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Assessment and Remediation of Heavy Metals in Community Tap Water from Manila, Philippines

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Abstract. Water is important for daily living. As man uses the commodity, it can enter the systemic circulation through the skin and via ingestion. Being an urbanized area, the environment in Manila, Philippines is not as contaminant free compared to other provinces in the country. Different communities and resettlement areas for informal settlers are normally surrounded by wastes and pollutants that contribute much to the abundance of heavy metals. These chemicals, like lead and cadmium may cause chronic diseases/disorders. Using Atomic Absorption Spectrophotometry, this study identified the amounts of lead and cadmium from samples of water collected from households and office at the chosen community. The levels were compared with the standard limits set by the United States Environmental Protection Agency. Further, the water samples were remediated using chitin from the shells of *Perna viridis* or Tahong. The results of the study showed that tap water samples analyzed contained lead and cadmium with concentrations that exceeded the allowable set limit by the United States Environmental Protection Agency of 0.015ppm and 0.005ppm respectively. Chitin from the shells of *Perna viridis* or Tahong showed ability to remove lead (37.131% to 60.511%) and cadmium (42.982% to 62.411%.) from the collected community tap water.

Keywords: lead, cadmium, tap water, community, Manila, Philippines, AAS

1. Introduction

1.1. Background of the Study

Metro Manila, Philippines like most countries is not exempt from traces of heavy metals. Studies done in the area showed the presence of lead and cadmium in different samples to which water is included. Tap, deepwell, recreational [1] and restaurant drinking water have shown significant amounts of lead and cadmium [2]. Water is essential to man such that it must be kept clean and free from hazardous contaminants. Shell wastes of *Perna viridis*, *Helix pomatia* and *Crassostrea gigas* have shown the ability to decontaminate simulate heavy metal laden waste water [3]. The ability is said to be anchored on the shell's chitin and chitosan content [4].

The community assessed was BASECO (Bataan Shipyard and Engineering Company). It is a community built on an area where wastes and mud from Pasig river are dumped. Also debris of construction works are also placed there. This area receives subsistence from the government and non-government agencies. A project was built in this place called "Gawad Kalinga or GK BASECO". It became a resettlement place for informal settlers. Since this community is assumed to be contaminated with health hazards due to wastes, heavy metals lead and cadmium may also be present.

Lead is said to affect the bone marrows, the peripheral and central nervous systems especially on chronic exposure. It is readily absorbed through inhalation. Organic lead compounds are dermally absorbed as

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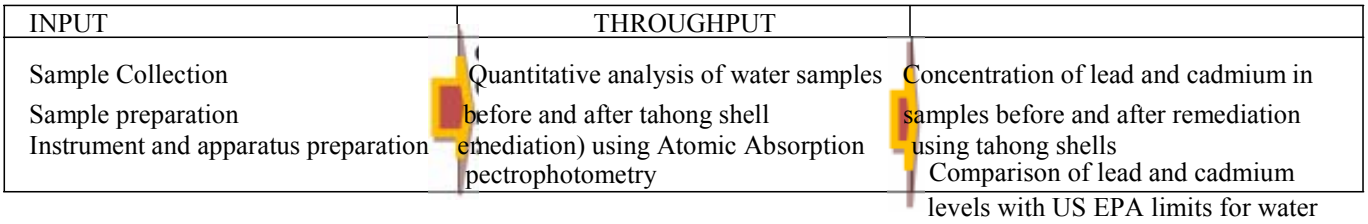
well. Adults absorb about 20-30% of lead on ingestion while children absorb more at 50% [5]. Cadmium may cause severe arthralgia and osteomalacia in middle aged postmenopausal women with low calcium and vitamin D intake, or itai-itai disease. It attacks the kidneys on chronic poisoning, lungs and gastrointestinal tract on acute inhalation and ingestion, respectively [5,6]. Around 25%is absorbed by inhalation, and 5% through ingestion. It is not well absorbed through the skin at 0.5%[5,7,8].

Through household and office water sampling and remediation, the study will be able to present solutions to problems of heavy metal contamination in the community tap water. It will be a springboard for the engineering of remediating substances into apparatus/es that may be placed directly to the nozzle of community faucets for water decontamination. The results of the study will also inform and forewarn the community of the possible hazards that can emanate from the heavy metal contamination in their area. Other research initiatives for remediation of similar areas may sprout from this study.

1.2. Conceptual Framework



1.3. Objectives of the Study

This study generally aimed to obtain the levels of heavy metals from water samples taken from GK BASECO community. Specifically, it aimed to quantitate the amounts of lead and cadmium from samples of water collected from households and office at GK BASECO. The levels were compared with the standard limits set by the United States Environmental Protection Agency. Further, the research intended to remediate the water samples using chitin from the shells of *Perna viridis* or Tahong.

1.4. Scope and Limitations of the Study

The research was conducted within the confined community area of GK BASECO. Only household and office tap water samples were analyzed and treated with chitin from tahong shells for decontamination. Only lead and cadmium were analyzed as heavy metal contaminants and AAS was used.

2. Materials and Methods

2.1. Research design

This study followed the experimental design with pre and post test. The concentration of lead and cadmium were obtained before and after the remediation using the chitin from tahong shells.

2.2. Locale of the Study

The research was conducted in Manila, Philippines. The water samples were collected from GK BASECO households and office. The samples were prepared at the University of the Philippines, Manila. The quantitative analysis using AAS was conducted at Dela Salle University, Manila.

2.3. Sample Collection

The tap water samples were randomly collected from the households and office at GK BASECO. Seventeen out of fifty houses and one from the office were obtained. The water samples were stored in well sealed polyethylene bottles.

2.4. Sample Preparation

One hundred milliliter of the sample filtrate was placed in a beaker. To it fuming nitric acid (5mL) was added and the beaker was covered with watch glass. The samples were heated in a hotplate and evaporated to 50mL without boiling. To it 3mL nitric acid was added and heated again, to allow evaporation to 40 ml. After the samples cooled down these were filtered using Whatmann #2 filter paper.

The filtrate were diluted to 50mL volume using volumetric flasks. The samples were stored at room temperature in well sealed polyethylene bottles prior to AAS [9].

2.5. Remediation

To 100 g of pulverized tahong shells, 50 ml of 1-10% sodium hydroxide solution was added. The solution was heated from 80 to 100 C in a water bath to remove the proteins. The solution was decanted. The liquid portion was dried over low fire using water bath. To the de-proteinized residue, 50 ml of 1-10% hydrochloric acid was added at room temperature to demineralize the tahong shells. The solution was decanted. The liquid portion was discarded. For colored residues, 1% sodium hypochlorite solution was used to decolorize the chitin [10]. Five grams of extracted chitin were placed in 50mL of each sample tap water. After twelve hours, the amount of lead in the water was determined using AAS [4].

3. Results and Discussion

The United States Environmental Protection Agency set the acceptable limit at 0.015ppm and 0.005ppm for lead and cadmium, respectively[11]. The amounts of lead and cadmium from the tap water samples taken before and after decontamination by chitin from tahong shells were obtained using AAS. In using the AAS, standard lead and cadmium were used to plot the calibration curve. In tables 1 and 2, the data used for the calibration curve of lead and cadmium standards respectively are recorded:

Table 1 Standard Calibration Curve for Lead

Concentration (ppm)	Absorbance
0.0500	0.0060
0.1000	0.0094
0.3000	0.0210
0.5000	0.0303

r=0.9979

Table 2 Standard Calibration Curve for Cadmium

Concentration (ppm)	Absorbance
0.0500	0.0328
0.1000	0.0666
0.3000	0.2057
0.5000	0.3346

r=0.9998

Based on the United States Environmental Protection Agency standards, the levels of lead in the water samples collected in the community under study went beyond the accept able limit of 0.015ppm. The range of the lead levels is from 0.0953 to 4.7822ppm (Table 3). The cadmium level in the water samples analyzed also went beyond the limit set by the United States Environmental Protection Agency at 0.005ppm (Table 4). The primary source of lead in most drinking water is the piping (lead fitting or solder) used for its distribution [12]. Contamination of drinking-water with cadmium may occur as a result of the presence of cadmium as an impurity in the zinc galvanized pipes or cadmium-containing solders in fittings, water heaters, water coolers, and taps [13] Another possible source of these heavy metals in water would be the site itself. It was mentioned that in BASECO where GK BASECO was placed, wastes of all sorts are present.

Table 3 Concentration of lead (ppm) In water samples before remediation

Areas	Concentration	Standard Deviation
Office	0.0123	0.0025

Table 4 Concentration of cadmium(ppm) in water samples before remediation

Areas	Concentration	Standard Deviation
Office	0.1639	0.0004

1	0.0141	0.0009	1	0.0953	0.0005
2	0.0207	0.0021	2	0.1287	0.0002
3	0.0140	0.0010	3	0.1175	0.0010
4	0.0455	0.0013	4	0.2194	0.0001
5	0.0152	0.0003	5	0.1565	0.0010
6	0.0110	0.0024	6	0.2306	0.0011
7	0.0128	0.0018	7	0.1379	0.0014
8	0.0114	0.0033	8	0.1713	0.0012
9	0.0122	0.0016	9	0.1231	0.0004
10	0.0098	0.0013	10	0.1879	0.0007
11	0.0223	0.0022	11	4.7822	0.0012
12	0.0155	0.0004	12	0.2380	0.0009
13	0.0244	0.0029	13	0.1602	0.0006
14	0.0177	0.0016	14	0.1398	0.0012
15	0.0276	0.0003	15	0.1787	0.0012
16	0.0260	0.0015	16	0.1954	0.0005
17	0.3565	0.0027	17	0.1583	0.0008

Water is essential to everyday living. Water touches the skin and enters the body. It i s used for cleaning, washing, bathing, cooking, gardening and drinking and so it is imperative to keep it as clean as possible. Contaminants in the environment like heavy metals lead and cadmium must be lessened if not removed. In this manner the public will not be exposed to undue health hazards. Decontamination of the water sources in GK BASECO will spare those living in the community from going to the hospital for chelation therapy should heavy metals in the body exceed that which is acceptable.

From a previous study, chitin from shells of *Perna viridis* or tahong was seen to remove lead from contaminated lead laden water [3]. It was used to remove lead and cadmium from the water samples collected from the community of interest. Based on tables 5 and 6, it is shown that lead was adsorbed from the water samples with a removal percentage range of 37.131% to 60.511% . Chitin adsorbed cadmium with a removal percentage range of 42.982% to 62.411%. The removal of heavy metals (lead) by chitin from contaminated water is due complexation reaction [14].

Table 5 Concentration of lead (ppm) in water after samples after remediation

Areas	Concentration	Standard Deviation	Percent of lead removed
Office	0.0048	0.0012	60.976
1	0.0053	0.0007	62.411
2	0.0098	0.0011	52.657
3	0.0061	0.0009	56.428
4	0.0212	0.0011	53.406
5	0.0065	0.0004	57.237
6	0.0047	0.0021	57.273
7	0.0051	0.0009	60.156
8	0.0065	0.0012	42.982
9	0.0058	0.0012	52.459
10	0.0045	0.0011	54.082
11	0.0099	0.0012	55.605

Table 6 Concentration of cadmium (ppm) in water after remediation

Areas	Concentration	Standard Deviation	Percent of lead removed
Office	0.0849	0.0006	48.200
1	0.0453	0.0004	52.466
2	0.0675	0.0003	47.552
3	0.0464	0.0008	60.511
4	0.1076	0.0003	50.957
5	0.0734	0.0007	53.099
6	0.1176	0.0010	49.003
7	0.0648	0.0012	53.009
8	0.0847	0.0010	50.554
9	0.0601	0.0006	51.178
10	0.0878	0.0005	53.273
11	3.0065	0.0013	37.131

12	0.0068	0.0008	56.129	12	0.1045	0.0008	56.092
13	0.0112	0.0019	54.098	13	0.0812	0.0005	49.313
14	0.0081	0.0011	54.237	14	0.0712	0.0010	49.070
15	0.0135	0.0004	51.087	15	0.0839	0.0010	53.049
16	0.0110	0.0008	57.692	16	0.0928	0.0006	52.508
17	0.1345	0.0016	62.272	17	0.0721	0.0007	54.454

4. Conclusions

The results of the study showed that tap water samples from households and office at GK BASECO in Manila, Philippines contained lead and cadmium heavy metals whose concentrations exceeded the allowable set limit by the United States Environmental Protection Agency of 0.015ppm and 0.005ppm respectively. Chitin from the shells of *Perna viridis* or Tahong showed the ability to remove lead (37.131% to 60.511%) and cadmium (42.982% to 62.411%.) from the collected actual community tap water.

5. Recommendations

An engineered decontaminating chitin from tahong shells that can be fitted into the nozzle of tap water faucets is recommended. Studies on water container with several layers of chitin in the structure are suggested to fully clean stored tap water prior to use. Microbial assays must be performed on the lead and cadmium decontaminated water to ascertain its safety prior to actual use. Researches geared on other decontaminating substances preferably coming from wastes like fruit and vegetable peels must be initiated. This will lead to sustainable development and somehow prevent the progress of global warming through waste recycling. It is highly recommended to find the source of the heavy metals in GK BASECO and remove them from the site through bio or phyto remediation. Residents of GK BASECO must undergo health assessment to ascertain extent of lead and cadmium body burden and receive medical treatment as necessary.

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