdrawal for agriculture, industrial, and urban use in excess of annual recharge. With the increased developmental activities demand for water is being increasing day by day. Maharashtra state often comes under grip of water scarcity Therefore, ground water has failed to escape pollution. In recent decades there were enormous reports of ground water contamination by contaminants like heavy metals, pesticides and other pollutants in Satara district. The proposed study aims at assessing the ground water quality which is generally difficult to detect and hard to resolve. Excess use of chemicals in agriculture, ineffective monitoring of industrial and household waste has led to decline in the quality of water. Thus, the proposed study will also help to enlighten the probable hidden sources of pollution which spoils the entire system without notice.

KEYWORDS: GIS.

MATERIAL AND METHODS

Water quality of ground water is changing day by day due to improper methods of disposing and discharging solid and liquid waste through the thick growing population belt all over the globe. Continuous increasing solid and liquid waste leads to problems of its disposal. Tourism business and increasing number of hotels are for disposal of their waste and it pollutes the ground water. Insufficient knowledge or awareness among people leads to harm the ground water quality which bearing direct and indirect impact on health of human being. The increase vulnerability of ground water is also reflected by growing concern for increasing scarcity of water. It is necessary to predict the concentration and distribution of the pollutant loads in ground water quality at different location.

Study Area

Satara District is district of Maharashtra statein western India with an area of 10,480 km² and a population of 3,003,741 of which 14.17% were urban (as of 2011). Satara is the capital of the district and other major towns.

include Wai, Karad, Koregaon, Koynanagar, Rahimatpu, Phaltan, Mahabaleshwar and Panchgani. This district comes under Pune Administrative Division along with Pune, Sangli, Solapur and Kolhapur. The district of Pune bounds it to the north, Raigad bounds it to the North-West, Solapur the east, Sangli to the south, and Ratnagiri to the west. The Sahyadri range, or main range of the Western Ghats, runs north and south along the western edge of the district, separating it from Ratnagiri District. The Mahadeo range starts about 10 m. north of Mahabaleshwar and stretches east and south-east across the whole of the district. The Mahadeo hills are bold, presenting bare scarps of black rock like fortresses. The Satara district is part of two main watersheds. The Bhima River watershed, which is a tributary of the Krishna, includes the north and northeast of the district, north of the Mahadeo hills. The rest of the district is drained by the upper Krishna and its tributaries. The hill forests have a large store of timber and firewood. The whole of Satara district falls within the Deccan Traps area; the hills consist of trap intersected by strata of basalt and topped with laterite, while, of the different soils on the plains, the commonest is the black loamy clay containing carbonate of lime. This soil, when well watered, is capable of yielding heavy crops. Satara contains some important irrigation works, including the Krishna canal. In some of the western parts of the district the average annual rainfall exceeds 5 m.; but on the eastern side water is scanty, the rainfall varying from 1 m in Satara town to less than 30 cm in some places farther east. The district is traversed from north to south by a railway line, which passes 15 km east Satara town.

Study Area: Google Earth Image of Study Area and Sampling Sites

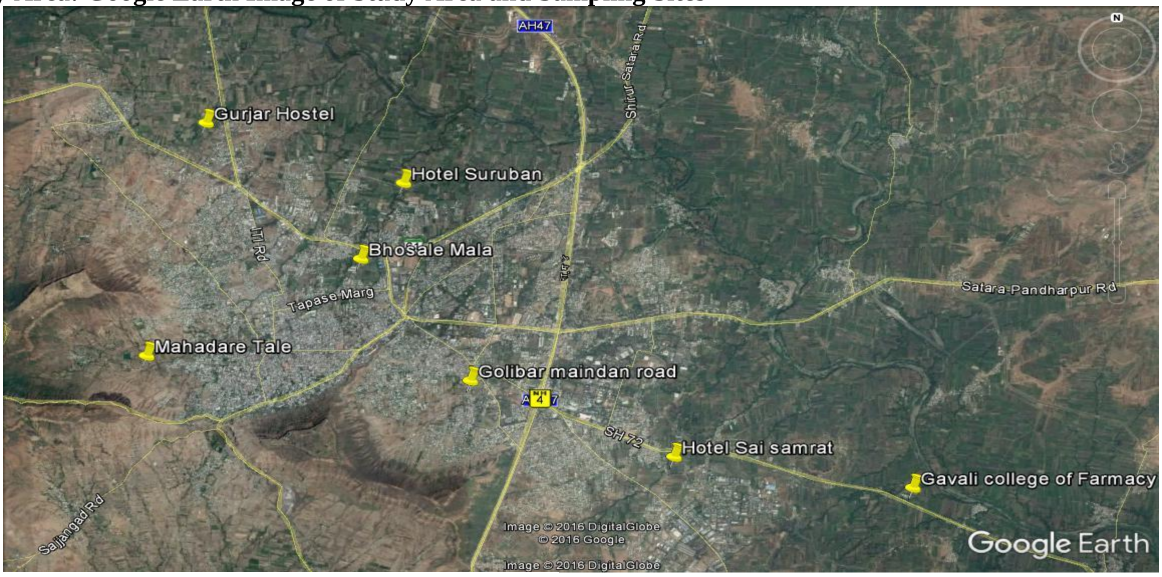


Table 1: The study area is Satara District. The sampling stations are selected from the agricultural area from Satara district.

Sr. No.	Site Name	Longitude	Latitude
1	Gurjar Hostel	73°58'53.81"E	17°42'43.87"N
2	Hotel Suruban	74° 0'18.03"E	17°42'15.38"N
3	Bhosale Mala	73°59'59.97"E	17°41'39.34"N
4	Mahadare Tale	73°58'30.32"E	17°40'53.67"N
5	Golibar maindan road	74° 0'46.75"E	17°40'41.73"N
6	Hotel Sai samrat	74° 2'13.48"E	17°40'5.38"N
7	Arvind Gavali college of Pharmacy	74° 3'55.81"E	17°39'50.40"N

The methodology adapted for the proposed study will be as follows:

Comprehensive review of relevant literature and maps such as: Toposheets, Geology maps, Geomorphology maps, land use land cover maps etc.

Data collection

B.1) Spatial Data

1. Geo referencing and digitizing the study area maps using ArcGIS / QGIS software
2. Obtain sampling point's locations from GPS and import to ArcGIS / QGIS using UTM projection and Zone 43 and convert to point feature and assign ID for each point.
3. Generation of final study area maps

B.2) Non- Spatial data

1. Sampling stations: Suitable sampling stations will be selected on the basis of land use parameters such as near the Industrial, agricultural, domestic and industrial area within study area.
2. Sample collection: Collection of groundwater, samples from the respective sites will be done by standard methods. Sampling will be seasonal i.e. pre-monsoon, monsoon, and post-monsoon for the two consecutive years.
3. Ground water sample analysis: The following Geo-chemical parameters will be analyzed and compared with the standards.

Water Sampling

Water sampling sites were decided first and then water samples were collected from selected sites. The sterilized polythene bottles were used for the water sampling.

Water samples were collected in clean polythene bottles of 2 liters capacity. Proper care was taken during sampling with due consideration to the material of the container, gaseous exchange, sample analysis time, preservation required etc. The sample containers were washed properly in the laboratory.

During the sample collection, containers were rinsed 2 – 3 times with the sample to be analyzed before filling. The containers were directly filled by samples through pipe. The open well or bore well water samples were collected from the each sampling site. The containers were tightly capped and carried to the laboratory for analysis. In the laboratory it was kept in refrigerator at 4ºC for further analysis. For field parameters glassware and reagents were carefully taken to the field without contamination and tests were carried out. The temperature of water samples were measured with the help of the thermometer on the field. Physicochemical analysis was carried out within 48 hrs. after collection of the samples.

Sampling Frequency

The frequency and duration of groundwater sampling is an important issue that should be considered when designing a sampling plan. For example, if the monitoring is for a basic groundwater resource assessment it is recommended quarterly sampling for groundwater levels, annual sampling for basic quality indicators (e.g., electrical conductivity (EC) and temperature (T)) and as-need basis for other quality parameters. Collection of long-term (one or more decades) water level data is recommended for better understating issues associated with groundwater availability and sustainability.

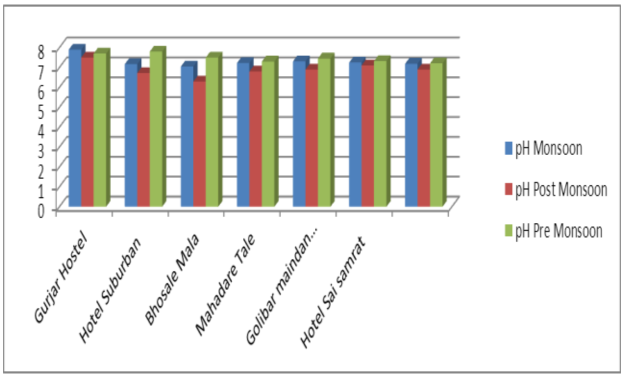
For the present study, 7 different sampling points were selected from different locations around Satara town, which were meant for public use. The samples were collected seasonally to detect noticeable changes in the quality of the ground water. Water samples were collected seasonally for a year from September (2016) to March (2017) from the study area. This study was carried for the detection ground water quality of the Satara and around area.

Physico-chemical Parameters

An element or a compound present in a natural water system will generally be distributed between varieties of Physico-chemical states. The distribution among these states, as well as the total concentration, varies between different environments.

Table 2: Following Physico-chemical parameters were selected for the study.

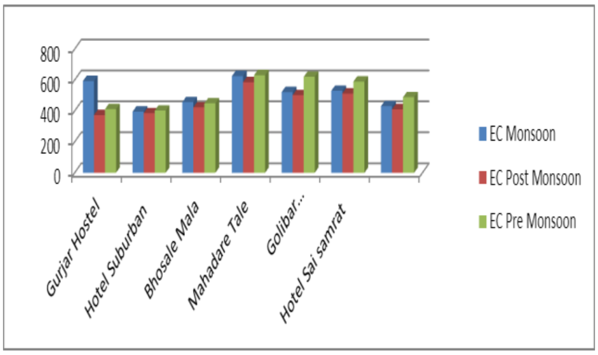
Sr. No.	Parameter	Unit	Method
1	pH	_	pH meter
2	Electrical conductivity	µ mohs	Conductivity meter
3	Alkalinity	mg/l	Titration method
4	Hardness	mg/l	EDTA Titrametric method
5	Turbidity	mg/l	Nephlometric method
6	TDS	mg/l	TDS meter
7	Nitrate	mg/l	Spectrophotometer
8	Phosphate	mg/l	Spectrophotometer
9	Sulphate	mg/l	Spectrophotometer
10	Chloride	mg/l	Titrametric method



Graph 1: pH of ground water from selected wells and bore wells from Study area.

pH- [Table No.6, Graph No.1]

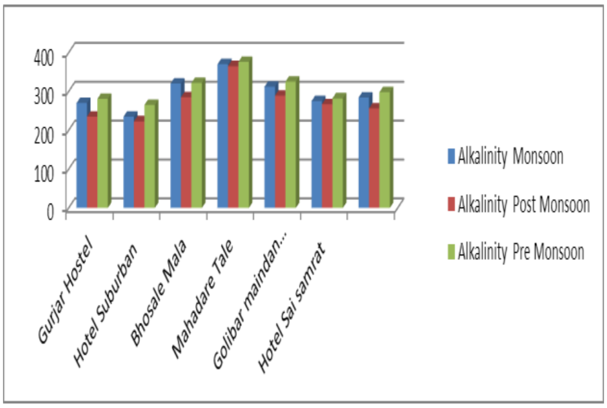
During the whole study it was observed that the average pH of all sites was within the range. The pH of various sampling area as per seasonis shown in Table No.6. And graph no.1 it was observed that the highest pH was 7.70 in Gurjar Hostel and minimum pH at Bhosale mala with pH of 6.95.



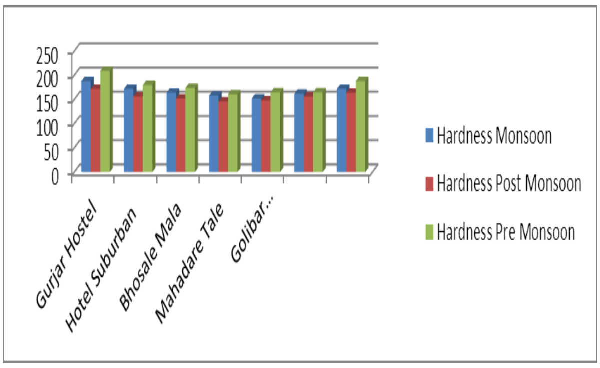
Graph 2: EC of ground water from selected wells and bore wells from Study area.

Electrical Conductivity (µ mhos/cm) - [TableNo.6, Graph No.2]

The Electrical Conductivity (E.C.) after the analysis it can be observed that the E.C. occurs is in the range of 392.5-693.16µ mhos /cm. The average reading of E.C. for the Ground water is indicated in the Table No. 6.



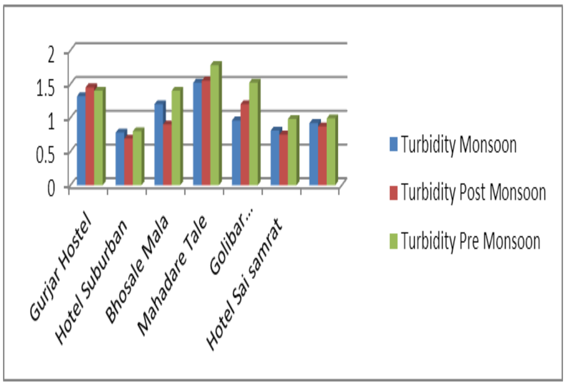
Graph 3: Alkalinity of ground water from selected wells and bore wells from Study area.



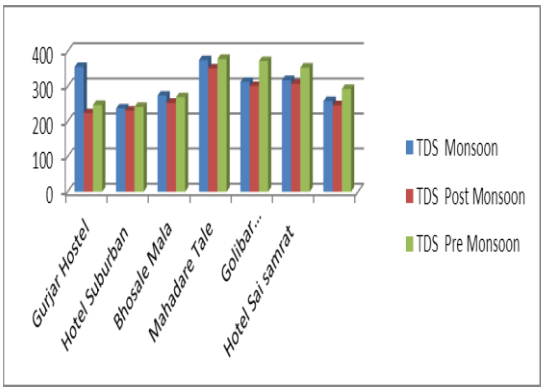
Graph 4: Hardness of ground water from selected wells and bore wells from Study area.

TDS (mg/lit) - [Table No. 9, Graph No.4]

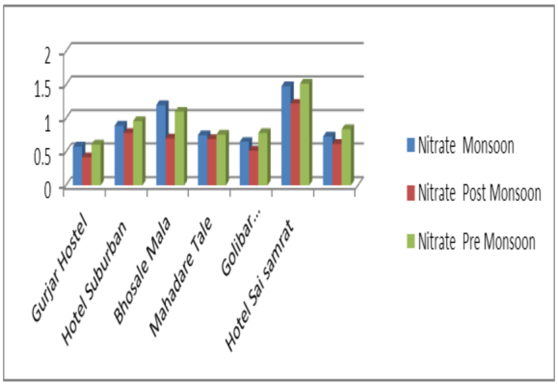
The TDS is observed in the Table No. 6, where it shows maximum reading of 368.17 at Mahadare tale and minimum at Gurjar Hostel with 235.6 mg/lit in. The Graph No. 3 clearly shows the variation among the groundwater in all Seasons and at all sites.



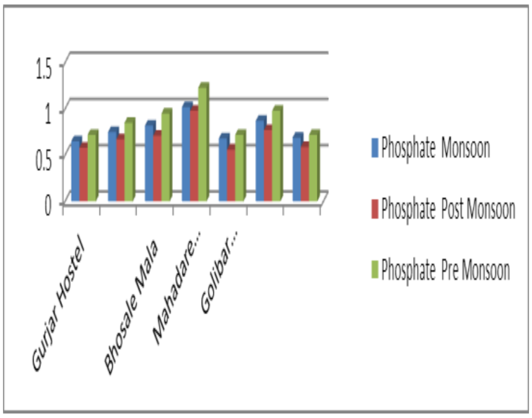
Graph 5: Turbidity of ground water from selected wells and bore wells from Study area.



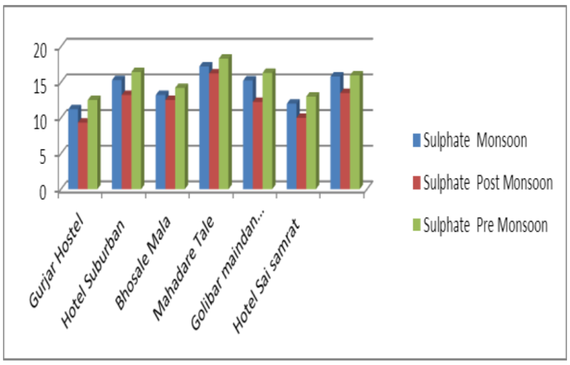
Graph 6: TDS of ground water from selected wells and bore wells from Study area.



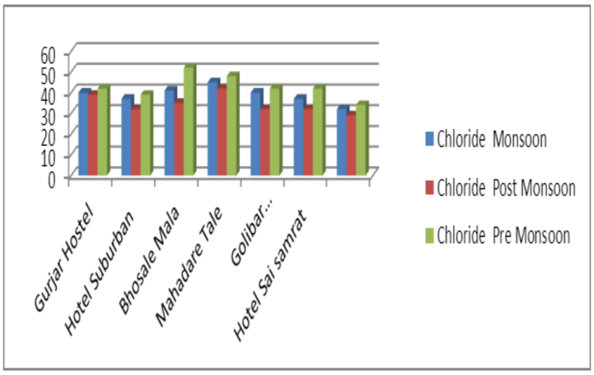
Graph 7: Nitrate of ground water from selected wells and bore wells from Study area.



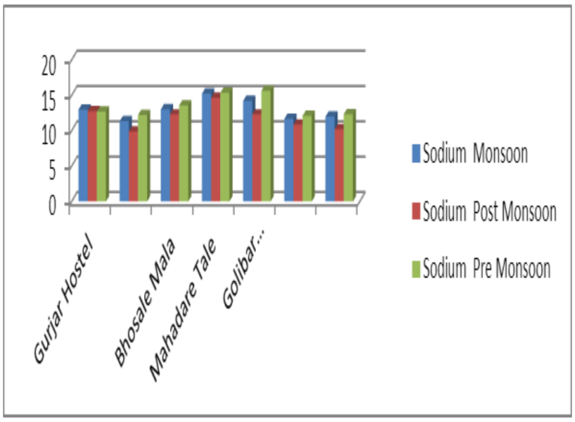
Graph 8: Phosphate of ground water from selected wells and bore wells from Study area.



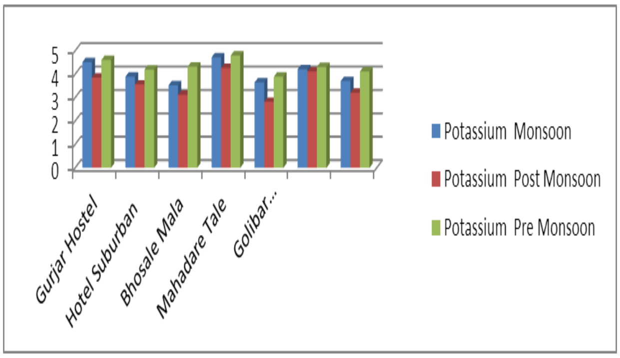
Graph 9: Sulphate of ground water from selected wells and bore wells from Study area.



Graph 10: Chloride of ground water from selected wells and bore wells from Study area.



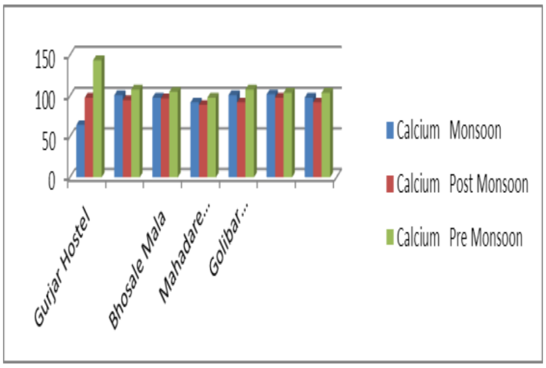
Graph 11: Sodium of ground water from selected wells and bore wells from Study area.



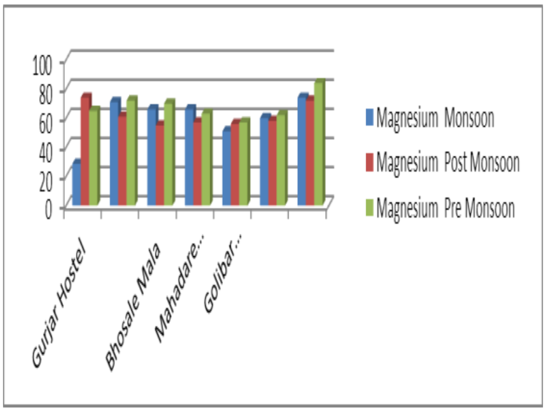
Graph 12: Potassium of ground water from selected wells and bore wells from Study area.

Ca and Mg Hardness (mg/lit) - [Table No. 6 and graph No. 11 and 12]

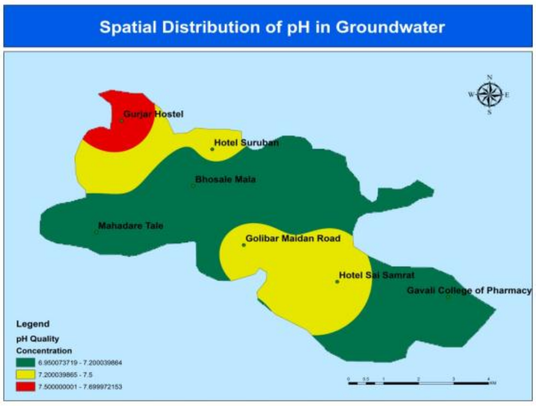
In the Table No. 6 it clearly observed that the Ca and Mg are the cations which are normally present in water. From the table it shows that the Ca is more dominant cation than the Mg detects during the analysis. The average number of concentration of the Ca and Mg in all seasons respectively indicates in Table No. 3, 4, 5 and 6.

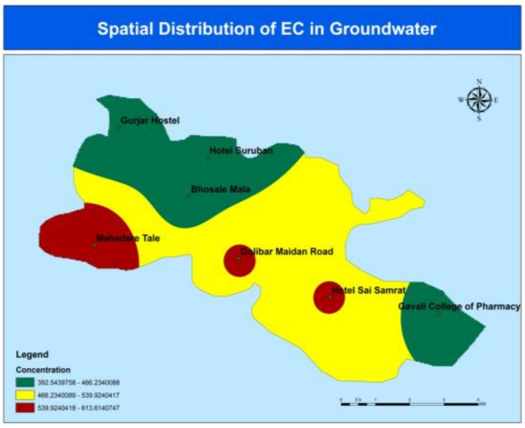


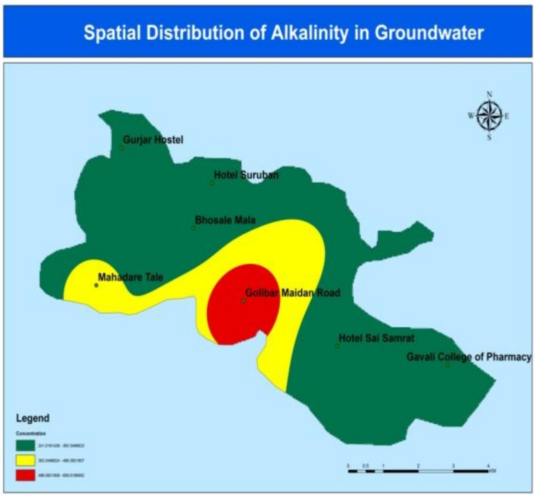
Graph 13: Calcium of ground water from selected wells and bore wells from Study area.

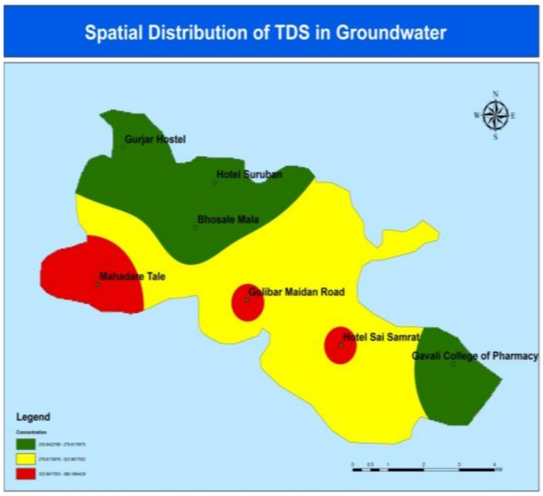


Graph 14: Magnesium of ground water from selected wells and bore wells from Study area.






Spatial Distribution of Alkalinity in Groundwater
Gurjar Hostel
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend


Spatial Distribution of TDS in Groundwater
Gurjar Hostel
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend


Spatial Distribution of Hardness in Groundwater
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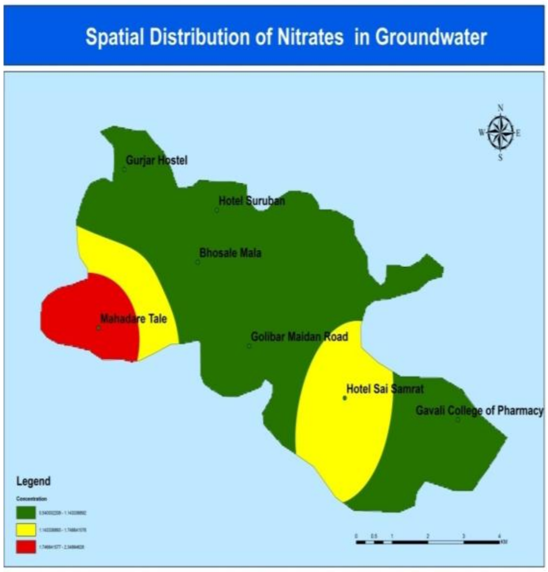
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend


Spatial Distribution of Nitrates in Groundwater
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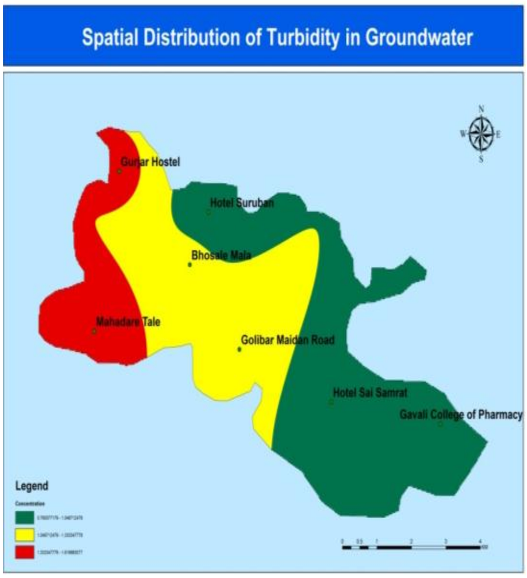
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend


Spatial Distribution of Turbidity in Groundwater
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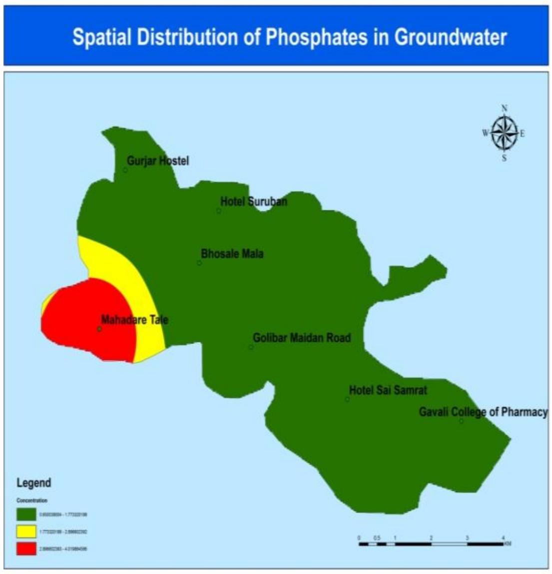
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend


Spatial Distribution of Phosphates in Groundwater
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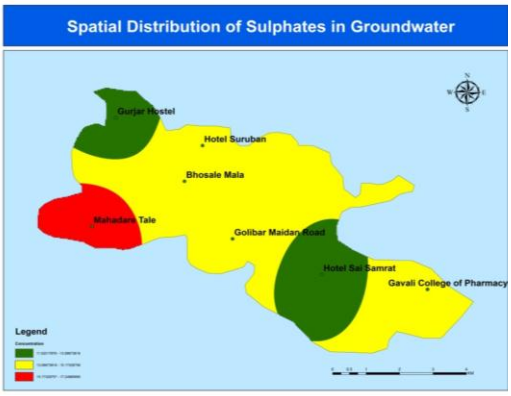
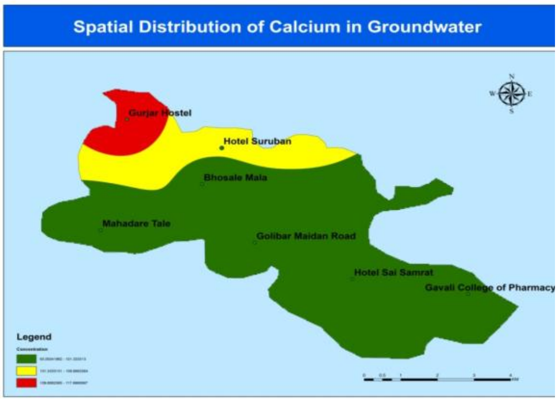
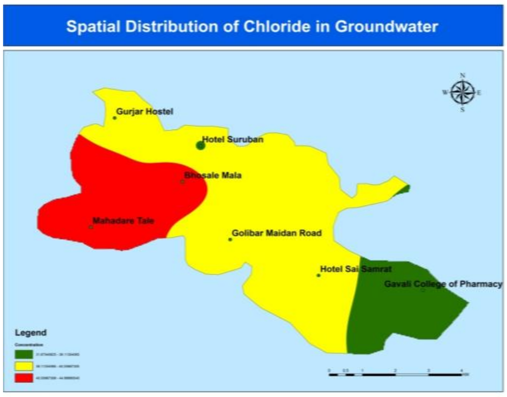
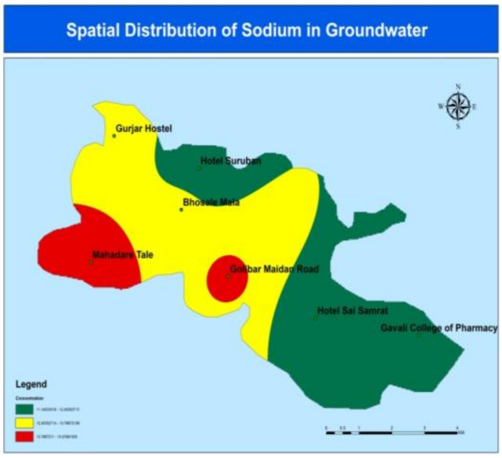
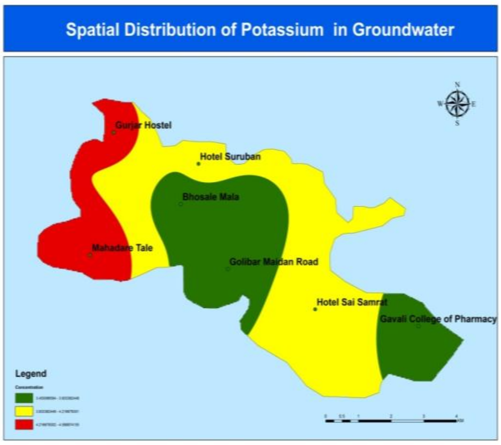
Hotel Suruban
Bhosale Mala
Mahadare Tale
Golibar Maidan Road
Hotel Sai Samrat
Gavali College of Pharmacy
Legend











DISCUSSION

Ground Water

As most of the people from Satara citydepends on the groundwater, hence it is necessary to check quality of groundwater, to find any contamination in the groundwater for this purpose, the study was carried out on "Groundwater Monitoring In and Around Satara City." In the present study various Physico-chemical parameters were analysed like pH, Temperature, TDS, Hardness, Ca and Mg hardness, Electrical conductivity, Alkalinity, Chlorides, Phosphate, Sulphate, Nitrate, Sodium and potassium contents for threeconsecutive seasons in various sampling sites which includes sampling sites from different sampling area such as from Satara town and around area.

Hydrogen ion concentration (pH)

The pH value in the study area ranges from 6.95 to 7.70 .The pH concentration map indicates that the groundwater is relatively basic in the places of Satara. The (BIS – 10500 (2004-2005) pH requirement desirable limit is 6.5 to 8.5) Low pH in the groundwater could be due to the presence of the laterite which is porous and permeable (Raghunathet al.2001), same rock structure is present over the study area so it is reason for the low pH concentration over the study area.Maiti(2013), and note that the acidic nature of groundwater in the study area can also accelerate the corrosion rate of metallic substances in water which in turn causes the rise of metallic substance in groundwater.

Electrical conductivity (EC)

The cause of high electrical conductivity in some of the boreholes may trace to the local environment of the water points in terms of geology, soil and land use activities (Idoko and Oklo). The cations and anions also contribute to the salinity of the groundwater but it varies temporally and spatially. Therefore, conductivity can indicate groundwater seepage or a sewage leak (CWT 2004). Pure water is a weak electrolyte, and the e.c of aqueous solutions will thus depend on the presence of charged ions. Because the mobility of a charged ion depends on ionic size and charge, the overall e.c of a fluid will depend on which chemical species are present and not just their concentration (Moore et al., 2008).

Total dissolved solids (TDS)

The TDS is regarded as one of the main factors which determine the use of groundwater for any purpose. TDS value found at Mahadaretale, Golibar Maidan road and Hotel Saisamrat. Total dissolved solids surpass in these sites due to the presence of all dissolved salts and ions in the water which must have been added during the interaction between the groundwater and subsurface minerals. High TDS in water may lead to decrease its consumptive value. Elevated concentrations of TDS in ground water may affect the persons who are suffering from the kidney and heart diseases, water containing high solids may also cause laxative or constipation effects (Senthilnathanet al., 2011).

Chloride (Cl^-)

Cl^- occurs naturally in all types of water. Chloride ion induces a salty taste to water (Jalali, 2010, Padmanabanet al., 2013). Residents living nearby the sites also complained about the salty taste in Sarnobatwadi and Kuditre. The possible anthropogenic sources of chloride are kitchen wastes from households, restaurants, and hotels. The concentration of Cl^- in study area is much higher in pre monsoon season and it was continuously slightly decreasingtowardsmonsoon to post monsoon season. But the average concentration of Cl^- is within the limit in study area.

Total Hardness

The hardness of water indicates water quality, mainly in terms of $Ca2^+$ and $Mg2^+$, Expressed as $CACO_3$ .The analysis is done by titration method. The Total Hardness ranges from 155 mg/l to 189.7 mg/l. Total hardness is combination of calcium and magnesium hardness which results are discussed below. Thus, calcium hardness and magnesium hardness has contributed to overall increase in the total hardness of the stated sites. Hard water are undesirable because they may lead to greater soap consumption, making food tasteless, scaling of boilers, causing corrosion and incrustation of pipes (Padmanabanet al., 2013).

Calcium ($Ca2^{++}$)

Calcium is a major ion in fresh water (Song et al. 2007). The crystalline limestone and prolonged agricultural activities could influence directly or indirectly to augment the mineral dissolution in groundwater (Bohlke 2002). At some places the Ca^{2+} hardness is beyond the permissible limits, the other values within the permissible limits. The calcium carbonate values increased within the sites where the ground water is affected by seawater intrusion due to mining activity.

Magnesium (Mg^{++})

The content of Mg^2+ is comparatively less than that of Ca^{2+}. By comparing with BIS – 10500 (2004-2005) requirement desirable limit such Mg^+ 30 mg/l. Its solubility in water is around five times that of calcium (Pradhan, 2011).The magnesium carbonates concentration is increasing as the total bicarbonates and calcium carbonates increases after the monsoon. The average concentration of the Mg in all the sites is not within the standards except some sites. Calcium and magnesium ions can be released when the water reacts with naturally occurring gypsum. The $Ca^{2+}$and Mg^{2+}could be traced to the dissolution of carbonates in the aquifer materials and also from the weathering of the accessory pyroxenes and amphiboles (Sami, 1992).

Alkalinity

The Alkalinity of water is due to hydroxides, carbonates and bicarbonates of the elements such as calcium, magnesium, sodium, potassium or ammonia and is expressed in $CaCO_3$ scale. It is quantitative capacity of water to neutralize strong acid. During the study it was found that the alkalinity was mostly in the range of the 241- 370.33 mg/lit in all consecutive Season. Average Alkalinity of the groundwater within the study area is increasing after monsoon season as the carbonates increases.(BIS – 10500, 2004-2005) Alkalinity limit is 200to 600 mg/lit.

Nitrate NO^{-3}

The NO^{-3} concentration recorded at all the places in the study area falls within the permissible limit (45 mg/l according to BIS – 10500 (2004-2005). The samples which are collected after monsoon having comparatively low NO^{-3} concentration then the sample which is collected during monsoon. Graph of nitrate concentration shows exact this pattern of nitrate concentration in different seasons. Since NO^{-3} is loosely bound to soils, it is expected to be more driven by the runoff in the rainy season. This may cause slightly rise of concentration in groundwater particularly in the rainy season (Rao et al. 2004). The NO^{-3} concentration of the study area is decreasing in post monsoon season as compare to pre monsoon season results, but the average concentrations are within the permissible limit.

Sodium (Na^+)

Na^+ is one of the important naturally occurring cations, and its concentration in fresh water is generally lower than that of Ca^+ and Mg^+. Sodium is often to be responsible for characterizing the groundwater as it readily combines with other ions like chloride, sulphate and bicarbonate. Sodium ions can be added into water by natural as well as by human activities. Sodium generally poses health risk if present in elevated amount. Groundwater from village Parite contained higher quantity of sodium. Sodium concentration in the groundwater is the result of chemical weathering of plagioclase feldspar present in the basalt (Deshmukh, 2013). Probably this may be the reason that sodium bearing rocks present beneath may have contributed to the groundwater. Natural sources of potassium in water are rainwater and the dissolution of mineral rocks. Also fertilizers and other anthropogenic activities supply potassium to water. In the present study potassium was found in traces in the residential sector as there was no any agricultural fields applying potash based fertilizers which would have get mixed with groundwater otherwise if present in huge amount. The slightly fluctuation occurs in the concentration of sodium within the sampling sites in all the seasons. During the monsoon season the sodium content is not within the limit.

Sulphate

The sulphate content of natural water is an important consideration in determining their suitability for public and industrial water supplies (Venkatesan and Swaminathan, 2009).Sulphate content in any of the residential sites was in very trace amount since no agricultural practice was observed in the proximity of the sampling sites. But the traced amount may be present in the groundwater due to oxidation of sulphide ores, gypsum and anhydride (Gupta and Roy, 2012; Roşuet al.,). Agricultural fertilizers and leachate are the main source of sulfate in groundwater (Kale et al., 2007). Although high sulphate in water may have a laxative effect (Obiefuna and Sheriff, 2011).Rainwater andanthropogenic activities can be important sources for other constituents such as sulfate (Paweret al.,1998). The primary mineral sources of sulfate ions include evaporate minerals (calcium and gypsum) and sulfates of magnesium and sodium (Pradhan, 2011).

CONCLUSION

Satara City is part of Western Ghats which is situated in Satara district of Maharashtra state. Satara is famous for its beauty and nature. It is also famous for Satara fort. There are several people living in Satara and its surrounding area.

As per survey done in 2011 the total population of Satara town is approximately 1, 16,682, where nearly in all area in Satara town. The people are totally depends on groundwater for the various purposes like for drinking purpose, domestic purposes and somewhere it is also used for agriculture purpose also, but in small scale. Hence, the reasons that for Satara people the whole and sole water source are groundwater which is in the form of dug well or bore well. Quality of groundwater determines the usefulness of water for the purposes of drinking, irrigation, and industrial uses. So now a day's aquifers are getting contaminated by different contaminants. . Leaching and percolation of toxic metals are the major threat to aquifers. Water quality has determined in various area like urban, suburban, agriculture, industrial activities. The chemical quality of groundwater is influenced to a Considerable extent by the chemical composition of rocks and soil mass through which it moves under various Physico-chemical conditions.

From the study the conclusions are

1) The pH values shows that the groundwater contains the neutral to slightly acidic type of water, for all sampling sites in all months but by comparing with Indian standard specifications for Drinking water 10500 standard it seems to be under the limit and sage for drinking water.
2) The Electrical conductivity which is also within the limit and the potability of water is secured.
3) The Total dissolved solids which are also within the limit but in Monsoon season they show high concentration.
4) The chlorides which are normally present in groundwater. During study it was observed within the limit and it is safe for drinking water quality.
5) The Hardness increases in pre monsoon season due to decrease in water level because use of water.
6) The Ca and Mg hardness also analyzed the Ca and Mg hardness occurs within the limit but some areas both occurs above the limit and the Ca- hardness increases compared to Mg- hardness as this shows deposition of Mg within the groundwater.
7) Average Alkalinity of the groundwater within the study area is increasing after monsoon season as the carbonates increases. The Alkalinity values are within the permissible limit.
8) The Nitrate, which occurs in groundwater and during present study it was found within the limit.
9) The Phosphate also occurs more in some places, but within the limit. Due to some agricultural practices, water runoff gets mixed in water and affects the water quality and hence the given water unsafe for drinking purposes.
10) The Potassium and Sodium contents are the cation which are found in little amount in present study.

Suggestions

Here are some suggestions about water conservation

1) Sewage waste water line must be properly managed and build.
2) Major source of drinking water must be properly maintained.
3) Drainage system must be properly placed.
4) Develop small scale water conservation projects.
5) The follow the screening practice during the rainy season for collecting drinking water from wells.
6) Avoid the deforestation which is done various purposes. Plantation should be done.
7) Avoid the types of pollutions which are harmful to mangrove plant as well as soil like oil pollution.
8) Ban on illegal Mining activities.
9) Water conservation projects must be developed.
10) Solid waste dumping sites are must be away from Human settlements and properly maintained.

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