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ANALYSE OF SELECTED HEAVY METAL CONTAMINATION IN THE MUDIKONDAN RIVER NANNILAM THIRUVARUR DISTRICT TAMIL NADU INDIA

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ABSTRACT

The present short-review briefly summarizes the status of heavy metal in Cauvery River and its sources and the status and effect of heavy metals in the river sediments and water. The difference in the heavy metals in different parts of the pathways of the river Cauvery is provided in addition to the pollution level and the effect of polluted water or enriched heavy metals on living systems. The pollution status and heavy metal contaminants level varies in water and in sediments with reference to different locations. The rapid population growth along the Mudikondan River has necessitated proper conservation and efficient utilization of freshwater bodies for sustainable development. This is necessary because there has been accelerated deterioration of water quality and also because of increased domestic, municipal and agricultural activities. Effluent discharge, urbanization and deforestation are the main causes of environmental degradation within the catchment.

KEYWORDS: Cauvery River, Contamination, Heavy metals, Pollution and Sediments.

INTRODUCTION

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. They may enter the human body via food, water, air, or absorption through the skin in agriculture, manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure is common in adults and ingestion the most common route in children (Roberts, 1999). Children may develop toxic levels from normal hand-to mouth activity (ie, coming in contact with contaminated soil or eating objects that are not food such as dirt or paint chips). Less common routes of exposure include a radiological procedure, inappropriate dosing or monitoring during intravenous nutrition, a broken thermometer or a suicide or homicide attempt (Smith, 1997).

Due to feeding and living in the aquatic environments animal are particularly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants (Saleh and Marie 2014). Fish, in comparison with invertebrates, are more sensitive to many toxicants and are a convenient test subject for indication of ecosystem health (Adams and Ryon 1994, Bauvais *et al* 2015). Heavy metals are produced from a variety of natural and anthropogenic sources (Demirak *et al* 2006). In aquatic environments, heavy metal pollution results from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products, also via wastewater treatment plants, Garcia *et al* 2015.

Biomarkers can be subdivided in three classes:

1. Biomarkers of **exposure**: covering the detection and measurement of an exogenous substance or its metabolite or the product of an interaction between a xenobiotic agent and some target molecule or cell that is measured in a compartment within an organism.
2. Biomarkers of **effect**: including measurable biochemical, physiological or other alterations within tissues or body fluids of an organism that can be recognized as associated with an established or possible health impairment or disease.
3. Biomarkers of **susceptibility**, which serve as indicators of a particular sensitivity of individuals to respond to the challenge of exposure to the effect of a xenobiotic or to the effects of a group of such compounds, in this case, individual changes included genetic factors and changes in receptors which alter the susceptibility of an organism to that exposure. However, other authors such as Walker *et al* (2012) stated that a number of

classifications of biomarkers have been proposed but the most widely used is division into biomarkers of exposure and biomarkers of effect.

Water pollution is the burning issue nowadays all over the world. Aquatic ecosystems are frequently contaminated with different toxicants through anthropogenic activities, and some of them such as metals may be naturally present and essential in low but toxic in higher concentrations (Pereira *et al*., 2013). Since not all chemical forms of pollutants are equally bioavailable and some pollutants can be accumulated in living organisms to a greater extent than others, we need to study the levels of pollutants in the organisms to be able to predict the environmental risk (Connell *et al*., 1999). On the other hand, due to the reduced rainfall as a consequence of climate change, these water resources are being depleted of water and increased in alarming rate of pollution. Recent report indicated that India is expected to face critical levels of water stress by 2025 and there will be serious water shortages (UN Climate Report, 2014).

Cauvery is a sacred river of southern India, rising on Brahmagiri Hill in the Western Ghats in Coorg district of Karnataka state, flowing in a southeasterly direction for 475 mi (765 km) through Karnataka and Tamil Nadu states across the Deccan Plateau, and descending the Eastern Ghats in a series of great falls. Before emptying into the Bay of Bengal south of Cuddalore, Tamil Nadu, it breaks into a large number of distributaries forming a wide delta. As far as the present review is concerned, the special emphasis on the heavy metal pollution status in river Mudikondan has been summarized.

Mudikondan River serves as a major fishing and drinking water resource for people living along the banks of the entire stretch of the river in Thiruvarur. Rapid urbanization and industrialization in many developing areas have given rise to contamination of water resources. The fast expansion of urban, agricultural and industrial activities spread by rapid population growth and the change in consumer habits have produced vast amounts of solid wastes. Unfortunately, managing this waste has been a challenge for many areas. In water resource technical, financial and institutional constraints have compounded this problem. Also, improperly designed solid waste disposal facilities and landfill sites have further contributed to contamination of surface and underground water resources. Akoteyon *et al*. (2011) investigated the heavy metal contamination of groundwater around a landfill site.

In an aquatic ecosystem, heavy metal pollution can result from atmospheric deposition, geological weathering or through the discharge of waste. The impact of the leachate indicated that the surface water was more polluted than ground water. Drinking water containing high levels of these essential metals, or toxic metals such as arsenic, cadmium, chromium, lead, and mercury may be hazardous to health (Salem *et al*., 2000). Water pollution due to anthropogenic activities in Cauvery River and many of its tributaries are reported to be the source of pollution, such as effluents from pulp and paper manufacturing, chemical industries, dyeing and bleaching units, and sewage are the major anthropogenic sources of water pollution in Cauvery River (Annalakshmi and Amsath, 2012).

MATERIALS AND METHODS

Study Area

The Mudikondan River, a major source of water for treatment and supply of pipe borne water to the metropolis takes its source from Cauvery River is a unique gift of the southern India. It has a catchment area of around Thiruvarur district Nannilam areas and its basin lies between latitudes 10º88’ and longitude 79º57’ and shares its boundary with Nannilam area, Nannilam is located 30km west of Karaikal and 30km east of Kumbakonam. The people mainly depend on agriculture, almost 70% of the population are employed in agriculture. Most of the villages developed along the river banks respectively, the Thiruvarur nartheast. The basin is underlain by crystalline rocks, comprising five formations, namely Birimian, super group intruded by Granites, Togo series, and Dahomeyan and Accraian sediments (Amuzu, 1975).

The recipient of the Mudikondan River is the Kallanai reservoir which is one of the main sources of water supply for the city of Nannilam. Nannilam is panchayat town in Thiruvarur district in the Indian state of Tamil Nadu. It is situated south of an ecologically important wetland where the Cauvery River runs through. Leachate from the landfill flows down slope directly east to enter the Cauvery River. Communities around the Cauvery River abstract water from the river for human and animal consumption.

Sampling Sites

Three sampling sites along the Mudikondan River in Nannilam, Thiruvarur district were selected for the study (as shown in Figure 3.1 and 3.2) from the leachate entry site before Nannilam near Achuthamangalam Station 1(S1), Nannilam Station 2 (S2) and just at leachate entry into the away from Nannilam near Thirukandiswaram east area Station 3(S3) Mudikondan River.

Sampling

Water and sediment samples were collected monthly from each of the three sampling sites from June 2018 to August 2018. Samples were collected along the river with the aid of a canoe. Water samples were collected at the water surface using 500ml HDPE (high density polyethylene) bottles. Water sampling bottles were rinsed twice with the water before sampling was done at each site. Sediment samples were also collected in plain sterile polyethylene bags using a plastic pipe to scoop sediment. The bags were sealed and transported together with the water samples in an ice chest to the laboratory. Three water and three sediment samples were collected from each site monthly during the study period. A sample of the leachate was also taken. Water and leachate samples were acidified with concentrated nitric acid, well labeled, kept over ice in ice chest according to the standard method (APHA, 1995) to maintain them at a temperature below 4 °C during transfer from the field to the laboratory.

Statistical Analysis

The data obtained from the chemical analysis were subjected to descriptive statistical analysis (mean and standard deviation at 95% confident limit).

RESULTS

Leachate from the Nannilam landfill site, an abandoned soil quarry which since 2011 has been used as a landfill, was detected to be high in heavy metals concentration. Mean concentrations of arsenic, cadmium, lead and mercury were 0.027mg/l, <0.004mg/l, 0.955mg/l and 0.035mg/l, respectively station 3(Table 1). These levels of heavy metals contained in the leachate from the landfill and different stations seeps into the River Mudikondan. Heavy metal concentration in River Mudikondan, point before it gets polluted by the leachate from the landfill stations was low and S1, S2 stations arsenic concentration was 0.021mg/l, 0.025mg/l at a point of water sources(Figure 1).

A similar trend was observed for cadmium during the period of June 2018 to August 2018 in Mudikondan River at Mean cadmium concentration in the river at station 1was below detection limit of <0.001 (Table 1). Cadmium was also recorded S2, S3 Stations as follows 0.004, 0.005 mg/l of these heavy metal concentrations in the Mudikondan River before entry of the leachate were within the WHO and USEPA stipulated limits for drinking water (Figure 1). Mean arsenic levels in the river sediment samples at a station 1 was 0.067 mg/kg. This concentration however increased to station S2 and S3 as follows 0.069 and 0.071mg/kg

(Table 2). At the point where the leachate from the landfill site enters the Mudikondan River, arsenic concentration in the river itself was almost a fifty percent decrease compared to arsenic levels in the actual leachate. Heavy metal concentrations in the sediment samples were generally higher than in the overlying water (Figure 2).

Similarly, mean lead and mercury concentrations were recorded 0.955, 0.035mg/l at a station S3 high level of comparing S1 and S2 stations. Following 0.827mg/l and 0.839mg/l lead and 0.031 mg/l, 0.034 mg/l mercury respectively (Table 1). During the period of June 2018 to August 2018 in Mudikondan River sediment levels of lead and mercury mg/kg was recorded the mean and contamination factor values are as following station S1, S2 and S3 0.607, mg/kg CF 0.030 and 0.759mg/kg, CF 0.038, 0.778mg/kg, CF 0.089 Mercury 0.009mg/kg, 0.005mg/kg and 0.004mg/kg both of the station mercury contamination factor not available respectively (Table 1).

Heavy metal concentrations in the sediment samples were generally higher than in the overlying water. This trend was observed in all the sampling stations with low levels of metals in the river water corresponding to high levels in sediment. (Figure 2) Mean arsenic, cadmium, lead and mercury in sediment samples were 0.071, 0.210, 0.778 and 0.004mg/kg, respectively (Table 2). The concentration of lead during the period of June 2018 to August 2018 far exceeds the WHO, and USEPA stipulated limits of 0.01 and 0.015mg/l respectively for drinking water (Table 2).

Table 1: Mean concentration (mg/l), Standard Deviation(SD) of Arsenic, Cadmium, Lead and Mercury in the River water.

Heavymetals	Arsenic	Cadmium	lead	Mercury
Sampling Stations	**Mean ±SD (mg/kg)**	**Mean ±SD (mg/kg)**	**Mean ±SD (mg/kg)**	**Mean ±SD (mg/kg)**
S 1	0.021±0.006	<0.001	0.827±0.041	0.031±0.004
S 2	0.025 ±0.008	0.004±0.003	0.839±0.047	0.034±0.003
S 3	0.027±0.006	0.005±0.005	0.955±0.007	0.035±0.002

Below detection limit, <0.001

Table 2: Mean concentration (mg/kg), Standard Deviation (SD) and Contaminationfactor (CF) of Arsenic, Cadmium, Lead and Mercury levels in sediment.

Heavy Metals	Arsenic		Cadmium		lead		Mercury	
Sampling Stations	Mean	CF	Mean	CF	Mean	CF	Mean	CF
S1	0.067±0.003	0.003	0.187±0.001	0.345	0.607±0.541	0.030	0.009±0.003	NA
S2	0.063±0.004	0.005	0.191±0.005	0.436	0.759±0.045	0.038	0.005±0.001	NA
S3	0.071±0.007	0.006	0.210±0.003	0.543	0.778±.377	0.089	0.004±0.005	NA

Below detection limit, <0.001 NA-Not Available

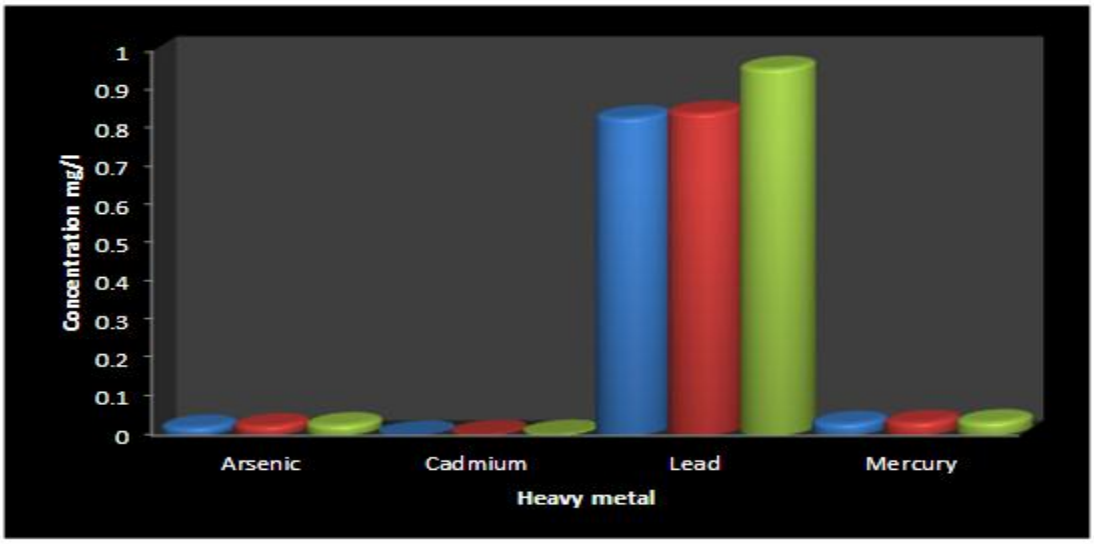

Figure 1: Selected Heavy metal level in the Mudikondan River water mg/l.

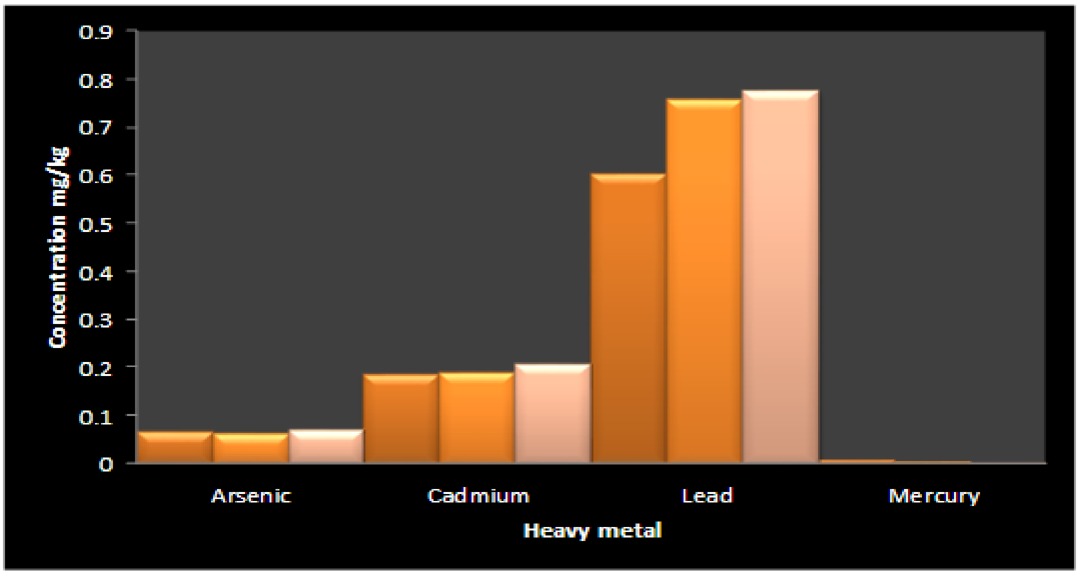

Figure 2: Selected Heavy metal level in the Mudikondan River mean concentration mg/kg in sediments.

DISCUSSION

This study has shown that leachate from the Nannilam landfill site substantially increases the heavy metal concentration in the Mudikondan River. Levels of arsenic, cadmium, lead and mercury in the leachate were high and did exceed the permissible levels set by the WHO and USEPA. Mercury and cadmium levels at a discharge point of stations were low and below detectable limit of <0.001mg/l and <0.002mg/l respectively (Table 1). Arsenic and lead were detectable probably from the diffusion of leachate within the water and also the channelling of residential waste water into the river. Similarly, the concentration of heavy metals in the sediments on during the periods was generally low with the contamination factor less than one (CF<1).

According to Karikari *et al* (2006) the Cauvery River could be generally classified as a good source of water supply along most of its stretches though areas around southern India fall into the poor water quality category. Due to the growing population densities, progressive industrialization and intensification of agricultural activities, the Cauvery River is presently one of the silightly polluted rivers in the Tamil Nadu (Abida begum *et al* 2009). However, Bhuvaneshwari *et al*. (2016) reported iron (Fe) levels in the River to be above the WHO standard for drinking water which may have adverse effects on the health of users of the water without treatment over a long period of time. It also reported lead levels to be above the WHO limits in the river after leachate discharge points of stations.

Heavy metals present could pose a health hazard to users of these contaminated water bodies (Akoteyon *et al*., 2011). USEPA and GEPA limits for drinking water except lead (Figure 1). Following further dilution stations 2 and deposition, 0.025, 0.004, 0.839 and 0.034mg/l for arsenic, cadmium, lead and mercury respectively were recorded. Lead levels exceeded the standard limit of 0.01 mg/l stipulated by WHO. Communities around this sampling site use the water for drinking and crop irrigation. However, this research detected high lead levels which could be attributed to accumulation in the water body.

Health risk assessment is a very important tool to evaluate the consequences of human action and also measures the adverse effect to public health (Abida *et al.* 2009and Ukoha *et al.,* 2014,). The health risk assessment or the non-cancerous effects of heavy metals due to consumption of water has been calculated for both children and adults. An evaluation of non cancer risk to human health associated with the consumption of drinking water containing metals was undertaken and the results were represented in (Figure 1&2).

Heavy metal poisoning particularly lead and cadmium has been reported to give rise to chemical syndromes; cadmium accumulation is associated with hypertension, osteomalacia and itai-itai disease and lead poisoning has been found to be associated with permanent brain damage, behavioral disorders and impaired hearing. The major effects of mercury poisoning manifest as neurological and renal disturbances because it can easily pass the blood-brain barrier and affect the brain (Resaee *et al*., 2005). Arsenic in drinking water can cause severe skin diseases including skin cancer as well as lung, bladder, and kidney cancers, and perhaps other internal tumors, peripheral vascular disease, hypertension and diabetes. It also has a negative impact on reproductive processes **(**Hopenhayn, 2006).

Heavy metal levels in the sediment samples were higher than the overlying water. This is because sediments are a major depository of metals, in some cases holding up to 99% of the total amount of metals present in a system (Ademoroti, 1996). Secondly**,** heavy metals dissociate from its complexes and come into solution at low pH while at high pH, little or no heavy metals dissociate but rather settle to the bed of the river water body in the form of a heavy metal complex.

CONCLUSION

In conclusion, the toxic effects of heavy metals in water and sediments have been demonstrated in the present study. It is abundantly clear that metals induce an early response in the sediments as evidenced by alterations both Stations.

Mean heavy metals concentration in the River Mudikondan S1 before the leachate discharge point was generally very low and below detection limit. However, levels of heavy metals in the leachate and the river Station S2 and S3 were very high. Heavy metals concentration in the river sediments was moderate for cadmium and low for arsenic and lead. The study has shown that levels of arsenic, cadmium and mercury in the Mudikondan River conform to the WHO maximum permissible limits. The research findings made it clear that the contamination of this water body with these heavy metals was primarily due to the leachate discharged points.

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