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A Study on Physico-chemical and Microbiological Quality of Drinking Water in Tribal Area of Hukumpeta Mandal, Visakhapatnam District, Andhra Pradesh, India

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A B S T R A C T

The present work was aimed for assessing the quality (physico-chemical and bacteriological) of water samples collected from 07 different locations of Hukumpeta Mandal, Visakhapatnam district, Andhra Pradesh, India in 2014-2015. The study was subjected for physico-chemical and bactrioiological analysis's involving parameters pH, Turbidity, Electric Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium, Magnesium, Chloride, Fluoride, Sulphate, Nitrite ,Dissolved oxygen(DO) etc and microbial analysis (Heterotrophic plate count, *faecal coliforms, E.coli and faecal steptroccoi)*, was performed (APHA,2005). On comparing the results against the drinking water quality standards lead by BIS and WHO, it was found that some parameters namely, EC, Turbidity, Total solids, Calcium, Magnesium, and DO were higher than the prescribed limits while other parameters, Fluorides, sulphates, nitrates, chlorides and total solids were observed to be lower than the limits. Bacteriological examination based on MPN/100 ml of sample, revealed that 90% of samples do not meet Bureau of Indian Standards BIS & World Health Organization (WHO) standards. Most Probable Number (MPN) count ranges between 14-1100MPN /100ml.The *faecal coliform* counts ranged between 0.32 x 10^4 CFU/100ml to 4.0 x 10^4 CFU /100 ml, exceeding the standard limit of BIS, 2006. Isolated and identified organisms were *Escherichia, Staphylococci, Salmonella, Shigeila species, Vibrio species, Pseudomonas species, Aeromonas etc.* The results indicate that prevalence of water borne diseases may be usually related to the source of drinking water. These interrelated effects have definite impact on developmental efforts and health status of the tribal community, and needed treatment before consumption.

Keywords

Physical, chemical, parameters, drinking water, WHO, BIS, E.coli, coliform.

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Introduction

Water is an essential unique solvent prerequisite for life, to the extent that extra-terrestrial life is sought by identifying whether a planet or heavenly body has water. In case of human beings, around 57% of the body weight is constituted by water (Guyton, 1991). Water can be obtained from a number of sources among which are streams, lakes, rivers, ponds, rain, spring and wells. About 97.2% of water on earth

has trace of salt and only 2.8% is present as fresh water from which about 20% constitutes ground water. Ground Water is rain water, which reaches the earth surface and percolates into the earth. During the percolation downwards, it comes into contact with a number of mineral salts present in the soil which may be dissolved in the water. It flows down till it reaches hard rock and may retread upward coming out in the form of spring water. Ground water is highly valued because of certain properties not possessed by surface water (Rajankar *et al*., 2011).

In about 85% cases, water supply from tube well and bore wells with proper sanitary protection are found to be good quality having few or no sign of contamination with bacteria of faecal origin. Tube wells sometimes show evidence of persistent contamination, even though sanitary inspection reveals few local hazards. This may be the result of aquifer contamination, which is a particular problem, where fissured geological strata are combined with thin topsoil. The ground water is generally believed to be free from contamination and thus considered it as safe. Contamination of drinking water may occur by percolation of toxins through the soil to the ground water (Sargaonkar *et al*., 2003).

Spring water has been very important to man's existence. Early human civilization centred depended on spring and streams. When ground water appears at the surface, springs are formed. Springs are a good source of water supply for small towns, especially near hills or bases of hills. In many developing countries, availability of water has become a critical and urgent problem and it is a matter of great concern to families and communities depending on non-public water supply system. Conformation with microbiological standard is a special interest because of the capacity of water to spreading water borne diseases to the barest minimum in addition to being pleasant to drink, which implies that it must be wholesome and palatable in all respects (Edema *et al*., 2001).

The ground water quality is a function of natural process as well as anthropogenic activities. Safe potable water is enormously essential for living being and groundwater is one of the sources for human consumption in both urban as well as rural areas. In India almost 80 percent of the rural population depends on untreated groundwater for potable supplies (Sudhakar *et al*., 2004). Around the world people have used groundwater as a source of drinking water, and even today more than half the world's population depends on groundwater for survival (UNESCO, 1992).

In India, about 80% of the diseases are believed to be water related and the World Health Organization has reported that nearly five million human deaths occur every year through polluted drinking water (Singh, 2004). The impact of anthropogenic activities has been so extensive that the water bodies have lost their self-purification capacity to large extent (Sood *et al*., 2008). The quality of water is typically determined by monitoring microbial presence, especially *faecal coliform* bacteria (FC) and physico-chemical parameters (EPA, 1999.)

The provision of potable water to the rural and urban population is necessary to prevent health hazards (Lemo, 2002). Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is palatable and safe for drinking (Tebutt, 1983).

The main source of drinking water in Hukumpeta Mandal is open wells and Kundi's (spring water, well and tap). Natural springs (Oota) are the only source available in remote villages for drinking water as well as utility purpose. The tribal population mostly drinks water without treatment under unhygienic conditions, the impact of the developmental activities on drinking water sources has not been explored, and hence there is a need to estimate the degree of contamination in the water.

The main objective of this study to analyze the twelve Physico-chemical parameters, of drinking water in Bore, spring, Well, Tap and tank (Kundi Water). To determine the most probable number (MPN) of *coliforms and E. coli* present in different drinking water sources and also to confirm characteristics of bacterial species by using standard microbiological methods.

Materials and Methods

Study Area

The study area Hukumpata Mandal is 12 km from Paderu Division located on the North Easter part of Visakhapatnam dist., in Andhra Pradesh, India. It lies between 18º12'44.4" North longitude and 82º54'51.6"E East longitude. The climate conditions are very cool in the area on account of elevation, green vegetation and think forest. The temperature gets down with the onset of south west monsoon and tumbles to a mean minimum of 4^{o}C by January after which there is reversal trend till the temperature reaches mean maximum of 34^{o}C by end of May, that is April to June are warmest Months. The average minimum temperature ranges from 30^{o} to 40^{o}C in November/December while average maximum temperature ranges from 35^{o}to 40^{o}C in May/June. Regarding rainfall and seasonal conditions usually the southwest monsoon starts from 3rd week of April every year and northeast monsoon starts from October.

Sample Collection

Drinking water samples were collected from springs, bores, wells and distribution system, of different villages by grab sampling method depending on the consumption sources. The water samples collected in sterilized bottles label with sample code and transported to the laboratory in an icebox and stored at 4^{o}C, by following the standard procedure laid by APHA 2005. The sample were processed and analyzed for their physical, chemical and bacteriological parameters.

The physical, chemical analyses were carried out at the Department Environmental Sciences laboratory, in Andhra University Visakhapatnam. The physical parameters pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium, Magnesium, Fluoride, and Chloride, Nitrates, BOD, Sodium, Potassium, Phosphors were determined. Bacteriogical assay was used in the determination of Heterotrophic Plate Count CFU/100ml (HPC), *Total coliforms* (100ml), *Fecal coliform* (100ml) analyzed in drinking water according to APHA (American public health Association 1995).

Analysis

Samples were collected from Oct 2014-15 respectively in Table1. The temperature was determined using a mercury thermometer (Tenson Delux make) on the spot, and the pH was measured by pH meter (Elico make), Electrical conductivity was measured by using a digital conduct meter (systronic make). Nephlo/Turbido meter was used for

turbidity determination. The samples are also analyzed for TDS, Total hardness, nitrate (NO3), calcium, Mg, chloride by using Titration methods. DO was determined by WINEUR'S Iodometric method. The Flouride was determined by SPADAN'S UV- Spectrophotometric. Method. (Systronic make). Turbidimetric method was employed for the estimation of sulfate (SO4), nitrate amount was derived by using the phenol disulphonic acid method. All the results were compared with the BIS (ISO-100500, 1994) and WHO standards for drinking water quality.

The microbiological quality was determined by standard most probable number (MPN) method. In total *coliform c*ounts (TC) after the necessary dilution was carried out in the water samples. 10 ml of the sample was taken in three tubes each with double strength lactose broth tubes 1 ml was taken into each of first three single strength lactose broth tubes and 0.1 ml sample was transferred into each one of the other three tubes and incubated at 37^{o}C for 24-48 hrs.

After the incubation period the gas accumulation in Durham tubes was observed and most probable *coliform* number was determined using the MPN index (APHA, 2005). The media used for the bacteriological analysis of water include Plate Count Agar (PCA), Nutrient Agar (NA), Lactose Broth (LB) and Eosin Methylene Blue Agar (EMB). A serial dilution method was used for total viable count and the presumptive tests for coliforms.

Results and Discussion

Physico-chemical aspects

In the study 16 physico-chemical parameters in the drinking water samples were collected from selected Bore, Well, spring, and tap water sources has been studied. The sampling stations were chosen on the basis of the consumption by the Tribal people in the study area. The samples were collected as per schedule and the parameters are analyzed three times in the season during the entire period of investigation. An average of three observations in a season with respect to each sampling station and parameters were calculated for further statistical analysis. The results are summarized in table 1&2.

pH: The pH value of the water samples in the study area varied from 6.5– 8.39 with a mean of 7.60 indicating slight acidic to alkaline nature. pH below 6.5 corrodes the water pipe lines thereby releasing toxic metals such as zinc, lead, cadmium and copper (Shrivastava and Patil, 2002). It was also observed that the relative quantities of calcium, carbonates and bicarbonates influence the pH value of the water. The water tends to be more alkaline when it possesses carbonates (Zafar, 1966; Suryanarayana, 1995). Generally the pH values of water source vary due to changes in temperature and biological activities. pH has been categorised under secondary drinking water standard as it does not pose a health risk. All biochemical reactions are sensitive to the variation of pH (Jeyakumar *et al*., 2003). PH value of all the sources found to be below the permissible limit of WHO i.e. 6.5-8.5.

Electrical conductivity

Electrical conductivity is a measure of water's capacity to conduct electric current since most of the salts in the water are present in the ionic form. In general, groundwater tends to have high electrical conductivity due to the presence of high amount of dissolved salts. Electrical

conductivity is a decisive parameter in determining suitability of water for a particular purpose. The recommended permissible limits for electrical Conductivity are 300µs/cm to 400µs/cm (ISO 10500:2004). The samples showed the Electric Conductivity ranges from 147 to 730 us/cm.

The Electrical conductivity is higher than the permissible limits in spring and well water samples. The similar observations were reported by Rao *et al*., (2004). , The mean electrical conductivity in pre and post monsoon are 378.5 us/cm. The high Electric conductivity may be due to the silt carried by the surface runoffs during rainy season in the hilly areas.

Turbidity

The turbidity indicates clarity of water and which is caused by living and nonliving suspended matter and also colour producing substances. The turbidity readings of the samples range from 7.8 to 12.9 NTU, with mean of 9.27 NTU in all the sources. In all the water samples the turbidity values were above the WHO and BIS standards, in the spring and open well the turbidity value were highly above the prescribed limits.

Since turbidity is a water quality parameter that which can be monitored easily, and it may also serve as a promising indicator for microbial contamination of wells and springs, although its reliability has been discussed controversially (Ryan and Meiman, 1996; Mahler *et al*., 2000; Pronk *et al*., 2006, 2007). Leaching of organic matter, industrial, domestic wastes etc., also contribute to turbidity in groundwater samples (Byragi *et al*., 2013).The presence of in organic nutrients such as nitrogen and phosphorus which may stimulate the growth of algae, also contribute to turbidity (Sawyer *et al*., 2000).

TDS

Total dissolved solids is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro granular suspended form Balachandar *et al*., (2010). Since TDS higher than 1000 mg/L impart taste to the water, therefore, a desirable value of 1000 mg/L is proposed by WHO. Furthermore, a value higher than 1000 mg/L results in excessive scales in water pipes, heaters, boilers and household appliances (WHO), Geneva, (2004).

The TDS values were recorded to be 380 mg/L to 1291mg/L and with mean of 812.85 mg/L. In spring water sample, the value was found to be in the ranges of 1280- 1291 mg/L. However 40% of samples are within the permissible limit and 60% of samples are having high total dissolved solids TDS, this may be due to the weathering of rocks and soil.

Total hardness

The total hardness is represented by $CaCo_3$ contamination in water. Hardness of water is primarily due to dispersion of bicarbonates, chlorides, and sulphates in water. According to classification of total hardness (Durfor and Becker, 1964). The value for the total hardness varies from 60 to 160mg/L, and with mean of 109.71mg/L. It can be seen in the table 03 hardness in all the sources were below the limits of WHO guideline i.e. 500 mg/L as CaCO3.

The hardness may be advantageous in certain conditions; it prevents the corrosion in the pipes by forming a thin layer of scale, and reduces the entry of heavy metals from the pipe to the water (Shrivastava *et al*., 2002). As a matter of fact, this guideline value is not proposed on the basis of health. Consumers can tolerate water hardness in excess of 500 mg/L. Water hardness above

500 mg/L needs excess use of soap to achieve cleaning.

Calcium and magnesium (Ca2+ and Mg2+)

The distribution of calcium and magnesium concentrations in the water samples were highly fluctuations during different periods. The average concentration of calcium and magnesium was 49.0mgL-1 and 60.71mgL-1 respectively. The desirable limits for calcium and magnesium for drinking water are 75 and 30 mg/L, respectively (BIS 1991). The values were above the permissible limit in both the monsoon period compared to the WHO standard value of 75 mg/L. Maximum concentration of Calcium was observed in well, spring and bore water and minimum was in tap water, where as the magnesium concentration found to be low in well and bore sample and high value was observed in spring and tap. Calcium may be added to water system as it passes through soil and rock containing large amounts of these elements in mineral deposits (Renn, 1970).

Chlorides

Chlorides occur naturally in all types of water but the concentration is very low in natural water. Higher value of chloride indicates pollution of water and gives an undesirable taste. The Chloride concentration ranges from 65 to 156 mg/L with the mean of 85.65 mg/L to. The desirable limit for chloride in drinking water is 250mg/L (WHO, 1984), as the observed in the table, 10 the values were below the permissible limits in all sources. In general, chlorides occur in all types of waters and the contribution of chloride in the groundwater is due to minerals like apatite, mica, and hornblende and also from the liquid inclusions of igneous rocks (Das and Malik, 1988).

Fluoride

The presence of fluoride in drinking water is essential and WHO (1984) prescribed 1.5 mg/L fluoride as desirable limits in drinking water. In this study fluoride concentration health problems may arise from either deficiency or excess amount (Gopal *et al*, 1985). The concentration of fluoride ions in drinking water of study area is observed to be within the permissible limits of WHO and BIS standards. Fluoride concentration of 0.4 ppm in drinking water causes mild type of dental fluorosis (Dinesh, 1999; Gupta *et al*., 1993; Yadav and Lata, 2004).

Sulphates

Sulphates are a naturally occurring anion found almost in all types of water. It gets leached into the ground water by many processes. One of those may be the breakdown of organic substance in the soil as mentioned by Alexander (1961). Sulphate ion is one of the major anions occurring in natural waters since they are readily soluble in water. In the study the SO_4^{-2} concentration varies from 1.6 to 20.5 mg/L. No sample from the different sources has exceeded BIS and WHO prescribed standards i.e. (200mg/L) in the overall study area the ground water appears to be suitable for drinking purposes in respect of SO_4. The levels of sulphate in these water samples are low. The sulphate recommended by WHO is 500 mg/L.

Nitrate

Presence of nitrate in water leads to organic pollution. The water samples had nitrite level range from 0.9 to 4.4 mg/L with mean of 2.34 mg/L present. The nitrates concentrations in all the samples were below the prescribed standard of WHO, the level of nitrate in the water samples is low generally.

Table.1 Sample Location and Samples Collected:

S.no	**Sampling location name**	**Sample code**	**Longitude**	**latitude**
1	Hukumpeta	S_1	18º12'44.4"N	18º12'44.4"N
2	Tadigiri	S_2	18º13'3.9"N	82º54'51.6"E
3	Konthili	S_3	18º17'9.2"N	82º47'36.5"E
4	Peddagaruvu	S_4	18º14'27.3"N	82º42'44.0''E
5	Kotanapalli	S_5	18º12'44.4"N	82º48'44.5'E
6	Rangasella	S_6	18º13'3.9"N	82º54'51.6"E
7	Sukuru	S_7	18º13'21.25''N	82º62 ' 38.2" E

Table.2 Analytical methods and equipment used in the study.

S.No.	**Parameter**	**Method**	**Instruments/Equipment**
A.	**Physico-chemical**		
1.	pH	Electrometric	pH Meter
2.	TDS	Electrometric	Conductivity/TDS Meter
3.	Hardness	Titration by EDTA	-
4.	Chloride	Titration by $AgNO_3$	-
5.	Nitrate	Phenol disulphinic Method	UV-VIS Spectrophotometer
6.	Fluoride	SPADNS	UV-VIS Spectrophotometer
7.	Turbidity	Nephlometric method	Turbidity Nephlometer
8.	Sulphates	(TurbidometricMethod)	Colourimeter
9.	Calcium	Titration by EDTA	-
10.	Magnesium	Titration by EDTA	-
11.	DO	Titration by Sodium thiosulphate solution	-
12.	BOD	5 days incubation at 20°C followed by titration	BOD Incubator

Table.4 MPN Index per100ml, HPC,Faecal streptococci and Faecal Coliform count.

Sampling location	**Sample code**	**MPN/100ml**	***Faecal coliform* count/ CFU/100ml**	**HPC/ CFU/100ml**	***Faecal Streptococci* CFU/100ml**
Hukumpeta	S_1	14	0.32×10^4	1.02×10^4	0.021×10^4
Tadigiri	S_2	20	0.54×10^4	1.62×10^4	0.012×10^4
Konthili	S_3	23	0.64×10^4	1.96×10^4	0.013×10^4
Peddagaruvu	S_4	120	2.21×10^4	2.86×10^4	0.69×10^4
Kotanapalli	S_5	150	3.20×10^4	3.24×10^4	1.23×10^4
Rangasella	S_6	460	3.65×10^4	6.90×10^4	1.45×10^4
Sukuru	S_7	1100	4.0×10^4	4.86×10^4	1.32×10^4

Table.3 Physico- Chemical Parameters of different sources.

S.no	Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7	mean	ISO (10500:2004) (Desirable limit)	WHO (Maximum allowable limit)
	SOURCE	**Bore**	**Bore**	**Bore**	**Spring**	**well**	**well**	**Spring**			
1	pH	7.60	8.39	6.92	7.76	8.39	6.50	7.65	7.601	6.5-8.5	6.5-8.5
2	TURBIDITY	8.6	7.8	8.9	10.2	8.5	8.0	12.9	9.271	5-10 NTU	-
3	CONDUCTIVITY	210	334	147	196	363	670	730	378.5	300-400us/cm	-
4	TOTAL SOLIDS	560	652	380	1291	658	869	1280	812.8	500 mg/L	-
5	TOTAL HARDNESS	66	160	144	88	90	60	160	109.7	300 mg/L	-
6	CALCIUM	38	60	12	49	40	34	110	49	75 mg/L	75mg/L
7	MEGNESIUM	28	100	132	39	50	26	50	60.71	30mg/L	50mg/L
8	CHLORIDES	86.1	78.2	156	68	69	77.3	65	85.65	250mg/L	250mg/L
9	FLOURIDES	0.6	0.2	0.1	0.3	0.2	0.3	0.2	0.271	1mg/L	1.0-1.5mg/L
10	SULPHATES	19.2	20.5	17.8	8.751	16.3	19.1	1.6	14.75	200mg/L	500mg/L
11	NITRATES	BDL	1.6	3.6	4.4	1.2	0.9	BDL	2.34	-	3mg/L
12	DISSOLVED OXYGEN	6.5	6.1	5.2	6.6	6.9	6.5	3.9	5.957	-	5.0mg/L

Table.6 Biochemical Characteristics of isolates:

Test	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Catalase	+	-	+	+	+	+	+	+	+	+	-	-	+	+	+
Oxidase	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+
Motility	-	-	+	+	-	-	+	+	-		+	-	+	+	+
Indole	-	-	-	+	-	+	-	+	-	+	-	-	+	-	+
Methyl-red	-	+	-	+	-	+	-	-	+	+	(+)	-	-	+	-/+
Voge-Proskauer	+	-	+	-	+-	-	-	+	-	-	+	-	-	+	+
Citrate Utilization	-	-	-	-	+	-	+	+	+	-	+	+	+	-	+
Urease	+	-	-	-	+	+	-	-	-	-	+	+	+	-	+
Hydrogen sulphide	-	-	+	-	-	+	-		+	-	-	-	-	-	-
Starch hydrolysis	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
Nitrate Utilization	-	-	+	+	+	+	+	+	+	+	+	+-	-	(+)	-
Gelatin liquefication	-	-	+	-	-	+	-	+	-	-	(+)	+	-	+	-
Lactose fermentation	-	A	-	AG	AG	-	-	AG	-	-	AG	-	A	AG	AG
Glucose fermentation	A	A	A	AG	AG	AG	-	AG	AG	A	AG	-	A	A	AG
Sucrose fermentation	A	A	A	A(+)	AG	AG+-	-	AG	AG	A+-	-	-	A	A	AG

W1-Staphylococcus, W2-Streptococcus, W3- Bacillus Sp., W4- E. Coil,
W5- Klebsiella Sp W6-, Proteus Sp.,W7- Pseudomonas sp., W8- Vibrio sp., W9- Salmonella sp., W10- Shigella, W11- Enterobacter aerogenes, W12- Micrococcus sp., W13- Acinetobacter sp., W14- Flavobacter sp., W15- Aeromas sp., A- Acid production only; AG - Acid and gas production; ± =Variable reaction; + - Positive; - = Negative ; (+) – Late Positive

Table.5 Morphological characteristics of isolates

Isolate	Morphogical Characteristics	Organism
W1	Non- spore forming and non- motile, gram positive cocci, circular, low convex with entire margin, smooth, medium, opaque colony on Nutrient Agar, Yellow colure colonies on Mannitol Salt Agra Media grown at pH 7 and 37^0 C	***Staphlococcus sp***.
W2	Gram positive cocci, thin, even, growth on Nutrient Agar, black or brown colure colonies on Bile esilin Agar.	***Group DStreptococcus,***
W3	Gram positive rod, spore forming, abundant, opapue, white waxy growth on Nutrient Agar .	***Bacillus Sp.***
W4	Gram negative rod, circular, low convex, with entire margin, mucoid, opaque, growth on Nutrient Agar, green metallic sheen colony on Eosin Methlene Blue (EMB) Agar.	***E. coil***
W5	Gram negative rod, Slimy, white somewhat translucent, raised growth on Nutrient Agar, Dark pink colure colonies on MacConkey Agar.	***Klebsiella Sp***
W6	Gram negative rod, thin, blue gray, spreading growth on Nutrient Agar.	***Proteus Sp.,***
W7	Gram negative rod, abundant, thin, white medium turns green on Nutrient Agar. pink Colure colonies on Phenothalin diphospate Agar.	***Pseudomonas sp.,***
W8	Gram negative curved rod, abundant, thick, mucous white colure colonies on Nutrient Agar. Yellow colure colonies on TCBS agar	***Vibrio cholera***
W9	Gram negative curved rod abundant, thick, mucous white colure colonies on Nutrient Agar. Green colure colonies on TCBS agar	***Vibrio .parahaemolytics***
W10	Gram negative rod, thin even grayish growth on Nutrient Agar	***Salmonella sp***
W11	Gram negative rod, thin even grayish growth on Nutrient Agar	***Shigella***
W12	Gram negative rod, abundant thick, white glistening growth on Nutrient Agar	***Enterobacter aerogenes***
W13	Gram positive, soft, smooth, yellow growth on Nutrient Agar	***Micrococcus sp.***
W14	Gram positive, grey-white with undulated margin on Nurient Agar	***Acinetobacter sp.,***
W15	Gram negative, non spore forming rod shaped, facultatively anaerobic bacteria. Thick, mucous white colure colonies on Nutrient Agar. Light yellow to light to tan homogenous free flowing powder on Starch Ampicillin Agar	***Aeromas sp.,***

Fig.1 Sampling Locations in Hukumpeta Mandal

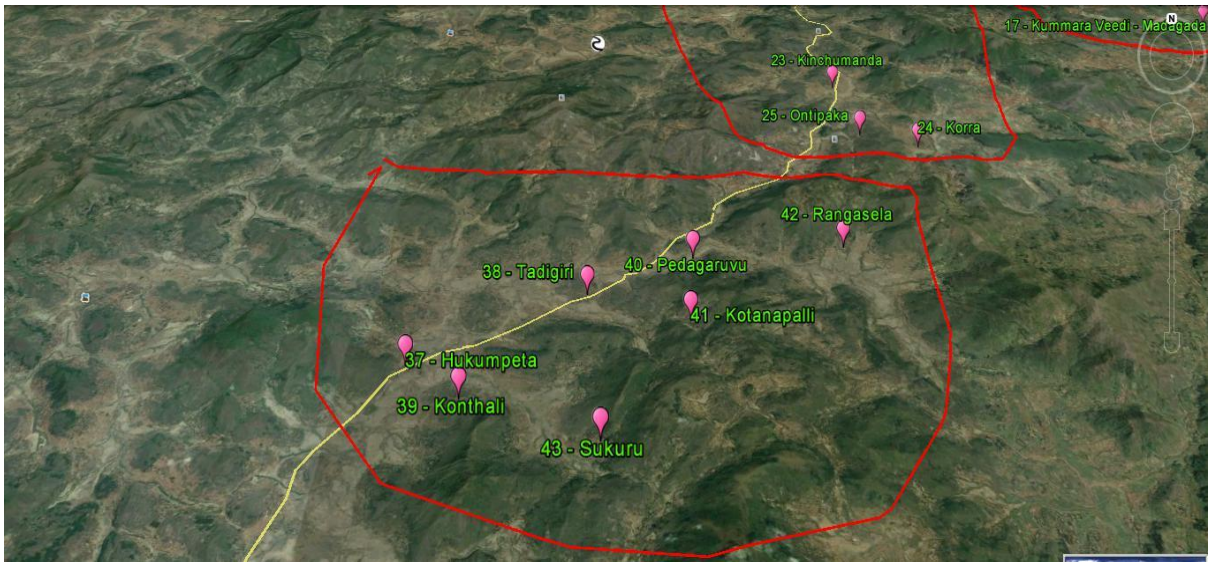
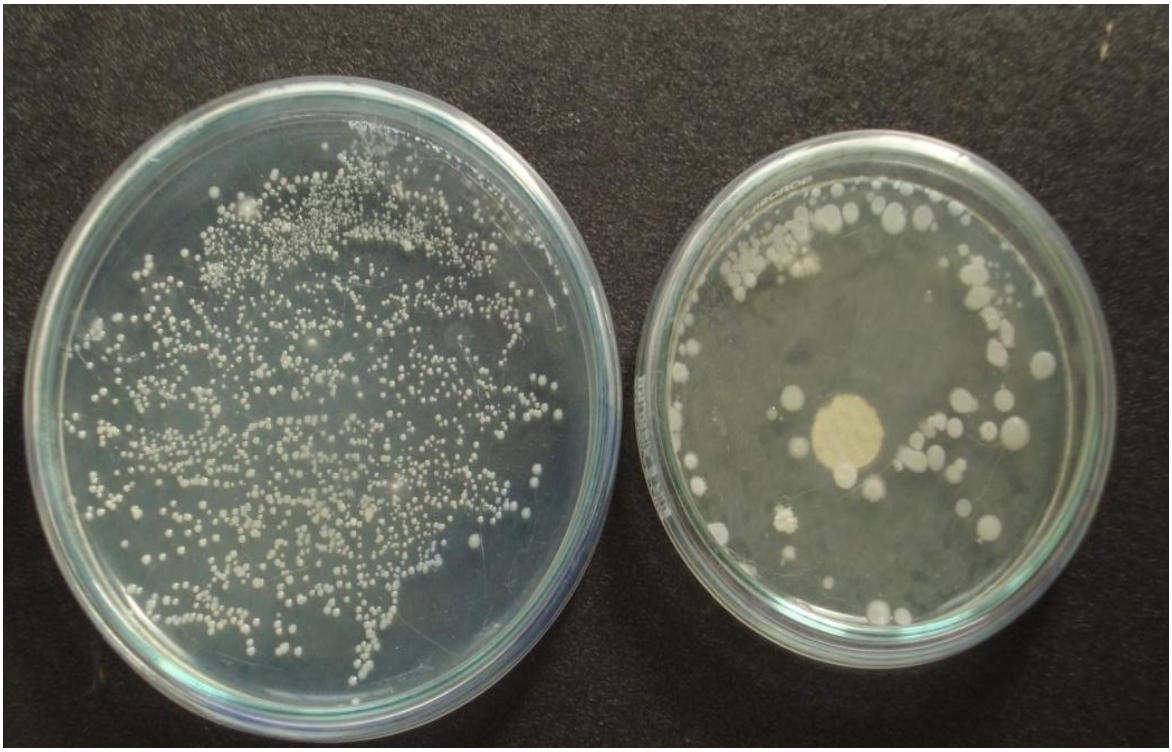
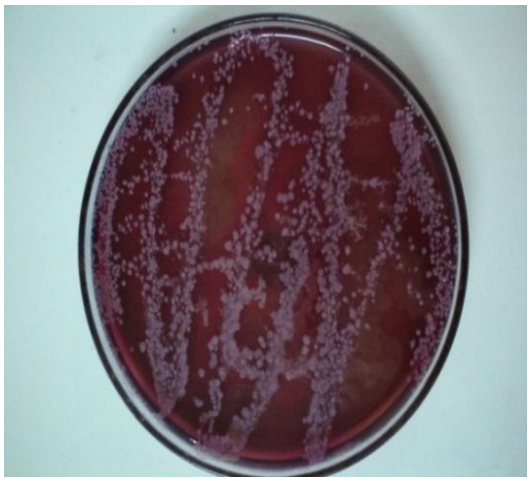


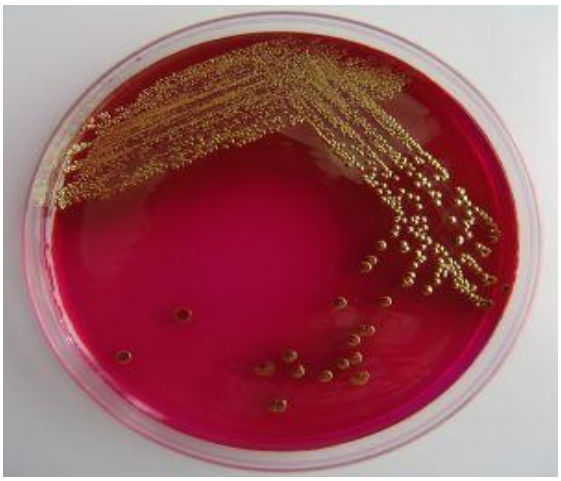
Fig.2 Microbial Results



HETROTROPHIC PLATE COUNT ON NUTRIENT AGAR

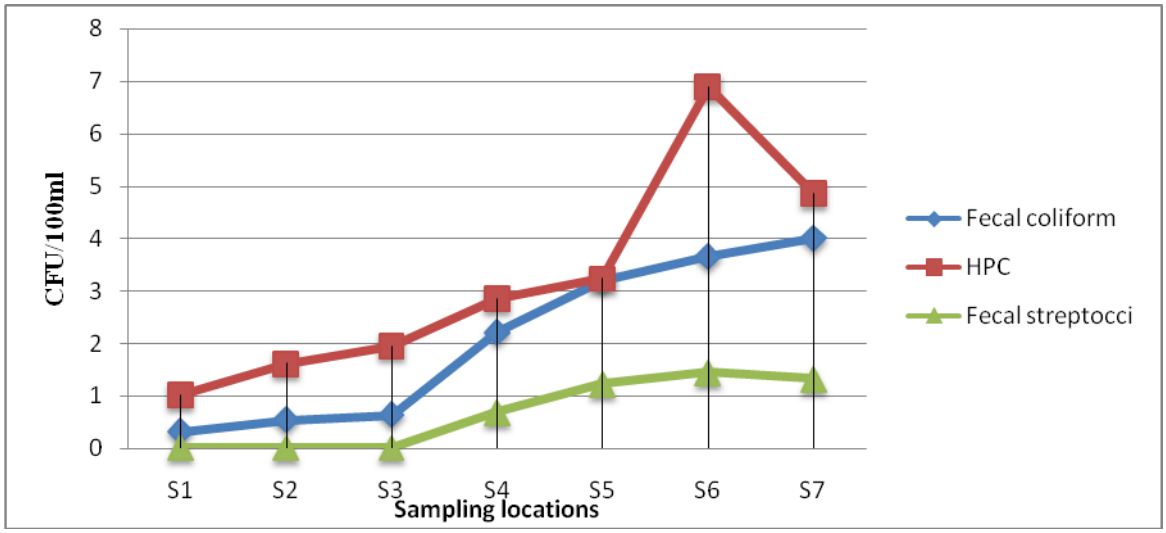


E.coli **(Dark Pink) on Endo agar.**



Brown colonies on Bileesulin Agar ***(Fecal Streptococci)***

Graph.1 HPC, Faecal streptococci and Faecal Coliform count in sampling locations



The WHO standard for nitrate is 50mg/L and above this limits may cause cyanosis disease or blue baby syndrome in infants less than 3months (WHO, 2006). Human and animal wastes, industrial effluents, application of agro chemicals, seepage and silage through drainage system are the main sources of nitrate contamination in groundwater (Robertson *et al*., 1991 and Agrawal *et al*., 1999).

Dissolved Oxygen

It is one of the most important aspect in evaluating water quality and signifies physical and biological process dealing with water quality. Good water should have solubility of oxygen in 7.0 to 7.6 mg/L at 35^0C to 36^0C respectively (Kudesia, 1995). Oxygen saturated water have pleasant taste. In the study, the DO found to be in the range of 13.9 to 6.9 mg/L with mean of 5.95mg./L. In spring bore and well sample the Do concentration were found to be slightly above the permissible limit of WHO i.e. 5.0 mg/L.

Microbiological aspects

In this study 07 drinking water samples collected from Different sources in Hukumpeta Mandal of Visakhapatnam were analyzed for the bacteriological quality. It was found that all microbiological and some chemical values determined from groundwater were above the limits set by CPCB and World Health Organization (WHO). The microbiological examination of water is a direct indicator of faecal contamination and its extent of risk to human health. Selected indicator organisms are routinely monitored to indicate the probability of pathogenic population in water. Many indicators have been studied and recommended for water quality assessment (ISO, 1990; Standard methods 1998).

The Most Probable Number (MPN)

The quality of water is typically determined by monitoring microbial presence, especially *Faecal Coliform* bacteria (FC) and physico chemical parameters (EPA, 1999). MPN counts were recorded highest at Sukuru spring (1100MPN/100ml) and Hukumpeta (bore) has recorded the lowest value of 14 MPN/100ml as shown in the Table 4. Presence of *coliforms* in drinking water sources indicates inadequate treatment and sanitation which is necessary for drinking (Christine *et al*., 2006). Accordingly the *Total Coliform* Count for all the samples was higher than the BIS. The high Coliform count obtained in the samples may be an indication that the water sources are *feacelly* contaminated. According to BIS Standards every water sample that has *coliform* must be analyzed for either *faecal coliforms or E.coli* (BIS, 2005). The present study exposed that the spring water and open well water has high load of coli form, when compared with that of some bore, tank and tap water samples.

Heterotrophic Plate Count

A number of aerobic and facultative anaerobic bacteria can be isolated by using Heterotrophic Plate Count. It includes both gram positive and gram negative bacteria. This HPC will give the total bacterial count present in 100 ml of water. They form the colony forming units by counting this CFU/100ml. In the study the minimum HPC count was 1.02×10^4 CFU/100ml in Hukumpeta bore (S_1) water and maximum count was observed at Rangaseela well water sample (S_6). HPC mean value was 3.06×10^4 CFU/100ml. The total bacterial counts for all the water samples were generally high exceeding the limit of 1.0×10^4 CFU/100ml which is the standard limit of heterotrophic count for drinking water (EPA, 2002).

Feacal Coliforms Count

The subset of the more comprehensive *coliform* or total *coliform* group that is more definitive as an indicator of homoeothermic faecal contamination consists of what are termed the *faecal colifroms*. The *Feacal Coliform* counts per 100ml of the Bore water samples on EMB agar plate mean ranged between 0.32×10^4 CFU/100ml to 0.64×10^4 CFU/100ml with mean of 0.54×10^4 CFU/100ml. Spring water samples showed 2.21×10^4 CFU/100ml to 4.0×10^4CFU/100ml with mean of 3.10×10^4 CFU/100ml. Hence it is resultd that the load of *Fecal coliform* count in Bore water is comparatively lesser than the well and spring water, and found to be little safer than the other sources with respect of *Fecal coliforms* (spring and well).

Faecal Streptococci

The *Faecal Streptococci* are a group of gram-positive Lancefield group D *Streptococci*. The *faecal streptococci belong to the genera Enterococcus and Streptococcus* (Gleeson and Gray, 1997). In the present study the count of *Faecal Streptococci* found minimum of 0.012×10^4 CFU/100ml in Thidigiri bore water (S_2) and maximum Count of 1.45×10^4 CFU/100ml in Rangaseela well water (S_6) with mean of 0.67×10^4 CFU/100ml. The bore water sources are found to be safer, in peril of contamination during rainy season than the well and spring sources, Hence the load of *fecal Streptococci* count observed to be lesser in number than the other sources (spring and well) which gets mixed with the surface runoffs during rainy season.

Characterization and Identification of Bacterial Species

The identified isolates are *Escherichia, staphylococci, salmonella, shigella species, Salmonella sp, vibrio species, pseudomonas species, Enterobacter aerogenes* and *Aeromonas sp.*, (Shown in table. 3) Number of Salmonella, *Shigella Species* and *Vibrio Cholerae* were higher than the BIS water quality standards for recreational usage in the study area, this leads to the public health significance, such as gastrointestinal infections such as diarrhoea, dysentery, typhoid and other infections (BIS, 2005).

Other bacteria isolated from all the water samples such as S*taphylococcus auras, Pseudomonas aeruginosa* and *Proteus species* are also of public health significance. *Entero bacter aerogenes* isolated from the water samples are examples of non-*fecal coliforms* and can be found in vegetation and soil which serves as sources by which the pathogens enter the Water (Schlegel, 2002). The British Standard Institute (BSI, 1993) specified that counts greater than 10^4 is considered unsatisfactory for *Enterobacter species.*

In conclusion, in this study it was found that some physico – chemical and microbiological parameters determined from the area were above the limits of BIS and WHO. The samples collected from spring and open wells showed deviations from water quality standards indicating water contamination. The comparison of different parameters spatially showed an increasing pattern of Turbidity, Total Dissolved Solids, Calcium, magnesium and DO. Microbiologically *faecal coliform* concentrations, MPN and Heterotrophic plate count in the water in Hukumpata sample, were above the limits of BIS and WHO. The people living in these areas are therefore at higher potential risk of contracting water-borne and/or sanitation related diseases, and water from these sites is unfit for drinking purpose. The existence of indicator organism demonstrates that there may be pathogenic bacteria present so

that it is necessary to disinfect the groundwater before human use. In conclusion, it is necessary to apply strong preventions immediately to save water from deterioration in the study area. Its evidence that water borne diseases, sewage treatment and purify the water to make it fit for drinking, since the associable organisms are of public health significance being implicated in one form of infection or other. The areas which are no facility of municipal tap water, in those areas educative programmes must be organized by researchers and Government agencies to aware the villagers on the proper use of surface water.

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