2. REVIEW OF LITERATURE

Since the rise of industrialization diverse problems of aquatic quality have been affecting the inland water bodies. The increasing input of various metals and other toxic materials are putting tyrannies on the water bodies passing through the city and industrial sites, and the sewage turn offs into the water bodies is a usual incident in the present pollution scenario. The anthropogenic pursuits are the principal cause behind trace metal pollution in aquatic environment. Industrial and urban refusals, atmospheric calamities are seen on regular basis to pollute aquatic ecosystem. In biogeochemical cycling of nutrients and various pollutants in the aquatic ecosystems, sediments too play a key role. Pavements from river drainages and anthropogenic effluents to the water bodies dwindles down the role of sediment in nutrient cycling in riparian ecosystems. The sediment saturated deport of several substances is rather significant. The substances issued from the erosion of rocks and minerals as well as from industries and other human made polluting activities permeate the sediment phase. That more than 90% of the total flux of Phosphorous (P), Nickel (Ni), Manganese (Mn), Lead (Pb), Iron (Fe) and Aluminum (Al) are impregnated with sediment fraction in riparian ecosystem came into reckoning . (Martin and Meyback, 1979).

It is also reckoned that the average out puts of these riverine resources in India is only 360 kg/km. In deed the yields of the riverine resources of India is much higher. The yielded potential of the lower reaches of river Ganga is enumerated at 198.3 kg/ha/yr whereas the actual yield is 30 kg/ha/yr and thus, only 15.2% of the production potential is collected (Sinha, 1999). This fact is due to decline of river and incapability of it to serve as a good haunt or birthplace for fish. Once and again the fish spoils from the rivers are placed in a favourable light.

***Effluent turn offs at a glance**

Place	Year	Cause	Source
River Ganga, Munger, Bihar	1968	Oil refinery effluents	Sunderesan*et al.*, 1983.
River Chahar, Alwage	1974	Pesticide	Joshi, 1994.
River Adyar, Madras	1981 1982	Tannery effluents	Joshi, 1994.
River Gomti, Lucknow	1983, 1984, 1986	Distillery waste	Joshi, 1994.
RiverTungabhadra,Harihar	1984, 1994	Poly fibre, rayon effluents	Murthy, 1984.
River Gomti, Tripura	1988	Epizootic ulcerative syndrome (EUS)	Das and Das, 1993.
River Shella, Meghalaya	1988	EUS	Das and Das, 1993.
River Churni, West Bengal	1993	Sugar mill effluents	Ghosh &Konar, 1993.
River Churni, West Bengal	1997	Sugar mill effluents	Konar, 1997.
River Yamuna, Haryana	1999	Sudden increase in turbidity due to sugar factory discharge	Anon, 1999.
River Bhavani, Tamil Nadu	1999	Untreated effluent of South India Viscose	Bhavani River Protection Council.
River BurhiGandak, Bihar	2000	Effluent from sugar mill	Alam*et. al.*, 2001.
River Sultej	2001	Probably effluents of NFL and Punjab Alkalis and Chemicals Limited.	The tribune, Chandigarh. 24th November, 2001.
River Gomti, Lucknow	2003	Effluent from sugar mill, paper mill, sugar mill and distilleries,	India-ej News, 13th July 2003

		upstream of Sitapur and Lakhimpur- Kheri	
River Gedilam, Tamil Nadu	2005	Sugar mill effluents of Nellikuppam.	The Hindu,11th May 2005
River Brahmaptura	2007	Chlorine in Wastewater	CIFRI report, 2007
River Karola, Jalpaiguri, WB	2011	Pesticide poisoning	CIFRI report, 2011

Singh and Mahavar (1998) cultivated in their study the nature of river ground of Ganga in its downcast extent ranging from Sultanpur to Farraka. In 1995 and 1996 the soil samples were procured from seven locations of the river ground /bed of Ganga. In their study the river bed of that extent was found extremely arenaceous by natureand poor in fecundity, evident in the values of organic carbon (0.05-0.20%) and total nitrogen (6.8-10.8 mg/ 100g soil). In their investigation they also observed the physic-chemical factors of the river soils affected by the seasonal changes.

Singh *et al.*, (2012) investigated the concentration status of heavy metals in the river water and silts at some chosen locations in the middle stretch of the river Ganga. In the river sediments the heavy metals were found in the ranges respectively as of Ni (BDL to 90 mg/kg) and Zn (BDL to 870 mg/Kg) ; Cu (BDL to 90 mg/kg); Cr (BDL to 140 mg/kg). But Cd was not found in the silt/sediment samples. The findings in the their investigation stated that the river sediments of Ganga at Bhagalpur could be deemed to be uncontaminated ones in connection with Cd, Cu and Ni, whereas Cr and Zn concentration were shown to pollute the river sediments, which might be baneful to the opulent river based biodiversity.

Dutta *et al*., (2005) in their investigation took into account a higher Pb concentration level in sediments following a comparative assessment on water sample collected from the river stretch (Berhampore to Uluberia) of Ganga. They found that a tiny alkaline nature of the river water eased off the headlong fall of the metal from water to sediment and also found that the concentration range of the bulk of the discovered sediment samples (about 75%) were of 8.1 – 60 mg/kg. Purushothaman and Chakrapani (2007) procured the sediments from the origin to downcast flux of the river Ganga and assessed the presence of heavy metals in sediments, accompanied with different chemical components. They also investigated the metal fragments in the sediments carrying SM and T protocol of heavy metal extraction, where a calculation was also made on different fractions of metal enrichment factor (MEF) and geo-accumulation index (GAI).

Muller, P. J., (1977) conducted geo-accumulation index (GAI) to look into extent of metal mass and affluence in the sediments and pollution range in the water bodies. They put on GAI and MEF values to apprehend the metal mass and affluence in sediments of down flux of water bodies, caused by collations of industrial and household discharges. It was found that there was a strong metal concentration of all metals in sediments, denoting highly polluted river in the down flux cantons due to particles encumbered industrial discharges and urban effluents. Kumar *et al*., (2011) made an experiment on the sediments from the effluents (Haldi and Rupnarayan) of down tract of Hooghlyembouchure. After analyzing the sediments from those tributaries they found the average concentrations of the metals in the sediments of Haldi river are respectively as 11.8 mg/kg. of Lead (Pb), 1.3 mg/kg of Cadmium (Cd), 17.0 mg/kg of Copper (Cu), 48.7 mg/kg of Zinc (Zn), 2.01% of Iron (Fe), 11.8 mg/kg of Cobalt (Co). On the other side, the concentration levels of the metals in Rupnarayan are respectively as 14.3 mg/kg (Pb), mg/kg (Cd), 15.1 mg/kg

(Cu), 49.5 mg/kg (Zn), 22.4 mg/kg (Ni), 1.72% mg/kg (Fe) and 11.8 mg/kg (Co). In their opinion '0.50' is the common pollution load index of heavy metals in the sediments of both rivers. In their investigation they also determined the fact that the concentration levels of heavy metals were low in comparison to the quality guideline values (GESAMP, 1982 and CCME, 1999) of the background and sediments of the earth. After all, no intensity of heavy metal contamination in the sediments of both tributaries was found in their study.

Gupta *et al.,* (2009) made an experiment on the sediments of river Ganga At Allahabad in relation to heavy metallic causation and bioaccumulation (Cu, Cd, Cr, Pb, Zn). The results they found revealed that the concentration of Zn was higher than that of Cd in riverain sediments. The release of Cd into environment was due to the industries like the plants of paints, alloys etc. and found forgathered with footsie silts and smithereens. The results also indicated that the Cd concentration in water was low in comparison to that in sediment. Singh *et al*., (1992) studied the heavy metal loads in the sediment and water of the river Ganga. They found maximum concentration values of Zinc and Arsenic at sewage offload points of Varanasi (Rajghat) and textile industry waste discharge point at Kanpur (Jajmau), and also found that of Chromium at Allahabad (Mavaiya).

Samanta, S., (2013) studied on contamination continuity of metals and pesticides in the sediments of three regions; the upper (Gangotri to Haridwar) middle (Haridwar to Farakka) and the lower (Farakka to the Bay of Bengal) stretches, of Ganga. The low metal contents they found in upper stretch as being free from human activities. The metal contents were ascribed to be issued from geochemical sources. The maximum content of the metals they found in the middle stretch receiving industrial discharges. But they reported that the Kanpur stretch of the river Ganga was massively polluted (NRCD, 2009), though that was not reflected in the metal content of the sediment.After all with respect to the allowable limits of heavy metals in sediments the river is reported as polluted to a certain extent. Mukherjee, D. P., (2012) conducted a hard-working study conducted on the role of sediments suspended in transportation in Hooghly river receiving maximum sediment load (annually 560 million tons) and hefty tides up to 5.5 m. It was reported that the suspended sediments were highly enriched with Cu, Cd, Ni, Cr and Zn due to anthropogenic activities including poor treatment of land for urbanization and industrialization. Approximately, the metal opulence occurrences in Hooghly river was found low in comparison to that in other rivers of the glove.

Singh *et al.,* (2005) conducted an analytical study on water and bed sediments of river Gomati a tributary of the Ganga in relation to heavy metal circumstances in the river. In their study the metals in sediments, found in the ranges respectively as for Cd (0.70-790 mg/kg), Cr (6.105-20.595 mg/kg), Ni (13.905-37.370 mg/kg) , Zn (15.72-99.35 mg/kg), Pb (21.25-92.15 mg/kg) , Mn (134.915-320.45 mg/kg), Fe (5051.485-8291.485 mg/kg) on the basis of dry weight. The samples for the above study were randomly collected from ground sediments of 10 different locations (December,2002 and March, 2003). Ramesh *et al.,* (1999) underwent a studied on the sparse earth elements and heavy metal disperse on river outfall sediments of east coast of India. They noted ales metal concentration at the Hooghly embouchure sediments, where as the peninsular estuaries were foundto be with less content of geological constituents.

Khwaja*et al*., (2001) carried on an investigation in the river Ganga at Kanpur region the two sites of which were chosen for the study. The sites situated at such points which were preceded and followed by the tannery industries. At those sites Chromium was found to be linked with tanneries. After analyzing chromium mixed sediment specifications they reported that the chromium apertures into the Ganga was occurring at the second site following tanneries. At the second site there was approximately ten times greater increase in Chromium than that in Chromium at the first one. In the upper stretch of the stream the Cr content in winter was 52.5 mg/kg, in the down stretch the content raised up to 320.1 mg/kg. Chatterjee *et al.*,(2012) conducted a study on mangrove wetland of Sundarban (North-Eastern part of the Bay of Bengal, India) in relation to the total Mercury (Total Hg) and Methyl Mercury (Me-Hg) status in sediment cores (<63 µm particle size, n=75) of that area. An ample range of variation, they found in total concentration of Hg (0.032-0.196 µg/g dry wt.) and Me-Hg (0.04-0.13 µg/g dry wt.), which showed a little cantonal contamination. They set forth that the mix-up process of sediments caused the prevalence of low Hg level in sediments. They observed on the basis of the low values of the index of geo-accumulation and effects range (ER-L) that there was no eco-toxicological hazard in the sediment due to being less polluted by Hg. Hence the medullary sediments of the Sundarban wetland revealed an ample range of Si-Al ratio (1.2-28.3) which showed different blends of core and fine-granulated materials (Windom et al., 1989 and Din, 1992). In conclusion they stated that there was an immense variation inconcentrations of Fe, Mn, Mg and Al at the said area.

Purkait*et al.*,(2009) in their study had taken initiatives to observe the influence of several parameters affecting the water of Ganga in Kolkata region. Some of the physical and chemical constituents of the samples were observed to be within an acceptable levels in Ganga water of Kolkata region. In the above observation the samples were found to opulent with nutrients and had legitimate level of pH for agricultural applications. But the sewage water was not suitable for irrigation in context of the ratio of EC and sodium absorption. A caution was drawn as a conclusion that the slush sans ulterior treatment, produced in Kolkata region does not deserve the suitability for agriculture pursuits.

Eggleton and Thomas (2004) said that the engrossment of heavy metals in the aquatic environments affects the physic-chemical parameters like pH, salinity, presence of quelante substances, water hardness, and dissolved oxygen of water. Singh and Mahavar (2003) conducted a study on pollutants' effects on limno-chemical factors of river Ganga between Kanpur and Varanasi (middle stretch) which showed n assessment on the pollutants of several types, originating from textile, sewage, industrial and city wastes. The above assessment in the study showed the high levels of BOD, COD, chloride, hardness, specific conductivity, nitrate, phosphate and free CO_2 in polluted and less polluted zones. At all the centers COD was observed unchangeably higher than BOD observed more than 4.4 mg/l. At Varanasi the highest absorbency of chloride (56 mg/l); At Kanpur specific conductance (1043-1152 μS/cm) and hardness of water (156mg/l) and at Allahabad the alkalinity (390 mg/l) and the lowest value of DO (0.32 mg/l) were witnessed as well as documented respectively. Thus the effect of pollutants was generalized in locality, and it was also localized that water keeps up its original characters after getting raked up from high stress of organic pollution over the area of a few hundred meters long.

Singh *et al.*,(2012) made an experiment on the metal concentration and sediment conditions in water and silt of river Ganga at identified zones. In that investigation some physic-chemical parameters like pH, phosphate-phosphorous, total hardness, DO and nitrate-nitrogen were observed to have a direct or indirect impact on the transport, specification and various incidents of the heavy metals. Singh *et al.*, (1999) was conducting a study in the mid extent of Ganga from June, 1989 to March, 1990 to assess the impact of effluents of several kinds on BOD and COD. Seven locations at all estuarine territories of Allahabad and Varanasi were observed as having values of BOD and COD. It was found that the value of BOD was significantly related to that of COD, which also in the observations of Boyd (1973) showed the resemblance.

Singh *et al.,* (1998) to assess the pollution status of the river Ramganga, a tributary of Ganga, carried out a study in the mid extent (about 110 km from Muradabad to Bareilly) of the river Ramganga during 1993-94. The study showed that the water particularly of the outflows of different sewage channels at different centres was highly polluted. The dominance of sewage waste conveyed high values of free CO_2 (14 mg/l), low DO (0-3.5 mg/l), high alkalinity (323 mg/l) and high hardness (145 mg/l) where the paper waste showed its impact on alkalinity (308 mg/l), hardness (160 mg/l) and dissolved oxygen (3.27 mg/l); rubber waste accompanied with the wastes of sugar factory reflected its effect high conductivity (1114 µmhos/sm), high chloride (284 mg/l) and high hardness (168 mg/l). Thus the above study revealed the baneful impact of sewage, paper and rubber wastes on the water quality of the river.

Mitra*et al.,* (2011) conducted an investigation on why and how the physicochemical parameters vary in space and stream in the puisne Gangetic delta land in West Bengal. It was taken in notice that the current inclination of industrialization, urbanization and construction of dam in the upstream belts are bringing seesaws in the landscapes of deltaic belt and the traits of the aquatic tributary forms. In Hooghly outfall extent of Gangetic delta zone the spatial and tidal changes of momentous physicochemical parameters were studied in the month of summer (April), 2008. In tidewater and ebb-tide (excluding the temperature and potassium of face water) the significant difference in the values of parameter highlights the impact of the water of Bay of Bengal on water quality. In connection with the surface water temperature there was a uniformity in twelve identified locations from the upstream to downstream regions. In context of the parameters like salinity of surface water, pH, alkalinity, BOD, DO, NO_3, PO_4, SiO_3, SO_4, Na, K, Cl, and total nitrogen the cabalistic spatial variation (at 5% level of significance) were taken into notice. Besides the anthropogenic factors issued from the adjacent cities and towns exerted a regular effect on the parameters like PO_4, NO_3, BOD, SO_4 and total nitrogen.

Khwaja*et al.,* (2001) discussed the influence of the wastes from the tannery industries as well as of the physicochemical characteristics of the Ganga water and sediments at Kanpur was done. It was found in their study that there was an enhancement in values of parameters like BOD, COD, Cl and total solids due to the domestic wastes just as much as due to the tannery wastes and higher inflow of phenols and sulphides from tanneries. They mentioned that for drinking water the physic-chemical parameter level in the Ganga is higher than that of the prescribed Indian standards (BIS-10500, 1991) for the same. It was also brought into notice that partly influenced by the religious issues, the particular area is being used for domestic purposes such as drinking, bathing , washing and so forth and this way the situation is rated as alarming.

Mukhopadhaya, S. K., (2003) observed that the Hooghly embouchure passing through the industrial cities Kolkata and Howrah assumed a high level of metals in water Cu 237 µg/l, Cd 80 µg/l, Cr 180 µg/l, Pb 410 µg/l and Zn 293 µg/l and all the values exceeded the USEPA admissible range for aquatic organisms. Samanta*et al.,* (2005) penned the levels of Cd, Cu, Mn, Pb, Zn ranging 2-14, 5-19, 8-88, 17-41 and 22-37 µg/l respectively while assessing the metal concentration in Hooghly and Haldi (at Haldia) river waters. The fact explicit in the data being compared with the critical criterion continuous concentration (CCC) of US EPA was that Cd, Cu and Pb were present at a frightful rate to discommode the aquatic life process at the particular area.

Nath*et al.*, (2003) highlighted that the mean concentration of Pb 9-410 and Cd 1-74 in the water of seven fjords of Sundarban was above USEPA criteria for aquatic organisms where as Cu and Zn concentrations subsisted within allowable extremities. Pandey *et al.,* (2010) carried on a study on heavy metal contamination of Ganga at Varanasi in context of atmospheric deposition. Along a stretch of 20 km length of the river they recherché twelve sampling stations. The data showed that the mid-drift water of Ganga at Varanasi was irreversibly defiled with heavy metals. The highest concentration of Pb, Cd, Cr, Cu and Ni at the time of winter and that of Zn in summer were recorded. The all-up concentration of heavy metals in water revealed the concentration tendency i.e. Zn>Ni>Cr>Pb>Cu>Cd. The study reported a significant positive relationship between the concentrations of heavy metals in water with the pace of atmospheric deposition at the respective areas. The study also in relevance to the above factor made sensing on the atmospheric water interaction in polluted environment and on the management of water bodies even through located away from direct anthropogenic discharges.

Kar*et. al.,*(2008) stepped for assessing heavy metal contamination in face water of the river Ganga in West Bengal during 2004-05. Berhampur, Palta, Dakshineswar and Uluberia, the four stations to be controlled over were chosen for the investigation. 96 water samples were amassed in the investigation. More than 92% of the total sample were Fe, Mn, Zn, Ni, Cu and Pb detected in the range of 25-5490 µg/l (Fe), 25-2720 µg/l (Mn), 10-370 µg/l (Zn), 12-375µg/l (Ni), 1-44µg/l (Cu) and 1-250 µg/l (Pb) respectively. The season wise existence of heavy metals observed in water are as followings: Fe in its maximum mean concentration (1520µg/l) was noticed in summer , Mn (423µg/l) in monsoon, Cd (3µg/l) and Cr (20µg/l) during wintry season. The station wise presence of the above are as followings: Fe (1485µg/l), Zn (85 µg/l) and Cu (6 µg/l) were observed in their highest mean concentrations at Palta, Mn (420µg/l) and Ni (54 µg/l) were observed in that at Berhampur, Pb (24 µg/l) and Cr (18 µg/l) in their maximum mean concentration were observed in the downstream station, Uluberia. Shah *et al.,* (2005) stated that the offloading of heavy metal loaded industrial waste in water might be the principal cause behind the highest concentrations of most of the heavy metal (Fe, Zn and Cu) at Palta. After all,in the surface water of the river Ganga the predominance of various heavy metals followed a succession: Fe>Mn>Ni>Pb>Zn>Cu>Cd. A significant correlation of Cd and Cr of water with conductivity was shown but a negative correlation was seen in between Mn and conductivity.

Singh *et al.,* (2012) noticed the heavy metals concentration range Cu (ND to 12 µg/l), Cr (BDL to 870), Ni (BDL to 120 µg/l) and Zn (BDL to 870 µg/l) in the middle stretch water of the river Ganga. Zinc and Chromium were seen present at an alarming rate in water as well as in sediment at that canton of Ganga. They concluded that the river Ganga got gravely contaminated with the toxic heavy metals and pesticides ejaculated from the evident and non-evident sources. Gupta *et al.,* (2009) conducted an investigation on valency and toxicity of some heavy metals in water. They showed that trivalence and hexavalence are the two states of Cr, in which seen present in water. Hexavalent state is conceived as massively toxic and is not detected in water due to its poor solubility (EPA,1992 and Besser*et al.,*2001).

Collvin, L., (1985) stated that the rivers are overflowed cumbersomely and the drainage system gets rampantly affected during rainy season (July – August), resulting in the blend of tainted and undefiled water and leading to dilapidating heavy metal concentration whereas in Summer, the concentration augmentation of heavy metals befall due to drought and fall of water level.

Singh and Mahaver (1998) observed the metal levels at Chirraghat, Tanda and Kattarniaghat national thermal power project (NTPC) in Ghaghara, U.P. They reported than as the fly-ash settles down it did not leave impact on metal concentration in water. Shaikh, M. J., (2013) conducted an investigation on the depot of heavy metals (cadmium, chromium, lead, nickel and zinc) in water and fish organs of the river Godavari at Nathsagar Dam, Maharashtra. They studied two different river belts of Godavari on August 2012, one of which (site I) was near the Nathsagar dam and another (site II) was at upstream water of the river Godavari, 2 km. Away from the Dam. They observed the metal concentrations in sampling water in a sequence i.e. Ni>Pb>Cd>Zn>Cr. The utmost volume of metal was of Nickel observed in the sample. At the site I the observed value of Nickel was 7.53µg/l and at the site II that of Nickel was 5.80µg/l. The chromium values were found insignificant at the sites i.e. 1.23µg/l at site I and 1.7 µg/l at site II. They opined that the overuse of pesticides and fertilizers in the arable belts along the banks of this river causes the higher levels of lead cadmium and Zinc in the river water.

Dutta *et al.*, (2005) assessed in their study the impact of lead (Pb) on water quality of river Ganga in West Bengal. Their study showed that in 83% of water samples the Pb content overstepped far the agreeable margin (5µg/l) defined by USEPA (2002). Recking of the state of Pb concentration in water, it might be concluded that such river water was not suitable for serving drinking purpose. The study put stress on the strict and close observation on raw casts into the river. Studies by Samanta*et al.*, (2007) on the content of trace elements of metal in water showed that the presence of Pb, Cd, Cu were sufficient to perturb the process of aquatic life in the riparian belts. Samanta. S., (2013) conducted a study on the pollution status of the river Ganga (Gangotri to Bay of Bengal) being affected by metals and pesticides. In their study the midstream of the Ganga (Haridwar to Farakka) catching the effluents of several kinds was observed to be drastically polluted with different metals i.e. Cd 0-28,Cr 2-119, Cu 0-170, Zn 1-311 µg/l. In conclusion it was stated that the Ganga river water flows in the gulf of pollution and thereby the aquatic organisms are differently being jeopardized in accordance with the degree of contamination.

Singh *et al.,* (2005) led a study on heavy metal concentration in Gomti River. They found in investigation the ranges of metal concentration respectively as Cd (1-5 µg/l), Cr (1.5-68.8µg/l), Cu (1.3-4.3µg/l), (7931-139µg/l), Mn (3.8-97.3µg/l),Ni (6.6-11µg/l), Pb (15.8-27.6µg/l) and Zn (14.4-29.8µg/l). A notable variation in heavy metals concentration in water and sediment samples was also shown in their study. In establishing the reason behind this variation they stated that the industrial and sewage waste volumes were different at different sampling stations of the river, causing concentration variation of heavy metals in the river water. They further showed the highest and lowest contamination levels in case of some metals in water. Fe and Mn were shown as the highest contaminating metals in water whereas Cd as the lowest contaminating one. Damodhar and Reddy (2012) conducted an investigation on concentrations of heavy metals in water as well as species of fish in the river Uppanar at Cuddalore (Tamilnadu). In the results of the investigation it was found that in water the average concentration of the trace metals was in such a sequence as Zn>Mn>Pb>Cu>Cd denoting the presence of Zn in the highest concentration among other metals. It was also shown study that almost all concentrations of heavy metals (Zn, Mn, Pb, Cd, and Cu) in the river water surpassed the permissible concentration limits of Indian standards.

Aktar*et al.,* (2010) conducted a study for 11 months (November, 2005 to October, 2006). In order to assess the quality of surface water of the river Ganga in the region of Kolkata. In order to reduce the concentrations (Fe,Mn,Zn,Pb,Cr and Ni) of heavy metal in surface water from two points: middle stretch of the river and metal ejaculating point at each location at four different cantons of Kolkata, where Fe was traced out to be in the concentration ranging from 13 to

5490µg/l, Mn, from 22 to 1780µg/l, Cu from 3 to 33µg/l, Zn from 5 to 293µg/l and Ni from 45 to 240µg/l. Besides, the season wise concentration variance of these was metal was also observed in the study where the concentration was found higher in rainy season and lower in winter. They broadly found that the surface at different locations of Ganga River almost on all sides of Kolkata in West Bengal abounded in essential micronutrients (Mn, Zn and Cu). They found that the waste water and excrements conveyed in sewers and slush befoul the face water of the river Ganga. That is why they gave a hint the fact that if keep particularly Fe, Pb and Mn within the prescribed safe levels the river water has to be brought under a suitable bio-chemical treatment. Ghosh *et al.*, (1983) pursued an investigation on pollution effect on Hooghly – Matlah estuarine system. They found that Hooghly estuary a major part of the estuarine system was being affected bit by bit by the massive load of discharges (1.28 million m^3 /d) from the industries of the types like tannery, rubber and cycle rim, pulp and paper, paints and varnishes, distillery and yeast, rayon and cotton textile, oil refineries, petrochemicals, thermal power plants etc. Besides, other contaminating stuffs like household discharges and biological rubbishes being freely bio-Decomposed, affect the oxygen content of the estuary. They found that the estuarine water contained high metal concentration in the industrial zone. High levels of Zn (1248µg/l), Cu (38.1 µg/l), Cr (10.3 µg/l), Cd (6.4 µg/l), Pb (124.7 µg/l) and Hg (0.2 µg/l) were observed in the industrial and mixed effluent receiving sites of the Hooghly estuary.

Many empirics incorporating Welch, 1952; Pennak,1955; Jitts,1959; Hutchinson,1967; Odum,1971; Hannan and Young, 1974; Spodniewska,1979; Geldermalsen,1985; Villar *et al.*, 1996; Elskens *et al.*,1997; Tafas and Economou-Amilli, 1997; Lind *et al.*, 1997; Virbickas, 1998; Olguin *et al.*, 2000 ; Pennak (1995) of aquatic phenomena during the second half of the 20^{th} century have provided us with rich and resourceful information on several aspects of lacustrine and riverine water organs or parts of different countries. They blazoned comparative descriptions of eight lakes of Colorado mountain and made reports on maximum values of nutrients during monsoon. Jitts (1959) investigated the fiords-ground sediment's suction of phosphate. Hannan and Young (1974) studied how the physico-chemical features of the river of Central Texas are influenced by the deep amassment repositories and indicated that the maximal volume of phytoplankton tethers the light infilteration of the river. Spodniewska (1979) after conducting a study on the eutrophication of Masurian lakes reported that there is a positive correlation between water opacity and bio-accumulation of phytoplankton. Villar *et al.* (1996) observed the initial outturn of large aquatic plants and nutrition density in the flood affected moorlands of lower South American River, tributary of Rio de la Plata and exhibited that flood affected moorlands are sinkinking into nitrate due to decrease of de-nitrification and macropytic uplifts. Tafas and Economou-Amilli (1997) treated a descriptive survey of the torrid lake Trichonis in Western Greece, having only one seasonal period of free circulation each year (monomictic lake) and remarked that the modes of phytoplankton mass hereditament correspond to changes in environment variables. Lind *et al.* (1997) oversaw the Lake Chapala, the largest lake in Mexico in relation to its sludge filthiness and the comparative births of bacterioplankton and phytoplankton in, and showed the negative impacts of that sludge opacity on the production bacterioplankton.

Yahia *et al.* (2004) conducted a study on the bay of Tunis in South Western Mediterranean Sea in connection with the place and time orient shapes of small planktonic crustaceans of the large class copepod in and reported the mesozooplankton are subjugated by the crustaceans or copepods. Castro *et al.* (2005) studied the structure of rotifer sect in three shallow shallow lakes in Portugal and after witnessing a high plurality and diversity of that sect of plankton in summer they showed that there is a positive correlation between temperature and their structure. Kideys *et al.* (2005) through observing the Caspian Sea in relation to the adequacy. Bio-accumulation and species structure of phytoplankton revealed that the decreased in zooplankton's feeding on phytoplankton causes the higher value of chlorophyll. Zaho Wen *et al.* (2005) in their study on the biological and ecological properties of saline lakes in Northern Tibet (China) reported that there is a significantly negative correlation between salinity and plankton species quantity. Gonzalves and Joshi (1946) made a study on the freshwater algae near Bombay, where they made a correlation of algae production with pH.

Venkateswarulu *et al.* (1994) conducted a study on the role of single celled alga also called diatom as the pollution indicator and reported that the environmental parameters influenced the accrual of that species of algae designated as the indicator of pollution. Khanna *et al.*(2000) by observing the seasonal recurring tendencies of plankton in Ganga River showed that in the month of January the total concentration of plankton was maximum and thereafter to July that concentration continues to be declined. In past decade, some reports are found on Indian water bodies these are Goswami and Goswami (2001), Malu (2001), Bhave and Borse (2001), Pajevar Madhuri *et al.*(2002), Reddy *et al.*(2002), Patil and Singh (2002), Arora and Mehra (2002,2003), Yalavarthi Eswari (2002), Nandi and Das (2003), Salaskar and Yeragi (2003) and Shrama (2005). Goswami and Goswami (2001) investigated the productivity indicators in Mori beel of Assam and found nine species of rotifers from one beel. Malu (2001) studying the phytoplankton diversity in Lonar Lake and opined that they are the bio indicators of water quality. Shilpa Choudhury and Devendra Kumar (2001) investigated the phytoplankton population of Boorsa Lake and found that Chlorophyceae constituted the major group of the Lake, and the summer months produced relatively more plankton than the rainy and winter months. Pande (1995) reported that waste waters from industries with high temperature causes marked ill effect on water quality, plankton, macrophytes and fish fauna of the lake. Reichwald *et al.* (2005) investigated the effects of temperature in the life history of *Daphnia* and found that somatic growth higher at higher temperatures but lower in fluctuating temperature. The qualitative and quantitative studies of phytoplankton have been utilized to assess the quality of water (A doni *et al*., 1985; Chaturvedi *et al*., 1999; Ponmanickam *et al*., 2007; Shekhar *et al*., 2008). Although, a number of studies have been carried out on ecological conditions of freshwater bodies in various parts of India (Rana,1991; Sinha and Islami, 2002; Singh *et al.*, 2002; Tiwari and Chauhan, 2006, Mandal *et al*. 2005, 2008 and 2010), information on relationship between physico-chemical parameters and plankton indicators of water pollution is limited (Ahmad and Siddiqui, 1995; Rana, 1996; Dadhichk and Saxena, 1999; Rajagopal *et al*., 2006; Bhuiyan and Gupta, 2007). In ecology, zooplankton are one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem, such as food chains, food webs, energy flow and cycling of matter (Murugan *et al.*, 1998; Dadhick and Sexena, 1999; Sinha and Islam, 2002; Park and Shin, 2007).

The complete qualitative faunistic inventions of fish fauna have been made in recent past (Jhingran and Sugunan, 1990; Marques *et al*., 1997; Hasson *et al.*, 1998; Ganasan and Hughes *et al.*, 1998; Rao *et al.*, 1999; Ricciardi and Rasmussen, 1998; Ajithkumar *et al*., 1999; Nair, 2000; Kurup, *et al.*, 2001; Kurup and Ranjeet, 2002; Bijukumar and Sushama, 2001; Jayaraj *et al*., 2001; Ahmed and Singh,1992; Allen and Lord, 2004; Ziliukas, 2005; Sutan *et al.*, 2005; Sutin *et al*., 2007).

Fish production in India during the past two decades has increased to around 7 million MT since 2008. Different aspects of the production and spawning of penaeid prawns have been reviewed by Wickins (1976); Muthu and Laxminarayana (1982); Muthu (1983); Rao (1983); Primavera (1983) and Browdy (1992). The nutritional quality of food organisms has to be maintained at optimum level in order to ensure the maximum growth and survival rate of aquatic culture animals. The nutritional value of food organisms is related to their biochemical composition, especially the lipid and fatty acid contents (Shamsudin, 1993).

In Indian subcontinent the River Ganga is the largest river system of Asia sheltering the most opulent diversity of fish (Bilgrami et al, 1992; Pathak et al, 2011a; Tripathi et al, 2015; Mayank et al, 2015a; Dwivedi et al, 2016a). The fish rearing resources of Ganga river also contributes an ample range of other services to the ecosystem (Pathak et al, 2014; Dwivedi et al, 2016b; Dwivedi and Mayank 2017). Chiefly in high riparian input systems the freshwater tidal expansions of the fiords can be extensive, which harbour a plenty of fish and active fisheries (Odum, 1978). Multitude of fishes of the Ganga system incorporating the Hooghly and other associated inlets were described by many authors (Hamilton, 1822; Annandale, 1922; Hora and Nair, 1940; David, 1954; Menon et al., 1972, Ghosh, 2008). Vijayalaxmi and Vijaykumar (2014) exhaustively showed 29 genres of fish in Bheema river, Karnataka.

In the recent past the fish plurality and its concentration pattern in connection with salinity region and other aspects in different estuaries of East Coast were taken into account by the investigators namely David (1954), Gopalakrishnan (1971), Menon et al. (1972), Sinha et al. (1998), Ghosh (2008 a, b), Ghosh and Satpathy (2008), Ghosh (2009) etc. Talwar et al. (1992) presented a limnology of the marine and estuarine fishes of West Bengal and also mentioned the fishes of lower saline regime of Hooghly estuary. Sen (1992) upheld a methodic limnology of the freshwater fishes of West Bengal. David (1963) mentioned the fishes of lower part of river Godavari in his account of fish and fisheries of Godavari and Krishna river systems. Babu Rao

(1976) gave an estimation of the ray-finned fishes and Visweswara Rao (1976) that of non ray-fined ones of Godavari estuary. Information about the fish fauna of the estuary are also available from The studies by David (1963b), Jhingran (1991), CIFRI (2000) etc. also contributed a lot of information of estuarine fish organisms. Ghosh and Satpathy (2009) in their study made a comparison on the present status of Hooghly and Godavari estuarine fish diversities. Some uncoordinated information on the fish animals in upper riparian stretch were made available from those including Singh and Singh (1988), Karmakar (2005), Karmakar et al., (2008) etc.