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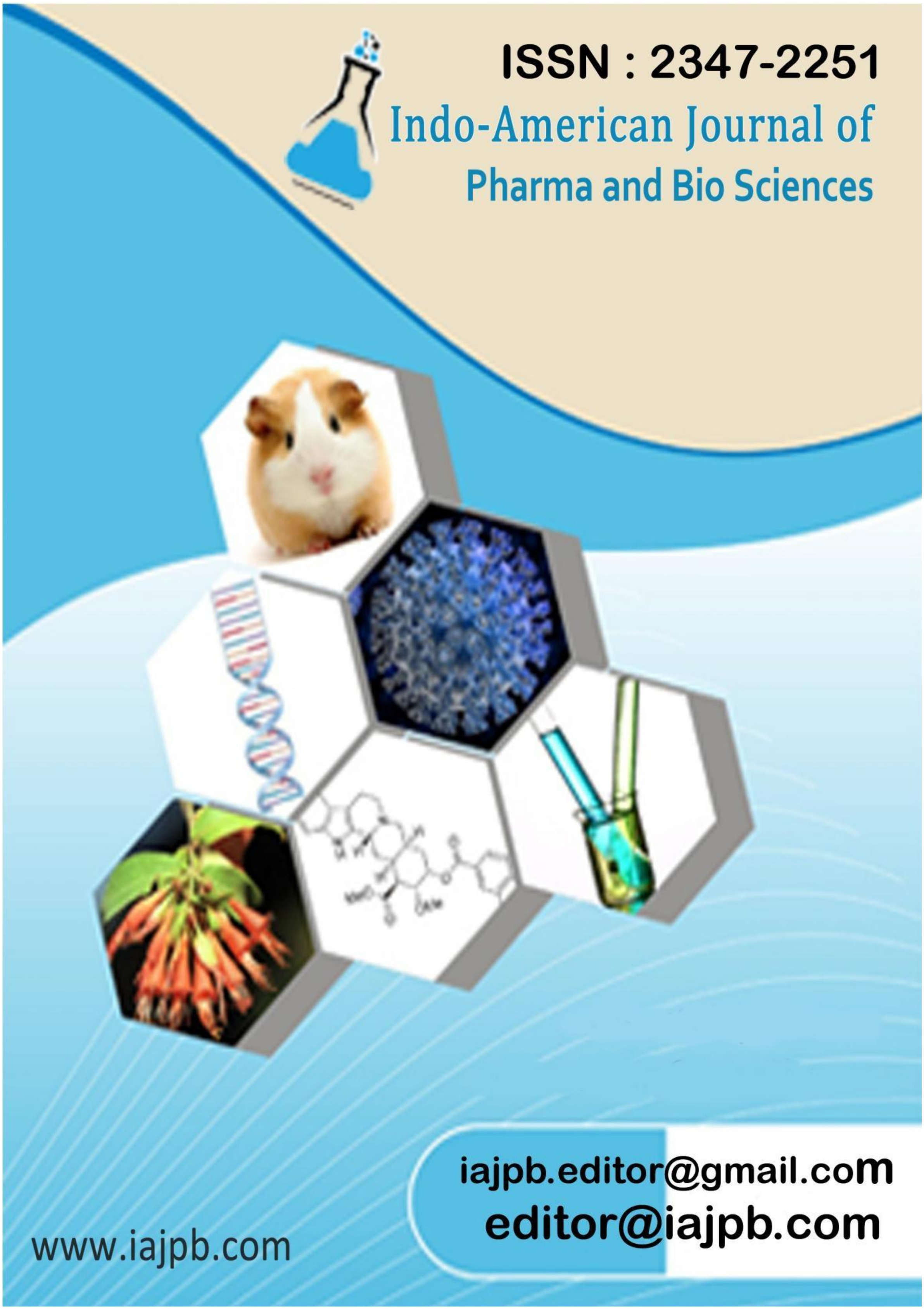

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"Role of *Telescopium telescopium* as a bioindicator of Heavy Metal Pollution in Punnakayal Mangroves "

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Abstract:

The present study investigates the heavy metal accumulation in *Telescopium telescopium* collected from the Punnakayal mangrove ecosystem. The analysis focused on three major heavy metals, namely Cadmium (Cd), Lead (Pb), and Mercury (Hg), over a period from January 2018 to December 2018.Specimens were collected periodically, and the concentration of heavy metals in the tissues was analyzed using standard analytical techniques. The results revealed the presence of all three heavy metals in varying concentrations, indicating bioaccumulation in *Telescopium telescopium*. Among the metals studied, Lead showed comparatively higher accumulation, followed by Cadmium and Mercury.The variation in metal concentration may be attributed to seasonal changes and environmental factors in the mangrove ecosystem. The findings suggest that *Telescopium telescopium* can serve as a potential bioindicator for monitoring heavy metal pollution in mangrove habitats.This study provides baseline data on heavy metal contamination and highlights the ecological significance of gastropods in environmental assessment.

Key words: Bioaccumulation, Bioindicator, Punnakayal mangrove ecosystem

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1 Introduction

Human require varying amounts of metals. Iron, cobalt, copper, manganese and zinc have been linked to human growth, development and reproductive activities. Excessive levels can be damaging the human organs. Other heavy metals such as mercury, cadmium and lead are toxic metals that have no known vital or beneficial effect on organisms and their accumulation over time in their bodies can cause serious illness (Liu *et al.,* 2020).

Heavy metal pollution in aquatic ecosystem has been recognized as a serious environmental problem. In many cases, heavy metals occur in natural water bodies at levels below their toxic thresholds, however due to their non-degradable nature, such low concentrations may still pose risk of damage via uptake and subsequent bioaccumulation by organisms, which cannot be effectively metabolized and these absorbed metals are bio concentrated or bioaccumulated in one or several compartments across food webs (Soegianto and Irawan, 2009; Celechovska *et al.,* 2008; Joseph Uday Rajan and Ramesh Babu, 2016).

Metal bioaccumulation can be of importance from the public health point of view, especially when humans consume the accumulators. Secondly, this phenomenon is now being explored in the assessment of environmental quality, in addition to chemical surveys of water and sediment and their concentration in the body tissues of organisms living in (Moi Javanshir *et al.,* 2013).

More and more attention has been drawn due to the wide occurrence of metal pollution in the aquatic system. Monitoring and prevention of heavy metal pollution is one of the hot topics in researches (Mingli *et al.,* 2008). As shown in review by (Mingli *et al.,* 2008) many of the bioindicator papers were about metal pollution, where in plants, invertebrates, fish and mammals were the widely used bioindicator species. Each bioindicator shows the special merits for the biomonitoring of metal pollution in aquatic ecosystem when compared to others (Joseph and Ramesh, 2016).

Punnakayal is situated in the confluence of a tributary of the perennial river Thamirabarani, 30 Km South of the industrial hub of Tamilnadu, Tuticorin, Southeast coast of India. The coastal ecosystem includes an estuary, mangrove patches and mud flats. The total estimated mangrove area is around 7 sq.km out of which 3 sq.km is denuded and in 1 sq.km restoration has been attempted. The area surrounding this mangrove thicket support rich fishery; an abode for resident and migratory birds and it is the livelihood dependence of about 80 fishermen families living in village Punnakayal (Jeyaseeli and Murugan, 2002). This mangrove supports rich biodiversity and fishery which is not documented till the present study was made. Largely in the global scenario, anthropological pressures and natural calamities threaten fragile coastal ecosystems. Punnakayal mangrove ecosystem lies in close proximity of massive Titanium Dioxide (Tio_2) plant, caustic soda plants, fish curing centers and salt pan drains in to the area.

This mangrove patch is also severely denuded by cutting the mangroves for fire – wood and building bunds for salt pans. Moreover, hypersalination due to salt pan brine release also curtails the growth of mangroves in this area, such pressures would ultimately lead to massive degradation and destruction of habitats (Vinoth Ravindran and Rajesh, 2013). Also the mangrove ecosystem of Punnakayal is affected by effluent discharges, urban and agricultural run off and solid waste dumping due to their proximity to urban development. Among the main anthropogenic impacts in mangrove ecosystems from these sources are heavy metals, due to their affinity and immbolization within anaerobic sediments (Rajesh *et al.,* 2011).

Metals may also be transported to estuarine waters when accumulated by mangroves and concentrated in exported leaf detritus, which is an important food source for higher organisms in estuarine and mangrove food chains. Mangrove muds have an extraordinary capacity to accumulate materials discharged from the near shore marine environment. Mangrove sediments are anaerobic and reduced as well as rich in sulphid and organic matter therefore favours the retention of water borne heavy metals and the subsequent oxidation of sulphides between tides allows metal mobilization and bioavailability (Ma *et al.,* 2003; Clark, 1998). Concentrations of heavy metals in sediments usually exceed those of overlying water by 3-5 orders of magnitude and with such high concentrations, the bioavailability of even a minute fraction of the total sediment metal content assumes considerable importance with respect to bioaccumulation with in both animal and plant species living in mangrove environment. Since heavy metals cannot be degraded biologically they are transferred and concentrated into plant and animal tissues from soils and pose long term damaging effects on them (Zabetoglou *et al.,* 2002; Jeyaseeli and Murugan, 2002; Rajesh *et al.,* 2011).

It is known that molluscs accumulate metallic pollutants at concentrations several orders of magnitude above those observed in the field environment. Owing to the widespread application of bivalves as biomonitoring organisms in the aquatic environment, they have been the subject of several studies on the interaction of heavy metals. Fewer studies have been done on gastropod molluscs, some of which are also considered as useful biomonitors of certain metals (Bryan *et al.,* 1983; Thilaga, 2005; Kesavan *et al.,* 2010).

Many studies were carried out on the bioaccumulation of heavy metals by molluscs. De wolf and Rashid (2007) on *Littorina scabra*; Sandhya *et al.* (2012) on *Bursa spinosa,* Yap *et al.,* 2013 on *Nerita lineata;* Kesavan *et al.,* 2013 on *Cerithidia cingulata.* Joseph udayrajan and Ramesh Babu (2016) on potamidis snails. Januar *et al.* (2019) on Anadara granosa and Rudiyanti *et al.* (2023) on *Perna virids.* Scrutinizing the literature on potamidids snails, there is paucity of information on bioindicator studies with respect to heavy metal pollution of

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Punnakayal mangrove study area. Hence the current investigation has been carried out to study the status of bioaccumulation of non-essential heavy metals specially cadmium, lead and mercury in whole body tissues of *T. telescopium*.

7.2 Materials and Methods

Monthly samples of *T. telescopium* were collected from the Punnakayal mangrove of Gulf of Mannar region during low tide by hand picking for a period of 12 months from January 2018 to December 2018. The animals were brought to the laboratory, washed thoroughly with seawater and the shells were broken without damaging the soft body of the animal. The soft tissues of the males and females were thoroughly washed with distilled water and dried in a hot air oven at a temperature of 60°C for 24 hours. The dried tissues were powdered using a pestle and mortar. Powdered samples were used for metal analysis.

Metal Analysis

A known quantity of tissues were weighed and acid digested in a mixture of nitric acid and perchloric acid (2 : 1 V/V) (Topping, 1973), till the samples were dried and became colourless. The residue was dissolved in 10 ml of 2 N hydrochloric acid. These samples were analysed in a GBC Aventaver 1.33 Atomic Absorption Spectrophotometer. Mercury was analysed by cold vapour technique using mercury analyser (OPEMEC, CECRI, PORT TRUST, TUTICORIN). Blanks and standards were also treated in the same manner as done for the samples.

Statistical Analysis

ANOVA was carried out to know the difference in levels of proximate composition between male and female.

3 Result

The concentration of non – essential metals like cadmium, lead and mercury in the body tissues of *T. telescopium* is presented in Figures (1, 2 and 3). The results of statistical analysis are given in the Tables (1,.2 and 3).

Cadmium

Males had cadmium levels ranging from 0.38 µg/g to 0.87 µg/g, whereas females had concentration of 0.56 µg/g to 0.96 µg/g, Cadmium levels were discovered to be highest in male in April 2018 (Summer) and lowese in females in December 2018 (Post – monsoon) (Fig. 1).

Lead

The result showed that the concentration of lead in males varied from 0.28 µg/g to 0.64 µg/g and in females it varied from 0.49 µg/g to 0.83 µg/g. Higher concentration of this metal accumulation was observed during April 2018 (Summer) in both the sexes, and lower concentration was noted in the month of December (Post monsoon) (Fig. 2).**Mercury**

The concentration of mercury varied from 0.11 µg/g to 0.28 µg/g in males and 0.27 µg/g to 0.44 µg/g in females. Maximum concentration was recorded in the month of April and minimum December (2018) in both the sexes are noticed (Fig. 3).

Statistical analysis

Statistically, there is insignificant (≤0.05) difference among the proximate composition (cadmium, lead and mercury) between male and female *T. telescopium* (Table 1, 2 and 3).

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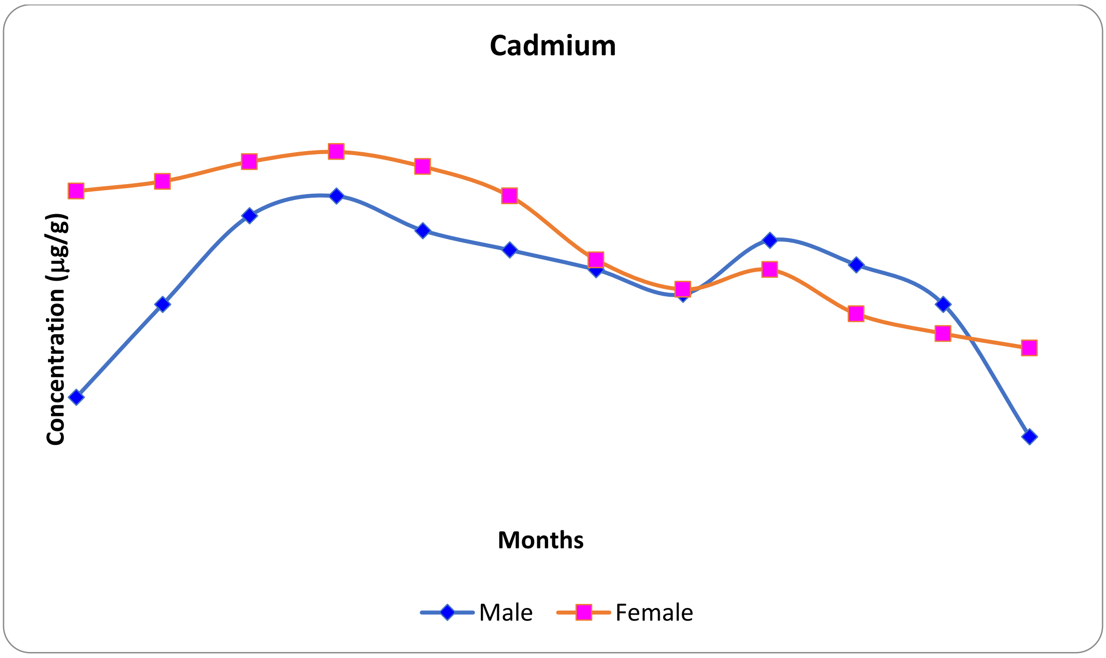

Fig. 7.1 : Concentration of cadmium in the body issue of Male and Female *T. telescopium*

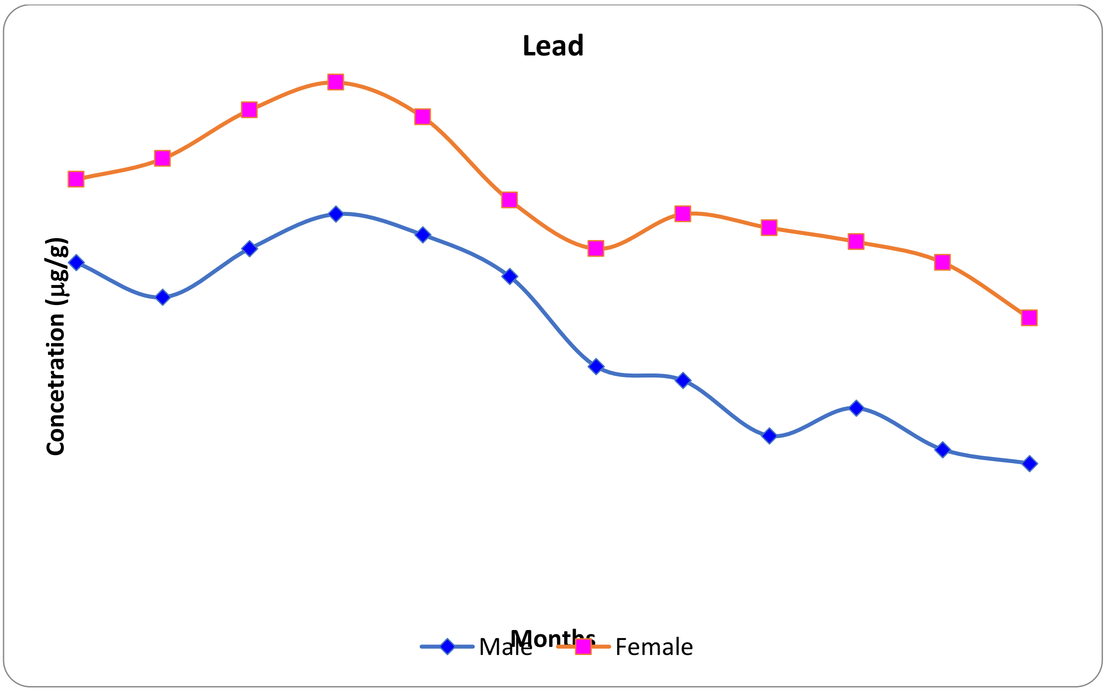

Fig. .2 : Concentration of Lead in the body issue of Male and Female *T. telescopium*

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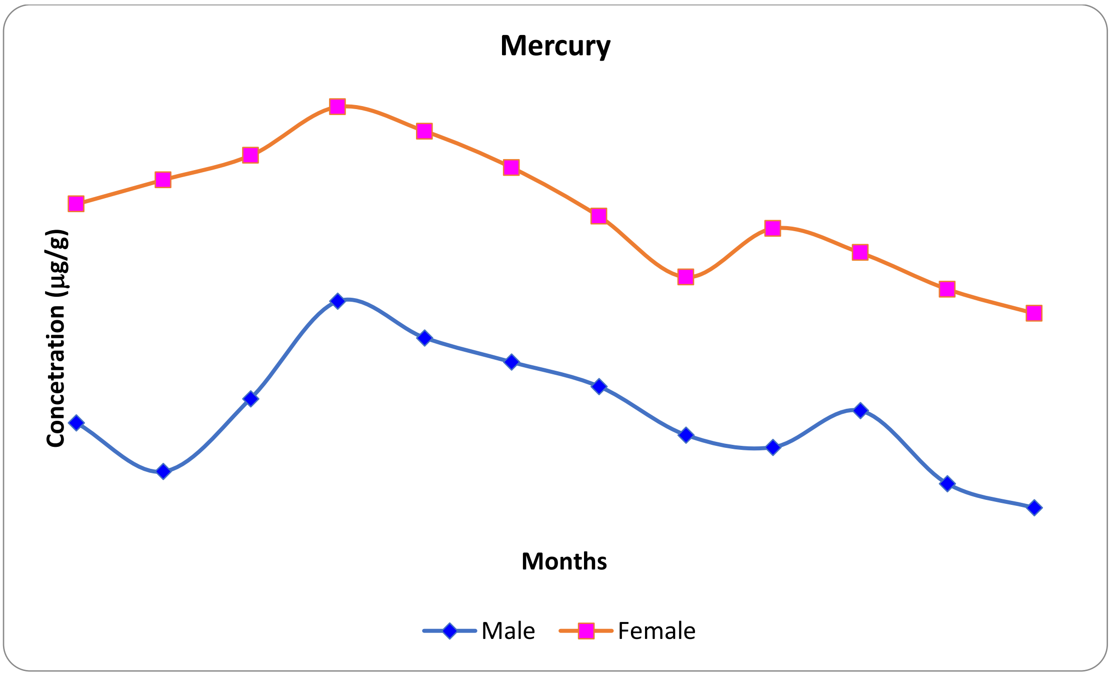

Fig. 7.3 : Concentration of Mercury in the body issue of Male and Female *T. telescopium*

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Table 1 : Anova – Cadmium (male and female *T. telescopium*)

Source of variation	SS	DF	MS	F	P-Value	F-crit
between Groups	0.0503	1	0.0503	2.3699	0.138	4.30
with in Groups	0.4674	22	0.212			
Total	0.5177	23				

*significant

Table 2 : Anova – Lead (male and female *T. telescopium*)

Source of variation	SS	DF	MS	F	P-Value	F-crit
between Groups	0.2646	1	0.2646	1.6368	0.0959	4.30
with in Groups	0.3301	22	0.015			
Total	0.5947	23				

*significant

Table 3 : Anova – Mercury (male and female *T. telescopium*)

Source of variation	SS	DF	MS	F	P-Value	F-crit
between Groups	39.216	1	39.3216	1.1505	0.2951	4.30
with in Groups	751.8947	22	34.177			
Total	791.2163	23				

*significant

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Table 4 : Indian standards for trace elements in fish and fishery products

Element	Standard	Approximate date of adaption
Hg	0.5 ppm	1982
As	1.0 ppm	1982
Cd	10.0 ppm	1983
Pb	5 ppm	1982
Zn	50 ppm	1971

Source: FAO: 1983

4 Discussion

Owing to its proximity to industrial zones and the potential load of metals in the atmosphere that might reach the area due to precipitation, the Punnakayal area is especially ripe for studies on the distribution of heavy metals in order to estimate the pollution load in the region (Vinoth Ravindran and Rajesh, 2013).

The bioavailability of metals in organisms is affected by a number of variables, such as geochemical and biological processes. The amount of bioavailable metal can be determined by looking at the metal concentration in the organism. Measurements of the metal content in tissues, however, do not reveal anything about the mechanism regulating the consumption of metals (Joseph and Ramesh, 2016). The rate of accumulation may change depending on the organism age, size, sex, eating activity, and reproductive status (Rajesh kumar, 2018).

Human and industrial activities are the primary contributors to coastal pollution, which has been an issue in recent decades (Doney, 2010; Valdes, 2016). Devastating consequences on aquatic life and the natural environment may result from heavy metal contamination (Velez

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and Montoro, 1998). Contaminated biomass and living organisms pose a threat to human health (Farombi *et al.,* 2007).

The yearly shifts in trace metal concentrations have been attributed to a variety of different factors. Both Paez osuna *et al.* (1995); Marlize Ferreira *et al.* (2009) state that seasonal variations in trace metals may be linked to shifts in the food supply and shifts in the run-off of metal particles to the sea as a result of heavy precipitation. It has been shown that local phytoplankton production varies with the seasons as well. As a result, a rise in phytoplankton productivity suggests an improvement in the nutritional state of molluscs, which in turn raises metal concentrations in the creatures that are actually being studied (Ferreira *et al.,* 2009).

The extent to which heavy metals accumulate in the tissues of snails has been shown to vary with both the kind of heavy metal and the species of snail. Variation in reproductive status, metabolic rate, body weight, and the existence or lack of an enzyme system that may breakdown the contaminants may account for the observed variations in metal concentrations in the tissues of male and female *T. telescopium* species (Valavanidis and Vlachogianni, 2010).

Non-essential heavy metals like cadmium, lead, and mercury may disrupt biological processes and are very harmful to human marine biota. Since fish and other marine organisms tend to be at the top of the aquatic food chain, they may accumulate significant amounts of heavy metal pollution due to bioaccumulation (Oluwatosin Ebenezer and Godwin Oladele, 2015). The metal cadmium may be found in both aquatic and terrestrial environments, and its emission can be traced to both natural and human-caused processes (eg. Pigments, nickel-cadmium batteries, smelting and refining of metals and many other sources). Due to its widespread use in a variety of commercial and agricultural processes, cadmium has become more prevalent in the natural world. The extended biological half life of cadmium increases the metals toxicity to living things. Cadmium is a heavy metal that accumulates permanently

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in cells, interacting with many cellular components and molecular targets despite being an unnecessary, nonphysiologically present element in animals (Roberto and Maria, 2014).

The geology of catchment soil and runoffs from phosphate fertilized agricultural soils, discarded nickel cadmium based batteries, and cadmium plated goods may allow cadmium to infiltrate the aquatic environment, as stated by Fianko *et al.* (2010). Cadmium metal is found in high concentrations in aquatic environments due to industrial discharge, household waste, sewage disposal, river runoff, and ship stripping and painting (Fatoki and Mathabatha, 2001; Vinoth and Rajesh, 2013). The range of cadmium concentrations in the current investigation was 0.38 µg/g to 0.87 µg/g in males and (0.56 µg/g to 0.96 µg/g) in females. Higher concentration of cadmium was recorded in the month of April 2018 and the lower concentration in the month of December 2018 both in males and females (Fig. 7.1).

Jeyaprabha (2013) observed that cadmium concentration varied from (1.99 µg/g to 4.76 µg/g) in males and (2.51 µg/g to 5.74 µg/g) in females in *T. brunneus*. Sharif *et al.* (2016) recorded the cadmium concentration of (0.56 µg/g) in *L. canarium*. Similar to the above findings in the present study also the cadmium recorded in the male *T. telescopium* varied from (0.87 µg/g to 0.38 µg/g) and in females it varied from (0.96 µg/g to 0.56 µg/g). Female *T. telescopium* recorded higher cadmium concentration than the males and this could be the reason that the female *T. telescopium* may be the voracious feeders than the males. The result of the present study agrees will with the findings of Thilaga (2005) who recorded the higher concentration of cadmium (0.998 ppm) in female *B. spirata*.

Lead is a highly noxious and non-disintegrative heavy metals and is the second element on the top 20 list of the most poisoning heavy metals. Lead rarely exist in nature and could be found in different forms such as organic and inorganic compounds. It is used in storage

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batteries, solders, bearings, cable covers, plumbing, pigments and vibration absorbers (Moyo *et al.,* 2017).

Young children and infants are more vulnerable to the negative effects of lead exposure, which may include lasting behavioural disorders, neurological impairment, and other developmental difficulties (Ibrahim Nesreen and Mohamed Abu El-Regal, 2014). This massive amount of fresh water run-off is what causes the lead content to rise during the monsoon season, as reported by Mitra (1998). The lead level along the Punnakayal mangrove has risen because to pollution from a variety of causes, including human waste, power plant operations, sediment dumping, agricultural runoff, leaked leaded gasoline from boats, and fly ash deposits.

Soft tissues of the mangrove snail *Nerita lineata* were found to have reduced concentrations of Cd and Pb, as reported by Yap and cheng (2013). Luk-yanova and Marten yanova (1996) reported the accumulation of lead and zinc in the body tissues of *Marcia recens* and found that the concentration of these metals in the body tissues of females were higher than the males. Thilaga (2005) recorded higher concentration of lead (0.998 ppm) in the body tissues of female *Babylonia spirata* than the males. Jeyaprabha found higher lead content (2.87 µg/g) in female *Turbo brunneus* than the males. In the present work also, the same trend has been observed. The higher accumulation of metals in the body tissues of females may be due to their rapid feeding nature.

The inorganic and biological forms of mercury can contribute to metal contamination. More people are paying attention to it now that they know it is very hazardous to aquatic species because to the infamous Minamata sickness that swept Japan (Chao chan Cheng, 1993). It could be understood that the effluent discharge from the chloralkali plants are the prime source of mercury in Punnakayal mangrove.

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In the present investigation higher concentration of mercury (0.44 µg/g) was recorded in the female *T. telescopium* than the males (Fig. 7.3). Similar to the present findings Thilaga (2005) recorded higher mercury content (0.089 ppb) in female *B. spirata* and Jeyaprabha (2012) also noticed higher concentration of mercury (0.06 µg/g) in the body tissues of female *T. brunneus*.

Higher metal concentrations were found in the body tissues of *T. telescopium* throughout the summer months of the current investigation. It has been observed that the breeding season for *T. telescopium* was summer. This could be related to higher feeding activity during the breeding season and also due to biomagnification through food chain relationship (Joseph and Srivastava, 1993; Tamil selvi, 2012).

Senthilnathan *et al.* (1998) recorded increased levels of metals during monsoon season in *Perna viridis* and *Croesostrea madrasensis*. Lyla (1991) recorded increased levels of metals in sediments during monsoon season. Kumaraguru (1990) recorded increased levels of metals during monsoon season in the Vellar estuary and Killai backwaters. Rajesh *et al.* (2011) observed higher metal loads in monsoon and low in summer from the sediments of Punnakayal mangrove. However the increase of metals in the present study could be attributed to the higher feeding activity during breeding season. Low concentration of these metals during December might be attributed to the spent period of *T. telescopium*. During this period, feeding rate would also be low, resulting in the probable low accumulation of metals through food.

When analyzing the metal accumulation, it was observed that the seasonal variations on the bio availability of metals could not only be related to the concentration of metals in the environment, but also to the food and particulate matter. According to Bryan (1983), Hutchins *et al.* (1996). The bioaccumulation of metals by aquatic species is largely reliant on the aforementioned factors, as stated by Thilaga (2005) and Jeyaprabha (2012). The results of this investigation indicate that the levels of cadmium, lead, and mercury found in *T. telescopium* body tissues are much below the maximum allowable limit of the Indian standard, which is set for fish and fisheries products intended for human consumption (FAO, 1983; Table 4).

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