SUMMARY:

The present work highlighted on the industrial effluents effects in aquatic biota on the mouth of Haldi river, West Bengal. The experimental river has been divided into three separate zones cased on their released effluents concentration. These are, Site 1 (major industrial effluent out fall at Patikhali in Hooghly river); site 2 (5 km down stretch from station 1); Site 3 (5 km above confluence on river Haldi). The present study investigated based on the physico-chemical parameters of soil and water, heavy metal concentration of soil and water parameter, biological parameter like diversity and density of planktonic organisms, variability and bioaccumulation of fish has been carried out for a periods of two year.

All of the finding of the present work soil and water are summarized below;

- pH was recorded minimum at Site 3 as 7.0 during the rainy season and maximum at Site 2 as 8.4 during winter season. The desirable limit for pH is 6.0 -8.0. Hence, at Site 1 and Site 2 winter season the pH value exceeded the desirable limit.
- Organic carbon was recorded minimum at Site 1 as 0.18% during rainy and maximum at Site 3 as 0.91% during the summer season. The desirable limit for organic carbon is that less than 0.5% organic carbon are considered as less productive. 0.5-1.5% and > 1.5% organic carbon are considered as medium and high productive categories. Hence Site 3 the medium productive categories.
- Available nitrogen, phosphorus, potassium, were recorded minimum at Site 1 as 3.9 mg/kg, 0.06 mg/kg, 0.7 mg/kg during rainy season and maximum at site 3 as 60.35 mg/kg, 6.41 mg/kg, 4.0 mg/kg during winter season. The desirable limit for nitrogen 10-

50 mg/kg, phosphorus 2.2 to 5.4 mg/kg, potassium 0.1 to 0.2 mg/kg. Hence Site 3, the nitrogen, phosphorus, potassium exceeded within permissible limit.

- Sand, silt, clay was recorded minimum in Site 1 during rainy season as 66.3%, 4.4%, 5.0% and maximum in Site 3 during summer season as 84.3%,20.4%, 28.7% . Hence, percentage low in organic carbon, nitrogen, phosphorus, potassium was low concentration so soil texture also proportionately decreased value in Site 1.
- Cadmium concentration of soil was observed maximum at Site 1 as 3.33 mg/kg during summer season and minimum concentration during rainy season at Site 3 as 0.36 mg/kg. At almost all the sites of soil cadmium value was above the permissible limits of 0.01 to 0.07 mg/kg (BIS, 2012).
- Zinc was present in highest concentration in soil during the Site 1 winter season 301.25 mg/kg and lowest in rainy season at Site 3 as 12.89 mg/kg. Except, Site 1 winter season, At almost all the other sites of soil zinc values was within the permissible limits of 10 to 300 mg/kg (WHO,1993).
- Copper was present in highest concentration in soil during the Site 1 rainy season 26.98 mg/kg and lowest in winter season at Site 3 as 18.48 mg/kg. At almost all the sites of soil copper value was within the permissible limits of 2 to 100 mg/kg (WHO, 1993).
- Manganese concentration in Site 1 during rainy season was carried the maximum in soil as 414.70 mg/kg and minimum concentration of manganese at Site 3 during winter season as 93.67 mg/kg. At almost all the sites the manganese value was within the permissible limits of 20 to 3000 mg/kg (WHO, 1993).

- Lead concentration in Site 1 during winter season was observed the highest concentration as 39.68 mg/kg and minimum concentration at Site 1 summer season 27.85 mg/kg. The lead level was within at Permissible limit of 2 to 200 mg/kg (WHO 1993) in all sites.
- Correlation matrix study showed that the parametric data of the physic chemical parameters of the soil shows that the pH of the soil increases primarily with increase in Slit % and then secondly with clay% in soil which is statistically significant at $p < 0.01$. The concentration of the NPK % in soil was also equivalently determined with increase in percentage of sand, slit and clay with the highest correlation being with sand% followed by clay%. The percent of nitrogen and phosphorus was found to be positively correlated with highest magnitude of $r = 0.967$. The potassium and clay % seemed to be the highest common factor with positive correlation with all the other physic-chemical factors of soil. Hence these could help predict the soil health of an experimental land.
- The Pearson 2-tailed correlation matrix of the parametric data of heavy metal content of the soil shows that the concentration of cadmium (Cd), zinc (Zn) & Lead (Pb) have statistically significant relationship ($p < 0.01$). The variables are positively correlated and the increase of one of the variable proportionally increases the other two specifically with Cd & Zn. Similarly, the concentration of Zn is negatively correlated with Copper (Cu) & Manganese (Mn) whereas Cu is positively correlated with increase in Mn with r (coefficient of correlation) = 0.989. The magnitude of correlation within other metals are however moderate with r $[0.2 | < r | < 0.5]$.
- Temperature was recorded minimum at Site 3 as 21.6 °C during winter and maximum at Site 1 as 34.8 °C during the summer season.

- pH was recorded minimum at Site 2 as 7.5 during the rainy season and maximum at Site 1 as 8.6 during summer season. The desirable limit for pH is 6.5-8.5. Hence, at Site 1, the pH value exceeded the desirable limit.
- DO was recorded minimum at Site 1 as 2.3 mg/l during the rainy season. While it was recorded maximum during the summer season at Site 3 as 7.6 mg/l. At Site 1 during rainy season, the DO values was found below than the desirable limit of 4.0-6.0 mg/l (USEPA). Seasonally, the DO was highest in summer season, lowest in rainy season and intermediate in winter season.
- BOD was observed minimum as 6.0 mg/l at Site 3 during winter season. It was highest at Site 1 during summer season as 16.9 mg/l. At almost all the sites, the BOD value was above the permissible limits of 5.0 mg/l (WHO). This shows the river stream received a huge load organic waste. BOD was maximum during the summer season, lowest in winter season and intermediate in rainy season.
- COD was observed minimum at Site 2 as 33.5 mg/l during the winter season. While, COD was highest during the summer season 59.6 mg/l at Site 1. At all the sites, the recorded COD value are far above the prescribed limit set by WHO as 10.0 mg/l. This shows that the water is highly polluted and receives industrial waste. Seasonally, COD value was highest in summer followed by rainy then winter.
- The minimum Alklinity was recorded at Site as 108.6 mg/l during the monsoon season. While, the maximum was recorded at Site 1 as 156.0 mg/l during the summer season. Seasonally, Alkalinity was maximum during the summer , minimum in winter while intermediate during the rainy season. At all the sites are within the permissible limit set by BIS (200 mg/l).

- Phosphate was recorded minimum at Site 1 as 0.1 mg/l during rainy and winter season and maximum during the summer season at Site 1 as 3.5 mg/l. Except at Site 3 rainy and winter season, the phosphate at all the other site was above the permissible limit (0.1 mg/l) set by USEPA. Seasonally, phosphate was maximum in summer, minimum in rainy and intermediate in winter.
- Nitrate was recorded minimum at Site 3 as 0.3 mg/l during the monsoon season. While it was recorded highest as 3.4 mg/l at Site 1 during summer season. At all the sites nitrate values were within the permissible limits of 45 mg/l by WHO.
- Maximum concentration of Cadmium was observed in water 1.36 mg/l during the summer season and minimum concentration was observed during rainy season in Site 3 0.002 mg/l. Except, Site 3, all the other sites water metal concentration was crossed permissible limit set by BIS, 2012 (0.003 mg/l).
- Highest concentration of Chromium was observed Site 1 in water 0.15 mg/l during the summer season and lowest concentration was observed during Site 3 at not detectable data in rainy and winter season. All the season of Site 1 and Site 2 only rainy season the concentration was slightly above than the permissible limit set by BIS, 2012 (0.05 mg/l).
- Copper was present in water, highest concentration during the summer season at Site 1 21.32 mg/l and lowest during the Site 3 rainy season 8.52 mg/l. At almost all the sites of water the Copper value was above the permissible limits of 5.0 mg/l (BIS, 2012).
- Nickel concentration was recorded highest in the water at Site 1 during summer seasons as 1.87 mg/l and Site 2 and Site 3 all seasons were data not founded. Only Site 1 three seasons was slightly crossed the permissible limits of 0.02 mg/l.

- Lead concentration in Site 1 during summer season was carried the maximum in water as 43.32 mg/l and minimum concentration of lead at Site 3 during rainy season as 19.51 mg/l. At almost all the sites the Lead value was so far above the permissible limits of 0.01 mg/l (BIS, 2012).
- Zinc concentration in Site 1 during summer season was observed the highest concentration as 47.23 mg/l and minimum concentration at Site 1 rainy season 23.29 mg/l. The Zn level was below at Permissible limit for aquatic life 120 mg/l (USEPA, 2011 a) in all sites.
- Mouth of Haldi river Site 3 was showed the healthy floristic assemblage throughout the study area. This indicates about healthy ecosystem of this site. 24 plankton species from different taxonomical groups were recorded from the stretch of river mouth Haldi. These groups contains algae (7), Cladocerans (4), Rotifers (7),Copepeda (6). And 23 Fish species also available in the site 3.
- On the basis WQI of the considering rivers it was found water quality of the mouth of Haldi river at the study sites Site 1 and Site2 showed poor water quality and Site 3 study sites showed good water quality. WQI if the river mouth of Haldi Site 1 was ranged from 57 to 74 and Site 2 was ranged 37 to 52. Site 3 ranged was observed 28 to 49.
- Correlation matrix study showed that the parametric data of physico-chemical parameters of the water shows that the pH of the water body is directly correlated with salinity and temperature. The dissolved oxygen of the water was diminished with increase in BOD, COD, pH, temperature, hence a negative correlation r [- 0.3 |<r | < - 0.8] with almost all the heavy metal in water.

- The Pearson 2-tailed correlation matrix of the parametric data of heavy metal content of the water of Haldia river shows that the concentration of all the six metals are positively and strongly correlated, the increase of one proportionality increases the other in a concentration gradient $p < 0.01$. Precisely, Cd & Ni were strongly correlated with $r = 0.931$ followed by Pb & Zn with $r = 0.844$. The magnitude of correlation is quite appreciable with r $[0.5 | < r | < 0.9]$.