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Groundwater Quality and its Suitability for Drinking and Agricultural purpose around Wailpalli Area, Yadadri Bhuvanagiri District, Telangana State, India

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ABSTRACT

Assessment of suitability of groundwater for domestic and agricultural purposes was carried out in Wailpalli area, Yadadri Bhuvanagiri district of Telangana state. Groundwater is the major source for domestic and agricultural activity in the study area. Hydro geochemical studies have been carried out on 25 groundwater samples collected from the existing bore well/tube wells, dug wells, dug cum bore wells and surface water bodies i.e., in Wailpalli area. Parameters such as Electrical conductivity, pH, TDS and major on concentrations such as Ca^{+2}, Mg^{+2}, Na^{+}, K^{+2}, CO_3^{-2}, HCO_3^{-}, Cl^{-}, and F^{-} were studied. The study area forms a part of the stable peninsular shield and is a granitic terrain consisting of unclassified crystalline of Precambrian age is main litho logical formations. The analytical result indicates that groundwater is acidic to alkaline and mostly hard in nature. Possible source of fluoride are due to weathering and leaching of fluoride bearing minerals.

Keywords: Water Quality, Drinking purpose, Sodium Absorption Ratio, Residual Sodium Carbonate.

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INTRODUCTION

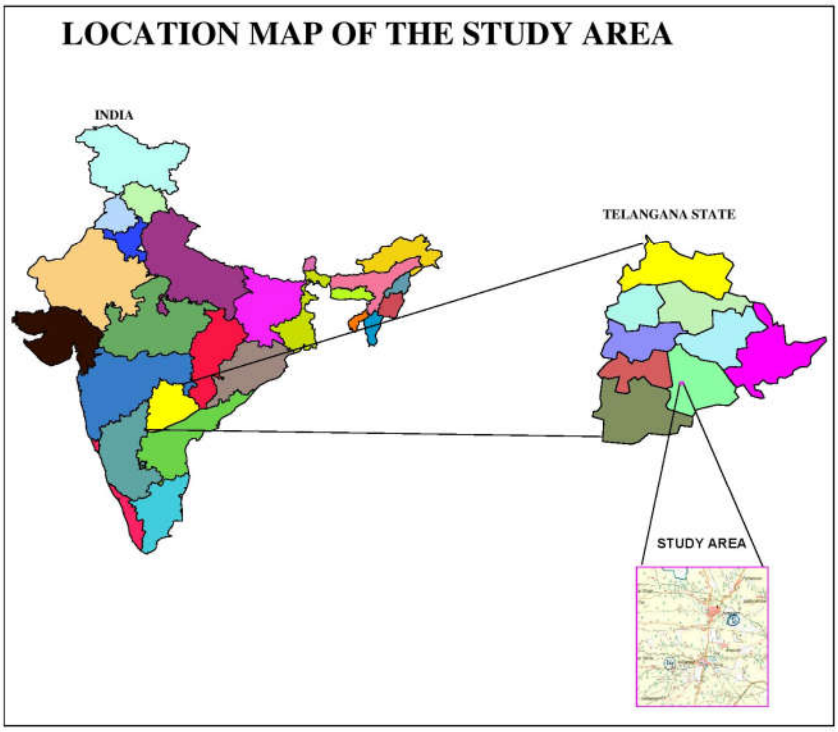
Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world's population. It is the estimated that approximately one third of the world's population use groundwater for drinking. The increased demand for the water due to agriculture expansion, growing population and urbanization, so water resources management has become very important. The interaction of the natural and anthropogenic factors leads to various water types. According to Hamzaoui-Azazam [1], the increased knowledge of the geochemical evolution of water quality could lead to effective management of water resources. In India and various parts of the world, numerous studies have been carried out to assess the geochemical characteristics of groundwater [2-5]. Importance of hydrochemistry of the groundwater had led to a number of detailed studies on the geochemical evolution of groundwater [6]. The graphical representation diagrams of US salinity and Wilcox diagrams will help to recognize the various types of hydrogeochemical data in groundwater system. It will helps in evaluation of the suitability of the groundwater for irrigation purposes. The objective of this study is to determine the groundwater quality of Lamapur area and to delineate regions where groundwater is suitable or unsuitable for drinking and irrigation purpose. The study area lying between North latitude from 1640' - 1635' and East longitude 7910' - 7915' is located in the survey of Imfia Topo Sheet No. 56 p12 and experiences semi-arid climate. The study area is covered by Archean granites intruded by dolerite dykes, Quartz reffs, pegmatits and quartz veins.

MATERIAL AND METHODS

Study of the area

The study area occurs in the western part of Yadadri Bhuvanagiri district and lies between latitudes 17^{0}00\` - 17$^{0}$10\` N and longitudes 78^{0}48' – 79^{0}00' E covering Survey of India toposheet 56 K/16. Major part of the investigated area falls in Narayanpur mandal while very small part falls in Mungod mandal in the east and Chandur mandal towards south (Fig.1)

The study area covering of 213 sq.km comprises eleven revenue villages in the three mandals. There about 36 hamlets, which are located in the interior hilly terrain in the west part of the area. These hamlets/tandas are mostly occupied by Lambada tribes. Among eleven villages, five villages viz.., Kurmakothaguda, Jangao, Wailapalli, Puttapaka and Chillapur fall in Narayana mandal.



GEOLOGY AND STRUCTURE:

The study area is underlain by Archaean Group of rocks represented by older Group of rocks and Peninsular Gnessic Complex. The older rocks include hornblende schist biotite schist, and amphibolites while peninsular gneissic complex is represented by pink and porphyritic granite gneisses, pink granites and injuctions of quatz, pegmatites and epidote veins. Dolerites mark the last phase of igneous activity in the area and they cut across all the above rocks.

OLDER METAMORPHIC ROCKS:

Among the older rocks, biotite schists and hornblende schists are found to occur as inclusions in the migmatitic gneiss. The common and characteristic feature of these intrusive is there alignment parallel to the gnessocity of enclosing migmatites. Biotite schist inclusions which are fine grained, frequently seen in the grey migmatitic gneisses are in the form of streaks, bands, clots, pods, lenses etc.

PENINSULAR GNEISSIC COMPLEX:

Among this group of rocks, grey granite gneiss occupy major part of the area and occur as sheet like exposures or as gentle demo-like hills. These rocks are medium to Red sandy loam is the chief soil type. It is derived from the weathering of granites gneisses and found on the plain and in the valley bottoms. Black cotton soils found on higher elevations and are surrounded by the red soils.

STRUCTURE:

The area experienced substantial structural disturbances resulting in the development of well marked jointing and fracture features. Major sets of joint trends are in N 10^{0} W – S 10^{0} E and N 75^{0} E – S 75^{0} W and are vertical in nature. The main features are aligned along NW – SE, NNE – SSW and WNW – ESE directions. These are tensile, vertical fractures. They occur near the surface and are as a result of decompression of the crystalline rocks. The EW and NS fractures are noramllu filled with intrusive like dolerite dykes.

Experimental

The sampling bottles soaked in 1:1 HCL for 24h were rinsed with distilled water followed by deionized water. At the time of sampling, the bottles were thoroughly rinsed two or three times, using the groundwater to be sampled. The chemical parameters viz. pH and electrical conductivity (EC) were collected in 1000-ml polyethylene bottles from hand pump/bore holes in the study area. The bottles were labeled, tightly packed, transported immediately to the laboratory, and stored at 4°C for the chemical analyses.

The samples were analyzed for total alkalinity(TA) as CaCo3, total hardness (TH) as CaCo3, calcium (Ca2+),sodium(Na+), potassium (K+), bicarbonate (HCo3), chloride(Cl_), Sulfate(So4), Nitrate(No3), and fluoride (F_), following the standard water quality methods (Table-2).The evaluation of chemical characteristics of groundwater and suitability for drinking, irrigation and industrial purposes have been carried out. Total dissolved solids (TDS) were computed as per Hem (1985, 1991) and Karanth (1987) from EC values multiplied by 0.64 and magnesium (Mg2+) was calculated, using the values of TH and Ca2+ .

The flame photometer (Systronics, 130 India), concentrations of sodium (Na+) and potassium (K+) in the groundwater were measured. Electrical conductivity (EC) and pH were measured by conductivity meter (Systronics,304) and digital pH meter (systronics, 802).

RESULTS AND DISCUSSION

Suitability of groundwater quality for drinking purpose was assessed, following the drinking water quality standards of Bureau of Indian standards [6] and [8] to know the implication of health conditions; irrigation needs was judged, using the salinity hazard and sodium hazard with the United states Salinity Laboratory staff USSLS, 1954) diagram, the total salt concentration and percent of sodium in the Wilcox (1995) diagram, the residual sodium carbonate [9], to assess the adverse impacts on crop-growth was evaluated with respect to the chemical parameters, i.e., pH, TDS, TH, HCO3, Cl-, and F- to assess the common undesirable effects of incrustation and corrosion.

The pH of water is easily measured in the field and must be measured in-situ to achieve accuracy. When groundwater is exposed in to the atmosphere, dissolved CO2 escapes and the pH rises. The combination of CO2 with water forms carbonic acid, which affects of the pH in the water. The pH in the groundwater is varied from 7.25 to 8.36 in all the groundwater samples of the study area and is within safe limit.

Pure water contains low electrical conductance of around 0.1µS/cm. Ionic species dissolved in the water, then increase the conductivity, but conductance measurements cannot be used to estimate ionic concentrations, natural water contain a variety of dissolved species in various amounts. The value of EC is between 300 and 3650 µS/cm .The Ec is a measure of a materials ability to conduct an electric current so that the higher Ec indicates the enrichment of salts in groundwater. The TDS, which indicates total dissolved ions in the water, is between 207 and 2518mg/L. Based on total dissolved solids, groundwater is classified [10] into desirable for drinking (up to 500 mg/L), permissible for drinking (500-1000 mg/L), useful for agriculture purposes (up to 300 mg/L) and unfit for drinking and irrigation (above 3000 mg/L). Accordingly, the quality of groundwater in present study area is classified as desirable for drinking, permissible for drinking for drinking, agricultural purposes and unfit for drinking and irrigation in 30% (samples 2,4,and 5);) and 10% (sample 1 and 5) of the total water samples respectively. The high TDS, may be due to the influence of the anthropogenic sources, such as domestic sewage, septic tanks, and agriculture activities. 60% groundwater of the study area exceeds the desirable limit of 500 mg/L of TDS .Generally, the higher TDS decreases palatability, and causes gastrointestinal irritation in the consumers. It has also laxative effect, especially upon transits . But, the extended intake of water with the higher TDS can cause kidney stones, which are widely reported from different parts of the country [11].

Table - 2: Instrumental and volumetric methods used for chemical analysis of groundwater in the adjoining Wailpalli area Yadadri Bhuvanagiri District, Telangana State, India.

Chemical Parameters	Units	Method, instrument (make)	Reagents	Reference
pH	pH	meter (Systronics)	pH 4, 7, and 9.2 (buffer solutions)	[5]
EC	µS/cm	EC meter (Systronics)	Potassium chloride	[5]
TDS	mg/L	EC×conversion factor	(0.55 to 0.75)	[5]
TA	mg/L	Volumetric	Hydrochloric acid (HCl) and methyl orange	[5]
TH	mg/L	Volumetric	Ethylenediaminetetraacetic acid (EDTA),ammonia and eriochrome black-T	[5]
Ca2+	mg/L	Volumetric	EDTA, sodium hydroxide and murexide	[5]

Mg^{2+}	mg/L	Calculation		[5]
Na^+	mg/L	Flame photometer	Sodium chloride (NaCl), KCl and calcium carbonate ($CaCO_3$)	[5]
K^+	mg/L	Flame photometer	NaCl, KCl and $CaCO_3$	[5]
HCO_3^-	mg/L	Volumetric	Hydrosulfuric acid (H_2SO_4), phenolphthalein	[5]
CO_3^{2-}	mg/L	Volumetric	Hydrosulfuric acid (H_2SO_4), methyl orange	[5]
Cl^-	mg/L	Argentometric	Silver nitrate, potassium chromate	[5]

Calcium and Magnesium are the principle ions responsible for total hardness. The observed value of TH in the groundwater is between 285 and 775 mg/L. The TH can be classified as soft, if the TH is less than 75 mg/L; moderately hard, if the TH is varied from 75 to 150 mg/L; hard, if the TH is between 90 and 445 mg/L; and very hard, if the TH is more than 300 mg/L. According to the classification of TH, approximately 90% of the groundwater comes under the hard category and the remaining 10% of the groundwater fall in the very hard category.

Bicarbonate is a major element in human body, which is necessary for digestion. When ingested, for example, with mineral water, it helps buffer lactic acid generated during exercise and also reduces acidity of dietary components. It has a prevention effect on dental cavities. The concentration of HCO_3^- is observed from 158 to 738 mg/L. The Cl^- plays an important role in balancing level of electrolytes in blood plasma, but higher concentration can develop hypertension, risk of stroke, left ventricular hypertrophy, osteoporosis, renal stones, and asthma [12]. The concentration of Cl^- is between 14 and 666 mg/L. 50% of groundwater is within the desirable limit of 250 mg/L (Table-2). This is the second largest ion, after HCO_3^- ion. In fact, the Cl^- is derived mainly from the non-lithological source and its solubility is generally high and the groundwater is caused by the influences of poor sanitary conditions, irrigation-return flows and chemical fertilizers.

The concentration of Na^+ is varied from 18 to 438 mg/L than that of the recommended limit of 200 mg/L for safe water and all groundwater samples are within the safe limit. Generally, the concentration of K^+ is less than 10 mg/L in the drinking water. It maintains fluids in balance stage in the body. The K^+ is observed between 0.20 and 3.5 mg/L, which is below the prescribed limit (Table-2).

The Ca^{2+} is an important element to develop proper bone growth. The concentration of Ca^{2+} is between 26 and 62 mg/L. 50% of groundwater has below the standard limit of 75 mg/L, while that of the concentration of Mg^{2+} is varied from 13 to 177 mg/L. 50% of groundwater has below the prescribed limit of 30 mg/L (Table-2). Although, Mg^{2+} is an essential ion for functioning of cells in enzyme activation, but at higher concentration, it is considered as laxative agent [11].

Table-2: Criteria for groundwater quality for drinking in the adjoining Lamapur area, Nalgonda District, Telangana State India

Chemical parameter	BIS (2003)	WHO (2004)	Sample numbers exceeding the safe limit	% of samples
pH (units)	6.5–8.5	6.5–8.5	0	0
TDS (mg/L)	500	500	20	80
TH (mg/L)	300	300	13	52
Ca^{2+} (mg/L)	75	75	0	0
Mg^{2+}(mg/L)	30	30	15	60
Na^+(mg/L)*	200	200	3	12
K^+(mg/L)	–	10	5	50
HCO_3^-	–	10	5	50
Cl^- (mg/L)	250	200	3	12

*Holden (1970).

Irrigation water quality

Excessive amounts of dissolved ions in irrigation water, which can affect to the plants and agricultural soils as physically and chemically, it will reduce the crop productivity. The physical effects of these ions decrease the osmotic pressure in the plant structural cells, thus preventing water from reaching the branches and leaves, while the chemical effects disrupt plant metabolism (Ravikumar, 2011).

Sodium Adsorption Ratio (SAR)

Wilcox (1955) and US Salinity Laboratory Staff (1954) proposed irrigational specifications for evaluating the suitability of water for irrigation use. There is a significant relationship between sodium adsorption ratio (SAR) values for irrigation water and the extent to which sodium is adsorbed by the soils. If water used for irrigation is high in sodium and low in calcium, the cation exchange complex may become saturated with sodium, which can destroy the soil structure owing to dispersion of clay particles (Singh, 2002). Sodium hazard is a tendency of water to replace adsorbed Ca2+ plus Mg2+ with Na+, which is expressed in terms of sodium adsorption ratio (SAR). This is a ratio of Na+ ion concentration to square root of half of combination of Ca2+ and Mg2+ ions concentration (Eq. 1).

$$SAR = Na/(\sqrt{(Ca+Mg)/2})$$

Where all the ionic concentrations are expressed in mill equivalents per liter.

The measured value of EC is varied from 300 to 3650 µS/cm the computed value of SAR is between 0.60 to 6.65 with an of the groundwater collected from the study area .The chemical data of the area plotted in the salinity hazard versus sodium hazard diagram designed by the USSLS (1954;).which judges the water quality for irrigation. The values of electrical conductivity and SAR values, plotted on a US Salinity diagram, show that 80% of the total groundwater samples (1, 2, 3, 4 and 5) fall in the zone of C3-S1, indicating high-salinity hazard (C3) and low-sodium hazard (S1), which can be used for irrigation on almost all soil types, with little danger of exchangeable sodium. Approximately 10% of the groundwater samples (6) fall in the zone of C4-S2 indicating poor quality of water for irrigating plants. In the zone of medium salinity hazard C2 and low sodium hazard S1.

Percent Sodium (Na+)

Another expression of sodium hazard is percent sodium (%Na+). This is a ratio of combination of Na+ and K+ ions concentration to combination of Ca2+, Mg2+, Na+, and K+ ions concentration, which is multiplied by 100 (Eq. 2).

$$\%Na = (Na+K)/(Ca+Mg+Na+K) * 100$$

Where all ionic concentrations are expressed in milliequivalents per liter.

RESIDUAL SODIUM CARBONATE (RSC)

Carbonate ions (HCO_3^-+CO_3^{2-}) have an effect on water alkality through the precipitation of alkaline earths (Ca^{2+} +Mg^{2+}), thereby increasing the percentage of Na+ [9]. This is more, when the concentration of carbonates is in excess of the concentration of alkaline earths. The excess carbonates combine with Na+ to form $NaHCO_3$, which affects the soil structure. This is called the Residual Sodium Carbonate (RSC). Therefore, a relation between carbonates concentration and alkaline earths concentration can be used to explain the suitability of water for irrigation. The RSC is computed by subtracting the amount of alkaline from the amount of the carbonates, as shown below (Eq - 3).

$RSC=[(HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})]$

Where an ionic concentrations are expressed in milli equivalents per liter.

Based on the RSC values, the water can be classified as suitable, if the RSC is less than than1.25 meq/liter; marginally suitable, if the RSC is between - 4.70 and 3.40 meq/liter; and unsuitable, if the RSC is more than 2.50 meq/liter. The higher RSC leads to increase of absorption of Na+ in soil, which reduces the soil permeability and hence not supporting the plant growth. The value of RSC is between -8.55 and -29.48meq/liter in the present study area (Table-4). It is also observed that approximately 100% of the groundwater samples have the RSC less than 1.25 meq/liter and hence suitable for irrigation.

RESIDUAL SODIUM BICARBONATE (RSBC)

Gupta and Gupta [13] defined the Residual Sodium Bicarbonate as given in (Eq-4):

$RSBC= (HCO_3^- - Ca^{2+})$, Where all the ionic concentrations are expressed in milli equivalents per liter.

The samples of RSBC values varied from -3.5 to-26.94 meq/liter in the study area . All the samples collected from study area also were found to be satisfactory (<5 meq/liter) according to the criteria set by Gupta [13].

CONCLUSION

The groundwater sources in around Wailpalli area, Yadadri district of T.S, have been evaluated for their chemical composition and suitability for drinking and irrigation purposes .In the study area malignity of groundwater samples are within permissible limits prescribed for drinking water. Wilcox and US Laboratory Salinity Staff diagrams reveal that 80% of the groundwater locations are suitable for irrigation purposes .Based on RSC, RSBC, groundwater is considered suitable for irrigation purposes.

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