SUMMARY, CONCLUSION AND SUGGESTIONS

A total of 33 quality parameters related to physico-chemical, microbiological and trace metals were analysed for 357 water samples drawn from different drinking water sources of Bhimavaram during the study period 2009-2011. Summary of these results is as follows:

5.1 Summary of physico-chemical investigations including trace metal analysis

According to my observations, considering the physico-chemical and microbial analysis the downstream water sample of canal i.e CW3 is found to be polluted when compared to up and mid stream waters. This may be due to leaching of urban waste, presence of dumping yard nearby and practice of open defecation. In CW3, trace metal Lead is observed to be higher than the permissible levels(WHO) leading to severe pollution.

While comparing the values of pond water quality parameters with respective recommended standards, it was observed that the values of the 15 parameters namely pH, Fluoride, Magnesium, Uranium, Cobalt, Vanadium, Copper, Nickel, Arsenic, Chromium, Aluminium, Manganese, Iron, Zinc and Cadmium were found within the desirable limits for drinking water in all the samples during the study period. On the other hand, the concentrations of parameters like Turbidity, EC, TH, TDS, D.O, BOD, Alkalinity, Chloride, Sulphate, Nitrate, Sodium, Potassium, Phosphate, Calcium, Lead and Mercury were found above the desirable limit in most of the samples. Other parameters
found in varied concentration values were observed to be above the desirable limit in 19% samples in rainy and summer seasons whereas turbidity values were above the desirable limit for all the samples except municipal tap waters. Calcium hardness during the study period was observed as more dominant than Mg hardness during the study period. It was observed that concentration of most of the pollutants were maximum in the rainy season and minimum in winter season.

It revealed from the analysis results of groundwater (open well) samples that values of the 13 parameters namely $P^H$, Fluoride, Uranium, Cobalt, Vanadium, Copper, Nickel, Arsenic, Aluminium, Chromium, Manganese, Zinc and Cadmium were found within the desirable limit for drinking water in the study period. On the other hand, the values of parameters like Turbidity, EC, TH, TDS, D.O, BOD, Alkalinity, Chloride, Sulphate, Phosphate, Nitrate, Sodium, Potassium, Calcium, magnesium, Lead, Mercury, and Iron were observed above the desirable limit throughout the investigation period. This may be due to the percolation of contaminated water into the groundwater.

All the 30 parameters in the tap water samples, namely $P^H$, Turbidity, EC, TH, TDS, D.O, BOD, Alkalinity, Fluoride, Chloride, Sulphate, Phosphate, Nitrate, Sodium, Potassium, Calcium, magnesium, Mercury, Iron, Uranium, Cobalt, Vanadium, Copper, Nickel, Arsenic, Aluminium, Chromium, Manganese, Zinc and Cadmium were found within the desirable limit for drinking water in the study period, except lead which was recorded to be above the desirable
limit in TW14 and TW16. This may be due to the use of lead pipes for drinking water supply. Therefore, there may be a chance of dissolved lead to enter into the water passing the pipes. Aluminium was also recorded to be above the desirable limit in TW14. This may be due to the addition of excessive amount of Alum in water than required during the water treatment process.

All the 29 water quality parameters observed in sachet water like the pH, Turbidity, EC, TH, TDS, D.O, BOD, Alkalinity, Fluoride, Chloride, Sulphate, Nitrate, Sodium, Potassium, Calcium, magnesium, Mercury, Iron, Uranium, Cobalt, Vanadium, Copper, Nickel, Arsenic, Aluminium, Chromium, Manganese, Zinc and Cadmium were found within the desirable limit for drinking water in the study period except Lead and phosphorus which were found in higher concentration when compared to the standards. The higher Pb concentration in SW4 industry which is located adjacent to aqua cultural tanks is due to the seepage of water from aqua tanks.

5.2 Summary of correlation matrix results

Correlation matrix for canal water revealed that significant positive correlation was found between EC and TDS, Turbidity and BOD, Turbidity and EC, Turbidity and Phosphate, Turbidity and TH, EC and Chloride, EC and Sodium, EC and Calcium, TDS and Alkalinity, TDS and BOD, Sulphate and Potassium, Chloride and Sodium, Alkalinity and Fluoride, Lead and manganese, Lead and Iron, Lead and Copper, Lead and Manganese which are characteristic of the surface water sources in the study area.
Similarly, pond water matrix revealed that significant positive correlations were present between EC and TDS, TDS and potassium, Calcium and Potassium, Calcium and Sodium, Nitrate and Phosphate, Mercury and Zinc, Mercury and Cobalt, Mercury and Nickel, Iron and manganese. Significant negative correlations was observed between Potassium and TH, this indicates the pond water contamination by anthropogenic activities. This may be attributed due to the percolation of domestic sewage into the pond water in the study area.

The correlation matrix for tap water revealed the significant positive correlation between EC and TDS, Turbidity and TH, Turbidity and Sulphate, Phosphate and BOD, Phosphate and Alkalinity, Phosphate and Magnesium, pH and Arsenic, EC and Aluminium, Iron and Aluminium, Manganese and Aluminium.

Similarly, open well water matrix reveals the significant positive correlation between EC and TDS, Chloride and TDS, TDS and Sodium, Magnesium and TDS, Calcium and Chloride, Calcium and Phosphate, TH and Calcium, TH and Magnesium, Calcium and Magnesium, Nitrate and Phosphate, Chloride and Sodium, Mercury and Cobalt, Mercury and Cadmium, Iron and Nickel which indicate groundwater was contaminated due to anthropogenic activities.

The correlation matrix of sachet water revealed the significant positive correlation between EC and TDS, Total hardness and Magnesium, TH and
Sodium, Iron and Zinc, Iron and Aluminium, Manganese and Zinc, Manganese and Iron, EC and Zinc, EC and Iron these relationships are characteristics of the surface water and ground water sources in the study area.

The quality of water is described by its physical, chemical and microbiological characteristics. Since these characteristics are interlinked, correlation between various parameters measured is useful in assessing the quality of water. The correlation analysis of water quality parameters revealed that all parameters were more or less correlated with each other.

5.3 Summary of microbiological investigations

The coliform group of microorganisms is usually derived from the faeces of human and other animals. Throughout the investigation period, TC is maximum during monsoon and minimum during winter season in surface water. TC count was found to be higher in pond, canal water and open well water when compared with municipal tap water and sachet water. The low value of TC in municipal tap water and sachet water may be due to coagulation, sedimentation, filtration and disinfection. The seasonal value of FC was found maximum during the rainy and minimum during winter season in all the surface water sources under the study. Seasonal fluctuation of FC followed the similar pattern of fluctuation just as TC, their presence in these sources revealed faecal contamination.

The excess TC and FC counts observed in the canal and pond water samples throughout the study period indicate a poor bacteriological quality,
which may be attributed to the polluted water received from the local drains and runoff from nearby areas, unscientific garbage disposal and unsanitary practice of open defecation. Prior treatment is required before making it suitable for drinking and other human requirements. However, the municipal tap waters were found to be comparatively safe for human consumption.

Ideally, the potable water should be free from coliform organisms. In practice, this is not possible attained. The majority of health related problems is the result of bacteriological or other biological contamination. Nevertheless, a significant number of very serious problems may occur as a result of the chemical contamination of water resources.

### 5.4 Summary of water quality indices results

The water quality of canal water in downstream was found to be marginal. It implied that the presence of high lead content was responsible for lower values of HWQI which could be used for drinking only after proper treatment.

In case of open well water, according to HWQI, OW2 has come under ‘poor’ category. But, according to AWQI, OW3 have come under ‘poor’ category. Therefore OW2 and OW3 are unfit for drinking. This might be due to the fact that in the rainy season, the pollutants in the atmosphere get settled through precipitation and then find their way along with the industrial, municipal and domestic waste into surface water bodies. Unethical practices like open
defecation, cloths washing, cattle bathing and inflow of agricultural run-off adds to the pollution load.

In case of pond water source, according to HWQI, all ponds have come under the ‘excellent’ category except PW7, according to DWQI, PW1, PW5 have come under the ‘fair’ category. According to AWQI all ponds have come under the ‘marginal’ category. PW7 was found to be marginal in all the water quality indices (AWQI, HWQI, DWQI).

The water quality of tap water sources, HWQI in both TW14 and TW16 values were found ‘fair’. It implied that the presence of high lead content was responsible for lower values of HWQI which could be used for drinking only after replacing the old pipes. Owing to contamination with enteric pathogens, desinfection was also recommended.

In case of sachet water source, HWQI in SW4 was found ‘fair’. It implied that the presence of high lead content was responsible for lower HWQI which could be used for drinking only after switching over to lead free water sources.

5.5 Suggestions

Based on the results obtained in the present investigations, critical analysis of the data and correlating the data with the prevailing conditions of the cultural practices, the water supply system, canal system, open well, pond and sachet water of Bheemavaram, we arrive to the following suggestions.

Fast urbanization, extensive agricultural and aquaculture farming and intensive resulting in discharge of untreated or partially treated wastewater,
coupled with a massive exploitation of water for irrigation, industrial and domestic use, are the main causes of water quality degradation in the canal waters.

As supply of safe water was made as a right, it is recommended that water sources need to be checked at regular intervals to monitor its quality and water should be treated before use for drinking purposes. Clean water is not a luxury but a necessity. With sensible policies, water sources can be protected from pollution. Lead contamination can be avoided by resorting to lead free supply pipes.

- The drainage canals and septic tanks must be constructed far away from the wells.
- Generally, water pipelines and septic pipe lines of the town run parallel to each other thereby giving chances for contamination of drinking water. Enough care should be taken by municipal authorities to separate these lines to prevent faecal contamination. Faecal contamination may take place because of open defecation practices, running of water pipes close to sewage lines, developing of negative pressure and intermittent supply of water. Therefore, continuous water supply is recommended.
- Open air defecation along the canal bunds should be banned.
- Good sanitation practices should be implemented near open well and tap water sources.
- Strict enforcement of laws over sachet water manufacturers is recommended. Suggested assessment of water quality at all stages of productions (pre-production, production and post production) in order to ensure water quality and good health to people.

- Regularly biochemical and microbiological tests should be carried out so as to protect the public from waterborne disease outbreaks.

- Ozonization in place of chlorination is recommended.

  Green technologies such as ion exchange, RO, nanotechnologies