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The Potential of Digestive Caecum in Mudflat Snail *Telescopium telescopium* as a Possible Cadmium Source for Industrial Application

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Abstract

This paper cited the cadmium (Cd) data in the seven different soft tissues (foot, cephalic tentacles, mantle, muscle, gill, digestive caecum (DC) and remaining soft tissues) of mudflat snail *Telescopium telescopium* that were previously published by Yap and Noorhaidah [1]. These Cd data were re-evaluated from the point of the industrial use. The data were re-analyzed by using probability analysis and were calculated for bioaccumulation factor (BAF). In general, it was found that Cd levels were the highest in DC when compared to other different organs/soft tissues. Also, the Cd levels in the DC are comparable to habitat surface sediment based on BAF. This strongly indicated that DC is the main target organ for Cd storage and accumulation based on the accumulation pattern of Cd in the seven soft tissues. Therefore, it is suggested that DC of the mudflat snails is a possible Cd source for industrial application.

Keywords: *Telescopium telescopium; Cd Distribution; Different Soft Tissues*

Introduction

Cadmium (Cd) has many chemical and physical properties that make it desirable for industrial and consumer applications. These characteristics include resistance to corrosion and chemicals, tolerance of high temperatures, a low melting point and excellent electrical conductivity. Therefore, Cd is suitable for use in alloys, pigments, coatings, stabilizers and rechargeable Ni-Cd batteries. For example, Cd pigments are predominantly used to colour engineering plastics that are processed at high temperatures. Besides, they also have important applications in ceramics, glasses and specialist paints [2].

Earlier, Hutton [3] quantified the significant sources of Cd in the European Community and assessing the relative significance of such inputs to the environmental compartments, air, land and water. According to Tabelin., *et al.* [4] "naturally contaminated rocks" contain various hazardous and toxic inorganic elements including Cd. If left untreated, these naturally contaminated rocks could pose severe problems not only to the surrounding ecosystem but also to people living around the construction and disposal sites. Therefore, besides Cd mining, an alternative Cd source from biological tissues that can reduce the Cd toxicity to the environment is necessary.

Distributions of heavy metals in the different soft tissues of *Telescopium telescopium* have been reported in the literature [5-8]. This is due to the accuracy of using a particular organ/tissue of snails for biomonitoring of heavy metal pollution in the coastal ecosystem [1,7]. Previously, Yap and Noorhaidah [1] reported bioavailability and contamination by Cd in the tropical intertidal area, using different soft tissues of *T. telescopium*. However, there is no discussion on the industrial application for identified specific organ/tissue of high accumulation of Cd. Therefore, the objective of this paper was to re-analyze the data cited from Yap and Noorhaidah [1] for probability analysis and bioaccumulation factor. This is important to understand which tissue can be suggested as a Cd source as a possible material for industrial uses.

Materials and Methods

The data of Cd levels in the seven different soft tissues, namely foot, cephalic tentacle CT), mantle, muscle, gill, digestive caecum (DC) and remaining soft tissues (REST), and habitat surface sediments (SED) are cited from Yap and Noorhaidah [1]. The cited Cd data were re-analysed for Probability Analysis (PA) by using Kaleidah Graph (Version 3.08, Synergy Software) and bioaccumulation factor (BAF; tissue/sediment).

Results and Discussion

Table 1 shows the increasing order of Cd levels in the seven different soft tissues of *T. telescopium* from 18 sampling sites in Peninsular Malaysia. In general, DC shows the highest Cd levels among all the seven soft tissues studied. DC from 14 out of 18 populations recorded the highest Cd concentrations, ranging from different background sampling sites. KJuru population had the highest Cd level found in DC could show Cd redistribution since DC also recorded the highest Cd level among all the soft tissues in this population.

Table 1: *Increasing order of Cd concentrations (mean; µg/g dry weight) in the different soft tissues of Telescopium telescopium from 18 sampling sites of Peninsular Malaysia [1].*

Note: CT: Cephalic Tentacle; REST: Remaining Soft Tissues; DC: Digestive Caecum; SED: Surface Sediment. Data cited from Yap and Noorhaidah [1].

No.	Sampling sites	Orders of Cd accumulation patterns							
1.	KJuru	Foot	CT	Muscle	REST	Gill	Mantle	SED	DC
		0.60	1.31	1.81	2.21	2.48	2.68	3.67	6.36
2.	KPPuteh	CT	Foot	Mantle	Muscle	Gill	REST	SED	DC
		0.62	0.69	0.9	0.92	1.83	2.28	2.60	2.7
3.	PPunggur	Muscle	Foot	Gill	REST	DC	Mantle	CT	SED
		0.03	0.27	0.59	1.1	1.36	1.64	1.81	3.10
4.	KSAyam	CT	Muscle	Mantle	DC	Foot	REST	Gill	SED
		0.03	0.1	0.26	0.45	0.6	1.03	1.25	4.49
5.	SBLaut	Foot	Mantle	Muscle	Gill	CT	REST	DC	SED
		0.03	0.14	0.28	0.47	0.53	0.58	0.89	4.12
6.	KLukutK	CT	Muscle	REST	Mantle	Foot	Gill	DC	SED
		0.03	0.03	0.03	0.04	0.18	0.31	1.8	2.11
7.	KLukutB	Muscle	Foot	CT	Mantle	Gill	REST	DC	SED
		0.02	0.03	0.04	0.05	0.63	0.93	1.05	2.06
8.	SepangB	Foot	CT	Muscle	Mantle	Gill	REST	SED	DC
		0.02	0.04	0.33	0.43	0.64	0.73	1.21	2.95
9.	BLalang	Foot	Gill	Muscle	Mantle	CT	REST	DC	SED
		0.54	0.68	0.75	0.82	0.83	0.85	1.35	1.58
10.	SepangK	Mantle	CT	Foot	Muscle	REST	SED	DC	Gill
		0.02	0.41	0.67	0.69	0.85	1.04	1.39	1.9
11.	KPJeram	Muscle	Foot	Gill	Mantle	CT	REST	DC	SED
		0.28	0.34	0.58	0.75	0.76	1.17	2.56	2.71
12.	SJanggut	Muscle	Foot	REST	Gill	CT	Mantle	DC	SED
		0.17	0.17	0.53	0.53	0.87	1.01	1.09	2.24
13.	PIndah	Muscle	Foot	Mantle	Gill	SED	CT	DC	REST
		0.61	0.67	0.87	0.91	1.18	1.25	1.41	1.42
14.	KDeralik	Muscle	Gill	REST	CT	Mantle	Foot	DC	SED
		0.04	0.25	0.55	1.47	1.64	1.96	2.14	2.65
15.	KSitiawan	Foot	Mantle	CT	Muscle	REST	Gill	DC	SED
		0.2	0.31	0.32	0.36	0.8	0.98	2.49	3.79
16.	JPBainun	Muscle	CT	Foot	Mantle	Gill	REST	SED	DC
		0.08	0.13	0.2	0.2	0.79	1.18	3.88	5.04
17.	KGula	Foot	Mantle	CT	Muscle	Gill	SED	REST	DC
		0.31	0.61	0.73	0.83	1.13	1.29	1.85	2.63
18.	Tumpat	Foot	SED	Mantle	CT	REST	Muscle	Gill	DC
		0.04	0.17	0.22	0.8	0.81	1.11	1.26	1.80

Table 2 shows the BAF values of Cd in the different soft tissues of *T. telescopium* from 18 sampling sites. It is found that DC has the most number (8/18) of sampling sites in which the BAF values are higher than 1. This indicated that Cd levels in the DC are higher than those in the habitat surface sediment.

Table 2: Bioaccumulation factor (BAF; tissues/sediment) of Cd in the different soft tissues of Telescopium telescopium from 18 sampling sites in Peninsular Malaysia.
Note: CT: Cephalic Tentacle; REST: Remaining Soft Tissues; DC: Digestive Caecum.

Cd BAF	CT	DC	Foot	Gill	Mantle	Muscle	REST
KJuru	0.36	1.73	0.16	0.68	0.73	0.49	0.60
KPPuteh	0.24	1.04	0.27	0.70	0.35	0.35	0.88
PPunggur	0.58	0.44	0.09	0.19	0.53	0.01	0.35
KSAyam	0.01	0.10	0.13	0.28	0.06	0.02	0.23
SBLaut	0.13	0.22	0.01	0.11	0.03	0.07	0.14
KLukutK	0.01	0.85	0.09	0.15	0.02	0.01	0.01
KLukutB	0.02	0.51	0.01	0.31	0.02	0.01	0.45
SepangB	0.03	2.44	0.02	0.53	0.36	0.27	0.60
BLalang	0.53	0.85	0.34	0.43	0.52	0.47	0.54
SepangK	0.39	1.34	0.64	1.83	0.02	0.66	0.82
KPJeram	0.28	0.94	0.13	0.21	0.28	0.10	0.43
SJanggut	0.39	0.49	0.08	0.24	0.45	0.08	0.24
PIndah	1.06	1.19	0.57	0.77	0.74	0.52	1.20
KDeralik	0.55	0.81	0.74	0.09	0.62	0.02	0.21
KSetiawan	0.08	0.66	0.05	0.26	0.08	0.09	0.21
JPBainun	0.03	1.30	0.05	0.20	0.05	0.02	0.30
KGula	0.57	2.04	0.24	0.88	0.47	0.64	1.43
Tumpat	4.71	10.59	0.24	7.41	1.29	6.53	4.76
BAF> 1	2.00	8.00	0.00	2.00	1.00	1.00	2.00

Based on PA, figure 1 shows the probability graph for the Cd levels in DC of *T. telescopium* in comparison to other different soft tissues and SED. This is clearly exhibited that Cd levels in DC are higher than those in the foot, CT, mantle, muscle, gill, DC and REST. This is evidently shown that the Cd levels in the DC are comparable to SED based on BAF values (Table 2). This strongly indicated that DC is the main target organ for Cd storage and accumulation based on accumulation pattern of Cd in the seven soft tissues (Table 1), PA (Figure 1) and BAF values (Table 2).

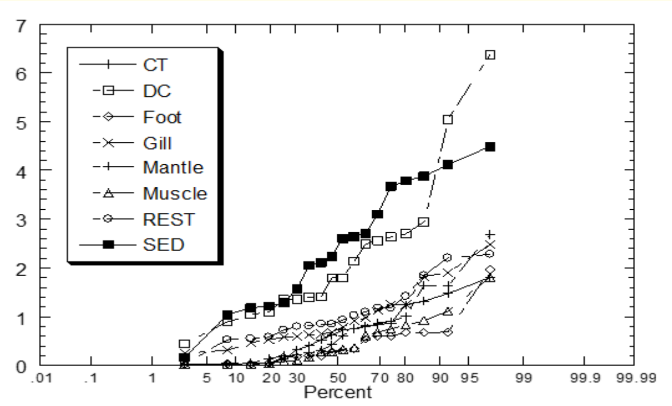

Figure 1: *Probability graph for the Cd levels in digestive caecum (DC) of Telescopium telescopium in comparison to other different soft tissues and habitat surface sediment (SED). Note: CT: Cephalic Tentacle; REST: Remaining Soft Tissues.*

The higher levels of Cd in the DC of *T. telescopium* is in accordance with the reported studied. From the literature, some researchers reported a high concentration of metals in the digestive gland of marine gastropods [9] and *Patella caerulea* in particular [10]. Digestive caecum may trigger gastric complications (Isik., *et al.* 2018a, 2018b). However, further study is needed to investigate the relationship between Cd levels and gastric complications. The metals are accumulated within intracellular mineralized granules as phosphates and within lysosomal residual bodies in association with sulphur [9]. These results could explain the high Cd levels found in the DC of *T. telescopium*, which formed part of the digestive glands. The elevated Cd concentration found in this DC indicated that DC is a storage site for this non-essential Cd, possibly in the form of metallothionein or granules as a Cd detoxification mechanism [11].

Gallego Ríos., *et al.* [12] quantified the contents of Hg, Pb, and Cd in muscle and waste material (head-gills, viscera, fins-tail), in one of the commercialized crevalle jack (*Caranx hippos*). They reported the highest Cd levels were found in the fins-tail (0.040 - 0.15 mg/kg) and viscera (0.040 - 0.174 mg/kg). Comparing to 0.45 - 6.36 mg/kg found in the DC in *T. telescopium*, the DC can be considered a Cd source since the Cd range is significantly higher than those in the fins tail and viscera of *C. hippos*.

For a safe consumption of the snails, the DC of *T. telescopium* should be discarded. Moreover, it is not recommended to use the waste material (discarded DC) for the production of the fish meal due to the adverse effects it could cause on both animals and humans. Alternatively, the discarded DC can be used as a possible material for industrial uses. Of course, this idea should be further investigated in future research [13].

Conclusion

This paper re-analyzed the Cd data in the different tissues of *T. telescopium* cited from Yap and Noorhaidah [1] and re-evaluated from the point of industrial use. Based on PA and BAF values, the Cd levels found in the DC are comparable to SED and also significantly higher than other different organs or soft tissues. DC is the main target organ for Cd storage and accumulation based on the accumulation pattern of Cd in the seven soft tissues. Therefore, it is suggested that DC of the mudflat snails is a possible Cd source for industrial application although further studies are needed.

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