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Determination of Lead Concentration of the Waters in the Angat River Network in Bustos, Bulacan

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Abstract: This study is a descriptive cross-sectional analysis of the concentration of lead of the waters in the Angat River Network in Bustos, Bulacan.
Through the use of Flame Atomic Absorption Spectrophotometer, it was established that the overall mean Lead concentration in the river is found to be 0.3037 ppm (mean standard error of 0.0018). The World Health Organization in 2010 set the legal limit for lead at 0.01 ppm. The river water is 30 times higher than the legal limit.
Furthermore, results of the one-way ANOVA revealed that the mean Lead concentrations significantly differ across the different barangay sampling location with a p-value of <0.0001. However, the mean Lead concentrations of water samples stratified according to levels of water sampling and river points where the samplings were done are almost the same.
Key Words lead concentration, river waters, FAAS andANOVA.

Introduction

Industrialization has brought forth so much progress, convenience and satisfaction to human lives. Factories and machines that were conceived unimaginable in the past have already taken form and reality in the present, and are sure to prosper even more in the future. Consequently, no one would dare put a halt to such an amenity in the modern world, lest doing such would cut short all the innovations and breakthroughs. However, environmentalists and conscientious minds attest that something is amiss with the explosion of industrialization. Together with the good effects of industrial activities are global warming, climate change, glacial meltdown, flooding, deforestation, ocean acidification and red tide, oil spills, flora and fauna extinction, genetic engineering malfunction and mutation, radiation, waste mismanagement, overpopulation, and pollution, etc.

One distinct by-product of industrialization in the Philippines is water pollution, specifically, the heavy metal contamination of river waters. With the influx of industrial activities in Bulacan, it is quite imperative to assess the state of quality of the Angat River Network. This study aims to establish if the levels of the concentration of lead in the river in Bustos, Bulacan are still within the permissible limits set by international standards.

The Angat River, which is also called the Bulacan River Network, snakes through the municipalities of Doña Remedios Trinidad, Norzagaray, Angat, Bustos, San Rafael, Baliwag, Plaridel, Pulilan, Calumpit, Paombong and Hagonoy which eventually leads to the Manila Bay. The Angat River Network in Bustos, Bulacan is a freshwater aquatic resource that starts from the Bustos Dam watershed and encompasses the barangays of Tibagan, Bonga Mayor, BongaMenor, Tanawan, Poblacion, San Pedro and Cambaog. This part of the river network harbors diversified freshwater fish, crustaceans and crab species which serve as the livelihood of municipal and subsistence fishermen who live in the outskirts of the river network waterways. This eight-

kilometer fishing ground produces several species of marine life endemic in Philippine freshwaters. However, several open garbage dumpsites and pig pens are strategically situated along the riversides. According to Samar (2013)[1] the pollution of the Pampanga River Basin with household garbage, rice field fertilizers and human excreta has been a perennial provincial problem. Discharge of domestic waste such as worn-off batteries, plastics materials, items made of rubber and the likes releases traces of heavy metals. Bioaccumulation of such elements in the river produce that are eventually consumed by humans is a very serious problem that is often left unnoticed. What's worse is that even an accidental ingestion of river water and even skin contact is very harmful, and at times, fatal.

In the study of Tabiriet. al.[2] of heavy metals (Zn, Pb, Cd and Cr) in fish, water and sediments in ten sampling areas in the southern coast of the Caspian Sea during spring of 2008, and using the analysis of variance (ANOVA) statistical treatment, they found out that the highest concentration of heavy metals in water and fish and sediment samples were related to Pb and Zn. The minimal and maximal concentrations of these metals in fishes, water and sediments were 53.67—2360.67 and 50.36—2497.25 for Pb and Zn, respectively. However, the observed heavy metal concentrations in fish, water and sediments were below the recommended limits.

On the other hand, the study of Shrivastava and Mishra[3] (2011) about various heavy metal in surface and ground water in BirsinghpurTown, State of Madhya Predesh, India revealed that in 2008-2009, the surface water Pb, Fe, Mn, Cu, Ni and Cd varied from the ranges of 0.006 to 0.110, 0.55 to 2.76, 0.125 to 0.292, 0.025 to 0.046, 0.014 to 0.019 and 0.003 to 0.016 mg/l, respectively. In ground water the concentration of these metals were found in the ranges of Pb (0.003 to 0.060 mg/l), Fe (0.024 to 2.38 mg/l), Mn (0.012 to 0.248 mg/l), Cu (nil to 0.058 mg/l), Ni (nil to 0.019 mg/l) and Cd (nil to 0.0083 mg/l). The above results indicate that some water samples contained Pb, Fe, Mn and Cd that is beyond permissible limits recommended by various national agencies.

Furthermore, another study by Abida Begum, Harl S. Krishna and Irfanulla Khan[4] in 2008 revealed that in Madivala Lakes of Bangalore, Karnataka, also in India, an appreciable increase in metal concentrations in going from the water to the sediment samples. To wit, the heavy metal concentration in water is as follows, Pb>Cr>Cd.Ni. The heavy metal concentration is sediments is as follows, Pb>Cr>Cd>Ni. The heavy metal concentration for fish muscle is Pb>Cd>Ni>Cr; for fish kidney is Pb>Cd>Ni>Cr; and for fish liver is Pb>Cd>Ni>Cr.

Generally, this study was undertaken to establish the baseline lead concentration of the waters of Angat River Network in Bustos, Bulacan, Philippines. Specifically, it aimed to determine if the lead concentration in the river differed among the different water sampling points stratified according to the barangay, water levels, and river points.

The possibility of contamination of the river with lead, or any other heavy metal for that matter, poses a great health hazard.Wikipedia[5] states that lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Hence, awareness of the toxicity level of the river is deemed significant since it will inform the people of the danger that may result from ingestion or skin contact with the river waters or eating marine life harvested from the river. The result of this study will also serve as a wake-up call, not only to the local government unit, but also to the community to help in the rehabilitation and preservation of the river.

Experimental

The determination of lead concentration of the river water can be conceptualized using the paradigm in Figure 1.

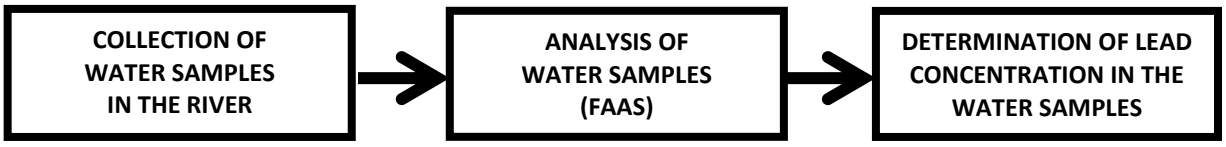

Figure 1. The Logical Framework of the Study

Figure 1 shows the conceptual framework of the study. Frame 1 in the graphic representation shows the collection of water samples from 90 sampling points in the Angat River Network in Bustos, Bulacan. Frame 2 in the paradigm is the submission of the water samples to the Flame Atomic Absorption Spectrophotometry in DLSU, Taft, Manila. And Frame 3 in the figure is the determination of lead concentration of the water samples expressed in parts per million.

This study utilized a descriptive cross-sectional research design. Water samples from 90 sampling points in the river were filtered and subjected to Flame Atomic Absorption Spectrophotometry to be able to quantify the lead concentration.

Sampling Area

There were thirty (30) sampling points (Figure 2) that were utilized for water collection in this study. Each sampling points were evenly distributed within the entire stretch of the Angat River Network that encroaches the municipality of Bustos, Bulacan. To ensure enhanced reliability and validity of results, three water samples were retrieved in each sampling point, namely, (1) surface river water, (2) middle river water, and (3) bottom river water. Therefore, there were a total of ninety (90) water samples subjected for testing using the FAAS.

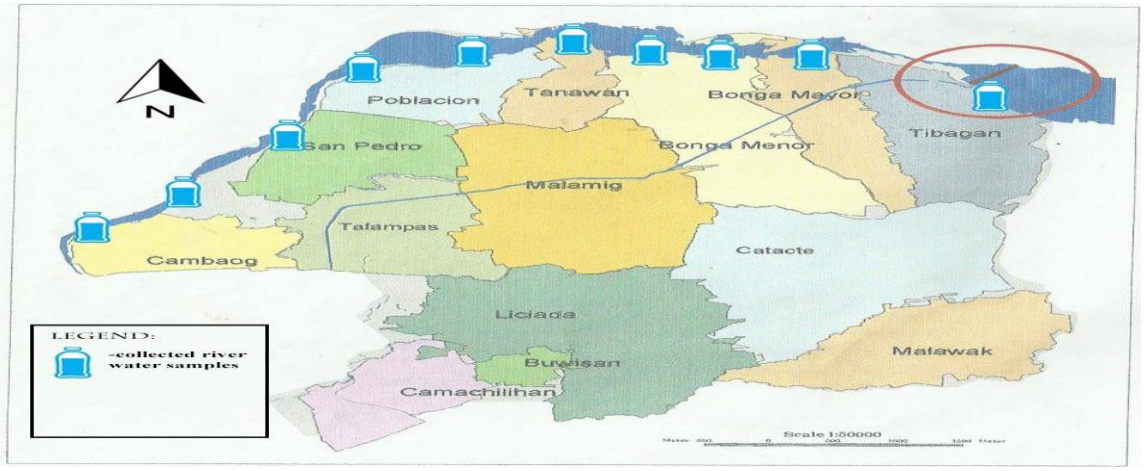

Figure 2.Water Sampling Points in the Angat River Network in Bustos, Bulacan

Water Sample and Standard Preparation

PET bottles were thoroughly washed with distilled water in preparation for the collection of river water samples.

The river water samples were collected from the Angat river network in Bustos, Bulacan, Philippines (Figure 1) and were contained in PET bottles. The collected water samples were filtered and the 100 ml filtrates were subjected for the FAAS test.

The following concentrations of the metal standard solution were prepared: 0.10 ppm, 0.25 ppm, 0.50 ppm, 0.75 ppm, and 1.00 ppm. Distilled water served as blank.

Research Instrument

The Flame Atomic Absorption Spectrophotometer AA-6300 (Shimadzu) used in this study was rented from the De La Salle University in Taft, Manila in October 30, 2014. The metal standard solutions of varying concentrations were subjected to analysis starting with the lowest concentration to the highest. Calibration curve was obtained. Water samples were then subjected to analysis. Distilled water was used to plush the line after every sample reading.

Table 1 is shows the list of all the tools and equipment used in this study. On the other hand, Table 2 shows the list of all the reagents and standard solutions used in this study.

Table 1. List of Tools/Equipment Used in this Study

Tools/Equipment	Quantity
Wash bottle	1
Goggles	5
Face mask	5
Gloves	5
Filter paper	90
Funnel	4
25 mL volumetric flask	5
1 mL and 10 mL pipette	2
Aspirator bulb	2
PET bottles	180
Atomic Absorption Spectrophotometer	1

Table 2. List of Reagents and Standard Solutions Used in this Study

Reagents and Standard Solutions	Quantity
Wilkins Distilled water	6 L
De-ionized water	6 L
Working metal standard solution	40 mL
0.10 ppm standard solution	10 mL
0.25 ppm standard solution	10 mL
0.50 ppm standard solution	10 mL
0.75 ppm standard solution	10 mL
1.00 ppm standard solution	10 mL

Statistical Treatment

The statistical treatment were done using Stata SE version 12. Samples were stratified according to sampling location and point (i.e. Barangay, level and river points). Mean lead concentrations with the standard error and 95% confidence interval were computed. Three-way Factorial Analysis of the Variance (ANOVA) was performed to determine if the mean of the lead concentration differ among the different sampling points.

Results and Discussion

Table 3 shows the detected lead concentration in the water samples used in this study.

It can be gleaned from the table that the overall mean lead concentration from the water samples is found to be 0.3037 ppm (mean standard error of 0.0018). The World Health Organization in 2010 set the legal limit for lead at 0.01 ppm.

The river water isabove the permissible limits set by the WHO. The lead concentration in the river is 30 times higherthan the legal limit.

Table 3. Concentration of Lead in the Water Samples from theAngat River Network in Bustos, Bulacan

Water Samples in the Angat River Network in Bustos, Bulacan	Concentration of Pb, ppm	Water Samplesin theAngat River Network in Bustos, Bulacan	Concentration of Pb, ppm
Bunga Mayor 1A - Top	0.2818	Poblacion 6A- Top	0.3017
Bunga Mayor 1A-Middle	0.2912	Poblacion 6A-Middle	0.3323
Bunga Mayor 1A-Bottom	0.2571	Poblacion 6A- Bottom	0.3193
Bunga Mayor 1B- Top	0.2724	Poblacion 6B- Top	0.3088
Bunga Mayor 1B- Middle	0.2912	Poblacion 6B- Middle	0.3299
Bunga Mayor 1B-Bottom	0.2665	Poblacion 6B- Bottom	0.3358

Bunga Mayor 1C- Top	0.2829	Poblacion 6C- Top	0.2853
Bunga Mayor 1C- Middle	0.2771	Poblacion 6C- Middle	0.3299
Bunga Mayor 1C- Bottom	0.2923	Poblacion 6C- Bottom	0.2959
BungaMenor 2A- Top	0.2829	San Pedro 7A- Top	0.3229
BungaMenor 2A- Middle	0.2747	San Pedro 7A- Middle	0.3240
BungaMenor 2A- Bottom	0.2806	San Pedro 7A- Bottom	0.3111
BungaMenor 2B- Top	0.2900	San Pedro 7B- Top	0.3135
BungaMenor 2B- Middle	0.3111	San Pedro 7B-Middle	0.3076
BungaMenor 2B- Bottom	0.3088	San Pedro 7B- Bottom	0.3053
BungaMenor 2C- Top	0.3017	San Pedro 7C- Top	0.3229
BungaMenor 2C- Middle	0.2853	San Pedro 7C- Middle	0.3029
BungaMenor 2C- Bottom	0.2982	San Pedro 7C- Bottom	0.3053
BungaMenor 3A- Top	0.3099	Talampas 8A- Top	0.3240
BungaMenor 3A- Middle	0.2994	Talampas 8A- Middle	0.3111
BungaMenor 3A- Bottom	0.2923	Talampas 8A- Bottom	0.3135
BungaMenor 3B- Top	0.2970	Talampas 8B- Top	0.3170
BungaMenor 3B- Middle	0.3076	Talampas 8B- Middle	0.2724
BungaMenor 3B- Bottom	0.2747	Talampas 8B- Bottom	0.3076
BungaMenor 3C-Top	0.3029	Talampas 8C- Top	0.3299
BungaMenor 3C- Middle	0.2841	Talampas 8C- Middle	0.2818
BungaMenor 3C- Bottom	0.3053	Talampas 8C- Bottom	0.3041
Tanawan 4A- Top	0.2853	Cambaog 9A- Top	0.3123
Tanawan 4A-Middle	0.3088	Cambaog 9A- Middle	0.3170
Tanawan 4A- Bottom	0.2994	Cambaog 9A- Bottom	0.3053
Tanawan 4B-Top	0.2947	Cambaog 9B- Top	0.3299
Tanawan 4B- Middle	0.3170	Cambaog 9B- Middle	0.3182
Tanawan 4B- Bottom	0.3041	Cambaog 9B- Bottom	0.3287
Tanawan 4C- Top	0.2994	Cambaog 9C- Top	0.3405
Tanawan 4C- Middle	0.3017	Cambaog 9C- Middle	0.3264
Tanawan 4C- Bottom	0.2900	Cambaog 9C-Bottom	0.3099
Poblacion 5A- Top	0.3111	Tibagan A- Top	0.3135
Poblacion 5A- Middle	0.2841	Tibagan A- Middle	0.3123
Poblacion 5A- Bottom	0.2853	Tibagan A- Bottom	0.3064
Poblacion 5B- Top	0.3006	Tibagan B- Top	0.3017
Poblacion 5B- Middle	0.2982	Tibagan B- Middle	0.3135
Poblacion 5B- Bottom	0.2876	Tibagan B- Bottom	0.3170
Poblacion 5C- Top	0.3099	Tibagan C- Top	0.3041
Poblacion 5C- Middle	0.3264	Tibagan C- Middle	0.3135
Poblacion 5C- Bottom	0.2947	Tibagan C- Bottom	0.3334

Tables 4, 5 and 6 reveals the mean lead concentration of river water in parts per million according to barangay sampling location, level of water sampling in the river water and river points sampling.

Table 4. Mean Lead Concentration (ppm) According to Barangay Sampling Location

Barangay Sampling Location	Mean Lead Concentration (ppm)	Mean Standard Error	95% Confidence Interval	
BungaMayor	0.2791667	0.0040490	0.2711214	0.2872120
BungaMenorA	0.2925889	0.0043099	0.2840252	0.3011525
BungaMenorB	0.2970222	0.0038622	0.2893480	0.3046964
Tanawan	0.3000444	0.0031864	0.2937131	0.3063757
Poblacion	0.3076000	0.0041741	0.2993061	0.3158939
SanPedro	0.3128333	0.0028146	0.3072408	0.3184259
Talampas	0.3068222	0.0062507	0.2944022	0.3192423

Cambaog	0.3209111	0.0037585	0.3134431	0.3283791
Tibagan	0.3128222	0.0030813	0.3066998	0.3189446

Table 5. Mean Lead Concentration (ppm) According to Level of Sampling

Level of Sampling	Mean Lead Concentration (ppm)	Mean Standard Error	95% Confidence Interval	
Top	0.3050167	0.0029906	0.2990743	0.3109590
Middle	0.3050233	0.0032266	0.2986121	0.3114346
Bottom	0.3011833	0.0032487	0.2947282	0.3076384

Table 6. Mean Lead Concentration (ppm) According to River Points of Sampling

River Points of Sampling	Mean Lead Concentration (ppm)	Mean Standard Error	95% Confidence Interval	
Left bank	0.3023533	0.0031808	0.2960332	0.3086735
Middle	0.3042800	0.0032277	0.2978667	0.3106933
Right bank	0.3045900	0.0031002	0.2984300	0.3107500

Samples collected from Barangay Cambaog were found to be having the highest lead concentration while the lowest concentration was noted from samples collected from BaranagayBunga Mayor. The mean lead concentrations of the river water from varying sampling levels and sides of the river bank were approximately similar to each other.

Table 7. One-way ANOVA F-statistics and Corresponding p-value

Factor	F statistics	p-value
Baranagay	7.95	<0.0001
Level	0.49	0.6130
River points	0.15	0.8643

Table 7 shows the F statistics and the corresponding p-values. Results of the one-way ANOVA revealed that the mean Lead concentrations significantly differ across the different barangay sampling location with a p-value of <0.0001. However, the mean Lead concentrations of water samples stratified according to level of water sampling and river points where the samplings were done are almost the same.

Conclusion and Recommendation

The overall mean lead concentration of the water from Angat River Network in Bustos, Bulacan is found to be 0.3037 ppm (mean standard error of 0.0018). The World Health Organization in 2010 set the legal limit for lead at 0.01 ppm. The river water is 30 times higher than the legal limit.

Furthermore, results of the one-way ANOVA revealed that the mean lead concentrations significantly differ across the different barangay sampling location with a p-value of <0.0001. However, the mean lead concentrations of water samples stratified according to level of water sampling and river points where the samplings were done are almost the same.

Based on the results of this study, it is hereby recommended that the local government unit should adopt and strictly enforce a comprehensive solid and liquid waste disposal systemin order to rehabilitate and preserve the water quality in the Angat River Network in Bustos, Bulacan. Furthermore, considering the lead concentration detected in the river waters and its danger to human health, periodic monitoring should be strictly undertaken and appropriate measures and municipal ordinances be implemented for the river water maintenance and preservation. Relevant and effective information dissemination programs should be in place to drive awareness among the people in the community of the lead contamination of the Angat River Network in Bustos, Bulacan.

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