SUMMARY, CONCLUSION AND SUGGESTIONS

6.1 SUMMARY OF EXPERIMENTAL WORK AND ANALYSIS

The river pollution has become a matter of great concern in recent years in regard of gradual increase pollution by industrial and urban activities. Small scale and other subsidiary industrial units are grown in and around the urban area which initiates severe air and water pollution in the neighbouring area. The water bodies of the nearby industrial and urban area are being gradually affected in respect of morphological and ecological aspects.

This research work was carried out to study on impacts in Tunia River water as a result of various human activities. Domestic waste water, municipal waste water, industrial effluents and other waste materials from various sources have been given due importance to suggest remedial measures to reduce pollution load in the river as well as on water of the Champamati River and soil and ground waters of the neighbouring area.

6.1.1 Parameters Monitored

To assess the water quality of Tunia River and Champamati River, to which Tunia River is conflunced, 51 physico-chemical and biological parameters were monitored in 9 sampling stations at strategic locations of Tunia River and 2 sampling stations of Champamati River season-wise during the years 2007, 2008 and 2009. The 51 parameters monitored are given in Table 6.1.
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<tr>
<th>Sl. No.</th>
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<td>Dissolved Oxygen</td>
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<td>Fluoride</td>
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<td>16</td>
<td>Hydrogen Ion Concentration (pH)</td>
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<td>Nitrate</td>
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<td>18</td>
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<td>19</td>
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<td>Sodium Absorption Ratio</td>
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<td>Total Nitrogen</td>
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<tr>
<td>27</td>
<td>Total Phosphorus</td>
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<td><strong>Chemical Parameters</strong></td>
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<td>28</td>
<td>Calcium</td>
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<td>29</td>
<td>Magnesium</td>
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<td>42</td>
<td>Zinc</td>
</tr>
<tr>
<td></td>
<td><strong>Trace Elements</strong></td>
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<tr>
<td>43</td>
<td>Biochemical Oxygen Demand (BOD)</td>
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<tr>
<td>44</td>
<td>Chemical Oxygen Demand (COD)</td>
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<tr>
<td>45</td>
<td>Oil &amp; Grease</td>
</tr>
<tr>
<td>46</td>
<td>Phenolic Compounds</td>
</tr>
<tr>
<td>47</td>
<td>Total Kjeldahl Nitrogen</td>
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<tr>
<td>48</td>
<td>Total Organic Carbon</td>
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<tr>
<td></td>
<td><strong>Organic</strong></td>
</tr>
<tr>
<td>49</td>
<td>Faecal Coliform</td>
</tr>
<tr>
<td>50</td>
<td>Faecal Streptococci</td>
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<tr>
<td>51</td>
<td>Total Coliform</td>
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</table>
6.1.2 Other Tests and Analysis

To assess the water quality, the following test and analyses were carried out:

- Bioassay Test.
- Statistical Analysis for correlation of parameters through correlation coefficient developed by Karl Pearson.
- Evaluation of National Sanitation Foundation Water Quality Index.
- Graphical Characteristics of Water Quality Index.
- Seasonal Index of Water Quality Parameters.
- BOD Classification.
- Percentage Saturation of Dissolved Oxygen Classification.
- Central Pollution Control Board (CPCB) Classification.
- ISI Classification.

6.1.3 Study of Impact

Study if impact of pollution on the Tunia River water system was done in respect of the followings:

- Impact on Physico-Chemical Quality.
- Eutrophication.
- Overgrowth of Water Hyacinth.
- Depletion of Fish.
- Impact on Bacteriological Quality.
6.1.4 Assessment of Quality of Effluent, Waste Water & Sewages and Pollution Load

Assessment of quality of effluent, waste water and waste water including sewages has been done in respect of the followings:

- Biochemical Oxygen Demand.
- Percentage Saturation of Dissolved Oxygen (DO%)
- Water Quality Index
- Pollution of Urban Activities.
- Agricultural Chemicals.
- Organic Pollution.
- Oil Pollution.
- Pollution Load

6.1.5 Assessment of Groundwater Quality

The groundwater quality has been assessed by collecting groundwater samples from tube wells and open wells and analyzing in seasonal basis for the physico-chemical and bacteriological parameters and estimating water quality indices to study the impact of pollution of Tunia River water on groundwater of the adjacent area. The evaluation of $\frac{FC}{FS}$ ratio have been made in respect of groundwater quality.

6.1.6 Assessment of Soil Quality

The soil samples were collected from three sampling sites and analyzed for various physical and chemical parameters on seasonal basis to study the consequence of soil quality in the river bank area along the river.
6.1.7 Survey of Impact

The impact of pollution of Tunia River water has also been assessed through observation of results of a survey performed by using a schedule. The schedule was used in direct interview or direct observation and was filled by researcher or field worker. The following impacts were studied:

- Impact on Horticulture
- Impact on Agriculture
- Impact on Water Sources.

6.2 CONCLUSIONS

Based on results of various parameters of Tunia River water, Champamati River water, industrial effluents, domestic waste water, urban waste water, sewages, groundwater and soil of the adjoining area monitored during the study period and interpretation and analysis done thereof, the following important conclusions in respect of impact of various human activities on Tunia River have been arrived at.

6.2.1 Impact on River Water

1. The water quality of Tunia River has been found to deteriorate in respect of most of the parameters by continuous discharge of effluent and waste waters into the river by industrial units, such as BRL, NEGPL, BRFM, NBIE, BCL, NBRJ, C&WW, Railway Colony, Bongaigaon Town and other human activities, such as crematoria, hotels & restaurants, hospitals & nursing homes, etc.

2. The water quality is partially improved at downstream of the discharge points by industrial and human activities due to receiving of natural hilly water, self-purification process and natural activities of the river system.
3. The water quality of the Champamati River is being partially deteriorated in terms of physico-chemical components after the confluence of Tunia River into it which shows the extent of pollution of Tunia River water.

4. Very high content of oil & grease and phenolic compounds in Tunia River water discharged into the river by industrial units initiated adverse impact to fish and other aquatic flora and fauna in the river water environment.

5. The pollutants are normally high in pre-monsoon and low in monsoon compared to other seasons. This is due to dilution by monsoon rainwater.

6. The bacteriological parameters such as faecal coliform, faecal streptococci and total coliform are generally high in river water due to discharge of wastewater, sewage and human excretes matters from various sources. These bacteriological components indicates the presence of pathogen in water which initiates water borne diseases after the flood at the downstream area.

7. Bioassay test indicates that the river water was partially toxic to fish and other aquatic fauna due to receiving of effluent, domestic wastewater, sewage and other waste materials from various sources.

8. Bioassay test also reveals that the content of oil & grease, phenolic compounds and other chemical constituents are normally high within SS₃-SS₄ and SS₁ along the stretch of the river where most of the industrial discharge is made compared to other stretches of the river.

9. High contents of phosphate, nitrate, chloride, BOD and compounds of phosphorus and nitrogen along with other components in the river water have given rise to eutrophication and overgrowth of water hyacinth.
10. The enhancement of turbidity and colour is due to high total suspended solids in water of the Tunia River.

11. Due to decomposition of organic matters discharged by effluent, domestic and municipal wastewater, sewage and other waste materials into the river by biochemical and chemical processes, the dissolved oxygen is being gradually decreased.

12. The dissolved oxygen show the negative correlation with all parameters in water system of the Tunia River.

13. The bacteriological parameters such as faecal coliform, faecal streptococci and total coliform are released into the river from the same sources.

14. High temperature of Tunia River water is due to enhancement by refraction and reflection of sunlight by high silica content, which is a characteristic of all rivers in Assam due to erosion as a result of high rainfall.

15. The water quality index indicates that the Tunia River is facing an acute organic pollution problem.

16. Most of the physico-chemical and bacteriological parameters have high seasonal index in pre-monsoon and consequently, the water quality is being more deteriorated in pre-monsoon due to scanty rainfall.

17. The water quality of the Tunia River is under Bad quality of water as per BOD Classification during the study period due to receiving of effluent, wastewater, sewage and other waste materials from various sources.

18. The direct discharge of human excreta through katcha latrines into the river at New Bongaigaon Area is the main cause of high BOD which makes the river quality ‘Bad’.
19. The high BOD is accelerating overgrowth of water hyacinth and eutrophication in the river system.

20. High BOD is depleting dissolved oxygen as a result of which aquatic fauna are unable to sustain in the river environment.

21. The water quality all along the Tunia River is found as Class-E as per CPCB and ISI Classifications due to presence of high content of oil & grease, phenolic compounds, bacteriological and other physico-chemical parameters in the study period so this water can be used for irrigation, industrial cooling, and controlled wastewater disposal under the designated best use of water.

22. The water quality of Champamati River is found as Class-C and Class-D as per CPCB and ISI Classification and as such the water of Champamati River can be used for purposes designated under these classes.

23. The Tunia River is facing an environmental problem in regard of eutrophication hazards due to human activities. The whole river is under the eutrophication, the nitrogen being the potential limiting factor for this. This problem is more serious in pre-monsoon due to lean flow, low level of water, abundance of nutrients, optimum temperature along with favourable climatic conditions in water of the river system.

24. The water hyacinth has been found to flourish abundantly in polluted stretch of Tunia River water which, in turn, has affected the water quality by increasing nutrients level and decreasing dissolved oxygen in water.

25. High evapo-transpiration, obstruction of water flow, curtailment of sunlight, depletion of dissolved oxygen and heavy mat formation reduces
the species diversity of flora & fauna and finally create partial anaerobic environment which releases odour in water environment of the Tunia River.

26. The excessive growth of water hyacinth has been accelerated by high content of chloride, phosphate and fluoride in water, which came to river through effluent, wastewater, sewage, waste materials from various sources and human excreta.

27. The fish is generally an ecological indicator and indicates the industrial pollution. Fishes such as Catla, Labeorohita, Labeobata and other fish species were available in the Tunia River before setting up the BRPL. These fishes along with other aquatic species are being gradually depleted from the river due to growing industrial and urban activities in the catchment area.

28. The high contents of O&G, Ph.C, BOD, COD, Am.N, and CO₂ and gradual decrease of DO initiated adverse impact to fish and other aquatic life in the Tunia river water. The eutrophication and over growth of water hyacinth initiated to hinder the movement of fish and other aquatic life in the river stretch.

29. The natural self-purification process has been disturbed in Tunia River by receiving of effluents, wastewater, sewage and other waste materials in spite of favourable natural climatic condition for self-purification process.

30. The water quality at source is Class-D water and at downstream is Class-E water of the Tunia River. This is happened due to limited length of river, minimum flow, presence of oil and grease, phenolic compounds and other
pollutants with high pollution load in compare to the assimilative capacity of the river.

31. The river ecology of the Tunia River is disrupted due to abundance of nutrients such as phosphates, nitrate, and various compounds of phosphorus and nitrogen along with other compounds, which initiate algal bloom. Overgrowth of water hyacinth and weedy growth of other aquatic plants along with eutrophication hazards are creating ecological problem in river along with neighbouring area.

32. The fish is not observed in degradation, active decomposition and recovery zones of the river because of high pollution load in river water resulting in partial formation of biological desert in the river system.

33. The species diversity of the Tunia River has been impaired due to receiving of pollutants from various sources.

6.2.2 Quality of Effluent, Wastewater & Sewages and Pollution Load

1. The effluent, wastewater and wastewater including sewages are Bad category of water as per the BOD analysis and water quality index and moderately polluted as per the DO% analysis.

2. The New Bongaigaon Railway Colony discharges more deteriorated form of water with compared to other sources.

3. The river receives about $9312 \text{m}^3/\text{day}$ of effluent from the industrial units and $9112.00 \text{m}^3/\text{day}$ of wastewater from the urban area.
4. The industrial units releases about $915.96_{day}^{kg}$ and domestic sources discharge about $3337.17_{day}^{kg}$ of organic pollution load into the Tunia River in the study period. Of these organic loads about $1341.87_{day}^{kg}$ are easily biodegradable and $2911.26_{day}^{kg}$ are less biodegradable matters in a day into the river in terms of chemical nature.

5. The river also receives $196.28_{day}^{kg}$ of oil and grease and $75.31_{day}^{kg}$ of phenolic compounds in a day from various sources.

**6.2.3 Impact on Ground Water**

1. The water of Tunia River has initiated adverse impact to ground water due to increase of bacteriological and physico-chemical parameters in the river water. The impact is more serious after flood due to submerge of drinking water sources by the river water during the time of floods.

2. Evaluation of water quality index of tube well and open well water reveals that the ground water cannot be used directly for drinking purpose.

3. The water of tube wells and open wells contain bacteriological components for which it is usually not desirable to use for drinking purpose.

4. The FC/FS ratio reveals that human being, domestic animal and birds are equally responsible for deterioration of ground water quality in terms of bacteriological parameters.

5. The bacteriological components indicate the presence of pathogenic microorganisms such as bacteria, viruses, protozoa, helminth etc. in the ground water, which spread out water borne diseases in the neighbouring area after the floods.
6. The water sources can be used as drinking water after conventional treatment followed by disinfection for sound health for sake of the people.

6.2.4 Impact on Soil

1. The soil is being gradually deteriorated by water of Tunia River through seepage and submergence of agricultural land during the time of flood by impairing oil and grease, phenolic compounds and other inorganic & organic components to the soil.

2. The parameters, except nitrogen and organic matters are found to increase with depth in soil during the study period. Nitrogen and organic matters are gradually decreased with depth in the soil.

3. The parameters, except pH, nitrogen and organic matters, are found to decrease with increase of distance from the river bank. Parameters such as pH, nitrogen and organic matters are found to increase with distance from the riverbank during the study period. This is happening due to high physico-chemical components in the river water.

4. The pollutants of river water particularly oil & grease and phenolic compounds impaired the natural nutrient system, soil microorganisms, soil properties and formation of organic matters in soil in the study period.

5. The nitrogen content is low in soil due to increase of oil & grease, phenolic compounds and other pollutants along with grazing and other activities of man and animal in the soil system.

6. The pollutants such as oil & grease and phenolic compounds along with other physical and chemical parameters had impaired the growth of organic
matters and nitrogen content. This is happened due to increasing pollutional load in the river water.

7. The river water initiated adverse impact to soil quality and finally retards to agricultural growth, production and development in catchment area of the river.

6.2.5 Survey of Impact

1. The local people observed that the production of betel nut and coconut are gradually decreasing compared to other parts of Bongaigaon District due to adverse impact of river water of the Tunia River.

2. The people observed that the agriculture production is being gradually decreased after commission of the BRPL in 1974 at Dhaligaon.

3. The river water carries oil & grease, phenolic compounds and other pollutants into the agricultural land through submersion of floodwater by the Tunia River during the time of floods.

4. The river water is reducing the soil acidity, which initiated adverse impact to rice production.

5. The people observed that horticulture, agriculture and drinking water sources are adversely affected by the Tunia River after commission of the BRPL in 1974 at Dhaligaon due to gradual deterioration of water quality of the Tunia River.

6.3 LIMITATIONS & CONSTRAINTS

The limitations of the present study are mentioned as follows;

1. Only grab samples were collected from the respective sampling stations.
2. The time lag in the analysis for few parameters because of long distances between the sampling stations and laboratory was unavoidable.

3. Approach roads were not adequate for collection of samples from the sampling stations.

4. Frequent rainfall might have altered the concentration of parameters during collection of samples from the sampling stations.

5. The flow of river water was less in pre-monsoon due to scanty rainfall.

6. Problem arisen for collection of samples during the time of floods.

7. The time constraint to carry out such work restrains in detailed study.

8. Representative nature of samples may be altered during the time of floods.

9. Representative nature of samples may be altered in pre-monsoon for scanty rainfall.

10. Frequent power failures delayed smooth analysis in the study.

**6.4 SCOPE OF FUTURE STUDY**

The scope of the future study may be mentioned as follows;

1. The impact on macro invertebrate and micro invertebrates may be studied due to continuous receiving of effluent, wastewater, sewage and other waste materials from various sources.

2. The impact on fauna of the Bhairab and Nakati reserved forests will have to be studied where animal is using Tunia River water for drinking and swimming.

3. Water and soil management research may be carried out under the flood and draught condition.
4. Overview of study will have to be carried out in regard of riverbed character.

5. The detailed adverse effects on flora and fauna are to be studied in the Tunia River water system.

6.5 SUGGESTION FOR IMPROVEMENT OF WATER QUALITY

The following appropriate measures to be taken against the pollution sources as for preservation of river water for greater interest of river eco-system along with the natural environment.

6.5.1 Action of Industrial Sources

1. The BRL have to maintain zero discharge for prevention of water pollution in the Tunia River. The BRL has wastewater treatment plant with tertiary treatment unit for reuse of treated water in regard to cooling water, garden and firewater make-ups of the complex. The surplus treated water, containing oil & grease, phenolic compounds, sulphide, and high COD along with other chemicals should be discharged into river through the Eco-Pond.

2. The BRL releases large amount of untreated storm water from the township and refinery complex which contain oil & grease, phenolic compounds and other organic & inorganic constituents. This untreated storm water is generally deteriorating the water quality of Tunia River. Therefore, the BRL have to release the storm water after treatment in the wastewater treatment plant.
3. The C&W Workshop (C&WW), NEFR should install the effluent treatment plant with secondary treatment facilities for removal of pollutants from the effluent. The railway authority should confirm the effluent standards before discharging effluent into the Tunia River.

4. The railway has to install the wastewater treatment plant for treatment of sewages and wastewater of New Bongaigaon Railway Junction. The BOD : COD ratio is in range of 0.36-0.40 and hence, it leads to necessity of installing the biological treatment process. A conventional Activated Sludge Process is more effective for removal of pollution load from sewages & wastewater.

5. The industrial units such as NEGPL, BRFM, BCL, IBP and OIPS have to install secondary effluent treatment plants in their industrial premises for treatment of effluent. The units should maintain the necessary standards of treated effluents before discharging into the Tunia River.

6. The railways have to minimize the wastage of diesel oil, grease and other oily matters of locomotives during the time of loading & unloading of these materials from the oil depot in the junction area.

7. The railway have to install closed drainage system for treatment of sewage, domestic wastewater and storm water in the proposed wastewater treatment plant. The storm water in junction area contains high quantity of oil & grease, night soil, urine and other organic waste materials which normally polluted the water of Tunia River. Therefore, the railway have to release this storm water after treatment in the wastewater treatment plant.
8. Automatic digital display board should be installed at the main gate of industrial units for display of up-to-date information of pollutant levels for public in respect of discharge of effluents and gaseous emission.

9. The polluter pays principle have to be applied to all kinds of sources including onsite and offside sanitation.

10. Promotion of construction of treatment facilities for domestic sewage, wastewater and other waste materials along with industrial effluents and development of appropriate technologies have to be taken into account in conjunction with sound traditional and indigenous practices.

11. Established standards for discharge of effluents and receiving water bodies would be published for the interest of preservation of river eco-system.

12. The industrial units have to submit the environmental audit report to State Pollution Control Board and other government agencies for better environment management system.

13. All proposed / new industrial units have to submit the environmental impact assessment report and appropriate remedial measures along with better environment management plan to the State Pollution Control Board or other Government Agencies for preservation of natural environment.

14. Public participation in awareness programmes may be implemented for conservation of the Tunia River for effluent & gaseous emission of industrial units.

6.5.2 Action of Urban Sources

1. The Bongaigaon Municipal Board have to setup wastewater treatment plant
for treatment of wastewater. The ranges of BOD : COD ratio is 0.50-0.57 and hence, it indicates necessity of biological treatment plant for more effective removal of organic load. The Board may install the conventional Activated Sludge Process for treatment of wastewater before discharging the water into the Tunia River and maintain required standards.

2. The railway have to install wastewater treatment plant in the New Bongaigaon Railway Colony Area. The range of BOD : COD ratio is 0.54-0.60 and hence the conventional Activated Sludge Process is more effective for removing the organic load from the wastewater in the aforesaid area.

3. All katcha latrines, numbering about 100, in the New Bongaigaon area should be banned on most priority basis for prevention of mingle of excreta in water of the Tunia River.

4. Open defaecation should be banned near and on the banks of the river on most priority basis.

5. Sulabh sanitary system is to be established at nearby public places.

6. Sanitary latrine should be constructed in every household in the catchment area of the river. The municipal board and Government agencies have to assist the households in this regard.

7. Solid wastes and other waste materials should not be deposited near the bank of the river and should be disposed in a scientific manner.

8. Dead bodies of animals and other carcassial materials should not be dumped at and near the banks of river.

9. Ashes of crematoria should not be mixed with water of the Tunia River.

10. Burnt and half burnt dead bodies should not be thrown into the river.
11. The crematoria should be shifted another place for preservation of river eco-system.

### 6.5.3 Protection of Ground Water

1. The river water quality should be improved for the protection of ground water quality.

2. Development of agricultural practices that do not degrade the ground water qualities.

3. Wastes of domestic sources and animals along with wastewater should not be disposed off near ground water sources.

4. Promotion of measures to improve the safety and integrity of village and village head areas to reduce intrusion of bacteriological pathogens and hazardous chemicals in aquifers of drinking water sources.

5. The ground water sources should be protected from the flood waters on most priority basis.

### 6.5.4 Protection of Soil

1. Burning of agricultural wastes should be stopped due to destruction of organic matter and microorganisms.

2. Identification of highly eroded areas in the catchment area and initiation of necessary measures to arrest erosion.

3. A green belt cover of 10 m width has to be declared along the riverbank.

4. Rational land use to prevent degradation, erosion and siltation to the river and other water bodies has to be practiced.

5. Identification and application of best environmental practices at reasonable cost to avoid diffuse pollution in regard to limited, rational and planned use
of nitrogenous and phosphorus fertilizers and other agrochemicals such as pesticides, herbicides and weedicides in agricultural practices.

6. Proper disposal of sewage from human settlements after production of manure.

7. Minimize soil run off and sedimentation in the catchment area during the time of monsoon season.

6.5.5 Other Remedial Measures

1. Encouragement and promotion for use of adequately treated and purified wastewaters in agriculture, aquaculture, industry and other sectors.

2. Treatment of municipal wastewater may be done for safe re-use in agriculture and aquaculture.

3. The appropriate methods and technologies should be applied for waste treatment, production of bio-fertilizers and other activities.

4. Necessary measures are to be provided against the degraded catchment area of the Tunia River.

5. Strengthening of administrative and legislative measures to prevent encroachments on existing and potentially usable catchment areas.

6. Educate communities about the pollution related impacts from use of fertilizers, agrochemicals and other chemicals on the water quality, food safety and human health.

7. Water hyacinth and other weedy plants in river should be removed for continuous movement of water flow in a year.