Summary & Conclusion

Water of good drinking quality is of basic importance to human physiology and man’s continued existence depends very much on its availability (Lamikanra, 1999; FAO, 1997). Due to the immense importance of water, the UN General Assembly, on July-2011, declared safe and clean drinking water and sanitation a human right essential to the full enjoyment of life and all other human rights (WHO, 2011). The UN has earmarked March 22nd of every year as the ‘World Water Day’ and has declared the period between 2005 and 2015 as international decade for action on proper utilisation of water (water for life).

Unsafe water, improper sanitation and hygiene kill about 2 million people every year mostly due to diarrhoeal diseases and most of them are children less than 5 years of age (UNICEF). UN says unsanitary water is responsible for 80 per cent of all illness and is world’s number one killer. An estimated 1.3 billion people living in per capita low income countries do not have access to safe drinking water (UNDP-HDR 2006). In 1996, the World Health Organization estimated that in every eight seconds a child dies from water related disease and each year more than five million people died from illness linked to unsafe drinking water or inadequate sanitation (Anon 1983).

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 from polluted drinking water (Singh, 2004). In a UN survey, scoring -1.31 water quality indictor value India occupied 120th rank out of total 180 countries surveyed for water quality (UN 2003). According to the official records of Ministry of Health and Family welfare, Government of India in 11th five year plan, the state of Andhra Pradesh prevailed in the first place with 17846 Hepatitis cases, 1,35,550 Typhoid cases, and prevailed in second place with 12,15,659 Diarrhoeal cases among the states of the nation regarding water sanitation.

Visakhapatnam (83°11’30” and 83°22’10”E, 17°39’16” and 17°45’58”N) is an important industrial urban city and second largest city spread over 540sq.km in state of Andhra Pradesh with a 14.5 lakh population on the Indian east coast. Some outskirt colonies have no access to Municipal drinking water supply and use ground water form open wells or bore wells.
The study area Gajuwaka is an industrial area associated to the port city of Visakhapatnam lying on the east coast of India in the state of Andhra Pradesh. Easy access to Highway, seaways and railway paved way for development of major public sector industries around this area like Vishakapatnam Steel plant, Hindustan Petroleum Corporation Ltd., Bharat Heavy Plates and Vessels, Hindustan Zinc Ltd., NTPC, Coramandel Fertilisers etc. Apart from the major industries there are various other associated industries, pharmaceuticals, sugar industries and cement industries to name a few. There are also a lot of other medium to small scale industries all around this area and more are to come up soon, especially in the pharmaceutical sector.

Gajuwaka presented an opportunity for mass migration when all the major Industries were set up. A lot of people moved in to fill the labour requirement and they settled around the industries in shoddy accommodation. Due to the lack of proper planning and infrastructure the colonies that developed lack proper amenities including proper drainage and toilets. Due to the high population density and lack of major fresh water source the drinking water situation in this region is very critical.

In order to address this issue, the physico-chemical and biological characteristics of ground waters in and around Gajuwaka industrial area have been analyzed and discussed in the foregoing chapters. Ground water sources representing bore wells, dug wells and taps were identified for the study on the basis of location, use, and access by the local people.

Samples have been collected on three major seasons such as summer, rainy, and winter during the period of investigation (2008-2012). A total of 12 water quality parameters namely pH, EC, TDS, Alkalinity, TH, Ca, Mg, Cl, SO$_4$, PO$_4$, DO, BOD were analyzed for three major seasons by following standard analytical methods of APHA (2005). The results were compared with the recommended standards for drinking water of BIS, and WHO to know the existing status and trend.

- The Electrical conductivity of the ground water indicates its ionic strength and its degree of ionic mineralization and the elevated concentrations of heavy metals (Naudet et al., 2004). As can be seen from the results the open well and bore well samples especially at Mindi and Venkanna palem showed very high EC. Strangely the municipal water supplies in some areas showed high conductivity as well. The results indicate pollution of water by heavy metals, back drift from sea water as well as anions in the bed rock.
Following the trend of EC, the Total hardness and Alkalinity were also high at the above mentioned places. Though the alkalinity of Municipal tap water was lesser than ground water, it showed high values in some areas.

The sulphate levels exceeded recommended standards in various open and bore well samples, while were acceptable in tap water samples. Strangely the sulphate concentrations in bore well samples were higher than open well water samples. This may indicated the presence of high amount of microbial activity in open wells as well as pollution of ground water.

Chloride followed a similar trend as above and was found in excess quantity in ground water samples. Though chlorine itself is not harmful in water, it may form various carcinogenic compounds when coupled with the organic matter in the water.

The Total Dissolved Solids were very high in both open and bore well water samples in many areas. The same areas mentioned above like Mindi, Zinc Colony and Venkannapalem showed very high values. TDS can be an indication of high pollution, organic, metal as well as microbial. The tap water showed lower TDS but some areas showed values that would not be considered potable or palatable.

The Dissolved Oxygen content was less in ground water and higher in Municipal waters as expected, but the variation in Open and bore well samples was not high. The Biological Oxygen Demand was lower in Municipal waters but was highest in some bore well water samples. This is a clear indication of pollutants being leached into the ground water.

The most common and wide spread health risk associated with drinking water is its microbial contamination, the consequences of which are so serious that its control must always be of paramount importance. Microbiological quality should therefore be regarded as a priority, although it may be impossible to attain the targets in the short or medium term. Bacterial indicators are measured instead of pathogenic organisms, because the indicators are safe and can be measured with faster and less expensive methods than the pathogens of concern.
The quality of water is typically determined by monitoring microbial presence, especially *Faecal Coliform* bacteria (FC) and physical chemical parameters (EPA 1999). These parameters could be affected by external and internal factors. There is an intricate relationship between the external and internal factors in aquatic environments. Coliform bacteria are used as microbiologic indicators for water quality. Freedom from contamination with faecal matter is the important parameter of water quality because human faecal matter is generally considered to be a great risk to human health as it is more likely to contain human enteric pathogens (Scott et al., 2003).

- The *Coliform* groups of microorganisms are usually derived from the faces of human and other animals. Throughout the investigation period, MPN of *coliforms* count was maximum value during rainy and winter season in well and tap water samples. Minimum value found during summer season in bore water samples.

- Microbial populations in bore well waters reveal that though the variations occur in waters of different places, the number was found to be quite less. This is mainly due to the fact that the water is drawn from deeper layers of the earth and that water is subjected to effective soil filtration. However, during the rainy season, when the water level increases the microbial number was found to be more because of less filtration effect. The evaluation of the drinking water in the rainy season indicates the presence of total coliforms and fecal coliforms. Presence of *E.coli* and *Total coliform* bacteria indicated microbial pollution of the groundwater by anthropogenic activities. The *Streptococci* and *Staphylococci* count is high in winter and summer seasons in well and tap water samples. *Pseudomonas* count also more in winter and rainy season in bore and well samples.

- Our investigations reveal that well waters are not safe for drinking purposes as they contains *Salmonella, Shigella, Vibrio species, Aeromas species* including the *coliforms*. The microbial populations varied from locality to locality.

- In the present study 87 drinking water samples were analyzed for bacteriological quality. The following bacteria, 1. Heterotrophic bacteria  2. Total coli form 3. Faecal coliform 4. Fecal streptococci 5. Staphylococci 6. salmonella  7. shigella  8. vibrio species  9. pseudomonas bacteria were analyzed to identify the present state of quality in different zones with environmental significance.
• As can be seen from the results there are only a few sampling points which can be considered safe for drinking water. Even the municipal water supply is compromised in various areas. None of the tap water samples are free from Faecal Coliform bacteria which present a very dire scenario. Only a few Bore well water samples were free from FC contamination but there are other opportunistic bacteria and Total Coliforms found in those samples as well.

• Apart from the above tests Characterisation ans Isolation of Bacterial species was done. The identified isolates include *Staphylococcus, Streptococcus, Bacillus Sp., E. coil, Klebsiella Sp., Proteus Sp., Pseudomonas sp., Vibrio sp., Salmonella sp., Shigella, Enterobacter aerogenes, Micrococcus sp., Acinetobacter sp., Flavobacter sp.,* and *Aeromas sp.* Bacteria isolated from all water samples have public health significance, for example *Staphylococcus aureus* is known to produce enterotoxin. The presence of opportunistic *Pseudomonas* in the water carries the potential for problems in an immunocompromised population.

• Water quality index has been done for the water samples in the study area and the results reveal that all of the water samples were unfit for drinking. Most of the samples have values above 100 which is the criterion for WQI. It can be concluded that the water is very unsafe for human consumption and for domestic usage as well.

The Overall situation of Drinking water in the Study area is very bleak. The Physico Chemical parameters of Municipal Tap water are better than the ground water samples but the presence of bacteria in the water makes it unsafe for drinking. The bore well water is not very palatable owing to its hardness and mineral content. Moreover the TDS and BOD levels indicate pollution by organic and inorganic pollutants. The Open well water can be considered worst of all the samples collected so far. It positively breams with microbial contamination and the Physico-chemical parameters indicate organic and inorganic pollution as well.
Based on the above study the Author has suggested the following measure to improve the water quality:

- Further studies should be commissioned in the region to properly identify the source of pollution.
- Infrastructure, like water treatment plants, drainage canals, public toilets and leak proof septic tanks etc., should be developed immediately to abate pollution.
- Awareness programs should be conducted for the local residents and the information should be displayed at all major gathering points.
- The municipal tap water should be boiled and filtered before use.
- The municipal water treatment system should be studied in detail and be renewed.
- Treatment plants should be set up for Open wells and the tops should be closed to avoid indiscriminate disposal of waste.
- Open wells should be lined with cement to avoid surface runoff of pollutants especially during rains.
- Communal water treatment plants could be set up for ground water sources.
PLATE 1

Bore water samples collected at KODI PANDALA DIBBA

Municipal water samples collected at MULAGADA
PLATE 2

Bore water samples collected at Andhra Steel Corporation Colony

Well water samples collected at Andhra Steel Corporation Colony
PLATE 3

Testing for Analysis of Hardness

BOD Analysis
PLATE 4

Plate: Most Propable Number Test (Positive)

Most Propable Number Test (Positive)
PLATE 5

Heterotrrophic Plate Count on Nutrient Agar

E. coli (Dark Pink)
Endo plate

(Dark on agar)
PLATE 6

Green Sheen on EMB Agar (E. coli)

Brown colonies on Bile Esulin Agar (Fecal Streptococci)
Growth Of Vibrio Cholerae and Vibrio Parahaemolyticus on TCBS AGAR

Growth Of Pseudomonas on CETRIMIDE AGAR
Colonies of Staphylococci on MANNITOL SALT AGAR

Coloreless Colonies (*Shigella*), Colorless with black colonies (*Salmonella*) on SS agar