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ASSESSMENT OF HEAVY METALS POLLUTION IN EDIBLE BIVALVES (*PERNA VIRIDIS*) AND SEDIMENT FROM PICHAVARAM MANGROVE FOREST AND VELLAR ESTUARY SOUTHEAST COAST OF INDIA

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ABSTRACT

The present survey aimed to study on heavy metal contamination in collected surface sediment samples and *Perna viridis* from Pichavaram and Vellar estuary. The mollusks are generally filter-feeding organism and live in the benthic habitat, while feeding on the bottom chemicals and metals might also accumulate in their organs such as gills, foot and mantle. The edible bivalves can be used for biomonitoring since it is consumed by local people. This study analyzed the following metals from both station such as Aluminum (Al), Manganese (Mn), Magnesium (Mg), Zinc (Zn), were examined in animal and sediment. The study was conducted for four seasons (Summer, Pre-monsoon, Monsoon and Post-monsoon) for the year of 2017. Among all the metal Al was showing higher and the lower was Zn in both sediment and bivalves. All metals were observed and their value ranged from tissue and sediment foolowed by Al (892.09 to 10751 µg/g), Mg(1589.25 to 4532 µg/g), Mn (119.4 to 246.63 µg/g), Zn (4.98 to 53.01 µg/g. The study concluded that Vellar estuary exhibited highly contaminated zone than the Pichavaram mangrove and it might be various drainage from the land, development of aquaculture, agriculture and industrial from the coastal area. In general, all the heavy metals were less than the permissible level according to WHO/EPA.

KEY WORD : Heavy metals, *Pernaviridis,* Sediment, Pichavaram mangrove forest, Vellar estuary, ICP-OES.

INTRODUCTION

Many heavy metals are necessary for the metabolism of many marine creatures, and they are bio-accumulated in the ocean. All metals, however, become poisonous when their bioavailability exceeds a certain level (Blackmore 1998). Because of their persistent, non-biodegradable, and poisonous qualities, their global dispersion and influence on marine organisms and human health are of major concern.

Long-term and extensive use of agricultural land with frequent application of pesticides may enhance the level of metals such as copper, nickel, zinc and cadmium in the topsoil (Nicholson *et al*., 2003). Eventually, coastal and estuarine areas are among the most important places for discharging the wastages arising as result of rapid urbanization and industrialization (Blackmore, 1998).

Heavy metals pollutants are considered to be persistent in aquatic ecosystems. Especially in marine environment trace metal present in all

([1]Ph.D, Research Scholar, [2]Senior Research Fellow, [3]*Associate Professor) compartments and accumulates in organisms from various trophic levels of marine food web and eventually leads to bioaccumulation. In Marine food chain benthic animals are at higher risk since they feed on the bottom, hence the probability of accumulation of heavy metals in their body is significantly high (Beijer *et al.*, 1986).

Marine benthic groups such as oysters, mussels, cockle and clams have extensively been used as bio monitors for trace metals due to their ability to accumulate metals without any harm to themselves. Marine mollusks can be used as reliable indicator organism for metal contamination (Jung and Zauk, 2008). Specifically bivalve mollusks like *Perna viridis* considered to be a potential bio monitor for metallic contamination in marine ecosystems (Kaladharan *et al.,* 2005).

Perna viridis is commonly found at the tropical and subtropical regions and reproduce rapidly even at extreme conditions like polluted harbors or bays just like on the results of the study of Rajagopal *et al.* (1997, 1998b) where very high densities of *P. viridis* have been reported from polluted harbors and submarine pipelines of coastal power stations. With this special reproduction behavior of the *Perna viridis*, a lot of local fishermen invest on culturing it on the coastal area. Culturing mussels at the intertidal zone is a common scenery. *Perna viridis* is not only part of their meal plan likewise it is a source of income for local fishermen Due to increasing prices of the basic commodities at the people look for food source which has a high nutritive value but on a cheaper price like *Perna viridis*. The *Perna viridis* is rich in amino acids, vitamins A, B1, B2, B3, B6, B12, and C. It is likewise rich on both macro and micro mineral contents. The macro mineral calcium, potassium, sodium and iodine were found to be high. Magnesium and iron were significantly detected in meager level. Trace metals like zinc and copper were in trace level (Saritha, 2015). It is better to understand that metal test is very crucial Interpreting the quality of water, therefore the aim of this study is to assess the accumulation of metals by using *Perna viridis* as a biological indicator and sediment samples as recipient of different depository materials from numerous anthropogenic sources on Vellar estuary and power plant in Parangipettai coast for metal test to determine the level of contamination in Vellar and Pichavaram mangrove region.

The uptake of heavy metals by benthic organisms depends on the contamination levels in sediments and their chemical forms (Morillo *et al.*, 2004). In aquatic environment the sediment imitate the quality of water and it act as greater carrier for heavy metals in hydrological cycle. Many of obstinate pollutants sink in the bottom of coastal and estuarine region and subsequently accumulate into animal tissue (Foster *et al.*, 1996). The coastal mangrove sediment sample have been used widely for pollutant assessment (Aksu *et al.*, 1998) and studies revealed that contamination of sediment by metals have greater impact on the survivability of benthic organisms within their environment and the level of metals in animal tissue will increase randomly (Malins *et al.,* 1984).

Even though number of studies related to heavy metals presence in Pichavaram and Vellar mangrove sediments are available, the detail study on accumulation of heavy metals and their impact on benthic organisms are not available. Therefore, the present study was conducted to study the spatial and temporal distribution of heavy metals (Al, Mn, Zn and Mg) in sediments animal (*Perna viridis)* tissue and its binding ability in relation to suspended matter from estuarine and mangrove ecosystems.

MATERIALS AND METHODS

Study Area

Sampling was conducted at two stations viz., Pitchavaram mangrove forest (Lat. 11° 25' 50.19 º N; Long. 79° 47' 20.79º E) and Vellar estuary ((Lat. 11° 29' 29.68º N; Long. 79° 46' 6. 78º E) The Pichavaram mangrove forest as good an example for the degradation of mangrove ecosystem due to increasing of aquaculture implementation. During 1970 there was no aquaculture pond in Pichavarma mangrove region when compare to 1984 as increased to 3.99 Km^2 and later area of aquaculture was occupied by 699 Km^2 (Hong Yeon *et al.,* 2004; Kathiresan, 2004). Moreover the ecosystem vulnerability has increased due to anthropogenic activities on this area which is significantly contributed by nearby densely populated area (Prasad, 2005). The heavy metal contamination in this area generated by deposition of anthropogenic input such as agriculture, domestic and industrial process which is carried by Sahab canal and it tend increase the vulnerability of ecosystem (Yeon *et al.*, 2004; Prasad, 2005).

The Vellar estuary is one of the largest estuary via

480 km travestying distance from Sevarayan hills, Salem district, Tamilnadu. The estuary has variety of mangrove plants, mud flat shrubs and it serves as favorable habitat for breeding particularly number of marine and brackish water organisms and it is one of the fertile estuary in Tamilnadu. Generally the estuary serve as both in pollution source for coastal sea and marginal filter for the river drainage basin. The Vellar estuary majorly influenced by human inhabitation, mechanized boat, agriculture and aquaculture activities which is mainly contributing to increase the level of metal contamination in the ecosystem particularly in edible fishes.

Sediment and animal sample collection

The present study intended to study the seasonal variation in heavy metal accumulation in both sediment and animal species at two study sites. Hence, sediment and Bivalve samples were collected from Pichavaram mangrove (PS-1) forest and Vellar estuary (VS-2) covering four months with respective to season, i.e. (February, May, July and November) during 2017. The sediment samples were collected during low at tide using a pre-cleaned and acid washed PVC (50 cm) corer and stored immediately into icebox for further analysis. The animal sample (*Perna viridis)* was collected from the region of mangrove through hand picking method at both stations. The animal tissue was removed from the shell with aid of plastic knife and the tissue samples were dried at 60 °C. The dried samples were then made into fine powder for further analysis using mortar and pestle. The powdered samples were stored into desiccator for further analysis.

Heavy Metals Analysis

The trace metal analysis was done by following the method proposed by Walting (1981). Two sets of one gram of the dried sample were taken into a beaker one is spiking with known concentration metals and other was without spiking. In the beaker 20 ml of conc. Nitric acid (HNO_3) was added and kept for 24 hrs. Samples were then allowed to evaporate to dryness on a hot plate at 120 °C, subsequently 20 ml of nitric acid and perchloric acid mixture was added in the ratio of 4:1respectively. The residue was allowed to dry completely and then it was cooled. Simultaneously, 10 ml of nitric acid was added and transferred to a 20 ml polytope vial and allowed this mixture to settle the residue for 2 hours. The supernatant was filtered by using cotton. The filtered samples were taken for metal analysis by ICP-OES (Agilent technologies 5100).

RESULTS

Sediment

Totally, 4 metals were analyzed in both sediments and sample and the detected concentrations of

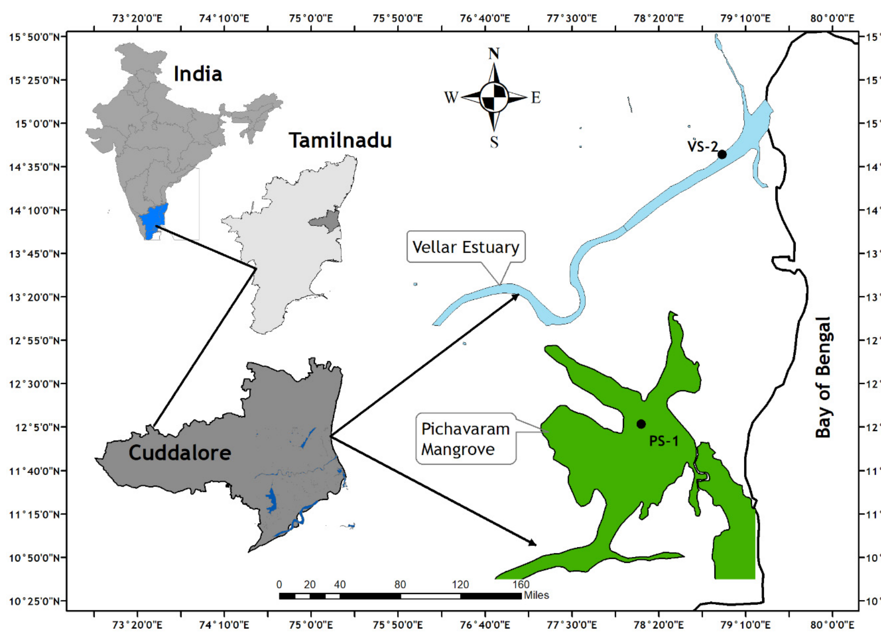

Fig. 1. Showing the sampling location of Pichavaram (PS-1) and Vellar (VS-2) stations.

metals are as follows: The Zinc (Zn) concentration was found to be almost similar in both stations, the higher concentration was detected during monsoon at Vellar and the lower concentration was observed during summer in Pichavaram study site. It ranged between 29.21 µg/g to 53.01 with mean value of 43.49 ± 8.64. Similarly, Manganese (Mn) values were also detected higher (209.31 µg/g) in Vellar station and lower (139.37 µg/g) in Pichavaram during monsoon and summer respectively.

The concentration of aluminium (Al) was found to be fluctuated and it varied from 5964 µg/g to 10751 µg/g with mean of 5497 ± 1655.77 with maximum at Vellar during monsoon and minimum at Pichavaram during summer. The concentration of magnesium (Mg) was observed to be varying among seasons. The high concentration of Mg (4532 µg/g) was measured at Vellar estuary during monsoon and the lower value was (2581 µg/g) detected at Pichavaram during summer with the mean value of 3507.5 µg/g ± 710.32.

Tissue

The result of whole observation in study period has exhibited less accumulation of heavy metal concentration in tissue when compared to sediment for both stations. The accumulation of all heavy metal in tissue was depending on the concentration of metal in sediment. Similar to sediments metal concentrations were found to be higher during monsoon season in Vellar estuary and lower in Pichavaram during summer.

The high concentration of metals such as Zn, Mn, Mg, and Al detected in muscle tissue samples are as follows: 21.05 µg/g, 246.63 µg/g, 2248 µg/g, 1860.45 µg/g, While the less concentration of all ten metals were found at Pichavaram station (1.98 µg/g, 119.4 µg/g, 1589.3 and 892.09 µg/g).

DISCUSSION

Sediment

In aquatic environments sediment is one of the major sinks for heavy metals and it might be a good indicator for heavy metal pollution. Similarly, the bivalves are also good for pollution monitoring in the aquatic environment (Brugmann, 1981). The sources of heavy metals from sewage and industrial wastage are dissolved in water and settled into the bottom of the sediment (Fung and Lo, 1992).

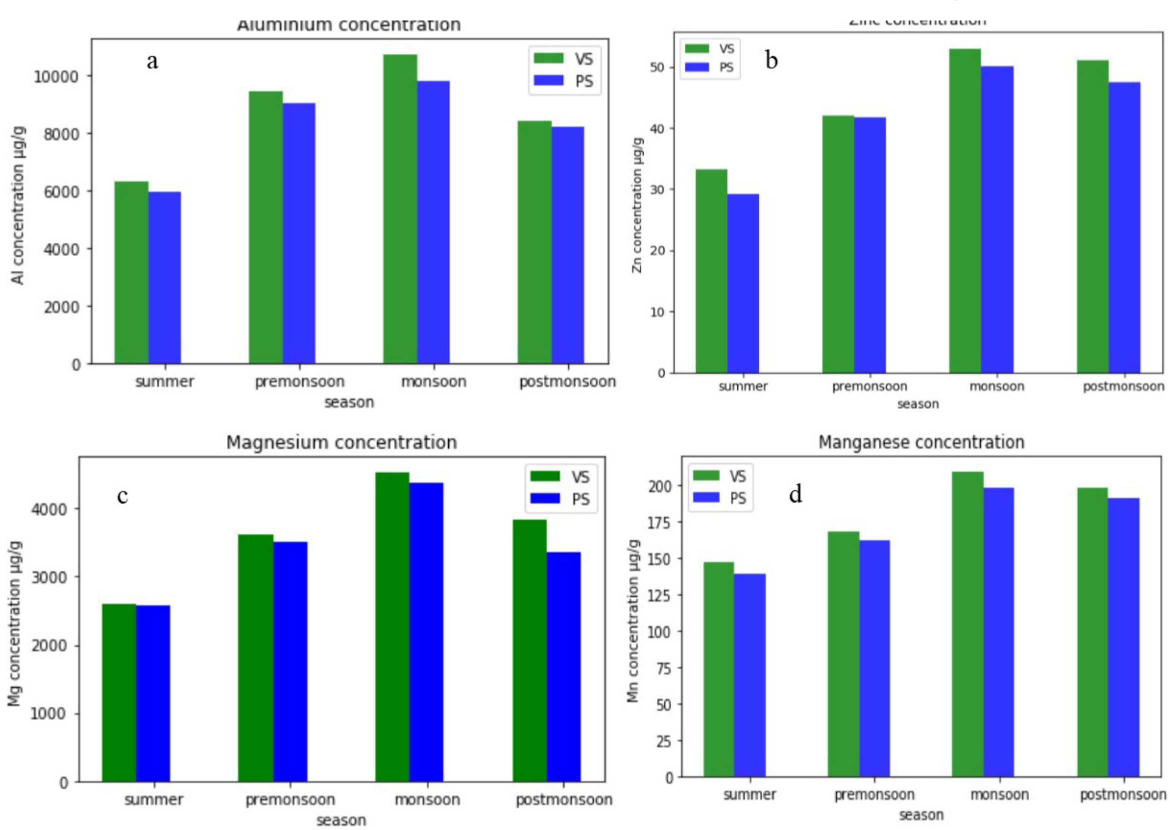

Fig. 2. The figure shows concentration of heavy metals in sediment.

As expected, the concentration of heavy metal was higher in sediment when compared with bivalves and also the comparison between two stations revealed Vellar estuary recorded higher than the Pichavaram Mangrove. The availability of metals in sediment poses a great threat to aquatic animals and within the environment the accumulation of metals can significantly increase and the possibility of transfer of metals to other animals by food chain is higher due to a phenomenon known as bioaccumulation. In this study, the order of metals accumulation in sediments are observed as Al> Mg>Mn>Zn>.

The Zinc (zn) concentration in both stations were found to fall between 29.21 µg/g and 53.01 µg/g which is lesser when comparing to the following studies: 240.0 µg/g at deep bay, Hong Kong (Tam and Wong, 2000) and 51.24 ± 39.97 µg/g at S. Buloh and 120.23 ± 13.90 µg/g at S. Khatib Bongsu, Singapore (Cuong *et al.*, 2005).

The wide variations in metals observed from sediments at both stations might relate to sediment grain size and organic carbon content presence (De Groot and Zschuppe, 1981). Moreover, it should be noted that the geological weathering and suitable physicochemical conditions created by well-developed mangrove forest system also might favor the accumulation of metals in mangrove region (Harbison, 1986). In addition, anthropogenic inputs such as discarded automobiles, transformers, batteries, tiers and crude oil spill, atmospheric fallout as well as water- waters disposal also play a vital role in the metal's accumulation in natural environment (O' Leary, 1995). The earlier studies have reported the metal concentration were high in vellar estuary than the Pichavaram mangrove due to lot of domestic sewage and organic disposal by local population into marine environment (Purvaja and Ramesh, 2000).

Tissue

The affected environment due to heavy metal pollution is an opportunity for studying impact of metals to organisms, especially by bottom feeding organism like bivalves. The present study studied several of metal concentration accumulation in the tissue of *Perna viridis*. Among the ten metal (Al, Mn, Mg and Zn) Aluminum concentration was found to be higher when compared to other metals, the order of accumulation of metals in tissue are as followed Al> Mg>Mn> Zn.

In monsoon season higher amount of metal concentrations in both stations were noted than other seasons, this could be due to high freshwater

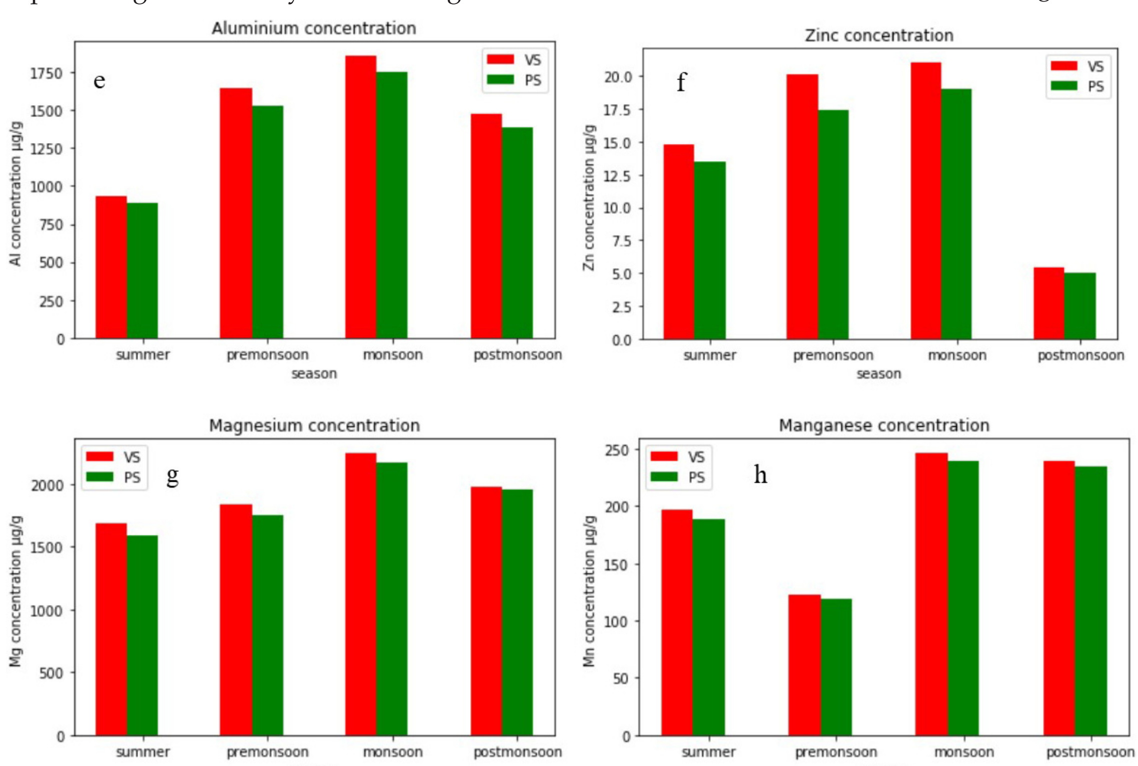

Fig. 3. The figure shows concentration of heavy metals in tissue.

influence which brings a huge amount drainage containing effluents and domestic waste from the land (Sundaramanickam *et al.,* 2016). However, during summer the metals exhibited less concentration which could be due to the decrease in drainage and sewage effluents from land sources with the absence of rainfall.

The observed metal concentration of Zn, 4.95 to 21.05 µg/g. The Zn concentration is lesser than earlier studies reported (Yap *et al.,* 2004). However, the metal concentrations range did not exceed the safe limits prescribed by the various recommended guidelines (USFDA, 1990; The Ministry of Public Health of Thailand (MPHT, 1986); NHMRC, 1987).

The Mn concentration (119.4 to 246.63 µg/g) also exhibited less while comparing with previous studies conducted with different species (Shanthi, 1987).

Contrastingly, Mg and Al, elements registered high values than earlier reports and the mean of Mg conc. was higher than the study carried out by Shanmugam (2007) who reported 151.3 ± 1.9 ppm. Similarly, Whereas Al concentration was found fall between 892.09 and 1860.45 µg/g which is greater than the observation made. The higher Mg concentration observed in the present study must be due to sediment nature *i.e.,* the clayey substratum has the ability to accumulate more metals than the substratum (Chester and Stoner, 2003). While in the case of Al, it is third most abundant element on the earth's crust after oxygen and silicon and it is abundantly available in sediment (Mason B and Moore CB. 1991).

The concentration of the heavy metals analysed in the present study exhibited considerable variation in sediment and tissue. Zn concentration were below the alarming level, whereas Mg (274 ± 12) content was higher in shell and tissue. The present exploration was made for a phase of one year (January to December 2017) on *Perna viridis* in the mangrove region of Pichavaram and Vellar. The study was conducted to monitor the heavy metal concentration in sediment and soft tissue (*Perna viridis*) to find out the possibilities of using *Perna viridis* as an indicator organism for heavy metals pollution. The metal concentration in sediment and tissue revealed that the maximum and minimum concentration was recorded during monsoon and summer respectively. The higher concertation observed during monsoon could be due to the heavy inflow of fresh water brings lot of effluent from municipal, domestic and agricultural wastes. The scrap metals from boat and fishing vessels and paint residues (antifouling paints) from local boat jetty may be the source of zinc in the sediment and finally in the tissue of *Perna viridis* as resulted in the present study.

The lower concentration in summer due to low fresh water in influence and absence of rain fall. Further the absorption, consequent sedimentation and flocculation due to salinity increase are some of the reasons for low metal concentration in summer. When compared to the other two season, the pre-monsoon showed higher values than post monsoon. The agricultural activities during the pre-monsoon season may be another reason for high metal concentration. The *Perna viridis* may be used as an indicator species for monitoring metal pollution and therefore can be used as sentinel organism to observe pollution in the mangrove environment due to the following reason. Since, *Perna viridis* accumulates high concentration of heavy metals in the aquatic environment and it may be used as a bio monitor of certain heavy metals in the mangrove environment.

CONCLUSION

The present study revealed the metals contamination from both station, the higher concentration was recorded from vellar station while the mini mum was observed in Pichavaram mangrove. The higher concentration of metal in Vellar estuary might be major influence of anthropogenic activities than the Pichavaram mangrove. Although the level contamination of all metals from both stations were lower than the standard level given by the NOAA. The metal accumulation on *Perna viridis* was low whereas the higher concentration recorded in sediment because of the composition of sediment and the rate of metal transfer into *Perna viridis.*

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Conflict of interest statement

Authors declare there is no competing or conflict of interest.

Author's contribution

The final correction and enrichment of paper was enhanced by corresponding author and second author. The first author was conducted the study and developed the manuscript, the fist author followed all suggestion which were given by corresponding author and second author for the enrichment of paper quality.

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Data availability

All the data has been included in this paper. If requested from journal all the data will be shared.

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