Tropical Technology Journal
Volume 17, January – December 2014
ISSN: 1656-0264

PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SPRING WATERS IN ARGAO, CEBU

Pinote JP, Alburo RP, Alburo HM and Cutillas AL
Cebu Technological University-Argao Campus

ABSTRACT

Water is one of the most vital and peculiar substances on Earth. It is very essential that every individual have access to safe drinking water because it is a basic human right. Without water, nothing could live. A person takes about eight to 10 glasses of water daily. This study was conducted to determine the physico-chemical and bacteriological qualities of 15 spring water sources in Argao, Cebu using the Philippine National Standards for Drinking Water (PNSDW). Water samples were brought to a DOH accredited laboratory to analyze the following parameters namely; Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) using Gravimetric method; pH using the Electrometric method; Salinity using Conductemetric method; Bicarbonates and Ca using Titration; Chlorides using Argentometric method; Mg by calculation; Na, Lead, and Mercury by *AAS* method; sulfates by Turbidimitric Method; zinc by Zircon Method and total hardness by EDTA Titrimetric Method. For Total Fecal Coliforms and *E. coli*, Multiple Tube Fermentation Technique was used. Results revealed that all the 15 water samples failed in Total Coliform and HPC test although it passed in the Fecal and *E. coli* test. Lead content is below the threshold level of 0.01 ppm. Seventy-seven per cent of the samples passed the standards while the rest failed. Overall results are alarming because communities derive their drinking water from these sources. It is deemed important that communities be educated on the proper care of their springs and the LGU to do periodic monitoring to prevent water-related diseases outbreaks.

Keywords: drinking water, water parameter, total coliform, standards, disease outbreaks

INTRODUCTION

Water resources are generally taken for granted until its use is threatened by reduced availability or quality. Pollution is a problem in almost all waterways-rivers, lakes, springs, estuaries, and even oceans, once erroneously thought to be able to assimilate almost everything. Water pollution affects man's health, aesthetic appreciation and recreational use of water. Water pollution is produced primarily by the activities of man, specifically his mismanagement of water resources. The pollutants are any chemical, physical or biological substances that affect the natural condition of water or its intended use. Because water pollution threatens the availability, quality and usefulness of water, it is of worldwide critical concern.

In recent years, Metro Cebu has faced an enigma in its water resources. Cebu's groundwater has already been depleted. Depletion has been translated and measured in terms of areal extent of seawater intrusion, decreasing quantity, and increasing poor quality. Since 1985, the 50-ppm isosalinity level of groundwater has progressively moving towards inland. As of 1995, this level has already reached at about 3-4 kilometers from the coast and, unfortunately, it is still moving inland (WRC, n.d.). The 50-ppm isosalinity line indicates seawater intrusion. Aside from the impacts of seawater intrusion on health, it further aggravates the low water supply of the area and degrades the quality of the resource.

A project study of Reffin (1994) has shown that 10 to 20 percent of the toxic and hazardous waste in Cebu's groundwater comes from domestic waste. Water can also cause illness and death when it becomes contaminated. Many people who cannot be secured by water supply services have to depend on dug wells, spring sources, rainwater, and other sources that are easily contaminated. This situation resulted in the findings that 80 percent of all diseases and over one-third of deaths in developing countries are caused by polluted water (Soriano, 1995).

These conditions prove the inefficiency of the current resource exploitation. Inefficiency has been brought about, partly by the inefficient pricing of the resources and, partly by negligence. The notion of water scarcity has not gained much consideration in any development plan in the area (Bagarinao, 1999). It can be seen in the low pricing scheme for the groundwater resource and the no-pricing scheme for surface water resources. The groundwater resource has been priced very low so that people tend to extract more. As more people continue to extract and use groundwater, the safe yield of the resource would gradually lessen. Because these people are practically paying nothing for the resource they extract, they tend to use water wastefully. This condition is very evident in remote areas where people use deep wells for their water supply. Or in case of piped water, it can be seen in the high unaccounted-for-water of the local water district. Approximately 38 percent of Metro Cebu Water district's total production is unaccounted for. Unfortunately, this figure is eight (8) percent higher than the overall average for developing countries (David *et.al*. 1998).

In the Municipality of Argao with the present population of almost 70 thousand only about six (6) percent have access to potable water while the rest of the populace rely their water sources from springs, rivers, and deep wells. Since the town is blessed with so many spring waters the researchers have decided to conduct a study to evaluate the physico-chemical and bacteriological parameters of the Argao spring water sources as basis for potable water source recommendation.

MATERIALS AND METHODS

Procurement of Permits

Prior to the actual field activity, necessary permits from the Local Government Units, both Municipal and Barangay was secured. A Memorandum of Agreement by and between the Local Government Unit of Argao and Cebu Technological University was also made for a collaborative endeavor.

Identification of Collection Sites

Most of the 15 springs identified in this paper are located within the Argao watershed. These springs are found in seven (7) barangays of the municipality. The 15 springs are: Balde, Arnis, Kilat, Cabongbongan, Alawihaw, Linao, Mantalaga, Masulog, Sandayong, Baki, Ulbuhan, Bulak, Ka-iran, Pawa and Banyo.

Collection of Water Samples for Analysis

Water samples were collected from August to November 2012. Within a day, samples were brought to Talisay Water Laboratory for the physical, chemical and microbial testing. Water samples were contained in sterile bottles (1000ml and 100ml capacity) and properly labeled containers provided by the laboratory to prevent accidental contamination.

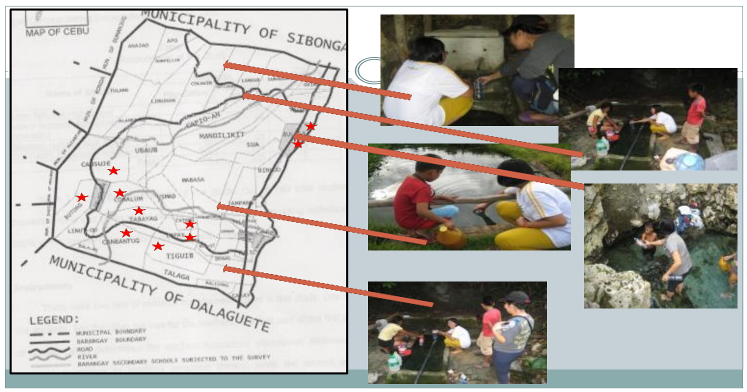

Figure 1.The Map of the Municipality of Argao with Barangays where Water were Taken.

Figure 2. Sample Sites with the Researches taking Water Samples.

RESULTS AND DISCUSSION

This section presents the results of the physico-chemical analysis and bacteriological test of the spring water samples collected in the barangays of the municipality of Argao.

Physico Chemical Properties

There were 15 water samples taken from the 15 spring water sources located in various barangays in Argao (Tables 1 and 2). Results of the laboratory analyses are presented based on specific parameters as follows:

ISSN: 1656-0264

Total Dissolve Solids (TDS). As reflected in Tables 1 and 2, the water sample taken from Arnis spring has shown the highest TDS of 986 ppm, while all the other water samples have a value lower than the Maximum Acceptable Level (MAL) of the (PNSDW), which is 500 ppm. This shows that Arnis spring relatively contains more inorganic salts like calcium, magnesium, potassium, bicarbonates, chlorides and sulfates. Solids can affect the taste and appearance of drinking water. Water with TDS between 0 and 500 mg/L is considered to be suitable for human consumption while water containing more than the MAL can be heated to reduce the TDS to drinkable quality level (Castor, 2012).

Table 1. Physical and Chemical Parameters using TDS, TSS, pH, Salinity, bicarbonates, calcium and chloride values of the 15 water samples tested.

Parameter/s	Method/s	MAL	RESULT/S														
			Balde, Usmad	Arnis, Bulasa	Kilat, Tabayag	Cabongbongan, Cansuje	Alawihaw, Bug-ot	Linao, Bulasa	Mantalaga, Usmad	Masulog, Cansuje	Sandayong, Malacorong	Baki, Malacorong	Catang, Ulbuhan	Cabantug, Bulak	Cabantug, Corbada	Pawa, Catang	Banyo, Catang
Total Dissolved Solids (TDS)	Gravimetric	500 ppm	382	986	362	296	350	434	366	264	386	416	268	157	149	266	341
TSS,mg/L	Gravimetric	25 ppm	22	72	0	6	0	40	12	6	0	10	0	0	0	0	0
pH (potential Hydrogen)	Electrometric	6.5-8.5	6.92	6.89	6.95	6.87	6.75	6.79	6.86	6.94	6.95	6.96	7.06	7.18	7.18	7.1	7
Salinity	Conductemetric	1 ppm	0.3 ppt	0.9 ppt	0.3 ppt	0.3 ppt	0.3 ppt	0.4 ppt	0.3 ppt	0.2 ppt	0.3 ppt	0.4 ppt	0.3 ppt	0.2 ppt	0.1 ppt	0.3 ppt	0.3 ppt
Bicarbonates (HCO_3) as	Titration	-	436.9	486	474.93	433.48	547.46	483.6	523.28	354.04	542.28	804.78	392.03	255.6	245.43	471.37	668.35
Calcium (Ca), mg/L	Titration	-	187.9	378.1	184.48	115.37	110.23	352.4	143.93	154.78	130.79	128.51	171.34	128.51	114.23	165.63	127.93
Chloride (Cl^-)	Argentometric	250 ppm	2.84	408.4	7.09	8.51	4.25	62.11	1.99	4.25	1.13	3.12	5.53	3.83	2.3	5.02	11.15

MAL – Maximum Acceptable Level based on PNS for Drinking Water 2007 guidelines
*ppm – parts per million
*mg/L – milligrams per liter

Table 2. Parameter Values of Magnesium, Sodium, Sulfates, Lead, Mercury, Zinc and Total Hardness of the Spring Water Samples.

Parameter/s	Method/s	MAL	RESULT/S														
			Balde, Usmad	Arnis, Bulasa	Kilat, Tabayag	Cabongbongan, Cansuje	Alawihaw, Bug-ot	Linao, Bulasa	Mantalaga, Usmad	Masulog, Cansuje	Sandayong, Malacorong	Baki, Malacorong	Catang, Ulbuhan	Cabantug, Bulak	Cabantug, Corbada	Pawa, Catang	Banyo, Catang
Magnesium (Mg)	Calculation	-	8.05	10.27	5.27	9.58	24.43	15.68	17.76	5.55	16.79	17.35	11.78	3.16	4.72	8.3	25.29
Sodium (Na)	AAS	mg/L	17.83	92.03	16.89	13.81	16.33	20.25	17.08	12.32	18.01	19.41	12.51	7.33	6.95	12.41	15.91
Sulfate	Turbidimetric	250ppm	84	0.45	0.11	<0.016	<0.021	8	<0.0167	<0.0162	0.5	0.79	4.81	1.88	1.68	5.55	2.1
Lead	AAS	0.01ppm	24	24	<0.0024	<0.0024	<0.0024	24	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024
Mercury	AAS	m	01	01	<0.0001	<0.0001	<0.0001	01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zinc ion	Zincon	5 ppm	05	05	<0.0005	<0.0005	<0.0005	05	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Hardness as CaCO3	EDTA Titrimetric	300ppm	221	420.4	206.18	154.78	210.75	317	217.03	177.62	199.9	199.99	219.83	141.53	133.65	199.78	231.99

*MAL – Maximum Acceptable Level based on PNS for Drinking Water 2007 guidelines
*ppm – parts per million *mg/L – milligrams per liter

Water Hardness	Classification	mg/L or ppm
	Soft	0 -17.1
	Slightly hard	17.2-60
	Moderately hard	61-120
	Hard	121-180
	Very Hard	181 & over

 ISSN: 1656-0264

Total Suspended Solids (TSS). Results also showed that the sample obtained from Arnis spring exhibited the highest TSS amounting to 72 ppm followed by Linao spring having 40 ppm, which both exceeds the maximum acceptable level of 25 ppm. Eight out of 15 samples exhibited zero TSS while the other five (5) springs have TSS below the MAL. This means that the waters in Arnis and Linao springs contain small amounts of solids like silt, decaying plant and animal matter, sewage and harmful solids which could be hazardous to health.

pH Level. Tables 1 and 2 also reflect the pH values of the water samples. The pH values in all the spring water sources ranged from 6.75 to 7.18. The lowest pH was recorded in Alawihaw spring while the highest was in Bulak and Ka-iran springs both in Canbantug. This means that pH levels of all the springs sampled are within acceptable standards with a MAL of 6.5 to 8.5. The pH value of any drinking water should be checked because when acidic waters (with low pH values) are in contact with certain chemicals and metals will often become more toxic than normal (Castor, 2012).

Salinity. The limit of water salinity for fresh water is 1 ppt or 1000 parts per million (Engineering toolbox.com). In Tables 1 and 2, it can be gleaned that all of the samples have salinity values ranging from 0.2 ppt to 0.9 ppt, which implies that all springs passed the standards for salinity. It was also noted that the water sample from Arnis spring had the highest salinity value of 0.9ppt. This is because Arnis spring is located near the shoreline.

Bicarbonates (HCO_3^-) as $CaCO_3$ mg/L. This parameter is one of the major functions of alkalinity. It is the total measure of the substances in water that have an "acid-neutralizing" ability. As can be gleaned from Tables 1 and 2, the water sample from Baki spring obtained the highest value of 804.78 while the lowest value of 245.43 is observed in Ka-Iran (Curbada) spring in barangay Canbantug. In Figure 6, the amount of Calcium in mg/L was observed to be highest in Arnis spring with **378.09** mg/L followed by Linao spring with **352.44** mg/L. The lowest value of 115.37 was observed in Cabongbongan spring in Cansuje. It means that Baki, Arnis and Linao springs have **very hard water**, Canbantug springs are considered **hard** while the spring water from Cabongbongan is considered as **medium hard** water. Hardness is expressed in milligrams per liter of equivalent calcium carbonate. The hardness of natural waters varies considerably and can be approximately classified according to the degree of hardness they contain. **Very soft** water has less than 15 mg/L of $CaCO_3$, **soft** water is between 15 to 60 mg/L of $CaCO_3$. Medium hard water has 61 to 120 mg/L, hard water ranges from 121 to 180 mg/L and very hard water has a value greater than 180 mg/L. The presence of more calcium results to formation of scales at elevated levels.

Chlorides. The presence of chlorides in water causes corrosion of metals at a higher concentration and the maximum acceptable value for drinking water is 250 ppm. The highest percentage of chloride is observed from the water sample taken from Arnis spring with 408.38 ppm while the lowest value of 1.13 ppm is obtained from Sandayong spring. This implies that water from the 14 other springs is within the Maximum Acceptable Level. Lower chloride content means that it has a lesser tendency to corrode metals such as iron whose reaction can be observed when faucet handles or fixtures turn to greenish color.

ISSN: 1656-0264

Magnesium (Mg) mg/L. This parameter indicates the hardness of water sample, as this is one of the components of water hardness. As shown in Tables 1 and 2, the water sample taken from Arnis spring still contains the highest value of 10.27. Hardness minerals in water have a wide impact on households. When hard water is heated, a hard scale is formed that can plug pipes and coat heating elements. Scale is also a poor heat conductor. With increase deposit on the unit, heat is not transmitted to the water fast enough and overheating of the metal cause failure. Build-ups of deposit will also reduce the efficiency of the heating unit thereby increasing the cost of fuel. Water hardness is reported as either milligrams per liter (parts per million) of calcium carbonate or grains per gallon.

Sodium. Freshwater consists less than 1,000 mg/L of sodium (salinity). Sodium is usually included with other salts and reported in water analysis as TDS. Based from results, only the water sample taken from Bulasa showed the highest percentage of Sodium, owing perhaps to the proximity of this water source to the shoreline. The rest of the water samples have Sodium contents within the maximum acceptable level.

Sulfates. The presence of sulfates in drinking water can cause noticeable taste and very high levels might cause a laxative effect in unaccustomed consumers (WHO, 2006). Tables 1 and 2 show that water sample from all sources have not exceeded the minimal value of 250 mg/liter. High concentrations of sulfate in the water that people drink can have a laxative effect when combined with calcium and magnesium, the two (2) most common constituents of hardness.

Lead. Tables 1 and 2 showed that all the water samples taken from the 15 spring water sources have passed the Maximum acceptable value of lead equivalent to 0-01 ppm. It means that there is no danger for the consumers of these water to develop an anti-social behavior or neurological abnormalities as observed in studies conducted (Solidum, REDTI VOL.6).

Mercury. Mercury occurs naturally in freshwater and groundwater in the inorganic form. The acceptable level of Mercury metal in drinkable water is 0.001 ppm or 0.001 mg/Litre according to PNSDW (2007). Tables 1 and 2 showed mercury value lower than the acceptable limit, which implies that the water taken from the spring water sources in Argao does not contain a harmful amount of mercury.

Zinc. Zinc imparts an undesirable astringent taste to water at a taste threshold concentration of about 4 mg/Liter based on the guideline value as zinc sulfate (PNSDW, 2007). Tables 1 and 2, showed the result of Zinc metal test. As can be seen from the tables, the samples have shown a value of 0.0005 ppm, which is far from the allowable limit of 5 ppm (WHO, 2006). This indicates that the water contains a very minimal amount of zinc and is not dangerous to the consumer.

Total Hardness. Hardness is due to the presence of naturally occurring divalent cations such as calcium, magnesium and strontium resulting from the contact of acidic ground water with rocks such as limestone and dolomite. As shown in Tables 1 and 2, the highest percentage of calcium carbonate is present in the water sample obtained from the springs in Bulasa namely Arnis and Linao springs. Hard water interferes with almost every cleaning task from laundering

 ISSN: 1656-0264

and dishwashing to bathing and personal grooming. Clothes laundered in hard water may look dingy and feel harsh and scratchy. Dishes and glasses may be spotted when dry. Hair washed in hard water may feel sticky and look dull. Hard water may cause a film on glass shower doors, shower walls, and bathtubs. In hard water, the soaps combined with hardness minerals to form soap curds or soap scum. Cooking in hard water can also be difficult. Hard water can also produce scale on pots. Some vegetables cooked in hard water lose color and flavor. Beans and peas become tough and shriveled. Hardness beyond the standard value maybe acceptable for drinking by the consumers in certain areas and most likely by the consumers of the places where water samples were taken.

Bacteriological Test Results for Drinking Water

Total Coliform and Heterotrophic Plate Count. As gleaned from Table 3 all the water samples taken from the 15 springs failed in Total Coliform and HPC test. This means that all the water samples contain coliforms and certain bacteria. The standard acceptable value for TC is <1.1 and HPC is <500 colony forming units per ml. All the results in TC test showed a value of >8. As for HPC, only three (3) water sources have a passing test while the other sources showed a very high range from 516 to a value >6500 CFU/ml. It means that the water is not safe for drinking. Disease outbreak may have not occurred among water drinkers from these springs because people might have already developed tolerance towards these parameters.

Table 3. Bacteriological Analysis of the Water Samples.

Waterspring Sources	Total Coliform (Standard: <1.1)	Fecal Coliform (Standard: <1.1)	*Escherichia coli*	Heterotrphic Plate Count
Balde, Usmad	>8	<1.1	negative	<500
Arnis Bulasa	>8	<1.1	negative	>6500
Kilat Tabayag	>8	<1.1	negative	516
Cabongbongan, Cansuje	>8	<1.1	negative	1462
Alawihan, Bug-ot	>8	<1.1	negative	>6500
Linao, Bulasa	>8	<1.1	negative	1349
Mantalaga, Usmad	>8	<1.1	negative	>6500
Masulog, Cansuje	>8	<1.1	negative	910
Sandayong, Malacorong	>8	<1.1	negative	1527
Baki, Malacorong	>8	<1.1	negative	>6500
Catang, Ulbuhan	>8	<1.1	negative	395
Bulak, Cabantug	>8	<1.1	negative	>6500
Cabantug, Corbada	>8	<1.1	negative	401
Pawa, Catang	>8	<1.1	negative	376
Banyo, Catang	>8	<1.1	negative	1218

Method Used: MTFT –Multiple Tube Fermentation Technique MPN/100 mL Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998l

CONCLUSION

Based on the parameters tested, Arnis spring consistently had high values on most parameters tested. It contains *986 ppm TDS*, *72 ppm TSS,* 420 mg/L Total Hardness, *92.03 mg/L* sodium and *408.4 mg/L* of chlorides. These results could be attributed to its close distance to the seashore while the water from Baki spring also contains the highest Bicarbonates value of *804.78 mg/L.* Although acceptability aspects of drinking water quality do not have adverse health implications. Standards are set to satisfy the need of consumers for a colorless, odorless and tasteless drinking water.

 ISSN: 1656-0264

Drinking-water supplies should be free from contamination by human and animal excreta, which can contain a variety of microbial contaminants. Microbiological parameters are indices of potential waterborne diseases and, in general, are limited to bacteria, viruses and pathogenic protozoa.

All spring water sources failed in terms of TC and HPC. Total coliform could be considered as part of natural aquatic flora because of their re-growth in water. Because of this characteristic, their detection in water supply may mean false positive for fecal contamination.

Another way by which false positive can occur is when the bacteria *Aeromonas* is present in the sample. *Aeromonas* can biochemically mimic the coliform group. *False negatives* can occur when coliforms are present along with high populations of HPC bacteria. The presence of HPC bacteria may restrict the activities of coliform group bacteria. Heterotrophic Plate Count (HPC) describes a broad group of bacteria that include pathogens, non-pathogens and opportunistic microorganisms. HPC could be used to indicate general biological condition of drinking water as a consequence of insufficiency of treatment processes, re-growth or recontamination of drinking water in the distribution system. The MAL is < 500 CFU /ml. Finally, from the 15 spring water samples only three sources have passed the MAL for HPC.

RECOMMENDATIONS

From the results of this baseline investigation, it is recommended that the Local Government Unit (LGU) thru the Municipal Health Unit and other agencies, including Cebu Technological University conduct information, education and communication campaign on hygienic practices for the communities using the spring waters. It is likewise suggested that periodic monitoring of water quality should be done to prevent outbreaks of water-borne diseases in the future. Furthermore, concerned agencies should also adopt water safety plans and follows the principles and concepts of multiple-barrier approach and Hazard Analysis Critical Control Point (HACCP) as used in the food industry such as the use of water reservoir where chlorination and filtration process be used to kill harmful bacteria in the drinking water. Finally, more studies on the culture and identification of the microorganisms present should be conducted.

LITERATURE CITED

The Encyclopedia Americana. (1980).International Edition.Vol.28.Grolier International, Inc.

Davies Dewen M., 1987. **Freshwater**. New York: Natural History Press.

Enger, Elden, D. et. al., 1988, **Concepts in Biology**. Michigan: Wm C. Brown Publishing Company.

Fuller, Edward C., 1987. **Chemistry and Man's Environment**. Boston: Houghton Mifflin Company.

 ISSN: 1656-0264

Keeton, William T. et al., 1993. **Elements of Biological Science**. 3rd Ed. New York: W.W Norton and Co.

Kobbe Fred, et al. Chemistry, Energy and Human Ecology. Boston: Houghton Mifflin Company, 1996.

Mesina, Allan., 1996. **A Primer on Philippine Environmental Data**. Philippines: Pages Publishing Artists Co.

Mc. Ghee, Terence J., 1991. **Water Supply and Resources**. New York: Mc. Graw Hill International.

Maybeck, Michel, et al., 1990. **Global Freshwater Quality**: A First Assessment United Kingdom: Oxford Publication.

Odum, Eugene P., 1981. **Fundamentals of Ecology**. Philadelphia: W.B. Saunders Company.

Revelle, K., et. al.,1991. **Survival Equation: Man's Resources and His Environment**. Boston Houghton Mifflin Company.

Santiago, Florenda I., et al., 1996. **Environmental Science: A Shared Responsibility Towards the Earth**. Manila: Rex Book Store.

Storer, Tracy I., et al., 1986. **General Zoology**. New York. Graw Hill Book Company, 1992.

Volk, Wesley A., et al. **Basic Microbiology**. 6th ed., New York: Harper and Row Publisher.

Baril, Carlito R. "Sustainable Development of Laguna de Bay Prospects and Problems," Philippine Technology Journal. Vol. XVII, no. 2 (April – June 1992), 5.

Bagarinao, R. "Measuring the Costs and Benefits of Groundwater Protection in Cebu City," Journal of Environmental Science and Management, 1999.

Barret, Mike; Nalubega, Mai and Pedley, Stephen. "On-Site Sanitation and Urban Aquifer Systems in Uganda", Waterlines, Vol. 17, no. 4, April 1999, p. 10.

Chio, Joseph, etl al. "A Study on the Environment Impact of Detergents I: Detergents Level in Laguna de Bay and Davao River." The Philippine Journal of Science, (December 1992).

Cohen, M. Environmental Information vs. Environmental Attitudes. Journal of Environmental Education. 1973, 5: 5-8.

David Mac Donald et al, Pit Latrines. A Source of Contamination in Peri-Urban. Dhaka, Waterlines, Vol. 17, (Nov. 4, April 1999), 6.

 ISSN: 1656-0264

Dura, Fredisvinda B. "An Assessment and Suggested Treatment of the Pollution Load of the Pachderm Lagoon Wastewater." The Philippine Scientists, Vol. 16. 1989.

Environmental Protection Agency (EPA) Volk, Manual of Individual Water Supply Systems, U.S. Office of Drinking Water, Washington, DC., 1982

Genthe, B. et. al. Water Sciences and Technology, Waterlines, vol. 17, April 1999.

Guerrero, Rafael III. "The Conservation of our Freshwater Ecosystem," R and D Publication, Vol. 10, No. I. (December, 1992), 32.

Health and Home, vol. 36, 1996, p. 24.

Herrera, Christine. "Boracay Operators Cry." Philippine Graphic, (July 1997).

Madamba, Lilia S. P. "Pollution Load Contribution of Sta. Cruz River to Laguna de Bay." Philippine Journal Science, Vol. 121 no. 3 (1992).

McCarthy, Laura Flynn. Family Life, August 1998, p. 40-43.

Olson, Erik, Natural Resources Defense Council, Family Life, August 1998, p. 42,

Philippine National Standards for Drinking Water, (PNSDW) Memorandum 2007-0012, march 9, 2007.

Tacio, Henrilito, "R.P. Faces Pollution and Pollution Problem." Philippine Graphic, (January, 1997).

Young Students Learning Library, Water: Vol. 21, Newfield Publication Inc., 1972, p. 2549

Waterlines. UNICEF, vol. 18 no.1, July, 1999.

Woodiwiss, C. "Notrolotriacetic Acid (NTA) Concentration in Philippines Water, River Water and Drinking Water Survey," R and D Publication, (March 21, 1988), 11.

Zuckerman, L. "The Pollution Syndrome," The Journal of Environmental Education, Vol. 3, no. 1, (1991), 28.

Argao Comprehensive Developmental Master Plan, Argao Cebu. Region VII. 2000-2005.

Comprehensive Development Plan. 1980-2000, December, 1980. Municipality of Calamba, Laguna, Region IV.

Brown, Robert, "The Power of Human Values," Lectern, (February, 1995), 1.

Encyclopedia American, Vol. 14.

 ISSN: 1656-0264

Geothe, B., et al. Water Sciences and Technology, Waterlines, Vol. 17, 1999, 24.

Hairston, James E. et al. Physical Contaminants and Problems, Water Hardness – The Alabama Cooperative Extension Service, Aubrun University, p. 1 of 1.

Haupt, Frank. Hairston et al. Depend or Service Sanitation and Hygiene Promotion in the Aral Sear Director Zone, Waterlines, Vol. 18, (Nov. 1, July 199), 30.

Howard, Guy. On-Site Sanitation and Ground Water: The Art of Balancing the Unknown Risks, Waterlines, Vol. 17, No. 4, (April 1999), 23.

Kobayashi, J. "Relationship Between the Ita-Itai Disease and Water Pollution of River Water by Cadmium from a Mine," Advance in Water Pollution Research 5th International Conference, 1981.

Mike Barret, Mai Nalubega and Stephan Pedley, On-Site Sanitation and Urban Aquifer Systems in Uganda, Waterlines, Vol. 7, (Nov. 4, April 1999), 10.

Progress Report Prepared by the Mines and Technology Division Mines and Geo Sciences Bureau. Department of Environment and Natural Resources, 1996.

Reed, Tommy. "How Pollution Affects Wildlife?" www.\\http. Pollution. Wildlife.

Saywell, Darren. Pollution from On-Site Sanitation The Risks?, Waterlines, Vol. 17, (Nov. 4, April 1999), 22-23.

Saywell, Darren and Shaw, Rod. On-Plot Sanitation in Low Income Urban Communities, Waterlines, Vol. 18, (Nov. 1, July 1999), 19.

Third Annual report, The Council for Environmental Quality, (1996: 111)

Tacudin, Vitaliano. "Pollution – Coastal Pollution." A paper presented during the 9th BIOTA Convention, 1995.

World Health Organization (WHO), 1994, p. 5.

Downloaded from Internet

American Water Works Association (AWWA), http/www.goggle.waterlines.com, p. 1 of 3.

Dissolved Oxygen, http//www.watersheds., page 1 of 3.

Dioleno, et. al. 1996. (http//www.watersheds., page 1 to 3).

 ISSN: 1656-0264

Hairston, James E., Striblling, "Typical Contaminants and Problems", Water Hardness. The Alabama Cooperative Extension Service, Auburn University, (Downloaded from the Internet pp. 1, 2, 3, 4, 5).

http/www.goggle.water.com

McCann, Alyson, et. al. Water Quality Facts, University of Rhode Island, September 1994. (http//www.watersheds., page 1 to 5).

Water Sheds, Water Resource Characterization DSS – Salinity, page 1 of 3.

Water Sheds, Water Resource Characterization DSS – Turbidity, page 1 of 3.

Water Sheds, Water Resource Characterization DSS – Viruses, page 1 of 3.

Water Sheds, Water Resource Characterization DSS – Pesticides, page 1 of 4.

McCann, Alyson et al., Water Quality Facts, University of Rhode Island, 1994, page 1 of 5 and page 1 of 3.