INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 22, No. 6, p. 13-18, 2023

RESEARCH PAPER OPEN ACCESS

# Water Quality of Major Freshwater Sources in Cagayan de Oro City, Philippines

**Ronnie L. Besagas*, Romeo M. Del Rosario, Girlie D. Leopoldo, Noel T. Dael, and Antonio Y. Asoy**

*University of Science and Technology of Southern Philippines, Cagayan de Oro City, 9000 Philippines*

**Key words:** Water quality, Heavy metals, Total coliform, *E. coli*, Physico-chemical characteristics

http://dx.doi.org/10.12692/ijb/22.6.13-18 Article published on June 05, 2023

## Abstract

This presents the results of the study that tested the water from two sources in Cagayan de Oro City: a deep well in Macasandig and the Bubunawan River. The study evaluated the water's physico-chemical characteristics, heavy metal content, and microbiological quality. For the deep well water, the physico-chemical characteristics met all standards and were deemed aesthetically pleasing. The water had low levels of heavy metals and other metals, except for antimony, which, while within Philippine and WHO standards, may exceed the limits set by the USA and EU due to a higher detection limit. The Bubunawan River water had good physico-chemical characteristics and low heavy metal levels, except for antimony, which was below the Philippine standard but may not meet the USA and EU standards. The water's microbiological quality was also poor, failing tests for total coliform and *E. coli*. Chlorination by the water treatment plant was effective in addressing this issue. The Bubunawan River water was less mineralized than the deep well water but had higher turbidity, which may affect its clarity and transparency. Additionally, the river water had a higher aluminum content, which was approaching the standard limit. Further investigation and monitoring may be necessary to ensure that the aluminum levels do not exceed the allowable limit. Overall, the study highlights the importance of proper disinfection procedures to address microbial issues in both water sources. The study also suggests ongoing monitoring to ensure the water meets acceptable standards and that any potential issues are identified and addressed promptly.

* **Corresponding Author:** Ronnie L. Besagas ✉ rlbesagas@ustp.edu.ph

## Introduction

Water is an important resource to all life on earth. It is vital for the existence of life, for without water, life on earth would not exist. About 71% of the planet is covered by water. This amounts to 1,386,000,000 cubic kilometers, $km^3$, of water worldwide. But 97% of this total water is in the ocean, seas, and bays, which is too salty for drinking, irrigation, or industry (except as coolant). About 2% is frozen in glaciers and polar ice caps, which leaves less than 1% available for human use through lakes, rivers, reservoirs, and aquifers (USGS, 2014; Soh *et al.*, 2007; Wetzel, 2001; Miller, 2000). This shows how precious a commodity freshwater is in terms of quantity.

Freshwater is an essential and dynamic component of the natural environment. Humans rely heavily on it for drinking, washing, bathing, and other areas of human endeavor, such as agriculture and industry. Because humans need to consume water, the quality is a very important consideration. The water for intake must be free from substances or contaminants that can cause illness. Water quality is more than just microbial safety, like passing the standard for indicator organisms (total coliform/*E. coli*). Ample attention must also be given to reducing the exposure of individuals to chemical and physical hazards that can be ingested through contaminated drinking water (Besagas, 2022; Liyanage *et al.*, 2017).

Freshwater is a limited resource in many parts of the world. According to the WHO (2000), 1.1 billion people lack basic access to safe drinking water supplies, and 2.4 billion people lack basic sanitation services. With an increasing demand for freshwater due to population growth, rapid industrialization and economic development, this problem will, in no doubt, be intensified if not addressed. These growths and development only end up producing massive amounts of anthropogenic and industrial wastes, which can degrade our water systems. In addition, the two major environmental problems facing mankind today, climate change and ozone depletion, further threaten the quality, quantity and treatability of this vital resource (Soh *et al.*, 2007).

On the basis of the above, there is an imperative to study the levels of selected physico-chemical, heavy metal, and microbial characteristics of the major freshwater resources Cagayan de Oro City, Philippines. The city has been the locus of many changes—man-made and natural—that could have brought about changes in freshwater qualities of different sources. The results can become good bases for decisions on managing water resources for human consumption.

## Materials and methods

### *Sampling*

Water samples were collected in a clean polyethylene bottle. All bottles were acid-washed and thoroughly rinsed with high-quality distilled water. Separate sterile bottles were used for water samples to be used for microbial testing. An aseptic technique was observed in collecting samples for microbiological testing. All samples were immediately placed in a polystyrene foam box with ice and kept therein while in transit to the laboratory.

### *Physico-chemical analyses*

The following parameters were analyzed: pH, temperature, turbidity, conductivity, total dissolved solids (TDS), salinity, chlorides, total hardness, and total organic carbon (TOC). The conductivity, TDS, and salinity were using HACH sension5 Conductivity Meter. The chloride content was calculated from the salinity using the formula:

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

The turbidity was also determined onsite using the HACH 2100Q turbidimeter. The total hardness was determined by the standard EDTA titration method (PCARRD, 1991).

The total organic carbon (TOC) was determined using the spectrophotometric method of Hach—Method 10129 (Direct Method). This is a low-range method for TOCs from 0.3 to 20.0 mg/L based on indicator color change as affected by a change in pH due to the $CO_2$ generated from the oxidation of organic carbon

by persulfate in a special reagent-containing vial. The absorbance was measured at 598 and 430 nm using HACH DR 5000 UV-Vis spectrophotometer.

*Analysis of heavy metals and other metals*

There were nine metals included in this research: arsenic, cadmium, copper, mercury, lead, aluminum, zinc, iron and antimony. Flame atomic absorption spectroscopy was employed to analyze the zinc, copper, iron, lead and cadmium contents of the samples, while cold vapor spectrometry was used to analyze the mercury. Inductively coupled plasma–optical emission spectroscopy was employed in the analysis of antimony.

The arsenic was analyzed using silver diethyldithiocarbamate, while the aluminum was analyzed using eriochrome cyanine R. Water samples that could not be analyzed within 24 hours from the time of sampling were preserved by adjusting the pH to 2.0 using concentrated nitric acid.

*Microbiological test (Total coliform and Escherichia coli)*

The microbial testing of all samples was carried out using the membrane filtration method. The number of colonies was counted for total coliform, while the *E. coli* was simply presence or absence based on the appearance of *E. coli* colonies.

## Results and discussion

*Basic information of the major sources*

Cagayan de Oro City is a chartered city that is actually independent of the Misamis Oriental Provincial Government. Geographically, it is the 11th local government unit (LGU) from the west end of the province.

The water supply system of the city is managed by Cagayan de Oro Water District or COWD, a government-owned and controlled corporation. The majority of the COWD customer are provided with potable and treated water from deep wells.

**Table 1.** Quality of Freshwater – COWD Deepwell: Physico-Chemical.

| 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 $CaCO_3$) |
| 1st | 613.0 | 8.12 | 4.10 | color-less | 0.30 | 25.8 | 289.0 | 0.3 | 166 | 222.3 |
| 2nd | 591.0 | 7.71 | 5.25 | color-less | 0.27 | 28.4 | 287.0 | 0.3 | 166 | 223.4 |
| 3rd | 598.0 | 6.91 | 6.40 | color-less | 0.13 | 30.8 | 288.0 | 0.3 | 166 | 223.6 |
| 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)
[2]Drinking Water Standards and Health Advisories – USEPA (2012)
[3]Drinking Water Directive – European Union (1998)
[4]Guidelines for Drinking Water Quality – WHO (2011).

In January 2007, the Bulk Water Supply Project (BWSP) of COWD, a supply agreement scheme between the COWD and the contractor for a period of 25 years, was implemented. The western of the city availed of this project. COWD has 26 of the 29 deep wells that are operational. These pumping stations are located in the central (Macasandig), eastern (Bugo, Agusan, Tablon), and western (Canitoan, Balulang, Carmen) parts of the city. The bulk water supply comes from surface water in Baungon, Bukidnon, where it passes through a water treatment facility prior to distribution. Distribution is mainly in the western part, including Opol, Misamis Oriental. Two major sources of water that are tapped by the COWD are a deep well at Brgy. Macasandig and a river-Bubunawan River in Baungun, Bulidnon. The latter is the bulk water supply project referred to earlier—actually through the operation of a private company that withdraws water from the river and subjects it to treatment to produce drinkable water.

**Table 2.** Quality of Freshwater – COWD Deepwell: Heavy Metals and Other Metals.

| 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) |
| 1st | <0.003** | <0.002** | <0.02* | <0.005* | <0.001* | <0.01* | <0.002* | 0.060 | <0.005* |
| 2nd | <0.003** | <0.002** | <0.02* | <0.005* | <0.001* | <0.01* | <0.002* | <0.002* | <0.005* |
| 3rd | <0.003** | <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

**Reporting Unit

[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)

*Quality of the water from the major sources*

The following Tables present the results of testing the water from the deep well in Macasandig, Cagayan de Oro City. Table 1 shows the physico-chemical characteristics of the water, while Table 2 displays the heavy metals and other metals found in the water. Table 3 contains the results of the microbiological tests.

**Table 3.** Quality of Freshwater – COWD Deepweell: Microbiological.

| Samling | Parameter | |
|---|---|---|
| | Total Coliform (colonies/100 mL) | *E. coli* |
| First | 18.5 | Present |
| Second | TNTC | Present |
| Third | 18.0 | 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).

Upon analyzing the physico-chemical characteristics, it is evident that the COWD deep well water meets all standards and is, therefore, aesthetically pleasing. Additionally, the water performs well in terms of heavy metals and other metals, except for antimony (Sb). Although the levels of antimony are within the Philippine and WHO standards, they may exceed the USA and EU standards due to a detection limit of 0.01 mg/L, which is higher than the maximum level allowable for these standards. However, all samples failed in the microbiological characteristics tested, such as total coliform and E. coli, exceeding all standards except for WHO.

These issues can be eliminated through proper disinfection procedures, such as chlorination, which is already included in COWD's standard operating procedures.

**Table 4.** Quality of Freshwater – Bubunanwan River: Physico-Chemical.

| 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 $CaCO_3$) |
| 1st | 89.27 | 8.03 | 10.2 | color-less | 4.40 | 26.3 | 42.20 | 0.1 | 55.3 | 37.96 |
| 2nd | 403.0 | 8.59 | 15.3 | color-less | 4.79 | 25.8 | 193.3 | 0.2 | 111 | 40.51 |
| 3rd | 200.3 | 8.32 | 7.55 | color-less | 4.52 | 26.0 | 96.80 | 0.2 | 111 | 39.50 |
| 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)
[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 next set of tables presents the results of testing the water from the Bubunawan River. Table 4 shows the physico-chemical characteristics of the river's water, while Table 5 displays the heavy metals and other metals found in the water. Table 6 presents the results of the microbiological tests.

Similar to the deep well water, the Bubunawan River water performs well in terms of physico-chemical characteristics and heavy metals and other metals. The only concern is antimony (Sb), which is below the Philippine standard but may not meet the standards of the USA and EU. However, like the deep well water, the river's water failed in its microbiological tests, particularly in total coliform and *E. coli*. Nevertheless, these issues are addressed through effective chlorination by the company that treats the water before it is passed on to COWD.

**Table 5.** Quality of Freshwater – Bubunawan River: Heavy Metals and Other Metals.

| 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) |
| 1st | <0.003** | <0.002** | 0.17 | <0.005* | <0.001* | <0.01* | <0.002* | <0.002* | 0.160 |
| 2nd | <0.003** | <0.002** | 0.20 | <0.005* | <0.001* | <0.01* | <0.002* | <0.002* | <0.005* |
| 3rd | <0.003** | <0.002** | 0.14 | <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
**Reporting Unit
[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).

It was found that the Bubunawan River water is less mineralized compared to the deep well water. This is evidenced by its lower total dissolved solids and total hardness levels. However, it has greater turbidity, which may affect the water's clarity and transparency.

In terms of metals, the Bubunawan River water contains a relatively higher aluminum content, which is approaching the standard limit. This may require further investigation and monitoring to ensure that the aluminum levels do not exceed the allowable limit.

**Table 6.** Quality of Freshwater – Bubunawan River: 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).

Both water sources failed microbiological tests, but the average microbial density in the deep well water is lower than that of the river water. This highlights the need for proper disinfection procedures to address microbial issues, particularly in the Bubunawan River water.

## Conclusion

Both the deep well water and the Bubunawan River water perform well in terms of physico-chemical characteristics and heavy metals and other metals but require proper disinfection procedures to address microbiological issues. The concern regarding antimony (Sb) levels in both water sources may require further investigation to ensure compliance with all relevant standards.

## References

**Besagas RL.** 2017. The Heavy Metals and Microbiological Profiles of the Major Drinking Water Supply System of Cagayan de Oro City, Philippines. International Journal of Biosciences **20(3),** 154-160

**Liyanage C, Yamada K.** 2017. Impact of population growth on the water quality of natural water bodies. Sustainability **9(8),** 1405.

**Miller GT.** 2000. Living in the Environment, Brooks/Cole, Cengage Learning, 20 Davis Drive, Belmont CA 94002-3098, USA.

**PCARRD.** 1991. Standard Methods of Analysis for Soil, Plant Tissue, Water and Fertilizer. Los Baños, Laguna, Philippines.

**Soh Y, Roddick F, Leeuwen J.** 2008. The future of water in Australia: The potential effects of climate change and ozone depletion on Australian water quality, quantity and treatability, from http://www.search.proquest.com/pqcentral/docview/22171507/A18A3C21F87D4ODAPQ/3?accountid=141440

**USGS.** 2014. How much water is there on, in, and above the earth? From http://water.usgs.gov/edu/earthhowmuch.html.

**Wetzel RG.** 2001. Limnology - Lake and River Ecosystems 3rd Ed. San Diego. Academic Press.