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Assessment on Heavy Metal Pollution of Ground Water and Surface Water in and around Manali Area Near Buckingham Canal Chennai, Tamil Nadu

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Abstract
The purpose of the study is to find heavy metals in the groundwater in Manali, which is close to Chennai's Buckingham Canal. Heavy metal concentrations (As, Ba, Co, Cr, Ni, Cu, Pb, Zn) in water were examined to gain an understanding of the metal contamination caused by industrialization and urbanization surrounding the Manali Industrial region in Chennai, Southern India. This industrially advanced area is dominated by industries that produce hazardous waste, such as petrochemicals, fertilizers, and refineries. Six surface water samples and four groundwater samples were collected from Buckingham Canal and its environs throughout the monsoon and summer seasons of 2021-2022. An atomic absorption spectrophotometer was used to determine the amounts of the trace elements, which included zinc, nickel, lead, copper, and chromium. The resulting data were then contrasted with the standard values established by the World Health Organization (2008). Analysis of water samples from both sides of the canal reveals that proactive measures are required to lower the level of lead and nickel pollution.

Key Words: Buckingham Canal, zinc, copper, lead, nickel, ground water

1. Introduction

The water is an essential constituent for the maintenance and survival of all living beings. Freshwater is a fundamental thing that plays a crucial role in supporting the survival of various species, encompassing plants, animals, and other living entities. Moreover, it is essential for the survival of humankind in the natural world (Muthulakshmi et.al.).Global overexploitation of mineral resources has produced large quantities of metal mining waste, which has negative ecological repercussions (Gautametal.,2016).Hazardous substances that do not decompose include heavy metals, including arsenic, lead, cadmium, and chromium. These substances originate from either natural deposits of minerals or factories outlets (Qin et al. 2020).

In recent years, the extensive utilisation of heavy metals as a result of rapid modernization and industrialization has caused the depletion of natural resources (Cao etal., 2021). The environment has been significantly contaminated by a variety of substances, including radioactive isotopes, organic and inorganic contaminants, nano particles, and organ metallic compounds; this has exacerbated the pollution problems (Sharma et al.,2021).

Heavy metals are widely recognised as posing significant risks to human health, as they have the ability to act as mutagens and carcinogens (Saravanan et al., 2021). Priority pollutants, according to the United States Environmental Protection Agency (USEPA), are heavy metals. Cadmium (Cd) is ranked as the sixth most hazardous metal on the US Agency for Toxic Substances and Diseases Registry (ATSDR) list of the most dangerous substances. Mercury (Hg) and arsenic (As) follow lead (Pb) as the most toxic substances. As an ecological hazard, the elevated levels of metals such as lead in aquatic and terrestrial ecosystems is considered a significant cause for concern (Budianta et al.,2021)

In general, the designation "heavy metal" denotes metallic elements that are heavier than their atomic weight. Fe (55.8 g mol-1) or a density exceeding 5.0g cm-3 is metals that occur naturally in the surroundings. Heavy metal ion accumulation has resulted from a significant rise in the dispersion of waste from industries into the environment, primarily into soil and water, as a consequence of the expansion of urbanisation and the mining of natural resources. The global community is confronted with a significant peril in the form of environmental contamination caused by hazardous metals and toxic chemicals. These substances possess the characteristic of not undergoing decomposition into non-toxic compounds, resulting in persistent and enduring impacts on the ecosystem.

The study by (Asha et al., 2013) says that required to clean up renewable assets has results to the creation of novel techniques that focus on destroying them instead of the usual method of harming them. Sustenance chain organisation. The problems in contamination of heavy metal in the natural surroundings is of international concern because of the non-biodegradable nature of these metals and their ability to induce deleterious effects on living organisms beyond a specific threshold of concentration (MacFarlane and Burchett, 2000).

The development of urbanisation and the natural resources extraction have led to a dramatic improve in the dispersion of waste from industries into the surroundings, particularly into water and land, leading to a build up of trace metal ions. One of the greatest threats to the global ecosystem is pollution from harmful chemicals and metals that do not biodegrade and so remain in the environment indefinitely.

The drainage of acid mines is a prevalent occurrence linked to mining activities, frequently generated as a result of mining operations and additional geochemical processes. It is produced by the exposure of pyrite (FeS2) and sulphide minerals in aquifers, as well as oxidising microbes like Thiobacillus ferrooxidans, in present and former mining sites. As byproducts of this oxidation are acidity, sulphate, and other metal ions (Ogwuegbu and Muhanga, 2005).

$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$

$2FeSO_4 + 2H_2SO_4 \rightarrow Fe\ (SO_4)_3 + SO_2 + 2H_2O$

$Fe\ (SO_4)3 + 2FeAsS + 9/2\ O_2 + 3H_2O \rightarrow 2H_3ASO_4 + 4FeSO_4 + S$

2. Review of literature

Recent research (Asha et al., 2013) suggests that in an effort to clean up these natural resources, new technologies have emerged with a focus on their depletion rather than the more traditional method of pollution. sustenance chain organisation. Heavy metal contamination is a global problem because these elements are not biodegradable and can have harmful effects on living things at concentrations beyond a certain threshold (MacFarlane and Burchett, 2000).

Extremely densely populated regions encompass the aquatic system, which is subject to severe exploitation. The primary sources of metallic elements in the environment are lithogenic and anthropogenic (Figure 1). The main sources of lithogenic heavy metal contribution include chemical dissolution of minerals, drainage basins, and shoreline discharge. The main human-caused sources of pollution are industrial and urban effluent discharges, fossil fuel combustion, mining and smelting operations, the processing and manufacturing sectors, and the disposal of waste including garbage dumps (Clavins et al., 2000).The surge in urbanisation and industrialization during the last twenty years has resulted in a corresponding escalation in marine discharges, which in turn has contributed to the overall accumulation of pollutants in the seawater (McGlashan, 1989). These emissions may contain, in addition to other contaminants, heavy metals. Biomagnification is an inherent biological process by which trace quantities of metals accumulate in diverse food chains, subsequently elevating concentrations to levels that may be hazardous to human beings and other organisms (Bryan, 1971).

Mercury (Cu), silver (Ag), arsenic (As), and gold (Au), cadmium (Cd), cobalt (Co), and chromium (Cr) are human contaminants are substances that have been released into the environment as a result of human activity such as metal mining, farming, and garbage disposal.. (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn), in excessive quantities of which are hazardous to human health. The body simply can't break down this chemical. To thrive and perform at their best, plants require trace amounts of specific metals. However, as the result of the industrial age, a variety of components have become increasingly concentrated in soil and water, endangering marine and terrestrial ecosystems. Because of their inability to degrade into not harmful states and the lasting damage they do to ecosystems, metals like lead are a major cause for concern when released carelessly into the world's soil and water. There are many elements that are harmful even in minute amounts. In addition to being cytotoxic, elements like arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc are also carcinogenic and mutagenic (Salem et al., 2000).

3. MATERIAL AND METHODS

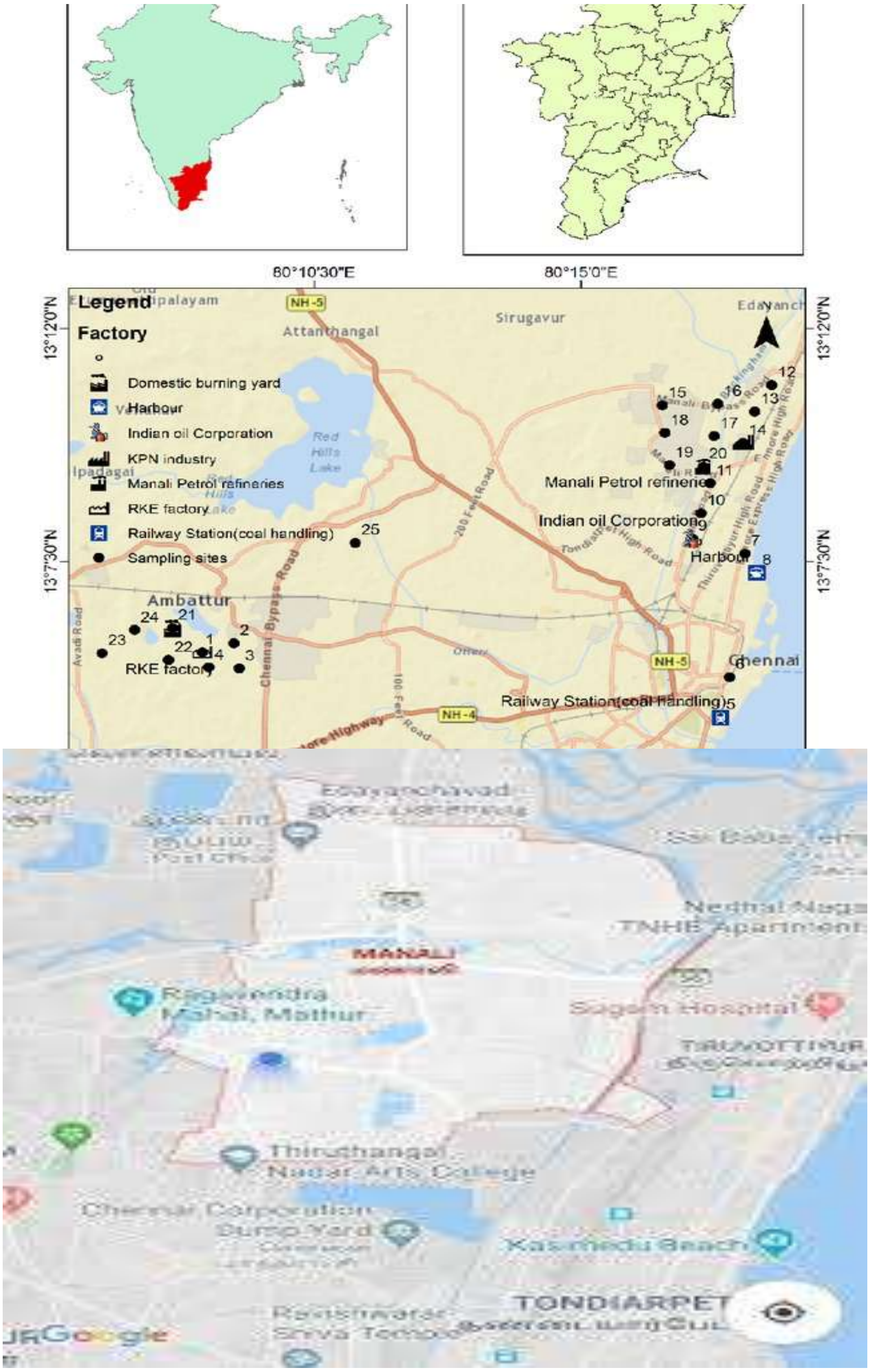
3.1 STUDY AREA

The Manali industrial region is on the Central Pollution Control Bureau's (CPCB) list of polluted places in India. Located to the north of Chennai, the industrial town of Manali is conveniently adjacent to the Buckingham canal. Its expanse exceeds 800 hectares and is traversed by villages. In recent years, the region has witnessed the emergence of approximately 300 industries, encompassing various processing sectors such as plastics and chemicals. Notable companies like Madras Fertilisers, Madras Petro-chemicals Ltd., and Madras Refineries Ltd. have also flourished in this area.

The study site is located at 80°15'43" East longitude and 13°10'4" North latitude, 20 kilometers from North Chennai. The location of the study area for groundwater assessment is depicted in the map in Figure 1. About 2000 hectares of Manali Industrial Complex is located in Manali Village, Voyagadu Sadayanguppam, Amulawayal, Ampathur Taluk and Chinnasekkadu & Village in Tiruvallur District in Tamil Nadu State, India. The area is bounded by the Buckingham & Tiruvottiyur canal on the east and Chennai city on the south. Ponneri taluk is bordered by the Kosathaliyar river in the north and Manchambakkam, Madhavaram and Mathur villages in the west of Tiruvallur district. The complex is connected to the Egmore High Road to the east, the Kolkata-

Chennai NH-5A highway to the west, the Manali-Ponneri highway to the north and the Madhavaram-Manali road to the south. Tiruvottiyur is 3 kilometers (15 kilometers) from Ennore port, industrial complex and adjacent railway station. Average rainfall in the region is approximately 100 to 120 cm, average summer and winter temperature ranges around 450 and 200°C respectively, with 70 to 80 percent humidity.

LOCATION MAP OF THE STUDY AREA



3.2 Collection of samples

Heavy metal concentrations were measured in both monsoon and summer months using samples collected from a variety of surface and groundwater sources, including open and tube wells. The selection of sampling locations was predicated on residential areas; specifics regarding sampling locations are provided in Table 1. The samples were gathered in 2.5 L polyethylene vessels that had been filled with water that had been distilled after being meticulously washed and moved to the sampling location. Atomic absorption spectroscopy was employed to ascertain the heavy metals concentrations including Cu, Zn, Pb, Ni, and Cr. The obtained results were subsequently cross-referenced with the WHO standard values.

4. Results and Discussion

The data for the average amount of metals in groundwater was collected between May 2021 and November 2022.

Table: 1 Mean value of metal ions concentrations of Ground water and surface water samples collected in and around manali area during the year May-2021

Station		Heavy metals				
		Zn	Cu	Pb	Fe	Cr
S1	S.w (canal)	8.32	10.45	1.89	15.33	8.57
S2	S.w (canal)	4.3	4.36	0.85	8.96	4.33
S3	S.w (canal)	6.73	9.86	1.75	13.75	7.45
S4	S.w (canal)	2.67	1.75	0.49	5.64	1.22
S5	G.W (bore well)	1.87	0.95	0.19	3.45	0.81
S6	G.W (bore well)	3.21	1.65	0.29	4.98	1.67
S7	G.W (bore well)	2.32	2.35	0.23	2.99	0.98
S8	G.W (bore well)	2.98	1.87	0.26	5.87	1.67
S9	G.W (bore well)	3.54	2.69	0.35	6.99	1.23
S10	G.W (bore well)	2.34	1.98	0.34	5.23	1.98

Table: 2 Mean values of metal ions concentrations of Ground water and surface water samples collected in and around Manali area during the year NOV- 2022

Stations	Heavy metals				
	Zn	Cu	Pb	Fe	Cr
S1	4.32	16.94	1.54	14.51	10.34
S2	1.23	1.11	0.2	2	0.57
S3	5	8.43	1.1	10.34	8.43
S4	2.54	1.45	0.21	3.12	1
S5	1.32	0.68	0.11	2.1	0.73
S6	1.94	1	0.2	3.43	1.2
S7	1.67	1.1	0.19	2.3	0.9
S8	2.1	1.12	0.2	3.45	1
S9	3.97	1.5	0.2	5.34	1.9
S10	1.23	1.24	0.24	2.34	1.1

4.1 Zinc:

The metal zinc, in the form of organic complexes or salts, is a required trace mineral present in almost all consumable food and drink. Protein synthesis is unable to occur without it. When taken orally, zinc is widely considered safe for human consumption. On the contrary, overabundance of these substances may lead to systemic dysfunctions, which in turn may disrupt development as well as reproduction (INECAR, 2000; Nolan, 2003). The zinc concentrations measured in this investigation varied between 0.02 and 0.06 parts per million. The zinc concentrations in all of the samples were determined to be within the WHO-recommended permissible limit of 3ppm.

4.2 Lead

Lead affects the gastrointestinal tract, kidneys, and central nervous system. Lead disrupts the blood-brain barrier and interferes with normal brain development in children. Lead is released from food and air in approximately equivalent amounts, and it is a severe systemic toxicity. Due to the fact that lead inhibits a number of crucial enzymes that are integral to the process of hemo-synthesis as a whole, metabolic intermediates accumulate (P. Gautham et al.). The observed Pb concentrations vary between 0.02 and 0.08 ppm. High levels of Pb, as recommended by the WHO (0.01ppm), were detected in every water sample analysed in our research. The process of infiltration from industrial waste water, domestic sewage, phosphatic fertilisers, and waste from agriculture containing both human and animal refuse may contaminate groundwater with lead. Extremely high blood pressure can induce detrimental alterations in the renal arteries, leading to hypertension and subsequent kidney injury (Y. Cao et.al)

4.3 Copper

Copper is often regarded as a necessary nutrient for human beings. It is widely dispersed in nature. Copper is an essential material for human health. however, prolonged exposure to contaminated drinking water may result in anaemia, as well as injury to the liver and kidneys. In this investigation, the copper concentration in the groundwater varied between 0.02 and 0.03 ppm. Copper concentrations in all of the samples were found to be below the WHO-recommended limit of 2 ppm, according to the study.

4.4 Iron

A component of the hemoglobin system, iron is biologically vital for all living things. A high concentration results in mild toxicity, bitterness, an inky flavour, and an astringent flavour. Iron-rich water weakens and discolours fingernails and teeth, and makes hair and water viscous. Our investigation revealed a range of Fe concentrations between 0.01 ppm and 0.36 ppm. The Fe concentrations in all groundwater samples were determined to be within the range recommended by the WHO (1.0ppm).

4.5 Chromium

Chromium penetrates natural waters via soil leaching, emissions directly from industrial activities, and weathering of C-bearing rocks. Allergic reactions, sleep disturbances, headaches, and mood shifts are all symptoms of chromium toxicity. An elevated risk of kidney or liver injury may result. The Cr concentrations are determined to be between 0.02 and 0.04 ppm. The Ni concentrations in all of the groundwater exceeded the WHO-recommended threshold of 0.01ppm.

4.6 Heavy metal pollution Index

The Heavy Metal Pollution Index (HPI) is a way to quantify the overall effect of multiple metals on the purity of water. The rating, which can be anywhere from zero to one, serves as an indication of the relative significance of particular quality aspects. For all other parameters, it correlates negatively with the Si recommendation. The HPI is determined through the subsequent procedures: first, the total mass age of the i^{th}value is computed and second, the grade classification for each heavy metal is determined.

The weight age of i^{th} parameter

Wi = k/si ---(i)

Wi is the age in units, while Si is the preferred value for the ith parameter,
(i=5), while k is the constant of proportionality.

A rating of individual quality is determined by expression

Qi = 100vi/Si ---(ii)

Where Qi is the sub index of i^{th} parameter, Vi is the monitored value of the i^{th} parameter in µg/l and Si the standard or permissible limit for the i^{th} parameter.

The heavy metal index (HPI) is then calculated as follows

HPI= $\Sigma_{1=0}^{n}$(Qi$\ast$ Wi)/ $\Sigma_{i=0}$ (W_i)---------------------------------------(iii)

The sub index Qi represents the ith parameter. Wi denotes the age in units of weight for the ith parameter, while n represents the count of parameters taken into account. The crucial pollution index value is 75 water is unfit for consumption above this level.

Table 3: Calculation of HPI values for the Heavy metal concentation of ground water samples around Manali area near Buckingham Canal Chennai.

Heavy metals	Mean value in ppm(V_i)	Highest permitted value (WHO) (S_i)	Unit weightage (wi)	$W_i \times Q_i$
Zn	3.8	3	0.0023	0.2913
Cu	3.79	0.05	0.1380	10.21
Pb	0.66	0.01	0.6900	41.40
Fe	7.31	0.3	0.0230	55.95
Cr	2.99	0.05	0.1380	80.0

HPI = 189.5

Table 4: Calculation of HPI values for the Heavy metal concentation of Surface water samples around Manali area near Buckingham Canal Chennai.

Heavy metals	Mean value in ppm(V_i)	Highest permitted value (WHO) (S_i)	Unit weightage (wi)	$W_i \times Q_i$
Zn	2.5	3	0.0023	0.1915
Cu	3.4	0.05	0.1380	93.8
Pb	0.4	0.01	0.6900	27.60
Fe	4.8	0.3	0.0230	36.8
Cr	2.7	0.05	0.1380	74.5

HPI = 51.4

Status categories of HPI

HPI	QUALITY OF WATER
0-25	Very good
26-50	Good
51-75	Poor
Above 75	Very poor(unsuitable for drinking)

In this study, HPI was obtained for groundwater of Manali region. Calculated HPI value of 86.7 This water quality assessment clearly reveals that the water body condition is not suitable for drinking water. Because an HPI value above 75 belongs to very poor water. Water samples showed high values of Pb and Nickel in groundwater.

5. Conclusion

Groundwater samples were taken from nearby areas and the Buckingham Canal. Atomic absorption spectroscopy was employed to ascertain the heavy metals concentration, including Zn, Pb, Ni, Fe, and Cu, in the water samples. The current investigation revealed comparatively elevated levels of Pb and Ni in relation to the WHO-approved thresholds. In contrast, the concentrations of Zn, Cu, and Fe are all below to the WHO-recommended allowable maximum. Systematic water quality monitoring is required to determine the heavy metals concentrations in water so that corrective actions can be taken to prevent heavy metal contamination of groundwater.

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