



POLLUTION STATUS OF HEAVY METALS IN THE SOUTHERN STRETCHES OF RIVERINE STATIONS UNDER VEMBANADU LAKE

Sailaja Kumari M.S¹, Maya T², Dr Tulasi V³, Gayathri Unnikrishnan⁴, Vijayasree V⁵, Ambika Devi⁶

1. Associate Professor, Regional Agricultural Research Station, Kumarakom
2. Head, Department of Plantation Crops and Spices, College of Horticulture, Kerala Agricultural University, Vellanikara
3. Associate Professor, Regional Agricultural Research Station, Pattambi
4. Project fellow, Wood science and Technology Department, Kerala Forest Research Institute, Peechi
5. Assistant Professor, Department of Agricultural Entomology, College of Agriculture, Vellayani
6. ADR Retd, RARS, Kumarakom

Communicated :28.08.2022

Revision: 11.09.2022 & 19.09.2022
Accepted: 01.10.2022

Published: 30.01.2023

ABSTRACT:

Vembanadlake is the largest estuarine ecosystem in Kerala. The lake is fed by major rivers like Achankovil, Manimala, Meenachil, Pampa and Moovattupuzha. Long-term stagnation of this lake had encouraged the accumulation of pollutants. The concentrations of Fe, Mn, Zn, Cu, Ni, Pb, Cd and Cr in water samples from Meenachal, Manimala, Pampa, Achankovil river stations were studied for four consecutive months. The Heavy Metal Pollution Index (HPI) was calculated from the data obtained for the water quality assessment based on heavy metal contamination of the four investigated rivers. The HPI values indicated that the water quality of the rivers except Achankovil was poor coming under the category of HPI: 50-75, which will be riskier to human health. The study is significant for creating awareness on the action plans forest rictingthe pollutant influx into rivers there by creating a reduct ionin heavy metal pollution.

Keywords: - Pollution, heavy metal, Pollution index, kuttanadu and water quality

INTRODUCTION :

Heavy metals from industrial wastes are a major source of pollution. Anthropogenic activities generate industrial wastes, agricultural wastes, domestic wastes and mining release heavy metals into the environment. Heavy metals originate from both natural and anthropogenic sources (Mortvedt, 1996; Wei and Yang, 2010; Tiwari and Singh, 2014; Ali and Khan, 2018).

Among various organic and inorganic water pollutants, metal ions are found to be toxic, hazardous and harmful due to their non-degradable nature (Jumbe and Nandini, 2009). Concentrations of trace metals in coastal estuaries may be elevated due to high inputs

from both natural and anthropogenic sources. Some metals were useful for the metabolic activity of the organism, but there is a narrow difference between their essentiality and toxicity. Rapid growth in population leads to urbanization resulting in considerable land use, land covers changes, and creates a sequence of environmental and food security problems. Due to speedy urbanization the agricultural lands have been converted into no-agricultural activity (Tripathi, 2017). Such activities remove agriculturally productive topsoil, affects soil nutrient that is viable for agricultural growth. In addition to the removal of fertile top soil, it also emits harmful gases into the atmosphere which impacts the available natural resources. It was

found that neighbouring areas of polluted water bodies has low organic matter content and soil nutrients, and high soil electrical conductivity, low pH, changes the chemical and biological characteristics of soil and water. It directly affects the food production system and could threaten the livelihood of present and future generations by degrading agricultural soil. (Jeet et al., 2021; Tripathi, 2017).

Vembanad Lake is the largest estuarine ecosystem in Kerala, India. The lake has got a freshwater-dominant southern zone and a saline-dominant northern zone, both separated by a causeway at Thanneermukkam, where the lake has its minimum width. Vembanadu Lake is part of the Vembanadu Kole wetland system, which extends from Alappuzha in the south to Azheekkode in the north (Radhakrishnan and Jayaprakas, 2015; Kolathayaret al., 2019).

The lake is fed by major rivers like Achankovil, Manimala, Meenachil, Pampa and Moovattupuzha. The Vembanadu wetland has created its own network of estuaries, lagoons and canals. The Vembanad wetlands have been listed as Wetlands of International Importance under the Ramsar Convention for the Conservation and Sustainable Use of Wetlands (Arya and Syriac, 2018).

Long-term stagnation of the Vembanaduwater body had encouraged the accumulation of pollutants towards the south of the barrage causing threatening to fisheries, human health and tourism. Sources of these pollutants were domestic sewage, untreated sewage from motor launches and houseboats, municipal and hospital waste, industrial and agricultural waste and coir soaking net, kerosene and oil exhaust from motorboats (Pakistan, 2016). The use of chemicals like insecticides, fungicides, nematicides and rodenticides were increasing widely in the Kuttanadu ecosystem. Sediments could contain and accumulate many metals added to natural water. Favourable

physicochemical conditions of the sediment can remobilize and release metals into the water column. Toxic metals were bio-accumulative and relatively stable, as well as carcinogenic, and therefore required careful monitoring (Gupta and Ali, 2001). Moreover suspended sediments from dredging activities caused changes in water quality (Kjelland, 2015).

The main crop of Kuttanad is rice in the wetlands with coconut and vegetables on the surrounding slopes. It has been reported that about 500 tonnes of pesticides and about 20,000 tonnes of fertilizers are used annually in the Kuttanad region and a portion of this enters the waterways and lakes when water is pumped out of the paddy fields (Kumar and Kunhamu, 2021; Sruthi et al., 2017). Under these circumstances, a study on the status of heavy metal pollution in the southern stretches of the river stations below the Vembanadulake was conducted to assess heavy metal contamination in the Achankovil, Manimala, Meenachil and Pamapa river stations.

MATERIALS AND METHODS

2.1 Water Sampling

Sampling was carried out during the year 2016 to 2017 before the 2018 floods in Kuttanadu. Data on heavy metals like iron, manganese, zinc, copper, nickel, lead, cadmium and chromium for the months of January, February, March and April were collected for the study. Water samples were randomly collected from different riverine locations in the southern stretches of Vembanad wetlands covering four sampling locations (fig.1). The water samples collected at a depth of one foot from water surface consisted of 3 composite samples from each site. Samples were collected and placed in an ice-box and transported to the laboratory immediately for further analysis. The collected samples were filtered and acidified with concentrated nitric acid as suggested by the standard procedure. The concentrations of heavy metals were

determined using atomic absorption spectrometry after acid-digestion procedure (APHA, 2012). All analyses were carried out in triplicate, and the results were expressed as mean.

2.2 Heavy metal pollution index (HPI)

Effect of heavy metals on water quality was assessed based on heavy metal pollution index developed and formulated in terms of its concentration in water samples (Mohan et al., 1996).

The HPI shows the overall quality of water with respect to content of the heavy metals. The weighted arithmetic average of the concentrations was used to calculate HPI values using the Eq. 1 Where W_i is the unit weightage defined as the reciprocal value of S_i where S_i is the maximum permissible limit for drinking water given by BIS (2012), and n is the number of parameters considered. Q_i is the sub-index of the with parameter and calculated by Eq. 2

$$HPI = \frac{\sum W_i Q_i}{\sum W_i} \quad \text{Eq 1}$$

$$Q_i = \frac{\sum (M_i - I_i)}{(S_i - I_i)} \times 100 \quad \text{Eq 2}$$

Where M_i is the monitored value of heavy metal in ppb ($\mu\text{g/L}$), S_i is the standard value (maximum permissible limit) of the i th parameter ($\mu\text{g/L}$), I_i is the ideal value of the i th parameter (Prasad and Bose, 2001).

RESULT AND DISCUSSION:

Analysis of heavy metals in water samples from four riverine stations viz., Manimala, Meenachil, Achankovil and Pampa in the year 2016-17 revealed the presence of iron, Manganese, Zinc, Copper, Lead, Cadmium, and Nickel. Chromium was below detectable level in all the water samples. Highest concentration of 103ppb in Iron was observed for Meenachil river water samples (table 4). Manimala and Meenachil river water samples recorded high concentration of cadmium when compared to other river stations (Table 3 and Table 4). Highest concentration of lead and zinc was 3.07 ppb and 14ppb respectively which was found in water

samples from Pampa river (Table 2). The average heavy metal concentration of Achankovil river is given in Table 1.

3.1 Data evaluation and indexing approach

The Heavy Metal Pollution Index (HPI) is a very useful tool for assessing the overall pollution of water bodies with regard to heavy metals. The HPI of four river stations Manimala, Meenachil, Achankovil and Pampa was calculated. Average concentrations of each of the eight heavy metals (Fe, Mn, Zn, Cu, Pb, Cd, Cr and Ni) for four consecutive months from January to April were measured and HPI values were determined. Table 5 provides details on the calculation of HPI, W_i and Q_i values quoting data from Achankovil was set as an example. The critical value of the heavy metal pollution index is 100 (Milivojević, 2016). The HPI status categories are shown in Table 6. The HPIs of different sampling sites were compared to assess the pollution load and water quality assessment for the selected sites in Table 7.

Examination of the data revealed that the maximum HPI of 68.39 was observed for Pampa river station, followed by Manimala (HPI-59.46) and Meenachil (HPI-59.330). This indicated the poor water quality of these rivers with respect to the level of heavy metals contents indicating significant pollution. This representation had a long-lasting threat to human health. This may be mainly due to industrial and domestic waste/waste-water discharge into river.

The least HPI was observed at the Achankovil River (HPI-38.01). Among various organic and inorganic water pollutants, the metal ions are found to be toxic, hazardous and harmful due to their non-degradable nature (Jumbe and Nandini, 2009). Sediments are the final repository of many chemical compounds including heavy metals from natural and anthropogenic sources. Favourable physico-chemical conditions of the sediment can remobilize and release metals into the water

column. Hence contaminated sediments can endanger creatures in the benthic environment (Begum et al., 2009). Sixteen major industries around Cochin discharge had nearly 0.104 million m³/d of waste containing organic load released into nearby backwaters. The Cochin estuarine system receives annual effluents containing a large amount of heavy metals (Balachandran et al., 2002).

The high HPI values were mainly caused by industrial and domestic wastewater discharged into the river. HPI values were above the critical index limit at all sites except Achankovil. The HPIs for the four river stations were calculated and presented in Table 7.

CONCLUSION:

In conclusion, our study on the pollution of river stations in Achankovil, Manimala, Meenachil and Pampa showed that all places except Achankovil were polluted by heavy metals which was classified as poor quality and unsafe for drinking, mainly due to discharge of pollutants from industry, agricultural waste and tourism. The study could significantly contribute in creating awareness campaigns, designing control measures and action plans to reduce the inflow of pollutants into rivers.

CONFLICT OF INTERESTS: - The authors declare that there is no conflict of interests regarding the publication of this paper.

REFERENCES:

Ali, H. and Khan, E., 2018. Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. *Environmental chemistry letters*, 16(3), pp.903-917.

APHA, (American Public Health Association), 2012. *Standard Method for Examination 475 of Water and Wastewater*, 22nd ed. APHA, AWWA and WEF, Washington, DC.

Arya, S.R. and Syriac, E.K., 2018. Wetlands: The living waters-A review. *Agricultural Reviews*, 39(2), pp.122-129.

Balachandran, K.K., Joseph, T., Nair, K.K.C., Nair, M. and Joseph, P.S., 2002. The complex estuarine formation of six rivers (Cochin backwaters system on west coast of India)-Sources and distribution of trace metals and nutrients.

Begum, A., Krishna, S.H., Khan, I., Ramaiah, H., Veena, K. and Vinuta, K., 2008. Analysis of flouride level in water and fish samples of Sankey, Bellandur and Madivala lakes of Bangalore, Karnataka. *Rasayam J Chem*, 1, pp.596-601.

BIS, I., 2012. 10500 Indian standard drinking water-specification, second revision. Bureau of Indian Standards, New Delhi.

Gupta, V.K. and Ali, I., 2001. Removal of DDD and DDE from wastewater using bagasse fly ash, a sugar industry waste. *Water Research*, 35(1), pp.33-40.

Jeet, P., Singh, A., Sundaram, P., Upadhyaya, A., Patel, S. and Sarkar, B., 2021. Effect of brick kilns emissions on land, water, agriculture production, socio-economic and livelihood status: A Review: Effect of brick kilns emissions agriculture-based economy, *Journal of AgriSearch*, 8(4), pp.299-304.

Jumbe, A.S. and Nandini, N., 2009. Heavy metals analysis and sediment quality values in urban lakes. *American Journal of Environmental Sciences*, 5(6), p.678.

Kjelland, M.E., Woodley, C.M., Swannack, T.M. and Smith, D.L. (2015). A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. *Environment Systems and Decisions*, 35(3), 334-350.

- Kolathayar, S., Sitharam, T.G. and Yang, S., 2019. Coastal reservoir strategy to enhance India's freshwater storage by impounding river flood waters: a detailed overview. *Water Supply*, 19(3), pp.703-717.
- Kumar, B.M. and Kunhamu, T.K., 2021. Ecological and historical perspectives of rice cultivation in Kerala: a synthesis. *ORYZA-An International Journal of Rice*, 58(2), pp.241-261.
- Milivojević, J., Krstić, D., Šmit, B. and Djekić, V., 2016. Assessment of heavy metal contamination and calculation of its pollution index for Uglješnica River, Serbia. *Bulletin of environmental contamination and toxicology*, 97(5), pp.737-742.
- Mohan, S.V., Nithila, P. and Reddy, S.J., 1996. Estimation of heavy metals in drinking water and development of heavy metal pollution index. *Journal of Environmental Science & Health Part A*, 31(2), pp.283-289.
- Mortvedt, J.J., 1996. Heavy metal contaminants in inorganic and organic fertilizers. In *Fertilizers and environment* (pp. 5-11). Springer, Dordrecht.
- Pakistan, M.F.F. (2016). *A handbook on Pakistan's coastal and marine resources*. MFF Pakistan, Pakistan.
- Prasad, B. and Bose, J. (2001). Evaluation of the heavy metal pollution index for surface and spring water near a limestone mining area of the lower Himalayas. *Environmental Geology*, 41(1), 183-188.
- Radhakrishnan, R. and Jayaprakas, V., 2015. Free living protozoans as bioindicators in Vembanad lake, Kerala, India, an important Ramsar site. *Int. J. Fish. Aquat. Stud*, 2(3), pp.192-197.
- Sruthi, S.N., Shyleshchandran, M.S., Mathew, S.P. and Ramasamy, E.V., 2017. Contamination from organochlorine pesticides (OCPs) in agricultural soils of Kuttanad agroecosystem in India and related potential health risk. *Environmental Science and Pollution Research*, 24(1), pp.969-978.
- Tiwari, A.K. and Singh, A.K., 2014. Hydrogeochemical investigation and groundwater quality assessment of Pratapgarh district, Uttar Pradesh. *Journal of the Geological Society of India*, 83(3), pp.329-343.
- Tripathi, V.K., 2017. Simulating soil water content under surface and subsurface drip irrigation with municipal wastewater: Simulating soil water content under surface and subsurface drip irrigation, *Journal of AgriSearch*, 4(3), pp.167-172.
- Wei, B. and Yang, L., 2010. A review of heavy metal contaminations in urban soils, urban road dusts and agricultural soils from China. *Microchemical journal*, 94(2), pp.99-107.

Table1:Average of heavy metal concentration (ppb) in Achankovil river

Month	Fe	Mn	Zn	Cu	Pb	Cd	Cr	Ni
January	61	14	Trace	89	0.80	0.15	0	0
February	320	30	43	24	2.60	0.10	0	0
March	0	Trace	Trace	0	1.10	0.34	0	0
April	14	Trace	Trace	0	2.34	0.02	0	0
Sum	395	44	43	113	6.84	0.62	0	0
Mean	98.75	11	10.75	28.25	1.71	0.15	0	0

Table2:Average of heavy metal concentration (ppb) in Pampa river

Month	Fe	Mn	Zn	Cu	Pb	Cd	Cr	Ni
January	11	10	42	80	2.40	0.15	0	0
February	330	28	0	23	3.50	0.30	0	0
march	13	0	0	0	3.06	0.18	0	0
April	4.7	0	14	0	3.40	0.11	0	0
Sum	358.70	38	56	103	12.36	0.74	0	0
Mean	89.68	9.50	14	25.75	3.09	0.19	0	0

Table3:Average of heavy metal concentration (ppb) in Manimala river

Month	Fe	Mn	Zn	Cu	Pb	Cd	Cr	Ni
January	15	8	38	97	2.3	0.2	0	0
February	290	30	0	24	2.8	0.15	0	0
march	85	0	0	0	1.2	0.18	0	0
April	6	0	0	0	4.4	0.298	0	0
Sum	396	38	38	121	10.7	0.83	0	0
Mean	99	9.5	9.5	30.25	2.68	0.21	0	0

Table4:Average of heavy metal concentration (ppb) in Meenachil river

Month	Fe	Mn	Zn	Cu	Pb	Cd	Cr	Ni
January	90	21	0	19	2.68	0.11	0	0
February	320	30	46	27	3.4	0.28	0	0
march	1.5	0	0	0	3.85	0.23	0	0
April	1.0	0	0	0	0.83	0.22	0	0
Sum	412.5	51	46	46	10.76	0.84	0	0
Mean	103.12	12.75	11.5	11.5	2.69	0.21	0	0

Table 5: HPI calculation for riverine water samples from Achankovil

Heavy metal	Concentration (ppb) _{mi}	Standard permissible level(ppb) _{Si}	Ideal level(ppb) _{li}	Unit Weightage, _{Wi}	Sub index (_{Qi})	_{Wix Qi}
Fe	98.75	300	0	0.0033	32.92	0.1097
Mn	11.00	300	100	0.0033	44.50	0.1483
Zn	14.33	15000	5000	0.0001	49.86	0.0033
Cu	28.25	1500	50	0.0007	1.50	0.0010
Pb	1.71	3	0	0.3333	57.00	19.0000
Cd	0.1543	10	0	0.1000	1.54	0.1543
Cr	0	50	0	0.0200	0.00	0.0000
Ni	0	20	0	0.0500	0.00	0.0000
				Σ _{Wi} =0.5107		Σ _{WixQi} = 19.416
			Heavy metal pollution index HPI=19.416/0.5107=38.018			

Table 6: Status categories of HPI

Sl no	HPI	Category
1	<25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very poor
5	>100	Unsuitable for drinking

Table 7: Comparison of water quality based on HPI of different riverine

Sl no	River stations	Heavy pollution metal index (HPI)	Category
1	Achankovil	38.02	Good
2	Pampa	68.41	Poor
3	Manimala	59.46	Poor
4	Meenachil	59.33	poor