5.1 Conclusion from water analysis:

The modern civilization, industrialization, urbanization and increase in population have led fast degradation of water resources. Considering the present situation of water quality degradation there is a need for a systematic and careful study about the water quality to build up a reliable data base. Since water is directly related to human health, it is necessary to bring awareness among the present and future generation about the causes and consequences of water pollution.

The water sources, selected for this study, have been in use for a long time for meeting drinking water needs and for various other purposes. No detailed analysis of the water quality of these sources had been undertaken before. The present work has been undertaken with a view to strengthen the environmental database so that the proper steps can be taken at the planning level to reduce the extent of water pollution. On the basis of these data it is easy to formulate sound public policies and to implement water quality improvement programmes.

In the present investigation the values of water quality parameters have been found to be in the following ranges:

- Temperature: $17^\circ\text{C}$ to $30^\circ\text{C}$
- Turbidity: 1.5 NTU to 61 NTU
- Conductance: $40\mu\text{Scm}^{-1}$ to $720\mu\text{Scm}^{-1}$
- $p^H$: 6.4 to 8.6
Total Solid : 35mg/L to 675mg/L
Total Dissolved Solid : 25mg/L to 405mg/L
Total Suspended Solid : 5mg/L to 270mg/L
Dissolved Oxygen : 4.0mg/L to 8.5mg/L
BOD : 0.2mg/L to 5.4mg/L
Chloride : 10.5mg/L to 133.6mg/L
Nitrate : 0.2mg/L to 13.5mg/L
Fluoride : 0.2mg/L to 1.6mg/L
Sodium : 1mg/L to 198mg/L
Potassium : BDL to 69mg/L
Calcium : 10.07mg/L to 94mg/L
Magnesium : 1.6mg/L to 40.1mg/L
Iron : 0.12mg/L to 14.02mg/L
Copper : BDL to 0.196mg/L
Zinc : 0.07mg/L to 4.27mg/L
Nickel : BDL to 0.108mg/L
Lead : BDL to 0.45mg/L
Arsenic : BDL to 0.122mg/L

(BDL = Below Detection Level)
Total coliform organism : ND to 920 MPN/100 ml
(ND = Not Detected)

The parameters showed large variations from source to source as well as from season to season. Water pH varied widely but within WHO and ICMR limit. Its values were towards the alkaline side. Turbidity showed remarkable variations during the study. In 85% samples turbidity value exceeded WHO guideline value 5 NTU. Electrical
conductance were found to be within the WHO guideline values for safe drinking water and a linear correlation of conductance and total dissolved solids were observed. Variations in TDS, TS and TSS were observed in the investigated samples with TSS concentrations exceeding the maximum admissible limit (5mg/L) of USPH standard. Iron content was found to be heterogeneously distributed in the ground water of the present study area. The iron contents of tube well waters need immediate attention and the data exceeds the WHO guideline value of 0.3 mg/L in most cases. The all season’s average value of Na, K, Ca and Mg were found within the WHO permissible limit. The chloride concentration was within the approved WHO guideline values and no fixed trend of variation of chloride could be ascertained which may be due to evaporation, precipitation, human activity and waste disposal. Though fluoride content of all the investigated samples were within the WHO permissible limit (1.5 mg/L), in two sampling points the values were towards the upper normal range which needs careful observation. Again comparatively higher values of fluoride were observed near the foot hill of Arunachal Pradesh. Nitrate concentrations were within the tolerable limit prescribed by WHO. In three sampling points nitrate concentrations were observed above 10 mg/L. High value of nitrate in our area may be due to excessive application of nitrogenous fertilizers, manures and irrigation, leakage from septic tanks, human and animal waste contaminations etc. BOD values above 4 mg/L were observed in most of the cases which indicate that waters in the district are not absolutely clean and fall under slight pollution category. Among the trace metals zinc concentration was found to be highest during the study and comparatively higher values of zinc were recorded in tube well waters. Lead concentrations exceeded WHO guideline value and ISI permissible limit in most of the cases and higher concentration of lead was noticed during monsoon season. Copper concentrations were within or much below the ISI (1.5 mg/L) and USPH
(1.0 mg/L) limit and comparatively higher values of copper were recorded in ring wells during monsoon period. Arsenic content exceeded ISI guideline value (0.05 mg/L) in three locations but no report of arsenocosis from these areas has been reported till now. High amount of arsenic indicates that the problem is serious and needs a proper thought and then action accordingly. In 65% samples, the measured Most Probable Number (MPN) indices of total coliform organisms were found to be above WHO guideline value (10 per 100 ml samples). Again the values of coliform bacteria were found to be considerably higher in ring wells and river compared to the tube wells and supply waters.

Analysis of the water quality parameters reveals that the concentration of all the chemical parameters in the investigated sources show increasing trend in monsoon and post-monsoon seasons which clearly indicates the entry of these chemical parameters into subsurface water by leaching during monsoon period at an increasing rate.

Based on above results the following recommendations are given to improve the quality of drinking water in the district:

(a) High turbidity and iron can be removed by alum treatment and filtration technique at least in rainy season.

(b) Hardness can be softened by boiling. This process also kills bacteria.

(c) Disinfection with chlorine should be done to minimize bacteriological contamination.

Over and above the general conclusion on water quality, source wise the following conclusion can be made.
5.1.1 Tube well:

The general appearance of the tube well waters was seen to be colourless having some odours. But the water was seen to have high turbidity values with $pH$ range between 6.4 to 8.2. Total hardness lies between 35 mg/L to 180 mg/L with sufficient DO. BOD values were comparatively lower than the other sources, ring wells and river. Iron contents of tube well waters were higher than the other sources and it was recorded upto 14.02 mg/L. This may be due to soil origin, corrosion of the pipes, and also due to the age old life of the tube wells as they are not washed properly. Zinc contents were higher than the other sources. Arsenic contents exceeded permissible limit in a number of cases and compared to other sources higher value was recorded in tube well waters. Lead contents were found to be higher than the permissible limit of ISI and WHO in most of the cases. All seasons average nickel content was within the guideline value. Copper contents were lower than the other sources (ring well and river) and were found much below the ISI permissible limit. The presence of coliform bacteria was found to be low and it was not detected in a number of cases. Bacteriologically tube wells were found to be safe as a source of drinking water than ring wells and rivers. The possible reason for microbial contamination of the tube well water may be excessive extraction of ground water, which may create vacuum thereby increasing the chances of suction of contaminated water. Besides this, the contaminated water may also mix with the potable water in the bore hole through seepage from the manholes and soak pits adjacent to the tube well. Regarding other parameters their concentrations do not exceed the permissible limit. The water of tube wells at Badati and Matmora, tube well at Dhalpur and tube well at Chawldhuwa was not fit for drinking purpose due to the presence of excess amount of arsenic, iron and lead respectively.
Implementation of the hand pump project (tube wells) for rural people in Lakhimpur district would be most effective regarding improvement of health situation.

5.1.2 Ring well:

The water of the ring wells showed high turbidity with the presence of considerable amount of suspended matter. The DO content was sufficient to sustain aquatic life. BOD values of ring wells were found to be higher than the other sources. The conductivity values were sufficiently large which is indicative of the presence of substantial amount of ionic substances. TDS values of ring well water were higher than the tube wells and supply waters. The concentrations of chloride, sodium, potassium, calcium magnesium were quite large. Sufficiently high amount of calcium and magnesium were responsible for increased level of hardness of the water samples collected at different periods. The iron contents exceeded the WHO limits in most of the cases. Of the trace metals, their amounts were not very high. The concentrations of arsenic, zinc, lead and nickel were present at a lower concentration level in ring wells than the tube wells. Only the copper concentration was found to be at a higher level compared to the other sources. Nitrates and fluorides were within the WHO and ISI limits. Bacteriologically, ring well waters were not safe as a source of drinking water. The water showed high MPN indices for total coliforms organisms. So the water of the ring wells can not be recommended for drinking purposes directly without proper treatment.

5.1.3 Public water supply:

This is water supplied by the Public Health Engineering Department of the Government of Assam. Four such water samples were taken into consideration- one from...
North Lakhimpur town, one from Panigaon, one from Dhalpur and one from Badati. During analysis high turbidity value was recorded for supply waters. Ideally, drinking water should have a turbidity of less than 1 NTU for aesthetic as well as for efficient disinfection. The supply water had not met these criteria. Considerable amount of suspended matter was always present in the water samples. Above these the substantial amount of iron was seen and in three samples out of four, iron content exceeded the WHO limit of 3 mg/L for aesthetic quality. Trace metals were within the permissible limit. The water was also contaminated by coliform organisms but these values were not very high.

5.1.4 River:

In the present investigation only one river Subansiri was taken for consideration. The water samples from this river Subansiri was collected at Chawldhuwa. A number of highway Dhabas are situated near the river Subansiri at Chawldhuwa and the river water was used by these Dhabas for various purposes including drinking. The DO content of the river water was sufficient to sustain aquatic life with high BOD values. pH was towards the alkaline side. A very high turbidity value was detected with a considerable amount of suspended matter. It may be mentioned that a parking facility exits on the bank of this river and river water is frequently used for washing vehicles on the bank as well as for public bathing. The washings from the bank re-enter the river and this may be responsible for high value of turbidity. The amount of suspended solid was found to be highest among all the sources. The calcium, magnesium, sodium, potassium, nitrate and fluoride were present at a lower concentration levels compared to other sources and were within the WHO and ISI limits. Amount of trace metals were not very high compared to the other sources and were within limits. Compared to the other drinking water sources
the river water was found to be less hard. Iron content was above the limit 0.3 mg/L but at a much lower level than tube wells and ring wells. Very high MPN indices of total coliform organisms were present in the river water which may be due to undesirable activities on its bank. From bacteriological analysis river water was seen to be totally unfit for drinking purpose without proper treatment.

5.2 Protective measures:

To keep drinking water sources clean and safe the following measures should be adopted:

(a) Location: water sources should be on a higher location at least 10m to 15 m away from polluting sources like latrine, soak pit, garbage etc.

(b) Plateform: A cement concrete plateform around the tube wells and ring wells extending 1m in all directions having gentle slope outwards towards a drain should be built. These plateforms should be free from cracks and damages.

(c) Drain: Water sources should have sound drainage systems to check stagnancy. Waste water should not be allowed to accumulate in these areas.

(d) Covering: The mouth of a ring well should always be covered at all times to prevent foreign materials from entering it.

(e) Lining: The lining of a ring well should be built of stones set in cement upto a depth of atleast 6m so that water enters from the bottom and not from the sides.

5.3 Conclusion from health survey:

From the field survey it can be concluded that the supply of pure and safe drinking water was inadequate in the town areas and was almost non-existent in the rural areas in the district. Piped water is available only in limited locations and only a small
segment of the total population was benefited by the public water supply scheme. Tube wells and ring wells are the most common source of drinking water. Some of these may be safe for use while others may not be safe for drinking purposes. As a result scarcity as well as bacteriological contamination of water affects a large number of people. Proper waste disposal and drainage system do not exist in the district. The slum areas in and around the urban centers have grown very rapidly and the residents in these areas neither have safe drinking water nor do have any system of waste disposal. Therefore it is in these areas where most diarrhoeal deaths occur. Majority of the people in the district are living under the poverty line. Most of the rural families are unconscious about their sanitation. Many of the people use water directly from the sources for various domestic uses including drinking. Some of the people have ordinary sand and stone filters as the only treatment given to water before using it for drinking and cooking. Disinfection is seldom done. Most of the people are ignorant about the causes and consequences of water pollution. Majority of them have no idea about the water-borne diseases. As a result outbreak of water borne diseases are very common among the people of the Lakhimpur district. Medical facilities even in modern time are not satisfactory. Increased deforestation and population growth also affect the water resources in the district.

The overall health status of the people in the district appears to be unsatisfactory. Outbreak of water-borne diseases such as typhoid, dysenteries, infectious hepatitis and water related diseases encephalitis, malaria, skin rashes etc are very common among the people in the district. Illiteracy and lack of awareness about their health and environment, poverty and large family size, poor drainage and sanitation system and absence of proper medical facilities are the main reasons for the poor health conditions of the people in the district. Being a backward district it is confronted with a very major social problem which is a great concern for the programmed eradication of water borne
diseases. For the improvement of health status of the people in the district, the changing of current socio-economic structure is most essential.

5.4 Management and conservation strategy:

Considering the present situation of water quality and health problem in the district some effective measures are urgently required to enhance the drinking water quality by delineating an effective water quality management plan for the district. Some of the management and conservation strategies which can be adopted in the district considering the present status of ground water development are as follows:

(a) Assessment and periodic monitoring of water quality, specially with respect to salinity and bacteriological contamination should be carried out.

(b) Encouragement should be given to build septic tanks instead of leach pits to control bacteriological contamination of ground water.

(c) People awareness regarding water disinfection, hygienic condition and prevention and remedial measure with respect to water quality and causes of water borne diseases are of prime importance.

(d) Improvement in the maintenance and management of water supply pipe line to avoid mixing of excreta to prevent bacteriological contamination in water should be taken in case of supply water.

(e) Today rainwater harvesting for domestic use and as drinking water source is becoming increasingly popular as the availability of good quality water declines. Rain water is acknowledged as sustainable source of water that has less impact on the environment. So people are also to be encouraged about rainwater harvesting for domestic use.
(f) In addition, water quality surveillance programmes, infrastructure set up and public participation become the need of the hour.

The present study based on random selection of large number of drinking water sources scattered all over the district may not be adequate to arrive at some definite correlation between water quality and health. This may be a very potent area for further work. Also it is expected that the study will inspire further investigation of water quality and proper management of drinking water in Lakhimpur district.

5.5 Summary:

This chapter gives a conclusion on quality characteristics of waters from different types of sources along with a conclusion on health hazard survey. Some protective measures to keep the drinking water sources clean and safe are discussed. Moreover some of the management and conservation strategies which can be adopted in the district considering the present status of ground water development are also underlined. The suggestions for further work are given at the end of the chapter.