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Heavy Metal Pollution in Wetlands around Coimbatore

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Abstract: Heavy metals can be the major cause for the wetland pollution in Coimbatore. This results in causing harmful effects to aquatic organisms, plants, animals and humans thereby polluting the environment. As wetlands are the one of the world's most productive ecosystems and they provide valuable goods and services for humankind, in this review importance of wetlands, commonly available metals in wetlands, contamination, threats and ill-effects caused due to metal contaminants are discussed. This information will be useful in knowing harmful effects caused in the wetlands due to heavy metals and also to find better treatment methods for developing contamination free wetlands in Coimbatore.

Introduction

Wetlands situated in the vicinity of the cities generally undergo rapid degradation due to various factors related with city development such as waste dumping, industries and large-scale reclamation for other uses.Globally, wetland is estimated to cover 5–10% of theearth’s terrestrial surface (Mitsch and Gosselink 2007).Coimbatore being a rapidly developing city in the western part of Tamil Nadu, has several wetlands and lakes in and around its limits. These wetlands have been facing rapid degradation due to liquid or solid waste disposal, filling and reclamation, real-estate ventures and industrial development has open drainage and sewerage systems which joining these lakes without any prior treatment. Hence, the present review wasundertaken in Coimbatore on urban lakes wetlands to know about water quality of these water bodies with reference to the pollution from various sources. It is also one of the fastest growing cities in Tamil Nadu, India that has around 28 wetlands in and around the city which are fed by the river Noyyal. These wetlands serve as storage and percolation tanks.They are the major recharge sites for groundwater (Rachna et al.,2010). The wetlands are highly polluted due to heavy metals such as lead, chromium, cadmium, nickel and copper.

Heavy metals are the most common type of pollutant and are used as environmental monitoring factor. They are formed from chemical leaching of bed rock, discharge of urban, industrial and rural waste waters and water drainage. Various methods such as toxic unit, probable effect level (PEL), Enrichment factor (EF), geo acccumulation index (I_{go}) (Panda et al,2010) have been provided to detect heavy metal contamination.Wetlands in Coimbatore sufferfrom pollution due to various industrial, municipal and domestic sources and heavy metal contamination (Mohanraj et al.,2000) which results in various ill-effects to humanity and avian habitat andwhile industrialised countries can probably pay for most of theseservices from tax incomes, this is not so in developing countries, where wetlanddestruction can have a very serious impact on the livelihoods of the rural poor.

Importance of Wetlands

Wetlands are the main custodians of these valuable water resources. They act as ‘banks’ from where water may be drawn, and groundwater replenished. The wetland values are best understood in terms of their intrinsic conditions (biological, chemical and physical), which allow them to carry out their distinctive functions andgenerate products (Dugan, 1990). Their functions comprise those natural processes that sustain economic activities and fortify ecological integrity. Examples are groundwater discharge and recharge, flood control, shoreline stabilisation and nutrient retention. Besides water being the most basic product that a wetland can provide, food, fuel wood, wildlife, fisheries, forage and agricultural resources are additional wetland products. Wetland attributes are closely intermeshed with the ethical and aesthetic values that human beings attach to them (Roggeri, 1995).

Wetlands play a major role to attain the healthy environment and a range of ecosystem services in various ways. They protect and regulate the water resource as they hold back water during floods and release it during dry periods and help to prevent soil erosion. They also purify water by trapping many pollutants by acting as natural filters and helps in flood control (Boyd and Banzhaf, 2007).Wetlands produce 50 to 70% of watarshedstreamflow even though they comprise only $1/3^{rd}$ of the basin. Modern wetlands provide many critical functions in global ecology, including providing habitat and food for diverse species, and aiding in groundwater recharge and water detention and retention, which allows for high maintenance of water table in wetlands as well as reduce flooding in adjacent ecosystems (Stephen et al., 2006). They provide important services to human society (Nitin et al, 2014). It has unique ecological factors includes carbon sequestration, flood control, nutrient removal, toxic retention, ground water recharge (Turner et al, 2000). They help to conserve soil, water, biodiversity (Balasubramaniam and Selvaraj, 2003).

Adamus& Stockwell (1983) identified and documented the functions that wetlands perform for people:

- Ground water recharge
- Ground water discharge
- Flood storage and desynchronization
- Shoreline anchoring and dissipation of erosive forces
- Sediment trapping
- Nutrient retention and removal
- Food chain support
- Habitat for fisheries
- Habitat for wildlife
- Active recreation and
- Passive recreation and heritage value.

Coimbatore and its Wetlands

Coimbatore is gifted with a unique spread of a number of water bodies that store rain water, recharge groundwater and provide shelter for a vast array of biodiversity. Ramsar convention defines wetlands as “areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres”

If we look at patterns of human settlements at any time of history we will notice that most cities, towns and villages are located around wetlands. Similarly Coimbatore developed in the watershed expanse of the Noyyal river basin and consists of a network of lakes and canals. In the past, there were numerous lakes in the surrounding areas but most got filled up. Currently, there are 24 lakes in Coimbatore.

1. KurichiLake (Ukkadam)
2. Pudukulam (Vedapatti Lake)
3. Kolarampathy Lake
4. Narasampathy
5. KrishnampathyLake
6. SelvampathyLake
7. Kumaraswamy (also known as Muthannakulam)
8. SelvachinthamaniLake
9. SottaiyandiKuttai Lake
10. Ganganarayananasamudharam Lake

11. Puttuvikki Lake (aka Perur Lake or Sundakkamuttur Lake)
12. Senkulam (aka Kuniyamuthur Lake)
13. Kuniyamuthur small Lake
14. Periyakulam (also known as Ukkadam Big Lake)
15. ValankulamLake
16. Kurichi Lake
17. Vellalore Lake
18. Singanallur Lake
19. Pallapalayam Lake (aka Odderpalayam Lake)
20. Kannampalayam Lake
21. Irugur Lake
22. Achankulam (aka Neelambur Lake)
23. Sulur Big Lake
24. Sulur Small Lake

Heavy Metal Contamination in Coimbatore Wetlands

Among all the possible pollutants that are responsible for the contamination of wetlands and ground water, heavy metals are most important. Heavy metals are stable and persistent in environment because they cannot be degraded (Yuvaraja et al., 2014).They pose risks not only to humans but also to plants and animals because of their extremely toxic effects and have been the main reason behind large number of afflictions (Taha et al., 2001). Heavy metals tend to accumulate in the living organisms since they are not readily biodegradable and cause various diseases and disorders (Guo et al., 2002). Through food chain these heavy metals reach human body. Some of heavy metals such as zinc, copper are good for the human health but in certain concentrations. So, it is extremely important to eliminate these heavy metals from wastewater in order to protect living organisms and environment. Therefore, it is necessary to develop new; environmental friendly process for the treatment of wastewater and industrial effluents (Gaballah et al., 1998).

Cadmium

Cadmium waste streams from the industries mainly end up in wetlands. The causes of these waste streams are zinc production, welding, electroplating, pesticide fertilizer, CdNi batteries, nuclear fission plant (Aluri et al., 2007), phosphate ore implication and bio industrial manure. It can strongly adsorb the organic matters and hence is extremely dangerous, as the uptake through food will increase. Cadmium is a cumulative poison and the biological half-time for total body burden in human beings is between 10 and 30 years.Animals eating or drinking cadmium sometimes get high blood-pressures, liver disease and nerve or brain damage (Saikaew*et al.,* 2009). Cadmium also causes lung fibrosis, dyspmea and weight loss.

Chromium

Excess amounts of chromium uptake are very dangerous due to its carcinogenic effects. Chromium is widely used in electroplating industry as a protective coating for iron and steel, and in alloys with other metals. High soil chromium levels are usually associatedwith anthropogenic contamination, mainly fromindustrial operations (Avudainaayagam, 2002).Leather tanning and chromium plating industries are also the major causes for environmental influx of chromium (Trivedi, 1989). Chromium is a potential soil, surface water, groundwater, sediment and aircontaminant.As a result, in industrialized city like Coimbatore we are living in an environment with potentially harmful toxic metal ions. It will spoil water quality, soil fertility and may affect better living. Chromium exists in +III and +VI oxidation states which are poisonous to living organisms (Park et al., 2007). In low concentration, Cr(III) is beneficial for the living organisms but it is highly toxic in high concentrations (Gode, 2006). Cr(VI) is 500 times toxic than Cr(III) (Sarin, 2006). Cr(VI) causes severe and serious health problems such as lung tumors and cancer. It also poses problems such as kidney, liver and gastric damages (Mohan et al., 2005).

Copper

The release in aquatic environment and accumulation of copper could result in toxicity to both human and aquatic life (Sudhir et al., 2007). They are extremely toxic as they damage nerves, liver, kidney and bones and also block functional groups of vital enzyme. Among the heavy metals, copper is the major available type of heavy metal in the aquatic environment. Copper in the blood system may generate reactive free oxygen species and damage the lipids, proteins and DNA (Brewer, 2010). The excess Cu compound in the body may also affects on aging, mental illness, Indian childhood cirrhosis, schizophrenia, Wilson's and Alzheimer's diseases (Hossain et al., 2010). Too much intake of copper results in its accumulation in the liver. Excess copper causes gastrointestinal problems, kidney damage, and anemia. Lung cancer is related to long term inhalation exposure of copper containing sprays (Liu et al., 2009). Long term exposure also causes nose, mouth and eyes irritation, headache, dizziness and diarrhea (Sud et al., 2008). According to World Health Organization the maximum acceptable concentration of Cu (II) in drinking water is 1.5 mg/L (Rao, 1992).

Zinc

Zinc is an essential metal and is a constituent element of human diet, its daily requirement is 10 to 20 mg. It occurs widely in nature and major production of this heavy metal is used in manufacture of dry cell batteries and in the production of alloys such as brass and bronze. Though zinc is basically less toxic than other heavy metals and its permissible limit for surface water is 5.0 mg/l but an excess of zinc does causes a number of ailments (Hasan et al., 2003). Zinc is responsible for governing various physiological functions of the living tissues. Different biochemical processes in the living organisms are also controlled by Zinc. However, excessive zinc can cause health problems such as stomach cramps, skin irritations, vomiting, nausea and anemia (Oyaro et al., 2007). It also causes short term illness called "metal fume fever" and restlessness.Zinc induced damage to living systems mainly includes impairment in functioning of several essential enzymes involved in metabolism (Rout and Das, 2003).

Nickel

Wastewater commonly includes nickel in it. Due to inefficient industrial effluent treatment techniques, many rivers and streams in Coimbatore are serving as receptacles for industrial effluent containing hazardous materials including heavy metal such as lead. Whenever it is exposed to the natural eco-system, accumulation of metal ion in human bodies will occur through either direct intake or food chains. Because of the high solubility, nickel make enormous detrimental impact on the quality of river water and associated aquatic lives.

They cause global deterioration of environmental quality, contamination of soils, ground water, sediments, surface water and air with hazardous and toxic chemicals (Ansari *et al.*, 2007).When the concentration of Nickel is greater than its critical concentration it causes serious damage to lungs and kidneys, gastrointestinal problems, pulmonary fibrosis and skin dermatitis (Borba et al., 2006). It is a human carcinogen. The acceptable limit of Ni is 20.0 mg/L (Prasad and Freltas, 2000, Bulut, 2003).

Lead

Lead levels in the aquatic environments of industrialized societies have been estimated to be two to three times higher than those of pre-industrial levels. Any measurable amount in lead may have negative health effects. The toxicological effects of lead in humans include inhibition of haemoglobin formation (anemia), sterility, hypertension, learning disabilities. It is also present in soil at varying concentration levels and found in vehicle exhausts, used motor oil, paints and insecticides (Dingwang et al., 2001). Lead is the potential toxic metal in marine ecosystem affecting growth and respiration in organisms (Senthilkumar et al., 2014).Hence, the removal of lead from water is essential to protect human and environmental health.Lead causes damage to central nervous system. Lead can also damage vital organs such as kidney, liver. It has unhealthy effect on the reproductive system, basic cellular and brain functions. Various diseases such as anemia, insomnia, headache, and dizziness, and irritability, weakness of muscles, hallucination and renal damages [34] are also caused by high lead concentrations. According to EU (European Union), USEPA (United Stated Environmental Protection Agency) and WHO (World Health Organization), the maximum acceptable values of lead in drinking water and surface water used for drinking are 10 mg/L and 50 mg/L, respectively. However, recently as per instructions mentioned in an EPA (Environmental Protection Agency) document, a zero lead value has been recommended as national primary drinking water standard. In India, the permissible limit of lead in drinking water is 0.01mg/L (Frisbie et al., 2002). Accumulation of the lead in humans causes abnormal calcium metabolism and immune disorders. Fetuses and babies are particularly vulnerable to lead-induced intelligence impairment.

Arsenic

Arsenic in natural waters is a worldwide problem. Arsenic is mobilized by natural weathering reactions, biological activity, geochemical reactions and other anthropogenic activities (Dinesh et al., 2007). Most environmental arsenic problems are the result of mobilization under natural conditions. However, mining activities, combustion of fossil fuels, use of arsenic pesticides, herbicides, and crop desiccants and use of arsenic additives to livestock feed create additional impacts. Inorganic forms of arsenic most often exist in water supplies (Bodek et al., 1998). Long term drinking water exposure causes skin, lung, bladder, and kidney cancer as well as pigmentation changes, skin thickening (hyperkeratosis) neurological disorders, muscular weakness, loss of appetite, and nausea (Jain et al., 2000) . This differs from acute poisoning, which typically causes vomiting, oesophageal and abdominal pain, and bloody “rice water” diarrhea (Duker et al., 2005). Long term exposure of drinking water contaminated with arsenic causes skin, lung, bladder, and kidney cancer. It also causes pigmentation changes, skin thickening (hyperkeratosis) neurological disorders, muscular weakness, loss of appetite, and nausea. High levels of arsenic causes vomiting, esophageal, abdominal pain, and rice water diarrhea. According to the World Health Organization (WHO), the permissible limit for arsenic in drinking water is 10 ppb (Dinesh et al., 2007).

Table.1 Heavy Metals and its Toxicities (Barakat, 2010)

Heavy Metals	Toxicities
Cadmium	Kidney damage, Human carcinogen, Renal disorder
Chromium	Headache, Vomiting, Carcinogenic, Diarrhoea, Nausea
Copper	Wilson disease, Insomnia, Liver damage
Nickel	Dermatitis, Nausea, Human Carcinogen, Chronic asthma, Coughing
Lead	Circulatory system and Nervous system, Damage the fetal brain, Diseases of the kidneys
Arsenic	Skin, Lung, Bladder, and Kidney cancer as well as pigmentation changes, skin thickening (hyperkeratosis) neurological disorders, muscular weakness, loss of appetite, and nausea
Zinc	Stomach cramps, Skin irritations, Vomiting, Nausea and Anemia

Contaminations Caused Due to Heavy Metals

Wetlands are among the worlds' most important, but also most threatened, environmental resources. Wetland losses have been in progress particularly from the industrial revolution onwards, because wetland functions could not successfully compete for space with other land uses (Best et al., 1993). Coimbatore has many wetlands and these wetlands are now transforming to wastelands unfortunately because of the increasing discharge of effluents from different industries. These effluents havehazardous effects which reduce the productivity of the soil and also contaminate the natural waterbodies as well as the ground water. This may cause the wetlands unfit for human and animal consumption. Heavy metals such as Cd, Cr, Cu, Ni, Pb which are present in this effluent tend to exceed the permissible limit are not applicable for drinking purposes and irrigation facilities.

Threats to Wetlands

Though wetlands are the most productive of ecosystems on earth, they are also themost threatened. Wetland destruction and alteration has been and is still seen as anadvanced mode of development, even at the government level. Wetlands and their valueremain little understood and their loss is increasingly becoming an environmentaldisaster.Wetland loss is evident wherever major developments like dams, irrigation schemes andconversion projects are present in the developing world. While most of the threats thatwetlands face result from their misuse, many are also related to unsustainable resourceextraction. Another important reason for their vulnerability is the fact that they aredynamic systems undergoing continual change. As a result, manywetlands are temporary features that disappear, reappear and re-create themselves overtime (Barbieret al., 1996).The threats to the various wetlands are related to the morphology and the forcing variables of thesystem. They can be divided into current and long-term ones.Current threats are due largely to human activities are, changes in hydrology leading to increaseddischarges, decreases in water level fluctuation,drawdown, desiccation and subsequent mineralizationof the topsoil, air pollution leading toacidification, eutrophication and toxificationofterrestrial and aquatic ecosystems and directeutrophication and toxification of surface waters(Connell, 2003).

Desiccation is caused by drainage and increased use of surface water for agriculture, togetherwith greater withdrawal of groundwater for drinking water purposes.In terrestrial and marine systems, eutrophication is mainly caused by nitrogenous substances and potassium. In freshwater aquatic systems phosphate concentration is more critical. Wetlands, which contain both terrestrial and aquatic landscape elements, often suffer, therefore, from all substances responsible for eutrophication. Many nature reserves are mainly impacted byatmospheric deposition of nitrogenous substances,but also by polluted surface- and groundwater.General effects are loss of species diversity and increases in primary production.Systems which are suffering already from acidification are extra sensitive for heavy metal deposition thereby results in the toxification of wetlands.Acid deposits harms the irrigation and it originates largely (85%) from industrial activity outside the country. Effects on the abiotic environment are decreases in pH of the open and pore water, release of heavy metals and increases in nitrate and sulphate, which usually result in decreases in primary production and deterioration of flora and fauna.

Long-term threats

Long-term threats are expected to occur mainly because of climate changes which are also partly of man-made origin. Because the climate changes strongly affect the hydrological cycle, which is so critical for wetlands, wetlands are expected to be very sensitive to these changes. Two climate change-related factors are considered important for wetlands: the rise in temperature and the increase in ultraviolet-B irradiation.

Climate change - Increased air temperature; shifts in precipitation; increased frequency of storms, droughts, and floods; increased atmospheric carbon dioxide concentration; and sea level rise could also affect wetlands.

Urbanization - Wetlands near urban centres are under increasing developmental pressure for residential, industrial and commercial facilities. Urban wetlands are essential for preserving public water supplies.

Anthropogenic activities - Due to unplanned urban and agricultural development, industries, road construction, impoundment, resource extraction and dredge disposal, wetlands have been drained and transformed, causing substantial economic and ecological losses in the long term.

Agricultural activities - Following the Green Revolution of the 1970s, vast stretches of wetlands have been converted to paddy fields. Construction of a large number of reservoirs, canals and dams to provide for irrigation significantly altered the hydrology of the associated wetlands.

Hydrologic activities - Construction of canals and diversion of streams and rivers to transport water to lower arid regions for irrigation has altered the drainage pattern and significantly degraded the wetlands of the region.

Deforestation - Removal of vegetation in the catchments leads to soil erosion and siltation

Pollution - Unrestricted dumping of sewage and toxic chemicals from industries has polluted many freshwater wetlands

Introduced species - Indian wetlands are threatened by exotic introduced plant species such as water hyacinth and salvinia. They clog waterways and compete with native vegetation.

Water Pollution

Metal pollution and eutrophication are caused due to large quantities of municipal effluents like dyes and electroplating effluents which are discharged into the wetlands. Eutrophication declines fish populations and hence results in loss of cultural services by the wetlands (Verhoven et al, 2006). High nutrient content initiates algal growths, which are the reasons for eutrophication (Zhenglei et al, 2016). Untreated effluents which are discharged from small scale industrial units lack in adequate treatment facilities are the major factor polluting these water bodies. They are also polluted due to the important factors such as discharge of industrial and domestic effluents, exploitation of ground water and reclamation. Water in the most of wetlands is heavily degraded due to pesticides and fertilizers and discharge of industrial and municipal waste water (Liu and Diamond, 2005).

Dumping of wastes

The waste lands appears to be dustbins in the Coimbatore city due to high population and expanding industries which led to large amount of domestic, industrial, municipal wastes. Hospital waste and discarded plastic bags which are dumped in the water bodies that makes the water bodies highly unhygienic.

Overfishing and Destructive Fishing

Overfishing may result in the loss of some fish species and their replacement by others (Lemlem, 2003).This effect cascades throughout the trophic food web and ends in structural ecosystemchanges, which are sometimes difficult to detect unless monitored on a continual basis.Amongst the destructive fishing techniques employed on these lakes are the use ofherbicides, fishing in reed belts, chase and trap fishing and shore beach-seining. Theseactivities deplete juvenile stocks and destroy nursery grounds. The immediate and longtermeffects of over-fishing and destructive fishing on biodiversity resources have notbeen properly assessed.

Common threats to all lakes

- Institutions for the management and proper use of fisheries are weak, as is law enforcement for resource and protected area conservation;
- Lack of awareness, information and research on wetlands;
- Poverty, the lack of livelihood alternatives for farmers, poor agricultural technology and productivity;
- Dependence of local communities on wood fuel for energy;
- The delicate arid and semi-arid environment surrounding the lakes, associated low and erratic rainfall and the threat of high human population pressure;
- Illegal settlement in parks and conservation areas;
- Livestock pressure on conservation areas.

ILL-Effects of Heavy Metal Pollution in Wetlands

Depletion of Ground Water - The wetlands around Coimbatore which acts as storage and percolation lakes are the major sources of ground water which is used in domestic and industrial activities. Heavy exploitation of groundwater is the root cause for the serious damage to the aquifer. This results in fall in water levels of the wetlands.

Declinein Agriculture - Total irrigated area had declined since there is no concern for protecting the wetlands. The wetlands have been converted to real-estate plot, that the farmers around the wetlands are selling their lands.

Contaminationof Ground Water - The industrial activities are affected because of high concentration of electrical conductivity and total hardness. The content of total dissolved solids (TDS) levels and poisonous substances in the contaminated wetlands are very high. Human systems and eco-systems are highly severe damaged due to the contamination.

Weed Growthand Eutrophication - Due to the discharge of sewage in these wetlands vast sheet of mesquite (*Prosopisjuliflora*), water hyacinth (*Eichorniacrassipes*) and pink morning glory (*Ipomoea carnea*) covers most of the wetlands.

Destructionof Avian Habitat - Water bodies are highly contaminated which affects the habitat. Water birds near the top of the most wetland, food chains are highly affected. This results in the decline of bird population. The birds such as pelican, spot-billed which are regular visitors just stop coming to the wetlands.

Conclusion

Wetlands being the major source for the healthy environment are polluted by various means which causes the threat for the wetlands such as depletion of ground water and decline in agriculture.The main pollutants are the heavy metals such as cadmium, lead, copper, chromium and nickel. The impacts of these heavy metals are hazardous and it affects the humanity and causes destruction of flora and fauna.These pollutants are analysed using various parameters.

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