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Geohydrological and Hydrogeochemical Studies of Kamalapuram Mandal, YSR District, Andhra Pradesh

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Abstract

Drinking water is an important resource that needs to be protected from pollution and biological contamination. Water is vital to health, well-being, food security and socioeconomic development of mankind. Underground water is clean but it depends upon quality and quantity of minerals dispersed and dissolved in it. Therefore, the presence of contaminants in natural fresh water continues to be one of the most important environmental issues in many areas of the world, particularly in developing countries where several communities are far away from potable water supply. Low- income communities, which rely on untreated surface water and groundwater supplies for domestic and agricultural uses are the most exposed to the impact of poor water quality. The aim of this study is to conduct an assessment of the Geohydrological and Hydrogeochemical Studies of Kamalapuram Mandal, YSR District, Andhra Pradesh. The proposed study area in the Kamalapuram Mandal of YSR District and is shown in the figures 1 & 2. The study area falls in the survey of India Toposheet No: 57 J/10 and J/11 on 1:50,000 scale. Twenty three samples of ground water using for drinking and agricultural purpose were collected from either hand pumps or open wells at different villages of Kamalapuram Mandal of YSR District, during the summer season month of February 2018. The pH of ground water in the study area is ranging from 7.0 to 8.4. The total hardness of the groundwater in the study area is ranging from 71 to 462

mg/l. Water hardness is primarily due to the result of interaction between water and the Geological formation. The calcium concentration of Groundwater in the study area is ranging from 40 to 304 mg/l during the post-monsoon period. The chloride concentration of the ground water in the study area ranging from 100 to 800 mg/l during post-monsoon period. The bicarbonate concentration of the groundwater in the study area is ranging from 60 to 220 mg/l during the post-monsoon period.

INTRODUCTION

Drinking water is an important resource that needs to be protected from pollution and biological contamination. Underground water is clean but it depends upon quality and quantity of materials dispersed and dissolved in it. Water picks up impurities in during its flow, which are harmful to man and vegetation. The reason for contamination and pollution of water in the natural surroundings and in the storage are pesticides, fertilizers, industrial wastes, inorganic and organic salts from top soil and geological strata (Nanoti, 2004). The domestic water bodies are being used for cattle drinking, human bathing, cloths washing and other domestic purposes. The quality of groundwater is highly related with local environmental and geological conditions. The quality of soil and rock and the water table determines the quality of groundwater. Groundwater constitutes an important source of water for drinking, agriculture and industrial production. The use of groundwater has increased significantly in the last decades due to its widespread occurrence and overall good quality. The contribution from groundwater is vital; because about two billion people depend directly upon aquifers for drinking water, and 40 percent of the world's food is produced by irrigated agriculture that relies largely on groundwater (Morris et al., 2003). Despite its importance, contamination from natural, human activities, steady increase in demand for water due to rising population and per capita use, increasing need for irrigation, changes in climates and overexploitation etc., among others has affected the use of groundwater as source of drinking water.

Multidisciplinary scientific integrate surveys were generally carried out to quantify the resource potential of the area, to know the status of exploitation of resources and to identify any degradation due to unscientific management. The investigation agents broadly outline the development options based on available resources. The thematic maps produced on resources will enable planners to formulate programme to optimize productivity from existing resources, and to initiate measures to correct imbalances due to unscientific management and inherent deficiency. Environmental mapping and resource evaluation survey of Kamalapuram Mandal of YSR District is taken up identification of areas for further development.

Analysis of remotely sensed data for drainage, geological, geomorphological and lineament characteristics of terrain in an integrated way facilitates effective evaluation of ground water potential zones. Similar attempts have been made in the generation of different thematic maps for the delineation of ground potential zones in different part of the study area. (Obi Reddy et al., 1994; Krishna Murthy and Srinivas, 1995; Rao et al;, 1996;

Srinivasa Gowd et al., 1998). A total of three thematic maps such as geological, geomorphological and hydrological maps were prepared based on image interpretation studies with limited field checks and analysis of available database (Figs.3, 4 &5). The lithological map portrays distribution of several of rock types and structural maps shows the structural frame work of the area. The geomorphology map depicts the various landforms evaluate through timely by geomorphic process and is a basic input to evaluate resource potential associated with the landforms. The hydrological map provides a basis for potential and non potential areas for groundwater development based on geomorphological, geological and structural information.

Objectives

- The present study aims to generate different thematic maps using satellite data along the ancillary data (Geology, Geomorphology, and Geohydrology).
- To prepare action plan for water resources
- Assessment of water quality by studying hydrogeochemistry.

Study Area

The climate of the study area is hot and semiarid. The monthly maximum, minimum and mean temperature as measured at Kadapa are 44°C, 14°C and 27°C respectively. The mean annual rainfall recorded at the Kadapa is 759 mm. The YSR district is aptly called the district of Pennar as almost the entire district is drained by the Pennar River and its tributaries.

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The important tributaries joining the river from the north include the rivers Kunderu, Sagileru and Tummalavanka while those from the south include the rivers Chitravati, Papaghni, Buggavanka, Cheyyeru, and Kalletivagu. Bahuda, Mandavi, Pukkangi and Gunjaneru are the tributaries of the Cheyyeru. The rivers and streams in the district are mostly ephemeral under the influence of heavy spells of rainfall by cyclonic storms in the Bay of Bengal (MRK Reddy et al., 2000). The study area falls in the Survey of India Toposheet No: 57 J/10 and J/11. Sample location map of the study area shown in Fig 1.

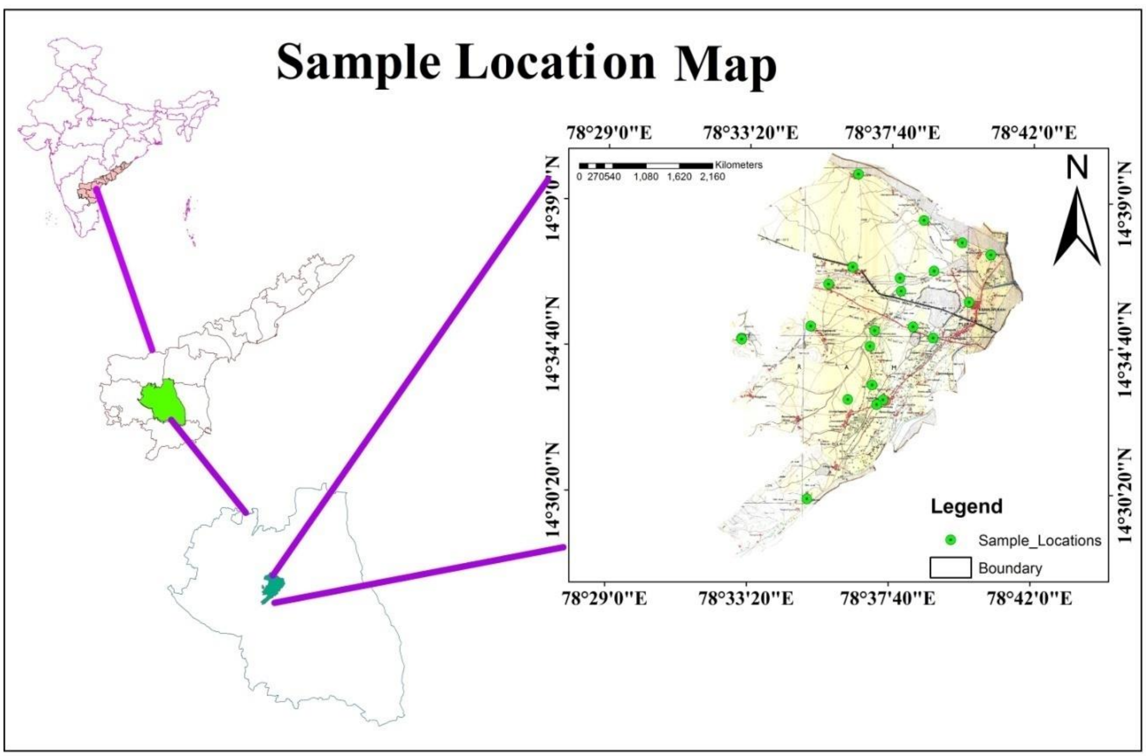

Fig 1 shows the sample location map of the study area

Geology

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The oldest rocks of the area belong to Late Archaean or Early Proterozoic era which is succeeded by rocks of Dharwarian Age and both are traversed by dolerite dykes (Murthy et al., 1979). The older rocks are overlain by rocks of Cuddapah Super group and Kurnool Group belonging to Middle and Upper Proterozoic Age. The main lithological units consist chiefly of quartzite, limestone, and shale. Alluvium consisting of gravel, sand, silt and clay occur along the river courses in the study area.

GROUP	FORMATION	LITHOLOGY
	Nandyal Shale	Shale
Kurnool Group	Narji Limestone	Massive / Flaggy Limestone
		Quartzite with Conglomerate
	Banaganapalle Quartzite	Quartzite
--------Unconformity--------		
Chitravati Group	Tadipatri formation	Shale, Tuff
--------Unconformity--------		
Papaghni Group	Vempalle formation	Basic flows
--------Unconformity--------		
Peninsular Gneissic Complex	Granite Gneisses, Schist, Granitoids with acidic and basic intrusive	

Cuddapah Supper Group

The Cuddapah Super Group is represented by thick sequence of sedimentaries unconformabally overlain by the place or basement complex. In the study area Cuddapah Super Group is represented by rock types belonging to Papaghni group covering an area about 180 sq km.

Basic intrusives

These dykes are generally medium grained and consists mainly of plagioclase, pyroxenes. Field evidence shows that they are of two generation of dykes. The spectral characteristics of these litho units are tone, texture and linear ridge. These dykes are easily delineated during interpretation. Geology map of the study area shown in fig 2.

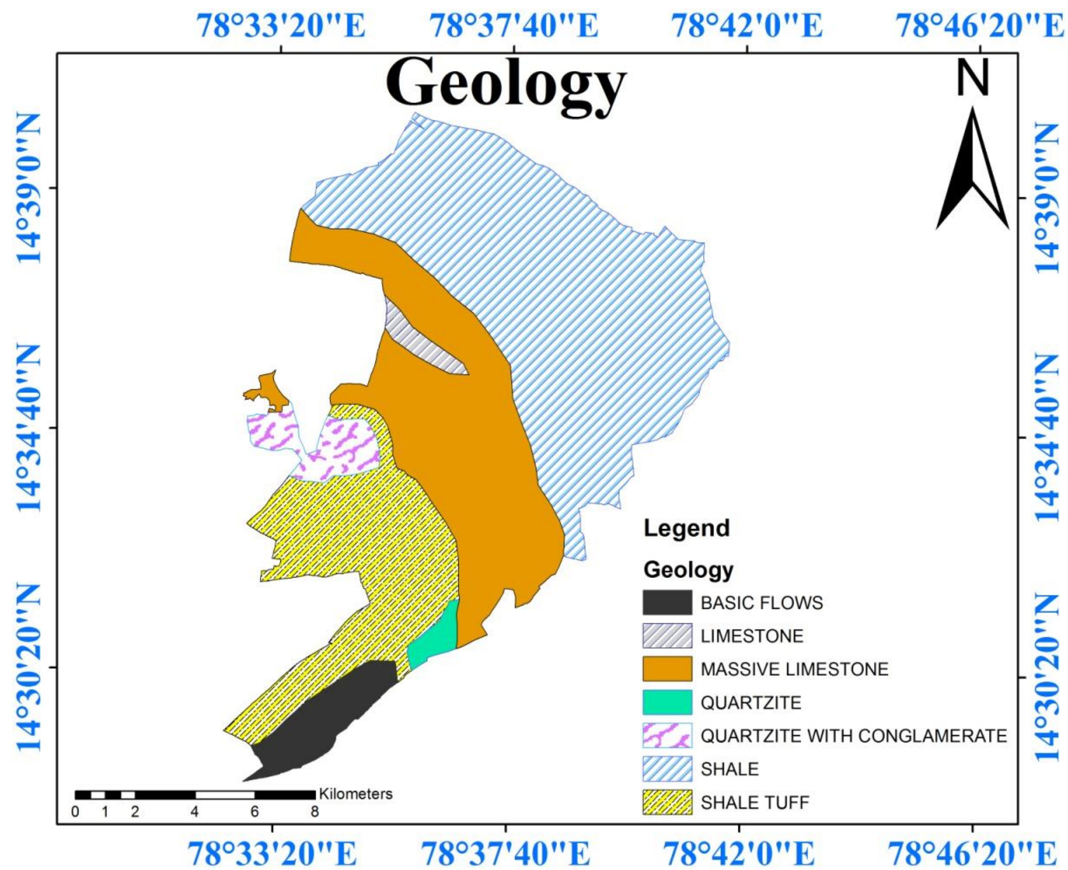

Fig 2 Geology map of the study area

Geological Structures

Structures

Bedding, joints, faults, lineaments, folds, fractures are some of the structure elements interpreted using satellite imagery No: 57 J/10, and J/11.

Dykes and faults, Lineaments are the most important structures developed in the area. The lineament either coincide with the drainage directions, alignment with the tanks, vegetation etc.

Bedding

Bedding is manifested by colour banding or compositional layering as observed the formation. The trend of the bedding varies from NW-SE to NNW-SSE with shallow dips (8^0-15^0) two wards NE or ENE.

Geomorphology

Geomorphology involves study of landforms, reconstruction of process responsible for their origin and study of influence of tectonics in time space frame. The geomorphological mapping includes inventory and classification of landforms. Each landform depends by its composition depth of weathering structural frame and the environment which includes soil cover, hydrology and hydrogeology. The landforms are classified on the basis of mode of origin, relief slope factor and surface cover. The landforms occurring in the area as grouped as pediplain, residual hill, and structural hill. Fig 3 shows geolomorphology of the study area.

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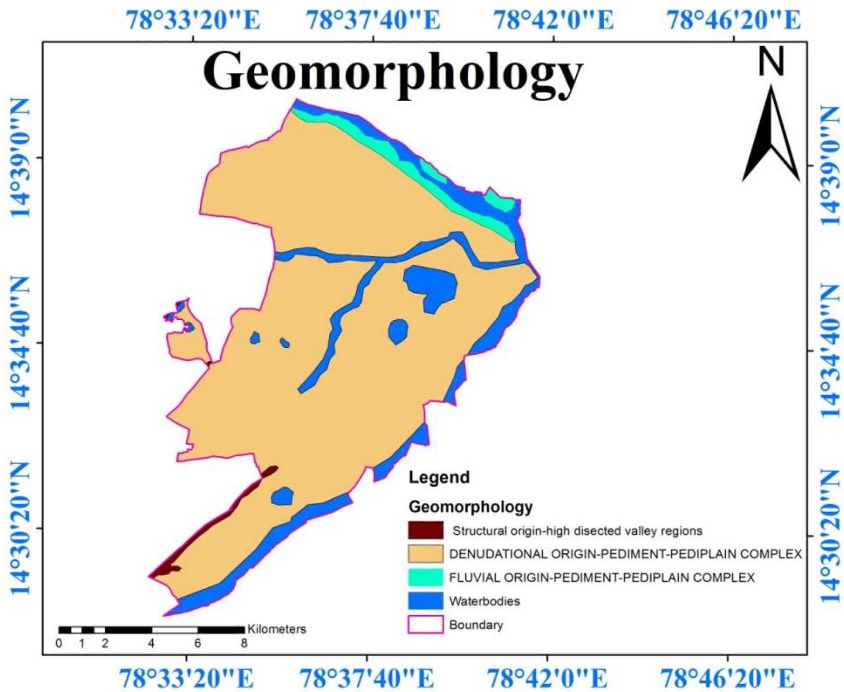

Fig 3 Geomorphology of the study area

Pediplain

It is gently sloping ramp of 2-5^{0} slope originated by coalescence of several pediments and finally merges with major tributary stream valley and floodplain.

Hydromorphology

Ground water occurrence in hard rock terrain is confined to certain landform and fractures. As the aquifer material and alluvium is usually confined to certain landform. Further lineaments, landform development and their elevation and their elevation and distribution is controlled by faults, streams, segments and fractures. Structurally exclusive litho units like dykes and acidic intrusive, it is evident from the above factors it is imperative that detail landform mapping cum classification elevation and an understanding of morpho techniques is imperative for ground water exploration in hard rock terrain.

It is a map which depicts various aspects of geomorphology, geology and character of aquifers so as to have an idea of the possibility of ground water in different units. The hydromorphologic map is to be prepared by demarcating the geomorphic units as the landforms as an important input for land management, soil mapping and identification of potential zones of ground water occurrence. The geological details like lithology, rock types and structural details are also depicted on this map since this information is necessary in identifying the ground water potential. For instance pediment, pediplain without fractures, joints and lineaments normally moderate to poor ground water prospect whereas the same geomorphic unit with a network of fractures, joints indicate good ground water prospects. Similarly pediplain area of crystalline/metamorphic rock is marked by poor to moderate ground water prospect whereas the same unit in sandstone or limestone sedimentary rock may have a good to moderate prospect.

METHODOLOGY

Twenty three samples of groundwater used for drinking and agricultural purpose were collected from ground water at different villages of Kamalapuram Mandal of YSR District during post-monsoon season in the year 2018. This season was selected because in this season often contamination increases due to low dilution and this tends to the accumulation of ions. Before sampling, the water left to run from the source for few minutes. Then water samples collected in pre cleaned sterilized

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polyethylene bottles of one litre capacity. The samples were analyzed to assess various physicochemical parameters according to APHA, 2007 (Fig.6).

RESULTS AND DISCUSSION

Water Quality Definition The concept of water quality is complex because so many factors influence in it. In particular, this concept is intrinsically tied to the different intended uses of the water; different uses require different criteria. Water quality is one of the most important factors that must be considered when evaluating the sustainable development of a given region. (Cordoba et al., 2010). Water quality must be defined based on a set of physical and chemical variables that are closely related to the water's intended use. Water whose variables meet the pre-established standards for a given use is considered suitable for that use. If the water fills to meet these standards, it must be treated before use. Water quality is considered the main factor controlling health and the state of disease in both man and animals.

Table 1. Water Sample Locations

SAMPLE NO	NAME OF THE VILLAGE	LATITUDE	LONGITUDE
1	APPARAOPALLE	78 37'07.5"	14 33'32.6"
2	C.GOPALAPURAM	78 37'58.9"	14 36'20.7 "
3	CHINNACHEPALLE	78 36'23.1"	14 33'06.3"
4	DADIREDDIPALLE	80 44'45.7"	15 34'63.5"
5	GANGAVARAM	78 40'43.1"	14 37'26.9"
6	GOLLAPALLE	78 37'11.1"	14 35'09.8"
7	JAMBAPURAM	78 37'02.8"	14 34'41.8"
8	KAMALAPURAM	78 40''04.1"	14 36'02.1"
9	KOKATAM	78 36'38.5"	14 39'48.8"

10	LETAPALLE	78 33'07.2"	14 34'54.1"
11	MIRAPURAM	78 38'58.9"	14 36'57.1"
12	NALLINGAYAPALLE	78 35'13.8"	14 35'16.6"
13	PACHIKALAPADU	78 37'56.7"	14 36'43.8"
14	PANDILLAPALLE	78 35'45.6"	14 36'32.0"
15	PEDDACHEPPALLE	78 37'28.0"	14 33'06.3"
16	PODADHURTHI	78 35'09.8"	14 30'08.4"
17	RAMACHANDRAPURAM	78 38'58.4"	14 34'57.5"
18	SAMBATUR	78 38'39.5"	14 38'27.3"
19	T.SADIPIRALA	78 38'21.4"	14 35'17.3"
20	THURAKAPALLE	78 33'07.3"	14 34'51.7"
21	VIBHARAPURAM	78 39'50.2"	14 37'48.1"
22	YELLAREDDYPALLE	78 37'16.1"	14 32'57.6"
23	YERRAGUDIPADU	78 36'30.0"	14 37'02.9"

Factors Affects Water Quality

Water is vital to health, well-being, food security and socioeconomic development of mankind. Therefore, the presence of contaminants in natural freshwater continues to be one of the most important environmental issues in many areas of the world, particularly in developing countries, where several communities are far away from potable water supply. Low-income communities, which rely on untreated surface water and groundwater supplies for domestic and agricultural uses are the most exposed to the impact of poor water quality. Unfortunately, they are also the ones that do not have adequate infrastructure to monitor water quality regularly and implement control strategies. (Ayoko et al., 2007; Kazi et al., 2009) reported that human activities are a major factor determining the quality of the surface and groundwater through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use.

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Environmental pollution, mainly of water sources, has become public interest. The chemical composition of ground water is controlled by many factors that include the composition of precipitation, mineralogy of the watershed and aquifers, climate and topography. These factors can combine to create diverse water types that change in composition spatially and temporally. (Chenini I and Khemiri S., 2009). Exploitation of groundwater resources beyond their potential renewal capacity, results in a hydrological deficit. Generally, this is expressed as a decline in groundwater levels but in coastal aquifers this may cause intrusion of seawater.

Concept of Ground Water Quality

The concept of ground water quality seems to be clear, but the way of how to study and evaluate it still remains tricky (Badiker et al., 2007). Consider that the definition of water quality is not objective, but is socially defined depending on the desired use of water. Different uses require different standards of water quality.

Safe Drinking water: Potable or "drinking" water can be defined as the water delivered to the consumer that can be used for drinking or cooking. This water must meet the physical, chemical, bacteriological and radionuclide parameters when supplied by an approved source, delivered to the consumer through a protected distribution system in sufficient quantity and pressure. (Zuane J., 1997).

Table: 1 Physico Chemical Parameters of ground water of the Study area

Sample No	pH	EC (μs)	TDS (Mg/L)	Chloride Mg/L	Total Hardness	Bi Carbonate (HCO_3)	Calcium (Mg/L)
1	7.8	1040	760	220	71	220	240
2	7.4	1250	850	180	284	120	280
3	7.3	1050	600	320	248	60	120
4	7.6	1130	740	100	178	84	160
5	8.0	1600	890	260	355	108	104
6	7.3	1230	680	130	263	132	200
7	7.0	1970	1160	200	405	144	320
8	7.6	1010	818	180	355	108	200
9	7.8	1610	870	200	383	84	40
10	7.8	1380	940	140	320	144	200
11	8.0	1360	810	140	178	132	208
12	7.4	2010	1050	120	462	142	120
13	8.4	2400	1070	400	242	108	272
14	7.4	2480	1080	120	284	168	128
15	8.2	2190	1279	800	249	132	144
16	7.2	1690	1040	380	142	156	200
17	7.0	1620	930	100	426	180	304
18	7.8	1660	870	280	92	132	152
19	7.8	1420	880	120	171	132	176
20	8.0	1090	630	140	213	156	120
21	7.6	1010	667	320	284	158	120
22	8.1	1230	840	180	178	180	182
23	7.8	1600	880	380	320	192	160

Water Quality Standards / Guidelines: 2.2.1 The Guidelines for drinking-water quality: The Guidelines describe reasonable minimum requirements of safe practice to protect the health of consumes and/or derive numerical "guideline values" for constituents of water or indicators of water quality. In order to define mandatory limits, it is preferable to consider the guidelines in the context of local or national environmental, social, economic and cultural conditions (WHO, 2008).

The Standard for drinking-water quality: By definition, a standard "a rule or principle considered by an authority and by general consent as a basis of comparison. It is something normal or average in quality and the most common form of its kind". A proper standard for drinking water quality is thus the reference that will ensure that the water will not be harmful to human health. The framework against which a water sample can be considered good or "safe" is a drinking water quality standard (Solsona F, 2002).

2.2.3 WHO Guidelines: The primary purpose of the Guidelines for Drinking-water Quality is the protection of public health. Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all improving access to safe drinking-water (WHO, 2008).

Salient features of major ion chemistry

Hydrogen Ion Concentration (pH)

The pH of water is very important of its quality and provides important piece of information in many types of geochemical equilibrium or solubility calculations (Hem, 1991). The limit of pH value for drinking water is specified as 7.0 to 8.4 (ISI, 1983).

In most natural waters, the pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. As the equilibrium is markedly affected by temperature and pressure, it is obvious that changes in pH may occur when these are altered. Most ground waters have a pH range of 6 to 8.5

(Karanth, 1987). The pH of groundwater in the study area is ranging from 7.0 to 8.4. pH values for all the samples are within the desirable limits. It is observed that most of the groundwater is alkaline in nature. Though pH has no direct effect on the human health, all biochemical reactions are sensitive to variation of the pH.

Total Hardness

Hardness is an important criterion for determining the usability of water for domestic, drinking and many industrial purposes (Karanth, 1987) and results from the presence of divalent metallic ions, of which calcium and magnesium are the most abundant in the groundwater. Other elements could be included are strontium, barium and some heavy metals. These, however are seldom determined under usually present in insignificant amounts relative to calcium and magnesium.

The degree of hardness in water is commonly based on the following classification

Hardness classification of water
(After Sawyer and Mc Carty)

Hardness, mg/l as $CaCO_3$	**Water class**
0-75	Soft
75-100	Moderately hard
150-300	Hard
Over 300	Very hard

The total hardness of the groundwater in the study area is ranging from 71 to 462 mg/l. The limit of total hardness for drinking water is specified as 300 mg/l (ISI, 1983). Water hardness is primarily due to the result of interaction between water and the geological formations.

Groundwater of the entire study area exceeds the desirable limits. Granitic rocks significantly contribute to groundwater hardness.

Calcium

The range of calcium content in groundwater is largely dependent on the solubility of calcium carbonate, sulfate and rarely chloride. The solubility of calcium carbonate varies widely with the partial pressure of CO_2 in the air in contact with the water. The salts of calcium and magnesium are responsible for the hardness of water. The permissible limit of calcium in drinking water is 75 mg/l (ISI, 1983). The calcium concentration of the groundwater in the study area is ranging from 40 mg/l to 304 mg/l during post-monsoon period.

Chloride

Chloride bearing rock minerals such as sodalite and chlorapatite which are very minor constituents of igneous and metamorphic rocks, and liquid inclusions which comprise very insignificant fraction of the rock volume are minor sources are chloride in groundwater. It is presumable that the bulk of the chloride in groundwater is either from atmospheric sources or sea-water contamination. Most chloride in groundwater is present as sodium chloride, but the chloride content may exceed the sodium due to base-exchange phenomena (Karanth, 1985) and also weathering of phosphate minerals and domestic sewage (Karanth, 1987). The upper limit of chloride concentration for drinking water is specified as 250 mg/l (ISI, 1983). The chloride concentration of the groundwater in the study area is ranging from 100 to 800 mg/l during post-monsoon period.

Total Alkalinity (CO_3 and HCO_3)

The primary source of carbonate and bicarbonate ions in groundwater is the dissolved carbon dioxide in rain, which, as it enters the soil, dissolves more carbon dioxide. An increase in temperature or decrease in the pressure causes reduction in the solubility of carbon dioxide in water (Karanth, 1989). The alkalinity of natural water is due to the salts of carbonates, bicarbonates, borates, silicates and phosphates along with hydroxyl ions in the free salt. However, the major portion of the alkalinity in natural water is caused by hydroxide, carbonate and bicarbonates, which may be ranked in order of their association with pH values.

The bicarbonate concentration of the groundwater in the study area is ranging from 60 mg/l to 220 mg/l during pre-monsoon period. The permissible limit of carbonate (CO_3) in drinking water is 10 mg/l and the rejection limit is 50 mg/l. The permissible limit of bicarbonate (HCO_3) in drinking water is 500 mg/l. (Todd, 1980). Most of the water samples of the study area contain no carbonate ions.

Conclusion

The pH of groundwater in the study area is ranging from 7.0 to 8.4. pH values for all the samples are within the desirable limits. It is observed that most of the groundwater is alkaline in nature. The electrical conductivity of the groundwater is ranging from 1010 μSiemens/cm-2480 μSiemens/cm at 25°C. The pH and EC were measured with pH meter and conductivity meter respectively. The Total Hardness of the groundwater in the study area is ranging from 71 to 462 mg/l.

The limit of Total Hardness for drinking water is specified as 300 mg/l (ISI, 1983). Water hardness is primarily due to the result of interaction between water and the geological formations. Groundwater of the entire study area exceeds the desirable limits. The calcium concentration of the groundwater in the study area is ranging from 40 mg/l to 304 mg/l during pre-monsoon period. The upper limit of chloride concentration for drinking water is specified as 250 mg/l (ISI, 1983). The chloride concentration of the groundwater in the study area in ranging from 100 to 800 mg/l during post-monsoon period. The bicarbonate concentration of the groundwater in the study area is ranging from 60 mg/l to 220 mg/l during post-monsoon period.

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