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Quality Assessment of Drinking Water from Kondiba an Agency Area, Andhra Pradesh

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ABSTRACT

A study was conducted to evaluate the quality of drinking water in Kondiba panchayat of Ananthagiri mandal in Visakhapatnam district, which has always been crucial with reference to public health. In this study drinking water samples were collected from a hand bore, a well, and a stream for a period of one year i.e., from April 2011 to March 2012. The various constituents monitored include the physicochemical characters, the bacterial parameters like Total plate count (TPC), Most probable number (MPN) and isolation and identification of pathogenic bacteria. The physicochemical characters of all the three drinking water samples were within the recommended permissible level of WHO. The total plate count was above the WHO guidelines values (<10CFU's/ml) in the three water samples studied the highest count was during August and September. Increased presence of colifroms was noticed during August and September in stream and bore well while in well water it was during June to August. All the water samples were found to be contaminated with pathogenic bacteria such as *E.coli, Salmonella, Shigella, Staphylococcus, Group D Streptococcus, Vibrio cholera and V. parahaemolyticus.* Hence the water sources used for drinking should be monitored from time to time for reducing disease epidemics.

Keywords: Drinking water, Quality assessment, Pathogenic bacteria, Kondiba panchayat

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INTRODUCTION

All living organisms require a variety of inorganic compounds for growth, repair, maintenance and reproduction and such inorganic compounds are abundant in water. Hence, water plays an essential role in human life. Several studies indicated that consumption of untreated or poorly treated water lead to the outbreak of waterborne diseases such as typhoid, cholera and bacillary dysentery. In our country 70% of the water is seriously polluted and 75% of illness and 80% of the child mortality is attributed to water pollution (Zoeleman, 1980)[1]. During the past decade, widespread reports of ground water contamination have increased public concern about drinking water quality (Yanggen and Born, 1990) [2]. The most dangerous water pollution occurs when faecal contaminants like *Escherichia coli, Salmonella, Shigella, Vibrio cholerae* enter the water. Though bacteriological quality of drinking water is being monitored in urban areas and some rural areas, such monitoring was uncommon in some rural areas and specially so in tribal areas. Hence, the bacteriological quality of drinking water is important and periodical monitoring is essential for potable water. The present paper deals with the physicochemical and bacteriological quality of different sources of water used for drinking during April 2011 to March 2012 in Kondiba panchayat, a tribal area of Ananthagiri mandal in Visakhapatnam district.

MATERIAL AND METHODS

Study Area

Ananthagiri ($18^0$17'14"N, 83 ^{0}6'43"E) is about 60km away from Visakhapatnam and lies on the top of the Eastern Ghats. The area of the Ananthagiri mandal is roughly 50sq km and the entire area is inhabited by aboriginal tribes.

Of the 25 panchayats in Anantagiri mandal, Kondiba panchayat with 20sq.km area was selected for the present study. The total population present in this panchayat is around 5,000 and includes 1,000 literates. The different tribal types present in this panchayat are "Konda Dora, Parena Karja, Petege, Bagatha, Valmiki and Gadaba" and most of them depend on agriculture. The mean temperature is 36^oc and receives 1171.0mm normal annual rainfall. Based on their economic status they live in different types of houses such as sheet houses, tiled houses and slab houses. Drinking water sources include 12 hand bores; 7 wells and a small stream running from hills. The stream is the main source of drinking water.

In the present study, water samples were collected from three sources i.e., a well, a hand pump and stream once in a month for a period of 12 month from April 2011 to March 2012, in white plastic bottles, which were previously rinsed with distilled water and sterilized with 70% alcohol. At the collection point, the containers were rinsed thrice with the sample water before being used to collect the samples. The collected samples were placed in a thermocol box. The temperature in the box was maintained at 4^oC by using ice packs.

Plating for microbial isolation

The collected samples were serially diluted tenfold in order to reduce the number of microbes in the water samples. The bacteria were isolated by pour plate and spread plate methods using10^{-3} and 10^{-4} dilutions.

In pour plate method 1ml of the sample was taken from both 10^{-3} and 10^{-4} dilutions separately and transferred into two petri dishes. The nutrient agar was autoclaved and then poured in the petri dish. The agar was allowed to solidify and incubated at 37^0c for 24-48 hrs. In spread plate method sterile petri dishes were taken and sterilized nutrient agar was poured into them. On the solidified agar surface, 0.1ml of the sample (diluted sample i.e., 10^{-3} and 10^{-4} dilutions) were poured and spread evenly using a L- shaped bent glass rod (spreader). The plates were incubated at 37^0c for 24-48 hrs.

Microbial analysis and identification of bacteria

Total plate count was determined by pour plate method. After 48 hrs of incubation colonies were counted by using colony counter and results were expressed as CFU/ml. Coliforms in the water samples were determined by Most probable number (MPN) method (FAO 1992). Water analysis was carried out by multiple tube method. In this method double strength and single strength Mac conkey broth was prepared. Measured volumes of water to be tested were added to tubes containing medium and incubated. Most probable number (MPN) coliforms per 100ml of water sample were calculated from the relevant MPN table.

For identification of bacteria staining, colony characteristics, cultural characteristics, biochemical tests and characteristics of bacteria were used. In staining of bacteria Gram staining, Endospore staining, Capsule staining and Motility test were done. In order to study the morphology of bacteria, cells were heat killed and fixed on the slide. The fixed bacteria were stained and observed for size, shape, arrangement, spore formation and capsulation etc. Hanging drop method was performed to study motility of bacteria.The colony characteristics such as size, shape, margin and elevation were observed on nutrient agar medium. Haemolytic behavior was observed on blood agar. The cultural characteristics of isolates were observed on selective media. The media used were Eosin Methylene Blue (EMB), Salmonella – Shigella agar (SSA), Mac- conkey agar, Manitol salt agar, TCBS agar and Bile esilin agar. Biochemical behavior of bacteria for utilization of specific substrate and enzymatic activity were studied by carbohydrate fermentation, catalase test, gelatin hydrolysis, IMViC test and urease test.

Escherichia coli (E.coli)

It is a gram negative rod. It forms circular, low convex mucoid, opaque colonies with entire marginal growth on nutrient agar. Green metallic sheen colonies were observed on EMB agar. *E.coli* is the causal agent of gastroenteritis, urinary tract infections, and neonatal meningitis.

Staphylococcus aureus (S.aurerus)

It is a gram positive coccus, non spore forming and non- motile bacteria. It forms circular, low convex with entire margin, smooth, medium opaque colony on nutrient agar. It forms yellow coloured colonies on mannitol salt agar. *S.aureus* incidence ranges from skin, soft tissue, respiratory, bone, joint, endovascular to wound infections. It causes a range of illnesses, from minor skin infections, such as pimples, impetigo, boils (furuncles), cellulitis folliculitis, carbuncles, scalded skin syndrome, and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome (TSS), bacteremia, and sepsis. It is still one of the five most common causes of nosocomial infections and is often the cause of postsurgical wound infections.

Group D Streptococcus

It is a gram positive coccus. It forms thin, even growth on nutrient agar. Black (or) Brown coloured colonies were observed on bile esilin agar. *Group D Streptococcus* causes urinary tract infections, meningitis, neonatal sepsis, spontaneous bacterial peritonitis, septic arthritis, and vertebral osteomyelitis diseases.

Vibrio cholerae: (V.cholerae)

It is a gram negative curved rod. It forms abundant, thick, mucous white coloured colonies on nutrient agar and yellow coloured colonies on TCBS agar. *Vibrio cholerae* is responsible for the occurrence of cholera.

Vibrio parahaemolytics: (V.parahaemolyticus)

It is a gram negative curved rod. It forms abundant, thick, mucous white coloured colonies on nutrient agar and green coloured colonies on TCBS agar. *V. parahaemolytics* is responsible for gastrointestinal illness in humans.

Klebsiella pneumoniae: (K.pneumoniae)

It is a gram negative rod. It forms slimy, white somewhat translucent, raised growth on nutrient agar and dark pink coloured colonies on mac - conkey agar. *Klebsiella pneumonia* is responsible for pneumonia, thrombophlebitis, urinary tract infection (UTI), cholecystitis, diarrohea, upper respiratory tract infection, wound infection, osteomyelitis, meningitis, and bacteremia and septicemia.

Salmonella typhi: (S.typhi)

It is a gram negative rod. It forms thin even grayish growth on nutrient agar and dark green colonies on SS agar. *Salmonella typhi* causes typhoid.

Shigella dysenteriae: (S.dysenteriae)

It is a gram negative rod. It forms grayish growth on nutrient agar and colourless colonies on SS agar. *Shigella dysenteriae* is the bacillary dysentery causing bacterium.

Analysis of water for physicochemical characters:

The P^H of the water samples was measured by using the electrometric methods and other physicochemical parameters such as Total dissolved solids and Fluoride content were analysed by standard methods given in APHA(1989).

RESULTS AND DISCUSSION

Water samples collected from Kondiba panchayat for a period of one year i.e., during April 2011 to March 2012 were analysed for physical, chemical and bacteriological characteristics. The physical characteristic measured is P^H. Among the chemical characteristics Total dissolved solids (TDS) and fluoride contents were measured. For total number of viable bacteria total plate count (CFU/ml), for faecal and total coliforms most propable number (MPN/100ml) and for isolation and identification of bacteria staining, biochemical and growth on selective media were performed.

The mean P^H value of stream water was 7. In bore water it was in the range of 7.0-7.2 with the mean P^H value 7.06. In well water it was in the range of 6.92-7.1 with mean P^H value 7.005. The P^H value in the three water samples is in the safe limit as recommended by WHO.

The amount of total dissolved solids of the stream water was on the average 107.84mg/l and Fluoride content on the average was 0.1mg/l. The amount of total dissolved solids of the bore water on the average was 273.25mg/l and Fluoride content on the average was 0.104mg/l. The amount of total dissolved solids of the well water on the average was 175.08mg/l and Fluoride content on the average was 0.109mg/l. Both the values in the three samples were in the permissible limits as recommended by WHO.

The total plate counts of bacteria in the three water samples are given in figure1. In stream water the total plate count fell in the range of 39-65 CFU's/ml. The water sample showed the maximum number of CFU's(65CFU's/ml) in August followed by September (59CFU's/ml), October(54CFU's/ml), November(50CFU's/ml), January(50CFU's/ml), February(49CFU's/ml), April(46CFU's/ml), July(45CFU's/ml), May (44CFU's/ml), December(43CFU's/ml), March(40CFU's/ml) and June(39CFU's/ml). In bore water the total plate count fell in the range of 31-63 CFU's/ml. The water sample showed the maximum number of CFU's(63CFU's/ml) in August followed by September (54CFU's/ml), October and February(49CFU's/ml), January(48CFU's/ml), December(45CFU's/ml), April and March(44CFU's/ml), November(41CFU's/ml), May (39CFU's/ml), July(38CFU's/ml), and June(31CFU's/ml). In well water the total plate count fell in the range of 71-52 CFU's/ml. The water sample showed the maximum number of CFU's(71CFU's/ml) in August followed by September (69CFU's/ml), October(65CFU's/ml), April and November(61CFU's/ml), July and December(60CFU's/ml), February and May(57CFU's/ml), March(56CFU's/ml)

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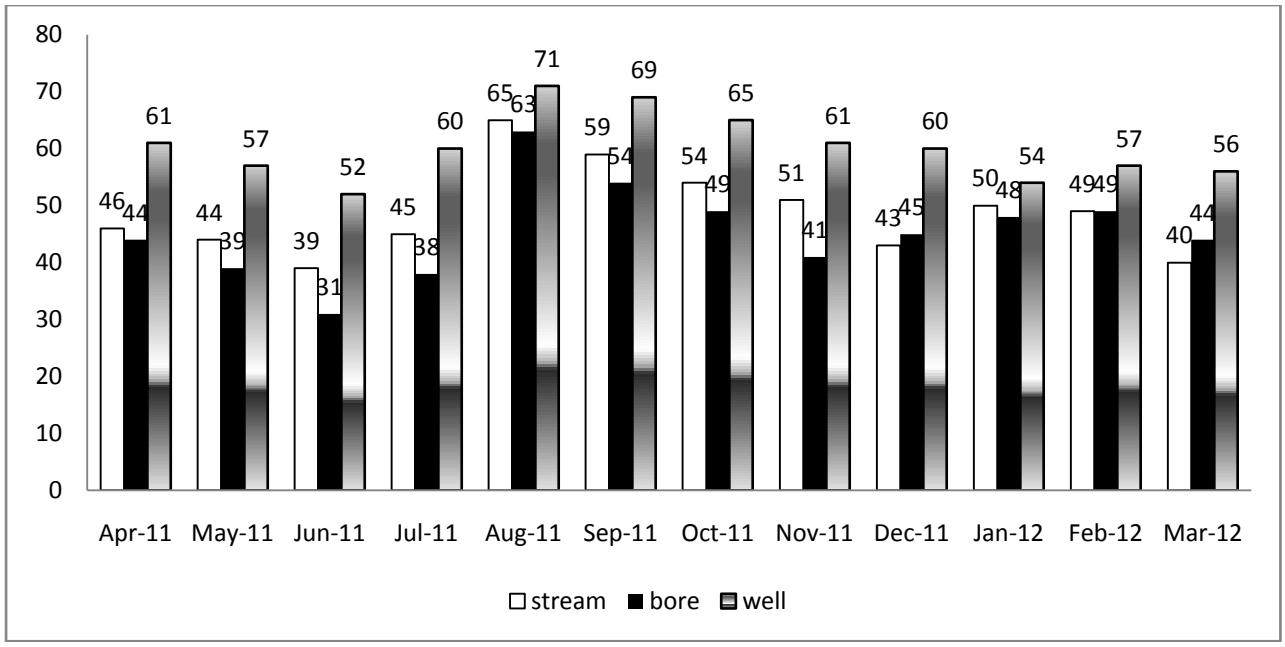
January(54CFU's/ml), and June(39CFU's/ml). Total plate count for bacteria performed for all water samples showed that the bacteria in all the samples were above the WHO guideline values(<10CFU's/ml). The total plate count in all the three water samples was highest during the rainy season i.e., August – October and was due to the contribution of all the pathogenic bacteria. However the water samples of well showed relatively higher plate count throughout the year. This may be due to the presence of sewage surrounding the well which continuously seeps into the well water. This study is in conformation with the result of Zaky *et.al* [3] (2006) who reported increased bacterial content in the water of Manzala Lake, Egypt which is polluted by drainage and sewage.

Figure 1: Total Plate Count (CFU/ml) of Bacteria in three water samples:



The MPN values for Coliforms present in all the water samples are presented in Figure 2. In stream water the MPN index ranged from 1-9/100ml. The maximum MPN index was recorded in August and September (9/100ml) followed by October (7/100ml), May, June, July, December, January, February (3/100ml) and April and March (1/100ml). In bore water the MPN index ranged from 1-9/100ml. The maximum MPN index was recorded in August (9/100ml) followed by September (7/100ml), May, June, July, November and March (4/100ml), April, October, December and February (3/100ml) and January (1/100ml) . In well water the MPN index ranged from 3-15/100ml. The maximum MPN index was recorded in June and August (15/100ml) followed by July (14/100ml), October, November, December (9/100ml), September, February (7/100ml), March (4/100ml), April, May, January (3/100ml). The coliforms also showed their increased presence during August and September in stream and bore well while in well water the increase was noticed during June, July and August.

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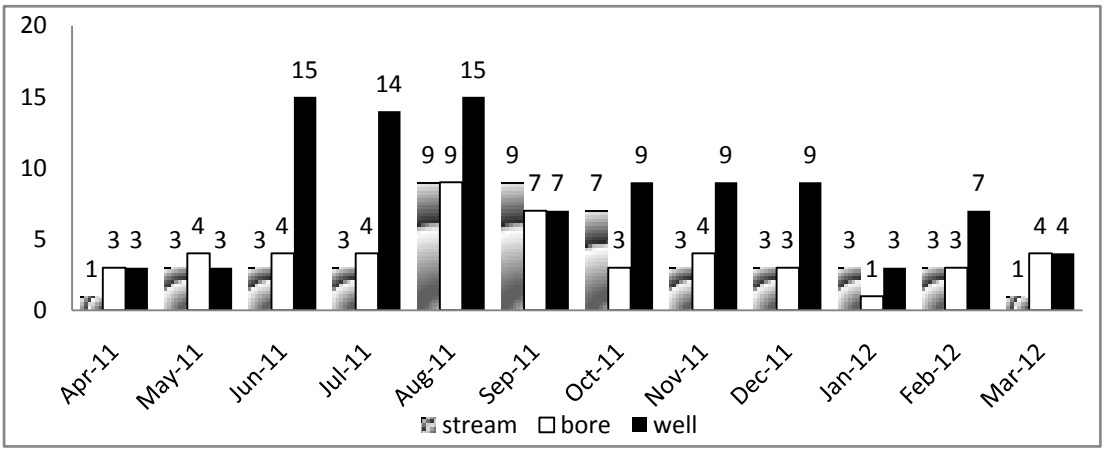
Figure 2: Most Probable Number (/100ml) of Coliforms in three water samples:



During the study period all the three water samples (i.e. stream, bore and well) showed the presence of the eight pathogenic bacteria such as *Escherichia coli, Klebsiella pneumoniae, Salmonella typhi, Shigella dysenteriae, Staphylococcus aureus, Group D Streptococcus, Vibrio cholerae* and *V. parahaemolytics*.

Among the pathogenic bacteria the most dominant species in stream water (Table 1) was *Escherichia coli* (28.3%) followed by *Staphylococcus aureus* with 15.16%, *Vibrio cholerae* with 12.5%, *Salmonella typhi* with 11.2%, *V. parahaemolytics* with 9.45%, *Shigella dysenteriae* with 8.79%, *Klebsiella pneumoniae* with 7.47% and *Group D Streptococcus* with 7.03%, contribution.

In bore water (Table 2) the most dominant species of bacterium was *E.coli* (27.9%) followed by *Staphylococcus aureus* with 19.9%, *Salmonella typhi* with 10.6%, *Vibrio cholerae* and *V. parahaemolytics* with 9.84% each, *Shigella dysenteriae* with 8.2%, *Group D Streptococcus* with 8.03% and *Klebsiella pneumoniae* with 5.44%, contribution.

Analysis of well water (Table 3) revealed that the predominant bacterium was *E.coli* (26.16%) followed by *Staphylococcus aureus* with 19.57%, *Salmonella typhi* with 12.40%, *Shigella dysenteriae* with 10.65%, *Vibrio cholerae* with 9.30, *V. parahaemolytics* with 8.13%, *Group D Streptococcus* with 7.17% and *Klebsiella pneumoniae* with 6.58%, contribution.

The faecal coliforms *E.coli* and *Klebsiella pneumoniae* were recorded in all the water samples in the present study. High level of contamination of ground water with faecal coliforms were found in urban areas of Karachi (Zubair and Rippy 2000[4]; Khan *et al* 2000 [5] found that more than 50% water samples of Peshawar, Nowshera and Charsada were highly contaminated with pathogenic microorganisms and were considered unfit for human consumption. These faecal coliforms were also reported from Umian lake water (Rajurkar *et al.,* 2003) [6] and from different water samples at Sivakasi (Radha krishnan *et al.,* 2007)[7]. The presence of *E.coli* is an indication of faecal contamination. It can cause urinary tract infections. Certain strains of *E.coli* produce enterotoxins that cause traveler's diarrohea and occasionally cause very serious food borne diseases (Tatora *et al.,* 2009) [8].

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Table 1: Pathogenic bacteria in stream water

Month	Name of the Bacterium								Total plate count
	E.coli %	*S.aureus* %	*V.cholerae* %	*S.typhi* %	*V.parahaemolytics* %	*S.dysenteriae* %	*K.pneumoniae* %	*Group D Streptococci* %	
Apr 2011	7.75	7.24	10.5	5.88	9.3	5	5.88	9.3	46
May 2011	6.2	7.24	8.77	7.84	6.9	7.5	5.88	6.25	44
June 2011	6.2	5.79	3.5	3.9	6.9	7.5	5.88	6.25	39
July 2011	7.75	5.79	5.26	9.8	6.9	5	8.82	6.25	45
Aug 2011	12.4	11.5	10.5	9.8	9.3	15	11.76	9.3	65
Sep 2011	10.8	13.04	10.5	7.84	13.9	10	14.7	12.5	59
Oct 2011	12.4	11.5	8.77	11.76	9.3	7.5	8.82	6.25	54
Nov 2011	7.75	8.69	10.5	9.8	9.3	5	8.82	9.3	51
Dec 2011	6.97	5.79	5.26	7.84	6.9	7.5	8.82	6.25	43
Jan 2012	7.75	7.24	12.2	5.88	9.3	10	5.88	9.3	50
Feb 2012	9.3	8.69	5.26	11.76	4.6	12.5	8.82	12.5	49
Mar 2012	4.6	7.24	8.77	7.84	6.9	7.5	5.88	6.25	40
Total%	28.3	15.16	12.5	11.2	9.45	8.79	7.47	7.03	

Table 2: Pathogenic bacteria in bore water

Month	Name of the Bacterium								Total plate count
	E.coli %	*S.aureus* %	*S.typhi* %	*V.cholerae* %	*V.paraha emolytics* %	*S.dysenteriae* %	*Group D Streptococci* %	*K.pneumoniae* %	
Apr 2011	9.25	10.38	9.7	5.26	7.89	9.3	9.67	9.52	44
May 2011	7.4	5.19	7.31	5.26	7.89	6.25	6.45	4.76	39
June 2011	5.55	6.49	7.31	7.89	5.26	9.3	6.45	9.52	31
July 2011	5.55	6.49	9.7	13.15	7.89	9.3	9.67	4.76	38
Aug 2011	12.9	10.38	14.6	13.15	10.5	12.5	12.9	14.28	63
Sep 2011	9.25	7.79	9.7	10.5	7.89	9.3	12.9	9.52	54
Oct 2010	11.11	10.38	7.31	5.26	7.89	6.25	9.67	9.52	49
Nov 2011	7.4	7.79	7.31	7.89	10.5	6.25	9.67	9.52	41
Dec 2011	5.55	10.38	7.31	5.26	5.26	9.3	6.45	4.76	45
Jan 2012	9.25	10.38	7.31	7.89	7.89	6.25	3.22	4.76	48
Feb 2012	7.4	7.79	4.87	7.89	10.5	9.3	6.45	4.76	49
Mar 2012	9.25	6.49	7.31	10.5	10.5	6.25	6.45	14.28	44
Total %	27.9	19.9	10.6	9.84	9.84	8.2	8.03	5.44	

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Table 3: Pathogenic bacteria in well water

Month	Name of the Bacterium								Total plate count
	E.coli %	*S.aureus* %	*S.typhi* %	*S.dysenteriae* %	*V.cholerae* %	*V.parahaemolytics* %	*Group D Streptococci* %	*K.pneumoniae* %	
Apr 2011	7.4	5.94	9.37	7.27	12.5	4.76	8.1	8.82	61
May 2011	6.6	8.91	9.37	9.09	8.33	9.52	8.1	2.94	57
June 2011	5.9	6.93	6.25	5.45	6.25	9.52	10.8	5.88	52
July 2011	8.8	8.91	7.81	10.9	8.33	7.14	10.8	8.82	60
Aug 2011	13.3	11.88	9.37	9.09	10.4	11.9	5.4	14.7	71
Sep 2011	11.8	7.92	10.9	9.09	8.33	7.14	10.8	5.88	69
Oct 2010	10.3	9.9	9.37	10.9	10.4	9.52	5.4	8.82	65
Nov 2011	7.4	8.91	7.81	7.27	8.33	7.14	5.4	8.82	61
Dec 2011	8.8	9.9	9.37	4.09	6.25	9.52	8.1	11.76	60
Jan 2012	7.4	5.94	6.25	7.27	6.25	7.14	10.8	5.88	54
Feb 2012	5.1	8.91	6.25	5.45	8.33	7.14	10.8	8.82	57
Mar 2012	6.6	5.94	7.81	9.09	6.25	9.52	5.4	8.82	56
Total%	26.16	19.57	12.40	10.65	9.3	8.13	7.17	6.58	

The faecal streptococci group comprises of *Streptococcus faecalis, S.bovis, S.equinus* and *S.avium*. In the present study all the water samples were contaminated with *S.avium*. It was positively correlated with the faecal streptococci group in Ooranis and well water samples at Ramanathapuram district, in the range of 0.0 to 2.8 x 10 FS/100ml (Joshi *et al.,* 2002)[9]. This group was also recorded from drinking, borewell and sewage water samples of Thiruthangal and were not found in all water samples of S.N Street and N.N Street of Sivakasi (Radha Krishnan *et al.,* 2007)[7]. The reason for the high number of faecal streptococci might be due to addition of human and warm blooded animal's excreta.

Human and animal wastes are the primary source of different bacteria in water. The sources of bacterial contamination include run off from feedlots, pastures, dog runs and other land areas where animal wastes are deposited. Bacteria from these sources can enter in wells that are either open at the land surface, or don't have water tight casing or caps, or don't have seal in the annular space (the space between the wall of the drilled well and the outside of the well casing). Insects, rodents and animals entering the well are other sources of contamination. Another way through which bacteria can enter the water supply is through inundation or infiltration by flood waters or by surface runoff. Flood water commonly contains high level of bacteria. Small depressions filled with flood water provide excellent breeding ground for bacteria (Ley and Samant, 2003) [10]. In the present study area the places surrounding the drinking water sources are not hygienic. The open wells are surrounded by drainage, throughout the year. The daily house hold activities like washing clothes and cleaning utensils are being carried out at the hand bores. The stream water gets polluted in multiple ways. Cleaning the domestic animals and washing clothes in the stream and throwing domestic wastes into the stream contaminate the water throughout the year.

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CONCLUSION

Results of the present study indicated that water in Kondiba panchayat is contaminated with various pathogenic bacteria and unfit for drinking. Open defecation, water-logging environment, poor drainage facilities and unscrupulous dumping of domestic wastes resulted in the deterioration of water quality in the study area. The study also revealed that large-scale water-borne diseases in this area are prevalent. Since quality of water is critical in disease prevalence, the water sources used for drinking should be monitored from time to time for reducing disease epidemics.

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