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# ECOTOXICOLOGICAL IMPACT ASSESSMENT OF HEAVY METALS IN CORE SEDIMENTS OF KATTAMPALLY - A WETLAND IN THE SOUTHWEST COAST OF INDIA

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**ABSTRACT:** Vertical distribution of heavy metal concentration in four cores from Kattampally wetland system was studied. Concentration of iron, manganese, nickel, zinc, cadmium, lead and copper in each slices of sediment was determined. Degree of contamination for each station was determined. Qualities of the sediments were evaluated based on sediment quality guidelines, pollution load index and sum of toxic units. The results of the study revealed the concentration of heavy metals in the core sediment variesconsiderably across depths. Higher concentration of trace metals in surface layers than in deeper ones. Core sediments in Kattampally were polluted in heavy rate for nickel and moderate rate for zinc, according to effects based sediment quality guidelines. The potential acute toxicity of nickel in some stations exceeded the effect range median levels, which represents a probable effect range within which adverse biological effects frequently occur. Statistical analysis showed that the correlation among completely different parameters differs with reference to stations. The present study confirmed that the Kattampally wetland is under considerable contamination due to heavy metals.

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**KEYWORDS:** Core sediments, Heavy metals, Vertical distribution, Sediment quality guidelines.

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## 1.INTRODUCTION

Sediments will be sensitive indicators for observation contaminants in aquatic environments. The favourable physico-chemical conditions of the sediment will remobilize and unharness the metals to the water column. Core sediments give helpful data on the changes within the quality of the lake from a past amount. Several researchers had studied the pollution history of aquatic system by core sediments [12]; [16]; [20]. Sediment cores were accustomed study the behavior of metals [9]. Sediment core contain data concerning the events that occurred in precultural time within the lakes and its catchments space. The sediment history broadly speaking reflects the contamination history of a region. Currently, environmental pollution owing to urbanization and industrial development may be a major concern [11]; [28].Sediment quality analysis of a water body is one in all the necessary aspects of evaluating the whole health standing of land ecosystems because it reflects long quality condi tion [21].The high concentrations of serious metals square measure derived from anthropogen etic inputs from industrial activities round the body of water [30].; [3]. Concentration of trace metals in coastal estuaries will be elevated thanks to high inputs from natural likewise as anth ropogenetic sources. Therefore understanding the transport and distribution of trace metals in estuaries may be a goal of environmental chemists [35].Kattampally is a coastal wetland in the North Malabar region of Kerala.Extensive wetland areas lying fallow and abandoned on either side of the Kattampally River, a tributary of the Valapattanam River. The ecologically sensitive Kattampally wetland system was once noted for Kaipad cultivation. There is no study available about the status of core sediments of this wetland on heavy metal contamination status. Thus, this study was carried out to understand the vertical distribution of heavy metals in wetland core sediments that will give some insight in to the pollution status of the Kattampally and to identify possible sources.

## 2. MATERIALS AND METHODS

The core samples of sediments were collected using the Kajak gravity corer of 1m length. The sampling stations include Munderikadavu (K1), Pulluppi (K2), Mathodam (K3) and Varamkadavu (K4). A total of four sediment cores were collected, cut into slices ofapproximately 2-4 cm length and properly labelled. The details of the samplingstations are indicated in Fig. 1. The samples (each slices of the core) were delivered to the laboratory victimisation ice baggage and keep in a verydeep freeze unit till the drying procedure [34].For the digestion of the sediment sample one gram of dried and homogenized sediment samples were weighed and placed into an acid washed PTFE digestion vessel. The digestion was performed with a mixture $HNO_3$ and $HClO_4$.The digested samples were analyzed for heavy metals with atomic absorption spectrometer [36]. The concentration of iron, manganese, cadmium, copper, lead, nickel and zinc were determined in each slices of the core sediment and the values are reported in units of mg/kg except iron and manganese which is in g/kg.The need for chemical pointers that would be wont to predict adverse biological effects in contaminated sediments cause the event of sediment quality pointers [15] ;[17];[19]. Numerical sediment quality pointers (SQGs) are wont to establish contaminants of concern in aquatic system[17].The National Oceanic and region Administration (NOAA) developed a collection of empirical SQGs [14] that has 2 values, effects vary low (ERL) and effects vary median(ERM), that delineate 3 concentration ranges for every explicit chemical and therefore the corresponding estimation of the potential biological impact. The concentrations below ERL represent a minimal- effects vary, that is meant to estimate conditions wherever biological effects are seldom determined. Concentrations adequate to or bigger than ERL, however but ERM represents a spread with during which biological effects occur sometimes. Concentrations at or on top of ERM values represents a probable impact vary with, during which adverse biological effects of times occur. Sediments also are accustomed rank and/or grade contaminated areas or chemicals of concern for additional investigation or accustomed value spacial pattern of sediment contamination[2]; [6]. Sediments were classified as: nonpolluted, moderately impure and heavily impure, supported SQG of EPA [24].The tactic recommended by Hakanson et al. (1980), to search out out the contamination issue (Cf) and therefore the degree of contamination (Cd), that describe the contamination of given harmfulsubstance has been employed in this study. The potential acute harmfulity of contaminants in sediment sample iscalculable because the total of the toxic units (PTU) outlined because the magnitude relation of the determined concentration to pixel price [23]. Tomlinson et al. (1980) had utilized an easy methodology supported pollution load index (PLI) to assess extend of pollution by metals in body of water sediments. The PLI price of o1 indicate no pollution, were as forty one indicates pollution of the aquatic system. The extend of pollution increase with increase within the numerical rate.

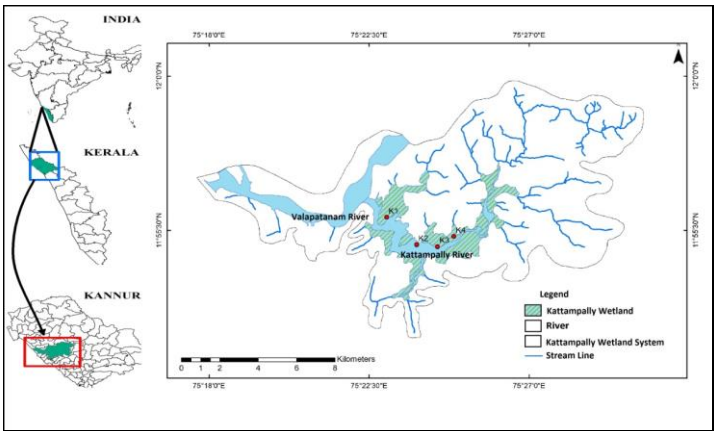


**Fig. 1.Area map of Kattampallywetland showing sampling sites**

## 3. RESULTS AND DISCUSSION

### 3.1. Variation of heavy metal along the core

Vertical distribution of heavy metals concentrations in the present study revealed that, iron (Fe) showed the highest concentration compared to other heavy metals in all samples. The concentration of iron varied from 14.24 g/kg to 102.71g/kg (fig 2a). The highest distribution was found at the station K4 which is an agricultural area. The distribution pattern is almost uniform along the core with small increasing trend at stations k2,k3 and k4. Spatial variation of average concentration of iron was in the order K4> K2> K3> K1. The concentration of manganese (Mn) varied from 0.03g/kg to 1.11g/kg.(fig 2b) The average manganese concentrations is in the order K2> K3> K4> K1 with a slight increase in concentration towards the top layers except K3. Nickel was present at high concentrations in marine core sediment. The concentration of Ni ranged between 32.5 mg/kg to 120 mg/kg. Vertical distribution of Ni is not consistent from the surface layer towards the lower layer of sediment. (fig 2c). The average nickel content of K1, K2, K3 and K4 were 48.5,82, 85 and 93mg/kg. An EPA criterion for heavily polluted sediments for Ni is >50 mg/kg and K2, K3 and K4 exceeds the limits. The concentration of zinc varied from 22.50 to 102.50mg/kg. The pollution due to zinc in the sediments is moderately polluted as it compared with the USEPA sediment quality guidelines (1999).Concentration of copper was found to be below detection limit in K1 and K2. But the pollution of the Wetland with respect to copper is very high and exceeds the EPA criteria for heavily polluted sediments of >50 mg/kg in K3 and K4. A maximum concentration of copper (75 mg/kg) was found in the bottom layer of the sediment cores. The down core variation of copper follows a increasing trend. The concentration of lead and cadmium were found to be below detection limit in all the core samples collected from Kattampally wetland system. The spatial and temporal variations are given in Fig.2a to 2d.

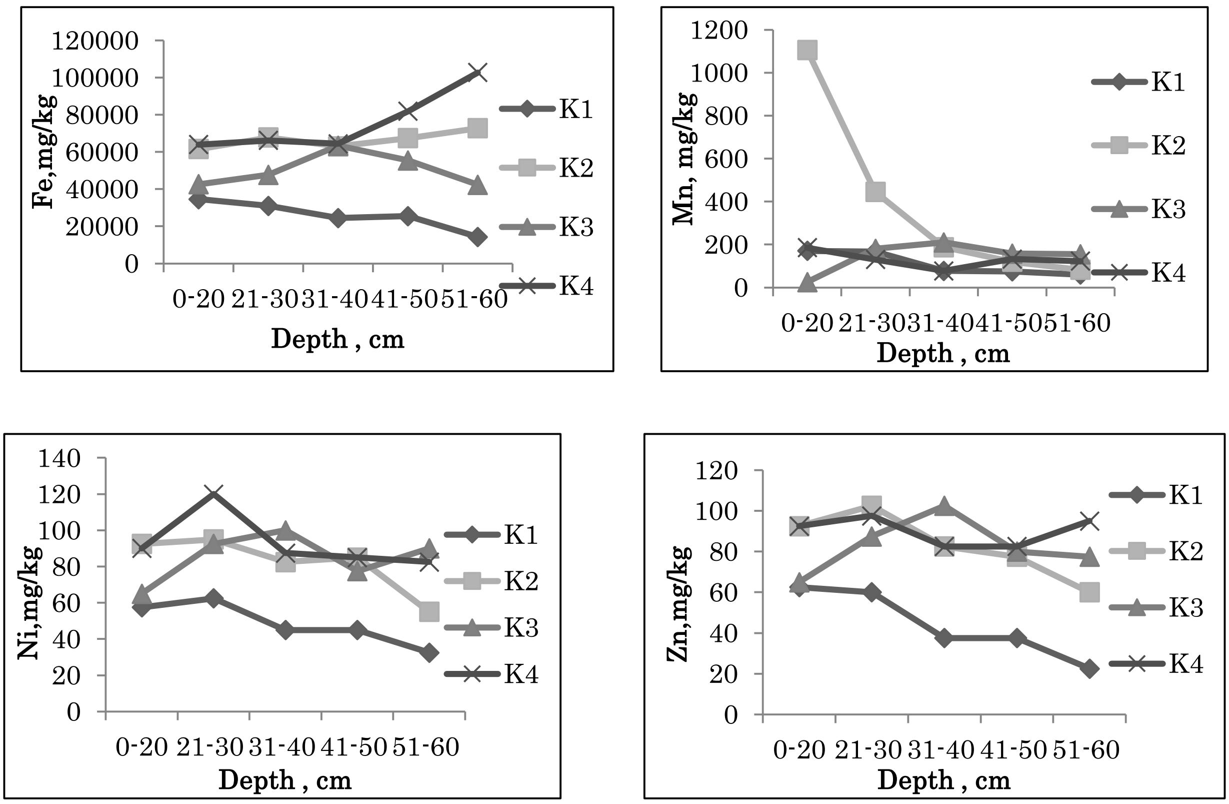


**Fig. 2. (a), (b), (c), (d) Down core variation of iron, manganese, nickel and zinc in Kattampally wetland**

## DISCUSSION

### 4.1. Statistical analysis

Accumulation of trace metals happens in higher sediment in aquatic setting by biological and geochemical mechanisms and becomes noxious to sediment-dwelling organisms and fish, leading to death, reduced growth, or in impaired replica and lower species diversity [22]. The variation in weathering, erosion, transport conditions, and aquatic productivity, the accumulated sediments have totally different characters in grain size, mineral, organic matters content, etc., which might additionally produce anomalously high serious metals concentration moreover as anthropogenic contamination [13].The concentration and distribution of serious metals within the aquatic systems ar influenced by sorption and co-precipitation with iron and atomic number 25 oxides [10].so as to quantitatively analyze and make sure the connection among sediment parameter (organic matter) and serious metal content, a Pearson's correlation analysis was applied to the dataset and also the results were tabulated in Table 1.The present study revealed that the correlation among different parameters differs with respect to stations. In the station K1, the organic matter showed good positive correlation with all the heavy metals. But for K2 manganese, nickel and zinc showed negative correlation with organic matter whereas iron showed positive correlation with organic matter. In the station K3, iron only showed negative correlation with organic matter and in k4 the organic matter showed positive correlation with all the heavy metals. The metals iron and manganese showed positive correlation with other metals in core collected from stations K1 and K3. But in K2 Manganese showed a positive correlation with nickel and zinc.

**Table 1: Pearson's correlation among organic matter and the heavy metal content in each slice of the sediment cores**

Average organic matter for station K1= 17.6%

| *K1* | *om* | *Fe* | *Mn* | *Ni* | *Zn* |
|---|---|---|---|---|---|
| om | 1 | | | | |
| Fe | 0.824938 | 1 | | | |
| Mn | 0.91394 | 0.871186 | 1 | | |
| Ni | 0.764957 | 0.93688 | 0.932871 | 1 | |
| Zn | 0.882221 | 0.963808 | 0.968723 | 0.976269 | 1 |

Average organic matter for station K2= 25.98%

| *K2* | *om* | *Fe* | *Mn* | *Ni* | *Zn* |
|---|---|---|---|---|---|
| om | 1 | | | | |
| Fe | 0.688487 | 1 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Mn | -0.70689 | -0.65595 | 1 | | |
| Ni | -0.67672 | -0.72496 | 0.575789 | 1 | |
| Zn | -0.82856 | -0.60129 | 0.605638 | 0.935304 | 1 |

Average organic matter for station K3= 12.99%

| *K3* | *om* | *Fe* | *Mn* | *Ni* | *Zn* |
|---|---|---|---|---|---|
| om | 1 | | | | |
| Fe | -0.24313 | 1 | | | |
| Mn | 0.538277 | 0.652493 | 1 | | |
| Ni | 0.526149 | 0.507409 | 0.917859 | 1 | |
| Zn | 0.212602 | 0.822892 | 0.892318 | 0.893443 | 1 |

Average organic matter for station K4= 10.44%

| *K4* | *om* | *Fe* | *Mn* | *Ni* | *Zn* |
|---|---|---|---|---|---|
| om | 1 | | | | |
| Fe | 0.172971 | 1 | | | |
| Mn | 0.109075 | -0.09307 | 1 | | |
| Ni | 0.642425 | -0.47726 | 0.077772 | 1 | |
| Zn | 0.938742 | 0.1553 | 0.439419 | 0.561421 | 1 |

O.M- Organic Matter.

**4.2. Assessment of sediment pollution using different indices sediment contamination by comparison with effect based sediment quality guidelines**

Average concentration of serious metals in sediments at totally different|completely different} depths and their comparative assessment with different international sediment quality tips (SQGs) prompt by Perin et al. [24].square measure tabulated in Table a pair of. altogether the stations except K1, concentration of nickel was higher than fifty mg/kg, that belongs to the category of heavily contaminated sediments in line with SQG and USEPA. The concentration of Zn was 90mg/kg in K4 that belongs to the category of moderately contaminated sediments in line with SQG. The concentration of Mn and metal was found in an exceedingly vary between low result level in line with Ontario MOE. The concentration of Ni was underneath heavily contaminated and metal was underneath moderately pollution classes. iron and Mn were the 2 metals having the next contribution in sediments of the study website compared to different metals (Table 2). The concentration of iron was nearly thrice on top of the low result level of Ontario MOE whereas Mn was below it. The sources for iron and Mn square measure weathering and soil erosions [31]. Iron and Mn square measure vital parts for metabolic reactions in plants and animals. but in excess concentrations, they typically disrupt metabolism, circulation and nerve sensations in animals [29]. Ni was ascertained quite 5 times on top of the low result level of Ontario MOE in sediments of this study. Major sources of Ni and metal square measure domestic wastewaters, waste matter effluents, agricultural runoff, and fuel burning, steel and metal alloys [25]; [26]; 7]; [27]. These metals effect serious human health consequences in skin, lungs and nervous systems [4].

**Table 2: Concentration of heavy metals in the sediment core and its comparison with different SQGs.**

| | | | | | **SQGs** | | | | **OntarioMOEa** | | **USEPA** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element mg/kg | Sampling stations | | | | SQG NP | SQG MP | SQG HP | | LEL | SEL | NP | MP | HP |
| | K1 | K2 | K3 | K4 | | | | Fe | 20,000 | 40,000 | - | - | - |
| Mn | 110 | 388 | 145.2 | 129.5 | - | - | - | Mn | 460 | 1100 | - | - | - |
| Ni | 48.5 | 82 | 85 | 93 | <20 | 20-50 | >50 | Ni | 16 | 75 | <20 | 20-50 | >50 |
| Zn | 44 | 83 | 82.5 | 90 | <90 | 90-200 | >200 | Zn | 120 | 820 | <90 | 90-200 | <200 |

**4.3. Assessment of sediment contamination by comparison of concentration with those of background sediments**

The contamination factor and degree of contamination for the core sediment samples at each station were calculated using modified equation of Hakanson et al. [8] proposed by Abrahim and Parker (2008) (Table 3).Taylor's (1972) crustal abundance was used as the reference baselines. The following terminologies are used to describe the degree of contamination (mCd).

| | |
|---|---|
| mCd ≤ 1.5 | Nil to very low degree of contamination |
| 1.5 ≤ mCd < 2 | Low degree of contamination |
| 2 ≤ mCd < 4 | Moderate degree of contamination |
| 4 ≤ mCd < 8 | High degree of contamination |
| 8 ≤ mCd < 16 | Very high degree of contamination |
| 16 ≤ mCd < 32 | Extremely high degree of contamination |
| mCd ≥ 32 | Ultra high degree of contamination |

From the results it was found that the contamination factor values were found in a range of 0.30-2.20 for Fe, 0.03-1.23 for Mn, for 0.48-1.76 Ni and 0.24-1.84 for Zn. All metals were observed in two classes namely low contamination (LC) and moderate contamination (MC) (Table 3). Fe and Ni were found in moderate contamination throughout the depths except in sampling station K1. On the basis of average CF values the metals were found in the sequence of Fe >Ni >Zn>Mn. But the degree of contamination calculated for the stations K1,K2, K3 and K4 were 0.46, 0.98,0.84 and 1.02, respectively, which are very low. This indicates low degree of heavy metal contamination

**Table 3: Contamination factor and degree of contamination of the wetland core sediments**

| *Cf* | | | | |
|---|---|---|---|---|
| Element | K1 | K2 | K3 | K4 |
| Fe | 0.56 | 1.42 | 1.08 | 1.62 |
| Mn | 0.12 | 0.43 | 0.16 | 0.14 |
| Ni | 0.71 | 1.21 | 1.25 | 1.37 |
| Zn | 0.46 | 0.87 | 0.87 | 0.95 |
| mCd | 0.46 | 0.98 | 0.84 | 1.02 |

**4.4. Assessment of pollution by computing the pollution load index (PLI)**

Pollution load index proposed by Tomlinson *et al.* (1980), has been used in the present study to determine the mutual pollution effect at different stations by different elements ([18]. The PLI values for each of the stations were calculated. The average concentration and the concentration present at the surface of the sediment core were compared with the average concentration of world shale [33].The trace element concentration along with the calculated PLI values was given in Table 4.

**Table 4:Comparison of heavy metal in each core with average shale value and the numerical value of PLI calculated using the method of Tomlinson et al. (1980).**

| Element/ Stations | K1 | | K2 | | K3 | | K4 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Concentration of metal in different parts of the core sediment | | | | | | | | |
| | Average | Surface (top layer) | Average | Surface (top layer) | Average | Surface (top layer) | Average | Surface (top layer) | **Average Shale** |
| Fe, g/kg | 25.93 | 34.55 | 66.48 | 61.55 | 50.27 | 42.57 | 75.83 | 63.97 | **45.7** |
| Mn, g/kg | 0.11 | 0.17 | 0.39 | 1.11 | 0.15 | 0.03 | 0.13 | 0.19 | **0.85** |
| Ni,mg/kg | 48.50 | 57.50 | 82.00 | 92.50 | 85.00 | 65.00 | 93.00 | 90.00 | **68** |
| Zn,mg/kg | 44.00 | 62.50 | 83.00 | 92.50 | 82.50 | 65.00 | 90.00 | 92.50 | **95** |
| **PLI** | 0.38 | 0.52 | 0.83 | 1.2 | 0.71 | 0.45 | 0.81 | 0.82 | |

The calculated values of pollution load index of sediment samples were observed in two classes value between 0.5 and 1, which suggest more detailed study to monitor the site and value greater than 1 Indicates an immediate intervention to reduce pollution. PLI values greater than 1 was reported in K2.

**4.5 Ecotoxicological sense of heavy metal contamination**

The sediment quality guidelines developed by Bakan and Ozkoc for marine and estuarial system [1]were utilized in the current study to see the ecotoxicological sense of serious metal contamination within the core sediments of poultry body of water. Chemical concentrations comparable to the tenth and fiftieth percentiles of adverse biological effects were referred to as the results range-low (ERL) and effects-range median (ERM) pointers, severally [15]. Considering the results, the serious metal concentration of nickel at station K1 and metallic element in any respect stations were below ERL that represent a minimal-effects vary, that is meant to estimate conditions wherever biological effects area unit seldom ascertained. For stations Godwin Austen, K3 and K4 concentration of nickel exceeded the ERM levels, that represents a probable impact vary with during which adverse biological effects often occur. The potential acute harmfulity of contaminants in sediment sample was calculable (Table 5) because the total of the toxic units (PTU) outlined because the magnitude relation of the determined concentration to constituent price [23].The harmful unit values at stations K1, K2, K3 and K4 area unit one.29, 2.21, 2.28 and 2.50 respectively.

**Table 5: Sum of toxic units (TU) of core sediments and various guidelines for heavy metals.**

| Element | Stations | | | | TEL | PEL | ERL | ERM |
|---|---|---|---|---|---|---|---|---|
| | K1 | K2 | K3 | K4 | | | | |
| Ni ,mg/kg | 48.5 | 82.00 | 85.00 | 93.00 | 15.90 | 43.00 | 20.90 | 51.60 |
| Zn, mg/kg | 44 | 83.00 | 82.50 | 90.00 | 124.00 | 270.00 | 150.00 | 410.00 |
| ΣTU | 1.29 | 2.21 | 2.28 | 2.50 | | | | |

## 4. CONCLUSION

The study of ecotoxicological impact assessment of trace metals in core sediments of Kattampally wetland demonstrates that the estuary is facing severe heavy metal pollution. The concentration of heavy metals in the sedimentofKattampally wetland variesconsiderably across depths. The present study reported higher concentration of trace metals in surface layers than in deeper ones due to development of industries and other man-made activities. Down-core differences of elements indicate an increase of trace elements probably during the past few periods. The Kattampally wetland receives many pollutants from the nearby sources such as agriculture run-off, domestic sewage, effluent from a plywood industries at present. The average concentration of heavy metals in various stations of was found in a sequence of Fe> Mn > Ni > Zn > Cu > Pb>Cd. The present study revealed that the correlation among different parameters differs with respect to stations. The organic matter showed good positive Correlation with iron in all stations. Core sediments in Kattampally were polluted in heavy rate for nickel and moderate rate for zinc according to effects based sediment quality guidelines. Moderate degree of contamination of iron and nickel were found throughout the depth. The potential acute toxicity of nickel exceeded the ERM levels, which represents a probable effect range within which adverse biological effects frequently occur. The spatial variation in contamination due to different heavy metals is due the difference in the location of industrial units. Anthropogenic source from the industrial activities at the upstream is the main reasons contributing heavy load of trace metals to the Kattampally wetland and major sources of Ni and Zn are domestic wastewaters, sewage effluents and agricultural runoff. The above results confirmed that the Kattampally wetland is under considerable contamination due to heavy metals. Although no research work was done before on the heavy metals in sediments of this important Wetland, this study forms baseline information on heavy metal contamination in the wetland, which can be used for further research. This data can also be helpful for policy makers in making management plan of this wetland.

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**CONFLICT OF INTEREST**

No conflict of interest exists.

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