

Assessment of Heavy Metal Concentration in Arasalar River, Karikal Region, Puducherry, India

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Abstract: Heavy metal contamination in rivers may lead to many issues like public health risks, risk to aquatic organisms, risks while used for agriculture and fisheries, etc... Heavy metals accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. The objective of this study is to analyze the heavy metal concentration in the River Arasalar at Karaikal region, Puducherry union territory for a seasonal variation of 4 months duration. Water samples were collected from six different locations of the Arasalar River for four consecutive months of the year 2015 & 2016 (i.e. from October 2015 to January 2016). The samples were analyzed for the presence of Chromium (Cr), Copper (Cu), Iron (Fe), lead (Pb), Nickel (Ni), Zinc (Zn), Arsenic (As), Cadmium (Cd), Manganese (Mn) and Mercury (Hg) by standard methods. High level of Manganese (0.65mg/l) was found in samples during October, 2015 while the other heavy metal concentrations ranged below 0.06µg/l. About 0.55mg/l of magnesium (550%) exceeds the level of concentration prescribed by the Central Pollution Control Board (CPCB). In the month of November, the level of Manganese and Iron decreased to 0.01mg/l and 0.01 respectively while the other elements were found completely nil. In the December month, the level of Manganese and Iron again raised to 0.48 mg/l (0.38mg/l exceeds) and 0.23µg/l (normal) respectively. In January, the Manganese and Iron levels reached the peak and they were analyzed as 2.416mg/l (2.316mg/l exceeds) and 1.466µg/l (1.166µg/l exceeds) respectively while the concentrations of other metals below 0.04µg/l only. The source for these heavy metal contaminations is industries prevailing in the Karaikal region. As this region is a delta region, the heavy metal contamination in the Arasalar River may also lead to the contamination in the sea too. So as early as possible, steps should be taken to control the situation prevailing in Arasalar River of Karaikal region, Puducherry, India.

Keywords: Heavy metal contamination, Arasalar River – Karaikal region, Seasonal variation

I. INTRODUCTION

Within aquatic ecosystems a complex interaction of physical and biochemical cycles exists. Anthropogenic stresses, particularly the introduction of chemicals into water, may adversely affect many species of aquatic flora and fauna that are dependent on both abiotic and biotic conditions (Carpenter et al, 1998 and Fergusson, 1990). Normal water quality parameters are traditionally dissolved oxygen (because it may cause fish kills at low concentrations) as well as phosphates, ammonium and nitrate (because they may cause significant changes in community structure if released into aquatic ecosystems in excessive amounts). But heavy metals and many synthetic chemicals can also be ingested and absorbed by organisms and,

if they are not metabolised or excreted, they may bioaccumulate in the tissues of the organisms (Abbas Alkarkhi et al, 2008). Hence the concentration of heavy metals in a water body must be monitored periodically.

The usual situation in the assessment of water quality is the measurement of multiple parameters, taken at different monitoring times, and from many monitoring stations. Therefore a complex data matrix is frequently needed to evaluate water quality (Chapman, 1992). Furthermore, in river monitoring, it is frequent to face with the problem of determining whether a variation in the concentration of measured parameters should be attributed to pollution (manmade, spatial) or to natural (temporal, climatic) changes in the river hydrology (Wunderlin et al, 2001). Also, it should be determined which parameters are the most significant to describe such spatial and temporal variations, the pollution sources, etc. Thus this study aims to monitor the occurrence of heavy metals in the Arasalar River of Karaikal region, Puducherry union territory, India.

Study area description

The river Arasalar is one of the seven rivers that are running in the Karaikal region of Puducherry, a union territory of India. Arasalar River in Karaikal region is located at the latitude 10° 54' 52''N Longitude 79° 51' 09'' E (Figure 1). Arasalar River separates as a tributary of Cauvery at Papanasam, near Kumbakonam. It is a branch of the major river, the Cauvery.

At the place near to Pullambadi the River Cauvery is been stopped by Lower dam and from Tiruvaiyaru this Arasalar separates from the River Cauvery. This Arasalar takes its course from Tiruvaiyaru of Tanjore district, covers and travels through Kumbakonam and enters into the Sea, Bay of Bengal at Karaikal. Karaikal once served as a River Port till 19th century where the Yachts and "Marakkalam" ships of Karaikal Marakkayar harboured in and, loaded and unloaded the Goods and materials towards Exports and Imports. The location map of the study area (Circled) is shown in Figure 1.

Hazards of heavy metal contamination

The main threats to human health are associated with heavy metal exposure. These heavy metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO (1996). Heavy metals have been used by humans for thousands of years. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed and developing countries, than the developed countries.

Some water pollutants which become extremely toxic in high concentrations are, however, needed in trace amounts. Copper, Zinc and Manganese, for example, can be toxic or may otherwise adversely affect aquatic life when present above

certain concentrations, although their presence in low amounts is essential to support and maintain functions in aquatic ecosystems (Pesce and Wunderlin, 2000).

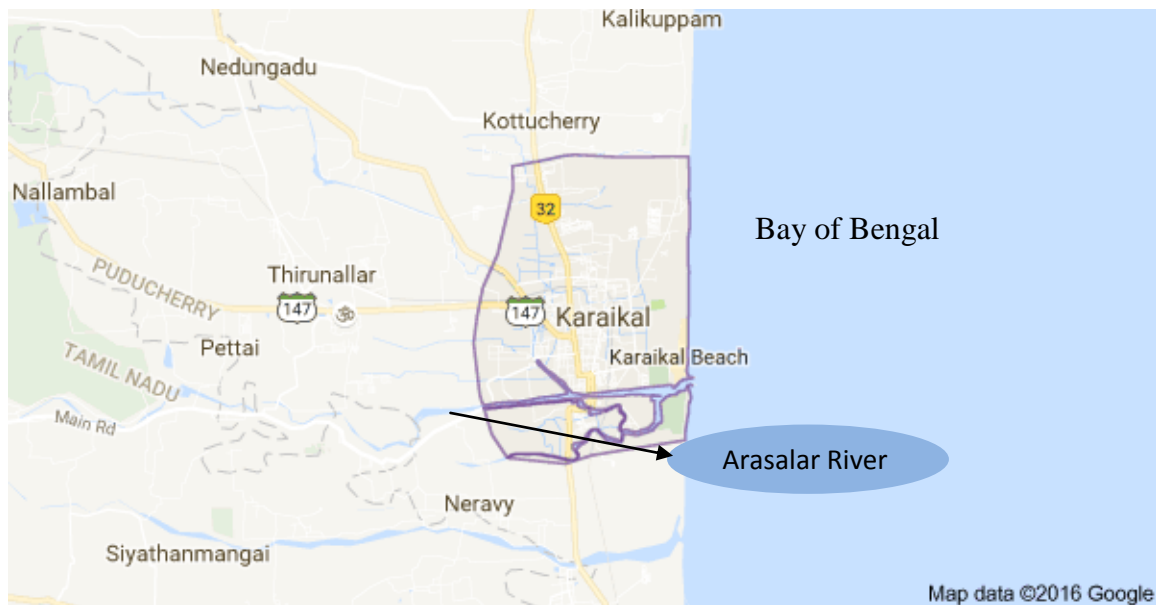


Figure 1: Map showing the Arasalar River that was monitored in the Karaikal region

Arsenic, Cadmium, Chromium, Lead, and Mercury are known to induce multiple organ damage, even at lower levels of exposure (Tchounwou et al., 2012). Though some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for life processes in plants and microorganisms, while many other metals like Cd, Cr and Pb have no known physiological activity, but they are proved detrimental beyond a certain limit (Marschner, 1995; Bruins, *et al.*, 2000), which is very much narrow for some elements like Cd (0.01 mg/L), Pb (0.10 mg/L) (ISI, 1982) and Cu (0.050 mg/L). The deadlier diseases like edema of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stuffiness of the head and gastrointestinal, muscular, reproductive, neurological and genetic malfunctions caused by some of these heavy metals have been documented (Johnson, 1998; Tsuji and Karagatzides, 2001; Abbasi, *et al.*, 1998). Therefore, monitoring these metals is important for safety assessment of the environment and human health in particular.

Approach to Water Quality Management

The water quality management in India is performed under the provision of Water (Prevention and Control of Pollution) Act, 1974 (Anonymous, 2008). The basic objective of this Act is to maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution. The Act does not define the level of wholesomeness to be maintained or restored in different water bodies of the country. The CPCB has tried to define the wholesomeness in terms of protection of human uses, and thus, taken human uses of water as base for identification of water quality objectives for different water bodies in the country. The use of environmental laws, policies and regulatory controls to protect the water environment ensuring water is safe for humans, animals and plants, and suitable for other important uses, like swimming, drinking-water

supply, livestock watering, irrigation, fisheries, recreation and other activities. Keeping in mind, this project was done to assess the water quality of Arasalar River of Karaikal region.

II. MATERIALS AND METHODS

Samples were collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle following the general guidelines for surface water sampling prescribed by Central Pollution Control board (2008). Six samples were collected in a month at different location of the river at Karaikal region. Samples were analyzed for the presence of Chromium (Cr), Copper (Cu), Iron (Fe), lead (Pb), Nickel (Ni), Zinc (Zn), Arsenic (As), Manganese (Mn) and Mercury (Hg) by UV Spectroscopy and Cadmium (Cd) by Gas Chromatography.

III. RESULTS

Six surface water samples of the River Arasalar were analyzed for the presence of Cr, Cu, Fe, Pb, Ni, Zn, Ar, Cd, Mn and Hg every month from various sampling stations. Sampling was done in consequent months October, November, December (2015) and January (2016) at the same sampling stations. The mean values, along with standard deviation of the heavy metal concentration in Arasalar River of Karaikal region during October, November, December and January months were presented in the Table 1. The acceptable limit of heavy metal concentration in water bodies recommended by CPCB is also given in Table 1.

In all the four months, the occurrence of Mn and Fe were found consequently while other elements were found occasionally. During November, the presence of other elements was found nil while Mn and Fe were found at the lowest

concentrations. They were at peak during January (Table 1). The concentration of Mn was above the acceptable limit in all the four months (Figure 4) while the concentration of Fe was above the acceptable limit only during January. The concentration of Hg was constant (0.001 µg/l) in all the months was in acceptable limit. Cu, Pb, Zn and Cd concentration was in acceptable limit in all the four months. Ni and Mn concentrations were found above the acceptable limit in all the months except November. The concentration of As during October and December was above the acceptable limit (Figure 3).

The concentrations of Cr, Cu, Pb and As during December and Ni and Zn during October reached their peak. The level of Cd was found equal during October and December while

it was lowered during January (0.001 µg/l). All in all, the dominance of various heavy metals in the surface water of the river Arasalar followed the sequence: Mn > Fe > Ni > Zn > Cr > Cu > Pb > Cd irrespective of the months.

Among the ten heavy metals, the concentrations of Cr, Fe, Pd, Cd and Mn were significant during October whereas in case of Cu, Ni, Zn, Ar and Hg the concentrations were not significant. During December Cu, Fe and Zn concentrations were significant while others were not significant. Cu, Fe, Cd and Mn concentrations were significant during January while other heavy metal concentrations were not significant. The heavy metal concentrations during the four months were depicted in the figure 2.

Table 1: Mean values and Standard Deviation of Heavy metal concentration in October, November, December (2015) and January (2016) in Arasalar River, Karaikal region

Heavy Metals	October 2015	November 2015	December 2015	January 2016	Acceptable Limit
Chromium (µg/l)	0.03±0.0	0.0±0.0	0.07±0.01	0.03±0.01	0.05 µg/l
Copper (µg/l)	0.03±0.01	0.0±0.0	0.04±0.0	0.02±0.0	0.05 µg/l
Iron (µg/l)	0.266±0.12	0.1±0.0	0.2±0.11	1.466±0.17	0.3 µg/l
Lead (µg/l)	0.002±0.0	0.0±0.0	0.003±0.0	0.002±0.0	0.003 µg/l
Nickel (µg/l)	0.07±0.01	0.0±0.0	0.05±0.01	0.04±0.01	0.02 µg/l
Zinc (µg/l)	0.04±0.01	0.0±0.0	0.03±0.0	0.03±0.01	0.05 µg/l
Arsenic (µg/l)	0.06±0.01	0.0±0.0	0.07±0.0	0.02±0.0	0.03 µg/l
Cadmium (µg/l)	0.002±0.0	0.0±0.0	0.002±0.0	0.001±0.0	0.003 µg/l
Manganese (mg/l)	0.65±0.12	0.01±0.0	0.4±0.07	2.416±0.20	0.1 mg/l
Mercury (µg/l)	0.001±0.0	0.0±0.0	0.001±0.0	0.001±0.0	0.001 µg/l

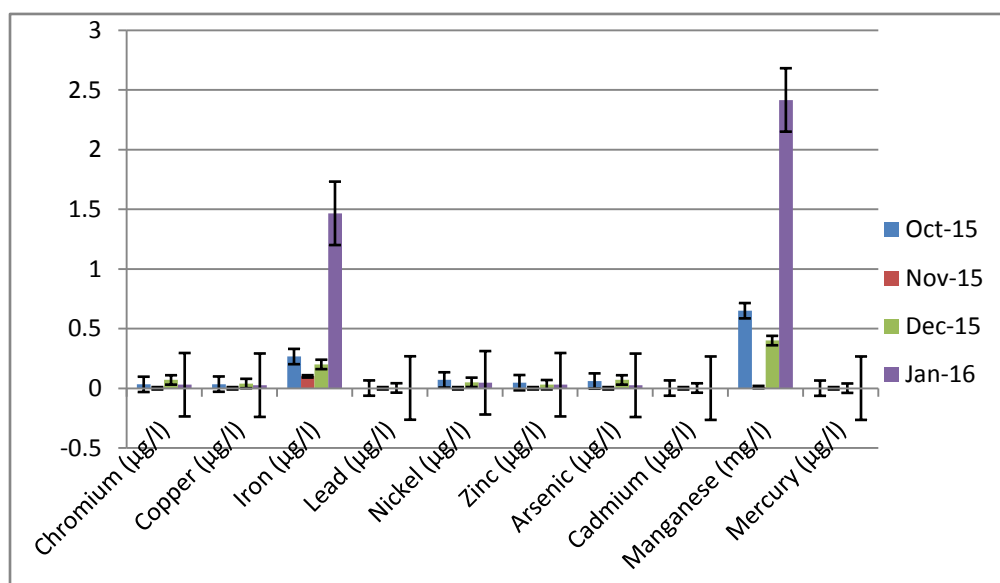


Figure 2: Chart showing monthly concentration of heavy metals with standard error bars

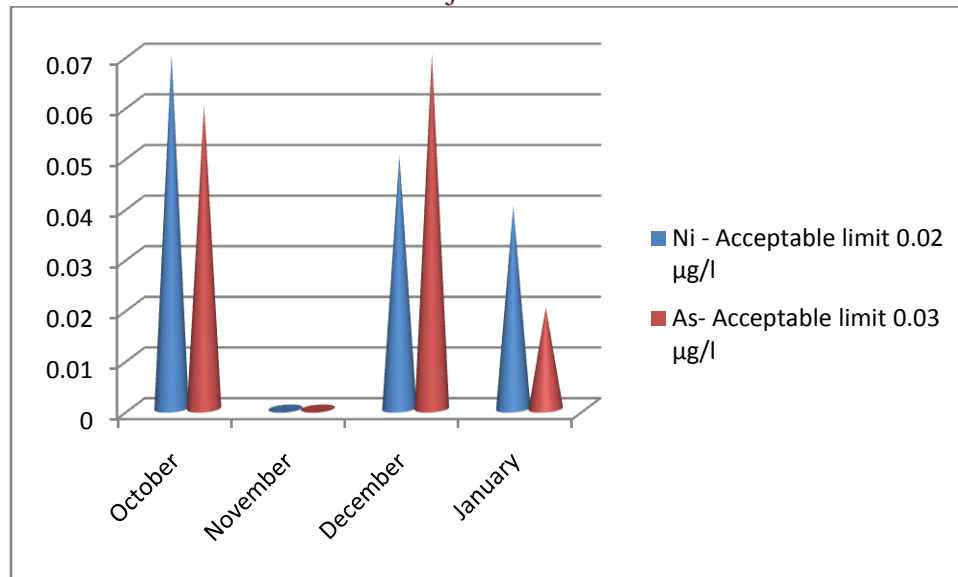


Figure 3: Ni and As concentrations in the four months in µg/l and their acceptable limits

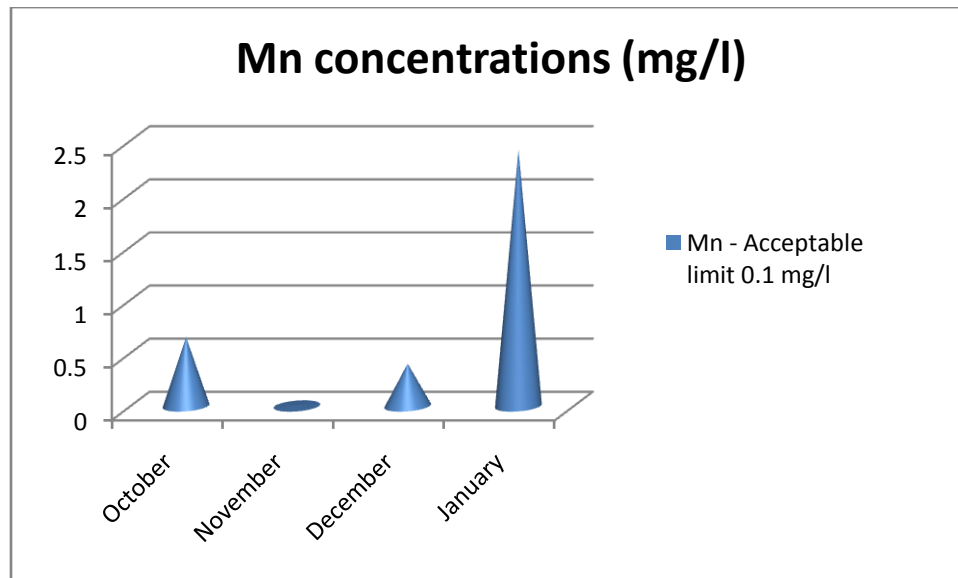


Figure 4: Mn concentrations in the four months in mg/l and its acceptable limit

DISCUSSION

The River Arasalar drains into Bay of Bengal at Karaikal region of Puducherry Union territory. As the harbor at Karaikal is very active, many discharging activities takes place in this area. Industries also discharge their effluent in this river. Municipal drainage and domestic drainages were also discharged in this river. As the river merges into the sea, Bay of Bengal the heavy metal contamination in the Karaikal region may also pollute the sea too (Sholkovitz, 1976).

The result regarding the concentration of heavy metals in the Arasalar River is in accordance with that of the result obtained in the River Ganga. The sequence of presence of heavy metal concentration is almost similar to the results derived in the River Ganga by Kar et al (2008) but with slight variation in the order. Heavy metals though essential for life can be toxic if taken in excess. According to the analysis, only in the month of November, the heavy metal concentration is normal i.e. below the prescribed level of CPCB. In October, December and January the concentration of heavy metals was considerably increased.

The Manganese and Iron concentrations were seen above the acceptable limit. Except for Mn and Fe, the concentrations of other metals in the Arasalar water were nil during November. The reason for the increased and decreased concentration of Mn and Fe must be monitored. Ni was found always above the acceptable limit. Thus the presence of other heavy metal concentrations beyond the acceptable limit must also be monitored and controlled. The sources of pollution in the Karaikal region must be studied and controlled.

Arsenic contamination causes severe effect on human beings. Here, the arsenic concentration was above the acceptable limit during October and December. The reason for the increase in concentration level during these months in particular must be investigated. Since natural water bodies have got to be used for various competing as well as conflicting demands, the objective is aimed at restoring or maintaining natural water bodies or their parts to such a quality as needed for their best uses. According to this concept, this project has been done as a preliminary effort in monitoring the water quality of Arasalar River. The work on

restoration and preventive measures on the heavy metal concentration must be analyzed and worked down.

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