EUROPEAN ACADEMIC RESEARCH
Vol. II, Issue 3/ June 2014

Impact Factor: 3.1 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Assessment of Heavy Metal Content in Sediment of Godavari River Basin

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Abstract:

Sediment in aquatic environment plays a very important role. The benthic organisms are most likely members to be affected by metals in sediments, because, the benthic environment is the main repository of particulate materials that wash into aquatic system. In sediment, heavy metal are elements (Properties of metals satisfied) of high atomic number they have high utilities in industrial application from papers to automobiles, by their heavy characteristic properties. They found in the deep bowels of the earth as ores (complexes of mixture). The metals are segregated from these ores, leaving behind the tailings that find their way into the environment as toxic pollutants. Higher content of sedimentation can affect aquatic insect by altering biochemical conditions, food resources, respiratory diffusion gradients and habitat space. Higher content of sedimentation can affect aquatic insect by altering biochemical conditions, food resources, respiratory diffusion gradients and habitat space. Hence the present study is aimed to investigate some of the important heavy metal contents in sediments such as Iron, Copper, Chromium, Zinc, Lead, Cadmium, and Fluoride of the Godavari river basin from Trimbakeshwar to Rawer in Maharashtra.

Key words: Heavy Metal, Sediment, Godavari River Basin, Pollutants and Environment.

Introduction

Sediment in aquatic environment plays a very important role. The benthic organisms are most likely members to be affected by metals in sediments, because, the benthic environment is the main repository of particulate materials that wash into aquatic system. Heavy metal pollutants are a major problem in aquatic environment because of their toxicity, their persistency and tendency to accumulate in organisms and undergo food chain amplification. Heavy metals can affect the aquatic organism as toxic substances in water and sediment or as a toxicant in the food chain. Heavy metals, which occur naturally in trace amounts in aquatic environments, are essential for the normal metabolism of aquatic organisms, hence, such certain metals are accumulated by the organisms for their physiological functions and use them as structural components (Krishna, 1991). Aquatic organisms may be adversely affected by heavy metals in the environment. The toxicity is largely a function of the water chemistry and sediment composition in surface water system. Slightly elevated metal contents in natural waters may cause several effects in aquatic organisms (Connell et al.,1984).

The massive growth of industry leads to over deposition of industrial wastes containing different chemical substances in the water of streams, lakes, rivers, dams thereby polluting the water in different ways, these waste threaten the aquatic fauna. The non-biodegradable substances have a tendency to accumulate in the bio system. Heavy metal salts constitute a very serious type of pollution in freshwater bodies because they being stable compounds and are not easily removed by oxidation, precipitation or other processes and affect the activity of the animals.

Wastewater is the source of aquatic pollution, which contains toxic substances in the form of pesticide residues, heavy metal salts, oil, radioactive substances etc. The introduction of these innumerable pollutants individually or in combination in natural water causes ecological abnormalities (Ghorade I.B. 2013). The indiscriminate and widespread use of these chemicals for various purposes has caused irreparable environmental damage and ecological crisis.

In sediment, heavy metal are elements (Properties of metals satisfied) of high atomic number they have high utilities in industrial application from papers to automobiles, by their heavy characteristic properties. They found in the deep bowels of the earth as ores (complexes of mixture). The metals are segregated from these ores, leaving behind the tailings that find their way into the environment as toxic pollutants. These heavy metals are well known pollutants, which are often encountered in many ponds, Lakes, rivers and dams of India and the most important aquatic fauna being subjected to stress caused by these heavy metals (Patil, et.al 2014; Lohar, 2000).

Higher content of sedimentation can affect aquatic insect by altering biochemical conditions, food resources, respiratory diffusion gradients and habitat space. Avoidance of sediment regions was due to the loss of interstitial space between stone and behavior revealed that the flow of running water, usually means of dams and reservoirs has influenced nearly all of the world's major river systems (Willianms and Feltmate, 1992)

Hence the present study is aimed to investigate some of the important heavy metal contents in sediments such as Iron, Copper, Chromium, Zinc, Lead, Cadmium, and Fluoride of the Godavari river basin from Trimbakeshwar to Rawer in Maharashtra (2010-2011).

Material and Methods:

For analysis of heavy metals in sediments, sediments samples were collected, pre-cleaned, acid washed PVC corer, transferred to clean poly-bag and brought to the laboratory during the year 2010-2011. These samples were washed with metal free double distilled water and dried in hot air oven at 110 ^{0}C for 5 to 6 hours and grinded to powder in a glass mortar and stored in pre cleaned polythene bags; 500mg of the sample was taken and digested with a mixture of 1 - 2 ml Conc. H_2SO_4. A few drop of HF was added to achieve complete digestion and the sample is filtered and marked up to 25 ml with metal free double filtered distilled water for the estimation of Iron, Copper, Chromium, Zinc, Lead, Cadmium, and Fluoride using Atomic Absorption Spectrophotometer (AAS).

Result and Discussion:

In the study areas following metals content in the sediment were analyzed in ppb unit and results obtained are given **Table No.1 to 7 and Fig. No. 1 to 7.**

Iron (Fe):

The red-rod disease of water caused by bacterial precipitation of hydrated oxides of ferric iron with consequent unaesthetic appearance to water, clogging of pipes, pitting of pipes and occurrence of foul smells, is due to the presence of relatively high iron in sediment and water. The concentration of iron in natural is controlled by both plysico-chemical and microbiological factors. The weathering of rocks and discharge of waste effluents from the industries area in the river is probably considered the main source of iron in sediment and water. Iron migrates as adsorbed to suspended matter insoluble hydrated iron. Dissolved carbon dioxide, pH and EC of water affect the nature of aqueous iron species present in water. Iron concentration in surface water and sediment is extremely variable, reflecting difference in underlying bedrock, erosion to a lesser degree and municipal and industrial discharge. Iron releases as corrosion products in water and soil environment. (Smith, 1981).

The concentration of Iron in ppb level **[Table No. 1 and Fig.No. 1]** during the year 2010-11 was varied from 0.54 (S5) to 0.65 (S7) in summer, from 0.49 (S5) to 0.60 (S1) in monsoon and from 0.41 (S5) to 0.49 (S9) in winter season.

Copper (Cu):

The Bureau of Indian standard has recommended 0.05 mg/l as the desirable limit and 1.5 mg/l as the permissible limit in the absence of alternate source (WHO, 1993, BIS 1991). Beyond 0.05mg/l the water imparts astringent taste and cause discoloration and corrosion of pipes, fitting and utensils. Copper can also contaminate water through chemical weathering and soil leaching. Copper salts are highly soluble in water with a low pH. Under conditions of normal alkalinity they can hydrolyze and may precipitate copper, greatly reducing the likelyhood of transport of copper to humans through water (SDWC, 1977).

The concentration of copper in ppb level **[Table No. 2 and Fig.No. 2]** during the year 2010-11 was varied from 0.41 (S9) to 0.53 (S8) in summer, from 0.30 (S5) to 0.48 (S7) in monsoon and from 0.33 (S2) to 0.56 (S11) in winter season.

Chromium (Cr):

Most rock and soils contain small amount of chromium. The Cr in which the metal exists in the trivalent form. Hexavalent chromium also exists naturally. In it's naturally, occurring state in a highly insoluble form but can be converted into more soluble form due to weathering, oxidation and bacteria. Because of low solubility, the levels found in water are usually low, however there are examples of contamination of water. Effluent containing chromium compound have discharged in to river and produced environmental problem (Chavan, 2002).

According to Ghorade (2013), the physical and chemical characteristics of river water showed seasonal fluctuations, interacting with one another and having a combined effect on animals and plants. Rivers are important sensor of the kind of human activities that are developed around. Nicolau et.al.,(2006) observed that rivers are dominant pathway for metals transport and that the existence of heavy metals in aquatic environments has led to serious concerns about their influence on plant and animal life.

The concentration of chromium in ppb level **[Table No. 3 and Fig. No. 3]** during the year 2010-11 was varied from 8.29 (S2) to 9.64 (S7) in summer, from 9.19 (S2) to 10.29 (S8) in monsoon and from 5.18 (S2) to 6.33 (S8) in winter season. Chromium content in sediment was high may due to dumping of wastes, domestic waste, human activities and agricultural runoff from the nearby villages. Similar results were obtained by Nicolau et.al. (2006), Obire et.al. (2003) and Chavan (2002). Metals are either necessary in low concentration to the human beings (trace metals) or extremely toxic for them in any concentration (heavy metals). Increase in chromium adversely effects on respiratory and dermatology. Effect that have been observed in humans are chronic tonsillitis, chronic pharyngitis, minor renal impacts, runny nose and ulceration of nasal septum, stomach pains, cramps, ulcers and lung cancer (ATSDR, 2000a).

Zinc (Zn):

Zinc is a lustrous bluish white metal. It is brittle at ordinary temperatures, but it becomes ductile and malleable when heated between 110^{0}C and is a fairly reactive metal that will combine with oxygen and other non metals and will react with acids to release hydrogen (Singh et.al.,1991). It is one of the most abundant essential trace elements in the human body. It is a constituent of all cells, and several enzymes depend upon it as a cofactor (Forstner and Wittmann, 1983). High content of zinc in *Siganus rivulatus* are reported that majority of zinc are from dietary sources rather than water (Moore and Ramamoorthy, 1984; Pourang, 1995 and Kargin et. al., 1991).

The concentration of Zinc in ppb level **[Table No. 4 and Fig.No. 4]** during the year 2010-11 was varied from 1.03 (S2) to 1.73 (S7) in summer, from 0.28 (S2) to 0.69 (S9) in monsoon and from 0.36 (S5) to 0.68 (S9) in winter season. The zinc content was high in summer in water and sediment may be due to the anthropogenic activities, domestic wastewaters, industrial effluents, pesticides. Similar results was observed by Rashed, (2001) and Cetesb, (2005) while The zinc content in water and sediment showed same trend but the sediment accumulated less heavy metals than water, it has been also reported by Bower (1979), Fabris et.al.(1994), Lau et.al.,(1998), Besada et.al.,(2002), Chindah and Braide (2004) and Eja et.al.,(2003).

Sediment is the major depository of metals, holding more than 99 % of total amount of a metal present in the aquatic system (Odiete, 1999). The observed low concentrations of Zn, Cd and Cu in this present study are consistent with the findings of Obire et.al.,(2003) who worked on the creeks but contrary to the reports of Chindah and Braide (2004) who observed higher levels of Cd and Pb in this aquatic body. This observation is also different from the findings of Lau et.al.,(1998), in the sediment of Hg Sarawak Kanan, Malaysia and Eja et.al.,(2003) in great Kwa river Estuary, Calabar.

Lead (Pb):

Lead is a soft, malleable and stable metal, which is often used in the manufacturing storage batteries and as an anti-knocking additive in gasoline. Major sources of lead included mining, smelting and refining of leads. In water lead tends to accumulate in aquatic organism through the food chain and by direct uptake.

According to EPA (2006), the health effect of lead exposure has been extensively studied. When lead enters the body, it travels through the blood to the soft tissues, such as brain, liver, and kidneys. In adults, most lead taken into the body is excreted, with a small amount of stored in bone and teeth, where it may accumulate with repeated exposure. Chronic exposure to lead may cause a variety of adverse health effect it include adults, including brain and kidney damage, poor reaction time, joint weakness, anemia, memory impairment, and possibly increased blood pressure. Lead is classified by EPA as a probable human carcinogen, based on evidence from rodent studies. Large dose of the lead have caused tumors in rats and mice. Nevertheless, there is not yet enough information to determine whether lead causes cancer in humans. Tomazelli (2003) studied Piracicaba River (Sao Paulo State, Brazil), obtained higher lead concentrations in the sediment. The concentrations ranged between 80.0 mg/kg and 233.0 mg/kg. The acceptable content of lead for river sediments is up to 72.0 mg/kg (Cetesb, 2005). The sediments in Ribeira do Iguape Basin presented higher concentration than those obtained by Aksoy et.al.,(2005) whose studies on Sulthan Marsh, a natural wetland sediment and water may be due to the washing of vehicles in the catchments, disposal of batteries, popes, electrical appliances and industrial effluent (Hadjmohammadi, 1988; Tomazelli, 2003 and Aksoy et.al.,2005).

The variation of Lead metal in ppb level **[Table No. 5 and Fig.No. 5]** during the year 2010-11 was varied from 16.13 (S7) to 19.36 (S10) in summer, from 21.13 (S9) to 24.59 (S6) in monsoon and from 14.28 (S11) to 16.40 (S5) in winter season. The concentration of lead in sediment may be due to the washing of vehicles in the catchments, disposal of batteries, pipes, electrical appliances and industrial effluent reported by Hadjmohammadi, 1988; Tomazelli, 2003 and Aksoy et. al., 2005). The increase in Pb in soil may be sources of municipal solid wastes material because that contains various compounds like glass, electrical wires, batteries etc. Increase in lead content in water may cause hypertension reproductive disorders, neurological and metabolic problems. The high content of lead tolerate into bloodstream, possibly along after the body was exposed to the lead.

Cadmium (Cd):

Cadmium in soils is derived from both natural and anthropogenic sources. Natural sources include underlying bedrock or transported parent material such as glacial till and alluvium. Anthropogenic input of cadmium to soils occurred by aerial deposition and sewage sludge, manure and phosphate fertilizer application. Cadmium is much less mobile in soils than in air and water. The major factors governing cadmium speciation, adsorption and distribution in soil are pH, soluble organic matter content, hydrous metal oxides content, clay content and type, presence of organic and inorganic legends and competition from other metal ions (Ghorade, 2013).

The variation of Cadmium metal in ppb level **[Table No. 6 and Fig.No. 6]** during the year 2010-11 was varied from 1.08 (S3) to 1.71 (S8) in summer, from 3.7 (S3) to 4.33 (S7) in monsoon and from 3.15 (S2) to 4.26 (S10) in winter season. The use of cadmium- containing fertilizers in bed(Agricultural field) of Godavari river may wash in rainy season and goes to Dam to produced sources of cadmium in water or sediment of dam and sewage sludge was arising from different tributaries also primary reason for the increase in the cadmium content of soils. Atmospheric cadmium emission deposition on to soils has also responsible significantly for concentration of cadmium (Mukunoki and Fujimito 1996). Indeed, recent study have documented that atmospheric emission have a significant impact upon the cadmium content of soil.

The control point and non-point sources of water pollution in our nation's rivers, sediments contaminated with metals and other pollutants may be pollution sources to overlaying waters and benthic food chains for years to come (Lyman et.al., 1987). Heavy metals from industrial and wastewater treatment plant effluents can form stable complexes with inorganic and organic compounds (Nienke and Lee 1982, Moore and Ramamoorthy, 1984). Rivers, lakes and ponds containing excess cadmium can contaminate surrounding land, either through irrigation for agricultural purpose, dumping of grudged sediments or flooding. It has also been demonstrated that rivers can transport cadmium for considerable distances up to 50 km, from the source (WHO, 1993). Nevertheless, studies of cadmium contamination in major aquatic systems over the past 20-30 years have conclusively demonstrated that cadmium level in the water bodies have decreased significantly since the 1960s and 1970s (Elgersma et.al.,1992; Mukunoki and Fujimoto, 1996). Studies on the Rhine River basin indicated that the point source cadmium discharges to the Rhine River decreased from 130 11 mt per year over 11 year time span, a reduction of over 90% (Elgersma et.al.,1992). As sediments serve as the ultimate depository for much of the particulate matter that moves through watersheds, sediments are a well studied environmental matrix (Moore and Ramamoorthy, 1984; Kamman et.al., 2005). Harland et.al.,(2000) found that the metal content in the soil to depend on organic matter and particle size content. Zelewski et.al., (2001) reported that metal content in soil ranged from 8 ppm to 86 ppm.

Fluoride (F^-):

As fluoride is naturally present in water and sediment it becomes toxic to animal and human being when present at more than 1.0 mg/l concentration in drinking water. At the level of 1.5 mg/l, molting of teeth and bones has been reported very occasionally and above 3.0 mg/l skelton flourisnes may be observed when a concentration of 10 mg/ l is exceeded it may cause crippling problem (Goyal *et. al.*, 2006).

The results obtained in the present study are significant because the earth crust in which contains granite, which is a major fluoride source. Use of fluoride containing fertilizers in these areas is another contaminant of ground water with fluoride. Fluoride containing fertilizer when applied, it dissolves in water and percolates down the soil layer and contaminates the ground water. Prolonged consumption of ground water containing about 1.5 mg/l of fluoride causes fluorosis (Mariappan, *et. al.*, 2000). Dental fluorosis is reported, if the consumption exceeds 1.5 mg/l and skeletal fluorosis beyond 3.0 ppm if water is consumed for 8-10 year (Nawlakhe and balusu, 1989). Recent studies suggested that fluoride accumulates with age and may reach toxic bone levels in a person's lifetime (at water content of 0.79 ppm) (Danielson *et.al.*, 1992).

The variation of fluoride metal in ppb level **[Table No. 7 and Fig.No. 7]** during the year 2010-11 was varied from 0.21 (S2) to 0.36 (S6) in summer, from 0.11 (S2) to 0.18 (S8) in monsoon and from 0.11 (S3) to 0.19 (S8) in winter season. The trace metals can exist in a variety of chemical forms in natural water including free ions, inorganic complexes, and organic complexes and metal absorbed on or incorporated into particulate matter (Kamman, 2005) as well as the chemical composition of the natural water and sediments. Recent investigations (Anderson et. al., 2001) have demonstrated that the toxicity and availability of trace metals is highly dependent on their chemical form. The investigators have shown that biosocial responses to dissolved trace metals is a function of the free metal ion concentration and is determined not only by the total dissolved metal concentration but also by the extent of metal complexation to both organic and inorganic ligands.

There are several reports on the chemical and physical processes in the sediment is widely believed to act as a filter for many metals passing from terrestrial to the marine setting (Schubel and Kennedy, 1984; Tam and Wong, 2000 and Morillo et. al., 2004) and to accumulate some metals in marine water bodies. The accumulation metals in marine sediment could pose problems because such metals may act as a source of contamination when the physico-chemical characters of environment are changed. Markiewicz- Patkowska et. al., (2005) conducted laboratory-based experiments of the adsorption and releases of metals from soil materials to solution. The heavy metals are known for their strong attraction to biological tissues. Metal ions once adsorbed into body are capable of reacting with a variety of binding sites and disturbing the normal physiology of organism leading to toxicity. Population explosion have increased the demand of water resources for a rapid industrialization due to which water has become highly polluted and hence including man various organisms are presenting a potential threat for survival in their respective trophic level.

Table. No. 1: Seasonal variations in Iron (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	0.56	0.60	0.43
S2	0.59	0.56	0.42
S3	0.56	0.57	0.43
S4	0.58	0.54	0.45
S5	0.54	0.49	0.41
S6	0.56	0.50	0.42
S7	0.65	0.55	0.48
S8	0.63	0.56	0.46
S9	0.62	0.58	0.49
S10	0.61	0.56	0.44
S11	0.57	0.58	0.48
S12	0.56	0.60	0.45

Fig. No. 1: Seasonal variations in Iron (ppb) content of Sediment during the year 2010-11

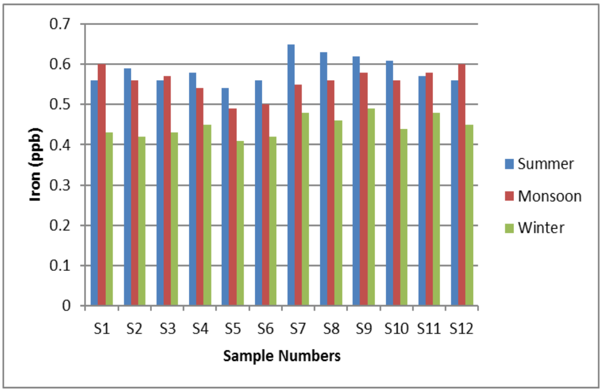


Table No. 2: Seasonal variations in Copper (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	0.46	0.36	0.41
S2	0.42	0.32	0.33
S3	0.44	0.33	0.36
S4	0.46	0.31	0.39
S5	0.52	0.30	0.42
S6	0.51	0.38	0.40
S7	0.45	0.48	0.42
S8	0.53	0.31	0.39
S9	0.41	0.36	0.45
S10	0.52	0.42	0.44
S11	0.48	0.39	0.56
S12	0.46	0.37	0.48

Fig. No. 2: Seasonal variations in Copper (ppb) content of Sediment during the year 2010-11

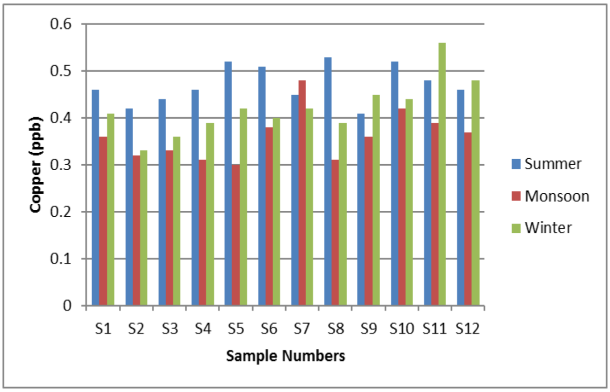


Table No. 3: Seasonal variations in Chromium (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	8.70	9.90	5.90
S2	8.29	9.19	5.18
S3	8.44	9.23	5.19
S4	8.75	9.44	6.10
S5	9.10	9.58	5.29
S6	8.93	9.20	6.22
S7	9.64	9.30	5.58
S8	8.29	10.29	6.33
S9	8.75	10.12	5.93
S10	9.53	9.33	6.13
S11	8.80	9.50	5.90
S12	9.12	10.26	5.80

Fig. No. 3: Seasonal variations in Chromium (ppb) content of Sediment during the year 2010-11

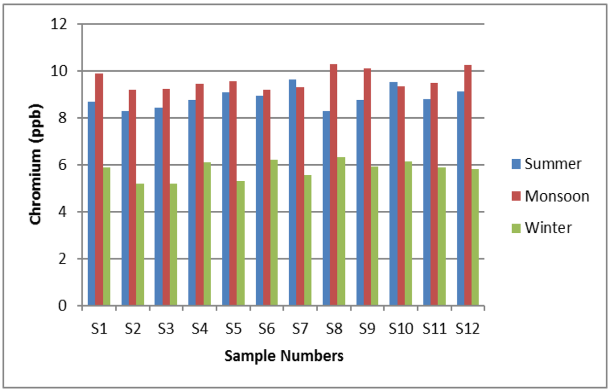


Table No. 4: Seasonal variations in Zinc (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	1.35	0.41	0.55
S2	1.03	0.28	0.38
S3	1.16	0.31	0.41
S4	1.40	0.38	0.46
S5	1.12	0.41	0.36
S6	1.11	0.49	0.54
S7	1.73	0.59	0.63
S8	1.70	0.54	0.60
S9	1.69	0.69	0.68
S10	1.62	0.49	0.61
S11	1.30	0.54	0.49
S12	1.39	0.62	0.54

Fig. No. 4: Seasonal variations in Zinc (ppb) content of Sediment during the year 2010-11

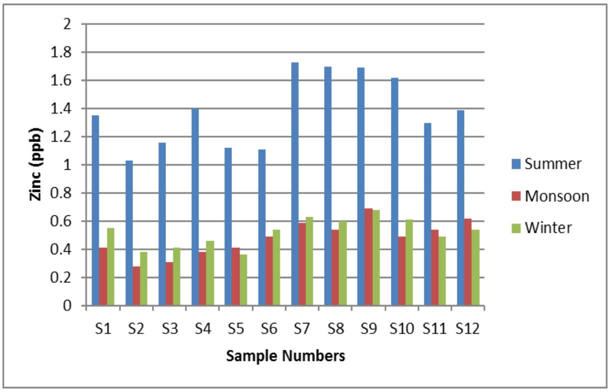


Table No. 5: Seasonal variations in Lead (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	17.10	24.13	16.22
S2	16.35	20.56	14.29
S3	16.44	21.89	15.22
S4	17.11	21.55	15.33
S5	16.74	22.14	16.40
S6	16.93	24.59	15.55
S7	16.13	23.11	15.88
S8	17.56	23.88	16.30
S9	17.50	21.13	16.11
S10	19.36	22.36	15.10
S11	18.89	24.56	14.28
S12	18.19	23.73	15.50

Fig. No. 5: Seasonal variations in Lead (ppb) content of Sediment during the year 2010-11

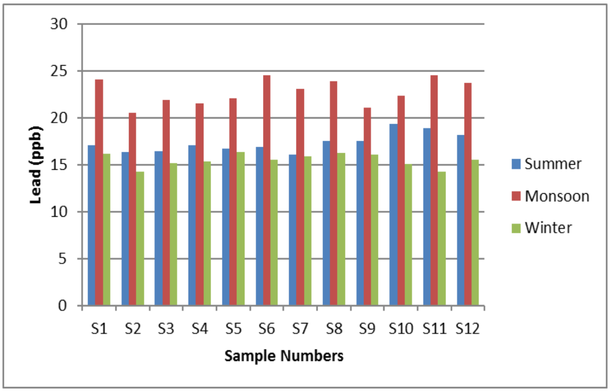


Table No. 6: Seasonal variations in Cadmium (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	1.22	3.28	3.33
S2	1.14	3.19	3.15
S3	1.08	3.17	3.20
S4	1.10	3.28	3.17
S5	1.50	3.34	3.90
S6	1.63	4.13	3.26
S7	1.33	4.33	3.88
S8	1.71	3.78	4.10
S9	1.08	3.93	3.90
S10	1.13	3.50	4.26
S11	1.19	3.95	4.14
S12	1.59	4.11	3.80

Fig. No. 6: Seasonal variations in Cadmium (ppb) content of Sediment during the year 2010-11

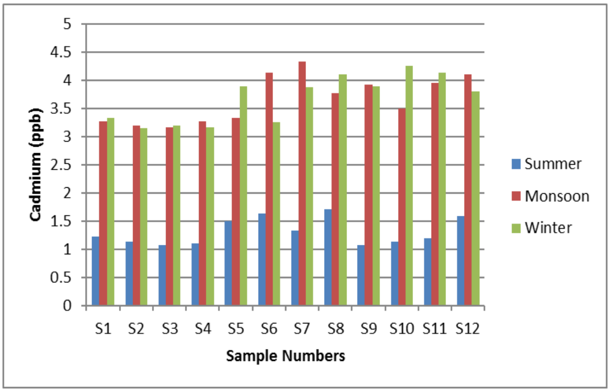
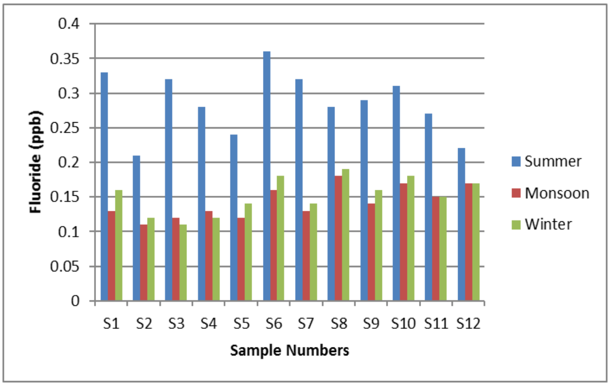


Table No. 7: Seasonal variations in Fluoride (ppb) of Sediment during the year 2010-11

Station Number	Summer	Monsoon	Winter
S1	0.33	0.13	0.16
S2	0.21	0.11	0.12
S3	0.32	0.12	0.11
S4	0.28	0.13	0.12
S5	0.24	0.12	0.14
S6	0.36	0.16	0.18
S7	0.32	0.13	0.14
S8	0.28	0.18	0.19
S9	0.29	0.14	0.16
S10	0.31	0.17	0.18
S11	0.27	0.15	0.15
S12	0.22	0.17	0.17

Fig. No. 7: Seasonal variations in Fluoride (ppb) content of Sediment during the year 2010-11



Conclusion:

This study will help in understanding the amount of toxic compounds (heavy metals) being received in the river water and its biological magnification in animals, particularly those at the lower level of food chain. This study will also help to make aware those local people or adjacent farmers for proper management of waste disposal and also to minimize use of synthetic inputs. The study indicated that increase in toxic waste day by day in Godavari River. The river produced biological magnification in food chain, which is a challenge to scientists, policy makers, administrators and all those involved in the conservation of the environment. Construction activity near the left and right banks of the river needs to be checked, encroachments removed, and encroachers suitably resettled elsewhere. This will improve the drainage, and reduce pollution. However, a participatory approach in the management of the water body is desirable. Creating awareness among the people in the neighborhood, and attempting reorientation of the stakeholders towards the cause of conservation of the reservoirs are important from this point of view.

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