Seasonal Variation in Heavy Metal Concentrations in *Perna viridis* from Batangas City, Philippines

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ABSTRACT

Abstract – The concentrations of lead, cadmium, and mercury were analyzed seasonally in muscle tissues of Perna viridis (tahong) sold in the Old and New Public Markets in Batangas City, Philippines. Cadmium concentrations in Perna viridis collected from the Old and New Public Markets during wet season were significantly higher than in dry season. The mean cadmium concentrations in Perna viridis taken from Old and New Public Markets during wet season were significantly lower compared with the maximum allowable level set by the Food Standards Australia and New Zealand (FSANZ). Based on a person's average diet, the heavy metal concentration detected in the study are within the provisional tolerable weekly intake (PTWI) but can still impose detrimental health risksif continuous consumption is exercised.

Index Terms –bivalve mollusk, Perna viridis, heavy metal, AAS

1 INTRODUCTION

MANY coastal communities rely on bodies of water as primary source for their livelihood and food. They opt for jobs like catching and culturing fishes, crustaceans, shellfishes, and more. They are alsoknown to consume large amounts of these seafood due to their abundant access to the seas. From catchment areas to a long route to markets and households, seafood has become a staple to many people's diet and continues to grow in each generation that comes.

On a hind sight: environmental pollution continues to represent a major problem to many underdeveloped countries including the Philippines. The coastal marine environment gets contaminatedby polluted waters that are drained and collected along agricultural, urban, and industrial areas [1].Of these pollutants, heavy metals areconsidered to be among the most hazardous due to their toxicity and capacity to accumulate in marine organisms.

Some of the most hazardous heavy metals found in natural sources include cadmium, lead, and mercury. Cadmium has an extremely long residence time of over 20 years in the human body where it is mostly stored in the liver and kidney. Long term exposure to high doses of cadmium may cause biochemical and functional changes in critical organs. Ingestion of more than 300 mg of cadmium is already considered fatal [2].As far as studies show,lead can cause several unwanted effects in the body such as disruption of the biosynthesis of hemoglobin and anemia, a rise in blood pressure, kidney damage, brain damage, declined fertility of men through sperm damage, diminished learning abilities of children and behavioral disruptions such as aggression, impulsive behavior and hyperactivity [3].On the other hand, mercury is a known disruptor of the nervous system. It is known to cause brain damage, DNA and chromosomal raptures, various allergic reactions, and negative reproductive effects such as birth defects and miscarriages [4].

Many mussel species have been noted to biologically accumulate heavy metals found in sediments where they get their food during filter feeding [5].In fact, their bio-accumulative ability is highly acknowledgedin monitoring levels of heavy metal contaminants in aquatic systems. If mussels that are contaminated with heavy metals are to be eaten by humans, the heavy metals can get absorbed in their systems and can also accumulate in time, hence the occurrence of possible adverse effects if not treated properly.

Perna viridis is an abundant mussel species that is naturally found or cultured in coastal areas and sold in local markets at cheap prices throughout the year. It is a powerful storehouse of many essential nutrients required by the body, especially phosphorus, potassium, protein, vitamin A, and iron[6]. However, since they are mostly collected from the coastal areas, there are great chances that they can be contaminated with chemical pollutants present in bodies of water.

There are limited studies conducted on the amounts of heavy metals in mussels, specifically on *Perna viridis*. It is important, therefore, to conduct a study along this area in order to have basis in assessing the current state of contamination risks to marine organismswith respect to the rapidly growing industrialization within the area. This study is not only significant for evaluating food safety but also relevant to the protection of human lives.

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2 METHODOLOGY

This study focused the determination of heavy metal concentration in *Perna viridis* collected from the Old and New Public Markets in Batangas City during wet and dry seasons. Three (3) heavy metals were considered for the metal analysis namely cadmium, lead, and mercury.

2.1. Sampling

Sampling schedule for wet and dry seasons was determined based on the total monthly rainfall data obtained from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA)in Region IV for the past four years. Samples were gathered on the month January to represent for the dry season and on June to represent for the wet season. Sample acquisition was done from 6:00 to 6:30 in the morning to ensure that mussels were still fresh from catchment.

2.2. Sample Preparation

The *Perna viridis* acquired from both markets were separately placed in two clean containers while being partially dipped in water and was brought straight to the laboratory. 0.5000 gramsof sample was weighed in a 50mL porcelain crucible, then ashed inside a furnace at 550^{o}C for one hour. The ash was then carefully transferred into a 100mL beaker. Next, 2mL of concentrated HNO_3 and 50mL HCl was added. The beaker was covered with ribbed watch glass and was allowed to digest to 20mL. It was then filtered directly to a 100mL volumetric flask using Whatman #5 and was diluted to mark using distilled water. The resulting solution was mixed thoroughly. Three (3) replicate samples were prepared for each metal analysis.

2.3. Heavy Metal Analysis

The prepared samples were analyzed for presence of cadmium, lead, and mercury using Flame Atomic Absorption Spectrophotometer (AA 7000 – Shimadzu).

2.4. Statistical Analysis

Two tailed t-test was used to compare the heavy metal concentrations in *Perna viridis* taken during dry and wet seasons.

3 RESULTS AND DISCUSSION

3.1 Heavy metal concentrations in *Perna viridis*

Table 1 shows the concentrations of cadmium, lead, and mercury in*Pernaviridis* collected from the Old Public Market during dry and wet seasons.Mean concentrations for lead and mercuryduring dry and wet seasons were below the detection limit of the instrument used. On the other hand, mean concentrations for cadmium during dry and wet seasons were <0.02 mg/Kg and 0.31±0.01 mg/Kg, respectively.

TABLE 1
Mean Concentrations of Heavy Metals
In *Perna viridis* collected from the Old Public Market during Dry and Wet Seasons

Heavy Metal	Dry Season*	Wet Season*
Cadmium (Cd)[a]	<0.02	0.31±0.01
Lead (Pb)[b]	<0.06	<0.06
Mercury (Hg)[c]	<0.10	<0.10

**Mean concentrations in mg/Kg*
Detection limits of instrument used (mg/Kg): a=0.02; b=0.06; c=0.10

Table 2 shows that the mean concentration of cadmium, lead, and mercurypresent in *Perna viridis* collected from the New Public Market during dry and wet season. Mean concentrations for lead and mercury during dry and wet seasons were below the detection limit of the instrument used. However, the mean concentration for cadmium during dry and wet seasons were <0.02 mg/Kg and 0.54±0.02 mg/Kg, respectively.

TABLE 2
Mean Concentrations of Heavy Metals
In *Perna viridis* collected from the New Public Market during Dry and Wet Seasons

Heavy Metal	Dry Season*	Wet Season*
Cadmium (Cd)[a]	<0.02	0.54±0.02
Lead (Pb)[b]	<0.06	<0.06
Mercury (Hg)[c]	<0.10	<0.10

**Mean concentrations in mg/Kg*
Detection limits of instrument used (mg/Kg): a=0.02; b=0.06; c=0.10

The concentration of cadmium in unpolluted fresh waters is generally less than 0.001 mg/L while the concentration of cadmium in seawater is about 0.00015 mg/L [7]. Cadmium can be transported over great distances as it gets absorbed by industrial sludge. This cadmium-rich sludge gets deposited in the environment due to its high binding capacity to organic matter in soils and sediments. When the soil is acidified, cadmium uptake by organisms can be greatly increased [8]. Shellfishes, such as mussels, oysters, and clams can concentrate cadmium to extremely high levels in their tissues [9].

The trend on heavy metal concentrations in *Perna viridis* taken from both markets shows similarity with each other. Based on the key informant interview conducted prior to sampling acquisition, vendors from both markets acquire their goods from Cavite. Hence, the similaritymay be

accounted to the fact that both markets obtain their goods from the same source.

Wastes of the operating industries, leachates from municipal wastes, and even the discharges of the residents with their daily household activities that use water are contributing factors that can contaminate waters with heavy metals. Some of the industries that are located along the catchment area includedistillery, steel, petroleum, and power plant.

Oil spill from the nearby coasts could also reach the bay through tidal and sediment movements. There have been several cases of oil spills in Cavite, and nearby coasts in Nasugbu, and Calatagan, where most of the *Perna viridis* are caught and sold to markets in the province of Batangas.

3.2 Comparison of heavy metal concentration in *Perna viridis* during dry and wet season

The study shows that lead and mercury were not detected on both sampling seasons because their concentrations were below the detection limit set on the instrument used. The concentration of cadmium during dry season was also below the detection limit but not during wet season.

Table 3 shows the comparison of cadmium concentrations in *Perna viridis* collected from Old Public Market during dry and wet seasons. Since the computed p-value of 0.000142 was less than 0.05, then the null hypothesis is rejected.Hence, there is a significant difference on the concentration of cadmium in *Perna viridis* collected from the Old Market during dry and wet seasons. Cadmium concentrations in *Perna viridis* collected during wet season was higher than that duringdry season.

TABLE 3
Comparison of Cadmium Concentrations
In *Perna viridis* collected from Old Public Market
during Dry and Wet Seasons

Parameters	Computed t-value	Computed P- value	Interpretation
Cd	11.926	0.000142	Significant

Table 4 shows the comparison of heavy metal concentrations in *Perna viridis* collected from New Public Market during dry and wet seasons. Since the computed p-value of 0.000212 was less than 0.05, then the null Hypothesis is rejected. Hence, there is significant difference on the concentration of cadmium in *Perna viridis* collected from New Market during dry and wet seasons. Cadmium concentrations in *Perna viridis* collected during wet season was higher than that during dry season.

TABLE 4
Comparison of Cadmium Concentrations
In *Perna viridis* collected from New Public Market
during Dry and Wet Seasons

Parameters	Computed t-value	Computed P-value	Interpretation
Cd	10.747	0.000212	Significant

Shifts in metabolic and heavy metal contamination rates of bivalve mollusks depend on season and bioavailability of metals in the surrounding environment [10]. This is because seasonal cycles cause fluctuations in the salinity of catchement areas resulting to differences in the heavy metal concentrations [11]. Heavy rains cause trace metals to precipitate more in sediments increasing their bioavailability.

Bivalve mollusks have greater rates of filtering water at colder temperatures which can increase the risk of potential contamination. During wet seasons, they filter and retain heavy metals at a slower rate than during the summer, but will take a great deal longer in wet season to clear their intestinal tract of a contaminated meal, than in summer[12]. This, along with the industrial effluents carried by freshwater discharges impose a greater rate of filtration in mussels resulting higher concentrations of trace metals in *P. viridis*.

3.3 Dietary Risk Assessment

Long term exposure to high doses of cadmium can cause biochemical and functional changes in some critical organs in the body while ingestion of more than 300mg of cadmium canalready result to death[3].The mean concentrations of cadmium in *Perna viridis* taken from the old and new markets during wet season were 0.31±0.01 mg/Kg and 0.54±0.02 mg/Kg, respectively. Based on this data, an individual should consume up to around 500kg of *Perna viridis* meat before he accumulates 300mg of cadmium. If one is to eat a kilo per week, it is estimated that it will take about 10 years before the fatal limit is reached.

The results show an increase in the concentration of cadmium during wet season in *Perna viridis* sold in both markets. The concentration of cadmium in all samples were below the Food Standards - Australia and New Zealand (FSANZ)for cadmium. A computed average weekly intake of 1.58kg of *Perna viridis* for a 70kg person is still safe and within the provisional tolerable weekly intake (PTWI) set by the FSANZ. However, most of the coastal communities in the Philippines who rely only on marine species for food have higher tendency to exceed this amount of weekly intake because of their extensive access to such resources.

TABLE 5
Australian and New Zealand Food Standards

Standard	Cadmium
FSANZ	2.0 mg/Kg

The mean cadmium concentrations in *Perna viridis* collected from Old and New Public Markets during wet season were 0.31±0.01 mg/Kg and 0.54±0.02 mg/Kg, respectively. These values fall within the limit set by FSANZ. This means that *Perna viridis* sold in the Old and New markets of Batangas City is still safe for consumption despite the considerable amount of cadmium detected during wet season.

However, the biological half-life of cadmium can last from 20 and 30 years. About 50 percent of ingested cadmium is stored in the liver and kidney. Other storage sites may also include the pancreas, salivary gland, joints, arteries, periosteum or covering of the bones, and virtually all body tissues [13]. Only a small proportion of absorbed cadmium is eliminated, mainly in the urine and feces. Negligible amounts are eliminated through hair, nails, and sweat. Daily excretion of cadmium for the normal adult has been considered to be 0.002 mg [14].

Even though the detected cadmium level is low to cause acute toxic effect due to short term exposure at high concentration, the consumers should still take proper precautionary action to avoid chronic effect due to long term exposure at low level since the said metal can bio-accumulate.

Extreme caution should be taken if these bivalves are to be considered for feeding children because they have about five times the gastrointestinal absorption rate of adults and consumption of these bivalves by children may predispose them to cadmium exposure. Moreover, extreme care must also be exercised when feeding these bivalves to pregnant women as cadmium can be passed to the fetal brain if the pregnant mother is given certain amounts of cadmium. A study also suggests that females absorb more dietary cadmium than males, and that iron-deficient women absorb up to 20 percent of the cadmium ingested [15].

4 Conclusions

A high concentration of cadmium was obtained from *Perna viridis* taken from Old and New Public Markets during wet season while significantly lower concentration was obtained during dry season. On the other hand, low concentrations of lead, and mercury in *Perna viridis* from both markets during dry and wet seasons were below the detection limits of the instrument used.The mean cadmium concentrations in *Perna viridis* taken from old and new markets during wet season fall within the standards set by FSANZ.

6 Disclosure of Interest

The author hereby declares that there is no conflict of interest regarding the publication of this article.

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