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RESEARCH ARTICLE

GIS aided assessment of physico-chemical properties of the ground water from the villages of Puttaparthi mandal, Anantapur district, Andhra Pradesh (India)

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Abstract

The geogenic leaching of the minerals in aquifers and excessive use of fertilizers coupled with improper sewage disposal has resulted in severe degradation of the ground water quality. The present study is focused on assessing the pH, total dissolved solids (TDS), fluoride and nitrate ion content in the groundwater of the Puttaparthi mandal, Anantapur district, Andhra Pradesh.The water samples were collected from the bore-well and the results of the physico-chemical analysis were compared with the drinking water standards set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). The range of physiochemical parameters observed were pH (7.47 to 8.54), TDS (317 to 1030 mg/l), fluoride ion (1.28 to 4.48 mg/l) and nitrate ion (0.27 to 212.1 mg/l) during this study. The latitude-longitude of the sampling points was taken for geospatial mapping using the Geographical information system (GIS). The results revealed that most of water samples exceeded the permissible limits set for fluoride and nitrate ion by the WHO & BIS. Hence the ground water in the study area was deemed not fit for drinking purpose without a pre-treatment.

INTRODUCTION

Water is the insignia of life on a planet. About 97 percent of water on earth is in the form of salt water and out of the remaining 3 percent freshwater, 69 percent is trapped in the form of icecaps and glaciers. With 30 percent fresh-water locked under the earth surface as the ground water, only 1percent is directly accessible to us in the form of lakes and rivers (USGS, 2009).The rainfall condition all over the world is uneven, scanty and unpredictable. Since majority of human habitat have no direct access to the fresh surface water sources, groundwater becomes the only available and reliable source of drinking water for millions of rural and urban families, besides catering to the irrigation and industrial needs (Kumar &Tushaar, 2004). Ground water contains dissolved as well as suspended substances of organic, inorganic and mineral origin, which in higher concentrations lead to water pollution (Patil, et al., 2014). It becomes essential to identify and establish protected areas for sources of drinking water supply as we attempt a parallel means of waste disposal and develop innovative methods to reduce the pollution (Sivasankar et al., 2014)

Water pollution, both geogenic and anthropogenic has become a major source of concern all over the world. The ground water level is plummeting down alarmingly in wake of the ever increasing demands of the growing population. The problem gets only compounded by the pollution caused by rapid urbanization, industrialization, improper waste disposal practices and excess use of chemical fertilizers and pesticides in the agriculture.

One of the widely distributed pollutants in the geological environment is fluoride. It is generally released into the groundwater by slow dissolution of fluorine-containing rocks (Banks, et al., 1995). Fluoride and nitrate ions have been identified by the WHO as the major pollutants in water which causes a large scale health problem (WHO, 2011). Over the last few decades, the excessive use of fertilizers in the cropland has resulted in an increase in the concentration of nitrate ion in the groundwater (Naganathan & Sankar, 2014). The lack of proper sewage treatment and indiscriminate dumping of animal waste has also contributed to the nitrate ion contamination in the ground water (Bala Chennaiah J., et al., 2013). According to the WHO and BIS, the permissible limit of fluoride and nitrate ion in drinking water is 1.5 mg/L and 45 mg/L respectively (WHO 2011 & BIS 2009).

Geographic information system (GIS) is emerging as a powerful tool for storing, analyzing, and displaying spatial data and using these data for decision making in several areas including engineering and environmental fields (Sadat Noori, S.M.,Ebrahimi, K., Liaghat, A.M, 2014).

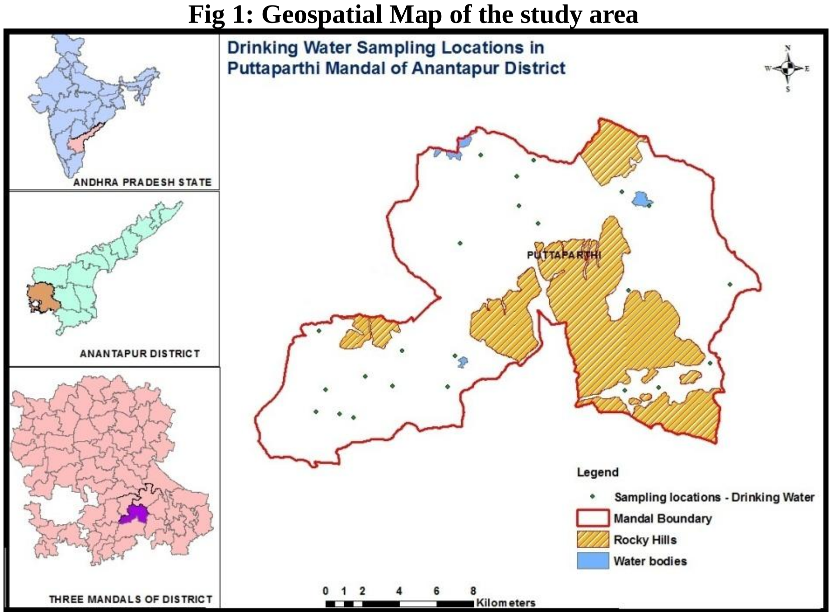
In the present study the water samples were collected from the borewell as per the APHA guidelines and were assessed for drinking water quality in the Puttaparthi mandal of the Anantapur District. The geospatial maps were developed to identify areas with high fluoride and nitrate ion concentration. The concentration gradients in the GIS maps guided us in identifying potentially suitable locations to tap new ground water sources which are situated far from the fluoride rich zones. It also helped us in diagnosing the cause of nitrate ion pollution which was attributed to excessive fertilizer usage and improper sewage disposal in the villages.

2. Material and Methods

The present study area is located in the rain-shadow area of the Rayalseema region in the Anantapur District of Andhra Pradesh State (Fig.1). The Puttaparthi mandal spans from14° 2.84' N to 14° 10.38' N latitude and stretches across 77°42.38'E to 77°55.1' E longitude, covering an area of about 201.9 sq kms. The fresh water samples were collected at pre-monsoon from the borewells as described by APHA (2001). The pH was measured by microprocessor based pH meter (Labmate model) and the TDS was measured by the digital TDS meter, Systronics 308 model. The fluoride and nitrate ion concentrations were determined by the Ion Chromatography of Metrohm Basic IC plus 883 Model. The latitude and longitude was recorded in Terra Sync supported Trimble handheld set. Geospatial mapping of these water parameters were done by using Arc GIS 9.2 software. The study area map was imported and the geo-reference was marked by using the coordinate system. With sampling locations as the geo-reference, the fluoride and nitrate ion concentrations were selected as the input parameters and their concentration values were interpolated.

3. Results and Discussion

Fig 1: Geospatial Map of the study area



The results of the present study are presented in table 1.The pH of the water samples in the study area ranges from 7.47 to 8.54. The village Peddakamavaripalli showed the highest pH of 8.54 and the lowest pH of 7.47 was observed in the village Venkatagaripalli. pH is one of the most important operational water quality parameters as it determines the effectiveness of the water pre-treatment and also determines the corrosive nature of the water to pipe line. The pre-treatment of water by chlorination becomes less effective in higher pH conditions and the pipelines get corroded at lower pH. In general, the acceptable range of pH is 6.5 to 8.5(W.H.O, 2011), where Peddakamavaripalli with 8.54 has marginally crossed the accepted limit.

According to the WHO guidelines on drinking water (2011), the palatability of water is good and acceptable below 600 ppm but above 1000 ppm water becomes increasingly unpalatable. In the current study, 50 percent of the villages were observed to have TDS exceeding 600 ppm and Buggapalli was found to have a TDS of 1060 ppm. The concentrations of fluoride ion exceeded the permissible level of 1.5 ppm set by WHO and BIS in 96 percent of villages in the study area with Karnatakanagepalli, Amagondapalyam, Cherlopalli, Bidupalli, Gangireddipalli, Buggapalli, Diguvucheruvupalli, Rachuvarupalli, Guvalaguttapalli, Iragarajupalli exceeding 3 ppm and Rayalvandlapalli exceeding the most with 4.48 ppm. The excess intake of fluoride ion which primarily enters through drinking water in the human system leads to dental and skeletal fluorosis. The main source of fluoride ion in water is the fluoride containing minerals which leaches into the groundwater as the rainwater permeates through the earth crust and its concentration also depends on the anion exchange capacity of aquifer materials.

Table1: The physicochemical parameters of the groundwater from Puttaparthi Mandal

Sample No	Village name	pH	TDS(mg/L)	Fluoride(mg/L)	Nitrate(mg/L)
1	Karnatakanagapalli	8.13	323	3.25	9.67
2	Bontolapalli	7.58	394	2.03	10.65
3	Cherlopalli	7.88	775	3.56	70.75
4	Vengalammacheruvu	7.86	610	2.14	39.63
5	Amagondapalyam	7.68	597	3.79	52.18
6	Peddakamavaripalli	8.54	338	1.51	3.73
7	Bidupalli	7.98	723	3.54	12.12
8	Satharlapalli	7.90	645	2.46	0.50
9	Gangireddipalli	8.41	628	3.78	12.05
10	Diguvucheruvupalli	7.66	565	3.70	2.0
11	Pedapalli	7.99	717	2.68	18.03
12	Kotlapalli	7.95	317	2.63	42.45
13	Danduvaripalli	7.67	539	2.12	11.22
14	Gajulapalli	7.92	351	1.97	53.62
15	Buggapalli	7.71	1030	3.01	193.34
16	Rachuvarupalli	7.91	681	3.53	35.60
17	Marlapalli	7.60	585	2.72	2.06
18	Guvalaguttapalli	7.91	846	3.51	32.77
19	Paipalli	7.91	424	2.85	71.08
20	Venkatagaripalli	7.48	851	1.85	212.1
21	Jagarajupalli	7.59	664	1.96	70.03
22	Rayalvandlapalli	7.88	363	4.48	0.27
23	Enumunapalli	7.69	562	2.13	50.09
24	Puttaparthi	7.51	721	1.28	30.45
25	Chinnarajupalli	7.65	616	1.98	142.50
26	Iragarajupalli	7.76	539	3.61	23.58
	Maximum	8.54	1030	4.48	212.1
	Minimum	7.47	317	1.28	0.27
	Average	7.84	592.46	2.77	46.25
	Standard Deviation	± 0.246	±177.83	±0.824	± 54.877

The nitrate ion concentration in the ground water of Cherlopalli, Amagondapalyam, Gajulapalli, Buggapalli, Paipalli, Jagarajupalli, Enumunapalli, exceeded the permissible limit of 50 ppm set by W.H.O with Chinnarajupalli(143 ppm), Buggapalli (193.3 ppm) and Venkatagaripalli (212.1 ppm) exceeding the most. High nitrate ion levels in drinking water causes methaemoglobinaemia or blue-baby syndrome in the bottle-fed infants (Fuller, 1976).

Figure 2 and 3 shows the interpolation of the chemical dispersion of fluoride and nitrate ion in the groundwater respectively.The intensity of the colour shows the concentration gradient of the contamination.

Figure 2: Geospatial map showing concentration gradient of fluoride ion in the study area

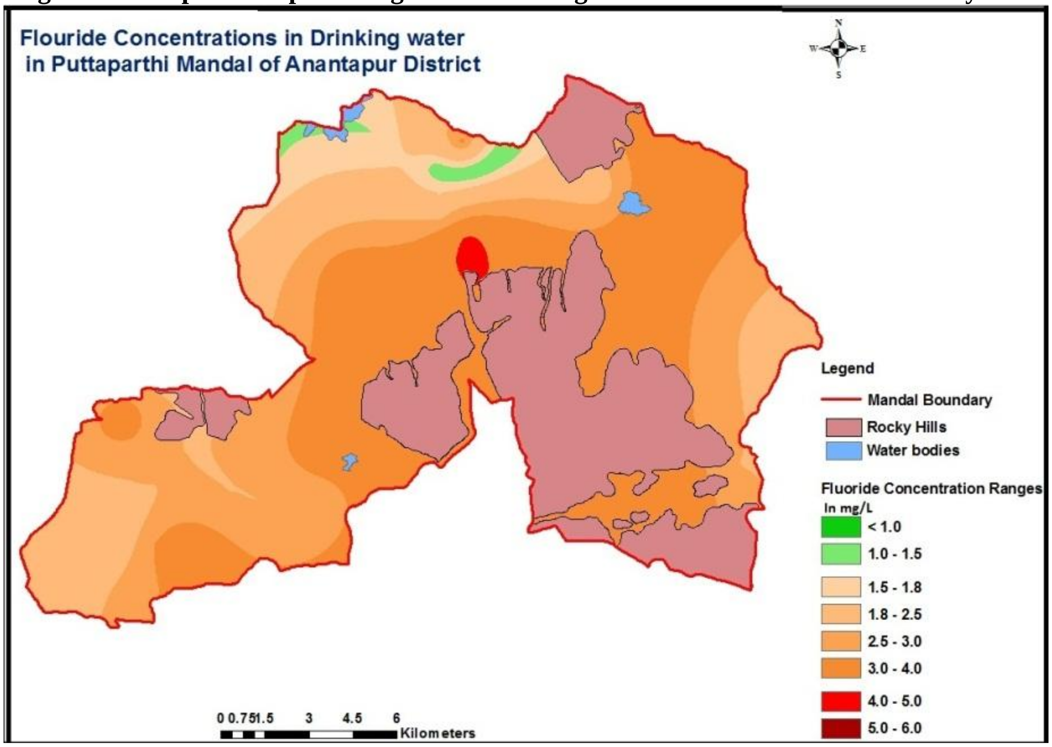
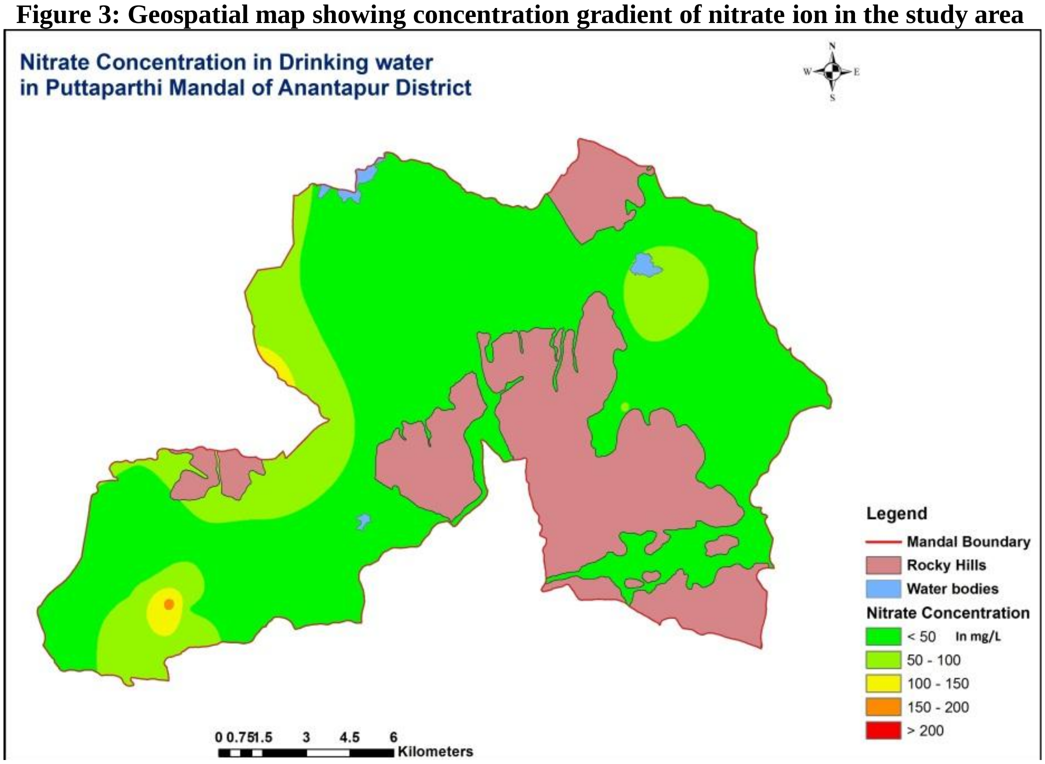


Figure 3: Geospatial map showing concentration gradient of nitrate ion in the study area



4. Conclusion:

The results of the present study reveals that the TDS, fluoride and nitrate ion content in majority of the villages exceeds the acceptable limit set by WHO and BIS. The high concentration of fluoride ion in the ground water of the study area can be attributed to geogenic source and hence the borewell site to tap the groundwater source should be carefully chosen based on the results of the geospatial maps that reveal the trend of concentration gradient of fluoride ion. The nitrate ion contamination is due to excessive usage of fertilizers and improper dumping of animal waste which should be regulated immediately in the regions identified to have high nitrate ion content in ground water. The groundwater requires pre-treatment before the domestic consumption on account of high fluoride and nitrate ion contamination in the Puttaparthi mandal.

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