5.1. CONCLUSION:

In the present study it was observed that alkaline effluent within average PH value 8.16 at the outlet was released to the watercourse of Elenga beel, as a consequence of which watercourse of Elenga beel was alkaline. However, water of the beel gains the quality of the river after the confluence points and river water was not affected in respect of PH by the discharge of effluent. Similarly, a higher value of PH was observed for the bed sediments. The higher PH values of bed sediments towards the downstream as compared to the up stream of the beel could be due to deposition of Na-lignate and other hydroxylated compounds on the bed of the bill. The PH values of groundwater were well within the prescribed value of drinking water.

Although the average value of suspended solids of the effluent after treatment was drastically reduced but the value does not meet the requirement of MINAS for wastewater discharge. Again the average value of suspended solid at sampling station 2 was higher than the reference sampling station 7. This clearly shows that the suspended solid concentration increases due to the discharge of effluent. However, the average values of suspended solid after sampling station 2 were found to be lower than the average value at the reference sampling station. This means river water contains sufficient amount of suspended solids.
Although the average values of TDS at sampling station 1 lies far below the tolerance limit for industrial effluent discharge into inland surface water, but it is true that the water quality was deteriorated in respect of total dissolved solids due to release of effluent of the paper mill. A linear relationship was obtained between TDS and conductance, as the conductance of the water samples were mostly due to dissolved inorganic matter, which was ionic in nature. The TDS of groundwater at the well no.3 during June 1997 exceed the permissible limit of drinking water. The average value of TDS at all other well were well within the prescribed values for drinking water and higher value at well no.3 could be related to the dumping of solid waste near this well.

The higher temperature of the effluent at J.B was due to release of hot effluent from different section. The temperature of the watercourse was not raised due to the release of effluent of paper mill, as the temperature of the effluent brought down to atmospheric temperature before releasing to watercourse. In the present study higher temperature of the water in all the sampling stations during summer was due to greater heating of water and insolent heat from sun. The fluctuation of temperature of the water course of beel was mainly due to seasonal variation, as the sampling time was kept fixed. Similarly, seasonal fluctuation of temperature was also observed in case of groundwater.

The conductance value of treated effluent and watercourse was seems to be quite high. The average value was found to be higher than the average value at the reference sampling station 7. Higher conductance value indicate the presence of large amount of ionic substance. However, on the basis of earlier report, the entire beel as well as the river water were quite safe.
for irrigation with respect to electrical conductivity. The electrical conductivity of bed sediment of the beel showed that the soil with such electrical conductivity have been found good permeability.

The value of alkalinity exceeds the tolerance limit for industrial effluent discharge into inland surface water. The high alkalinity of the effluent at the outlet indicates that the effluent after treatment has also high pollution load. The alkalinity of watercourse at sampling station 2 was high. This means that the watercourse of the beel was polluted with respect to alkalinity by the discharge of effluent. The fluctuation of alkalinity of the watercourse is in accordance with the fluctuation in the pollution load of the effluent. However, the alkalinity at sampling station 6 after traveling 25 km became negligible and quite comparable with the average alkalinity value at sampling station 7. A positive correlation has been found between the total alkalinity and COD (r = 0.53) at sampling station 6. The alkalinity values of groundwater samples were within the desirable limits for drinking water. From the values obtained on the analysis of the groundwater, it is clear that most of the water samples collected from seven numbers of well were slightly acidic to neutral. None of the well water was found alkaline as against the alkaline nature of the effluent discharge into the natural course of water.

The higher hardness values of the discharge course of the effluent than the reference sampling station 7 indicate that paper mill effluent introduces some hardness to the beel water. The presence of higher concentration of calcium and magnesium in the effluent is the main reason for increase of hardness value of the natural water. Present study shows that DO content of Elenga beel water system was very low owing to the constant discharge of effluents with high
BOD and COD. Hence it can be concluded that because of low DO the fishes of the natural water system are adversely affected. The DO of the effluent was quite low which reduce the DO of the Elenga beel watercourse. Deficiency of DO persisted all along the watercourse indicating the deoxygenation rate due to biological decomposition of organic matter, which was higher than reoxygenation from the atmosphere. This results in obnoxious anaerobic condition in the beel and no aquatic life can survive under such an extreme condition excepting the anaerobic microorganisms.

The BOD values shows marginal pollution load to the beel water body and values were within the permissible limits, not pose any serious threat to the Flora and Fauna.

The higher values of COD throughout the sampling station of the beel, indicate that the water was saturated with organic waste and the high values of COD load of the paper mill effluent caused an increase in COD load of the beel water system. The ratios of COD and BOD for different sampling stations J, 1, 2, 3, 4, 5, 6, 7 are: 5.6, 13.5, 11.5, 20.7, 18.1, 25.0, 40.8 respectively.

The residual chlorine was found in the discharged effluent up to sampling station 2 and afterwards it could not be detected throughout the stress of the beel water. The free chlorine is harmful for flora and fauna. It was revealed from the analysis of the results that the residual chlorine concentration of effluent was much higher that the tolerance limit for industrial effluents discharge into inland surface water. Some report regarding heavy fish mortality that appearing in the newspaper in the natural water system of Elenga may be due to the residual chlorine.
chloride content of all sampling station of the beel was within tolerance limit of effluent discharged into inland surface water. However, higher values of chloride content in the upstream of the beel water samples could be attributed to the addition of paper mill effluent. The sulphate content was found within the tolerance limit. The oil and grease contents were not found regularly in the effluent of paper mill and Elenga beel water system. The tannin and lignin were found to exceed the tolerance limit and were one of the major pollutants of paper industry. It is responsible for contributing high COD and colour in the effluent. Therefore colour reduction becomes necessary to meet COD standard.

The most serious and intriguing effluent disposal problem is called by colour of the wastewater, generated by pulp and paper mill. The removal of colour from the paper mill effluent has not been found economically feasible and practically usable, because lignin derivatives are highly resistant to microbial attack and consequently escape through the biological wastewater treatment technology into the receiving water.

The heavy metals containing effluent is discharged into the Elenga beel water system and as a consequence of which concentration of these metals increases in the water system. The mercury was however, not detected always at the sampling station 1 and was found to be below the BIS prescribed limit. A higher concentration of lead for all sampling stations of the beel water body was observed in comparison to sampling station 7. This means that the concentration of lead in the beel water system had increased due to discharge of paper mill effluent. However, all the values were within BIS tolerance limits. The higher concentration of cadmium for all sampling station of beel water system was observed in comparison to sampling station 7, but all values were within BIS tolerance limits. This means that cadmium concentration of beel water samples were increased by the discharge of paper mill effluent. However, the concentration of
copper of the effluent at the outlet was far below the maximum permissible limits of BIS. The concentrations of copper content were quite comparable with the concentration of copper values of river water. The zinc concentrations of the surface water samples for all sampling stations of Elenga beel were within the BIS tolerance limit. Nevertheless, the paper mill effluent increased the concentration of zinc in the water sample of Elenga beel water system. Arsenic content of water sample was found below the detection limits.

The analysis of bed sediments samples of Elenga beel system showed the presence of high concentration of heavy metals like copper, cadmium, lead, zinc and iron. The heavy metal concentration of bed sediment at reference sampling station 7 was quite negligible as compared to Elenga beel system. This clearly indicates the contamination of heavy metals in the surrounding watercourse Elenga beel from the paper mill effluent. The concentration of heavy metals in the bed sediment samples was found to be more than in water samples in Elenga beel. The heavy metals containing effluent that discharged from paper mill into the beel water system normally comes in the form of colloids and getting mixed up with the bed sediment.

It reveals from the analysis of the sediment samples that the quality of sediment has changed greatly towards the upstream of Elenga beel due to deposition of pollutants from paper mill effluent. The water holding capacity of bed sediment was found in decreasing order from discharged point to confluence point of river Kolong. The water content percentage of bed sediment of Elenga beel was found in increasing order from outlet to confluence point of river Kolong. The change of bulk density of bed sediment was also observed. This may be attributed to the effects of direct accumulation of large quantities, inorganic and organic materials, more towards the upstream of the beel. Moreover, lots of fine pulp fibers were settled down on bed of
the beel. The pH values of the bed sediment samples were higher than reference sampling stations at 7. This higher values of pH towards upstream of the beel as compared to the downstream may be the effect of accumulation of large quantities of sodium salts coming from the paper mill effluent. Nagaon paper mill effluent has also been found to increase the EC of bed sediments. The high value EC of bed sediments also confirmed the accumulation of salt on the bed of the beel. The average concentrations of calcium and magnesium in the samples of bed sediment were higher than concentration at the reference sampling station at 7. The values of organic matter and organic carbon percentage in bed sediment samples showed a decreasing trend from sampling station 1 to 6 and all values were higher than the reference sampling station at 7. The increase in organic matter and organic carbon percentage of bed sediment samples might be due to addition of suspended and dissolved solids from the effluent.

The pH of all groundwater samples were neutral to slightly acidic type. As the discharged effluent of the mill was alkaline, the contamination of groundwater by the effluent was not established. The values of electrical conductivity, hardness, chloride, calcium, magnesium, sodium and potassium contents of groundwater samples, collected from the surrounding of the paper mill, were within the tolerance limits of drinking water as per WHO and BIS. As there is no prescribe standard values for EC, total alkalinity, DO and COD for drinking water comparison can not be made from experimental results but general conclusion were drawn. it is established that groundwater of surrounding paper mill was not contaminated by the wastes of paper mill.

Although the Nagaon paper mill is equipped with pollution control facilities, but it could not meet all the requirements as laid by MINAS for large paper mill and still the water pollution
is a major problem for the mill. From the present research findings the following conclusions are drawn.

1. A remarkably high value of almost all parameters of the untreated effluent of Nagaon paper mill was observed however after the treatment of effluent at treatment plant these were considerably reduced.

2. The analysis of treated effluent showed a higher value in respect of PH, SS, EC, alkalinity, COD, residual chlorine, colour than the standard limit for Industrial effluent discharge into inland surface water. However, parameters like chloride, oil and grease, all heavy metals, are below the tolerance limit for Industrial effluent discharge into inland surface water. The physical appearance of water at sampling station No 1 indicated strong effect of the effluent. The beel water was found to be foamy, coloured and turbid. Hence this stretch of the beel may be considered as grossly polluted zone.

3. A comparison of the values of different parameters of surface water samples of Elenga beel at sampling station 2 with reference sampling station at 7 showed that the quality of water was deteriorated with respect to all these parameters due to discharge of effluent.

4. This study reveals that discharge of pulp and paper mill effluent significantly enhanced the concentration of heavy metals in the surrounding watercourse of Elenga beel.

5. Analysis of bed sediment samples showed a general decreasing trend of PH, alkalinity, EC, organic matter, organic carbon, heavy metals viz. Cu, Cd, Pb and Zn. from sampling station no. 1 to 6. However, the average value of water holding capacity, water content on
dry basis, bulk density, Ca$^{2+}$, Mg$^{2+}$, Sulphate of bed sediment samples collected from sampling station no. 1 to 6 has an increasing trend. This means that upstream of the beel was highly polluted with respect to reference sampling station at 7. So it can be concluded from the analysis of results that the addition of paper mill effluents have some undesirable effect on the sediments of the beel and alter its properties to a certain extent.

6. The critical analysis of physical and chemical parameters of Elenga beel water system and bed sediment indicates that at present the impact of heavy metals may not be very serious, but in future these constituent may increase due to continuous entry of effluent from the mill and bring drastic changes in the water and sediment quality of the effluent receiving body.

7. In the present investigation contamination of groundwater was not at all serious. However, the study on the possibility of contamination of groundwater by heavy metals could not be done in the present research work. Further study in this direction may provide some useful information in this regards.

8. Finally it can be concluded that the wastewa ter of the Nagaon paper mill caused some environmental impact on the surface water and sediment of the beel. The general quality of surface water and sediment of the investigated stretch of Elenga beel was relatively poor. The effluent characteristics indicate that the quality of effluent does not justify it to be discharged by the mill as such.
5.2 SUGGESTIONS:

From the findings of the present investigation it is clearly established that the treatment of the effluent of the mill is not adequate to safeguard the environment. To meet the standards stipulated by BIS, Pollution control board and other controlling bodies, it is therefore suggested to take following steps to combat pollution menace and to save the environmental components.

1. The performance of present ETP should be improved by minimization breakdown of Machineries. There are different process technologies for effluent treatment plants. The modification / rectification of effluent treatment technologies may be considered for better plant efficiency.

2. It is seen that a large no of parameters studied are not fulfilling the criterion for the discharge of the effluents The Nagaon paper mill should go for technology that ensures complete treatment of paper mill wastewater. The industry must take immediate step to meet the requirement as laid down by APCB, BIS, WHO, ICMR. and the strict adherence to the norms is utmost important.

3. The volume of effluent is quite large as compared to the capacity of the Elenga beel water system to sustain input of waste generated by the Nagaon paper mill. Therefore, a closed pipeline should be adopted. Presently the Nagaon paper mill is discharging its effluent to an open drain, which usually overflows to the Elenga beel water system, polluting the natural watercourse. Therefore it is very important to ensure that the treated effluent is discharged
through a closed pipeline covering the entire stretch of beel water system. With this type of arrangement the effluent are uniformly getting mixed across the river.

4. The pulp and paper mill effluent contains substantial colouring matter due to lignin. It should be minimized to a certain extent so that the effluent discharged into the inland surface water bodies is acceptable to downstream users. Presently there is a great problem of removing colour from effluent. Since lignin and its derivatives can not be degraded by conventional biological methods and consequently, the industry cannot satisfy the effluent discharge limit for COD and BOD. It may be highlighted that a bench scale process of colour removal from first alkaline extraction process using naturally occurring microbial consortium consisting of several bacteria and yeast had been developed recently at National Chemical laboratory, Pune. These cultures in presence of sucrose or glycerol removed 90-95% colour under non-sterile conditions within 48 hours. COD and BOD were also removed by more than 90%. Therefore, it is suggested to put various efforts in further development of the process and look into the industrial applicability of the method.

5. Steps are to be taken for maintaining equipments in good condition so that overflow, spillage, accidental drainage are minimized.

6. Special attention has to be paid to the bleaching section of the mill that generates 70-80% of total effluent load.

7. Mercury removal plant is to be kept in good condition.

8. Re-cycling of wastewaters should be done as far as practicable.

9. Use of waste paper as a substitute of virgin pulp is an important factor for controlling the generation of wastewater because it will reduce the requirement of pulp to be generated from fibrous materials.
10. Possibility of adopting advanced anaerobic method of treatment of paper mill effluent may also be tried.

11. The reduction of organochloride compounds emissions can be achieved by the use of improved technology of bleaching either ECE or TCF as a bleaching sequences.

12. Some measures should be taken so that no residual chlorine containing more that 1mg/l is discharge into the watercourse.

13. It was also observed that the effluent of the mill contain sufficient amount of heavy metals viz Cu, Cd, Pb, Zn and as a consequence of which surface watercourse was polluted. These heavy metals finally accumulate at the bottom of the beel with a higher concentration. Therefore, it is suggested to adopt some suitable method for removal of these heavy metals from effluents of mill.

14. Consumption of mill water for each tonne of paper manufactured is to be controlled. Average discharges of water from Western European paper mills are now use less than 20 cubic meter waters per tonne of paper produced. Total closure of the mill water system means that all process waters are treated and returned to the mill process. Such a mill is said to operate a zero liquid effluent (ZLE) system. The term "ZLE (zero liquid effluent) papermaking" means papermaking operations in which discharges of liquid aqueous effluents are reduced to a level at which the overall environmental impact is minimized. It is probably the high time to think over the adoption of ZLE technology, because of increase density of population and increasing concern of the public about the quality of environment.