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Geohydrological and Geochemical Studies of Yerraguntla Mandal, YSR (Kadapa) District, Andhra Pradesh, using Remote Sensing Techniques

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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 Geochemical Studies of Yerraguntla Mandal, Kadapa District, Andhra Pradesh, using Remote Sensing Techniques'. The proposed study area in the Yerraguntla revenue mandal of Kadapa Disrict and is shown in the figer 1. The study area falls in the survey of India Top sheet No:57J/06 & 10. Twenty one samples of ground water used for drinking purposed were collected from either hand pumps or open wells at different villages of Yerraguntla mandal of Kadapa District, during the summer season month of March and April 2014. The pH of ground water in the study area is ranging from 2.45 to 8.54. The total hardness of the groundwater in the study area is ranging from 80 to 880mg/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 350 mg/l during the pre-monsoon period. The chloride concentration of the ground water in the study area ranging from 127 to 2016.4 mg/l during pre-monsoon period. The bicarbonate concentration of the groundwater in the study area in ranging from 24.4 to 1146.8 mg/l during the pre-monsoon period. The fluoride concentration of the groundwater in the study area ranging from 0.44 to 6.18 mg/l during the pre-monsoon period. Low concentration of fluoride (0.44mg/l) is observed in kalamalla village and high concentration of floured (6.18mg/l) is observed peddanapadu village. Proper deflouridation techniques have to follow to monitor fluoride contamination.

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.

Excess amount of physic-chemical components, cause a certain ecological and physical problems to human. A chloride present in excess imports the salty taste to water and people who are not accustomed to high chlorides are subjected to laxative effect, due to chloride present in excess amount the salinity of water also increases. Turbidity is a measure of cloudiness in water, when water is highly turbid, which can clog fish gill, reduce growth rate and residence of disease (http://www.indiawaterportal.org/sites/indiawaterportal.org/files/ Know your water). The presence of nitrate in water has been associated with methamoglobinemia and also certain disease in animal (Frank and Shannon, 2005). It was harmful for irrigation due to presence of carbonates as it increased salinity of soil (Tambekar *et al*, 2008). Dissolved oxygen present in drinking water was highly fluctuating factor. The physic-chemical properties of ground water clearly explain its geological profile, pollution states as well as human and animal health problems and other perspective. Major problems are being faced by the country due to the presence of excess fluoride, arsenic and nitrate in groundwater in certain parts of country. At present twenty nine countries are reported to be affected with fluorosis, the fluoride related disease. Fluoride problems are wide spread in nine states covering almost the entire country.

OBJECTIVE OF STUDY

The objective of this study is to conduct an assessment of the quality of groundwater resource in and around Yerraguntla Mandal, kadapa District, India.

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 Kadapa district is aptly called the district of pennar as almost the entire district is drained by the Pennar River and its tributaries. The important tributaries joining the river from the north include the rivers Kunderu, sagilere and Tummalavanka while those from the south include the rivers Chitravati, Papaghni, Buggavanka, Cheyyeru, and kalletivagu. Bahuda mandavi, Pukkangi and Gunganeru 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/6 and J/10. Sample location of the study area is shown in figure: 1.

METHODOLOGY

Twenty one samples of groundwater used for drinking purpose were collected from either ground water or surface water at different villages of Yerraguntla Mandal of Kadapa District during post-monsoon season in the year 2014. 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 polyethylene bottles of one litre capacity. The samples were analyzed to assess various physicochemical parameters according to APHA (2007).

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. For each variable, acceptable and unacceptable values must then be defined. 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.

Factors Affected 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. 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. (Chenini I and Khemiri S., 2009). (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 not used for drinking, cooking. Only used washing. 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).

Water Quality Standards/Guidelines: 2.2.1 The Guideliness for drinking-water quality: The Guideliness 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).

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

Sample Number	pH	TH mg/l	Ca^{2+} mg/l	Cl^- mg/l	F^- mg/l	HCO3+ mg/l
1	8.16	480	224	610	3.81	1146.8
2	8.13	520	248	411.8	1.53	463.6
3	8.42	200	184	340.8	4.39	341.6
4	8.54	80	240	149.1	6.18	536.8
5	2.45	520	144	1583.3	1.53	24.4
6	8.00	1040	78	426	1.28	561.2
7	8.11	360	350	220.1	2.99	634.4
8	7.89	360	128	234.3	1.62	439.2
9	7.74	360	64	184.6	0.903	292.8
10	8.23	680	56	702.9	1.75	536.8
11	8.10	520	48	440.2	2.06	414.8
12	8.43	480	40	227.2	1.13	244

13	7.69	440	56	326.6	1.05	317.2
14	8.26	200	56	234.3	1.12	292.8
15	7.95	400	80	340.8	0.974	219.6
16	7.96	880	88	639	1.00	268.4
17	7.66	2360	240	2016.4	0.852	390.4
18	8.06	680	96	525.4	1.31	292.8
19	8.20	560	80	369.2	0.987	244
20	8.10	960	88	468.6	4.74	488
21	7.16	360	56	127.8	0.411	97.6

Table: 2 Water Sample Locations

S.No	Name of The village	Latitude	Longitude
1	Tippaluru	N14°36'40"	E78°34'39"
2	Sunkesula	N14°36'17"	E78°33'57"
3	Koduru	N14°35'53"	E78°32'14"
4	Peddanapadu	N14°35'03"	E78°31'15"
5	Dondlapadu	N14°37'51"	E78°31'14"
6	Valasapadu	N14°37'05"	E78°31'04"
7	Tummalapalli	N14°36'26"	E78°30'32"
8	Kadirivaripalli	N14°37'53"	E78°30'43"
9	Nidizivve	N14°38'40"	E78°30'07"
10	Chilamkur	N14°38'51"	E78°28'06"
11	Kalamalla	N14°41'38"	E78°28'21"
12	Krishnanagar	N14°41'33"	E78°21'24"
13	Mekalapalli	N14°43'01"	E78°28'24"
14	Chinnadandluru	N14°44'20"	E78°28'52"
15	Potladurthi	N14°42'31"	E78°32'42"
16	Malapadu	N14°42'31"	E78°30'38"
17	Venkatapuram	N14°42'37"	E78°30'55"
18	B.Khadarpalli	N14°41'40"	E78°38'44"
19	Hanumangutta	N14°40'59"	E78°34'15"
20	Yerraguntla	N14°38'40"	E78°32'16"
(s)21	Kalamalla	N14°41'38"	E78°28'21"

Salient features of major ion chemistry

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 6.5 to 8.5 (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 2.45 to 8.54. 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 80 to 880 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 exceed 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 350 mg/l during pre-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

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for drinking water is specified as 250 mg/l (ISI, 1983). The chloride concentration of the groundwater in the study area is ranging from 127.8 to 2016.4 mg/l during pre-monsoon period.

Fluoride

Fluoride in drinking water has now become one of the most important geo-environmental and toxicological issues in the world. During the last three decades, high fluoride concentrations in drinking water sources and the resultant disease “Fluorosis” is being highlighted throughout the world. In developing countries, especially in the tropical regions, rural communities, how mostly depend on groundwater sources for their domestic water supplies, face this problem seriously. In India alone about 25 million people in 8700 villages are consuming water with high fluoride concentrations (Apambire et al, 1997). Andhra Pradesh, Rajasthan, Uttar Pradesh, Gujarat and Tamil Nadu being the states with the highest rating of endemic Fluorosis. Fluoride concentrations as much as 20 mg/l have been recorded in groundwater from these areas (Handa, 1975). The prominent health related problems due to high fluoride concentration are dental concentrations as much as 20 mg/l have been recorded in groundwater from these areas (Handa, 1975). The prominent health related problems due to high fluoride concentration are dental caries, teeth mottling endemic cumulative fluorosis causing skeletal damage and deformation to children and adults. According to Indian standard specification for drinking water (BIS, 1991; WHO, 1985), 1.5-mg/l fluoride is the maximum permissible limit. Dental fluorosis is visible sign that fluoride has poisoned enzymes in the body. Poor nutrition exacerbates the toxic effects of fluoride exposure, which is the region why the poor communities are common victims. According to the agency for toxic substances and Disease Registry, "Existing data indicate the subsets of the population include the elderly people with deficiency of calcium, magnesium and vitamin C, and people with cardiovascular and kidney problems".

In recent times the interest in fluoride has greatly increased, owing to its importance in the precipitation of fixation of phosphate in minerals like fluorapatite, and to the recognition of pathological conditions in man and animals, described as fluorosis.

Effect of Fluoride on human health

Fluoride is beneficial to certain extent when present in concentrations of 0.8-1.0 mg/l for calcification of dental enamel especially for the children below 8 years of age. But it causes dental fluorosis if present in excess of 1.5 mg/l and skeletal fluorosis beyond 3.0 mg/l if such water is consumed for about 8 to 10 years. As per W.H.O guidelines for drinking water quality and water technology mission of the Government of India, the permissible limit for fluoride in drinking water is 1.0 mg/l. It can be extended to 1.5 mg/l if there is no alternative source in the village.

Dental Fluorosis

Generally ingestion of water having a fluoride concentration above 1.5- 2.0 mg/l may lead to dental mottling, an early sign of dental fluorosis which is characterized by opaque white followed by pitting of teeth surfaces. The degree of mottling depends largely on the amount of fluoride ingested per day. With increasing concentrations of fluoride, the effect becomes progressive. Dental fluorosis can produce considerable added dental costs (tooth deterioration) and significant physiological stress for affected populations.

Skeletal Fluorosis

Skeletal fluorosis may occur when fluoride concentrations in drinking water exceed 4-8 mg/l. The condition itself as an increase in bone density leading to thickness of long bones and calcification of ligaments. The disease may be present in an individual at subclinical, chronic, or acute levels of manifestation. Symptoms range from mild rheumatic or arthritic pain in joints and muscles, to severe pain in the cervical spine region along with stiffness and rigidity of the joints. Crippling skeletal fluorosis can occur when a water supply contains more than 10 mg/l (WHO 1970). The fluoride concentration of the groundwater in the study area is ranging from 0.411 mg/l to 6.18 mg/l during pre-monsoon period. Low concentration of fluoride (0.411 mg/l) is observed in Kalamalla village and high concentration of fluoride (6.18 mg/l) is observed in the village Peddanapadu.

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 inorder of their association with pH values.

The bicarbonate concentration of the groundwater in the study area is ranging from 24.4 mg/l to 1146.8 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 contains no carbonate ions.

Conclusion

The pH of groundwater in the study area is ranging from2.45 to 8.54. 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 357 µSiemens/cm-4180 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 from80 to 880 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 exceed the desirable limits. The calcium concentration of the groundwater in the study area is ranging from 40 mg/l to 350 mg/l during pre-monsoon period. The Mg concentration of the groundwater in the study area is ranging from ………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 127.8 to 2016.4 mg/l during pre-monsoon period. The bicarbonate concentration of the groundwater in the study area is ranging from 24.4 mg/l to 1146.8 mg/l during pre-monsoon period. The fluoride concentration of the groundwater in the study area is ranging from 0.411 mg/l to 6.18 mg/l during pre-monsoon period. Low concentration of fluoride (0.411 mg/l) is observed in Kalamalla village and high concentration of fluoride (6.18 mg/l) is observed in the village Peddanapadu. Proper defluoridation techniques have to be followed to monitor fluoride contamination.

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