5. RESULT:

5.1. PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL:

The results of physico-chemical characteristics of soil has been recordedin the year 2016 and tabulated in the Table-1.

5.1.1. pH:

Generally in all three seasons sediment of all the site (Site: 1 to 3) was alkaline in nature. The sediment pH values recorded at the Site 1 (Major industrial effluent out fall at Patikhali in Hooghly river) was lowest in the rainy season i.e. 7.3 and highest in the winter season i.e. 8.1.The lowest pH value i.e. 7.7 was recorded in rainy season and highest i.e. 8.4 in winter seasons observed in the Site 2 (5 km down stretch from site 1). In Site 3 (5 km above confluence on the river Haldi) minimum pH value recorded in the season of monsoon i.e. 7.0 and maximum values recorded winter i.e. 8.0.

As compared with Site 2, the pH levels of soil at these sites were significantly ($P < 0.01$) high.

5.1.2. Organic carbon:

Organic carbon content is low during summer as compared to monsoon in many stretches. The values of sediment organic carbon at the Site 1 of the river during minimum in the season of rainy i.e. 0.18 % and maximum values in the season of winter i.e. 0.77 %. The values of sediment organic carbon at the Site 2 was minimum during of rainy i.e. 0.47 % and maximum values in the season of winter i.e. 0.68 %. The values of sediment organic carbon at the Site 3 was minimum during in the season of rainy i.e. 0.55 % and maximum values in the season of summer i.e. 0.91 %.

As compared with Site 3 soil organic carbon content in the Site 1 soil was significantly ($P < 0.01$) low.

5.1.3. Available nitrogen:

The values of sediment available nitrogen at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) was minimum in the season of rainy i.e. 3.9 mg/100g and maximum values in the season of summer i.e. 10.8 mg/100g. The values of sediment available nitrogen at the Site 2 (5 km down stretch of site 1) was minimum in the season of rainy i.e. 10.64 mg/100g and maximum values in the season of winter i.e. 16.0 mg/100g. The values of sediment available nitrogen at the Site 3 (5 km above confluence on river Haldi) was minimum in the season of rainy i.e. 22.0 mg/100g and maximum values in the season of winter i.e. 60.35 mg/100g.

Site 1 recorded less soil nitrogen content among all the sites. The soil nitrogen values were significantly ($P = 0.01$) high at Site 3.

5.1.4. Available phosphorous:

The values of sediment available phosphorous at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) was minimum in the season of rainy i.e. 0.06 mg/100g and maximum values in the season of summer i.e. 1.01 mg/100g. The values of sediment available phosphorus at the Site 2 (5 km down stretch of Site 1) was minimum in the season of rainy i.e. 0.6 mg/100g and maximum values in the season of summer i.e. 2.32 mg/100g. The values of sediment available phosphorus at the Site 3 (5 km above confluence on river Haldi) was minimum in the season of rainy i.e. 1.07 mg/100g and maximum values in the season of winter i.e. 6.41 mg/100g. Site 3 soil recorded the higher phosphorous content whereas it was less at site 1, among all the sites. Statically the phosphorous content at Site 3 was significantly ($P < 0.05$) high as compared with Site 1.

5.1.5. Available potassium:

The values of sediment available potassium at the Site 1 level was minimum in the season of monsoon i.e. 3.92 mg/100g and maximum values in the season of summer i.e. 22.01 mg/100g and average values i.e. 16.01 mg/100g. The values of sediment available potassium at the Site 2 level was minimum in the season of monsoon i.e. 10.64 mg/100g and maximum values in the season of winter i.e. 16.47 mg/100g and average values i.e. 14.57 mg/100g. The values of sediment available potassium at the Site 3 level was minimum in the season of monsoon i.e. 1.12 mg/100g and maximum values in the season of summer i.e. 20.00 mg/100g and average values i.e. 15.26 mg/100g. As compared with Site 1 the potassium content in the soil at Site 2 and Site 3 was significantly ($P < 0.05$) high.

5.1.6. Soil texture:

5.1.6.1. Sand: The values of soilsand at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) of the river was minimum in the season of rainy i.e. 66.3 % and maximum values in the season of winter i.e. 75.2 %. The values of soil sand at the Site 2 (5 km down stretch of site 1) was minimum in the season of rainy i.e. 60.6 % and maximum values in the winter season is 92.0 %. The values of soil sand at the Site 3 (5 km above confluence on river Haldi) was minimum in the rainy season is 69.8 % and maximum values in the season of winter is 84.0 %.

5.1.6.2. Silt:

The values of soil silt at the Site 1 was minimum 4.4 % in the rainy season and maximum 27.7 % values in the winter season. The values of soil silt at the Site 2 was minimum 2.3 % in the rainy season and maximum values in the winter season i.e. 18.8 %. The values of soilsilt at the Site 3 was minimum values 4.2 % in the rainy season and maximum values 20.4 % in the winter season.

5.1.6.3. Clay:

The values of soil clay at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) was minimum values 5.0 % in the rainy season and maximum values 21.8 % in the summer season. The values of soil clay at the Site 2 (5 km down stretch of Site 1) was minimum values in the rainy season i.e. 4.3 % and maximum values in the summer season i.e. 20.0 %. The values of soil clay at the Site 3 (5 km above confluence on river Haldi) was minimum in the rainy season i.e. 7.4 % and maximum values in the summer season i.e. 28.8 %.

The soil sample from all the sites contained rich amount of sand.

5.2. PHYSICO-CHEMICAL CHARACTERISTICS OF WATER:

The results of physico-chemical characteristics of water has been recorded in the year 2016 and tabulated in the Table-2. The monitoring of aquatic environment can be assessed by physical, chemical and biological methods. The physico-chemical analysis has direct or indirect relation with the biotic community of aquatic ecosystem. Considering the fact the following physico-chemical parameters are analyzed and the results are described below:

5.2.1. Temperature:

The values of water temperature recorded at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) of the river in the year 2016 was lowest in the season of winter i.e. 25.4ºC and highest in the season of summer i.e. 34.8 ºC. The values of water temperature recorded at the Site 2(5 km down stretch of Site 1) of the river in the year 2016 was lowest in the season of winter i.e. 26.7ºC and highest in the season of summer i.e. 32.2 ºC. The values of water temperature recorded at the Site3 (5 km above confluence on river Haldi) of the river in the year 2016 was lowest in the season of winter i.e. 21.6ºC and highest in the season of summer i.e. 30.2 ºC.

5.2.2. pH:

The pH values of water recorded at the Site 1 were lowest in the winter season i.e. 7.9 and highest in the summer season i.e. 8.6. The values of water pH recorded at the Site 2 were lowest in the season of rainy i.e. 7.4 and highest in the season of summer i.e. 7.8. The values of water pH recorded at the Site3 were lowest in the season of summer i.e. 7.6 and highest in the season of winter i.e. 7.8.

pH varied significantly (P= 0.02) along sampling sites and ranged between 7.4 to 8.6.

5.2.3. Dissolved Oxygen (DO):

The values of dissolved oxygen of water recorded at the site 1 were lowest in the rainy season i.e. 2.3 mg/l and highest in the season of summer i.e. 2.9 mg/l. The values of water dissolved oxygen recorded at the site 2 were lowest in the rainy season i.e. 3.1 mg/l and highest in the season of summer i.e. 3.8 mg/l. The values of water dissolved oxygen recorded at the site 3 were lowest in the rainy season i.e. 5.1 mg/l and highest in the season of summer i.e. 7.6 mg/l. DO varied insignificantly (P= -0.05) along sampling sites.

5.2.4. Biological Oxygen Demand (BOD):

The values of biological oxygen demand of water recorded at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) was lowest in the winter season i.e. 15.4 mg/l and highest in thesummer season i.e. 16.9 mg/l. The values of water biological oxygen demand recorded at the Site 2 (5 km down stretch of Site 1) was lowest in the season of winter i.e. 10.0 mg/l and highest in the season of summer i.e. 10.5 mg/l. The values of water biological oxygen demand recorded at the Site 3 (5 km above confluence on river Haldi) was lowest in the summer season i.e. 6.0 mg/l and highest in the rainy season i.e. 9.5 mg/l. BOD varied significantly (P< 0.01) all sampling sites.

5.2.5. Chemical Oxygen Demand (COD):

The values of chemical oxygen demand of water recorded at the Site 1 were lowest in the season of winter i.e. 44.6 mg/l and highest in the season of summer i.e. 59.6 mg/l. The values of water chemical oxygen demand recorded at the Site2 was lowest in the season of winter i.e. 33.5 mg/l and highest in the season of summer i.e. 45.1 mg/l. The values of water chemical oxygen demand recorded at the Site 3 was lowest in the season of summer i.e. 37.0 mg/l and highest in the season of summer i.e. 40.8 mg/l.

5.2.6. Alkalinity:

The values of alkalinity of water recorded at the site 1 were lowest in the rainy season i.e. 112.8 mg/l and highest in the winter season i.e. 156 mg/l. The values of water alkalinity recorded at the site 2 were lowest in the rainy season i.e. 108.6 mg/l and highest in the winter season i.e. 130.2 mg/l. The values of water alkalinity recorded at the site3 was lowest in the rainy season i.e. 110.9 mg/l and highest in the winter season i.e. 119.5 mg/l.

5.2.7. Salinity:

The values of salinity of water recorded at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) were lowest in the season of rainy i.e. 2.4 ppt and highest in the season of summer i.e. 3.3 ppt. The values of water salinity recorded at theSite2 (5 km down stretch of Site 1) were lowest in the season of rainy i.e. 1.9 ppt and highest in the season of summer i.e. 3.8 ppt. The values of water salinity recorded at the Site3 (5 km above confluence on river Haldi) were lowest in the season of rainy i.e. 2.5 ppt and highest in the season of summer i.e. 4.0 ppt.

5.2.8. Nitrate (NO_3):

The values of nitrate of water recorded at the Site1 was lowest in the rainy season are 1.2 mg/l and highest in the summer season are 3.4 mg/l. The values of water nitrate recorded at the Site 2 was lowest in the rainy season i.e. 0.5 mg/l and highest in the summer season i.e. 1.4 mg/l. The values of water nitrate recorded at the Site 3 was lowest in the rainy season i.e. 0.3 mg/l and highest in the summer season i.e. 0.9 mg/l.

5.2.9. Phosphate (PO_4):

The values of phosphate of water recorded at the Site 1 (major industrial effluent out fall at Patikhali in Hooghly river) of the river in the year 2016 was lowest in the season of rainy i.e. 3.1 mg/l and highest in the season of winter i.e. 3.5 mg/l. The values of water phosphate recorded at the Site 2 (5 km down stretch of site 1) of the river in the year 2016 was lowest in the season of summer i.e. 0.7 mg/l and highest in the season of winter i.e. 0.9 mg/l. The values of water phosphate recorded at the Site 3 (5 km above confluence on river Haldi) of the river in the year 2016 was lowest in the season of rainy i.e. 0.1 mg/l and highest in the season of winter i.e. 0.5 mg/l.

5.3. HEAVY METALS:

The amount of heavy metal micro contaminants in mouth of Haldi river water and sediment samples was analysed with Atomic Adsorption Spectophotometer (AAS), and analysed were Cadmium (Cd), Zinc (Zn), Copper (Cu), Manganese (Mn), Lead (Pb), Chromium (Cr)**,** Nickel (Ni).

5.3.1. Trace metal in sediment

Trace metal content in the sediment was tabulated in the Table-3

Cadmium (Cd) is one of the most toxic metals was detecting in the sediment samples in the three seasons. The sediment of cadmium (Cd) values recorded at the Site 1(major industrial effluent out fall at Patikhali in Hooghly river) was highest in the winter season i.e. 3.33 mg/kg and lowest in the rainy season i.e. 2.09 mg/kg. The values of sediment in cadmium (Cd) at the Site 2 (5 km down stretch of Site 1) the maximum in the summer season i.e. 2.81 mg/kg and minimum values in the rainy season i.e. 1.62 mg/kg. The values of sediment of cadmium (Cd) at the Site 3 (5 km above confluence on river Haldi) maximum 1.11 mg/kg in winter season and minimum values in the rainy season i.e. 0.36 mg/kg.

The sediment of zinc (Zn) values recorded at the Site 1was highest in the season of winter i.e. 301.25 mg/kg and lowest in the season of rainy i.e. 40.67 mg/kg. The values of sediment zinc (Zn) at the Site 2 maximum in the winter season was 105.68 mg/kg and minimum values in the rainy season was 24.64 mg/kg. The values of sediment zinc (Zn) at the Site 3 maximum in the summer season are 103.61 mg/kg and minimum values in the rainy season was 12.89 mg/kg.

The sediment of copper (Cu) values recorded at the site 1highest in the rainy season i.e. 29.98 mg/kg and lowest in the winter season i.e. 23.36 mg/kg. The values of sediment copper (Cu) at the site 2 maximum in the rainy season are 26.85 mg/kg and minimum values in the winter season values recorded are 19.57 mg/kg. The values of sediment copper (Cu) at the site 3 maximum in the rainy season values are 24.28 mg/kg and minimum values in the winter season i.e. 18.48 mg/kg.

The sediment of manganese (Mn) values recorded at the site 1was highest in the season of rainy i.e. 414.70 mg/kg and lowest in the season of summer i.e. 294.79 mg/kg. The values of sediment manganese (Mn) at the site 2 maximum values are in the season of rainy 301.66 mg/kg and minimum values are in the season of winter i.e. 95.20 mg/kg. The values of sediment manganese (Mn) at the site 3 maximum values are in the rainy season 228.29 mg/kg and minimum values are in the winter season of 93.68 mg/kg.

The sediment of lead (Pb) Site 1 values are recorded at 39.68 mg/kg highest in the winter season of winter and lowest in the summer season i.e. 31.42 mg/kg. The values of sediment lead (Pb) at the site 2 was maximum in winter season values are 33.64 mg/kg and minimum values in the summer season i.e. 29.02 mg/kg. The values of sediment lead (Pb) at the site 3 was maximum in the rainy season values are 30.88 mg/kg and minimum values in the summer season are 27.85 mg/kg.

5.3.2. Metal content in water

Metal content in the water was tabulated in the Table-4

The water of cadmium (Cd) values recorded at the Site 1 was highest in the season of summer i.e. 1.36 mg/l and lowest in the season of rainy i.e.1.09 mg/l. The values of water cadmium (Cd) at Site2was maximum in the summer season of 0.55 mg/l and minimum values in the rainy season of i.e. 0.37 mg/l. The values of water cadmium (Cd) at the Site 3 was maximum in the summer season i.e. 0.018 mg/l and minimum values in the rainy season of 0.002 mg/l.

The water of Chromium (Cr) values recorded at the Site1(major industrial effluent out fall at Patikhali in Hooghly river) was highest in the season of summer i.e. 0.15 mg/l and lowest in the season of rainy i.e. 0.13 mg/l. The values of water Chromium (Cr) at the Site 2 (5 km down stretch of site 1) was maximum in the season of summer i.e. 0.09 mg/l and minimum values in the season of winter i.e. 0.05 mg/l. The values of water Chromium (Cr) at the Site3 (5 km above confluence on

river Haldi) of the year 2016 was maximum in the season of summer i.e. 0.01 mg/l and minimum values in the season of rainy and winter data is not detectable.

The water of Copper (Cu) values recorded at the Site 1 was highest in the season of summer i.e. 21.32 mg/l and lowest in the season of rainy i.e. 16.93 mg/l. The values of water Copper (Cu) at the Site 2 was maximum in the season of summer i.e. 11.59 mg/l and minimum values in the season of winter i.e. 10.41 mg/l. The values of water Copper (Cu) at the Site3 was maximum in the season of summer i.e. 9.46 mg/l and minimum values in the season of winter i.e. 8.52 mg/l.

The water of Nickel (Ni) values recorded at the Site 1(major industrial effluent out fall at Patikhali in Hooghly river) was highest in the season of summer i.e. 1.87 mg/l and lowest in the season of rainy i.e. 1.53 mg/l. The values of water Nickel (Ni) at the Site 2 (5 km down stretch of site 1) was maximum in the season of summer i.e. 0.53 mg/l and minimum values in the season of rainy and winter i.e. not data founded. The values of water Nickel (Ni) at the Site 3 (5 km above confluence on river Haldi) was did not found in all seasons.

The water of Lead (Pb) values recorded at the Site1was highest in the season of summer i.e. 78.32 mg/l and lowest in the season of rainy i.e. 58.54 mg/l. The values of water Lead (Pb) at theSite2 was maximum in the season of summer i.e.78.12 mg/l and minimum values in the season of rainy i.e. 45.30 mg/l. The values of water Lead (Pb) at the Site3 was maximum in the season of summer i.e.67.23 mg/l and minimum values in the season of rainy i.e. 39.51 mg/l.

The water of Zinc (Zn) values recorded at the site 1(major industrial effluent out fall at Patikhali in Hooghly river) was highest in the summer season of 69.32 mg/l and lowest in the rainy season of 35.93 mg/l. The values of water Zinc (Zn) at the site 2 (5 km down stretch of site 1) was maximum in the winter season i.e. 207.22 mg/l and minimum values in the season of rainy i.e. 105.50 mg/l.

The values of water Zinc (Zn) at the site 3 (5 km above confluence on river Haldi) was maximum in the season of summer i.e. 166.29 mg/l and minimum values in the season of rainy i.e. 86.29 mg/l.

5.3.3 Bioaccumulation of heavy metals in mouth of Haldi river fish tissues

In the gills and muscle of Arius, six heavy metals like Cd, Cr, Cu, Ni, Pb and Zn could be detected. These heavy metal also observed in the soil and water samples of the river mouth. The table-5 shows the heavy metal concentrations in the gills and muscle of Arius sp. Zinc (Zn) was observed in high concentration of gills and muscle. Cromium (Cr) and Nickel (Ni) was noted in trace levels.Copper(Cu) was observed at 3.51 mg/kg and 0.92 mg/kg in gills and muscles respectively. The gills showed 0.51 mg/kg of Cadmium (Cd) and muscle 0.26 mg/kg of Cd. Lead (Pb) concentrations of the gills and muscles were at 4.01 mg/kg and 2.72 mg/kg respectively. A maximum Zn concentration of 21.05 mg/kg was observed in the gills and muscles had 9.81 mg/kg of Zn.

5.4. DIVERSITY OF PHYTOPLANKTON AND ZOOPLANKTON IN MOUTH OF HALDI RIVER

In the present study three locations have been chosen for highlighting variations in the micro flora and fauna mouth of Haldi river. The sampling of planktonic populations, their quantitative distribution and quantitative variations have carried out. The Table-6 and Table-7 gives the numerical abundance of different plankton species in mouth of Haldi river. On the whole 24 species were identified, with seven phytoplankton species and seventeen zooplankton species.All the 24 species were not found in the same location at any point of the study. The species were found to be distributed among the three locations. In the first study location Site 1 rainy season, only three species were identified, two species belonging to phytoplankton population and remaining species belonging to zooplankton population. *Spirogyrasp, Keratellasp*, *Acartiasp*was the frequently

occurring species. Summer season site 1 six species were identified, three species belongings to phytoplankton population and remaining species belongings to zooplankton population. *Spirogyra sp, Chlamydomonussp, Uronemasp, keratellasp, Trichocereasp, Mesocyclopssp*was frequently present. Due to winter season site 1 six species were identified two species was phytoplankton and remaining four species was zooplankton. *Spirogyra sp, Uronemasp, Keratellasp, Trichocerasp, Acartia clause, Mesocyclopssp* was present in this site.

Next study location Site 2 in rainy season had 15 species: five phytoplankton species and ten zooplankton species present. *Spirogyra sp, Anabaena sp, Uronemasp, Keratellasp,* mysids shrimp, Nauplius stage, *Mesocyclopssp* were the dominant varieties. Summer season in site 2 had 20 species present. Six species were phytoplankton and other remaining species were zooplankton. This site the dominant species were *Spirogyra sp, Anabaena sp, Cyclops sp, Mesocyclopssp, Keratellasp, Filinalogisetasp,* winter season 17 species were present in site 2: five species were phytoplankton, here dominant species was *Spirogyra sp, Anabaena sp, Nostoc sp.* and other remaining species was zooplankton ,dominant species *Daphnia sp, Bosminasp, Cyclops sp,* Mysids shrimp , Nauplius stage present.

Next and last study location site 3 had 23 species present in rainy season i.e. seven in phytoplankton and others zooplankton population. Here *Spirogyra sp, Chlamydomonussp, Stigeocloniumsp, Daphnia sp, Bosminasp, Cyclops sp,* Nauplius stage, *Mesocyclopssp* were present in site 3 rainy season. Site 3summer season identified in 22 species whereas *spirogyra sp, Volvox, Nostocsp, Chlamydomonussp, Uronemasp, Anabaena sp, Stigeocloniumsp,*seven phytoplankton were identified and 15 species were zooplankton. Winter season 21 species had present in site 3 whereas seven in phytoplankton and other remaining 14 species were zooplankton.

5.4.1. Diversity indices of plankton

The diversity indices for the three different seasons in three different sites over a one year has been calculated. Calculated values for various diversity indices has been presented in Table-8. The Shannon's Diversity index classifies the site to have low diversity if the index value is below 1, moderate if between 1 and 2, and high diversity if the value is greater than 2. High values of H would be representative of more diverse communities. A community with only one species would have an H value of 0 because P_i would equal 1 and be multiplied by ln P_i which would equal zero. If the species are evenly distributed then the H value would be high. So the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community. Moderate to high species diversity was observed in all sampling sites.

In rainy season lowest Shannon diversity index was observed in Site-1 (H'=0.814) whereas the season of summer and winterhighest was in (H'=1.396) and(H'=1.286). Simpson indices showed a minimum value in Rainy season Site-1 (0.521) and a maximum value in winter season Site-1 (0.849).Low evenness value was observed in Site-1 rainy season (E=0.741) and High evenness value was observed in summer (E=0.910); hence, competition of species in summer Site-1 is high and low in rainy and summer season. High dominance value (D=0.476) observed in rainy season Site-1. The richness index (Margalef) for the present study was highest in winter season Site-1 (R=2.012) and lowest in rainy season Site-1 (R=1.028).

In summer season highest Shannon diversity index was observed in Site-2 (H'=2.851) whereas the lowest was in rainy season (H=2.413) and winter season Site-2 (H'=2.661). Simpson indices showed a maximum value in summer Site-2 (0.944) and a minimum value in rainy season Site-2(0.904). High evenness value was observed in winter Site-2 (E=0.947) and Low evenness value was observed in rainy season Site-2 (E=0.896); hence, season of summer competition of species in Site-2 is less

compared to other seasons. High dominance value (D=0.095) observed in rainy season Site-2. The richness index (Margalef) for the present study was highest in summer Site-2 (R=4.001) and lowest in rainy season Site-2 (R=3.261).

In summer season highest Shannon diversity index was observed in Site-3 (H'=3.011) whereas the lowest was in winter season Site-3 (H=2.913) and rainy season Site-3 (H'=2.961). Simpson indices showed a maximum value in winter Site-3 (0.962) and a minimum value in rainy and summer season in Site-3 (0.951). High evenness value was observed in summer season Site-3 (E=0.974) and Low evenness value was observed in rainy season Site-1 (E=0.954); hence, competition of species in summer Site-3 is less compared to other seasons. High dominance value (D=0.058) observed in rainy and summer seasons Site-3. The richness index (Margalef) for the present study was highest in rainy season in Site-3 (R=4.012) and lowest in summer season Site-3 (R=3.793).

Species diversity indices such as species richness and evenness were studied in order to measure the status of plankton diversity in the mouth of Haldi river. Diversity indices are given in Table 6. The table shows the planktonic abundance was high in site 3 summer season and Margalef species richness index was low in site 1 by virtue of the fairly high level of site 2 and site 3. Shannon-Weiner index showed the good status of species diversity at site 2 and site 3 and poor status of species diversity at site 1 rainy season. Pielou's evenness index was closer to 1 at site 2 and site 3, thus denoting the high evenness of planktons at this site. But site 1 rainy and winter season evenness index was not closer to 1 so this site low evenness of plankton. Lesser diversity at site 1 all seasons contributed to the higher species dominance index at site 2 and site 3.

5.5. DIVERSITY OF FISH AVAILABLE IN THE MOUTH OF HALDI RIVER:

The dominating fishes found in the mouth of Haldi river presented in Table-9.In the present study a total 23 fish species belonging to 7 orders, 17 families and 29 genera have been recorded. Among them Perciformes were most leading order of the total fish population followed by Siluriformes, Clupeiformes, Mastacembeliformes, Mugiliformes, Anguiliformes and Beloniformes. The major groups belongs to according to species abundance *Channa punctatus, Channa striata, Apogonnitidus, Oreochromis niloticus, Gobio morusdormitor, Latescalcarifer, Pomadasys argenteus, Glossogobius giuris, Sillago sihama, Gobiosomahildebrandi*(Perciformes); *Catla catla, Hypophthalmicthys molitrix* (Cypriniformes); *Arius* sp, *Mystus gulio*(Siluriformes); *Coilla* sp, *Setipina phansa*, *Sardinella* sp, *Setipina taty* (Clupeiformes); *Mastacembelu s*sp (Mastacemebliformes); *Mugil cephalus* (Mugiliformes); *Anguilla* sp. (Anguilioformes). *Xenetodoncancila* (Belonidae)present in the mouth of Haldi river.

Table 1:- Seasonal changes of physico-chemical parameter of soil in the mouth of Haldi River

Sampling Site	Season	pH	Organic carbon (%)	Available Nitrogen (mg/100g)	Available Phosphorus (mg/100g)	Available Potassium (mg/100g)	Sand (%)	Silt (%)	Clay (%)
Site 1	Rainy	7.3±2.12	0.18±0.09	3.9±1.2	0.06±0.02	0.7±0.04	66.3±9.33	4.4±1.8	5.0±1.2
	Summer	7.9±2.24	0.55±0.16	10.8±2.9	1.01±0.08	1.6±0.07	70.1±9.81	21.5±3.4	21.8±3.5
	Winter	8.1±3.42	0.77±0.23	10.4±2.6	0.82±0.25	0.9±0.02	75.2±10.03	27.7±3.1	17.5±2.2
Site 2	Rainy	7.7±2.76	0.47±0.15	10.6±2.5	0.61±0.22	0.8±0.41	60.6±7.51	2.3±1.4	4.3±1.9
	Summer	8.1±3.31	0.58±0.08	15.7±3.1	2.32±1.32	1.8±0.50	79.0±10.38	16.4±2.5	20.0±2.9
	Winter	8.4±3.53	0.68±0.34	16.0±3.7	1.06±0.86	1.7±0.73	92.0±11.47	18.8±2.2	19.2±2.3
Site 3	Rainy	7.0±2.77	0.55±0.17	22.0±4.1	1.07±0.83	1.4±0.25	69.8±7.63	4.2±1.3	7.4±1.7
	Summer	7.8±2.82	0.91±0.21	54.8±6.2	5.05±3.67	3.3±0.31	84.3±12.47	20.4±2.6	28.8±3.3
	Winter	8.0±3.22	0.79±0.17	60.5±6.9	6.41±4.84	4.0±0.57	74.0±10.33	17.0±2.9	27.5±3.2

Each data is the mean of three separate determinations and their Standard Deviation (SD)

Table 2:- Seasonal variation of physico chemical characteristics of water in the mouth of Haldi River

Sampling Site	Season	Temp. (°C)	pH	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Alkalinity (mg/l)	Salinity (ppt)	NO_3 (mg/l)	PO_4 (mg/l)
Site 1	Rainy	31.5±4.21	7.8±2.56	2.3±0.86	15.8±3.31	57.6±7.02	112.8±23.3	2.4±0.9	1.2±0.63	3.1±0.92
	Summer	34.8±5.03	8.6±3.02	2.4±0.84	16.9±3.03	59.6±6.83	131.9±31.2	3.3±1.3	3.4±0.61	3.4±1.01
	Winter	25.4±3.22	7.9±2.49	2.7±1.01	15.4±3.03	44.6±7.15	156.0±28.6	2.5±0.8	1.4±0.50	3.5±1.02
Site 2	Rainy	28.8±3.78	7.5±2.16	3.1±1.33	10.3±2.83	43.5±7.01	108.6±22.1	1.9±0.7	0.5±0.32	0.8±0.05
	Summer	32.2±4.83	7.8±2.25	3.8±1.39	10.5±2.67	45.1±7.10	116.6±23.2	2.8±0.8	1.4±0.27	0.7±0.03
	Winter	26.7±3.29	7.4±1.93	3.6±1.33	10.0±2.42	33.5±4.37	130.2±24.4	2.7±0.7	0.6±0.38	0.9±0.06
Site 3	Rainy	28.2±3.75	7.7±2.04	5.8±2.05	9.5±1.60	39.1±5.03	110.9±22.1	2.5±0.7	0.3±0.03	0.1±0.01
	Summer	30.2±4.18	7.9±2.65	7.6±3.10	9.1±1.33	40.8±5.42	115.6±15.2	3.4±1.3	0.9±0.02	0.2±0.04
	Winter	21.6±3.17	7.8±2.73	6.1±2.67	6.0±2.11	37.0±4.75	119.5±19.4	3.2±1.5	0.5±0.01	0.1±0.03

Each data is the mean of three separate determinations and their Standard Deviation (SD)

Table 3: Seasonal variation of metal concentration in the soil of the river mouth

Sampling Site	Season	Cd (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Pb (mg/kg)
Site 1	Rainy	2.09±0.01	91.67±5.32	26.98±2.01	414.70±37.24	37.33±3.11
	Summer	2.68±0.02	97.94±9.06	26.05±2.02	294.79±23.36	31.42±2.73
	Winter	3.33±0.01	100.25±13.13	23.36±1.72	240.55±21.04	39.68±4.11
Site 2	Rainy	1.62±0.01	84.64±3.02	26.85±2.13	301.66±29.13	31.80±2.22
	Summer	2.81±0.03	86.76±6.05	20.55±1.29	114.80±10.23	29.02±1.91
	Winter	1.77±0.01	95.68±9.81	19.57±1.01	95.20±8.22	33.64±3.42
Site 3	Rainy	0.36±0.05	82.89±1.03	24.28±2.24	228.29±20.12	30.88±2.61
	Summer	1.11±0.03	71.81±6.73	19.97±1.02	110.94±10.03	27.85±3.02
	Winter	0.86±0.01	93.61±10.02	18.48±1.11	93.67±8.82	30.29±3.47

Each data is the mean of three separate determinations and their Standard Deviation (SD)

Table 4: Seasonal variation of metal concentration in water of river mouth

Sampling Site	Season	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)
Site 1	Rainy	1.09±0.03	0.13±0.01	16.93±2.12	1.53±0.07	33.54±3.81	38.16±2.07
	Summer	1.36±0.03	0.15±0.01	21.32±4.05	1.87±0.08	43.32±4.13	47.23±3.22
	Winter	0.97±0.01	0.11±0.02	18.05±2.31	1.69±0.04	39.11±3.00	41.22±2.64
Site 2	Rainy	0.37±0.02	0.05±0.02	10.61±0.83	ND±0.001	4.30±2.33	24.08±1.51
	Summer	0.55±0.03	0.09±0.05	11.59±3.24	0.53±0.08	5.17±3.47	36.54±3.23
	Winter	0.26±0.03	0.06±0.01	10.41±2.25	ND±0.001	3.05±3.09	30.22±3.26
Site 3	Rainy	0.002±0.01	ND±0.001	8.52±1.01	ND±0.001	3.21±2.01	23.29±3.01
	Summer	0.018±0.02	0.01±0.01	9.46±3.43	ND±0.06	4.23±2.17	36.29±2.93
	Winter	0.004±0.01	ND±0.003	9.08±1.12	ND±0.002	3.91±2.32	33.70±3.11

Each data is the mean of three separate determinations and their Standard Deviation (SD)

Table 5: Heavy metals concentration of Arius sp. fish-tissues mouth of Haldi river.

Sl.No	Heavy metals	Fish Tissues	
		Gill (mg/kg)	Muscle(mg/kg)
01	Zinc (Zn)	21.05	9.81
02	Copper (Cu)	3.51	0.92
03	Cadmium (Cd)	0.51	0.26
04	Cromium (Cr)	0.23	0.09
05	Lead (pb)	4.01	2.72
06	Nickel (Ni)	0.21	0.08

Table 6: Seasonal abundance of phytoplankton in the Mouth of Haldi river

Name of Phytoplankton	Site1	Site2	Site3
Spirogyra sp	++	++	+
Volvoxsp	++	+	-
Chlamydomonussp	++	-	+
Anabaena sp	-	+	+
Nostocsp	-	-	++
Stigeocloniumsp	-	+	++
Uronemasp	++	-	+

'-'denotes absent; '+' denotes present; '++' denotes more abundance

Table 7: Seasonal abundance of zooplankton in the Mouth of Haldi river

Name of Zooplankton	Site 1	Site 2	Site 3
Filinialongiseta	-	+	+
Brachionu ssp	++	+	-
Keratella sp	++	+	+
Lepadella	-	-	+
Trichocerea	-	++	-
Notholca sp	-	-	+
B. angulsaris	++	++	-
Trichocerea sp	-	+	+
Mysids shrimp	-	+	+
Daphnia sp	+	+	+
Bosmina sp	-	-	+
Cyclops sp	++	+	+
Acartia clausi	++	+	-
Labidocera wollastoni	+	+	-
Eurytemora hirundoides	-	-	+
Nauplius stage	++	++	++
Mesocyclops sp	+	++	++

'-'denotes absent; '+' denotes present; '++' denotes more abundance

Table 8: Diversity indices of plankton in the mouth of Haldi river

Diversity Indices	Mouth of Haldi river sites								
	Site 1			Site 2			Site 3		
	Rainy	Summer	Winter	Rainy	Summer	Winter	Rainy	Summer	Winter
Taxa_S	3	6	6	15	21	17	22	22	21
Individuals	7	16	12	73	149	113	187	261	181
Dominance _D	0.476	0.191	0.151	0.095	0.063	0.077	0.058	0.050	0.048
Simpson_1-D	0.521	0.801	0.849	0.904	0.944	0.937	0.954	0.951	0.962
Shannon_ H	0.814	1.396	1.286	2.413	2.851	2.661	2.963	3.016	2.911
Evenness_e^H/S	0.741	0.910	0.718	0.896	0.936	0.947	0.954	0.975	0.960
Margalef	1.028	1.803	2.012	3.261	4.001	3.382	4.012	3.793	3.851

Table 9: Fish species recorded in the mouth of Haldi river

Sl. No.	Order	Family and Scientific name	Vernacular name/Local name	Season of collection
	Perciformes	Goblidac		
1.		*Gobiosoma hildebrandl*	Balkiri mach	Monsoon
2.		*Glossogobius giurls*	Tank goby/balkiri mach	Monsoon
3.		*Periophthalmus modestus*	Shuttles hopp fish/danphar mach	Winter
		Scatophagidae		
4.		*Scatophagu sargus*	Spotted scat/Vaja chauli	Monsoon and Summer
		Sillaginidae		
5.		*Sillago sihama*	Silver sillago/Sila mach	Monsoon and Winter
		Terapontidae		
6.		*Terapon jarbua*	Tiger perch/Kunkuni mach	Summer and Winter
		Leiognathidae		
7.		*Eubleekeria splendens*	Splendid pony fish/ Tekathi mach	Winter
		Eleotriae		
9.		*Gobiomorus dormitor*	Giant goby/Balkiri mach	Monsoon and Winter
		Latidae		
10.		*Lates calcarifer*	Silver grunt/Vetki mach	Monsoon and Winter
	Perciformes	Haemulidae		
11.		*Pomadasys hasta*	Silver grunt/Khurunda mach	Monsoon and Winter
	Clupeiformes	Clupeidae		
12.		*Corica soborna*	Gangas river sprat/Kagia mach	Winter
13.		*Anodontostoma chacunda*	Chacunda gizzard shad/Khayera mach	Winter and Summer
	Mugiliformes	Mugilidae		

14.		*Mugil cephalus*	Parse mach	Monsoon and Winter
	Siluriformes	Ariidae		
15.		*Arius sp*	Cat fish	Monsoon and Winter
16.		*Mystus sp*	tangra	Monsoon and Winter
17.		*Rita gogra*	Nadi tangra	
	Scorpaeniformis	Platycephalidae		Monsoon
18.		*Platycephalus indicus*		Monsoon
	Beloniformes	Belonidae		
19.		*Xenetodon cancila*	Gar fish	Monsoon and Winter

Table 10. Correlation co-efficient between physic-chemical parameters of water and density of total zooplankton mouth of Haldi river

Sl. No.	Relationship	Correlation co-efficient 'r'
1.	Air temp. Vs Total Zooplankton	-0.278
2.	Water temp. Vs Total Zooplankton	0.382
3.	pH Vs Total Zooplankton	-0.051
4.	Dissolved O_2 Vs Total Zooplankton	-0.291
5.	Free CO_2 Vs Total Zooplankton	0.459
6.	TDS Vs Total Zooplankton	0.213
7.	Total hardness Vs Total Zooplankton	-0.370
8.	Ammonia Vs Total Zooplankton	-0.113

Table 10: Correlation matrix for the soil heavy metal and soil physico chemical parameter

	Soil Parametres	Cd	Zn	Cu	Mn	Pb	pH	Org. C (%)	Av. N (%)	Av. P (%)	Av. K (%)	Sand (%)	Silt (%)	Clay (%)
Heavy Metals	Cd	1												
	Zn	0.65**	1											
	Cu	0.20	-0.24	1										
	Mn	0.24	-0.14	0.98**	1									
	Pb	0.51**	0.57**	0.48*	0.55**	1								
Physico-chemical factors	pH	0.51	0.62**	-0.54	-0.50	0.13	1							
	Org. C (%)	-0.15	0.40	-0.65	-0.60	-0.26	0.15	1						
	Av. N (%)	-0.59**	-0.08	-0.71	-0.67	-0.59	0.05	0.64**	1					
	Av. P (%)	-0.44*	-0.01	-0.71*	-0.66**	-0.57	0.15	0.59**	0.96**	1				
	Av. K (%)	-0.43	-0.01	-0.77*	-0.73**	-0.58	0.28	0.58**	0.94**	0.95**	1			
	Sand	-0.19	0.26	-0.89	-0.85	-0.25	0.58**	0.59**	0.68**	0.67**	0.79**	1		
	Silt	0.49*	0.81**	-0.57	-0.48*	0.10*	0.74**	0.65**	0.26	0.33	0.40**	0.59*	1	
	Clay	0.03	0.36	-0.79	0.74*	-0.45	0.57**	0.73**	0.69**	0.73**	0.82**	0.79**	0.80**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 12: Correlation matrix for the water heavy metals and water physico- chemical parameters

	Water Parametres	Cd	Cr	Cu	Ni	Pb	Zn	Temp	pH	DO	DOB	COD	Alkalinity	Salinity	NO_3	PO_4
Heavy Metals	Cd	1														
	Cr	0.78**	1													
	Cu	0.83**	0.87**	1												
	Ni	0.93**	0.71**	0.77**	1											
	Pb	0.71**	0.68**	0.89**	0.75**	1										
	Zn	0.47**	0.49	0.62*	0.59	0.85**	1									
Physico- chemical factors	Temp.	0.45*	0.63**	0.63*	0.42	0.49	0.31	1								
	pH	0.59*	0.85**	0.74**	0.52	0.51	0.32	0.68**	1							
	DO	-0.73**	-0.361	-0.37	-0.63	-0.22	-0.06	-0.12	-0.13	1						
	BOD	0.85**	0.50*	0.48	0.75**	0.33	0.11	0.16	0.38	-0.81*	1					
	COD	0.61**	0.28	0.32	0.67**	0.32	0.30	0.30	0.19	-0.64	0.67**	1				
	Alkalinity	0.58*	0.40	0.53	0.59**	0.58	0.51	-0.06	0.26	-0.34	0.475	0.22	1			
	Salinity	0.10	0.52*	0.44	0.04	0.40	0.38	0.31	0.64*	0.37	-0.115	-0.35	0.17	1		
	NO_3	0.81**	0.62**	0.60**	0.84**	0.51	0.38	0.46	0.56*	-0.56	0.75**	0.63**	0.34	0.17	1	
	PO_4	0.89**	0.53	0.57	0.80**	0.45	0.22	0.21	0.38	-0.74*	0.93**	0.68**	0.48	-0.06	0.80**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).