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Indian Standards, 2296, 1974. Tolerance limits for a inland surface water subject to pollution, ISI, New Delhi.

I.S.I. 10, 500, 1983. Indian Standards Institute, Manak Bavan, New Delhi, India.


Jagadiswara Rao, R., 1978, Development and protection of groundwater resources in the drought prone areas of south India, Paper presented at the UNESCO sponsored course, Seminar and tour on Scientific basis of groundwater research and protection, Moscow State University, Moscow, June - August, 1978.


Water technology Centre, 1977. Water requirement and irrigation management of crops in India, IARI, Monograph, No. 4, Indian Agricultural Research Institute.


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AN INTEGRATED DEFORMATION MODEL TO LOCATE GROUNDWATER POTENTIAL ZONES USING REMOTE SENSING STUDIES IN THE NIVA RIVER BASIN, CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA.

REDDY, T.V.K. 1, SRINIVASARAO, Y. 2, NAYUDU, P.T. 2,

1Dept. of Civil Engineering and 2Dept. of Geology, Sri Venkateswara University, TIRUPATI-517502, INDIA.

ABSTRACT. The Integrated Deformation Model put forward by Larsson presents a method of studying the total ruptural deformation of a hard-rock area. The same model was applied to the Niva river basin, Chittoor District, Andhra Pradesh, India, which lies in the Peninsular Archean Gneiss Complex, (covered by FCC, MSS, LANDSAT Scene 143-051) for locating potential groundwater zones. The lithological and structural details were analysed and different stress regimes were identified. Younger tensile fractures are identified as N35-45E and NS directions, and certain shear fractures in NE-SW and N35-45W directions are also considered suitable for groundwater development in the study area.

INTRODUCTION

Hard rocks generally possess no primary porosity, due to their lack of intergranular pore-spaces. The term "hard rock" in this context excludes some volcanic and sedimentary rocks, as these may possess primary porosity which, in general, is not present in most igneous and metamorphic rocks. Such hard rocks are, however, capable of storing and transmitting water through secondary porosity features, developed by fracturing or weathering. The extent of weathering varies from a few centimetres to a few metres, both laterally and vertically, depending on various factors, whereas fracture porosity may extend to depths of several hundred metres or more, locally, along certain lineaments. The weathered layer, due to formation of clayey minerals, may have relatively low permeability compared to the fracture zones. As regards the fractures, some of them may have been infilled by secondary intrusions such as dykes or veins etc., rendering them unsuitable for groundwater
exploitation. Therefore, in hard rock areas, the identification of open fractures, and their suitability for groundwater development is of utmost importance, especially in drought-prone areas. Hence, studies to identify suitable groundwater potential zones have been carried out in the Niva river basin, a drought-prone area of the Indian state of Andhra Pradesh.

INTEGRATED DEFORMATION MODEL

The method of study of the total ruptural deformation of a hard rock area in order to identify structures associated with groundwater occurrence is named the Integrated Deformation Model (Larsson, 1972). This model is only applicable to large-scale rock bodies. Igneous and metamorphic rocks are often highly deformed, and these deformations are typically associated with characteristic stress conditions. The main objective of the Integrated Deformation Model is the identification of different stress regimes based on an integrated study of ruptural deformations, dyke patterns, and "open" and "closed" fractures. From a hydrogeological point of view, four main types of fractures are considered in hard rocks, namely (1) tensile joints, (2) tensile fractures, (3) shear fractures and (4) non-tectonic fractures. Of these fractures, tensile fractures are considered to be the best locations for groundwater development, as many minor fractures of the same regime interconnect and collect groundwater. Next best are considered to be shear fractures of moderate dips, which possess moderate quantities of groundwater. Non-tectonic fractures, when connected with other fractures in the rock body, form good conductors of groundwater.
APPLICATION OF THE MODEL

The study area lies in the Mysore plateau, consisting of rocks of the Archean Gneiss complex of peninsular India. It is considered to be a part of the stable Indian Shield. The whole study area is underlain gneisses, granites and dykes. The granites stand out as relict, residual or denudational hills. The area is traversed by a number of dolerite dykes. No major folding is observed in the area.

A LANDSAT scene, no. 143-051 (path-row, dt.15.2.1989) covering the Niva river basin was selected for study on 1:50,000 scale. All possible geological structures (lineaments and fractures) and formations were demarcated (Fig.1), and a certain number of these were checked by field studies.

After visual interpretation, the LANDSAT scene was subjected to analysis by application of the Integrated Deformation Model. A grid was superimposed on the area, dividing it into a number of squares. The trends of fractures, lineaments and dykes falling in each square were measured. In this way, dykes and fractures running over long distances were counted more than once as they fell in more than one grid square. Proper weighting was applied to such structures in further analysis, and the resulting data were subjected to frequency analysis. The directions along which major sets of dykes trend are used as reference directions for the analysis of fracture/lineament directions (Fig. 2).

DYKE PATTERN

Discrete study of the data and the frequency diagram based on the number of dykes (Fig. 2) reveals that there are six 10°-sectors containing the majority of dyke directions in the area, namely,
N65-75E, N75-85E, EW, NS, N15-25W and N35-45E. Other directions which were observed may represent apophyses of the major dykes. Of the six sectors, N65-75E is the most prominent, with 26.6% of the total dykes, followed by the N75-85E sector with 24%. The EW sector is the third most prominent with 15%. This is followed by the NS, N15-25W and N35-45E sectors with 6%, 5.1% and 3.8% of the dykes respectively.

FRACTURE PATTERN

The fractures/lineaments occupy different directions (Fig. 2). The most prominent direction is represented by the 10°-sector N35-45E with 10.4% of all fractures. N65-75E, N75-85E, N35-45W, EW and NS directions lie in 2nd to 6th place, with 9.6%, 9.2%, 8.3%, 7.9%, 8.3% and 5.4% of all fractures, respectively. The N15-25E sector contains a very low percentage, i.e. 2%, of the total fracture alignments.

From the data above, and from the dyke frequency diagram, it can be inferred that there are four main tensile fracture directions, namely, N35-45E, N65-85E, EW and NS. The tensile fractures in the N65-85E direction are completely filled, leaving none, or very few, fractures left open. The EW tensile fractures are moderately filled with dykes and might be older than the N35-45E fractures. The N35-45E tensile fractures are considered to be of younger age and generally open, with only a moderate number filled with dykes. Two sets of shear fractures can be inferred running NE-SW and N35-45W, cutting the EW and N65-85E dykes. Prominent faulting could be observed in this direction in a number of places. Some of the older tensile fractures might also have been sheared during this later deformation.
The identification of unfilled tensile fractures and shear fractures from the study has, with the help of field checks, allowed groundwater potential zones to be delineated (Fig. 3).

CONCLUSIONS
From the above observations, it can be concluded that the area has undergone four major brittle deformation periods. Fractures resulting from the older periods have directions N65-85E and EW, the younger ones have N35-45E and NS directions. However, the younger deformations might have resulted in the closure of older tensile fractures (N65-85E and EW). After a careful study of the model, the most promising fractures for groundwater development are deduced and are considered below in order of merit. Fractures occurring in the N35-45E and NS sectors are open tensile fractures and are the most suitable for groundwater occurrence. Such fractures, in association with good recharge areas, form excellent sites for groundwater development. The EW tensional fractures are generally filled with dykes. If these fractures are found to be open, however, they are also suitable for groundwater targeting, but siting of boreholes should be performed with care. The N65-85E tensile fractures are almost completely filled with dykes and are thus not regarded as suitable for groundwater exploitation. Groundwater impounding is, however, observed at several places upstream of locations where N65-85E dykes cross-cut drainage. These are good locations for targeting groundwater exploration.

This study indicates a method of identifying preferable fracture directions for groundwater occurrence. Such fractures need to be subjected to further exploration techniques. In other words, the integrated Deformation Model, as presented in this paper,
indicates the tensile and shear fractures existing in the earth's subsurface which are suitable for groundwater occurrence, and reduces the target area where further detailed exploration methods (geophysics, exploratory drilling) need to be employed.

REFERENCES AND BIBLIOGRAPHY


Fig. 2 - Dyke and Fracture frequency in percentage
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IMPACT OF INDUSTRIAL EFFLUENTS ON GROUNDWATER - A CASE STUDY AROUND CHITTOOR TOWN, ANDHRA PRADESH

Y. SRIKAVSARAO*, T. V. K. REDDY**, AND P. T. NAYUDU*

*Dept. of Geology & **Dept. of Civil Engg.,
Sri Venkateswara university, Tirupati - 517 502, India

SUMMARY

Drinking water requirement of chittoor town is met with mostly by Groundwater and partly by surface water of Ponnai river. Due to inadequate supply of surface water, many individuals drilled their own wells for drinking purpose. Most of these wells are contaminated due to the impact of industrial effluents, which are letting into the nearby Niva river. Through this river bed, the entire groundwater in the vicinity of Chittoor town is contaminated. With a view to know the rate of contamination, in the first instance the Nitrates are estimated and they are found very much alarmingly abnormal in the potable water. Remedial measures to reduce or minimise the rate of pollution for an over all amelioration of the people of the entire area are suggested.

KEY WORDS: Industrial effluents, Nitrates, Ground water, Water table

INTRODUCTION:

Urban Chittoor is one of the main drought prone district headquarters, having the population of about 1.33 lakhs. It requires water to the tune of 5.82 m. cu.m. and this is being partly fulfilled by a double fold source of supply i.e. through the municipal supplies and individual wells.

An ephemeral river namely Niva is flowing right across the Chittoor town and most of the residents are tapping groundwater from the river bed for various purposes like drinking and irrigation (Fig.1). From the present investigation, it is found that most of these waters are giving foul smell and possess colouration. This aspect made the authors to be more curious to study the main reasons for such a conspicuous effect which is indeed acting as a health hazardous problem. Hence, an attempt is made to study the industrial effluents from the Srinivasa Distillaries, Dairy farm and Sugar factory which are entering into the nearby Niva river without any treatment, contaminating the groundwater in and around Chittoor. It is a well known fact that many industrial effluents cannot be treated upto the standards before leaving them into the nearby water courses as per ISI stipulations.


SURFACE GEOLOGY:

The rock formations in the study area of 80 Sq.Km are consisting of mainly granites, dykes and gneissic rocks of Archean age. The river course of Niva is mainly covered by recent alluvium and it's thickness ranges from 3 to 8 m. The effluents which are letting into the river are observed to percolate very quickly because of the presence of upper alluvial bed and thus reaching the water table resulting into the contamination of groundwater. The river is ephemeral in character, but a portion of the river which lies between the Srinivasa Distilleries and Sugar factory, is always perennial due to the industrial effluents and a pond near dairy farm which is observed to be always full perhaps due to discharge of Dairy effluents into it.

GROUNDWATER LEVELS:

Groundwater occurs under semi-confined and unconfined conditions. The variation of the water levels is observed to range from 4 to 13.5m b.g.l. The level of the piezometric surface varies from 10.5 to 25m b.g.l. in the second aquifer group. This wide variation of levels may mainly be due to the topographic inequalities. The water table contour map (fig.2) indicates that groundwater flow is towards the Niva river.

MATERIALS AND METHODS

Nitrate contamination of groundwater in urbanised areas has become very much concern. Nitrate is a highly soluble form of nitrogen and hence it can easily enter into groundwater by percolation. Groundwater contamination with regard to Nitrate has been reported by many investigators. Pandel et al have reported high concentrations of Nitrate in Nagpur well waters. Matisoff et al found nitrate contamination of subsurface waters in northern perry township in lake country, Ohio. Spruill found high concentrations of Nitrate in wells in central and eastern Kansas. The studies by William et al indicate the high concentrations of Nitrate in groundwaters of Long Island, New York.

High concentration of Nitrates in drinking water is toxic and its toxicity in human was first reported by Comly. Excessive Nitrate or Nitrite concentrations in drinking water pose a potential health hazard to infants. Chronic toxicity and possible development of cancer from nitrosamines may result when drinking waters contain high concentrations of Nitrate or Nitrite. High concentrations of Nitrate in drinking water also cause gastric carcinomas. This led the World Health Organisation to recommend a tentative limit of 45 mg/l of Nitrate in public water supplies. However, different countries and different agencies have established different limits of Nitrate concentrations for drinking water. Indian Council of Medical Research prescribed 50 mg/l Nitrate as the maximum limit in drinking water.

Knowledge of the concentrations of Nitrate in groundwater and the sources is essential to take necessary measures to control further contamination of groundwater. Authors have surveyed the groundwater quality with regard to Nitrate in Chittoor. Groundwater samples from 12 locations were collected from various tube wells, dugwells and dug-cum-bore wells to study lateral as well as vertical chemical quality variations and manifestation of groundwater contamination, if any. The locations and analytical results of water samples are given in figure. 1 and table 1 respectively.
TABLE I
CHEMICAL ANALYSES OF THE GROUND WATER SAMPLES
(Sample numbers and locations are given in figure 1)

<table>
<thead>
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<td>21</td>
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<td>240</td>
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<td>170</td>
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<td>235</td>
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<td>Sulphate</td>
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<td>150</td>
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<td>25</td>
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<td>25</td>
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<td>354</td>
<td>19</td>
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<td>399</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<td>0.5</td>
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<td>725</td>
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<td>870</td>
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<td>225</td>
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<td>381</td>
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<td>Electrical conductivity (micro mho's/cm at 25°C)</td>
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<td>4900</td>
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<td>2600</td>
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<td>950</td>
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<td>1700</td>
<td>650</td>
<td>2900</td>
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<td>8.3</td>
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<td>8.3</td>
<td>8.3</td>
<td>7.2</td>
<td>8.2</td>
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</table>

All the values in mg/l except EC & pH

RESULTS AND DISCUSSION

The study of analytical results indicate that the water in the area is alkaline in nature, hard and moderately mineralised. Sample 2 is highly contaminated having reddish in colour and all cations and anions are very high compared to WHO standards. All the 12 samples in and around Chittoor town are found to be contaminated by Nitrates which is mainly due to the impact of Distillery, Dairy and Sugar factory effluents. The highest concentration of Nitrates are observed for a length of 12 Km. The sample 3,4,5,7,9 and 10 exhibit the low concentration of Nitrates which lie in the northern direction of the study area which is free from the industrial pollutants partly and also due to their topographic locations. However, the significant aspect of chemical quality of groundwater in the area is the presence of high concentration of Nitrates both in shallow and deep aquifers. The Nitrate concentration ranges from 4 mg/l to 399 mg/l in dugwells, 15 mg/l to 354 mg/l in dug-cum-bore wells and 10.2 mg/l to 310 mg/l in borewells. The concentration values clearly indicate that the dugwells are easily prone to Nitrate contamination due to shallow aquifer character.

The Nitrate does not occur in groundwater in its natural state and is introduced extraneously. It is a direct index of contamination of the natural groundwater resources. As the pollution effect is expected to take place from shallow aquifer zones to deeper aquifers, the Nitrate concentration has been considered irrespective of depth span of groundwater.

An isonitrate contour map (Fig. 2) has been prepared. On the perusal of this map, it is observed that concentration is maximum at sample 11 (399 mg/l) and also at sample 8 (354 mg/l) which are contaminated
Fig. 1. Location map of the study area

Fig. 2. Isonitrate and water table contour map of the study area.
due to the effluents of Distillery and Sugar factory. The sample 12 consists of 310 mg l of Nitrates which is also due to contamination from Dairy effluents.

Nitrates are normally leached into the soil and groundwater by animal excreta, nitrates fertiliser, sewage and industrial wastes. The sources of Nitrate in the present area could be ascribed due to the following:
1. Due to the impact of industrial effluents mainly.
2. Unlined stagnant open drains
3. Sewage farms
4. Indiscriminate disposal of animal wastes.

CONCLUSIONS:

The present study reveals that the area in and around Chittoor town is affected by high Nitrate concentration and the main source of Nitrate contamination is industrial effluents which are situated within the vicinity of the study area. The following suggestions are made:
1. The industrial effluents must be treated as per the I.S.I. Standards before they let into the river and/or stream courses.
2. The sewage waters are also must be treated before letting them into the open ground.
3. The dugwells which are not in use must be closed completely.
4. Periodical determination of Nitrate level in tube wells may be measured at least once in a year so as to monitor the contamination hazard by some competent scientific organisation.

REFERENCES: