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Seasonal Variation in Heavy Metal Pollution at Pallathuruthy, A Coverging Point of Pamba and Vembanad Lake, Kerala, South India

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Abstract: ***The present study was conducted at Pallathuruthy, were Pamba River meets with Vembanad Lake. The study deals with the heavy metal contamination status of water at Pallathuruthy over three seasons like pre monsoon, monsoon and post monsoon. The study had revealed that the level of heavy metals like copper, lead, cadmium and chromium in the water samples collected from this area were above the stipulated level prescribed by Indian Standard. When assessing the seasonal variation in the level of heavy metals it was found most of the heavy metal showed high values in pre monsoon. The results of One Way Analysis of Variance showed that the distribution of lead and cadmium between seasons showed significant difference. The major factors that plunge the water quality of this area to this condition were the indiscriminate use of chemical fertilizers and pesticides and busy plying of house boats.***

Keywords: Pallathuruthy, heavy metal, season, cancer, house boats

1. Introduction

Pamba is the third longest river in Kerala which extends over a distance of 2235 km2 after originating from Pulachimalai hill at an elevation of 1650 m. It drains through Pathanamthitta and Alappuzha districts and finally empties into Vembanad Lake before joining with the Arabian Sea. Based on the topographical and physiographical aspects of Pamba River, it can be divided into three sectors like high land area, midland area and the low land area.The Pamba River is also now losing its sheen because of various pollutions [15]. Among these pollutions, pollution mediated through heavy metals draws great attention because of its escalated level now a day.The metals with high density (greater than 4.5 g/cm3), atomic number and atomic weight (from 63 to 200.6 g/mol) are called heavy metals.Among the various heavy metals arsenic, chromium, lead and mercury are the most toxic heavy metals found in the environment. Carcinogenic property of chromium and cadmium was well proved [4]. Excessive intake of cadmium will lead to degenerative bone disease and that of mercury results in central nervous system damage [4]. Industrialization and mining activities are the prime contributors of cadmium [9]. Considering the toxicity, cadmium is more toxic than chromium, when it crosses the limits will results in a disease called itai-itai. Even a prolonged exposure to smaller amount itself is strong enough to cause male sterility, high blood pressure and flu[5]. Since the riparian population of Pallathuruthy, a portion of KutanaddependsPamba River for their water requirements, it is ultimate to check the water quality especially that of heavy metal contamination to meet the health requirements. The present study examines the variation in heavy metal contamination of Pamba River at Pallathuruthy, the meeting point of Pamba River and Vembanad Lake, in three seasons like pre monsoon, monsoon and post monsoon.

2. Study Area

The area selected for the present study was Pallathuruthy(9.4599° N, 76.3695° E), the meeting point of Vembanad Lake with Pamba River, so it is an estuarine area (Fig 1). Vembanad Lake is one of the longest Lakes in India. This study area was a fresh water dominant section of Vembanad Lake separated by Thanneermukkom bund, which was constructed in 1975 for the protection of paddy fields from extreme salinity[14]. The considered study site was marked by the presence of busy plying of tourist house boats.

3. Literature Survey

Heavy metal pollution of rivers is a very sensitive field of pollution study worldwide. Ubong et al, [21] studied the heavy metal pollution of groundwater in Okrika mainland, Rivers. Zhengetal, [23] studied the heavy metal pollution in the sediment of three rivers in Huludao City, Northeast China. The heavy metal pollution in Ganga was also investigated byPaul [13]. In Kerala also many works were done on heavy metal pollution of Rivers. Koshyetal, [11] analyzed the heavy metal pollution in the sediments ofVattakayal, Kerala, India.Sajudeen[15] inspect various pollutions happened to Pamba River including the heavy metal pollution.

Figure 1: Location of Study Area

4. Materials and Methods

Water samples from Pallathuruthy were collected in three seasons like pre monsoon, monsoon and post monsoon with a regular interval of 30 days from September 2012 to August 2013. Each sample was taken in good quality polyethylene glass bottles kept in an ice box and were immediately brought to the laboratory for analysis.In the laboratory the heavy metal like Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd) and Chromium (Cr)content in water wereanalyzed. All parameters were analyzed as per the standard methods of APHA (2012). Instrument and methods adopted for the study were given in Table 1.

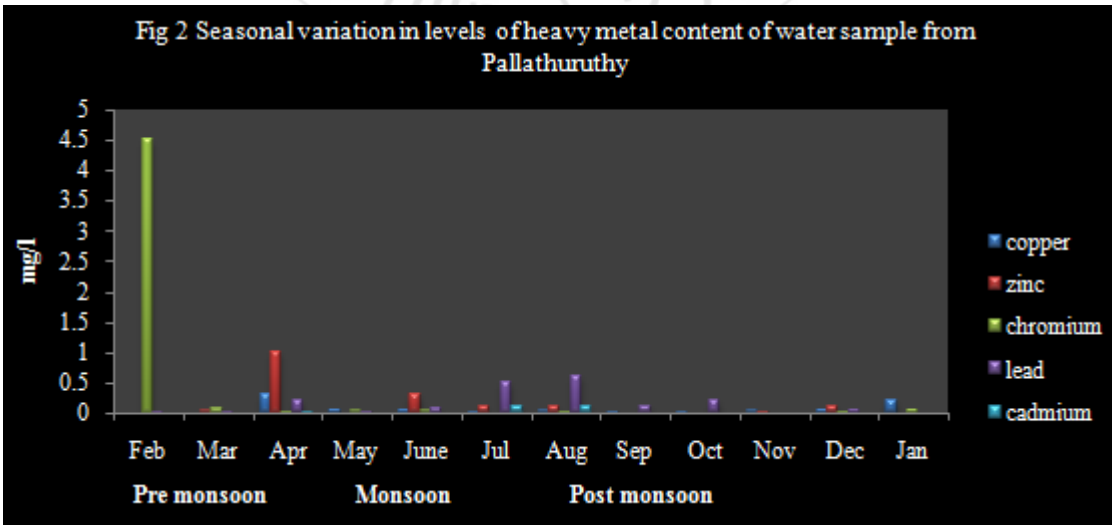
Table 1: Instruments /methods used for Estimation of Physico -Chemical Parameters

Sl No:	*Physico- chemical Parameters*	*Method/Instrument*
1.	Copper (water)	IS 3025 (part 42)
2.	Zinc (water)	IS 3025 (part 49)
3.	Lead (water)	IS 3025 (part 47)
4.	Cadmium (water)	IS 3025 (part 41)
5.	Chromium (water)	Annex j of IS 13428: 2005

The difference in heavy metal content in water between seasons was analyzed using One way Analysis of Variance (ANOVA).

Table 2: Seasonal values of heavy metal content in the water sample collected from Pallathuruthy

Heavy metals	*Pre Monsoon*					*Monsoon*					*Post Monsoon*				
	Feb 2013	Mar 2013	Apr 2013	May 2013	Aver	Jun 2013	Jul 2013	Aug 2013	Sep 2012	Aver	Oct 2012	Nov 2012	Dec 2012	Jan 2012	Aver
Copper(mg/l)	0	0	0.3	0.06	0.09	0.05	0.02	0.03	0.02	0.03	0.02	0.03	0.06	0.2	0.08
Zinc (mg/l)	0	0.03	1	0	0.26	0.3	0.1	0.1	0	0.13	0	0.02	0.1	0	0.03
Chromium (mg/l)	4.5	0.07	0.02	0.03	1.16	0.03		0.02	0	0.01	0	0	0.02	0.06	0.02
Lead (mg/l)	0.01	0.01	0.2	0.02	0.06	0.08	0.5	0.6	0.1	0.32	0.2	0	0.05	0	0.06
Cadmium (mg/l)	0	0	0.02	0	0.01	0	0.1	0.1	0	0.05	0	0	0	0	0.00



5. Results and Discussion

Copper is a reddish brown metal of natural occurrence found in rivers, rocks, soils and sea. In nature it is usually found in association with sulphur and oxygen to form compounds. The major source of copper are domestic wastes, leeching from household plumbing systems and a minor fraction may come from fecal matters. Copper is widely used in many products like pesticides,fungicides and wood preservatives. The copper content in water during the three seasons like pre monsoon, monsoon and post monsoon during the study period was given in Table 2. Average copper content in water during the three seasons ranged from 0.03 to 0.09 mg/l. The highest values were observed in pre monsoon season and lowest during the monsoon season.According to the standard prescribed by IS [10] the acceptable limit for copper in water is 0.05 mg/l and the maximum permissible limit is 1.5 mg/l.In the present study the copper level in water was above this prescribedlimit during pre-monsoon and post monsoon. So an immediate action is necessary to bring the condition under the normal level.The seasonal variation in copper content of water was represented in Fig 2. High load of copper in pre monsoon may happen because of intensified usage of pesticides in the nearby cultivation lands or may came from high precipitation in pre monsoon or due to the presence of decaying organic matter. These assumptions were supported by the study done by Sankaranarayanan and Reddy, [16]. As per the results of ANOVA the difference in copper content of water between seasons was not significant ($p > 0.05$) (Table 3).

Table 3: Result of ANOVA to test significance of copper (water) in different seasons

Response of Cu	*Df*	*Sum Sq*	*Mean Sq*	*Fvalue*	*Pr(>F)*	*Sign: code*
between season	2	0.02995	0.014977	1.26	0.296941	
between month	9	0.37117	0.041241	3.4696	0.004118	**
Residuals	33	0.39225	0.011886			

Signif. Codes:0 '***', 0.001 '**',0.01 '*', 0.05 '.',0.1 '',1

Zinc is an abundant metal found in earth crust. Both natural and anthropogenic sources add zinc to earth crust. Common anthropogenic sources that contribute zinc are smelter slags, fertilizers, wood preservatives, food wastes and mining places. According to the standards set by IS [10], the acceptable and permissible limit for zinc in water is 5 mg/l and 15 mg/l respectively. Human are susceptible to many health problems like skin irritation, nausea, anemia and vomiting, when exposed to high levels of zinc [22]. In the present study the average value of zinc in three seasons ranged from 0.03 to 0.26 mg/l (Table 2). The highest value was observed in pre monsoon season and the lowest in post monsoon season. When compared with the standard limits set by IS [10] the level has not reached above the prescribed limits. Comparatively high values of zinc in pre monsoon may occur because of high precipitation and small scale intrusionof fertilizers and domestic wastes to the river. The seasonal variation of zinc at Pallathuruthy was represented in Fig 2. In a study done by Joseph, [12] also the similar observations were found. According to the results obtained in ANOVA the zinc distribution in Pallathuruthy did not show any significant difference between seasons.

Table 4: Result of ANOVA to test significance of zinc (water) in different seasons

Response of Zn.	*Df*	*SumSq*	*MeanSq*	*Fvalue*	*Pr(>F)*	*Sign: code*
Between seasons	2	0.22436	0.112181	1.5629	0.224634	
Between months	9	2.30084	0.255649	3.5618	0.003472	**
Residuals	33	2.3686	0.071776			

Chromium is a toxic heavy metal present in earth crust in different forms like Chromium (II) chromium (III) and Chromium (IV). Chromium (III) is the natural form, which an essential element helping in fat, sugar and protein digestion. In wood preservatives, dyes, pigments and leather tanning, Chromium (II) and (IV) are chief ingredients. In the present study the average value of chromium in the water sample of Pallathuruthy in three seasons ranged from 0.01 to 1.16 mg/l. The highest value was observed in pre monsoon and the lowest was observed in monsoon season. As per the directives of IS [10] the desirable limit for chromium in water is 0.05 mg/l. The observed value for chromium in water sample from had cross the limit set by the IS [10]. So it is a clear indication of the unsuitability of this water for domestic purposes in the focus of health related issues. Increased level of salinity can lower the chromium level [12], but in spite of high salinity in pre monsoon at Pallathuruthy the level of chromium had crossed the stipulated limits in pre monsoon. After the heavy flush in monsoon as the water level continued to lower and by the arrival of pre monsoon season this lowered water level and high precipitation had raised the level of chromium in water. In a study done by Banyanman, [3], it was reported that it was this polluted water was the prime source of water requirement of 80% Kuttanad population. During his survey he reported the laymen opinion about their immunity power against pesticides due to continuous use of this water. The indiscriminate waste discharge by tourist house boats and chromium containing wood preservatives used in boats werethe other issues prevalent here [19].The result of ANOVA showed that the distribution of chromium in the water sample of Pallathuruthy did not show significant differences between seasons ($p > 0.05$) (Table 5).

Table 5: Result of ANOVA to test significance of chromium (water) in different seasons

Response of Cr.	*Df*	*SumSq*	*MeanSqF*	*value*	*Pr(>F)*	*Sign: code*
between seasons	2	0.7716	0.38582	0.8968	0.4176	
between months	9	3.741	0.41567	0.9662	0.4846	
Residuals	33	14.1966	0.4302			

Lead is a natural heavy metal usually found in association with other elements in the form of compounds. Alloys, which is a combination of lead with metals is a common ingredient in batteries, pipes, paints, dyes and diesel fuel combustion (BIS, 1991). If the water pH level was low it will accelerate the dissolution of lead from lead pipes[2]. In very low level, lead is also present in some food items. According to the stipulation of BIS [3], the desirable limit for lead in water should be below 0.05mg/l. But IS [10]prescribed the acceptable limit should be under 0.01mg/l. In the present study the average level of lead in water samples collected from Pallathuruthy in three seasons ranged from0.06 to 0.32 mg/l. This level was above the stipulated limits.High levels of lead were observed during the monsoon season. This high levels was the result of heavy diesel fuel combustion from the busy house boat services [18] (Fig 3), which was again supplemented by leeching from domestic piping systems as well as from an obsolete public water tank in the shore[20]. Results of ANOVA showed that lead distribution in water of Pallathuruthy showed significant difference between seasons ($p < 0.05$) (Table 6).

Table 6: Result of ANOVA to test significance of lead (water) in different seasons

Response of Pb	*Df*	*SumSq*	*MeanSq*	*Fvalue*	*Pr(>F)*	*Sign: code*
between seasons	2	0.61441	0.307206	63.1762	5.21E-12	***
between months	9	0.76179	0.084644	17.4068	3.84E-10	***
Residuals	33	0.16047	0.004863			

Figure 3: Busy plying of House boats

Cadmium is a heavy metal with high affinity towards sulphur and having a least occurrence in earth crust. Cadmium is easily mobile when the pH is below 8 and an oxidizing environment is available. This process can be furtheraccentuated by a heavy flow [8]. Major sources of cadmium are battery, fertilizers, plastic manufacture, paint and some industrial process like electroplating. Galvanized pipes and fittings are also a source of cadmium [7]. The safe limit of cadmium for public health is 2 microgram per liter [7], when the cadmium level crosses this limit it will results in intestinal bleeding, vomiting, kidney damage and finally can ends up in many types of cancers [7]. As per the norms of IS [10] the acceptable limit for cadmium in water is 0.003mg/l.In the present study the average value of cadmium in the water sample collected from Pallathuruthy in three seasons ranged from 0 to 0.05 mg/l. This level was above the stipulated limit. The highest value was observed in monsoon and the lowest in post monsoon.The seasonal variation of cadmium at Pallathuruthy was represented in Fig 2. The high load of cadmium may be the result of monsoon run off or from percolation of various fertilizers used in adjacent fields or may be the result of leeching out from domestic piping systems [17]. As studies have proved that a prolonged exposure to cadmium can lead to various cancers, the reports of cancer from Kuttanad were rising now a day [20]. The indiscriminate use of fertilizers in this area was also looked up in suspicion as a root cause for this cancer outburst [1].The result of ANOVA showed that the distribution of cadmium in water between seasons was significant ($p < 0.05$) (Table 7).

Table 7: Result of ANOVA to test significance of cadmium (water) in different seasons

Response of Cd.	*Df*	*SumSq*	*MeanSq*	*Fvalue*	*Pr(>F)*	*Sign: code*
between seasons	2	0.030117	0.015058	43.086	6.29E-10	***
between months	9	0.0372	0.004133	11.8266	4.76E-08	***
Residuals	33	0.011533	0.00035			

6. Conclusion

The present study gave the picture that the water quality of Pallathuruthy was not fit for domestic use with respect to heavy metal contamination. Among the five heavy metals considered for the present study except zinc all the other 4 heavy metals like copper, cadmium, lead and chromium were above the standard limits. Majority of heavy metal content escalated during the pre-monsoon season, which pores light on the fact that the high precipitation, indiscriminate use of fertilizers and pesticides and also the unprecedented increase in the plying of house boats related

with tourism were the prime factors responsible for the poor plight of water quality of Pallathuruthy.

7. Future Scope

The present study urged the necessity of an authorized body to check the water standard of this area monthly to monitor the water quality to sustain the public health. Also proper enlightenment is required among the laymen about the drawbacks of chemical fertilizers over natural alternatives. Proper monitoring should be implemented to curb careless dumbing of wastes by house boats in the river systems.

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