International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.4, pp 1836-1845, 2015

Determination of Ph Levels and Cadmium Content of Surface, Ground Water and Aquatic Life in Bustos, Bulacan, Philippines

Editha N. De Regla, Marilyn S. De Leon, Edwin A. Estrella, Butch Stephen C. Duay

Bulacan State University, Bustos Campus, Bustos, Bulacan, Philippines 3007

Abstract: This study is a descriptive cross-sectional analysis of the pH levels and the concentration of cadmium in the surface and ground waters in the Municipality of Bustos. Also it analyzed the cadmium content in selected species of aquatic life in Bustos, Bulacan.
Through the use of the Suntex Portable pH meter (Model TS-2) from the Bulacan State University Bustos Campus, it was established that the pH levels of the surface water from Angat River Network in Bustos, Bulacan and ground water from selected barangays in the Municipality of Bustos are all within the accepted level which is pegged at 7.
Through the use of Flame Atomic Absorption Spectrophotometer, it was established that that the cadmium concentration of the surface and ground water is within the allowable limits (WHO standard of 0.005 ppm (5ppb) for Cd, 2010).
Also it was established that cadmium concentrations in the head, meat, bone, tail and intestines of Leiopotherapon plumbeus or Lukaok, Glossogobius giuris or Biya, Oreochromis niloticus or Tilapia, Misgurnus fossils or Bulig, Cyprinus carpio or Carpa, and Macrobrachium rosenbergo or Prawn are within the allowable limits set by WHO. To wit, 0.005 ppm (5 ppb) for cadmium respectively.
Key Words: pH levels, heavy metals, flame atomic absorption spectrometry, Angat River Network in Bustos Bulacan, aquatic life, surface water, ground water.

Introduction

Section 2 of Republic Act 9275, An Act Providing for a Comprehensive Water Quality Management and for other Purposes, stipulates that the state shall pursue a policy of economic growth in a manner consistent with the protection, preservation and revival of the quality of our fresh, brackish and marine waters.

Water or H2O, as lifted from the Wikipedia, the Free Encyclopedia in the internet, "is the most abundant compound on the Earth's surface, covering 70 percent of the planet. In nature, water exists in liquid, solid, and gaseous states. It is in dynamic equilibrium between the liquid and gas states at standard temperature and pressure. It further states "that many substances dissolve in water and it is commonly referred to as the universal solvent. Because of this, water in nature and in use is rarely pure and some properties may vary from those of the pure substance. Water makes up 55% to 78% of the human body." (www.en.wikipedia.org/wiki.properties_of_water).[1]

History will attest that ancient civilization started where there is water. Great animal migrations tend to lead towards water sources. Humans can survive with just water for seven days. Water has many therapeutic uses. Hydroelectric power comes from water. Waterways serve as an important means of transportation ever

since time immemorial. And the list of water uses goes on and on. Needless to say, water is a necessity in human lives.

In chemistry, as lifted again from Wikipedia, "water pH (power of hydrogen) is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline.[2] Pure water has a pH very close to 7.The pH scale is traceable to a set of standard solutions whose pH is established by international agreement."

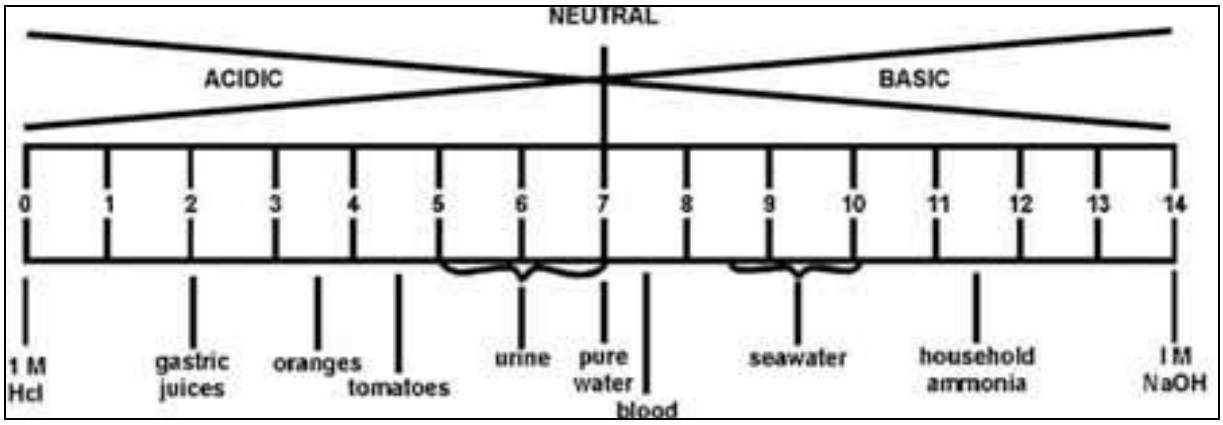

Figure 1.Water: Monitoring &Assessment

(Lifted from United States Environmental Protection Agency)

Figure 1 presents a graphical representation of the pH levels of water and other common liquids. In connection with the figure, Wikipedia also explains "that primary pH standard values are determined using a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such as the silver chloride electrode. Measurement of pH for aqueous solutions can be done with a glass electrode and a pH meter, or using indicators. pH measurements are important in medicine, biology, chemistry, agriculture, forestry, food science, environmental science, oceanography, civil engineering, chemical engineering, nutrition, water treatment & water purification, and many other applications."

The Background Document for Development of WHO Guidelines for Drinking-Water Quality, pH in Drinking Water explains that the pH of water is a measure of the acid-base equilibrium and, in most natural waters, is controlled by the carbon dioxide-bicarbonate equilibrium system.[3] An increased carbon dioxide concentration will therefore lower pH, whereas a decrease will cause it to rise. Temperature will also affect the equilibrium and the pH. In pure water, a decrease in pH of about 0.45 occurs as the temperature is raised by 25 degrees Celsius. In water with a buffering capacity imparted by bicarbonate and hydroxyl ions, this temperature effect is modified . The pH of most raw water lies within the range of 6.5-8.5 .

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.

Though water is essential in controlling temperature, hydration and almost all mechanisms in the human body, it is also quite imperative that humans ingest clean and potable drinking water. For drinking unsafe and unclean water can be both detrimental and fatal. Hence, water can also be a carrier not just of nutrients and electrolytes needed by the human body, but also of microbes, disease vectors and pathogens and above standard level of toxins like heavy metals. Such elements can pose as a health hazard or cause of death if left unnoticed, unabated or untreated. According to the Philippine National Standard for Drinking Water (2007), certain inorganic constituents may be present in drinking water as a result of leaching out of piping or plumbing materials such as lead, copper, asbestos, nickel and cadmium.[4] Some of these chemicals are known or suspected carcinogens such as arsenic, lead, cadmium and chromium, etc.

In the review of Chaitali V. Mohod and Jayashree Dhote (2013) of heavy metals in drinking water and their effect on human health in Maharashtra, India, they concluded that the drinking water samples contain metal concentration that are more than the admissible and desirable levels (WHO, EUC, EPA and USEPA).[5] They mentioned that the drinking water should be filtered and should pass through special water treatment lest it will have physiological effects on kidneys, digestive system, circulatory system, nervous system, etc.

According to Wikipedia, the Free Encyclopedia in the internet, the Flame Absorption Spectroscopy is a spectro-analytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation of light by free atoms in the gaseous state.[6] It further elaborates that in analytical chemistry, the said technique is used for determining the concentration of a particular element in a sample to be analyzed. The Flame Atomic Absorption Spectroscopy of FAAS can be used to determine over 70 different elements in a water solutions or can also be used directly in solid samples used in pharmacology, biophysics and toxicology research.

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, Bonga Menor, 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) the pollution of the Pampanga River Basin with household garbage, rice field fertilizers and human excreta has been a perennial provincial problem.[7] 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 can be fatal. Furthermore, Wikipedia also mentions that buildup of cadmium levels in the water, air, and soil has been occurring particularly in industrial areas. Acute exposure to cadmium fumes may cause flu like symptoms including chills, fever, and muscle ache sometimes referred to as "the cadmium blues." More severe exposures can cause tracheo-bronchitis, pneumonitis, and pulmonary edema. Symptoms of inflammation may start hours after the exposure and include cough, dryness and irritation of the nose and throat, headache, dizziness, weakness, fever, chills, and chest pain. Inhaling cadmium-laden dust quickly leads to respiratory tract and kidney problems which can be fatal, often from renal failure. Ingestion of any significant amount of cadmium causes immediate poisoning and damage to the liver and the kidneys. Compounds containing cadmium are also carcinogenic.

Sampling Area

There were thirty (30) sampling points (Figure 1) 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) samples that were brought to the De LaSalle University in Taft, Manila for the Flame Atomic Absorption Spectrophotometer Testing.

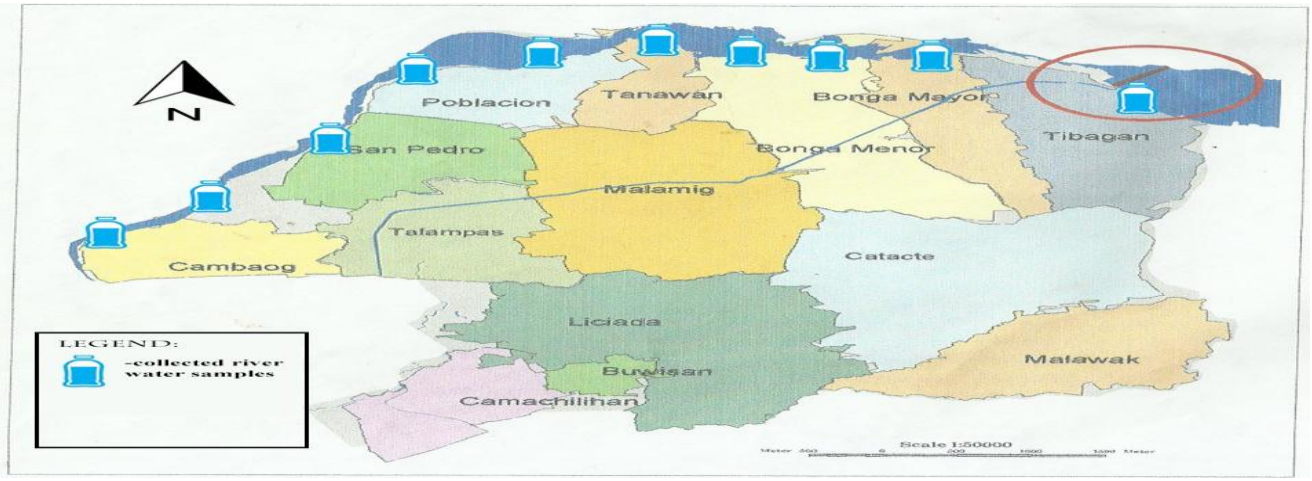

Figure 2. Surface Water Sampling Points in the Angat River Network in Bustos, Bulacan

There were seven (7) ground water sampling areas identified in the barangays of Tanawan, Poblacion, Tibagan, Bonga Mayor and Bonga Menor, San Perdo, Talampas. Figure1 shows the vicinity map where the samples of ground water were retrieved.

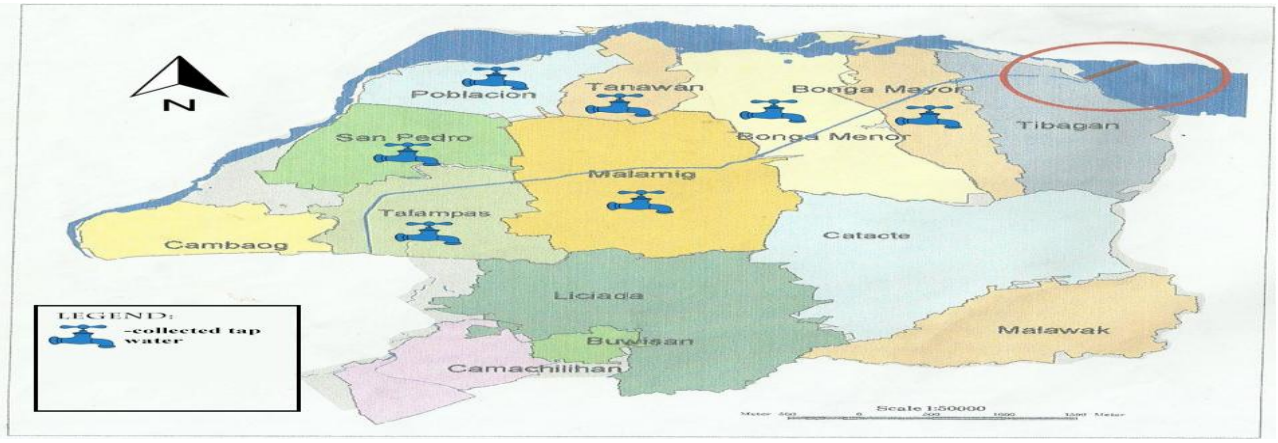

Figure 3. Ground Water Sampling Points in the Municipality of Bustos

The two fishermen who harvested several species of aquatic life were given expressed instructions to retrieve river produce within the entire eight-kilometer stretch of the Angat River Network in Bustos, Bulacan that starts from the Bustos Dam watershed and encompasses the barangays of Tibagan, Bonga Mayor, Bonga Menor, Tanawan, Poblacion, San Pedro and Cambaog (Figure 1).

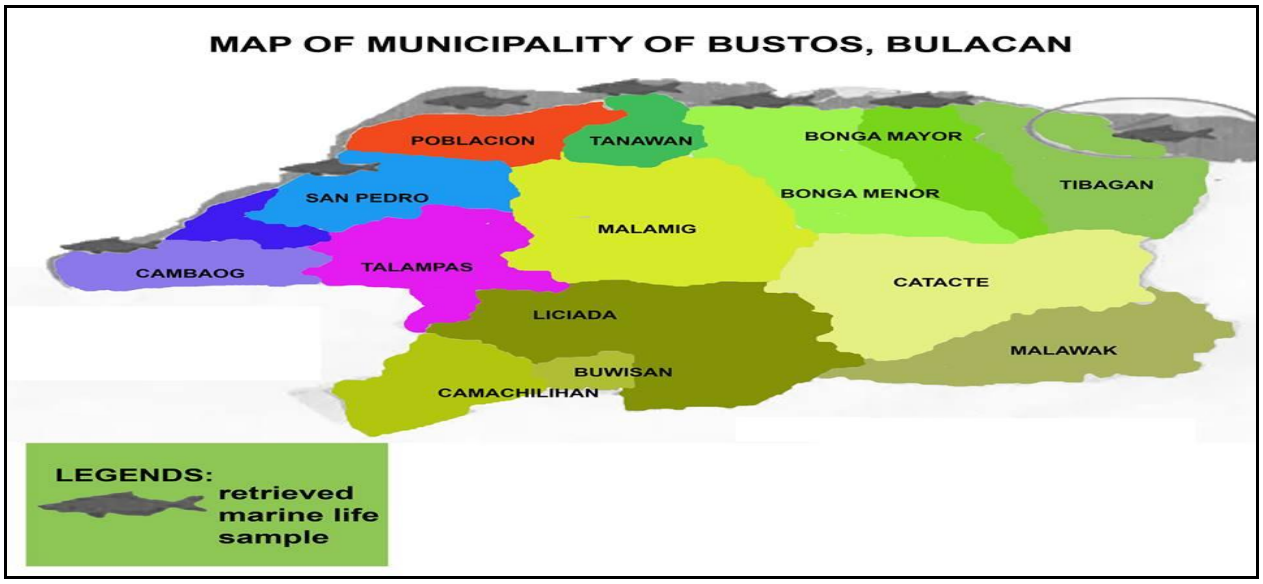

Figure 4. Stretch of the Angat River Network in Bustos, Bulacan where aquatic life were retrieved

Materials and Methods

PET bottles were thoroughly washed with distilled water in preparation for the collection of surface and ground water samples. The surface water samples were collected from the Angat river network in Bustos, Bulacan, Philippines (Figure 2) and stored in PET bottles. The ground water samples were collected from selected Barangays in the Municipality of Bustos, Bulacan, Philippines (Figure 3) and stored in PET bottles. The collected samples of both surface and ground water were filtered and the 100 mL filtrate solutions of both surface and ground water were subjected for the FAAS test.

The pH meter used is Suntex portable pH meter (Model TS-2), alaboratory equipment from the Bulacan State University Bustos Campus, Bustos, Bulacan.

The water samples were subjected to direct measurement of its pH levels using the pH meter. Results were gathered for further analysis.

While to determine the level of cadmium of surface, ground water and selected species of aquatic life , the Flame Atomic Absorption Spectrophotometer (FAAS) AA-6300 (Shimadzu) was rented and used from the De La Salle University in Taft, Manila in October 30, 2014. The filtrate solutions of surface, ground water and selected species of aquatic life were subjected to the FAAS test.

In case of the selected species of aquatic life, the analytic grade nitric acid (500ml) was purchased in Bangbang, Manila. The fish samples were collected from the Angat river network in Bustos, Bulacan, Philippines (Figure 4). The samples were put in an ice box then transported to the BulSU-Bustos Chemistry laboratory. The collected marine species were cleaned and washed with distilled water. These were dissected to different parts, specifically, the bones, tail, head, intestine and meat, and were left to dry at room temperature for three days. The dried samples were digested with the following procedures (Khalifa et.al., 2010): 1 g of each part was dissolved in 1 M nitric acid and then turn into boiling to complete the dissolution and then filtered. The precipitate was washed with 1 M nitric acid and transferred to 25 mL glass tube and fill up to the level with de-ionized water.[8]

Table 1 shows the list of all the tools and equipment used in this study, whereas, Table 2 shows the list of all the reagents and standard solutions used in this study. On the other hand, Table 3 reveals the list of aquatic life harvested in the Angat River Network in Bustos, Bulacan.

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

Tools/Equipment	Quantity
Wash bottle	4
PET bottles	440
pH meter	1
Goggles	10
Face mask	10
Gloves	10
Filter paper	120
Funnel	15
25 mL volumetric flask	10
1 mL and 10 mL pipette	4
Aspirator bulb	4
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	18 L
Buffer Solution pH 4	50 mL
Buffer Solution pH 7	50 mL
Dissecting Scissors	1
Dissecting Tweezers	1
1000 ml, 250 ml and 100 ml Beakers	4
Graduated Cylinder	1
Fume hood	1
De-ionized water	18 L
Working metal standard solution	120 mL
0.10 Ppm standard solution	10 mL

0.25 ppm standard solution	30 mL
0.50 ppm standard solution	30 mL
0.75 ppm standard solution	30 mL
1.00 ppm standard solution	30 mL

2% (v/v) HCl	1 L
2% (v/v) HNO_3	1 L
1 M HNO_3	500 mL

Table 3. List of Marine Life Harvested in the Angat River Network in Bustos, Bulacan

Local Name	Scientific Name
Lukaok	*Leiopotherapon*
Biya	*Glossogobius giuris*
Tilapia	*Oreochromis niloticus*
Gurami	*Trichogaster lalius*
Bulig	*Misgurnus fossilis*
Carpa	*Cyprinus carpio*
Prawn	*Macrobrachium rosenbergii*

Results and Discussion

Table 4 shows the pH levels of the surface water samples in the different sampling points in the Angat River Network in Bustos, Bulacan. On the other hand, Table 5 shows the pH levels of the ground water samples in selected barangays in the Municipality of Bustos.

Table 4. pH Levels of Surface Water Samples in the Angat River Network in Bustos, Bulacan

Water Samples from the Angat River Network in Bustos, Bulacan	pH Levels	Water Samples from the Angat River Network in Bustos, Bulacan	pH Levels
Bunga Mayor 1A – Top	6.99	Poblacion 6A-Middle	6.39
Bunga Mayor 1A-Middle	6.93	Poblacion 6A- Bottom	6.43
Bunga Mayor 1A- Bottom	7.01	Poblacion 6B- Top	6.46
Bunga Mayor 1B- Top	6.96	Poblacion 6B- Middle	6.50
Bunga Mayor 1B- Middle	6.94	Poblacion 6B- Bottom	6.46
Bunga Mayor 1B- Bottom	6.97	Poblacion 6C- Top	6.46
Bunga Mayor 1C- Top	6.95	Poblacion 6C- Middle	6.46
Bunga Mayor 1C- Middle	6.95	Poblacion 6C- Bottom	6.47
Bunga Mayor 1C- Bottom	6.78	San Pedro 7A- Top	7.05
Bunga Menor 2A- Top	7.05	San Pedro 7A- Middle	6.98
Bunga Menor 2A- Middle	6.97	San Pedro 7A- Bottom	6.92
Bunga Menor 2A- Bottom	6.95	San Pedro 7B- Top	6.87
Bunga Menor 2B- Top	6.95	San Pedro 7B-Middle	6.87
Bunga Menor 2B- Middle	6.94	San Pedro 7B- Bottom	6.85
Bunga Menor 2B- Bottom	6.88	San Pedro 7C- Top	6.84
Bunga Menor 2C- Top	6.89	San Pedro 7C- Middle	6.81
Bunga Menor 2C- Middle	6.88	San Pedro 7C- Bottom	6.81
Bunga Menor 2C- Bottom	6.93	Talampas 8A- Top	6.74
Bunga Menor 3A- Top	7.03	Talampas 8A- Middle	6.75
Bunga Menor 3A- Middle	7.19	Talampas 8A- Bottom	6.75
Bunga Menor 3A- Bottom	7.04	Talampas 8B- Top	6.77

Bunga Menor 3B- Top	7.02	Talampas 8B- Middle	6.75
Bunga Menor 3B- Middle	6.97	Talampas 8B- Bottom	6.84
Bunga Menor 3B- Bottom	6.94	Talampas 8C- Top	6.79
Bunga Menor 3C-Top	6.92	Talampas 8C- Middle	6.77
Bunga Menor 3C- Middle	6.90	Talampas 8C- Bottom	6.76
Bunga Menor 3C- Bottom	6.88	Cambaog 9A- Top	6.75
Tanawan 4A- Top	6.96	Cambaog 9A- Middle	6.79
Tanawan 4A-Middle	6.98	Cambaog 9A- Bottom	6.76
Tanawan 4A- Bottom	6.97	Cambaog 9B- Top	6.73
Tanawan 4B-Top	6.96	Cambaog 9B- Middle	6.85
Tanawan 4B- Middle	6.94	Cambaog 9B- Bottom	6.79
Tanawan 4B- Bottom	6.92	Cambaog 9C- Top	7.68
Tanawan 4C- Top	6.93	Cambaog 9C- Middle	7.61
Tanawan 4C- Middle	6.92	Cambaog 9C-Bottom	7.52
Tanawan 4C- Bottom	6.90	Cambaog 10A-Top	7.46
Poblacion 5A- Top	6.94	Cambaog 10A- Middle	7.55
Poblacion 5A- Middle	6.91	Cambaog 10A- Bottom	7.28
Poblacion 5A- Bottom	6.89	Tibagan A- Top	7.15
Poblacion 5B- Top	6.88	Tibagan A- Middle	7.03
Poblacion 5B- Middle	6.89	Tibagan B- Top	7.08
Poblacion 5B- Bottom	6.97	Tibagan B- Middle	7.03
Poblacion 5C- Top	6.93	Tibagan B- Bottom	7.01
Poblacion 5C- Middle	6.87	Tibagan C- Top	7.08
Poblacion 5C- Bottom	6.86	Tibagan C- Middle	7.14
Poblacion 6A- Top	6.35	Tibagan C- Bottom	7.12

Table 5. pH Levels of Ground Water Samples in Selected Barangays in Bustos, Bulacan

Ground Water Samples	pH Levels
Bunga Mayor 1	6.84
Bunga Mayor 2	6.85
Bunga Mayor 3	6.79
Poblacion	6.80
Tibagan 1	6.77
Tibagan 2	6.72
Tibagan 3	6.64
San Pedro 1	6.75
San Pedro 2	6.80
Tanawan	6.68
Malamig	6.65
Bunga Menor 1	6.75
Bunga Menor 2	6.73
Bunga Menor 3	6.70

It can be gleaned from Tables 4 and 5 that the pH levels of the surface water samples from the Angat River Network in Bustos, Bulacan and the ground water samples from selected barangays in the Municipality of Bustos are all close to the accepted pH level of water which is set at 7.0.

On the other hand, Table 6 shows the concentration of cadmium detected by the FAAS in the surface water samples in the different sampling points in the Angat River Network in Bustos, Bulacan.

Table 6 . Concentration of Cadmium in the Waters of Angat River Network in Bustos, Bulacan

Sample Waters in the Angat River Network in Bustos, Bulacan	Concentration of Cd, ppm	Sample Waters in the Angat River Network in Bustos, Bulacan	Concentration of Cd, ppm
Bunga Mayor 1A - Top	-0.0013	Poblacion 6A- Top	0.0016
Bunga Mayor 1A-Middle	-0.0055	Poblacion 6A-Middle	-0.0029
Bunga Mayor 1A- Bottom	-0.0023	Poblacion 6A- Bottom	0.0005
Bunga Mayor 1B- Top	-0.0023	Poblacion 6B- Top	-0.0029
Bunga Mayor 1B- Middle	-0.0039	Poblacion 6B- Middle	-0.0039
Bunga Mayor 1B- Bottom	-0.0055	Poblacion 6B- Bottom	0.0010
Bunga Mayor 1C- Top	-0.0031	Poblacion 6C- Top	-0.0016
Bunga Mayor 1C- Middle	-0.0016	Poblacion 6C- Middle	-0.0008
Bunga Mayor 1C- Bottom	-0.0039	Poblacion 6C- Bottom	-0.0003
Bunga Menor 2A- Top	-0.0034	San Pedro 7A- Top	0.0010
Bunga Menor 2A- Middle	-0.0010	San Pedro 7A- Middle	-0.0026
Bunga Menor 2A- Bottom	0.0013	San Pedro 7A- Bottom	0.0000
Bunga Menor 2B- Top	-0.0031	San Pedro 7B- Top	0.0018
Bunga Menor 2B- Middle	0.0000	San Pedro 7B-Middle	-0.0047
Bunga Menor 2B- Bottom	0.0023	San Pedro 7B- Bottom	-0.0023
Bunga Menor 2C- Top	-0.0005	San Pedro 7C- Top	0.0005
Bunga Menor 2C- Middle	0.0008	San Pedro 7C- Middle	0.0008
Bunga Menor 2C- Bottom	-0.0026	San Pedro 7C- Bottom	-0.0005
Bunga Menor 3A- Top	-0.0013	Talampas 8A- Top	-0.0010
Bunga Menor 3A- Middle	0.0005	Talampas 8A- Middle	-0.0034
Bunga Menor 3A- Bottom	0.0021	Talampas 8A- Bottom	-0.0003
Bunga Menor 3B- Top	0.0013	Talampas 8B- Top	-0.0010
Bunga Menor 3B- Middle	0.0013	Talampas 8B- Middle	-0.0010
Bunga Menor 3B- Bottom	-0.0021	Talampas 8B- Bottom	0.0005
Bunga Menor 3C-Top	0.0003	Talampas 8C- Top	0.0013
Bunga Menor 3C- Middle	-0.0023	Talampas 8C- Middle	-0.0034
Bunga Menor 3C- Bottom	0.0010	Talampas 8C- Bottom	-0.0023
Tanawan 4A- Top	-0.0010	Cambaog 9A- Top	-0.0010
Tanawan 4A-Middle	-0.0010	Cambaog 9A- Middle	-0.0023
Tanawan 4A- Bottom	-0.0031	Cambaog 9A- Bottom	-0.0008
Tanawan 4B-Top	-0.0021	Cambaog 9B- Top	-0.0010
Tanawan 4B- Middle	-0.0016	Cambaog 9B- Middle	-0.0013
Tanawan 4B- Bottom	-0.0010	Cambaog 9B- Bottom	-0.0005
Tanawan 4C- Top	-0.0023	Cambaog 9C- Top	0.0016
Tanawan 4C- Middle	-0.0016	Cambaog 9C- Middle	-0.0013
Tanawan 4C- Bottom	-0.0018	Cambaog 9C-Bottom	-0.0023
Poblacion 5A- Top	0.0005	Tibagan A- Top	-0.0021
Poblacion 5A- Middle	-0.0010	Tibagan A- Middle	-0.0034
Poblacion 5A- Bottom	-0.0042	Tibagan A- Bottom	-0.0031
Poblacion 5B- Top	0.0018	Tibagan B- Top	-0.0039
Poblacion 5B- Middle	-0.0008	Tibagan B- Middle	-0.0034
Poblacion 5B- Bottom	-0.0026	Tibagan B- Bottom	-0.0037
Poblacion 5C- Top	-0.0034	Tibagan C- Top	-0.0042
Poblacion 5C- Middle	-0.0005	Tibagan C- Middle	-0.0037
Poblacion 5C- Bottom	-0.0016	Tibagan C- Bottom	-0.0039
		MEAN	-0.0014

It can be gleaned from the table above that in all the 90 sampling points in the Angat River Network in Bustos, Bulacan, it was determined that the level of cadmium concentration was below the acceptable limits set by the WHO which is at 0.005 ppm (5 ppb).

It was further established that the highest cadmium concentration was retrieved in the center middle river waters in Bunga Menor, Bustos, Bulacan (0.0023 ppm), still below the acceptable limits.

The above results of the water samples retrieved from the Angat River Newtork in Bustos, Bulacan that were subjected to FAAS testing are similar to the results in the study of Samar (2013) et al. entitled Application of Stable Isotopes to the Assessment of Pollution Loading from Various Sources in the Pampanga River System in the Manila Bay, Philippines. In the said study, the cadmium concentration in the Pampanga River System was also within the allowable limits for public health.

Table 7 shows the concentration of cadmium detected by the FAAS in the selected species of aquatic life from the Angat River Network in Bustos, Bulacan.

Table 7. Concentration of Cadmium in Selected Species of Marine Life in the Angat River Network in Bustos, Bulacan

Fish Sample Scientific/ Local Names	Heavy Metal Concentration (Cd), ppm				
	Head	Meat	Bone	Tail	Intestine
	Conc.	Conc.	Conc.	Conc.	Conc.
Leiopotherapon plumbeus / Lukaok	-0.0462	-0.0434	-0.0461	-0.0459	-0.042
Glossogobius giuris/ Biya	-0.0464	-0.0414	-0.045	-0.0484	-0.0453
Oreochromis niloticus /Tilapia	-0.0431	-0.0478	-0.0475	-0.0484	-0.0392
Trichogaster lalius /Gurami	-0.0476	-0.0475	-0.0484	-0.0498	-0.047
Misgurnus fossilis/Bulig	-0.0475	-0.0453	-0.0453	-0.047	-0.0423
Cyprinus carpio /Carpa	-0.0436	-0.0475	-0.0456	-0.045	-0.0222
Macrobrachium rosenbergii /Prawn	-0.0442	-0.0489	N/A	N/A	N/A

It can be gleaned from Tables 7 that cadmium concentrations in the head, meat, bone, tail and intestines of Leiopotherapon plumbeus or Lukaok, Glossogobius giuris or Biya, Oreochromis niloticus or Tilapia, Misgurnus fossils or Bulig, Cyprinus carpio or Carpa, and Macrobrachium rosenbergo or Prawn are within the allowable limits set by WHO. To wit, 0.005ppm (5 ppb) for cadmium respectively.

Conclusion and Recommendation

The researchers therefore conclude that the pH level of the surface waters in the Angat River Network in Bustos, Bulacan and ground waters in selected barangays in the Municipality of Bustos are acceptable. On the other hand, the cadmium concentration in the surface and ground waters and some selected species of aquatic life are within the safe or negligible limits.

However, it is still recommended that the local government unit should adopt and strictly enforce a comprehensive solid and liquid waste disposal system in order to preserve the water quality in the Angat River Network in Bustos, Bulacan. Furthermore, periodic monitoring should be implemented on the river maintenance and preservation. Before river waters is used, distributed or fished upon, and before ground water is distributed, they should always pass the criteria on standard parameters set by the Philippine National Standards for Drinking Water and the World Health Organization

References

1. Properties of Water, "Wikipedia, The Free Encyclopedia". Wikipedia Foundation, Incorporated. 22 July 2004. Web 10 August, 2004. English Language Medium, Accessed on November 2, 2014. (http://en.wikipedia.org/wiki/properties_of_water).
2. pH of Water, "Wikipedia, The Free Encyclopedia". Wikipedia Foundation, Incorporated. 22 July 2004. Web 10 August, 2004. English Language Medium, Accessed on November 2, 2014. (www.en.wikipedia.org/wiki.pH_of_water)
3. World Health Organization, "Guidelines for Drinking-water Quality", pH in Drinking-water, Vol.2 2nd ed. (Health Criteria and other Supporting Information) Geneva, 1996.
4. 4. Philippine Standards for Drinking Water (2007), English Language Medium, Accessed on November 10, 2014
5. Mohod, Chaitali V. and Jayashree Dhote, "Review of Heavy Metals in Drinking Water and their Effect on Human Health", International Journal of Innovative Research in Science, Engineering and Technology, Vol.2, Issue 7, 2013.
6. Atomic Absorption Spectroscopy, "Wikipedia, The Free Encyclopedia". Wikipedia Foundation, Inc. 22 July 2004. Web 10 August, 2004. English, Accessed November 2, 2014. (http://en.wikipedia.org/wiki/Atomic_Absorption_Spectroscopy#Flame_atomizers).
7. Samar, Edna D., Mario Collado, Allan Anida, Marcelina Palis, Perla Estabello, Andrew Flores, Teoderica Fajardo, Frances Villajuan, Soledad, Efren Sta. Maria and Jennyvive Ramirez, "Application of Stable Isotopes to the Assessment Pollution Loading from Various Sources in the Pampanga River System in the Manila Bay, Philippines", 2013.
8. Khalifa K.M., A.M. Hamil, A.Q.A. Al-Houni and M.A. Ackacha, "Determination of Heavy Metals in Fish Species of the Mediterranean Sea (Libyan Coastline) Using the Atomic Absorption Spectrometry", International Journal of PharmTech Research CODEN USA, Vol.2, No.2, pp 1350-1354, 2010.

*****