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REVIEW ARTICLE

Heavy metals and River environment: A Review

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ABSTRACT

In India, owing to the unprecedented and exponentially growing human population, increasing pace of urbanization and rapid industrialization of the country has become inevitable. At present, even from the past, more attention has been focused on the fate of the heavy metals and their derivatives in the aquatic environment. The impact of heavy metals play important role in the environmental pollution. Therefore, a thorough understanding about the toxic effects of metals on living animals is needed nowadays. Though some metals are essential nutrients, they also serve as industrial and environmental hazards. The increasing industrialisation leads to the continual addition of pollutants to the environment. Recently, the accumulations of air-borne metals in plants and soils have received increasing attention. The pollutants from industries change the chemistry of water, thereby, damaging the biotic life. The heavy metals act either synergistically or antagonistically on the aquatic biota and in some cases may cause a decrease in biotic diversity.

Key words: River, Heavy metals, Wastes and Pollution.

HEAVY METALS AND ENVIRONMENT

Water pollution may be defined as the "alternation of physical and biological properties of water or any addition of foreign material and the natural water which may have harmful effect on living beings, human agricultural system and other biological aspects, either directly or indirectly or immediately or after sometimes or after a very long period" [1]. Among the several characteristics of water quality the most important factors such as temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, biological oxygen demand, chemical oxygen demand and nutrients, like phosphate, silicate, nitrate and nitrites, ammonia etc., and heavy metals *viz.*, copper, chromium, cadmium, lead, zinc, manganese and iron will play an important role in the life of aquatic organisms [2].

Water quality monitoring is an important aspect of the overall water quality management and water resources development. A well planned and well managed water quality monitoring system is required to predict changes or trends of changes in the quality of a particular water body, so that creative and preventive measures can be taken to restore and maintain ecological balance in the water body [3]. However the objectives of water quality monitoring under different hydrological situation may be different [4].

Environmental pollution monitoring is essential at strategic point in natural water bodies, as well as in commercial and industrial locations [5]. In general, there are two types of monitoring (a) Biological monitoring and (b) Physico– chemical monitoring. Biological monitoring is based on the assessment of population of critical species that are sensitive to pollution; while physico – chemical monitoring is based on the actual measurement of physical parameters e.g pH, temp, rainfall, turbidly. Chemical parameters such as pesticides, insecticides and heavy metals, *viz.*, copper, zinc, cadmium, chromium, lead, iron, cobalt mercury etc [6]. Biological monitoring directly provides qualitative information with regards to the health chemical monitoring provides quantative information about the presence of pollutants in the natural water bodies. Physico – chemical monitoring is also provides stable information with regards to incoming undesirable effluents, which eventually indicate the possible source of such effluents. Biological monitoring does not provide any such hints [7].

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Nearly 80% of ocean pollution enters from the land, virtually anthropogenic activities have serious effect on the quality of nearby water environment. The fertilizers that the farmers used previously are gradually washed by rain into the surface water or ground water nearby, chemicals / toxic chemicals / toxic substances released from the chimneys enters the atmosphere and then reaches the surface as rain entering rivers, lakes and finally seas causing water pollution that in why? It is such a difficult problem to the human beings at present. Further, nearly 8 billion peoples disposing sewage wastes to the environment. Sewage disposal affects immediate surrounding environments and leads to many water – borne diseases. The sewage water contains several chemicals and carries pathogens, which inturn cause illness such as hepatitis, cholera and typhoid. Fertilizers and sewage combined together to form rich nutrient which inturn can produce harmful algal bloom that are naturally reduces dissolved oxygen content in the water bodies so that aquatic organisms face respiratory problem.

Heavy metals are considered as major resources of pollution in natural water [8]. These have received considerable attention because of the inherent toxicity to the living aquatic forms. The toxicity of heavy metals in water in affected by pH, hardness, alkalinity and organic materials [9]. Another type of toxic pollution comes from heavy metals such as cadmium, mercury and lead. Recently, a high toxic chemical called tributyltin (TBT) is used in paints to protect boats from the ravaging effects of the ocean. Mineral, containing heavy metallic elements are of widespread occurrence in rocks and soils, when they weathered, cations of the heavy metals are liberated and find their may into surface waters and soil waters. Lead, copper and zinc have been extensively mined and whose environmental levels have been strongly influenced by man [10] all are toxic to living animals and are considered as serious pollution.

A number of industrial units in and around located on this coast and discharge their effluents, treated and or untreated into the sea, and coastal towns also discharge untreated municipal sewage into the sea. Environment and development are two side of the same coin. The need for development through socio economic activities especially with the growing populations and a desire for higher standard of living with industrial production in obvious practically all socio-economic activities for example Industries, agriculture, transport, construction, of road housing have contributed to the environmental degradation including water, air and soil. The complexity of the problems due to the involvement of increasing parameters, have necessitated a multi-disciplinary approach to environment pollution [11]. The role of water in nature not only for the view point of human considration but also forms the viewpoint of a suitable habitat for numerous organisms [12]. Rapid industrialization and extensive use of pesticides in agriculture have put a severe strain on the aquatic ecosystem resulting in the deterioration of its quality. Increasing pollution of water bodies has becomes a matter of great concern over a period of last few decades [13].

In aquatic ecosystem metallic compounds occur in low concentration. Heavy metals may come from natural sources, leached from rocks and soils according to their geochemical mobility and also from anthropogenic source as the result of human land occupation, and industrial pollution. Depending on their solubility, these metals may be eventually associated with suspended particulate matter or accumulate in the bottom sediments. The increase of industrial activities has intensified environmental pollution problems and the deterioration of several aquatic ecosystems, with the accumulation of metals in the target organs. Trace elements are essential to life but at high concentration may become hazardous. Heavy metals such as cadmium, arsenic and lead can cause several problems in aquatic environments due to their persistence, toxicity and tendency to accumulate in tissue [14].

Living organisms require trace amount of heavy metals for its survival while it exceeds to its level can be detrimental to organisms. All the heavy metals exist in colloidal, particulate and dissolved phases. Aquatic organisms may be adversely affected by heavy metals and tend to higher tropic level in the aquatic system. Heavy metals are finding their way into the system through chemical and physical weathering of rocks decomposition of plants and animals, detritus and plant exudates the anthropogenic inputs and predominantly from pollution centers and industrialized regions.

Heavy metals in the sediments are essential to assess the extent of metal pollution. The distribution of heavy metals in solution has widely been recognized as a major factor in the geochemical behavior, transport and biological effects of these elements in natural waters [15, 16]. Sediments samples have also been widely used to

monitor heavy metal pollution in coastal areas [17, 18]. Moreover, sediments have aptly been called as trace elements trap because they eventually receive almost all the heavy metals, which enter the aquatic environment [19]. Some studies were carried out on the distribution of heavy metals in water and sediments from Indian coastal regions are limited [20-23]. Many investigations have been carried out on adsorption of dissolved metals in estuarine in relation with the role of physical and chemical parameters [24 - 27].

In a plant soil system, strong absorption and fixing of heavy metals by soil can easily cause residual accumulation in the soil, resulting in over absorption of heavy metals by growing plant [28, 29]. The plant products are harmful to the health of humans [30]. It is consider that mangroves show the ability to accumulate metals and possess a certain tolerance to relatively high levels of heavy metals pollution [31]. Many studies had been carried out on various plants to determine its heavy metals accumulation capability [32, 33]. One of the major sources of heavy metal pollution is the mining and swelling of metalliferous ores [34]. Water pollution around the mining and smelting areas has been clearly demonstrated by the high concentration of heavy metals in water, sediments and aquatic [35]. One method of phytoremediation is phytoextraction which uses metal accumulating plants to remove pollutant from contaminated soil by concentration them in the harvestable above ground parts [36].

Concentration of heavy metals such as Copper, Zinc, Cadmium, Lead, Iron, Chromium and Manganese occur in marine seawater in different forms and in different concentrations. Heavy metals can enter a water supply by industrial and consumer waters or even from acidic rain, breaking down of soils and releasing heavy metals into streams, Lakes, Rivers and ground water [37]. Heavy metals such as copper, zinc, cadmium, lead, iron, chromium and manganese occur in the marine water in different forms at different concentrations.

Copper concentration was maximum during the monsoon seasons and minimum during the pre-monsoon. Such a seasonal variation of Cu concentration in sediments perhaps was due to the presence of major sources of metal pollution, intensive of human activity. All over the world discharge of domestic wastes and land run-off reaching the coastal area and also industrial effluents, sewage outlets and municipal wastes at . Phytoplankton activity might have also facilitated the seasonal variation in Cu as this metal is an essential one for phytoplankton.

Zinc concentration was high during the monsoon at both stations. High Zn concentration in water could have resulted due to the release of this metal from the sediments and abundant organic matter [38]. Zn Concentration was low concentration during the summer season at both the stations. This would have resulted due to the utilization and uptake of Zn along with other nutrients by the biota including phytoplankton. [39] have also established that Zn could get strongly depleted from the surface waters as it has a nutrient type of distribution in seawater.

Cadmium concentration was more during the monsoon at the both stations less during the summer season at both the stations. According to [40], Cd is released into the atmosphere by fossil fuel and by the burning of agricultural and municipal wastes, including dried sewage sludge. Lead concentration was more during the monsoon in both stations due various sources of pollutions paints diesel fuel combustions pipes and solder discarded batteries and Natural deposits. Lead reduces mental capacity, inference with Kidney and neurological functions, hearing loss, blood disorders, hypertension and death may due to high level.

Iron-concentration was more during the monsoon season in stations due to various sources of pollution leaching of cast iron pipes in water distribution system and by natural process. The effects of iron is to brackish color, rusty sediment, better or metallic taste, brown green strains iron bacteria and discolored beverages.

Chromium is highly toxic and responsible for several cases of poisoning through food. Small quantities of cadmium cause adverse changes in the arteries of human kidney. It replaces zinc biochemically and causes high blood pressures, kidney damage etc [41]. The sources of chromium pollution septic system industrial discharge and Geological mining sites both ststions show chromium concentrations high in monsoon season. A number of toxic elements are introduced into the aquatic environment from the effluents coming from the large industries resulting biodiversity and changes in water quality. For example effluents from textile mills and electroplating contained as much as 20-40ppm of chromium [42].

Manganese concentration was more in monsoon season in both Stations the various source of pollution are land fill and deposition of rocks and soils. [43] analyzed dissolved trace metals (Mn, Co, Cu, Fe and Zn) from the northern Indian Ocean and the Arabian Sea. Higher values of these trace metals were found in the surface layers when compared with the bottom, and exhibited a decreasing trend in their concentrations with depth. Except copper all other metals recorded higher values in inshore waters than in oceanic waters. An extremely low concentration of dissolved cobalt observed in northern Indian Ocean was attributed to its least occurrence in that area under certain conditions. Further, the author is of the opinion that the organic form of manganese in seawater plays a major role in its distribution in the marine environment.

The heavy metal Cadmium gets bioaccumulated in freshwater biota and affects severely. Normally a good correlation exists between total cadmium concentration in water and plant tissues. A positive correlation between residues of cadmium levels in benthic organisms and sediments are found. [44] found that population of *Potamogeton crispus* inhabitant near industrially contaminated lake had absorbed 1.5 kg of cadmium and that release of cadmium from dead plants could rise water concentration by a maximum of 1.0 ppm. Its importance in environmental toxicity lies with the fact that it can be toxic at very low concentration to aquatic organisms. Cadmium is extremely toxic to aquatic organisms.

The toxicity is quite variable and depend upon the type of test organism, its life stage, time of exposure and environmental parameters such as temperature, pH, dissolved oxygen, hardness, concentration of organic substance. The factors such as hardness and pH may affect amount of biologically active forms of cadmium, while others like dissolved oxygen and temperature may influence the tolerance capacity of the organisms. [45] reported that exposure of species of green algae to $CdCl_2$ resulted in the formation of intra mitochondrial cadmium granules. Cadmium also caused swelling, vacuolization and degeneration of mitochondria. Cadmium concentrations of 0.01 - 0.1 ppm also reduce the ATP and chlorophyll in many species and decrease oxygen production. Cadmium has been reported to cause depression in oxygen consumption of *Carcinus maenas* and *Cancer irroratus* at 0.5 to 4.0 ppm and 0.12 to 1.0 ppm respectively during 48 hours of exposure. In tests conducted for 30 days with cadmium concentration of 0.003 to 0.006 ppm. [46] found that the oxygen consumption was significantly increased. [47] investigated that cadmium may induce a number of biochemical changes at acute and subacute levels; these include changes in enzyme activities, modification of carbohydrate metabolism, hematological changes, and changes in ability of blood proteins to bind cadmium. [48] exposed *Daphnia magna* at 0.2 and 2.0 ppm cadmium for 8 days and found that the metal increased ALA-D activities at both the concentrations, but at 2.0 ppm haemoglobin content decreased.

Acute toxicity of Cd to fish is mainly caused due to gill damage, the fish has to obtain oxygen from water and results anoxia. Similarly it has also been stated that Cd inhibits the action of acetyl cholinesterase, causing death through paralysis of the respiratory muscles and depression of respiratory system. However, Cearley and Coleman (1974) suggested that damage to the ion regulating mechanism in fish rather than respiratory impairment or damage to the nervous system, is more likely to be the cause of death. [49] studied the transfer of cadmium through per fused gills from rainbow trout and found that a ten fold increase in Cd concentration resulted in a hundred fold increase in cadmium transfer. The cadmium transfer through the gills was reduced by addition of a strong complexing agent to the solution which suggests that the transfer is related to the concentration of the free cadmium ions.

Several studies have been carried on impact of cadmium on biochemical, histological haematological and behavioural responses of fish. [50] reported decrease in liver and kidney enzyme activities in rainbow trout following a chronic exposure [51]. The toxicity of the metal to freshwater fish depends upon the species, age weight, water quality and presence of other toxicants. [52] reported morphological aberrations in mature erythrocytes of *P. conchonius* exposed to 0.63 or 0.84 ppm Cd for 30 to 90 days. [53] reported the occurrence of deformed vertebrae in *Cyprinus carpio* exposed to 0.01 and 0.1 ppm cadmium. [55] found that 0.0034 ppm Cadmium inhibited the oxygen consumption of *Mystus vittatus* by 50 per cent exposure for 12 hours. [54] noted erratic movements, muscular spasms, and convulsions in bluegills after 13 weeks exposure to 0.85 ppm Cd in hard water. [54] showed that bluegills exposed to 0.1 and 0.25 ppm Cadmium for 14 days swam two to eight times faster than the controls. These fishes treated for the same test

period with 0.5 ppm Cadmium exhibited depressed swimming activity and 30 per cent mortality.

Ingestion of large amounts of cadmium (i.e., 13 to 15 µg/g cadmium) leads to nausea, diarrhoea, abdominal pains, muscular rheumatism and weakness [55]. The acute lethal dose by ingestion has been estimated to be between 5 and 50 µg/gm of body weight. Chronic cadmium poisoning was first recognised in industrial workers and mostly involved kidney damage, obstructive lung disease and tubular proteinuria. The initial symptom of the diseases was lumber pain and muscular rheumatism in the legs and later skeletal deformation took place as a result of softening of the bones.

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