Impact of Urbanization on the Microbiological Quality of Ground Water - A Case Study of Visakhapatnam City, AP. India

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Abstract: ***Water is a vehicle for transfer the transfer of wide range of diseases of microbial origin. Ground water is a precious natural resource and is a source for drinking in many parts of the world. The current rate of groundwater extraction is depleting the resource faster than it is being recharged. Therefore understanding the basic processes about groundwater and the factors that are affecting its quality is of vital importance in managing this significant resource. In the present study 25 groundwater samples were collected from residential areas in Visakhapatnam and were analyzed for bacteriological quality with reference to the anthropogenic impact. It was critically observed that feacal coliform values determined from groundwater analysis were above the limits set by Bureau of Indian Standards (BIS) and World health organization (WHO). The ratio of feacal coliform and the feacal streptococci indicated the higher anthropogenic impact on the ground water resources in terms of microbiological pollution. The existence of indicator bacteria in high amounts indicates the probable presence of pathogenic bacteria, such as important pathogens. So that it is necessary to disinfect the groundwater before human consumption.***

Keywords: urbanization, microbiological quality, ground water, coliform, streptococci

1. Introduction

Ground water is considered much cleaner than surface water. In many areas groundwater is polluted by human activities. In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies. If groundwater becomes polluted, it will no longer be safe to drink. The microbiological quality of groundwater is likely to arise from a variety of sources like leakage, infiltration and seepage of domestic sewage lines, household septic tanks, and infiltration from sewage treatment plants, earthen sewer lines, septic tanks, pits, lagoons, ponds, sanitary land filled areas and soak pits into the shallow aquifers. Even after enactment of water (prevention and control of pollution) Act as early as in 1974, water quality continues to deteriorate in India and it is also known fact that current rate of groundwater extraction is depleting the resource faster than it is being recharged. Therefore understanding the basic processes about groundwater as well as the factors that can affect its quantity and quality is of vital importance in managing this significant resource.

The water quality studies should include data collection of different locations throughout the region and evaluation of annual, seasonal variations that could be important in programme planning. Sources of significant constituents and the amounts contributed by each should be identified. Sampling and analytical techniques are especially important because all subsequent decisions about water uses and water quality control activities depend heavily on the validity of data.

Monitoring is the process by which the degree of suspicion to any potential threat can be known. The main purpose of monitoring is to measure any change of variation within a system of critical indicators related to health of the system. The routine monitoring of drinking-water quality plays an important role as it reveals basic water quality and the likely risk of an outbreak (WHO, 1996) [8], central pollution control board (CPCB, 2000) [2]. Hence keeping the every need of water quality studies, the current study on the anthropogenic impact on the microbiological quality of ground waters as a source for drinking in some areas in Visakhapatnam, the investigations were made for better and significant drinking water quality management that helps in mitigating the aquifer contamination and to protect the public health. During the present study two microbial groups namely Faecal coliform and Fecal streptococci were analysed to identify the present state of ground water quality in different residential areas with environmental significance and anthropogenic impact. As the quantitative ratio of bacteria from the faecal type coli group (FC) to faecal streptococci (FS) may be of fundamental importance in evaluating the type of pollution (Niewolak, 1998)[5].

2. Methods and materials

Study area: The population of Visakhapatnam urban agglomeration increased from 1.05 million in 1991 to 1.32 million in 2001.The growth of population was more than 80% during 1971-81, 37.11% during 1991-2001 and with a population of 14.5 million in 2006 and a land area of 540 square kilometers, Visakhapatnam is country's largest city in terms of land and Andhra Pradesh's second largest urban agglomeration in population. The details of population of the Municipal Corporation Visakhapatnam are given in table 1.

Table 1: Population Trends – Greater Visakhapatnam Municipal Corporation

ULB	Area(Sq Km)		Population (Lakhs)		Density (Persons/Sq.km)	
	2001	2006	2001	2006	2001	2006
Greater Visakhapatnam Municipal Corporation	111	540	9.69	14.5	8765	2685

Source: Greater Visakhapatnam Municipal Corporation

Sampling: Sampling was started during the rainy season i.e (Dec 2011- February-2012). The samples were collected only from tube wells scrupulously following appropriate methods.

Sampling locations: Hand held GPS unit (Garmin ®) was carried to the sampling locations and the geo reference of the sampling location was recorded and summarized in table. 2.

Table 2: Sampling locations and their Georeference coordinates

Code	*Sampling Location*	*Latitude and Longitude*
A	Appikonda	Latitude: N 17^0 35' 538 Longitude: E 83^0 09' 625
B	Ramky	Latitude: N 17^0 30' 381 Longitude: E 83^0 05' 102
C	Malkapuram	Longitude: N 17^0 46'467 Latitude:E 83^0 06'339
D	Akkireddy palem	Longitude: N 17^0 42' 601 Latitude:E 83^0 12' 566
E	Steel Plant	Latitude: N 17^0 39' 428 Longitude: E 83^0 09' 712
F	Gnanapuram	Latitude:N 17^0 43' 181 Longitude:E 83^0 17' 193
G	Velampeta	Longitude: N 17^0 42'12.84 Latitude:E 83^0 17 46.93
H	Kotaveedi	Longitude: N 17^0 41 30.11 Latitude:E 83^0 17 24.50
I	Appughar	Longitude: N 17^0 44 32.47 Latitude:E 83^0 20 32.21
J	East point colony	Longitude: N 17^0 43 31.40 Latitude:E 83^0 20 14.74
K	Kancharapalem	Longitude: N 17^0 45 05.79 Latitude:E 83^0 20 56.72
L	Endada	Longitude: N 17^0 49 06.20 Latitude:E 83^0 23 55.67
M	Gudlavanipalem	Longitude: N 17^0 45 43.26 Latitude:E 83^0 21 26.75
N	Sagarnagar Park	Longitude: N 17^0 46 00.67 Latitude:E 83^0 21 33.35
O	Rushikonda	Longitude: N 17^0 42 267 Latitude:E 83^0 18392
P	Pedda rushikonda	Longitude: N 17^0 47 31.40 Latitude:E 83^0 2302.10
Q	Simhachalam	Longitude: N 17^0 46'23.24 Latitude:E 83^0 14'18.85
R	Pineapple colony	Longitude: N 17^0 46' 40.03 Latitude:E 83^0 16' 19.98
S	Arilova	Longitude: N 17^0 45 45.94 Latitude:E 83^0 18 55.00
T	Maddilapalem	Longitude: N 17^0 44 10.88 Latitude:E 83^0 19 19.61
U	Nakkavanipalem	Longitude: N 17^0 46'460 Latitude:E 83^0 06'330
V	Madavadhara	Longitude: N 17^0 44 49.17 Latitude:E 83^0 15 00.89
W	PM Palem	Longitude: N 17^0 42'329 Latitude:E 83^0 18'392
X	Vambay colony	Longitude: N 170 50 46.96 Latitude:E 830 21 51.14
Y	Seethammadhara	Longitude:N 17^0 44 20.59 Latitude:E 83^0 18 20.96

3. Microbiological investigations

Faecal coliforms isolation and enumeration method adopted from Phirke, 1976[6]. FC (faecal coliform) medium (5.0 g proteose peptone, 3.0 g yeast extract, 10.0 g lactose, 7.5 g sodium chloride, 1.0 g sodium lauryl sulphate, 0.3 g bromothymol blue,15.0 g of agar ,distilled water 1.0 liter, pH 7.3) was used for isolation. Medium was sterilized by autoclaving at 15 lbs pressure for 15 minutes. 0.1 mL of 105 and 106 dilutions of the test samples were dispensed in Petri plates. After cooling the medium was poured into Petri plates. Plates were incubated at 41.5 +/- 0.5°C for 36 hours.

Faecal Streptococci isolation and enumeration method adopted from Hajna, 1951[4]. Faecal streptococcal medium (6.0 g beef extract, 10.0 g peptone 10.0 g lactose, 0.40 g sodium azide, 15.0 g agar, distilled water 1.0 liter, pH 7.0 +/- 0.2) was used for isolation. Medium was sterilized at 15 lbs pressure for 15 minutes and dispersed in to sterile Petri plates. 0.1 mL of 105 and 106 dilutions of the test samples were dispensed in Petri plates with medium and spreading of sample on the medium was done by using sterile glass spreader to ensure uniform distribution. Plates were incubated at 45°C for 36 hours.

Plating and incubation: Serial dilution of water samples were made in sterile distilled water.0.1 mL 105 dilutions of test samples were dispensed in to the Petri plates with sterile nutrient agar medium. Plates were incubated at prescribed temperatures for 36 hours. Analysis was performed in triplicate. Enumeration was developed on colony counter.

In the above isolations, the bacterial counts were made using the following formula:

Total # bacteria present in 100 mL of sample

$$= \frac{\#\text{colonies}}{\text{Amount plated X Dilution}}$$

4. Results and Discussions

Generally ground water is assumed that it is pure and safer than surface waters. The present study revealed that the bore well waters had high load of coliforms when compared with drinking water standards designed by national and international agencies. It might be due to percolation of water from sanitary land filled areas and leachates from septic tanks and urban establishments. It was critically observed that feacal coliform values

determined from groundwater analysis were above the limits set by Bureau of Indian Standards [1] and World health organization (WHO)[8].

Niewolak, 1998[5] investigated that the quantitative ratio of bacteria from the faecal coliform (FC) to faecal streptococci (FS) as of fundamental importance in evaluating the type of pollution.

Table 3: FC/FS ratio

CODE	*FC*	*FS*	*RATIO*	*IMPACT FACTOR*
A	23.8	7.2	3.3	1
B	24.8	3.4	7.3	3
C	27.2	4.6	5.9	2
D	29.4	6.6	4.5	2
E	22.2	3.8	5.8	2
F	28.4	6.6	4.3	3
G	20.2	4.4	4.6	2
H	28.4	6.4	4.4	2
I	19.6	6.8	2.9	1
J	23.6	5.2	4.5	2
K	37.2	5.8	6.4	3
L	24.4	4.4	5.5	2
M	23.4	4.2	5.6	2
N	22.4	4.2	5.3	2
O	26.4	5.3	5.0	2
P	25.6	5.5	4.7	2
Q	28.2	6.4	4.4	2
R	24.6	4.4	5.6	2
S	26.4	6.4	4.1	2
T	26.3	5.4	4.9	2
U	24.6	5.2	4.7	2
V	25.2	4.6	5.5	2
W	24.8	5.4	4.6	2
X	22.8	7	3.3	1
Y	23.6	4.8	4.9	2

FC: faecal coliform FS: faecal streptococci

In the above table, FC to FS values obtained were retrieved for ratio. The ratio values obtained was categorized to assess the human and urbanization induced impact, was factorized in to 3 categories, <4- high impact-1, 4 to 5.9- moderate impact-2, >6-less impact-3.

The present study revealed that the bore well waters had high load of faecal coliforms and faecal streptococci. It might be due to percolation of microbial polluted water from sanitary land filled areas and leachates from septic tanks in the vicinity of the bore well indicating the core of urbanization and anthopogenic impact on the microbiological quality of ground water in the study area.

Highest number of Faecal coliforms were recorded (37.2x 105 CFU/100mL) in Kancharapalem followed by (29.6x 105 CFU/100mL) in Akkireddy palem and least count was recorded (22.2 x 105 CFU/100mL) in Steel Plant. Highest count of Feacal streptococci was recorded (6.8 x 105 CFU/100mL) in Appughar followed by (6.6 x 105 CFU/100mL) in Akkireddy palem, the least numbers were recorded (3.4 x 105 CFU/100mL) in Ramky.

In general fecal pollution of drinking water may introduce a variety of intestinal pathogens like Salmonella, shigella, enterotoxigenic E.coli, Vibrio cholera, Yersinia enterocolitica and Campylobacter fetus. These organisms may cause diseases that vary in severity from mild gastroenteritis to severe and sometimes fatal dysentery, cholera or typhoid, rasher, fever and meningitis. Sewage polluted water may contain the viruses of poliomyelitis, other enteroviruses, and hepatitis viruses. Other organisms naturally present in the environment and not regarded as pathogens that also may cause occasional opportunist disease. Included in this category are Psuedomonas, Flavobacterium, Acinetobacter, Klebsiella and Serratia. Whereas feacal strepto cocci in drinking water may introduce a variety of organisms S. pyogenes - Lancefield group A, S. agalactiae - Lancefield group B , Enterococci Lancefield group D, and viridians bacteria like Streptococcus mitis, Streptococcus mutans Streptococcus salivarius, Streptococcus sanguis.

5. Conclusion

Shallow and permeable water table aquifers are the most susceptible to contamination, but susceptibility of all aquifers to contamination is determined largely by such site-specific characteristics as, Distance from the contamination source to the aquifer and residence time of the water in the unsaturated zone; presence of clay and organic matter in the unsaturated zone materials; potential of a particular contaminant to biodegrade and decompose; amount of precipitation, which affects recharge and the rate at which contaminants move downward. Hence strict cleanliness should be enforced in the vicinity of the well, personal ablution, washing of cloths and pets, dumping of the waste and refuse in the vicinity of wells should be prohibited. The study suggests that prevention is the best approach to groundwater pollution because cleanup is extremely difficult and expensive.

The present findings are at par with the observations of Tyagi et al., (2006)[7] which stated that worldwide coliform bacteria are used as indicators of faecal contamination and the possible presence of disease causing organisms, therefore, it is important to understand the potential and limitations of these indicator organisms before realistically implementing the guidelines and regulations to safe guard our water resources, public health and to reveal the total spectrum of water borne pathogens. This commitment is further strengthened by findings of Guilleman et al., (1991)[3] as they reported a mean viable count of 49/mL in bore wells of Sahelian area, Bukina-Faso in the ground water quality context.

The presented study indicated the need for a re-evaluation of the effectiveness of the traditional indicators as a quality assessment tools. The monitoring methodologies designed and observed to improve the assessment and management of the microbiological safety of the drinking water in the current study, signifying the need for changing to new methodologies in lieu of routine and traditional testing methods. The present study can serve as a better tool to verify the safety of the ground water and base for risk assessment. Outdated methods do not effectively identify heavily polluted aquifers. Thus it is necessary to gain better understanding of the role and usefulness of the new parameters for monitoring and testing.

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Author Profile

Dr. M. Vijaya Chandran was a post graduate in Microbiology form Andhra University in the year 2005, and he was awarded his Doctor of philosophy in Science from Andhra University for his full time research in the year 2012. His research topic was entitled “Studies on microbiological quality of drinking water in Visakhapatnam city, AP, India”. The present research article was one of the parts investigations from his PhD thesis. He was currently working as a research assistant in Pollution control board sponsored projects, in the Department of Environmental sciences, Andhra University, Visakhapatnam, India.