Aquatic Toxicity Due to Heavy Metal Contamination in River Cauvery: Tiruchirappalli Surroundings, Tamil Nadu, India

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Received: 20th September, 2022; Accepted: 14th November, 2022; Published online: 9th December, 2022

https://doi.org/10.33745/ijzi.2022.v08i0s.040

Abstract: The importance of water in our everyday lives cannot be overstated. Many heavy metals are present in natural water, but only at very low concentrations. Certain metals are essential to both human and animal health, but too much of these may be dangerous. The objective of this study was to ascertain whether or not the Cauvery River water in and around Trichy, Tamil Nadu, is fit for human consumption and other domestic applications. Ten samples of Cauvery River water were collected at different points in and around the Tiruchirappalli area. For this study, we used an atomic absorption spectrometer to determine the levels of Cu, Zn, Fe, Pb, and Mn. The studies were conducted at Tiruchirappalli, Tamil Nadu, on the Cauvery River after the monsoons had passed (2021). Copper and lead concentrations were found to be much over the legal limit (WHO, 2011). Heavy metal contamination of river water is an urgent environmental issue that needs fixing. Sewage from a wide range of commercial and non-commercial establishments must first undergo treatment before being discharged into the river. Awareness has to be promoted among those who work in industries, those who clean up after those companies, those who work for municipalities, and those who live in and around the areas being studied.

Keywords: Heavy metals contamination, Cauvery River, Industrial effluents, Anthropogenic, Remediation


https://doi.org/10.33745/ijzi.2022.v08i0s.040

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Introduction

The source of the Cauvery is Tala Cauvery, which is 1,341 m (4,400 ft) above sea level on the Brahmagiri Range in the Eastern Western Ghats. Water pollution can be caused by many things that happen naturally, such as gases, soil, minerals, humus, animal waste, and other forms of biological waste (Ghosh et al., 2018). Rivers are valuable resources because people use them for everything from drinking and bathing to farming and transportation to making electricity and even dumping trash. The water cycle includes river water, which is a source of surface water. It can be used around the house, in agriculture and industry, and to make electricity, among other
things. Because of the possibility of contaminants, there are stricter rules for the treatment and production of drinking water than for irrigation water (Shivakumar et al., 2014). Even though it has no calories or organic parts, all known forms of life need it to survive. Its chemical formula is H₂O, which means that each of its molecules is made up of one oxygen atom and two hydrogen atoms that are held together by covalent bonds. The angle between the hydrogen atoms and the oxygen atom is 104.45 degrees (Vezhaventan, 2018). Water is one of the most important things that all living things need to stay alive. Water is needed for many things that people do, like drinking, cooking, growing crops, and making things (Kavitha et al., 2015). In continents where water flows rarely and is scarce, a single drop could be all a person needs to stay alive. Most third-world countries have been dealing with this problem for a long time. People have said that their way of staying alive is an example of how humans are naturally able to adapt to changes in their environment (Latha and Jesu, 2015). However, we all know that this can not go on forever. Because of this, the right groups have started a campaign to get people to save water and teach them why it is important to do so (Kalavathy et al., 2015). Heavy metal contamination is measured using fish and shellfish. Because metals biomagnify in biota and are hard to break down, it is vital to analyse the metal concentration in fish and shellfish meat to ensure food safety and safeguard consumers (Malhotra et al., 2020). As a result of global warming, floods and droughts are happening more often, which has sped up the process of urbanisation. Heavy metals have been found in the water further down the Cauvery River, as shown by tests on the water, plankton, and fish sediment (Begum et al., 2009). Carbonate hardness was found to be very high in the water samples. Our infrastructure is also getting worse, which makes it more likely that people will cause accidents. Susheela et al. (2015) said about how important it is to protect a city’s infrastructure for sustainability from both natural and man-made dangers.

The objective of this study was to ascertain whether or not the Cauvery River water in and around Trichy, Tamil Nadu, is fit for human consumption and other domestic applications.

Materials and Methods

Study Area:
The Cauvery flows through the Tiruchirapalli District in Tamil Nadu, India. Tiruchirappalli, often spelled Trichy, is the district seat and largest city in Tiruchirapalli. For a total population of 2,722,290 in 2011, there were 1,013 females for every 1,000 men in the area. The district of Tiruchirappalli is part of Tamil Nadu. The total area of the district is 4,404 square kilometres. A major supply of both irrigation and drinking water, the Cauvery River runs along the whole length of the district. The total land area in the Tiruchirappalli district is 4,40,383 hectares, while the total cultivated area is 1,41,282 hectares. Irrigated farming covers an average of 98739 hectares (ha), whereas rainfed farming covers about 66652 hectares (ha). About 51 thousand hectares (ha) are irrigated by the Cauvery in the Trichy, Lalgudi, and Musiri divisions.

Major Industries around Tiruchirappalli district:
- Bharat Heavy Electricals Limited (BHEL)
- High Energy Projectile Factory (HEPF)
- Golden Rock Railway Workshop
- Ordnance Factory Tiruchirappalli
- Light and heavy engineering
- Leather Tanneries
- Food Processing
- Sugar Mills
- (Traditional) Cigar Making (village) Industries
- Hosiery and garments (to a small extent)

Heavy metal analysis:
All samples (S1 to S10) from various stations (Table 1) were tested using atomic absorption spectroscopy for heavy metals (Shimadzu). As a
radiation source, air acetylene lamps for Cu, Mn, Pb, Zn, and Fe (Shimadzu) were used.

**Results and Discussion**

**Copper:**

Copper's chemical inertness makes it useful in many applications. When exposed to humid air, metal gradually develops a protective deposit called patina, which has a distinctive greenish hue. The measured concentrations of copper fall within the range of 2.0 to 3.03 ppm (Table 2, Fig. 1). It has been determined that all river water samples are over the World Health Organization's recommended standard (2 ppm) In addition to causing dysentery, drinking copper-contaminated water may induce nausea, vomiting, abdominal pain, and diarrhoea.

Patients who are at a greater risk, such as those who have Wilson disease, should be educated about the signs and symptoms that may be alarming for worsening copper overload, as well as the many forms of excessive copper exposure and ways to prevent taking in excessive amounts of copper. It is possible to identify people at a greater risk for Wilson illness by screening the siblings and offspring of patients who have the condition (Collins and Klevay, 2011).

The body's natural safeguards against excessive copper intake may be defeated by consuming copper-rich foods. Accelerated intestinal absorption in the absence of a metabolic necessity for copper is one example of such a checkpoint. Overconsumption of copper may have negative consequences, hence a daily maximum of 10 mg has been set as a guideline. The danger of copper poisoning is higher in infants and newborns because their biliary excretion systems are not fully matured and because they absorb more copper via their intestinal walls (Copper IOM, 2001).

**Zinc:**

Zinc (Zn) levels in the range of BDL to 6.0 mg/l are much higher than the 3.0 ppm (Table 2, Fig. 1) threshold set by the World Health Organization in 2006. The male reproductive system cannot function without zinc. Zinc may be found in the skeleton, teeth, skin, liver, muscles, white blood cells, and testes. 2.2 to 4.4 ppm is the range discovered for zinc. All river water samples had zinc concentrations in excess of the World Health Organization’s (WHO) threshold of 3 ppm.
Copper, chromium, and zinc were shown to be correlated with lead content in drinking water. Corrosion of galvanized steel is another possible origin of the lead-zinc relationship, which might also apply to brass (Fisher et al., 2021). Zinc’s potentially harmful effects on aquatic life are the subject of a significant amount of study at the moment. For instance, the primary study emphasis of nations in Europe and the United States was directed toward the potentially lethal effects on species of salmonid fish, shrimp, fleas, hydroids, and phytoplankton taxa (Mottin et al., 2010).

The levels of metal toxicity found in different bodies of water might vary considerably from one another. If the lakes or rivers were contaminated by industrial effluent or were affected by algal blooms, then the pH of such bodies of water may become acidic (below 6) or alkaline (above 9) for a brief period of time (Yu et al., 2013). As a result of the enormous impact that pH has on the toxicity of zinc, the zinc standards that are applied to real water bodies may either over-protect or under-protect aquatic life depending on whether the actual water environment is acidic or alkaline and has a broad range of pH values (Li et al., 2018).

When it comes to zinc's effects, aquatic animal species span a wide toxicity tolerance range. Alterations occur as a result of familiarity with one's surroundings and age, respectively. Zinc depletion decreases a population’s resilience over time. For this reason, there is a broad range of doses that are deemed lethal. Concerns concerning zinc’s toxic effects on the body are not well understood. As it damages the tissues in the gills, which the fish need to breathe, at lethal concentrations, it is guaranteed to kill fish. Exposure to potentially lethal concentrations of this substance may cause stress that ultimately leads to death (And and Wood, 2004). This non-specific action of zinc implies that its effects will vary with both its concentration and the stage of life at which it is found. This is due to the fact that zinc has a redox potential and hence interacts with other elements in its surroundings.

**Iron:**

Foods containing iron benefit human health in several ways. An inherited disease is largely responsible for chronic iron excess. Anemia is caused by a lack of iron in the body. World Health Organization guidelines set the safe upper limit for iron at 1 ppm. The iron content is consistently greater than predicted in all of the river water samples tested. This ensures that the range of results for all samples is 1.11 to 3.28 ppm (Table 2, Fig. 1).

Oxygenated fluids are responsible for the oxidation of soluble ferrous ions (Fe II) to ferric ions (Fe III). It doesn't take long for ferric ions to become insoluble and precipitate out as hydroxides and oxyhydroxides in fluids with a pH greater than 6.5. Despite the intricacy of iron speciation, ferric precipitates are the most prevalent type of iron found in waters that might potentially support life (i.e., oxygenated and circumneutral pH). As a consequence of this, ferric precipitates are the primary kind of iron that should be taken into consideration when developing standards for the protection of aquatic life (Cadmus et al., 2018).

Singh et al. (2019) found that histopathological examination of the damaged tissues in the liver and fish gills showed significant histological changes. A correlation between time and concentration was shown to enhance the severity. Perl’s staining showed that the exposed fish’s liver had become overloaded with iron.

**Lead:**

Lead poisoning, for example, may cause high blood pressure and anaemia in humans and animals, and it can impair the brains of foetuses, young children, and pregnant women, among other vulnerable populations. When it comes to lead, the World Health Organization sets the safe level at 0.01 ppm. However, between 0.11 and 1.19 ppm is present throughout the board (Table 2, Fig. 1). Lead concentrations are found to be too high in every sample analyzed in this study. Kidney failure patients reported more discomfort after drinking
Table: 2. Study of Cauvery river water pollution and its impact on socio-economic status in and around Tiruchirappalli-Tamil Nadu

<table>
<thead>
<tr>
<th>Sampling Station</th>
<th>Cu</th>
<th>Zn</th>
<th>Fe</th>
<th>Pb</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>3.03</td>
<td>3.02</td>
<td>1.11</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>S2</td>
<td>2.02</td>
<td>3.01</td>
<td>1.14</td>
<td>1.12</td>
<td>0.12</td>
</tr>
<tr>
<td>S3</td>
<td>2.02</td>
<td>2.02</td>
<td>1.14</td>
<td>1.14</td>
<td>0.03</td>
</tr>
<tr>
<td>S4</td>
<td>3.03</td>
<td>2.02</td>
<td>1.16</td>
<td>1.14</td>
<td>0.04</td>
</tr>
<tr>
<td>S5</td>
<td>2.03</td>
<td>3.03</td>
<td>1.21</td>
<td>0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>S6</td>
<td>2.12</td>
<td>3.12</td>
<td>1.22</td>
<td>0.17</td>
<td>0.02</td>
</tr>
<tr>
<td>S7</td>
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<td>4.04</td>
<td>1.26</td>
<td>1.19</td>
<td>0.04</td>
</tr>
<tr>
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<td>3.33</td>
<td>1.33</td>
<td>1.16</td>
<td>0.04</td>
</tr>
<tr>
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<td>3.01</td>
<td>2.29</td>
<td>1.15</td>
<td>0.01</td>
</tr>
<tr>
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<td>2.03</td>
<td>4.02</td>
<td>3.28</td>
<td>1.09</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Fig.1: Heavy metals in water samples.

clean water, particularly water containing lead. The essential element lead (Pb) is toxic even in trace amounts.

It is widely recognized that even at modest levels of exposure, lead may have adverse effects on children's neurodevelopment. A correlation between lead in water and lead in children's blood has been shown in research using both population and toxicokinetic models at low lead concentrations in drinking water. Lead in water may be reduced by a number of different mitigating measures. Lead levels in water, how much water is drank, and the relative relevance of other sources all play a role in determining how much of a person's overall lead exposure may be attributed to drinking water. It is imperative that efforts be made to decrease lead exposure from all sources, including drinking water, since there is no safe amount of lead exposure that will not negatively affect a child's brain development (Levallois et al., 2018).

Manganese:
Inflammation of the liver and the brain might result from Mn buildup (Beckman et al., 1985). As
a transition metal, manganese has many applications in industry, notably in stainless steels. In this study the levels of manganese are measured to be between 0.01 and 0.12 ppm (Table 2, Fig. 1). There are 400 g/l of manganese in the water supply.

To begin, an individual’s vulnerability to Mn toxicity may be affected by age, gender, and ethnicity. When compared to adults, children store more Mn and excrete less, making them more vulnerable to Mn poisoning. Both academic performance and metabolic processes are susceptible to disruption due to hazardous exposures. The examination of bone manganese in humans without the use of intrusive techniques is now a possibility as a result of recent theoretical and technical breakthroughs. This technique has the potential to give unique data for the dietary monitoring of Mn levels in both children and adults, in addition to providing information on risk assessment. The manganese that has been accumulated in bone may, over the course of time, be released slowly and function as an internal source of manganese exposure (Tuschl et al., 2013).

It is crucial to be aware of the consequences of occupational, accidental, or iatrogenic exposures to manganese despite the fact that manganese toxicity, also known as manganism, is very uncommon. The extra-pyramidal side effects caused by this metal are the primary toxic consequences it is responsible for, and they are quite similar to the symptoms of Parkinson syndrome (Pfalzer et al., 2017). In order to determine Mn's toxicity, a high-risk situation was simulated, using fluids that were both acidic and gentle on the system. Six distinct kinds of tropical freshwater fish had their toxicity levels estimated (Harford et al., 2015).

Adsorption is a simple, efficient, and cost-effective way for cleaning wastewater, among many others. The goal of this research was to develop a chemical and natural process for cleaning all types of wastewater, such as that generated by factories, hospitals, and homes. Charcoalation, electrocution, salination, and filtering via pebbles and sand are just a few of the methods we use to clean up our wastewater. First, there is need to heat some dry bamboo pieces for two to four hours before letting them cool. Collect the wastewater, and then flush it via activated charcoal. When the salt is sterile, the water may be run through it to purify it (NaCl). After this, a circuit is formed using batteries or cathode and anode to transmit electricity via the collected water. Once completed all of these steps, then pebbles, sand, and coal may be used to construct a system or setup. Filter paper goes at the bottom of any container, then activated charcoal, then sand and pebbles. Once the treated water is run through this system, the resulting liquid is completely clean.

**Conclusion**

The current study revealed that the heavy metal concentrations of copper and zinc are much higher than the threshold allowed by the World Health Organization. However, low levels of Iron, Lead, and Manganese were detected in the river water samples collected for the Study. The findings provided in this research point to hospital effluents dumped into municipal sewage without treatment as a possible source of contaminants. The samples’ potential danger to aquatic life has been confirmed by ecotoxicological examinations. In addition to metals, a wide variety of chemicals present in untreated or partly treated effluent fluids may accumulate in sediments and contribute to their toxicity. The present findings lend credence to the idea that hospital effluents may benefit from the same cutting-edge technology used in today’s industrial and municipal sewage treatment facilities.

**References**


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