ASSESSMENT OF WATER QUALITY IN MAJOR FRESHWATER SOURCE OF EL SALVADOR CITY, PHILIPPINES

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ABSTRACT: *This study aimed to evaluate the quality of freshwater resources in El Salvador City, Philippines, by analyzing its physicochemical, heavy metal, and microbial characteristics. Water samples were collected from a deep well source and tested for various parameters. The results showed that while the physicochemical characteristics of the water were mostly within acceptable limits set by the Philippines, chloride levels occasionally exceeded the maximum limit. Heavy metal and other metal levels were generally within acceptable limits, except for antimony which exceeded the stricter standards of the USA and EU. However, the water consistently failed microbial tests for total coliform and E. coli, indicating possible contamination at the source, and making it unsuitable for human consumption. These findings emphasize the need for improved management of water resources to ensure access to safe drinking water in El Salvador City.*

Keywords: Water quality, heavy metals, total coliform, E. coli, physicochemical characteristics

I. INTRODUCTION

Water is an essential resource for all life forms on earth, as its existence is critical for survival. The planet is mostly covered by water, with approximately 71% of its surface being water, equivalent to 1,386,000,000 cubic kilometers worldwide. Unfortunately, 97% of this water is located in the oceans, seas, and bays, rendering it too saline for human consumption, agriculture, or industry, except as a coolant. Approximately 2% is present in frozen glaciers and polar ice caps, which means less than 1% of the world's water is available for human use in the form of lakes, rivers, reservoirs, and aquifers. This scarcity of freshwater resources highlights its significant value as a precious commodity in terms of quantity [1,2,3,4].

Freshwater is a vital and dynamic element of the natural environment, which humans heavily depend on for drinking, washing, bathing, and other activities such as agriculture and industry. Given that humans consume water, the quality of the water is of utmost importance. The water used for consumption must be free from substances or contaminants that may cause illness. Water quality encompasses more than just microbial safety, such as complying with the standard for indicator organisms (total coliform/E. coli). Adequate attention must also be given to minimize individuals' exposure to chemical and physical hazards that may be ingested through contaminated drinking water.

Access to freshwater is limited in many regions around the world. According to the World Health Organization's report from 2000, 1.1 billion people lack access to safe drinking water supplies, and 2.4 billion people lack basic sanitation services. The increasing demand for freshwater due to population growth, rapid industrialization, and economic development exacerbates this issue. These developments generate significant quantities of anthropogenic and industrial wastes that can compromise water systems' quality. Furthermore, the two major environmental challenges confronting humanity today, climate change and ozone depletion, threaten the quality, quantity, and treatability of this vital resource [2]. Failing to address these issues will undoubtedly intensify the problem in the future.

Given the factors mentioned above, it is crucial to conduct a study on the levels of certain physicochemical, heavy metal, and microbial characteristics of the key freshwater resources in El Salvador City, Philippines. As a primarily industrial zone, the city is home to numerous companies, plants, and factories. The findings of this study could serve as a valuable basis for decision-making regarding the management of water resources intended for human consumption.

II. MATERIALS AND METHODS

Sampling

Clean polyethylene bottles were used to collect water samples. Prior to use, all bottles were acid-washed and rinsed thoroughly with high-quality distilled water. For microbial testing, separate sterile bottles were utilized for the water samples. An aseptic technique was employed when collecting samples for microbiological analysis. After collection, all samples were promptly placed in a polystyrene foam box with ice and kept there until they arrived at the laboratory.

Physico-chemical Analyses

The parameters analyzed included pH, temperature, turbidity, conductivity, total dissolved solids (TDS), salinity, chlorides, total hardness, and total organic carbon (TOC). The HACH sension5 Conductivity Meter was used to measure conductivity, TDS, and salinity. Chloride content was determined using the formula calculated from the salinity:

$$Chloride\ \left(\frac{mg}{L}\right) = \frac{Salinity\ (in\ ppt)}{1.80655} \times 1000$$

The turbidity was also determined onsite using the HACH 2100Q turbidimeter. The total hardness was determined by the standard EDTA titration method [5].

The total organic carbon (TOC) was determined via the direct method of Hach, utilizing the spectrophotometric technique known as Method 10129. This low-range method is designed to measure TOC concentrations ranging from 0.3 to 20.0 mg/L, based on color changes observed in an indicator solution caused by changes in pH resulting from the CO_2 generated during the oxidation of organic carbon by persulfate in a reagent-containing vial. The absorbance was measured using the HACH DR 5000 UV-Vis spectrophotometer at 598 and 430 nm.

Analysis of Heavy Metals and Other Metals

This research analyzed nine different metals in the water samples, namely arsenic, cadmium, copper, mercury, lead, aluminum, zinc, iron, and antimony. The analysis methods used were flame atomic absorption spectroscopy for zinc, copper, iron, lead, and cadmium, and cold vapor spectrometry for mercury. Inductively coupled plasma-optical emission spectroscopy was used to analyze antimony, while silver diethyldithiocarbamate and eriochrome cyanine R were used to analyze arsenic and aluminum, respectively. For water samples that could not be analyzed within 24 hours, pH adjustment was done using concentrated nitric acid to preserve the samples.

Micorbiological Test (Total Coliform and Escherichia Coli)

The membrane filtration method was used to conduct microbial testing on all samples. Total coliforms were quantified by counting the number of colonies, while the presence or absence of E. coli was determined based on the appearance of E. coli colony/ies.

III. RESULTS AND DISCUSSION

The water quality data for the freshwater from the deep well at Brgy. Poblacion are presented in three tables below. Table 1 provides information on the physicochemical characteristics of the water. Table 2 shows the levels of selected metals and metals. Finally, Table 3 summarizes the results of microbial tests conducted on the water sample.

Table 1. Physico-Chemical Analysis of Freshwater in El Salvador City

Sampling	Parameter									
	Conductivity (µS/cm)	pH	TOC (mg/L C)	Appearance	Turbidity (NTU)	Temp (°C)	TDS (mg/L)	Salinity (ppt)	Chlorides (mg/L)	Total Hardness (mg/L $CaCO_3$)
First	929.0	7.34	11.6	color-less	0.14	29.2	455.0	0.5	277	143.9
Second	1001	7.23	44.9	color-less	0.08	27.6	419.0	0.4	221	108.4
Third	849.0	7.19	16.0	color-less	0.15	28.7	415.0	0.4	221	107.8
Fourth	848.0	7.29	21.2	color-less	0.11	29.9	414.0	0.4	221	149.1
PNSDW Std[1]		6.5-8.5			5		500		250	300
USA Std[2]		6.5-8.5			5		500		250	
EU Std[3]	2,500	6.5-9.5	No abnormal change	Acceptable, no abnormal change	Acceptable, no abnormal change				250	
WHO Std[4]										

[1]Philippine National Standards for Drinking Water (2007), [3]Drinking Water Directive – European Union (1998)
[2]Drinking Water Standards and Health Advisories – USEPA (2012), [4]Guidelines for Drinking Water Quality – WHO (2011)

Table 2. Freshwater Quality in El Salvador: Heavy Metal and Other Metal Content

Sampling	Parameter								
	Pb (mg/L)	Cd (mg/L)	Al (mg/L)	As (mg/L)	Hg (mg/L)	Sb (mg/L)	Zn (mg/L)	Cu (mg/L)	Fe (mg/L)
First	<0.003**	<0.002**	<0.02*	<0.005*	<0.001*	<0.01*	<0.002*	<0.002*	<0.005*
Second	<0.003**	<0.002**	<0.02*	<0.005*	<0.001*	<0.01*	<0.002*	<0.002*	<0.005*
Third	0.005	<0.002**	<0.02*	<0.005*	<0.001*	<0.01*	<0.002*	<0.002*	<0.005*
PNSDW Std[1]	0.01	0.003	0.02	0.05	0.001	0.02	5.0	1.0	1.0
USA Std[2]	0.015 (at tap)	0.005	0.05-0.2	0.010	0.002	0.006	5.0	1.3 (at tap)	0.3
EU Std[3]	0.010	0.005	0.200	0.010	0.0010	0.005		2.0	0.200
WHO Std[4]	0.01	0.003		0.01	0.006	0.02		2.0	

*Method Detection Limit [1]Philippine National Standards for Drinking Water (2007), **Reporting Unit [2]Drinking Water Standards and Health Advisories – USEPA (2012), [3]Drinking Water Directive – European Union (1998)
[4]Guidelines for Drinking Water Quality – WHO (2011)

Table 3. Quality of Freshwater – COWD Deepwell: Microbiological

Samling	Parameter	
	Total Coliform (colonies/100 mL)	*E. coli*
First	TNTC	Present
Second	TNTC	Present
Third	TNTC	Present
PNSDW Std[1]	<1; not more than 5% of samples positive in a month	Absent
USA Std[2]	Not more than 5% of samples positive in a month	Absent
EU Std[3]	0	Absent
WHO Std[4]		Absent

[1]Philippine National Standards for Drinking Water (2007)
[2]Drinking Water Standards and Health Advisories – USEPA (2012)
[3]Drinking Water Directive – European Union (1998)
[4]Guidelines for Drinking Water Quality – WHO (2011)

The water quality analysis showed that the physicochemical parameters of the deep well source water are generally within the acceptable limits set by the Philippines standards, except for occasional high chloride levels which exceed the maximum value of 250 mg/L. However, there are no aesthetic concerns related to other physicochemical parameters. Regarding heavy metals and other metals, all levels are within the acceptable limits set by the PNSDW and other standards, except for antimony which is <0.01 mg/L. It is worth noting that the stricter standards of the USA and EU require lower levels of antimony (0.006 mg/L and 0.005 mg/L, respectively), which means the current levels may exceed these standards. In terms of microbiological quality, all samples tested positive for total coliform and E. coli, indicating potential contamination at the source. This is a recognized issue in the area, and the deepwell water is not considered safe for drinking.

IV. CONCLUSIONS & RECOMMENDATIONS

Based on the findings presented, the water from the deepwell source in El Salvador City, Philippines, has physico-chemical characteristics that are generally within the standards of the Philippines, except for occasional elevated chloride levels. The heavy metals and other metals in the water are also within the PNSDW and other standards, except for antimony, which may exceed stricter standards set by the USA and EU. However, the water consistently failed microbiological tests for total coliform and E. coli, indicating a potential contamination source at the deepwell. Therefore, it cannot be considered as a safe source of drinking water. The findings suggest that there is a need to address the microbial contamination in the deepwell water to ensure the safety of the community's water supply.

V. REFERENCES

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