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HEAVY METAL CONCENTRATION IN VAIGAI RESERVOIR AND PICKUP DAM WATER, THENI DISTRICT, TAMILNADU

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ABSTRACT

The present investigation was aimed to analyse the water quality from Vaigai reservoir and pickup dam during 2017-2018. Heavy metals such as aluminum, cadmium, chromium, cobalt, copper, iron, nickel, lead and zinc were analysed in Vaigai reservoir and Pickup dam during 2017-2018. Iron showed to be high followed by nickel and chromium in Vaigai reservoir while chromium was high followed by iron in Pickup dam. The maximum and average value of heavy metals present was iron followed by chromium at both the sites. Among the heavy metals content, the lowest metal found in these sites was zinc. In these sites aluminum, cadmium, chromium, iron, nickel and lead were beyond the acceptable and permissible limits, while cobalt and copper were beyond the acceptable but within permissible limits. The highest average was chromium in Pickup dam and iron in Vaigai reservoir. Aluminium, cadmium, copper, nickel and lead are >5 and so it was seriously affected based on the categories of water pollution index in both the sites. Metal content in the study sites were found to be in the order of magnitude in Vaigai Reservoir as - Cd>Ni>Pb>Cr>Cu>Al>Fe>Zn and in Pickup Dam - Cd>Ni>Cr>Pb>Cu>Al> Fe>Zn.

KEY WORDS: Vaigai reservoir, Pickup dam, Water, Quality and heavy metals.

INTRODUCTION

The problems of contamination with toxic metals started in the Middle Age, with the mining activities, but were accelerated in the beginning of the nineteenth century, with the processing of metals in chemical plants (Vink *et al.,* 1999). Heavy metals are elements with a specific gravity that is at least four to five times the specific gravity of water at the same temperature and pressure (Duruibe *et al*. 2007; Garbarino *et al.,* 1995). Heavy metals causing serious health problems with adverse effects in human metabolism present obvious concerns due to their persistence in the environment. Heavy metal contamination may have devastating impacts on the ecological balance of natural water bodies including the loss of aquatic diversity (Vosyliene and Jankaite, 2006; Farombi *et al.,* 2007; Hayat and Javed, 2008). Many of these metals tend to remain in the ecosystem and eventually move from one compartment to the other within the food chain (Sadasivan and Tripathi, 2001).

MATERIALS AND METHODS

Study Area: Vaigai river basin or reservoir covers an area of about 7009.13 km^2. Vaigai Dam was built across the majestic river Vaigai near Andipatty, with a height of 111 feet can store 71 feet of water. It is about 7 km from Andipatty, 25 km from Theni. This dam was established in Vaigai Pudhur on January 21, 1959 (Plate 1). Pickup Dam is located about 1.5 km downstream of Vaigai Reservoir and it is also known as intake well (Plate 2). It sucks out water

Plate 1. Vaigai Reservoir

Plate 2. Pickup Dam

from Vaigai River supplied to purification plants.

Sample collection: Water samples were collected in sterilized plastic bottles which are rinsed well with the water being collected seasonally from 2017 to 2018. Samples were taken to the lab for analysis of heavy metals using Atomic Absorption Spectrometry (AAS).

Analysis: Two different quality indices were used to determine the metal contamination in the sites namely Vaigai reservoir and Pickup dam during the study period.

Pollution Index (PI)

It is based on individual metal calculations and categorized into 5 classes (Table 1) based on the following equation (Caerio *et al.*, 2005).

$$PI = \frac{\sqrt{(Ci/Si)2Max + (Ci/Si)2Min}}{2}$$

Where, Ci - the concentration of each element, Si - metal level according to national water quality criteria.

Metal Index (MI)

The higher the concentration of a metal compared to its respective MAC value, the worse the quality of the water. MI value >1 is a threshold of warning (Bakan *et al.*, 2010). According to Tamasi and Cini (2004), the MI is calculated using the following equation and categorized into 6 classes (Table 1).

$$MI = \sum_{I=i}^{n} \frac{Ci}{(MAC)i}$$

Where, Ci - the concentration of each element, MAC - maximum allowable concentration.

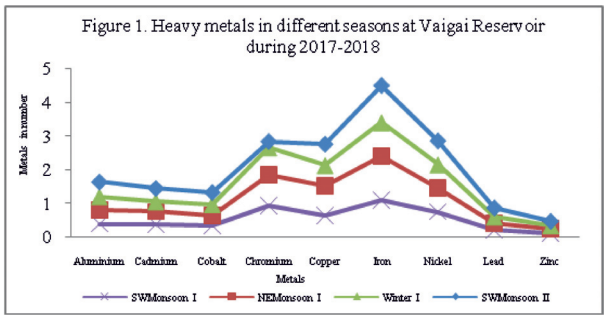
RESULTS

Heavy metals such as aluminum, cadmium, chromium, cobalt, copper, iron, nickel, lead and zinc present in Vaigai Reservoir and Pickup Dam water were analysed during 2017-2018. Altogether in all the seasons at Vaigai Reservoir, iron showed the peak followed by nickel and chromium. The lowest metals present here was zinc followed by lead (Figure 1).

When looking into the maximum heavy metals present, it was iron followed by chromium. The average value also showed the maximum in iron

Table 1. Categories of Water Quality using Pollution and Metal Indices

Class	Pollution Index		Metal Index	
	PI value	Class	MI value	Characteristics
1	<1	No effect	<0.3	Very pure
2	1-2	Slightly affected	0.3-1	Pure
3	2-3	Moderately affected	1-2	Slightly affected
4	3-5	Strongly affected	2-4	Moderately affected
5	>5	Seriously affected	4-6	Strongly affected
6	-	-	>6	Seriously affected



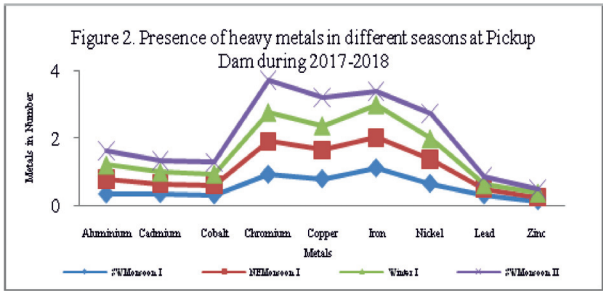
followed by chromium (Table 2).

Table 2. Heavy metals present in average, maximum, minimum and standard deviation in mg/l at Vaigai Reservoir between 2017 and 2018

Metals	Avg.	Max	Min	Std.dev
Aluminium	0.41	0.42	0.39	0.0129
Cadmium	0.36	0.38	0.3	0.0386
Cobalt	0.33	0.34	0.29	0.025
Chromium	0.71	0.94	0.17	0.3626
Copper	0.69	0.87	0.62	0.122
Iron	1.13	1.3	1	0.1258
Nickel	0.71	0.75	0.7	0.025
Lead	0.21	0.25	0.2	0.025
Zinc	0.11	0.13	0.1	0.0126

In this site, aluminium was beyond the acceptable and permissible limits. The permissible limit is 0.2 mg/l but the recorded value was 0.4 mg/l which is higher than the permissible limit. Cadmium was beyond the acceptable and permissible limits where the permissible limit is 0.03 mg/l but the recorded value fell above 0.3 mg/l. Cobalt was recorded beyond the acceptable limit but within the permissible limit. Whereas chromium was beyond the acceptable and permissible limits as it varied in the values from 0.17 to 0.94 mg/l (Table 2). Copper level was beyond the acceptable limit but within the permissible limit, while iron was beyond acceptable and permissible limits, as well as it had the highest value among the metals (Table 2 & Figure 1). Nickel also lounged beyond the acceptable and permissible limits as well as highest value next to iron. Lead content was beyond the acceptable and permissible limits, where the permissible limit was 0.01 and the recorded value was from 0.2 mg/l to 0.25 mg/l. Zinc at Vaigai Reservoir showed the value reclined within the acceptable and permissible limits (Table 2). The lowest metal found in this site was zinc (Figure 1).

In Pickup Dam, Chromium showed a peak followed by iron. Among the heavy metals content, aluminium showed beyond the acceptable and permissible limits. Cadmium was recorded as beyond the permissible and acceptable limits. Cobalt was recorded as beyond the acceptable but within the permissible limits. Chromium was beyond the acceptable and permissible limits while copper value was recorded here beyond the acceptable limit but within the permissible limits. Iron content was recorded as beyond the acceptable and permissible limits. Nickel value observed was beyond the acceptable and permissible limits. Lead value also recorded as beyond the acceptable and permissible limits. Amount of Zinc alone lounged within the acceptable and permissible limits. The same trend of peak and slope down was seen for all the seasons in this site (Figure 2).



Maximum recorded in Pickup Dam was iron followed by chromium and minimum was recorded in chromium followed by copper but the highest average was chromium (Table 3).

Table 3. Heavy metals present in average, maximum, minimum and standard deviation in mg/l at Pickup Dam between 2017 and 2018

Metals	Avg	Max	Min	Stdev
Aluminium	0.4	0.44	0.33	0.0499
Cadmium	0.33	0.35	0.31	0.0171
Cobalt	0.32	0.34	0.3	0.0171
Chromium	0.93	0.99	0.87	0.0506
Copper	0.8	0.86	0.73	0.0556
Iron	0.84	1.1	0.37	0.3245
Nickel	0.68	0.74	0.62	0.0589
Lead	0.21	0.3	0.11	0.0787
Zinc	0.12	0.13	0.11	0.0096

Pollution Index of heavy metals was estimated to evaluate the suitability of water in four different seasons at two different places, Vaigai reservoir and Pickup dam during 2017-2018. Pollution Index has to be taken care while treating water as it showed the metals like aluminium, cadmium, copper, nickel and lead are beyond 5 and so it was seriously

Table 4. Pollution Index and Average Pollution Index of heavy metals in four seasons at two different sites from 2017 to 2018

Sampling site	Season	Al	Cd	Cr	Cu	Fe	Ni	Pb	Zn	Total
Vaigai	SWMonsoon I	6.24	77.78	17.30	7.40	2.26	27.22	16.26	0.01	154.48
Reservoir	NEMonsoon I	6.57	89.57	18.27	6.40	2.59	26.52	14.85	0.01	164.78
	Winter I	6.91	87.21	17.69	8.70	3.06	24.75	16.97	0.01	165.31
	SWMonsoon II	7.08	89.57	3.30	6.20	2.59	24.75	17.68	0.01	151.18
	Average Pollution Index	6.7	86.03	14.14	7.18	2.63	25.81	16.44	0.01	6.7
Pickup	SWMonsoon I	5.56	80.14	17.69	7.80	2.59	22.63	21.21	0.01	157.64
Dam	NEMonsoon I	7.42	73.07	19.24	8.60	2.14	25.46	14.14	0.01	150.08
	Winter I	7.25	77.78	16.91	7.30	2.33	21.92	7.78	0.01	141.29
	SWMonsoon II	6.91	82.50	18.27	8.20	0.87	26.16	16.26	0.01	159.19
	Average Pollution Index	6.78	78.37	18.03	7.98	1.99	24.04	14.85	0.01	6.78

affected based on the categories of water pollution index (Table 1 & 4). Chromium must be taken care to be reduced to <1 because it showed the pollution index value as >5. The water is seriously affected except in Vaigai Reservoir during SWMonsoon II where the pollution index value was 3.30 which is strongly affected. Iron has no effect during SWMonsoon II of Pickup Dam and moderately affected in all the seasons and except winter 1 of Vaigai Reservoir which is strongly affected. Zinc alone has the pollution index within 1 (Table 4) which has no effect as given in the class of categories of pollution index (Table 1).

Metal Index of heavy metals were analysed using the formula following Caerio *et al.* (2005). In different seasons of Vaigai Reservoir and Pickup Dam, it ranged between 175 and 210 (Table 5). Metal index of Vaigai Reservoir during NEMonsoon I showed the highest value and low in SWMonsoon I, whereas in Pickup Dam it was high during SWMonsoon I and low during winter I followed by NEMonsoon I. In these sites, in all the seasons, the Metal Index of heavy metals showed above 100 and hence the water from the two sites were seriously affected (Table 1).

Table 5. Metal Index of heavy metals in two different sites during four seasons between 2017 and 2018

Season	Vaigai Reservoir	Pickup Dam
SWMonsoon I	194.85	199.38
NEMonsoon I	210.02	184.95
Winter I	207.51	175.34
SWMonsoon II	196.25	199.3

Hierarchy of pollution index: Vaigai reservoir showed similar hierarchy of average Pollution Index of heavy metals with Pickup dam except lead and chromium where lead was greater than chromium in Vaigai reservoir and vice versa in Pickup dam. The average Pollution Index of heavy metals ranged between 0.01 and 86.03 (Table 4).

The overall average concentration of elements in the Vaigai Reservoir and Pickup Dam, were found to be in the order of magnitude as follows:
Vaigai Reservoir - Cd>Ni>Pb>Cr>Cu>Al>Fe>Zn
Pickup Dam - Cd>Ni> Cr> Pb> Cu>Al>Fe>Zn

In this hierarchical order, cadmium was higher than all the other heavy metal Pollution Index. Aluminium pollution index was greater than iron, and Zn had the lowest Pollution Index (Table 4). Pickup Dam and Vaigai reservoir water showed the similar hierarchy of metal pollution index where cadmium is greater than nickel, copper is greater than aluminium and it follows as Cu>Al>Fe>Zn except Pb>Cr in Vaigai reservoir while Cr>Pb in Pickup Dam (Table 4).

DISCUSSION

Heavy metals like the aluminium, cadmium, cobalt, copper, iron, lead, nickel and zinc are the essential micronutrients required in minimum concentration for all the living organisms. The present study was aimed to analyze the presence of heavy metal in the sampling stations namely Vaigai River and Pickup Dam. Heavy metals in all the seasons together at Vaigai Reservoir showed the highest peak for iron (4.5 mg/l) and the lowest was (0.45 mg/l) zinc. Nickel showed the highest value (2.85 mg/l) followed by chromium and copper (2.75 mg/l). Aluminium and cobalt had the values between 1 and 2 (Figure 1). Heavy metals are the toxic environmental pollutant as they have the ability of bioaccumulation and exist as high toxicant in the environment. Jaiswar *et al*. (2015) reported that the heavy metal occurs at low concentrations in natural

water normally in nanogram to microgram per liter level. Due to bioaccumulation of heavy metals in an ecosystem and living organisms and human may have a fatal effect.

Cadmium is a metal and a byproduct of zinc production and it is released into the environment through volcanic eruptions, weathering, river transport and anthropogenic activities such as mining, tobacco smoking, incineration of municipal waste, and manufacture of fertilizers. Cadmium has been used in batteries, pigments, plastics and metal coatings and is widely used in electroplating (Martin and Griswold, 2009). Cadmium and its compounds are classified as Group 1 carcinogens. Premature birth and reduced birth weights resulted if cadmium exposure is high during human pregnancy (Henson and Chedrese, 2004). Cadmium is highly toxic to the kidney, lungs, osteoporosis, renal dysfunction, vomiting and diarrhoea (Bernard, 2008; Flora *et al.,* 2008).

Figure 2 showed the highest content of heavy metals were chromium, aluminium, cadmium and iron beyond the acceptable and permissible limits. Chromium followed by iron showed the highest content and the lowest, zinc followed by lead among the heavy metals in Pickup Dam. Cobalt and copper content was beyond the acceptable limit but within the permissible limit. This is in accordance with the earlier studies of Ambedkar and Muniyan, (2012) where cadmium, chromium, copper, lead, iron, zinc and manganese were in higher concentration and of above permissible limit in Gadilam River. Nickel and Lead values observed was above the acceptable and permissible limits in Vaigai reservoir and Pickup dam, on the contrary the study of Dhinamala *et al*. (2015) reported that nickel and lead were below permissible limit in Pulicat Lake. Aluminium is the third most abundant element found in the earth's crust (Gupta *et al.,* 2013). Aluminium occurs naturally in the air, water and soil. The sources of exposure to aluminium are drinking water, food, beverages, and aluminium containing drugs as studied by Jaishankar *et al.* (2014). Aluminium showed adverse effects on the nervous system and resulted in loss of memory, problems with balance and loss of coordination (Krewski *et al.,* 2007) nausea, mouth ulcers, skin ulcers, skin rashes, vomiting, diarrhoea and arthritis.

The toxicity of iron led to iron mediated tissue damage, mutation and malignant transformations (Grazuleviciene *et al.,* 2009). Chromium (VI) compounds are highly toxic due to its greater ability to diffuse through cell tissue and are carcinogenic. Chromium occurs in nature which is caused by human activity in the environment. Exposure to chromium compounds can result in the formation of ulcers, DNA damage as stated by Matsumoto *et al.* (2006). In large concentrations it is harmful. Exposure to chromium compounds can result in ulcers as studied by Jaishankar *et al.* (2014).

Zinc content was in low level and was within the acceptable and permissible limits. Silambarasan *et al.* (2012) stated that the zinc influences growth rate and bone development. The deficiency of zinc manifests itself by retardation of growth, anorexia, lesions of the skin, impaired development and function of reproductive organ.

CONCLUSION

Heavy metals such as aluminium, cadmium, chromium, iron, nickel and lead are present beyond the acceptable and permissible limits at Vaigai Reservoir and Pickup Dam. Chromium followed by iron is the highest metals present in Pickup Dam. The highest metal present in Vaigai Reservoir is iron. Pollution index shows that the highest pollution is at Vaigai Reservoir especially during winter I. Aluminium is greater than iron and zinc is the lowest metal in these two sites. Moreover cadmium, copper, aluminium, iron and zinc showed the same status in its Pollution Index in these sites. The highest content of metal is cadmium and the lowest is zinc in both the sites. Although zinc is the lowest content present in both the sites which falls within acceptable and permissible limits is also essential to be higher than this content. But the other harmful metals such as chromium, cadmium, aluminium, nickel, lead, cobalt, iron and copper are higher than the acceptable and permissible limits. The changes in the heavy metals at Vaigai Reservoir change the quality of water in Pickup Dam. Hence this water should not be used directly without proper treatment like ion exchange, reverse osmosis, distillation etc.

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