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Levels of cadmium, copper, lead, nickel and mercury in the muscles of Pigok (*Mesopristes cancellatus*) and sediments collected at lower Agusan river basin, Brgy. Pagatpatan, Butuan City, Agusan Del Norte, Philippines

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Abstract
Levels of Cadmium (Cd), Copper (Cu), Lead (Pb), Nickel (Ni) and Mercury (Hg) in the muscles of Pigok (*Mesopristes cancellatus)* and sediments collected from the lower Agusan River Basin, Brgy. Pagatpatan, Butuan City, Agusan Del Norte was determined. Sediments from three stations along lower Agusan River where the fishes were caught were also analyzed for Cd, Cu, Pb, Ni and Hg concentrations. The heavy metal concentrations in the muscles were found in the order of Pb>Cu>Hg>Cd>Ni while for the sediments, the order of heavy metal concentration were found to be of Ni>Cu>Pb>Cd>Hg. In fish muscles, Lead (Pb) concentrations were found the highest (30.056 ± 0.475 ppm) while in sediments, Ni concentrations were found highest (121.389 ± 2.845 ppm). Lead (Pb) concentrations of muscle samples were found to be above the values recommended by US EPA which is ≥0.5 ppm however, Pb in sediments was below the standard values recommended by FAO and WHO. The concentration of metals in the muscles were significantly higher than that of the sediments ($P<0.05$). Lead (Pb) concentrations in the muscles of Pigok revealed high concentrations exceeding recommended safe limits and this level may stand to cause potential health hazards in humans with frequent consumption of Pb contaminated fish in the areas being studied.

Keywords: Heavy metals, bioaccumulation, Pigok, *Mesopristes cancellatus*

1. Introduction

Fish constitutes an important and cheap source of food for human beings and a large number of people depends on fish and fishing activities for their livelihood. It plays a vital role in human diet because of its high protein content, low saturated fat, and sufficient omega fatty acids to maintain good health. Since they inhabit the different trophic levels with different ages, sizes and serve as important food source, fishes are good indicators of heavy metal contamination in the aquatic ecosystem [1-4]. Ultimately, fish samples are considered to be one of the utmost indicative factors in freshwater systems for the estimation of trace metals pollution [5]. Thus, many studies are focused on fish as an entity on determining heavy metal accumulation [6-9].

Pigok (*Mesopristes cancellatus*) is an exotic fish and is a scarce commodity in Agusan River Basin [54]. Female *M. cancellatus* release an estimated number of eggs ranging from 504, 900 to 1,700,00. However, the extremely small egg size and its sensitivity to slight change in water salinity attribute to very low fertilization rate success [54]. The fish is widely distributed in Asia including, Sumatra, Indonesia, New Guinea, Vanuatu to the Solomons island, Taiwan and in the northern part of the Philippines [55]. Apart from being rare, what makes *M. cancellatus* so exceptional among the fish enthusiasts is its delectable taste that justifies its selling price, being served and only in special occasions.

According to the reports, *M. cancellatus* is now threatened and becoming extinct due to the uncontrolled harvesting [10]. Its current rank is now declining and the regular catch over the years has significantly decreased [11]. Pigok or *Mesopristes cancellatus* noticeably considered a high valued freshwater fish in the country [12].

Several studies show that aquatic effluents from industrial, agricultural, household run-offs, transport animal and human excretions and domestic waste contribute to the heavy metals concentration in the Agusan River.

According to Roa [13] the degree of mercury contamination was attributed to mining activities in Mt. Diwalwal that encompasses the towns of Agusan Del Sur and Agusan Del Norte, including Butuan City emptying the Agusan River. As reported, small-scale mining in Diwalwal was found contribute mercury pollution in the river [13]. The existence of this pollutant from Diwalwal exceeded the recommended safe limits set by WHO [14] and US EPA [15]. This report pose a warning and a potential threat of bioaccumulation of mercury for humans and aquatic organisms that utilize the river. Further, continuous discharge of Hg through the process of methylation may pose potential risks in the years to come without appropriate intervention [16]. The fish is a popular and highly prized food source for the locals but its marketability is threatened by issues of potential heavy metal bioaccumulation. This study aims to determine the levels of cadmium, copper, lead nickel and mercury in *M. cancellatus* and sediments in the lower Agusan River basin to address this problem.

2. Materials and Methods

2.1 Locale of the Study

The study area is Lower Agusan River Basin a part of three sub-basins in the northeastern part of Mindanao, most commonly known as Lower, Middle, and Upper Agusan River Basins. Lower Agusan River Basin (downstream watershed) is the area downstream of the Agusan wetland along the downstream reach from Talacogon in Agusan Del Sur (Figure 1).

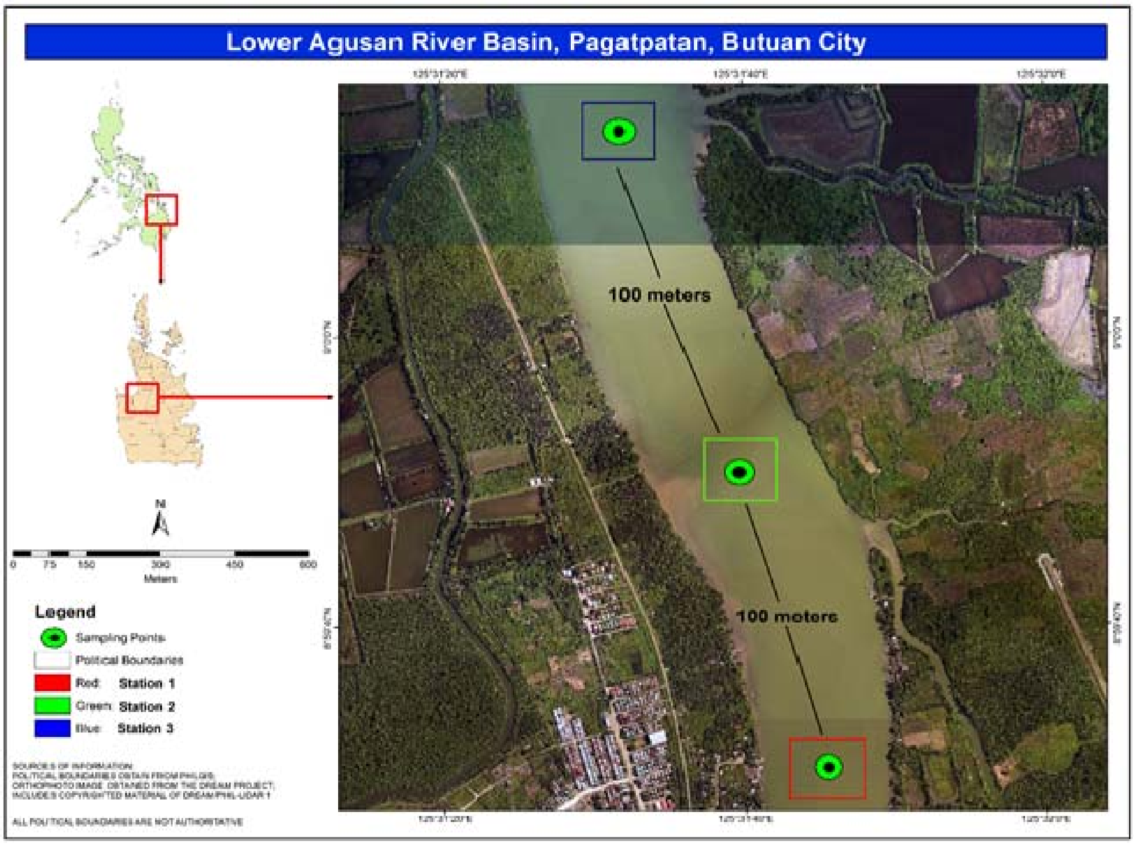

Fig 1: Map of the study stations in Lower Agusan River Basin, Brgy. Pagatpatan, Butuan City, Agusan Del Norte, Philippines.

2.2 Fish Collection

A collection of Pigok (*Mesopristes cancellatus*) for levels of cadmium, copper, lead, nickel and mercury (Hg) analysis was based on their consistent appearance in the river during the sampling survey (Figure 2). The collection of fishes was performed from April to May 2015. Due to its rarity, a total of nine (9) samples of *Mesopristes cancellatus* were collected randomly as three samples per locations (S_1, S_2, S_3). The collected samples were then placed in ziplock polyethylene bags and appropriately labeled with information about the area where it was collected together with the number of replicates. Fish samples were weighed using a digital weighing scale and the total body length (TL) was measured using a ruler. The actual total length of the fish ranges from 28.3333 ± 1.07152 SEM range (28-31 cm). Its body weight ranges from 555.556 ± 117.589 SEM range (300-800 g). A high-quality corrosion resistant stainless knife was used to cut the fish tissue (muscles). The samples were then labeled respectively.

Fig 2: *M. cancellatus* from lower Agusan River Basin, Brgy. Pagatpatan, Butuan City Agusan Del Norte, Philippines.

2.3 Sediment Collection

The samples of sediments were acquired from the same point where fish samples were collected. At each point, three sediment samples were taken from three established stations by using pre-cleaned 100 ml, wide-mouthed, disposable plastic containers and packed separately in pre-cleaned polyethylene bags. About 500 g of sediment samples from the study area. Samples in triplicates were placed in ziplock polyethylene bags properly labeled after collected. The samples of sediments were brought to the laboratory, dried under the sun and then ground into fine powder using mortar and pestle.

2.4 Digestion of fish muscles
Digestion process was adopted from the Analytical Methods for Atomic Absorption Spectroscopy (®PerkinElmer Incorporated). Samples of homogenized fish muscles without skin were dried in the laboratory oven at 100 ^{0}C for about 3 hours. The dried fish muscle samples were each ground with laboratory ceramic mortar and pestle to powder form. The samples were placed in ziplocks and coded labeled with the area where it was collected with the number of replicates.

A mixture of concentrated 5 ml Nitric acid (HNO_3) and 5 ml Sulfuric acid (H_2SO_4) were added to the 1 g of homogenized dried fish samples. 10 ml of concentrated Nitric acid (HNO_3) was added. After the samples become brown, it was added with 5 ml concentrated Hydrogen Peroxide (H_2O_2) continuously until the samples become clear or pale yellow. The resulting fish digested samples were then filtered using Wattman filter paper No.80 and diluted to 50ml with distilled-deionized water. Sample containers were pre-treated with 90% distilled- deionized water and 10% Nitric Acid.

2.5 Digestion of sediments
The method was adopted from the Analytical Methods for Atomic Absorption Spectroscopy by (®PerkinElmer Incorporated). Sample of sediments were air-dried. The dried sediment samples were ground with laboratory ceramic mortar and pestle to powder and sieved manually using No. 100 mesh sieve.

About 1 g of dried sediments was weighed using a digital weighing scale and placed in 100 ml beaker with a label. The labeled beakers covered with a watch glass were then transferred to the hot plate under the fume hood. A 20 ml Aqua Regia was added to the samples. The temperature was set to 240 ^{0}C for 3 hours. A pinch of Potassium perchlorate ($KCLO_3$) and 20ml (0.08M) Nitric acid (HNO_3) were added to the samples respectively. The temperature was set to 200 ^{0}C and heated to near dryness for about 20 ml. The resulting digested sediment samples were then filtered using a Wattman No.80 filter paper and diluted to 50 ml with distilled-deionized water. Sample containers were pre-treated of 90% distilled-deionized water and 10% Nitric Acid.

2.6 Determination of levels of Cd, Cu Pb, Ni and mercury (Hg) in fish muscles
The analysis for levels of cadmium, lead, nickel and mercury (Hg) was done at the Department of Agriculture, Regional Soils Laboratory located at Brgy. Taguibo, Butuan City. The analysis was done using the Agilent Technologies MY14300001 Atomic Emission Spectrophotometer with a detection limit of 0 ppm in all the heavy metals (Cd, Pb, Ni and Hg). Sodium Borohydride ($NaBH_4$) was used as reducing agent for samples.

The analysis for levels of copper in fish muscles was done at CSU - Chemistry Laboratory. The Cu concentration was determined by flame atomic absorption spectrophotometry Perkin Elmer Atomic Analyst 200 with a detection limit of 0.012 ppm. The preparation of solutions of copper were as follows: About 200 – 250 mL of 1% v/v HNO_3 used as a blank solutions and about 200 – 250 mL each of the three standards in 1% v/v HNO_3. The suggested standards of copper are 0.5 ppm (Standard 1), 1 ppm (Standard 2), 1.5 ppm (Standard 3) and 1 ppm (Reslope) following the official methods of AOAC International.

2.7 Determination of levels of Cd, Cu Pb, Ni and mercury (Hg) in sediments
The analysis for levels of cadmium, lead, nickel and mercury (Hg) was done by Department of Agriculture (Regional Soils Laboratory located at Brgy. Taguibo, Butuan City). The analysis was done using the Agilent Technologies® MY14300001 Atomic Emission Spectrophotometer with a detection limit of 0 ppm in all the heavy metals (Cd, Pb, Ni and Hg). Sodium Borohydride ($NaBH_4$) was used as reducing agent for samples.

The analysis for levels of copper in sediments was done at CSU - Chemistry Laboratory. The Cu concentration was determined by flame atomic absorption spectrophotometry Perkin Elmer Atomic Analyst 200 with a detection limit of 0.012 ppm. The preparation of solutions of copper were as follows: About 200 – 250 mL of 1% v/v HNO_3 used as a blank solutions and about 200 – 250 mL each of the three standards in 1% v/v HNO_3. The suggested standards of copper are 0.5 ppm (Standard 1), 1 ppm (Standard 2), 1.5 ppm (Standard 3) and 1 ppm (Reslope) following the official methods of AOAC International.

2.8 Statistical Analysis
PAST (Paleontological Statistics Software) was used in testing the difference of means of the concentration and levels of Cd, Cu, Pb, Ni and mercury (Hg) in the muscles and sediments. One-Way Analysis of Variance (ANOVA) was also used for testing the significant difference between muscles and sediments. Pearson correlation coefficient was used to analyze the relationship between the parameters for two data (muscles and sediments). Data was presented as mean ± standard error mean (SEM) and was calculated using column statistics in PAST software. All data were analyzed using Graph Pad Prism 5.

3. Results and Discussion
3.1 Levels of Cd, Cu, Pb, Ni and tHg in fish muscles
The recommended safe limits set by international agencies for fish and sediments in heavy metal concentrations are presented in Table 1.This would serve as basis for detecting if the levels in Pigok and sediments are still within limits without risk from exposure.

A total of nine (9) Pigok (*Mesopristes cancellatus),* were utilized for analyses of levels of Cd, Cu, Pb, Ni and Hg. The total length of fish utilized ranges from 28-31cm, and its body weight ranges from 300-800 g. The collected samples has a mean weight 555.556 ± 117.589 SEM range (300-800 g) and its mean length 28.333 ± 1.07152 SEM range (28-31 cm).

Table 1: Recommended Safe Limits of Heavy Metal Concentrations in Fish and Sediments (ppm).

Heavy Metals	Recommended Safe Limits in fish (ppm)	Agency	Recommended Safe Limits in Sediments (ppm)	Agency
Cd	≤0.05	US EPA	≤3	FAO
Cu	≤0.15 - 1.0	FAO, WHO, FEPA	≤100	FAO
Pb	≤0.5	US EPA	≤100	FAO
Ni	≤2	FAO, WHO FEPA	≤50	FAO
Hg	≤0.5	US EPA	≤0.1	FAO

Note: US EPA= United States Environmental Protection Agency [15]
FAO = Food and Agriculture Organization [19, 17]
FEPA = Federal Environmental Protection Agency [18]
WHO = World Health Organization [14]

The heavy metal concentration in the muscles of Pigok presented in Table 2a was in the order of Pb>Cu>Hg>Cd>Ni**.** Among the five heavy metals analyzed, Pb had the highest concentration in muscles mean (30.056 ± 0.475 ppm), followed by Cu (6.694 ± 0.417 ppm), Hg (0.888 ± 0.0319 ppm), Cd (0.5 ± 0.347 ppm), and Ni (0.5 ± 0.096) respectively. One-Way ANOVA revealed that Ni levels were significantly higher in the fish muscles samples (P=0.008). However, there are no significant difference between the levels of Cd, Cu, Pb, and Hg.

Table 2a: Mean concentrations of heavy metals (ppm) in fish muscles from Lower Agusan River Basin. Brgy. Pagatpatan, Butuan City, Agusan Del Norte. Philippines.

		Fish Muscles		
Heavy Metals	**Station 1**	**Station 2**	**Station 3**	**Mean ± SEM**
Pb	30.033 ± 0.601	30.167 ± 0.441	29.667 ± 0.441	30.056 ± 0.475
Cu	6.217 ± 0.277	6.9 ± 0.527	6.967 ± 1.597	6.694 ± 0.417
Hg	1.511 ± 0.898	0.66 ± 0.067	0.492 ± 0.148	0.888 ± 0.319
Cd	0 ± 0	1.5 ± 1.041	0 ± 0	0.5 ± 0.347
Ni	0.167 ± 0.167	1.166 ± 0.167	0.167 ± 0.167	0.5 ± 0.096

Note: The detection limit of the analyzer is 0 ppm except for Copper is 0.012 ppm.
Recommended safe limits in fish Hg= ≤0.5ppm [15] Pb= ≤0.5 ppm [15] Cd= ≤0.05 ppm [15]. Cu=≤0.15-1.0 ppm [19, 20, 18] Ni=≤2.0 ppm [19, 20, 18].

Lead (Pb) in the muscles had the highest mean value obtained (30.056 ± 0.0475 ppm) which exceeded the recommended safe limits of ≤0.5 ppm in food set by US EPA [15]. Since Pb showed the highest concentration and exceeds the recommended safe limits set by standards US EPA [15], FAO [19] and WHO [20], this implies accompanying risk of bioaccumulation without frequent consumption. High concentration of Pb in the body can cause negative effects on health. Subsequently, the human exposure of Pb contamination was associated with food source [50].

The possible accumulation of Pb in the muscles of Pigok was due to the reason that Pb naturally occurs in the environment as a by-product of human activity, and its concentration and presence in environmental media are highly variable [21]. Pb is released throughout the smelting and mining activities and from an automobile exhaust by combustion of petroleum fuels [22]. At the same time, Pb may be present in water to some extent as a result of its dissolution from natural sources but excessive Pb may predominantly from house hold plumbing [23]. Many of the scientists reported the concentration of Pb in the water ranges from, 0.0-0.52, 0.0-0.6, 0.013-0.16, 0.0-0.00083 mg/l and 6.97-30.73 µg/l, respectively [24-28].

The study area is the common waterway access of local communities transporting passengers and their commodities from one place to another by the help of bancas. These motorized bancas preferably used gasoline to operate. The spills of the leaded petrol from motorized bancas may eventually leak into the water. Over a long period of time, this could accumulate and contaminate the riverine community. Through this activity, the increase of lead deposition in the water column had been continuously arising from the past until the present time.

Apparently, high levels of Pb in the muscles of Pigok was associated with the high level of Pb in water of Agusan River and may be attributed to heavily-traveled roads that traverse along the river. The previous studies show that higher levels of Pb often occur in water bodies near highways and large cities due to high gasoline combustion [29]. Similarly, dust which holds an enormous amount of Pb from the combustion of petrol in automobile cars led to increasing Pb content [30].

Previous studies concluded that fish and other aquatic organisms may be contaminated by toxic metals mainly due to human activities such as the use of metal-containing pesticides, industrial waste, urban and agricultural runoff and dumping etc. [52]. Together with agricultural effluents from pesticides, sediments may contain lead arsenate, chemical, industrial, household run-offs and non-point sources since the river is situated where commercialization arises.

The mean Cu concentration in fish muscles were 6.694 ± 0.417 ppm has exceeded the recommended safe limits of 0.15-1.0 ppm set by FAO [19], WHO [20] and FEPA [18].The accumulation of Cu in the water bodies maybe due to the sources coming from agricultural and domestic sewages [32]. In the aid of biochemical processes, trace amount of Cu is essential nutrient in both plants and animals [5]. Significantly, Cu is responsible element for metalloenzymes, hemoglobin synthesis and catalysis of metabolic reactions of living organisms [53]. However, great intake of Cu will result to teratogenecity, increased rate of free radical formation and aberrations in chromosomes [34-37]. The accumulation of Cd through metallothioneins and its ingestion in the human body with an average of 3-330 mg/day and 1.5-9 mg/day causes toxicity [38].

The Hg concentration in fish muscles had the mean of 0.888 ± 0.319 ppm. This exceeded the recommended safe limits for mercury (Hg) in the fish muscle (0.5 ppm) set by US EPA [15]. Many studies indicate that fish is the foremost source of mercury (Hg) in human diet [31]. The accumulation of Hg had been identified as human toxicant and the primary source of mercury contamination in people is through eating fish [38].

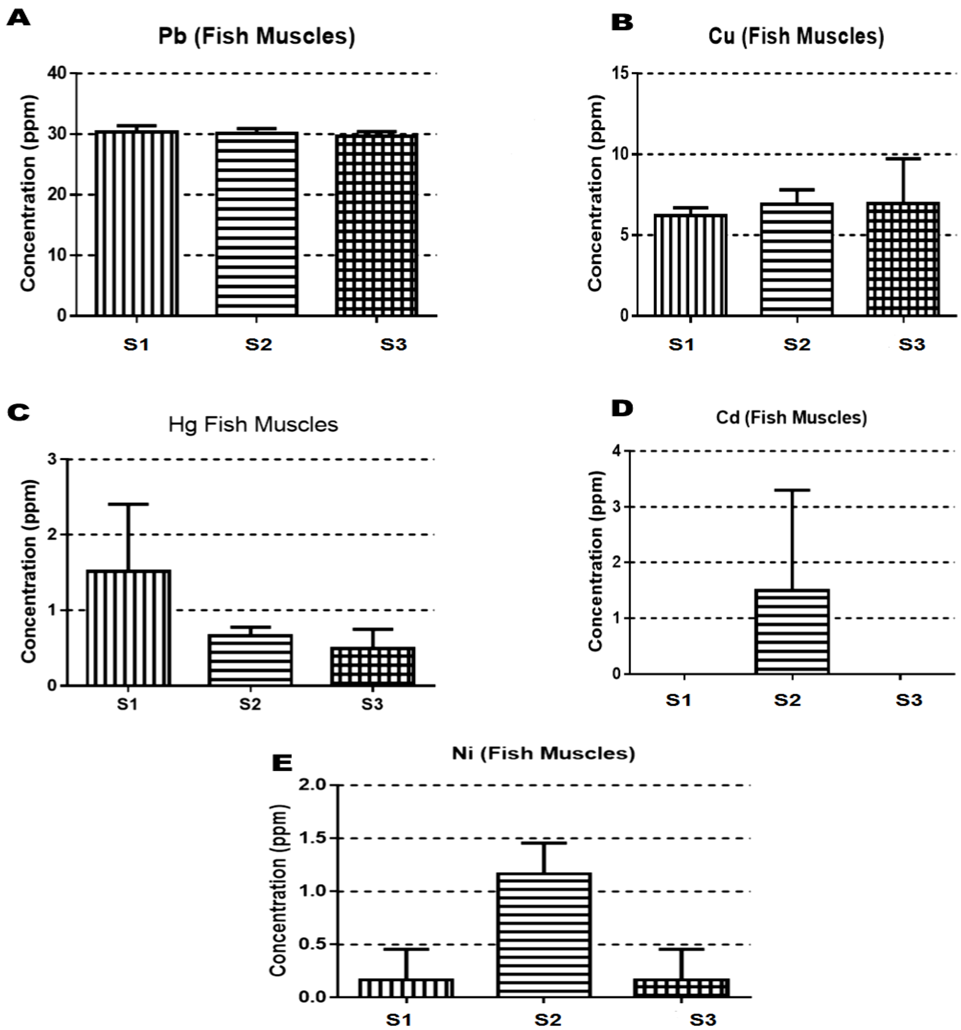

Fig 3: Graphical presentation of heavy metals concentration in the muscles of Pigok (*Mesopristes cancellatus*).
A. Lead (Pb) B. Copper (Cu) C. Mercury (Hg) D. Cadmium (Cd). E. Nickel (Ni).

The toxic form of mercury-methylmercury was not determined in this study, the results should provide caution as to the risk of possible bioaccumulation of mercury in the body with frequent and large consumption of mercury-contaminated fish.

Mean Cd across the three sampling stations (0.5 ± 0.347 ppm) exceeded the recommended safe limits set by FAO [19] and WHO [14], which is 0.05 ppm. Several organs like kidney, liver, lung, placenta, bones, brain, and central nervous system are directly affected when there is high concentration of Cd in the body [51]. Ni had a mean concentration (0.5 ± 0.096 ppm) and were below the recommended safe limits of 2.0 ppm according to FAO [19], WHO [14] and FEPA [18].

The data analyses show that the fish muscles had a very high levels of Cu, tHg and Cd toxicity. Pb established a highest concentration of toxicity and exceeded the recommended safe limit in foods set by FAO [19] and WHO [14]. The results suggest that the fishes tested were not free from heavy metal contamination. Among the five heavy metals tested, only Ni has shown values below the recommended safe limits set by FAO [19] and WHO [14].

Several studies identify that accumulation and concentration of mercury in the fish muscles could be due to the habitat type, physiological operation, behavior, and physico-chemical characteristics of the fish [40]. Related literature from Deb and Fukushima [41], mentioned that heavy metal concentration may also be high in the gills, intestine, and digestive glands [41]. The levels of heavy metal in the fishes could be attributed to its diversity, dissimilar food requirements and metabolic rates [42]. Also, water temperature may also be a basis for differences in metals deposition in various organs [43]. Finally, the concentration of heavy metals in different tissues and organs of fishes is directly influenced by contamination in the aquatic environment, up- take regulation and elimination inside the fish body [44].

3.2 Levels of Cd, Cu, Pb, Ni and Hg in sediments

The heavy metal concentration in the sediments collected at Lower Agusan River Basin, Brgy. Pagatpatan, Butuan City, presented in Table 2b was in the order of Ni>Cu>Pb>Cd>Hg. Among the five metals analyzed, Ni had the highest mean concentration (121.389 ± 2.845 ppm) and has exceeded the recommended safe limits in soil set by FAO [20] and WHO [14] which is 50 ppm. Concentrations of Cu (68.017 ± 7.079 ppm) is below the recommended safe limits set by FAO [19] and WHO [14] which is 100 ppm. With regards to Pb, the obtained mean concentration (32.222 ± 0.294 ppm) were below the recommended safe limits of 100 ppm set by FAO [20] and WHO [14]. The Cd concentration (8.5 ± 1.398 ppm) and exceeded the recommended safe limits set by FAO [20] and WHO [14], which is 3 ppm. The recorded mean of Hg concentration (0.77 ± 0.031 ppm) exceeded the recommended safe limits set by FAO [19] which is 0.1 ppm.

Table 2b: Mean concentrations of heavy metals (ppm) in sediments collected at Lower Agusan River Basin. Brgy. Pagatpatan, Butuan City, Agusan Del Norte, Philippines.

		Sediments		
Heavy Metals	**Station 1**	**Station 2**	**Station 3**	**Mean ± SEM**
Ni	121.167 ± 3.18	123.167 ± 7.80	119.833 ± 1.878	121.389 ± 2.845
Cu	67.65 ± 19.970	77.667 ± 4.740	58.733 ± 1.751	68.017 ± 7.079
Pb	33.833 ± 0.726	31.167 ± 1.691	31.667 ± 0.667	32.222 ± 0.294
Cd	24 ± 3.055	1.5 ± 1.5	0 ± 0	8.5 ± 1.398
Hg	0.122 ± 0.081	0.109 ± 0.021	0 ± 0	0.077 ± 0.031

Note: The detection limit of the analyzer is 0 ppm except for Copper is 0.012 ppm.
Recommended safe limits in sediments Hg= ≤0.1ppm [45], Cd=≤3 ppm [17] Cu=≤100 ppm [17] Pb=≤100 ppm [17] Ni=≤50 ppm [17]

The Ni concentration in sediments exceeded the recommended safe limits set by FAO [19] and WHO [14]. This indicates that the sediments in the area retained pollutants that directly affect the biological state of aquatic organisms including fish. Households sewage, industrial effluents constitutes and enhanced the increasing levels of heavy metal in the aquatic environment [38]. The high level of Ni and other metals in Agusan River may be attributed to the various by-products such as industrial and domestic sewages, animal/poultry wastes product, land-based fertilizers and pesticides. In this way, heavy metals accumulate through time in the sediments.

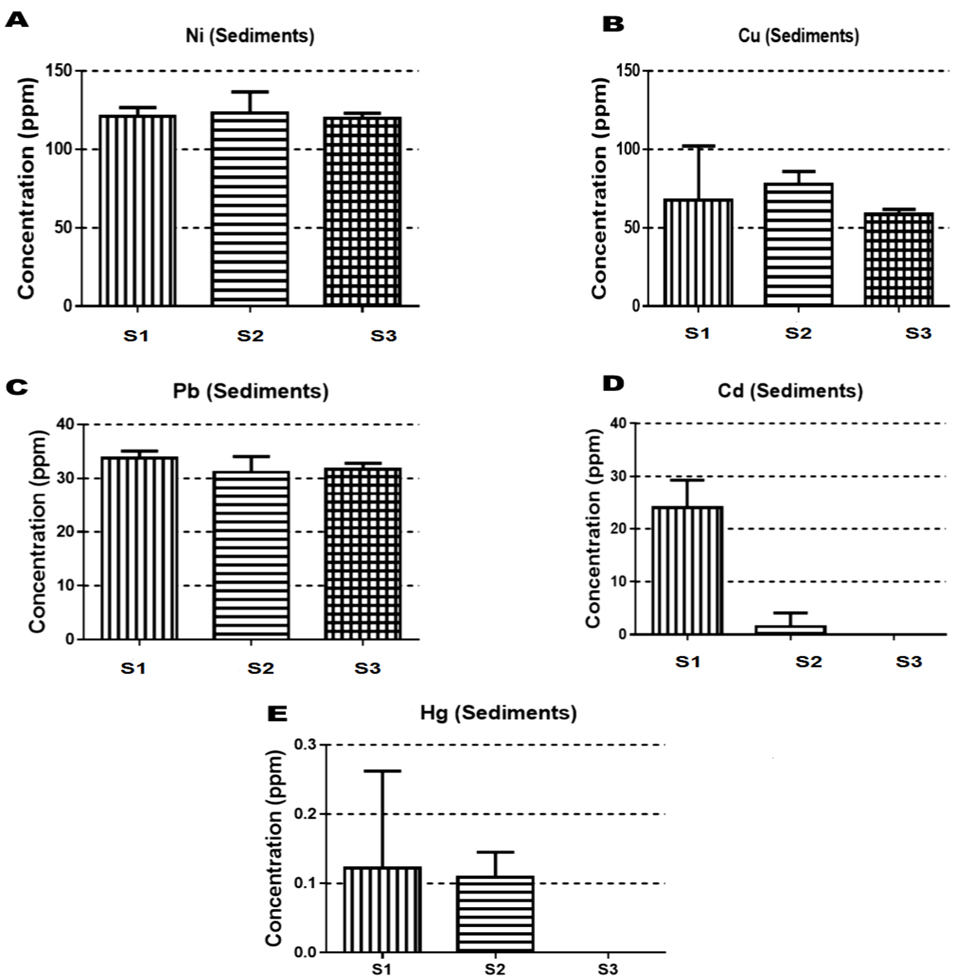

Fig. 4. Graphical presentation of heavy metal concentration in the sediments. A. Nickel (Ni) B. Copper (Cu) C. Lead (Pb) D. Cadmium (Cd) E. Mercury (Hg).

One-Way ANOVA revealed a significant difference between the concentration of heavy metals in the sediment samples (P=0.0002) in Cd. Conversely, Cu, Pb, Ni and tHg did not show any significant difference from each other. From the five heavy metals analyzed, three (Ni, Cd and Hg) metals exceeded the recommended safe limits set by FAO [19] and WHO [20, 14] in sediments. These high concentration have potential risk of bioaccumulation to humans and other aquatic organisms in the area with frequent exposure to contaminants.

The study of Roa [13] has reported alarming levels of Hg in some plant and fish species in Agusan River. The present study confirmed this result and further indicated clear evidence of Hg deposition in sediments and bioaccumulation of tHg in fish.

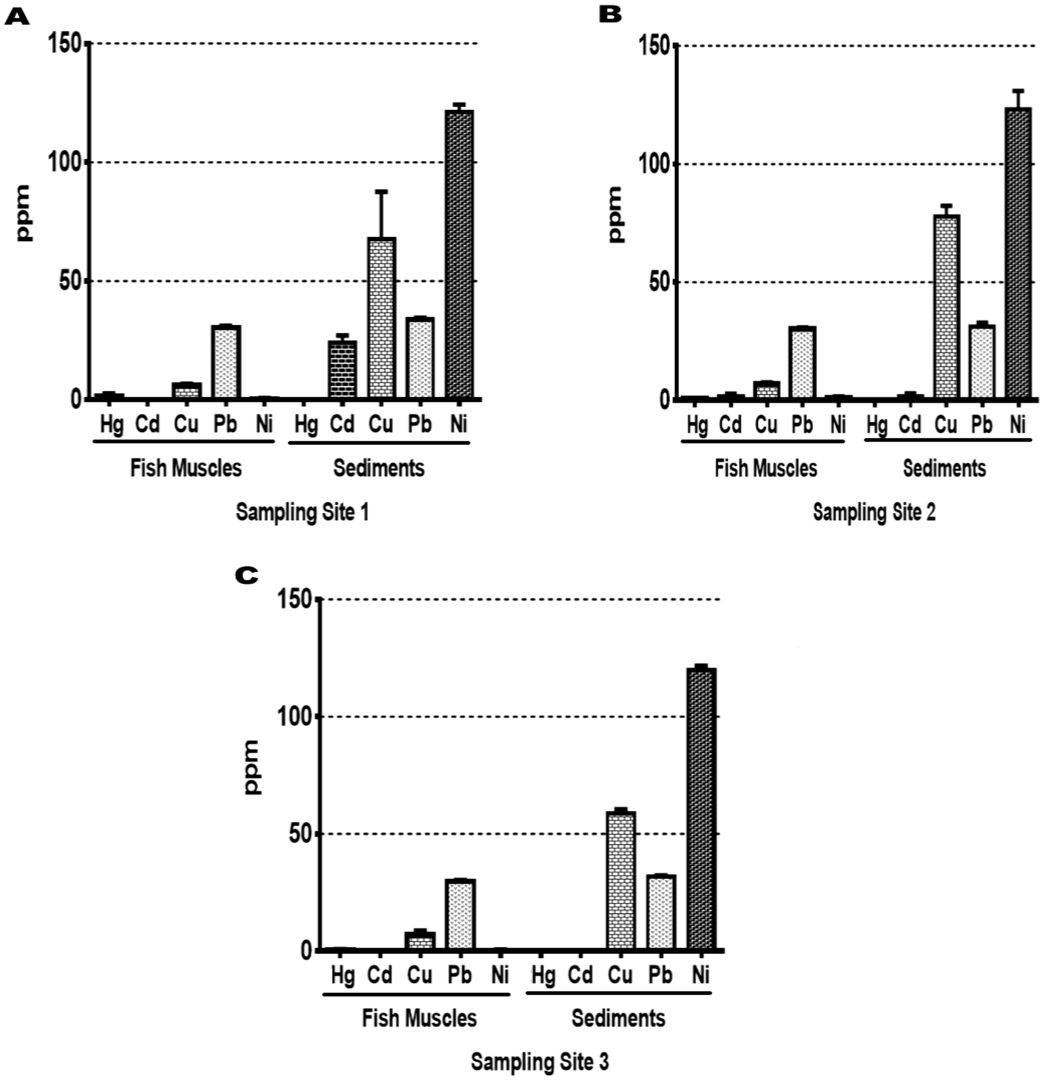

Fig 5: Comparison of heavy metal concentrations between fish muscles and sediments along three sampling stations in lower Agusan River Basin, Brgy. Pagatpatan, Butuan City, Agusan Del Norte, Philippines.

Results of the present study reveal higher concentrations in sediments than in *M. cancellatus.* According to Linnik and Zubenco [46], heavy metals cannot be degraded, they are set down, integrated or incorporated in water, sediment and even in aquatic animals [46]. Also, according to Gupta [47], sediments act as the most significant reservoir/sink of metals and other contaminants in the aquatic environment. The heavy metal discharges in the sediment can directly affect the state of water quality and the build-up of these metals in the aquatic organisms and could lead to a potential long standing health problem on human as well as in the environment [48].

3.3 Correlation between Fish and Sediment Samples

Pearson correlation revealed that the levels of Cd, Cu, Pb, Ni and Hg in fish muscles and sediments are positively correlated ($r = 0.9196$) for the three stations (Figure 6). The results implied that sediments may be one of the factors that affects the concentration and accumulation of Pb, Cu, Hg and Cd in fish muscles. Recent study conducted by Buhari and Ismail [32] have revealed that there were significant correlations between the heavy metal concentrations in the tissues of *P. schlosseri* and the concentrations of heavy metal in sediments which indicates the ability of fish to accumulate or control heavy metals in its tissues like intestine, operculum, scale, bone cartilage and liver. This is because *P. schlosseri* inhabit in mudflats, which is the sink of heavy metal pollution [32].

Openiano [12] indicated that feeding habits of Pigok (*Mesopristes cancellatus)* mainly consists of mud, sand, plastic, small shrimps, an odd mixture of fine twigs, and fibrous materials. Previous work done by Conclu [49] revealed that occurrence of majority of the life stages occur in the freshwater where most of the aquatic effluents occur. Perhaps, factors to be considered in assessing heavy metal concentrations in the tissues of the fish were its mass, age, as well as the environmental settings which might have influenced high level of pollutants in aquatic organisms.

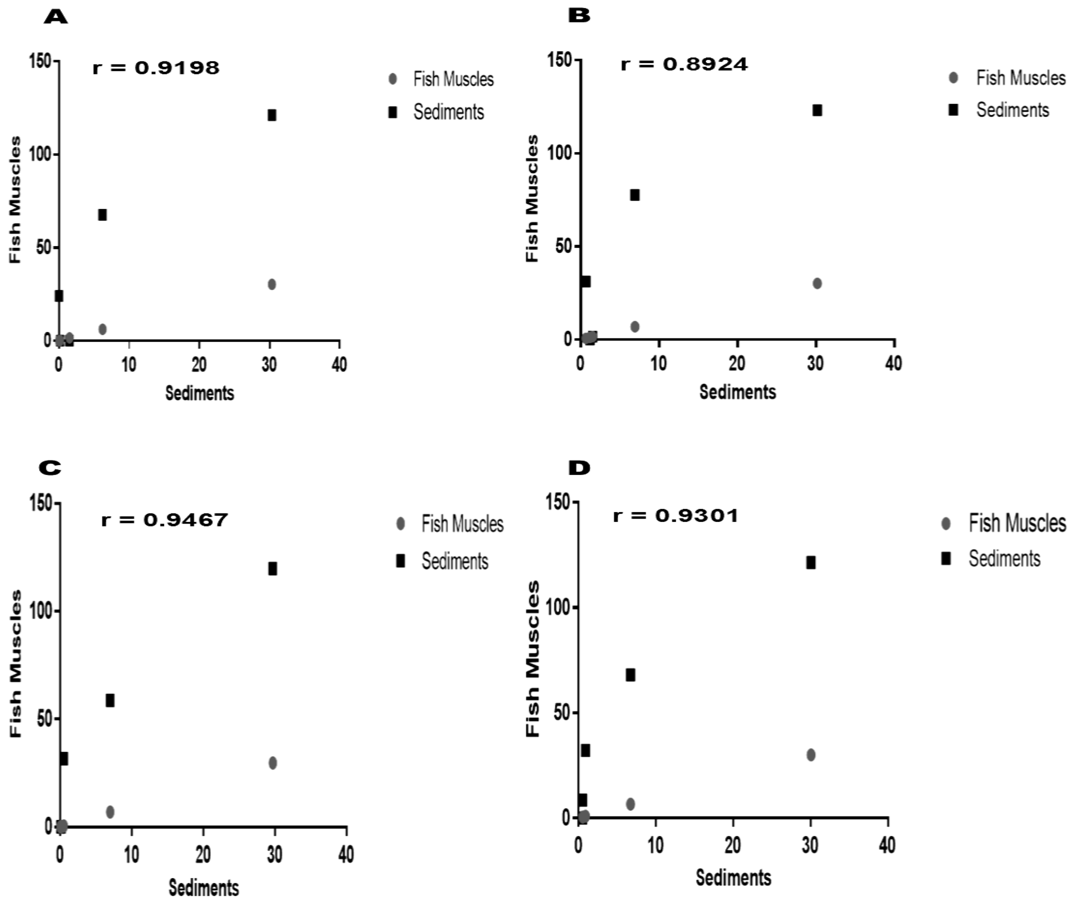

Fig 6: Scatter plots showing the correlation of heavy metals in fish muscles and sediments from three sampling stations. A. Station 1 B. Station 2 C. Station 3 D. Fish muscles vs. sediments

4. Conclusions

Levels of cadmium copper, lead nickel, and mercury were determined from the muscles of Pigok (*Mesopristes cancellatus*) and collected sediments at lower Agusan River basin. Results show that Pb had the highest concentration (30.056 ± 0.475 ppm) followed by Cu (6.694 ± 0.417), Hg (0.888 ± 0.319 and Cd (0.5 ± 0.347) which exceeded the recommended safe limits set by the authorized agencies. This implies that there is accompanying risk of bioaccumulation of these metals with frequent and large consumption of fish. Consequently, the sediment analyses showed that Ni had the highest mean (121.389 ± 2.845 ppm), and tHg (0.077 ± 0.031 ppm) exceeded the recommended safe limits in sediments set by FAO and WHO.

Data analysis revealed that levels of heavy metals are significantly high in sediments than in fish. Pearson correlation between the fish muscles and sediments show significant relation (r = 0.9222). Hence, sediments could be the direct factor influencing the Pb, Cu, Hg and Cd concentration and contamination in the fish muscles.

To consider the heavy metal concentrations in fish muscles, the most important factor is their toxicity to humans suitable for human consumptions. The result of this study showed that consuming Pigok frequently from Lower Agusan River Basin, Brgy. Pagatpatan, Butuan City, may pose risk of bioaccumulation of Pb, Hg and Cu. From the results perspective, this study showed high concentration of heavy metals in the muscles of Pigok that may cause health problems associated with bioaccumulation. Nonetheless, the threshold frequency of consumption of Pigok still needs to be determined in future studies.

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