Lead Content of Round scad (*Decapterus macrosoma*)from Batangas Bay, Philippines

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Abstract—*The main objective of the study was to determine the presence of lead in the head, flesh and internalorgans of roundscad (Decapterus macrosoma) collected from three sampling stations along Batangas Bay, Philippines. It is done to assess if the lead levels are still within the safety level set by United States Environmental Protection Agency (US EPA) and Food and Drug Administration (FDA).*

Quantitative analysis following Association of Official Analytical Chemists (AOAC) official method confirmed the presence of lead in the head, flesh and internal organs of round scad. Lead analysis of round scad was carried out using Flame Atomic Absorption Spectroscopy. The internal organs of round scad was found to contain the highest amount of leadas compared to the muscle and the head. Round scad samples collected along Batangas Bay had mean lead concentrationwhich is below the USEPA and FDA's standardand can be considered safe for consumption. Continuous monitoring of lead content of roundscad is recommended to effectively investigate the risk and effects of heavy metals on the environment and on the general public's welfare.

Keywords—*AtomicAbsorption Spectroscopy, Batangas Bay, Heavy metals, Lead, Philippines, Round scad*

INTRODUCTION

Fishes have always been a common table commodity for most Filipinos. It is a vital source of food and it is the single most important source of high quality protein and polyunsaturated fatty acids (PUFA).

The Batangas Bay is located at the heartof the Coral Triangle, the global center of marine biodiversity. About halfway between the provinces of Batangas and Mindoro, the Verde Island Passage contains the most diverse concentration of marine species in the planet. Recent studies conducted showed that its reefs are home to nearly 60% of the world's known shore fish, as well as over 300 species of coral. Batangas Bay contains various species of corals, fishes and other aquatic life.Commercial fishes such as round scad, anchovies, Indian Mackerel, yellowfin tuna, frigate tuna, skipjack, Spanish mackerel, slipmouth, grouper, threadfin bream are caught in large amounts and provides the locals with livelihood and ample supply of food.

Round scad (*Decapterus macrosoma*), locally known as *galunggong*is one of the popular commercial fishes caught in Batangas Bay. According tothe Philippine's Bureau of Fisheries and Aquatic Resources, in 2011, round scad is the major commercial fish with a total catch of 172, 498.52 metric ton (MT) or 16.7% of total commercial fish production in the Philippines [1].

Round scad can be caught in almost every part of the country. Large concentration of round scad can be found in Sulu Sea, Visayan Sea, Moro Gulf, Lamon Bay, Cuyo Pass, Ragay Gulf, Batangas Coast, Tayabas Bay, Samar Sea, Camotes Sea, Sibuyan Sea, Bohol Sea, Davao Gulf and Babuyan Channel [2].

The price of round scad is cheaper compared to other fishes due to the large volume of landings in the market [2]. Per capita consumption of 3 kg/year has proven that round scad is among the favorite fish among Filipinos. [1] Round scad can grow up to a foot in length and has a dark somewhat oily but tasty flesh [2].

Due to modernization and increasing population, the state of Philippine Fisheries,known for its rich biodiversity, is now in poor state. Nowadays, water pollution is widespread and plays an important role in shaping today's rivers, seas and other bodies of water [3].

Seas and other bodies of water often receive the majority of human waste, whether it is man-made emissionor from natural run-off from the land. Pollution of the aquatic environment by inorganic chemicals was alwaysconsidered a major threat to the aquatic organisms includingfishes [4]. Agricultural run offs, whichcontainssignificant amount ofpesticides and fertilizers, and industrial discharges provides the water bodies and sediments with huge amounts of inorganic anions and heavy metals. These pollutants, when released, enters the marine ecosystem slowlyincreasing their concentrations until it reach toxic levels [5]. It was noted that the contributions from these sources, either man-made or natural, are not the same in different regions and in different seasons, thus heavy metal concentrations in surface water and sediments varies both spatially and seasonally [6].

To monitor the extent of pollution in marine ecosystems, scientists nowadays utilized plant and animal species asbioindicators. Fishes are described to be a good bioindicator of aquatic pollution since it is constantly exposed to pollutants through water and food [7].

Heavy metals, which include lead (Pb), are among the pollutants which contaminate the major bodies of waters. The amount of lead in water bodies are generally low, but significant amounts of heavy metal-rich dusts and vapors can be transmitted by the air, from windblown materials and volcanic eruptions. Common source of lead, which contributes to large emission to theenvironment, are those derived from mining, smelting and refining of lead and other metals.Mobile sources of lead, which includes cars and other automobiles,is still a major factorand contributes to elevated levelsin ground and surface waters and other bodies of water.Once ingested, lead may cause an irreversible effect to the human body, inhibiting oxygen and calcium transport and affects the central nervous system. Once exposed to lead, a person can suffer from cardiovascular effects, increased blood pressure and incidence of hypertension, decreased kidney function and reproductive problems (in both men and women). Recent studies indicates that no amount of lead is safe for a growing child [8].

Food safety and quality is now a growing concern amongst consumer around the globe. Concerns on the assessment and control of food safety and quality in aquaculture is important, as is the development of an information base and other tools to enable objective assessment of hazards and risks [9].

The United States Environmental Protection Agency (US EPA) and Food and Drug Administration (FDA)are international agencies mandated to protect human health and the environment by writing and enforcing regulations based on laws passed by the United States Congress. Both regulatory agencies have set an allowable level in soils, water, and food products. These levels are calculated based on of the quantity of lead that a person can consume or ingest without having an ill affect. For instance, FDA has set an action level of 0.5 µg/mL (0.5 mg/kg) for lead in infant and childrens products and has banned the use of lead-soldered food cans [10].

OBJECTIVE OF THE STUDY

The main objective of the study is to determine the lead content in round scadfrom Batangas Bay. Specifically, it aims (1) to determine the concentrations of lead in the head, flesh and internal organs of round scad in three sampling periods;(2) to determine if there are significant differences between the lead concentration found in the head, flesh and internal organs of round scadamong the sampling stations and (3) among the sampling periods; and (4) to know if the lead concentrationsin round scadfrom Batangas Bay conforms to the specifications set by the United States Environmental Protection Agency (US EPA) and Food and Drug Administration (FDA).

SETTING OF THE STUDY

Batangas Bay is situated in the southern part of the Batangas province, which is located in the Southwestern tip of Luzon Island. The Bay sits at the heart of the heart of the Coral Triangle, the global center of marine biodiversity.

The coastline is about 470 km long. It is bordered by coastal municipalities of Tingloy in Maricaban Island, San Pascual, Bauan, Mabini and Batangas City. There are 44 coastal barangays along the Batangas Bay [11].

The coastline of Batangas Bay is home to different industries in Batangas province. Along its shores are 23 large scale industries, 3 of them are large petroleum companies located in the municipality of Mabini, San Pascual and Batangas City. Various industries like power generation, ship building, heavy metal fabrication, oleochemical manufacturing, petrochemical and chemicalmanufacturing and storage are distributed along the coastline of Batangas Bay [12].

Batangas Bay is also a busy road for both local and foreign vessels. It containsthe second largest international seaport in the Philippines, the Batangas Port. The port serves as the center oftransportation of goods that originate from Batangas province and serves as the trading point of all industries along the nearby provinces and from Visayas and Mindanao [13].

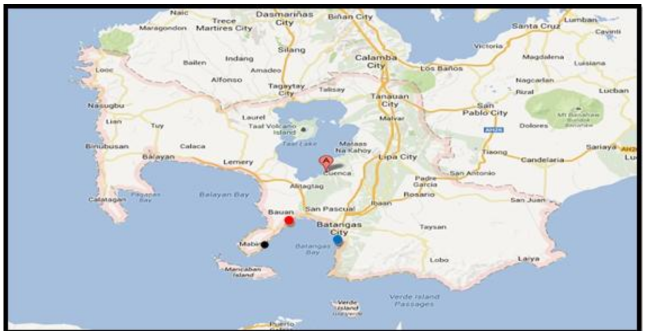

Fig. 1. Vicinity map of Batangas Bay, Philippines

MATERIALS AND METHODS

Sampling Design

Round scad samples were collected from 3 differentstations along Batangas Bay in three sampling periods during the rainy season (November 2013) and dry season (January 2014 and March 2014). Three stations were identified- Station I in Wawa, Batangas City (204° SW 13° 44' 25" N 121 ° 3'5" E), Station II in Aplaya, Bauan (235 °SW 13° 46' 52" N 121° 0' 13" E) and Station III in Talaga East, Mabini (325° NW 13° 44' 2" N 120° 56' 10" E). These stations were selected based on its location and proximity to various industries and some commercial establishments.

Immediately after collection, round scadsamples were stored and brought to an accredited laboratory for analysis.

Preparation and Analysis of the Sample

Round scad samples were dissected prior to analysis using a plastic knife. Samples of muscle, internal organs, head and gills were removed and isolated. It was rinsed with distilled water, and oven dried at 70˚C for 2 days. Each portion (muscle, head, and internal organs) were homogenized, and a weight of 0.5 to 1.0 grams was taken in a porcelain crucible and ash dried at 550˚C. Samples were acid-digested and the sample solution was filtered and filled to the 100-mL mark with distilled water [14].

Lead content of round scad caught in Batangas Bay were analyzed using Flame Atomic Absorption Spectroscopy. Standard Pb solution (1000 ppm Certipur, Merck) was used for calibration of the analytical instrument. Prepared standard solutions with different concentrations (0.05, 0.1, 0.2, 0.3, 0.5 ppm) of lead were used to calibrate the spectrophotometer prior to analysis using distilled water as blank.

Data Analysis

Data obtained were analysed using the Statistical Package for the Social Sciences (SPSS) software. One way analyses of variance (ANOVA) was used todetermine whether the lead content in different parts of the fish (head, flesh and internal organs), varies significantly among the sampling stations. Independent t-test, on the other hand, was used to determine whether the lead content in different parts of fish samples, (head, flesh and internal organs) varies significantly between the two sampling periods with values less than 0.05 ($p < 0.05$)regarded statistically significant.

RESULTS OF THE STUDY

Lead Concentration in Head, Flesh and Internal Organs of Round Scad (*Decapterus macrosoma*) in Three Sampling Stations along Batangas Bay.

Table 1 show the mean values of the lead concentration (mg/kg) in head, flesh and internal organs of round scad collected in three sampling periods from November 2013 to March 2014 along the three sampling stations in Batangas Bay.

Table 1. Lead Concentration of Round Scad collected along the Three Sampling Stations in Batangas Bay, Philippines

Sampling Station	Lead Concentration (mg/kg)								
	November 2013			January 2014			March 2014		
	1	2	3	1	2	3	1	2	3
Station I	nd	nd	nd	0.07	0.16	0.17	0.06	0.12	0.21
Station II	nd	nd	nd	0.06	0.06	0.27	0.08	0.07	0.22
Station III	nd	nd	nd	0.15	0.27	0.29	0.09	0.09	0.24

Note: 1-Head 2- Flesh 3- Internal Organs
Instrument Detection Limit= 0.06 mg/kg; nd- not detected

As shown in Table 1, the mean lead concentration of round scad, collected in November 2013, is below the instrument detection limit which is 0.06 mg/kg. This indicates that round scad obtained within Batangas Bay at specified sampling period and stations could be considered safe to consume and may not pose any hazard.

As specified in Table 1, in January and March 2014, the highest lead concentration among the tissues were observed in the internal organs from the round scad samplescollected in three sampling stations. Internal organs, particularly the liver, accumulate higher amount of metals comparatively and have been used widely to investigate bioaccumulation while kidneys functions in the excretion of trace metal ions. [4]

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The result is similar with the findings of Khalaf [7] wherein internal organs primarily the liver, lungs, gonads, and kidney of three *Decapterus* spp. were the primary organs for final metal deposition. It was also noted that the head, which contain the gills, from the fish samplescollected also contain considerable amount of lead. The general pattern of similarities was also present in researches made by Ozuni [15], Sia Su [16] and Solidum [17]. Heavy metals are also present in the gills because the exchange of gases and absorption of heavy metals, particularly the lead, takes place from external aquatic to internal body environment through the gills [18].

According to Jezierska and Witeska, the metal concentration in various organs may be different during the uptake and depuration. For instance, at the start ofexposure, concentration in the gills rapidly increases, and then usually decline. After the end of exposure, metals are rapidly removed from the gills. In case of dietary exposure, the level in the gills increases much slower and usually reach lower values [19].

Sia Su [16] noted that the heavy metal concentrations in the muscle is of great importance because this is the most commonly consumed portion of the fish. In his study, cited based from the literature, the extent of heavy metal accumulation in the muscle is generally low becausemetabolic activity is relatively lesserthan any part of the fish.

Difference in the values obtained between two sampling period (wet and dry season) is possibly due to the pre-existing conditions that were present during the time of sampling. Super typhoon Haiyan just devastated the Philippines two weeks before the first sampling was conducted. Molina [6] noted that seasonal conditions prior to sampling affect the metal concentration. Rains could affect the metal concentration by possible dilution of the water source. The amount of metals being absorbed by the species is dependent on the pre-existing environmental conditions [4]. The temperature of the water may cause the differences in metal deposition in various organs. Higher temperatures enhances heavy metal accumulation especially in the kidneys and liver. It was further explained that an increase in the accumulation of metals by fish at higher temperatures is a probable result of higher metabolic rate, including higher rate of metal uptake and binding. In a study conducted by Jezierska and Witeska [18], it was found out that the accumulation of metal in fish is time dependent. Their findings suggests that during the initial period of exposure, metal is absorbed and accumulated at a high rate, then the level stabilizes when an equilibrium of metal uptake and excretion rates is attained.

Table 2 shows the comparison of the lead concentration in round scad, collected in January 2014, between the head, flesh and internal organs among sampling stations.

Table 2. Comparison of the Lead Concentration in Head, Flesh and Internal Organs of Round Scad, collected in January 2014, among Sampling Stations along Batangas Bay

Parts of Round Scad	Computed f-value	p-value	Decision on Ho
Internal Organ	38.490	0.002*	Reject
Muscle	981.020	0.00004*	Reject
Head	256.016	0.000009*	Reject

*Notes: 95% confidence interval; * Significant*

The p value less than 0.05 obtained for the comparison of the lead concentration in round scad, collected in January 2014, between the head, flesh and internal organs among sampling stations signifies that the lead concentration between the tissues organs such as head, flesh and internal organs of round scad are significantly different.

Table 3 shows the comparison of the lead concentration in round scad, collected in March 2014, between the head, flesh and internal organs among sampling stations.

Table 3. Comparison of the Lead Concentration in Head, Flesh and Internal Organs of Round Scad, collected in March 2014, among Sampling Stations along Batangas Bay

Parts of Round Scad	f-value	p-value	Decision on Ho
Internal Organ	11.445	0.014*	Reject
Muscle	160.625	0.000029*	Reject
Head	3.428	0.115	Accept

*Notes: 95% confidence interval; * Significant*

The p value less than 0.05 obtained for the comparison of the lead concentration in roundscad, collected in March 2014, between the flesh and internal organs among sampling stations signifies that the lead concentration between the tissues organs, such as flesh and internal organs, of round scad are significantly different. However, the p-value of 0.115 obtained for the head sample, signifies that the lead concentration obtained in the head has no significant difference among the sampling station.

It is evident since the highest lead concentration is found in the internal organs where most metabolic activity is taking place. Lower levels of lead are noted for both flesh and head samples. The result is consistent with the researches done by Solidum [17], Khalaf [7], Ozuni [15], Sia Su [16], Dien [20] and Zhang [21] wherein the highest amount of heavy metals were obtained in the internal organs of fishes.

Data obtained from the study conducted by Jezierska and Witeska [19] and some previously mentioned studies, indicate that metals have different affinity to various organs. High amount of heavy metalfound in the liver and kidney is related to the dietary uptake route. Other tissues and organs, such as the gonads, bones, and brain may also show high metal levels, while the muscles, unlike other tissues, usually contains lower concentrations of metals but are still often analysed for metal content due to their use for human consumption. [19]

Tables 4, 5 and 6 show the shows the comparison of the lead concentration from the head, flesh and internal organs of round scad between the two sampling period (January and March 2014).

Table 4. Comparison of the Lead Concentration in Head, Flesh and Internal Organs of Round Scad, collected in Station I on January and March 2014

Parts of Round Scad	f-value	p-value	Decision on Ho
Internal Organ	72.086	0.003*	Reject
Muscle	88.200	0.003*	Reject
Head	2.400	0.219	Do not reject

*Notes: 95% confidence interval; *Significant*

Table 5. Comparison of the Lead Concentration in Head, Flesh and Internal Organs of Round Scad, collected in Station II on January and March 2014

Parts of Round Scad	f-value	p-value	Decision on Ho
Internal Organ	25.000	0.007*	Reject
Muscle	15.000	0.030*	Reject
Head	7.118	0.056	Do not reject

*Notes: 95% confidence interval; *Significant*

The p value less than 0.05 obtained for the comparison of the lead concentration in flesh and internal organs in Station I and II between the two sampling period signifies that there are significant difference in the lead concentration in the flesh and internal organs in Station I and II between the two sampling period (January and March 2014).

Table 6. Comparison of the Lead Concentration in Head, Flesh and Internal Organs of Round Scad, collected in Station III on January and March 2014

Parts of Round Scad	Computed f-value	p-value	Decision on Ho	Interpretation
Internal Organ	5.000	0.155	Do not reject	No Significant Difference
Muscle	1685.400	0.000032	Reject	Significant Difference
Head	173.400	0.001	Reject	Significant Difference

Notes:
95% confidence interval

The p value less than 0.05 obtained for the comparison of the lead concentration in flesh and internal organs in Station I and II between the two sampling period signifies that there are significant difference in the lead concentration in the flesh and internal organs in Station I and II between the two sampling period (January and March 2014). However, the p-value of the head, as shown in table 4 and table 5, which is 0.219 and 0.056, respectively, signifies that there are no significant difference in the lead concentration from both Station I and Station II between the two sampling period (January and March 2014). Also, the p-value of 0.155, obtained in the internal organs of round scad sample collected in Station III, signifies that there are also no significant difference in the lead concentration in the internal organs between the two sampling period (January and March 2014).

Quality of Round Scad, in terms of lead concentration, based on US EPA and FDA Standards

Table 7 shows the mean lead concentration of round scad collected along the three sampling stations in Batangas Bay.

Table 7. Mean Lead Concentration Round Scad*, collected along Three Sampling Stations in Batangas Bay

Sampling Station	Mean Lead Concentration (Pb, mg/kg)			Conformance with USEPA and FDA Specification
	Nov 2013	Jan 2014	Mar 2014	
Station I	nd**	0.13	0.13	Conformed
Station II	nd	0.13	0.12	Conformed
Station III	nd	0.24	0.14	Conformed

*Notes: *mean lead concentration of head, flesh and internal organs; **nd- not detected*

The mean lead concentration of round scad collected in three sampling station along Batangas Bay are within the limit set by the US Food and Drug Administration (FDA) and USEnvironmental Protection Agency (USEPA). Both regulatory agencies have set an allowable level in soils, water, and food products. These levels are based on the calculations of the amount of lead that a person can consume or ingest without having an ill affect. For instance, FDA has set an action level of 0.5 µg/mL (0.5 mg/kg) for lead in infant and childrens products and has banned the use of lead-soldered food cans. [10] Because low metal concentrations were determined in muscle tissue, people who consumes fishmuscle primarily as opposed to liver and other organs should be at lower risk of heavy metal contamination specifically lead contamination [7].

This further indicates that round scad collected along Batangas Bay at specified sampling period and sampling stations could be considered safe to consume and may not pose any hazard.

CONCLUSION

Highest concentration of lead in round scad, analyzed during the wet season (November 2013) and dry season (January and March 2014) in three sampling stations, was obtained in the internal organs while low lead concentration was obtained in the head and flesh.

The p value less than 0.05 obtained for the comparison of the lead concentration in round scad, collected in January 2014, between the head, flesh and internal organs among sampling stations signifies that the lead concentration between the tissues organs such as head, flesh and internal organs of round scad are significantly different.

The p value less than 0.05 obtained for the comparison of the lead concentration in round scad, collected in March 2014, between the flesh and internal organs among sampling stations signifies that the lead concentration between the tissues organs, such as flesh and internal organs, of round scad are significantly different. However, the p-value of 0.115 obtained for the head sample, signifies that the lead concentration obtained in the head has no significant difference among the sampling stations.

The p value less than 0.05 obtained for the comparison of the lead concentration in flesh and internal organs in Station I and II between the two sampling period signifies that there are significant differences in the lead concentration in the flesh and internal organs in Station I and II between the two sampling period (January and March 2014). However, the p-value of the head, as shown in table 4 and table 5, which is 0.219 and 0.056, respectively, signifies that there are no significant difference in the lead concentration from both Station I and Station II between the two sampling period (January and March 2014). Also, the p-value of 0.155, obtained in the internal organs of round scad sample collected in Station III, signifies that there are also no significant difference in the lead concentration in the internal organs between the two sampling period (January and March 2014).

The mean lead concentration of round scad collected during the wet season (November 2013) and dry season (January and March 2014) in three sampling stations along Batangas Bayconforms to the 0.5 mg/kg limit set by the US Food and Drugs Adminitsration (FDA) and US Environmental Protection Agency (US EPA).

RECOMMENDATION

Similar analysis should be conducted to other commercial fishes caught along Batangas Bay such as mackerel scad, short-bodied mackerel and sardines to determine the level of heavy metal uptake of these species and to determine whether the heavy metal deposition is species-dependent.

Other metals such as mercury, arsenic, cadmium, chromium and copper should be analysed on different commercial fishes caught along Batangas Bay to determine the amount of contamination present.

Regular monitoring on the heavy metal content of round scad caught not only in Batangas Bay but also in Verde Island Passage and Balayan Bay, Philippines should be done to determine the extent of pollution along the important water ways in Batangas, Philippines.

Water quality monitoring around Batangas Bay and its major tributaries should be periodically conducted.

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