JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Investigation of Hazardous Heavy Metals in Mumbai's Dabhol Creek

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ABSTRACT

In order to understand the level of harmful heavy metals in the water of Dabhol Creek near Mumbai, the present study was conducted for a year, from June 2012 to May 2013. Heavy metals like Pb, Cd, Cr, Fe, Zn, Cu, Ni, and Hg were found to have yearly average concentrations of 0.53, 0.25, 0.20, 0.04, 2.78, 0.49, 1.14, and 0.26 ppm, respectively. The average levels of Hg and Pb were found to be higher than the CPCB's (Central Pollution Control Board) 0.01 ppm and 0.1 ppm limits for inland surface water, respectively. The findings imply that in order to comprehend the variation in amount of these harmful heavy metals discharged into the creek water, such frequent scientific monitoring for a longer time period is required.

Due to the presence of poisonous heavy metals, it is thought that if the current issue is not addressed, it would worsen and endanger the aquatic ecosystems biological existence. According to the findings of the current inquiry, it appears that it is now necessary to move towards ecosystem-specific discharge criteria in order to preserve the health and productivity of the natural resources that are essential to the survival of the majority of the world's population.

Keywords**:** heavy metals; toxic metals; creek water; Dabhol Creek; Mumbai

1. INTRODUCTION

Environmental issues involving aquatic and coastal areas cannot be handled separately. Their connections to one another are closely entwined. The land and sediment load habitats of the land and sediment load are interdependent and connected by intricate interactions including the atmosphere, geology, physical, chemical, and biological elements. Today, it is understood that the only way to address environmental issues along the coastal and aquatic bodies is to take a comprehensive, methodical, and long-term approach [1].

Heavy metals are a major concern among the various contaminants that infiltrate water bodies. Toxic heavy metals entering the aquatic ecosystem can cause geoaccumulation, bioaccumulation, and biomagnification, as well as entering the food chain [2,3].

Heavy metal contamination of food chains has become a hot topic in recent years due to their potential accumulation in bio-systems via contaminated water [4-8].

In light of the ever-increasing pollution issues associated with water bodies in Konkan, India, we have launched a study to determine the level of toxic heavy metals in water samples collected along Konkans Dabhol Creek. Because the current study area receives heavy pollution load from the adjoining Vashishthi river River, the results of our study are expected to provide information on the trend in heavy metal pollution load entering the creek.

2. EXPERIMENTAL

2. 1. Study Area

Vashishti River (Dabhol Creek) is one of the waterways declared as National Waterway in March, 2016. The River Vashishti originates in the Western Ghats and snakes its way westwards towards the Arabian Sea. The study stretch is fully tidal. Out of the total length, the stretch from Arabian Sea at Dabhol Lat 17°34'51''N Long 73°09'18''E to Bridge at Pedhe Lat 17°32'39'' Long. 73°30'36'' has been declared as new national waterway.

The creek is the largest waste sink for most residential complexes and small-scale companies. The creek's waters stink because of the dumping of untreated industrial effluents further upstream. The creek is surrounded by mangroves and contains a mini-ecosystem. The Dabhol bay area, where Dabhol Creek meets the Arabian Sea, is a nominated tourist place, where migratory birds come to nest.

2. 2. Requirements

All glassware, casseroles, and various pipettes were thoroughly cleaned with tape water before being rinsed with de-ionized distilled water. Before final use, the pipettes and standard flasks were washed with solution. Analytical reagent (A.R.) grade chemicals and reagents were employed for analysis. The technique for estimating the various parameters was carried out in the laboratory.

2. 3. Water sampling and sample preparation

From June 2017 to May 2018, a one-year study on pollution levels along Mumbai's Dabhol Creek was conducted. Every month, creek water was sampled at several sites along the creek. The grab water samples were collected in 2.5 L polythene bottles. The bottles were thoroughly cleaned with hydrochloric acid, rinsed with distilled water to remove the acid, and then filled with the sample, leaving only a little air gap at the top.

Paraffin wax was used to Stoppard and seal the sample vials. The collected samples were combined to form a gross sample. Similar gross samples were analysed for harmful heavy metal content every month in order to determine the seasonal fluctuation in pollution levels along the Dabhol Creek.

The collected sample was filtered using Whatman No. 41 filter paper to estimate the dissolved heavy metal level in water. To prevent metal precipitation, the filtrate was stored with 2 mL nitric acid. The material was concentrated tenfold in a water bath before being digested with nitric acid using the microwave aided approach [9,10].

2. 4. Quality control/assurance

Before usage, all glassware was steeped in suitably weak acids overnight, cleaned with teepol, and rinsed with deionised water. Before usage, all instruments were calibrated. To eliminate cross contamination, tools and work surfaces were thoroughly cleansed for each sample. To ensure the precision of the analytical method and instrument, triplicate samples were analysed.

2. 5. Analysis of Heavy Metals

The heavy metal concentration of the water samples sampled was determined. The majority of trace metals such as lead (Pb), cadmium (Cd), chromium (Cr), iron (Fe), zinc (Zn), copper (Cu), and nickel (Ni) in water samples were analysed using flame atomic absorption spectrophotometer (AAS), whereas mercury (Hg) was analysed using cold-vapour techniques [18] using Perkin Elmer Analyst 200 Flame Atomic Absorption Spectrophotometer (2003 model).Calibration curves for each metal were constructed independently by running varying concentrations of standard solutions. Throughout the process, a reagent blank sample was run, and the blank readings were subtracted from the samples to account for reagent impurities and other environmental problems. For each determination, the average of three replicate analyses was calculated.

3. RESULTS AND DISCUSSION

Although there is no definite definition of a heavy metal, density is commonly used as the distinguishing criterion. Heavy metals are thus classified as those with a specific density greater than 5 g/cm^3. Heavy metals are among the most frequent contaminants in the environment, and their presence in waterways and biota indicates the presence of natural or anthropogenic sources.

Despite the fact that the harmful health consequences of heavy metals have been known for a long time, heavy metal discharge continues and is even rising in some places, particularly in less developed countries.

The most serious risks to human health from heavy metals are connected with lead, cadmium, and mercury exposure. Its accumulation and spread in the soil and aquatic environments is expanding at an alarming rate, threatening marine life [12-14].

Table 1 presents experimental data on the concentration (ppm) of harmful heavy metals such as Pb, Cd, Cr, Fe, Zn, Cu, Ni, and Hg in water samples collected along Mumbai's Dabhol Creek.

Extensive research [15-20] on the ecological and toxicological aspects of lead (Pb) and its compounds in the environment has revealed that Pb is neither needed nor advantageous to living organisms; all available data indicate that its metabolic effects are negative. Most of its chemical forms are poisonous, and it can enter the body through inhalation, ingestion, skin absorption, and placental transfer to the foetus.

Table 1. Heavy Metals in Dabhol Creek water.

Heavy Metals (ppm)	**Pb**	**Cd**	**Cr**	**Fe**	**Zn**	**Cu**	**Ni**	**Hg**
Jun-17	1.1	0.19	0.28	0.03	2.21	1.41	3.61	0.68
Jul-17	1.23	0.1	0.09	0.02	7.9	1.97	3.08	0.92
Aug-17	1.07	ND	ND	0.04	7.21	0.9	2.17	0.3
Sep-17	0.8	ND	ND	0.06	2.2	0.2	1.04	0.16
Oct-17	0.6	0.02	ND	0.04	2.16	0.28	0.81	0.2
Nov-17	0.48	0.05	0.06	0.04	2.03	0.21	0.78	0.14
Dec-17	0.35	0.2	0.09	0.02	1.83	0.16	0.7	0.17

Jan-18	0.34	0.15	0.2	0.02	1.5	0.21	0.48	0.15
Feb-18	0.23	0.34	0.18	0.01	1.58	0.11	0.59	0.13
Mar-18	0.05	0.4	0.24	0.03	1.15	0.14	0.21	0.11
Apr-18	0.07	0.45	0.3	0.04	1.53	0.17	0.13	0.1
May-18	0.09	0.57	0.38	0.08	2.05	0.12	0.1	0.11
Average	**0.53**	**0.25**	**0.20**	**0.04**	**2.78**	**0.49**	**1.14**	**0.26**
Max	**1.23**	**0.57**	**0.38**	**0.08**	**7.9**	**1.97**	**3.61**	**0.92**
Min	**0.05**	**0.02**	**0.06**	**0.01**	**1.15**	**0.11**	**0.1**	**0.1**

ND = Not Detected

It is a metabolic toxin that accumulates and affects behavior as well as the hematological, circulatory, neurological, renal, and reproductive systems. According to the findings of the current investigation, the concentration of Pb in creek water ranged from 0.05 to 1.23 ppm, with an annual average value of 0.53 ppm.

Except for mercury, copper is more hazardous to most fishes, invertebrates, and aquatic plants than any other heavy metal. It inhibits plant and animal development and reproduction.

Copper has a chronic level of 0.02-0.2 ppm [21]. Water plants absorb three times as much Cu as dry land plants [22]. High Cu concentration can harm roots by attacking the cell membrane and disrupting the natural membrane structure, inhibiting root growth and causing the creation of numerous short, brownish secondary roots [21]. Copper is highly toxic in aquatic environments, affecting fish, invertebrates, and amphibians, with all three groups equally vulnerable to chronic exposure [23,24].Copper bioconcentrates in a variety of organs in fish and mollusks. Copper also reduces sperm and egg production in several fish species, including fathead minnows, as well as early egg hatching, smaller fry (newly hatched fish), and a higher prevalence of deformities and lower survival in the fry [25]. Cu concentrations in water samples were found to be as low as 0.11 ppm in February and as high as 1.97 ppm in July in the current investigation. Copper concentrations were determined to be 0.49 ppm on a yearly basis.

The concentration of Zn in the creek water was observed to fluctuate from 1.15 ppm in March to 7.9 ppm in July, with an annual average value of 2.78 ppm.

Nickel (Ni) and nickel compounds have numerous industrial and commercial applications, and the advancement of industrialization has resulted in increased pollution emissions into ecosystems. According to our findings, the concentration of Ni in the water was as low as 0.1 ppm in May and as high as 3.61 ppm in June, with a yearly average value of 1.14 ppm.

Although Ni is prevalent and essential for many animals' survival, concentrations in specific locations from both anthropogenic and naturally fluctuating levels may be harmful to live organisms [26,27]. Nickel compounds have been well established as carcinogenic in various animal species and through several ways of human exposure, but their underlying processes remain unknown [28].

Cadmium (Cd) is a 20th-century metal that is primarily utilised in rechargeable batteries and the creation of specific alloys. The emergence of Itai-Itai bone disease in Japan in the 1960s brought the attention of the public and regulatory organisations to this heavy metal, which had been released into the environment at an unregulated rate for more than a century.

According to the findings of our investigation, the Cd concentration in creek water samples reached a peak of 0.57 ppm in May, with an annual average value of 0.25 ppm. Cd that has been disseminated in the environment can remain in soils and sediments for decades. When plants absorb Cd, it concentrates along the food chain and eventually accumulates in the bodies of people who consume contaminated foods. Cd's unusually long half-life in the human body is by far its most notable toxicological feature.

Once absorbed, Cd accumulates irreversibly in the human body, particularly in the kidneys, bone, respiratory tract, and other critical organs such as the lungs or liver [29]. Cd, in addition to its unusual cumulative qualities, is a highly poisonous metal that can affect a variety of biological systems, typically at considerably lower levels than most toxic metals [30-32].

Mercury (Hg) poisoning has recently gained attention as a result of global environmental degradation. High mercury concentrations, which could constitute an ecological risk by contaminating plants, aquatic resources, and bioaccumulating in the food chain [33]. The concentration of Hg in the water was found to be in the range of 0.1 to 0.92 ppm in the current study, with an annual average concentration of 0.26 ppm.

Chromium (Cr) is one of the most common skin sensitizers, and it frequently causes skin sensitization in the general population. Waste dumps for chromate-producing factories, which cause local air or water pollution, are one possible source of chromium exposure. Skin penetration causes painless erosive ulceration ("chrome holes") with delayed healing. They are most typically found on the fingers, knuckles, and forearms. The typical chrome sore starts as a papule and progresses to an ulcer with raised hard edges.

Apart from the lungs and the digestive tract, the liver and kidney are frequently targets for chromate poisoning [34-41]. In the current study, the concentration of Cr in the water samples reached a maximum of 0.38 ppm in May, with an annual average value of 0.20 ppm.

4. CONCLUSIONS

As governments throughout the world struggle to develop an effective regulatory structure to limit the discharge of industrial effluents into their ecosystems, the Indian economy is a double-edged sword of economic expansion and ecosystem collapse. More efforts are needed to decrease the risk to public health as colorless and odorless harmful chemicals are released into ecosystems as India moves towards strict regulation of industrial effluents to manage water pollution.

As a result, each enterprise must cleanse its effluents in compliance with regulatory criteria before releasing them into streams; otherwise, the "polluter pays" approach must be adopted. In India, the current regulatory framework for controlling industrial wastes needs significant improvement in terms of standard setting, monitoring, and enforcement.

The water quality monitoring system has to be upgraded in terms of parameters monitored, water resource coverage, and timely reporting to the public domain. These steps are critical in order to avoid irreversible environmental damage in the long run, which is sometimes obscured by short-term economic gain as a result of substantial industrial growth.

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