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Assessment of Quality of Drinking Water at Srikurmam in Srikakulam District, Andhra Pradesh, India

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Abstract

Water plays an important role in domestic and industrial usage. The quality of drinking water is a powerful environmental determinant of health. Assessment of water quality of drinking water supplies has always been paramount in the field of environmental quality management. Assurance of drinking water safety is a foundation for the prevention and control of water borne diseases. The suitability of drinking water has many requisite potable conditions. Groundwater quality of Srikurmam has a special significance and needs greater attention of all concerned since it is the only major source for domestic consumption. In this work we have estimated the ground water quality for drinking purpose at Srikurmam in Srikakulam district of Andhra Pradesh, India. The various parameters for quality of underground water in Srikurmam are analyzed and these are compared to established standards. The obtained results indicate that the quality of water slightly deviate from the potable conditions. The analysis showed that water is not well within the parameters of potable use.

Keywords: Water analysis, ground water quality, drinking water, srikurmam

Introduction

Water is nature's most wonderful, abundant and useful compound. Of the many essential elements for the existence of human beings, animals and plants, water is rated to be of the greatest importance. Without food, human can survive for a number of days, but water is such an essential that without it one cannot survive. Water is not only essential for the lives of animals and plants, but also occupies a unique position in industries. Of all renewable resources of planet, water has unique place. It is essential for sustaining all forms of life, food production, economic development of industry and agriculture, the water ecosystem has become perceptibly altered in several respects in recent years[1] and as such they are exposed to all local disturbances regardless of where they occur. Water is the elixir of life and plays a vital role in the earth's ecosystem. It is one of the most critical, scarce, precious and replenishable natural resources which cannot be created[2]. Apart from this water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation etc

Water is an essential resource for all life on the planet. Of all the water resources available on the earth only three percent is not salty and two-thirds of the freshwater is locked up in ice caps and glaciers. Of the remaining one percent, a fifth is in remote, inaccessible areas and much seasonal rainfall in monsoonal deluges and floods cannot easily be used. At present only about 0.08 percent of the entire world's fresh water[3] is exploited by mankind in ever increasing demand for sanitation, manufacturing, leisure and agriculture.

Water is a chemical substance and its molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at ambient conditions, but it often co-exists[4] on the earth with its solid state, ice, and gaseous state (water, vapour or steam). Water also exists in a liquid crystal state near hydrophilic surfaces[5].

Water is one of the most important compounds to the ecosystem. Physical, Chemical and Biological characters of water determine the quality of water. The water gets polluted due to increased human population, industrialization, use of fertilizers in agriculture and manmade activity. The natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to poor of water quality and its depletion. Therefore it is necessary that the quality of drinking water should be checked for its quality at regular time interval. According to WHO, about 80% of all the diseases in human beings is water borne. Despite the world Health Organization's guidelines[6]for drinking water quality, water pollution in various sources has been increasing over recent decades in most countries[7-9].

The demand for water has increased over the years and this has led to water scarcity in many parts of the world. The situation is aggravated by the problem of water pollution or contamination. India is leading towards a fresh water crisis mainly due to improper management of water resources and environmental degradation, which has lead to a lack of access of safe water to millions of people.

Safe drinking water is essential to human beings and other life forms. Access to potable drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack accesses to adequate sanitation. However some observers have estimated that by 2025 more than half of the world population will be facing water based vulnerability[10].

Ground water is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the Agriculture and Industrial sectors. Approximately 70% of the fresh water used by human beings goes to agriculture[11]. Intensive irrigated agricultural discharge and Industrial waste effluents into the ground water can bring about the considerable change in the ground water quality. Once ground water is contaminated, its quality cannot be restored by stopping the pollutants from the sources. Therefore it becomes imperative to regularly monitor the quality of ground water and to device ways and means to protect it. Further the groundwater, and the pollutants it may carry move with such a low velocity that it may take considerable time for the contaminants to move away from the source of pollution and also degradation in the groundwater quality may remain undetected for years.

Ground water is used for domestic and industrial water supply and irrigation all over the world. It is an important source of drinking water but is polluted because of the waste generated in the industrial, agriculture and domestic sectors. Water is essential for any development activity and the availability of good quality of water for domestic and industrial use will help in fast development of the region. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Human health is threatened by most of the agriculture development activities like application of fertilizers and unsanitary conditions .In India several places now suffer from non availability of water for domestic and industrial use due to its over exploitation and improper waste disposal, especially in urban areas.

The quality of groundwater is getting severely affected because the widespread pollution of surface water. Besides, discharge of untreated waste water through bores and leachate from unscientific disposal of solid wastes which are likely to be polluting ground water[12], thereby reducing the quality of fresh water resources. Due to discharge of untreated sewage into the Narmada River, the water quality of Narmada has been severely deterioted and the potable nature of water is being lost[13]. Changes in surface water physico-chemical parameters following the dredging[14], the water quality is localized and short terms due to that the impact of dredging .World population requires cleaner water for better living condition. In this paper, we present the obtained results related to the analysis of quality of underground water for drinking purpose in Srikurmam, Srikakulam District, and Andhra Pradesh, India.

Material and Methods

Experimental, Study area: Srikurmam Village is located approximately 13 kilometers east of Srikakulam town near Bay Of Bengal Sea and is in the Gara Mandal of Srikakulam District, Andhra Pradesh, India. Srikurmam is located at latitude of 18° 16' N, longitude of 84° 1' E and an altitude of 17 meters (59 feet). This village is historically known to people due to the oldest and famous Kurmanadha temple, only one of its kinds in India. In this village the majority of the people depend on underground water as a source for their day to day life.

Water sampling: The water samples are collected as per the standard methods in the month of June 2011 and again the samples were collected at the same places in the month of December 2011. The sampling area is shown in the Figure-1 and Figure-2

The fifteen water samples are collected from Borewells and wells. In addition to this, one more water sample is collected where the water purified by locally available water purifier with carbon trap technology by name Pureit of Hindustan Unilever Limited is also analyzed. The list of sample collection places in Srikurmam are given in the Table-1.These samples are collected in two liter plastic bottles, which are earlier washed and rinsed with triple distilled water before the collection of water samples. Separate and individual samples are collected for the purpose of dissolved oxygen. After sample collection, they are either analyzed immediately for various parameters like TDS, Hardness, Fluoride etc or preserved safely by taking suitable precautions to avoid deterioration or alterations.

Table-1
Areas of sample collection in Srikurmam

S.No	Sample no.	Location of sample	Source
1	1	Brahmin Street	Bore Water
2	2	Kurmanatha Temple opposite	Bore Water
3	3	Vyshnavi Street	Bore Water
4.	4	Near Bus Stand	Bore Water
5	5	Secondary Government School	Bore Water
6	6	Karnala Street	Bore Water
7	7	Karnala Street	Well Water
8	8	Kandra Street	Bore Water
9	9	Market Street	Bore Water
10	10	Devara Street	Bore Water
11	11	Segidipeta	Bore Water
12	12	Indiranagar colony	Bore Water
13	13	Velama Street	Well Water
14	14	Panchayati office	Well Water
15	15	Bankers colony(Pratap house)	Bore Water
16	16	Bankers colony(Pratap house)	Pureit Water*

Instruments: The following instruments are used to analyze ground water samples. Atomic Absorption Spectrometer (AAS) (PerkinElmer), Digital pH meter (Model 335, Systronics), Nefleometer (Model 132, Systronics), UV-visible spectrophotometer (Model 117, Systronics), Digital Conductometer (Model 306, Systronics), Micro processor based bunch P^H / Ion meter, Cyber scan 2100, Eutech instruments (USA) with fluoride sensitive electrode, Flame photometer (Elico,CL361) along with compressor (Elico, CL 158) and Shimadzu analytical balance (AUX 20, shimadzu Japan) .

Chemicals Required: All Chemicals used are of Analytical Reagent grade (Merck, BDH and Qualigens) and all the solutions are prepared by using triply distilled water and wherever water without carbon dioxide is used when required. Established methods [15] are used to prepare for standardized solutions.

Potassium hydrogen phthalate, Potassium hydrogen phosphate and borax buffer are used for pH meter calibration. Every time the instrument is calibrated, by using known pH buffer solutions and then the pH values of samples are measured. pH maintenance is one of the most important attributes of any aquatic system since all the biochemical activities depend on pH of the surrounding water. High value of pH may results due to waste discharge, microbial decomposition of organic matter in the water body[16].

After calibration of the conductivity meter, conductivity of the samples is measured. Standard Calcium Carbonate, standard EDTA, Buffer solution (NH_4Cl +NH_4OH), EBT indicator and Muroxide indicator are used for measuring the Total, Calcium and Magnesium hard nesses in the samples. In the estimation of p-alkalinity and m-alkalinity, standard Na_2CO_3, HCl and indicators of phenolphthalein and methyl orange are used. The standard NaCl, $AgNO_3$ solutions and K_2CrO_4 indicator are used for analysis of Chloride in the samples. Through gravimetric analysis, the sulphates in the samples are analyzed using the solutions of $BaCl_2$, HCl, $AgNO_3$ – Nitric acid reagent and methyl orange indicator. In the analysis of estimation of nitrites, the chemicals used are of standard nitrite solution, standard sodium oxalate ,Potassium permanganate, Ferrous Ammonium sulphate and Sulphanalamide reagent, N-(1-Napthyl)–ethylenediamine dihydrochloride and 1:1 H_2SO_4. For estimation of fluoride in the samples the required solutions are stock fluoride and Total Ionic Strength Adjustment Buffer (TISAB). The standard solutions of $K_2Cr_2O_7$, Hypo, 10% KI and 1% starch indicator are used for estimation of Dissolved oxygen in the samples In the determination of phosphates, standard phosphate solution (Potassium dihydrogen phosphate), vanadate –molybdate reagent (a proper mixture of Ammonium molybdate and Ammonium metavanadate) and dilute Hydrochloric acid is used for adjustment of pH. The **0.3**% of N-(1-napthyl)- ethylene diamine dihydrochloride solution and 0.5% sulphanilamide reagent is used in the estimation of nitrites in the samples.

For estimation of metals like Cadmium, Zinc, Iron and Copper in water are extracted by using APDC (Ammonium 1-pyrolidiene dicarbomate), MIBK (Methyl Isobutyl ketone) and concentrated HNO_3 solution.

Procedure: For estimation of following various components in the water samples are estimated by follow the standard methods[17].

Estimation of pH and Electrical conductivity: The pH and electrical conductivity of all water samples are measured by using digital pH meter and conductivity meter.

Estimation of total dissolved solids: 100 ml of sample water is taken into a clean porcelain dish and heated at 180 ± 2 ^{0}C up to dryness and it is cooled to room temperature and finally placed in a desiccator for complete removal of any moisture present in it. After that from the obtained weight, the amounts of total dissolved solids in the samples are determined by using appropriate formula.

Determination of Total hardness, Calcium and Magnesium: The known quantity of water samples are titrated in presence of Ammonia Buffer solution against with 9.3×10^{-3} N concentration of EDTA. The Calcium in the water samples are estimated by using with same EDTA in presence of KOH buffer solution. Finally the Magnesium content in the samples is estimated by using the consumed volumes of EDTA in the estimation of total hardness and Calcium hardness.

Estimation of Chlorides: Known quantity of water samples are titrated in presence of Potassium Chromate indicator against with 1.94×10^{-2} N Silver Nitrate solution.

Determination of Total alkalinity: Using phenolphthalein and methyl orange indicators, the total alkalinity in water samples is estimated with 2.5×10^{-2} M Hydro Chloric acid.

Estimation of Sulphates: Known quantity of water samples are taken and these are adjusted to a pH value of 4.5 to 5.0 by dilute HCl and these samples are heated up to desired conditions, while in hot, 10% $BaCl_2$ solution is added till a white precipitate is obtained and the precipitate is separated by Whatman no. 42 filter paper and is dried and weighed.

Estimation of fluoride: With the help of the standard fluoride solution (from Sodium Fluoride) the Ion analyzer instrument is calibrated. Now known quantity of water samples are added with 5 ml of TISAB buffer in a polythene container and then the concentrations of fluoride in the samples are estimated by ion analyzer.

Estimation of Sodium and Potassium: The flame photometer is calibrated separately with 4, 8, 12, 16 and 20 ppm of solutions of KCl and NaCl respectively at each time and immediately

directly measured the concentrations of Sodium and Potassium in ppm units.

Estimation of Nitrites: Known quantity of water samples are added with 2 ml of a reagent mixture of 0.5% of Sulphanalamide and 0.3% of N-(1-napthyl)-ethylenediamine dihydrochloride and the concentrations of nitrites in the samples are directly measured at 583 nm by UV-Visible Spectrophotometer.

Determination of Turbidity: The Nefleometer is calibrated with 1, 10, 100, and 500 NTU of Formazin solutions and finally the turbidity of water samples are directly measured by Nefleometer.

Extraction of metals: In the water samples the metals like Iron. Zinc, Copper and Cadmium are estimated by Atomic Absorption Spectrometer (AAS). The metals in the samples are extracted with APDC (Ammonium 1-Pyrolidine Dicarbamate), MIBK (Methyl Isobutyl ketone) and Conc. Nitric acid. After extraction of these metals the concentrations are estimated by AAS.

Results and Discussion

Water samples are analyzed for various parameters and these values (table -2 and table-3) are compared with values of Indian standards of drinking water (table- 5) for knowing the quality of water. In table 2and 3 the values except pH, EC and Nitrites and turbidity the remaining all parameters are expressed in mg/Lt or ppm unites. On the basis of the obtained results, it is observed that in most collected sites of the samples area contain high concentration of hardness, Total Dissolved solids, Calcium, Magnesium, and Chloride etc. Based on the results, it may be concluded that the underground drinking water at almost all the collected sites are not at all suitable for drinking purpose. Therefore, the use of water from the sample sites should be discouraged. The causes for contaminate in the ground water at Srikurmam may be either because of seepage of sewage and sullage or of natural geological conditions.

In addition, we have selected one of the samples at the sampling area (sample number -6, Karnala street-Bore water) and it is examined for hardness at the temperatures of 45 ^{o}C, 60 ^{o}C, and 80 ^{o}C to know the rate of decreasing of the hardness's of the sample at respective temperatures and these values are compared (Table- 4) with hardness of sample at room temperature. Based on the results obtained it is clearly indicate that the rate of decreasing of hardness is very less in the sample, it resembles that the water sample (6) has more permanent hardness constituents than temporary hardness constituents. Based on these results showing that, the selective method like heating is not suitable for removing the hardness of the water samples at the selected area.

We attempted to know process of the purification of water at sample area by using a water purifier pureit. The water sample (number 15) is passed through Pureit and the purified water is collected and it is analyzed for various components. These parameter values (Table- 2 and Table-3, Sample number 16) are low when compared to the direct source of water and slightly coincide with Indian standards. So it is one of the nearest alternate methods to purification of water.

Finally the water at Srikurmam is not fit for drinking without using a standard purification method. The two attempts to purify water using low cost practical methods like boiling water and using Pureit have not given us good result in making with water safe.

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Table -2
Values of various constituents in the water samples in June 2011

Sample No.	pH	EC	TDS	Total Hardness	Calcium	Magnesium	Chlorides	Alkalinity	Sulphates	Fluoride	Nitrites	Turbidity	Sodium	Potassium	Iron	Zinc	Copper	Cadmium
1	7.18	4.58	2514	609	92	92	407	948	689	0.23	2.78	0.08	28.7	270	0.045	0.063	0.015	0.008
2	7.11	4.36	3060	790	136	108	417	609	598	0.39	0.04	0.12	1.51	252	0.052	0.066	0.014	0.007
3	7.16	4.16	2092	647	132	76	359	590	521	0.47	0.016	0.06	0.20	255	0.041	0.202	0.021	0.007
4	7.08	3.36	2400	809	158	99	363	490	370	0.36	2.79	0.21	49.2	149	0.173	0.166	0.019	0.007
5	7.19	3.54	1719	567	128	60	304	339	440	0.22	0.02	0.02	31	235	0.121	0.054	0.016	0.007
6	7.01	5.54	4208	1302	104	263	780	157	353	0.22	0.49	0.10	740	763	0.037	0.033	0.022	0.007
7	7.13	5.89	4482	1307	229	176	850	490	407	0.44	0.29	0.09	770	836	0.034	0.059	0.013	0.007
8	7.29	1.03	216	414	151	89	76	387	177	0.53	Nil	0.05	155	120	0.038	0.043	0.016	0.007
9	7.18	2.97	1627	953	130	151	367	442	517	0.68	0.046	0.23	474	44	0.030	0.133	0.013	0.007
10	7.19	1.12	546	390	91	39	87	339	161	0.68	0.046	0.04	177	14.7	0.064	0.035	0.013	0.007
11	7.12	1.04	151	365	132	16	101	351	206	0.46	Nil	0.06	121	20.1	0.031	0.038	0.013	0.007
12	7.03	2.82	2114	1023	126	170	421	460	253	0.71	0.017	0.07	374	81.2	0.111	0.038	0.012	0.007
13	7.12	3.18	1156	716	945	115	446	545	236	0.43	Nil	0.13	376	494	0.082	0.491	0.054	0.015
14	7.38	0.98	110	348	56	50	95	375	320	0.53	Nil	0.07	107	41.4	0.106	0.103	0.028	0.015
15	7.23	2.28	835	544	110	65	198	333	402	0.79	0.080	0.03	46.6	25.2	0.224	0.098	0.016	0.007
16	6.83	2.04	489	451	91	54	160	251	259	0.62	nil	0.03	36.3	8.2	0.025	0.062	0.014	0.007

Table -3
Values of various constituents in the water samples in December 2011

Sample No.	pH	EC	TDS	Total Hardness	Calcium	Magnesium	Chlorides	Alkalinity	Sulphates	Fluoride	Nitrites	Turbidity	Sodium	Potassium	Iron	Zinc	Copper	Cadmium
1	7.20	4.62	2533	623	98	94	412	957	698	0.25	3.12	0.06	32.9	270	0.047	0.066	0.019	0.010
2	7.15	4.42	3102	801	139	112	421	623	612	0.42	0.02	0.11	6.51	252	0.054	0.069	0.018	0.006
3	7.19	4.18	2182	658	140	79	367	617	524	0.51	0.02	0.09	2.20	255	0.041	0.204	0.021	0.007
4	7.01	3.32	2401	821	164	101	372	510	371	0.39	2.63	0.27	42.2	149	0.174	0.166	0.019	0.008
5	7.26	3.62	1698	567	135	66	335	351	445	0.20	0.04	0.04	31	235	0.123	0.056	0.016	0.009
6	7.08	5.45	4156	1268	114	272	797	168	363	0.25	0.53	0.09	740	763	0.040	0.037	0.023	0.007
7	7.21	5.91	4460	1328	233	183	865	529	411	0.48	0.34	0.11	770	836	0.038	0.060	0.013	0.007
8	7.32	1.08	224	434	159	90	93	396	187	0.59	0.02	0.23	155	120	0.039	0.045	0.016	0.007
9	7.14	2.31	1603	969	136	158	376	431	526	0.72	0.05	0.27	474	44.3	0.028	0.133	0.013	0.006
10	7.23	1.16	534	413	98	45	95	339	169	0.74	0.04	0.08	177	14.7	0.070	0.038	0.016	0.007
11	7.14	1.08	158	395	141	21	115	345	201	0.48	0.03	0.09	121	20.1	0.032	0.039	0.017	0.008
12	7.10	2.90	2144	1037	129	174	425	467	255	0.78	0.02	0.07	374	81.2	0.112	0.041	0.012	0.007
13	7.18	3.23	1185	738	952	119	454	556	242	0.43	0.02	0.13	376	494	0.086	0.491	0.054	0.016
14	7.42	1.03	119	368	61	55	102	371	330	0.54	Nil	0.07	107	41.4	0.108	0.103	0.028	0.016
15	7.20	2.24	801	556	119	69	205	343	423	0.81	0.08	0.01	46.6	25.2	0.228	0.098	0.018	0.008
16	6.79	2.01	476	465	98	57	179	260	276	0.67	Nil	0.02	36.3	8.2	0.025	0.062	0.014	0.007

Table- 4
Test of hardnesses for the selective sample (Karnala) at different temperatures

S.no	water sample no and place	Hardness of water in ppm at temperatures			
		Room Temp.	45 ^{o}C	60 ^{o}C	80 ^{o}C
1	6, Karnala Street	1268	1243	1219	1128

Table- 5
Indian Standards – Drinking water Specifications IS 10500 – 1991(Reaffirmed)

S. No.	Parameters	Requirement (Desirable Limit)	Permissible limit in the absence of alternate source
	Essential Characteristics		
1	Colour, Hazen units, *Max*	5	25
2	Odour	Unobjectionable	Unobjectionable
3	Taste	Agreeable	---
4	Turbidity, NTU	5	10
5	*p*H value	6.5 to 8.5	No relaxation
6	Total hardness (as CaCO3) mg/L	300	600
7	Iron mg/L	0.3	1
8	Chloride , mg/L	250	1 000
9	Residual, free chlorine, mg/L,	0.2	---
10	Fluoride mg/L	1	1.5
	Desirable Characteristics		
11	Total Dissolved solids(TDS) mg/L	500	2 000
12	Calcium, mg/L	75	200
13	Magnesium, mg/L	30	100
14	Copper, mg/L	0.05	1.5
15	Manganese, mg/L	0.1	0.3
16	Sulphate, mg/L	200	400
17	Nitrate, mg/L	45	No relaxation
18	Phenolic compounds, mg/L	0.001	0.002
19	Mercury , mg/L	0.001	No relaxation
20	Cadmium, mg/L	0.01	No relaxation
21	Selenium, mg/L	0.01	No relaxation
22	Arsenic , mg/L	0.01	No relaxation
23	Cyanide , mg/L	0.05	No relaxation
24	Lead,, mg/L	0.05	No relaxation
25	Zinc , mg/l	5	15
26	Anionic detergents (as MBAS) mg/l, *Max*	0.2	1
27	Chromium,, mg/l	0.05	No relaxation
28	Mineral oil, mg/l	0.01	0.03
29	Pesticides, mg/L	Absent	0.001
30	Radioactive materials:		
	a) Alpha emitters, Bq/l	---	0.1
	b) Beta emitters, pci/l	---	1
31	Alkalinity mg/l, *Max*	200	600
32	Aluminium, mg/L	0.03	0.2
33	Boron, mg/L	1	5

Figure-1
The sampling area

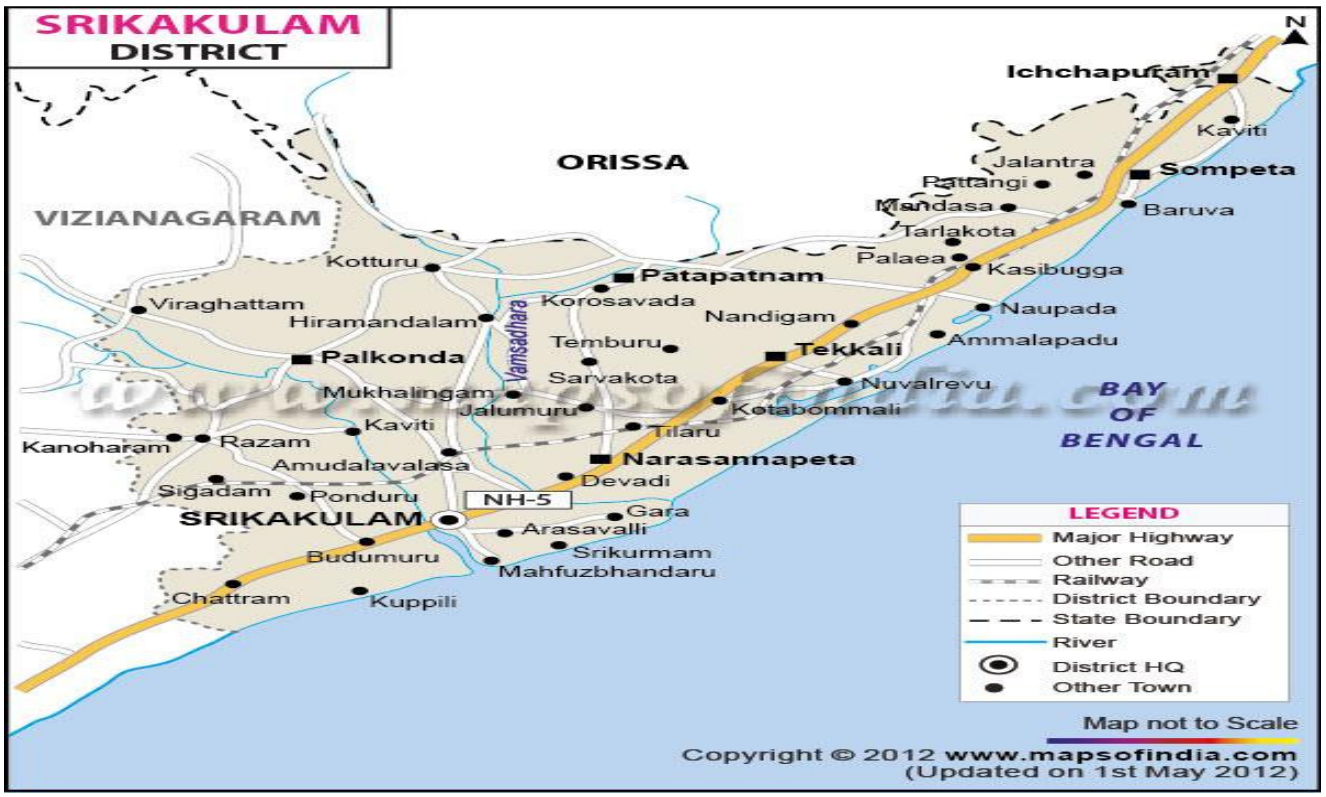

Figure-2
Map of the selected sampling area