MONITORING THE WATER QUALITY OF DOMESTIC AND DRINKING WATER FROM DIFFERENT WATER SOURCES IN CPU CAMPUS

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ABSTRACT

This study determined the quality of domestic and drinking water from different water sources in CPU. This study described the quality of water from the identified thirteen water sources inside CPU campus, nine of which were deep wells and/or water tanks (storing water from wells and from rain) and the four were drinking fountains connected to MIWD pipelines. Results showed that the obtained values of the parameters measured for domestic and drinking water sources both passed the permissible standard values set forth by DENR guidelines for domestic use, and the Philippine National Standard for drinking purposes, respectively. The comparison between the quality of CPU drinking water after treatment and the quality of bottled water shows that the results for conductivity, calcium, sodium, chlorine, sulfate, and magnesium exceeded the values specified for the same parameters in the bottled water. Using the results as the base line data, a flow process showing the steps to consider in case CPU decides to have its own drinking water facility, was prepared.

INTRODUCTION

Background of the Study

Since flooding became a frequent phenomenon in CPU and the surrounding communities, the demand for water quality tests and water treatment services has tremendously increased. For this reason, the CPU College of Engineering has put up a water quality testing and treatment laboratory as one of its outreach programs to assist the government in its campaign for clean and safe water. Once the quality of water has been established and the problems are identified, different water treatment methods will be tested to solve the problem.

Statements of the Problem/ Objectives

The purpose of this study was to determine the water quality of domestic and drinking water from different water sources inside CPU campus.

The following are the specific objectives:

1. To perform water quality tests on samples from different identified sources using color, temperature, pH, alkalinity, acidity, dissolved oxygen, total dissolved solids, conductivity, and turbidity as parameters;
2. To identify the water source contaminated with chemical and biological pollutants and perform additional tests on parameters like chlorine, magnesium, sulfate, sodium, calcium, and biochemical oxygen demand.
3. To perform the bacteriological analysis to all samples;
4. To perform water treatment if ever water quality problems are identified.
5. To retest the quality of the treated water to check the effectiveness of the method of treatment used, and;
6. To determine the capability of the present water laboratory of the College of Engineering to test water quality.

Significance of the Study

Through this project, the CPU community will be made aware of the quality of their domestic and drinking water supplies and at the same time will be encouraged to make necessary efforts to contribute in the preservation of these water resources.

This project will guide the College of Engineering management to identify the apparatus and reagents that should be made available to put the laboratory fully in operation.

This study will also serve as a source of information for the extension service of the university.

Scope of the Study

This study performed both water quality analysis and bacteriological analysis on the water samples collected from the identified water sources inside the CPU campus.

When the result of the analysis showed some problems, a specific water treatment method was applied. The effectiveness of the method applied was determined by retesting the quality of the treated samples.

The data in this study were the results of the experiments performed on the specified parameters of the water samples coming from eleven different water sources found inside the CPU campus.

METHODOLOGY

Research Design

This study described the quality of water from the identified thirteen water sources inside CPU campus, nine of which were deep wells and/or water tanks (storing water from wells and from rain) and the four were drinking fountains connected to MIWD pipelines. Considering that this study performed actual experiments in the laboratory, it is descriptive in nature.

Identification of Sampling Sites

The different water sources inside CPU campus were identified as shown in Table 1. The data gives the exact location of the water source with its corresponding station number.

Table 1. Location of Water Sources in CPU Campus

Location	Station Number
Deep well near Franklin Hall	Station # 1
Deep well near Roblee Hall	Station # 2
Pump near CPU Dumping Site	Station # 3
Deep well at the back of Agriculture Bldg.	Station # 4
Deep well at the back of Mary Thomas Hall	Station # 5
Deep well near Weston Hall	Station # 6
Deep well near Fine Arts Building	Station # 7
Deep well near University Church Parsonage	Station # 8
Water Tank Engineering Building	Station # 9
Drinking Fountain (Mary Thomas Hall)	Station # 10
Drinking Fountain (New Valentine Hall)	Station # 11
Drinking Fountain (Engineering Study Area)	Station # 12
Drinking Fountain (Basketball Court)	Station # 13

Sampling Procedure

In collecting the samples, the researchers had to take the following into account to ensure accurate results:

The sample bottles were rinsed two to three times with the water being collected. When the water samples were collected from faucets, the faucet was cleaned and opened fully and was allowed to run two to three minutes to permit clearing of service line. The flow was restricted to avoid splashing. The cover was lifted without exposing the inside to dust and wind and the bottle was filled after rinsing slowly to allow air space and was covered immediately.

When the samples were collected from the well, the cover was first removed, then the bottle was held near its base and its neck was plunged downward one foot below surface. The sample was collected by sweeping the mouth of the bottle forward.

In collecting samples from the hand pump, the water was pumped to waste for about 3 minutes before filling the sample bottles. This was to ensure that the sample will represent the ground water which feeds the well.

In collecting water samples for bacteriological analysis, 100-150 ml capacity bottles were used. Bottles were first sterilized by heating in the oven for 2 hours at 170°C to avoid contamination. Before sterilization, the caps of the bottles were covered with paper and tied with a string.

For dissolved oxygen determination, the dissolved oxygen bottle was dipped in water and was slowly filled to ensure that no air bubble was entrapped. The bottle was stoppered while still immersed in water. The bottle was turned upside down and sampling was repeated if a bubble was present.

For all water quality tests performed outside the CPU water laboratory, water was sent at once to reach the laboratory within six hours from time of collection.

During the period of transit of sample, the temperature was kept as close as possible to the temperature of the source by not exposing it to sunlight or anything that is hot.

Water Quality Tests Performed

Water quality tests were performed on three samples to all identified water sources in two seasons, during sunny days (April – May, 2002) and rainy days (July – August, 2002).

Tests for temperature, pH, alkalinity, acidity, dissolved oxygen, total dissolved solids, conductivity, and turbidity were conducted in the College of Engineering water laboratory.

Tests for color and biological oxygen demand were performed for a fee in the DENR water laboratory by the DENR personnel in the presence of the researchers. All samples were tested for color. Only one sample taken from sampling station #2 identified as the most polluted in the campus was tested for BOD. Water samples obtained from other sampling stations have no sewage content so these were not tested for BOD.

Tests for chlorine, magnesium, sulfate, sodium ,and calcium were conducted at the DOST Region 6 water laboratory by the DOST personnel in the presence of the researchers. These tests were conducted for two water samples, one from sampling station # 2 (deep well) identified as the most polluted being adjacent to Roblee Science Hall which housed the Chemistry and Life Science Laboratories, and another from sampling station # 12 (drinking fountain) being near the College of Engineering water laboratory, for the purpose of having a baseline data on these specified parameters from two different water sources, for drinking and for domestic use. Drinking water from MIWD pipeline (sampling station # 12) was also included for the purpose of comparing its quality to the quality of bottled water.

The bacteriological analysis was performed by the WVMC hospital's chemists in the presence of the researchers at the Western Visayas Medical Center.

Data Gathering and Processing

Tests which required the use of chemical reagents already available in the laboratory were performed first. These were the tests on pH, temperature, turbidity, conductivity, and dissolved oxygen.

Tests which can be performed in the CPU water laboratory but needed some chemical reagents and materials not available in the laboratory, were performed as soon as the ordered reagents and materials arrived. These were the tests on total dissolved solids, acidity, and alkalinity.

Other tests needed that cannot be done in the CPU water laboratory because of lack of equipment and apparatus were performed in the water laboratories of DENR, DOST and Western Visayas Medical Center.

After all tests were completed and problems were identified, the most appropriate treatment was applied. The quality of water samples were then retested to know whether the treatment applied was effective or not.

RESULTS AND DISCUSSIONS

Water Quality Tests of Domestic Sources

Data in Table 2 show the results of the different water quality tests for CPU domestic water sources. The tests were conducted during sunny days in April and May, 2002. The results for pH revealed that the water samples were almost neutral. It means that the relative amounts of hydrogen and hydroxide ions present were almost equal. The result falls within the DENR permissible limit of 6.5 – 8.5

Table 3 below presents the results of the different water quality test for CPU domestic water sources during rainy days. This was conducted July and August 2002. the results for pH revealed that they are still within the permissible limits of 6.5 – 8.5.

Comparison of the Quality of Domestic Water During Sunny and Rainy Days

Shown in Tables 2 and 3 are the quality of domestic water during sunny days and rainy days, respectively. Results of pH, conductivity, and turbidity increased while temperature, total dissolved solids, acidity, alkalinity, and dissolved oxygen decreased during rainy days.

Turbidity increased which means that the passage of light was being impeded by disturbed particles as a result of the rain. Dissolved oxygen results decreased during the rainy days due to lower levels of photosynthesis. Color results remained at 3 color units and total and faecal coliform tests both gave negative results for all domestic water sources.

Table 2. Quality of Water from Different Domestic Sources During Sunny Days

	Sampling Stations								
Parameters / Indicators	#1	#2	#3	#4	#5	#6	#7	#8	#9
PH	6.84	7.1	6.95	7.16	6.84	6.99	6.91	6.99	7.2
Temperature, °C	30	30	31	29	29.2	30.6	30	30	29.7
Conductivity (μ S/°C) @ T = 20°C	622	654	684	425	628	660	500	650	459
Total Dissolved Solids (TDS), mg/L	600	580	740	340	600	600	340	600	320
Acidity (mg/L $CaCO_3$)	470	404	372	220	540	324	384	444	235
Alkalinity (mg/L $CaCO_3$)	431	492	434	310	562	488	370	362	205
Turbidity (NTU)	4.62	4.0	6.0	5.4	10.9	11.5	3.82	5.88	4.359
Dissolved Oxygen, mg/li	7.44	7.44	7.1	7.46	7.37	7.6	6	5.7	6.89
Color (Color Units)	3	3	3	3	3	3	3	3	3
Total Coliform, MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 3. Quality of Water from Different Domestic Sources During Rainy Days

	Sampling Stations								
Parameters / Indicators	#1	#2	#3	#4	#5	#6	#7	#8	#9
PH	7.01	7.3	7.02	7.19	6.92	7.07	7.53	7.1	7.4
Temperature, °C	29	29	29.8	28.8	28.2	29.8	29.3	28.7	27.9
Conductivity (μ S/°C) @ T = 20°C	830	700	976	787	873	997	1060	886	560
Total Dissolved Solids (TDS), mg/L	250	300	260	203.3	88	228	127	137	302
Acidity (mg/L $CaCO_3$)	200	292	55.5	426	500	144	249	200	135
Alkalinity (mg/L $CaCO_3$)	400	300	400	362	346	430	336	278	105
Turbidity (NTU)	4.7	4.2	6.75	5.88	31.9	11.5	4.82	20.5	4.7
Dissolved Oxygen, mg/li	2.62	4.4	4.1	5.7	3.37	3.6	5.0	4.1	6.5
Color (Color Units)	3	3	3	3	3	3	3	3	3
Total Coliform, MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Water Quality Tests of Drinking Sources

Presented in Table 4 are the results of water quality tests for drinking water sources during sunny days/ Results obtained for pH fall within the MIWD permissible limit (6.5 – 8.5) for drinking water. Conductivity results of both domestic and drinking water showed quite similar results. Engineering drinking fountain (sampling station # 12) got the lowest of 4[illegible] µ S, followed by Mary Thomas drinking fountain (sampling station # 10) followed by the drinking fountain in New Valentine building (sampling station # 11) got the highest conductivity result.

Comparison of the Quality Drinking Water During Sunny and Rainy Days

Results of pH obtained during sunny and rainy days (Table 6) neither decrease or increase uniformly but they fall within MIWD permissible limit of 6.5 – 8.5 for drinking water. Temperature results during rainy days were less compared during sunny days. Results of tests for conductivity, turbidity, alkalinity, and acidity during sunny days. Color results remained at 3 color units and total and faecal coliform tests both gave negative results for all drinking water sources.

Table 4. Quality of CPU Drinking Water During Sunny Days

	Sampling Stations			
Parameters / Indicators	#10	#11	#12	#13
pH	7.75	7.21	7.63	7.7
Temperature, °C	29.5	31	29.7	29.6
Conductivity (µ S/°C) @ T = 20°C	514	640	495	563
Total Dissolved Solids (TDS), mg/L	530	440	230	350
Acidity (mg/L $CaCO_3$)	73	46	23	17
Alkalinity (mg/L $CaCO_3$)	202	274	162	173
Turbidity (NTU)	1.67	0.58	2.95	2.86
Dissolved Oxygen, mg/li	4.03	2.77	3.41	3.5
Color (Color Units)	3	3	3	3
Total Coliform, MPN/100ml	Nil	Nil	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil	Nil	Nil

Table 5. Quality of CPU Drinking Water During Rainy Days

	Sampling Stations			
Parameters / Indicators	#10	#11	#12	#13
pH	7.34	7.53	7.55	7.89
Temperature, °C	29.8	27.8	27	28.1
Conductivity (μ S/°C) @ T = 20°C	371	620	415	221
Total Dissolved Solids (TDS), mg/L	130	70	34	170
Acidity (mg/L $CaCO_3$)	64.33	31.5	22	5
Alkalinity (mg/L $CaCO_3$)	141	108	136	125
Turbidity (NTU)	1.02	0.16	1.5	1.86
Dissolved Oxygen, mg/li	5.68	2.38	3.35	5.87
Color (Color Units)	3	3	3	3
Total Coliform, MPN/100ml	Nil	Nil	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil	Nil	Nil

Quality of Domestic Water After Treatment

Table 6 shows the comparison of the quality of CPU domestic water obtained from sampling station #2 with DENR standard permissible values for domestic water before and after treatment. Sampling Station # 2 was selected because of its vicinity in the laboratories of Chemistry and Life Science Departments. Additional parameters like calcium, sodium, chlorine, ammonia, sulfate, and magnesium were tested. Results showed that the water sample contain salts, namely, calcium, sodium, chlorine, sulfate, and magnesium but the concentrations were below DENR permissible limit for domestic water. The most appropriate method of treatment selected in removing these salts or lessen their concentration was ion-exchange softening.

This process made use of a synthesized insoluble resin made by fusing quartz, kaolin and sodium carbonate with superior exchange property. In this process, sodium resin is represented by Na_2R, the R being the complex resin base, and the ion exchange reactions for water softening are written as

$$Mg^{+2} + Na_2R \quad MgR + 2Na^+$$

$$Ca^{+2} + Na_2R \quad CaR + 2Na^+$$

For the softening cycle, the concentration of sodium ions is low and the reaction proceeds from left to right. The magnesium and calcium ions are trapped by the insoluble solids and the sodium ions are released from the solids into the water stream. When all the available exchange sites on the resin have been occupied by calcium and magnesium, no further removal can occur, and the softening cycle then ends. Extra care was taken to avoid aeration or oxidation, which would produce ferric or manganic ions that would precipitate and clog the ion exchange bed.

After treatment, almost all water quality parameters decreased except for conductivity and sulfate ion results. The results showed that the treatment applied was effective.

Table 6. Comparison of the Quality of CPU Domestic Water From Sampling Station #2 with DENR Standard Permissible Values For Domestic Water Before and After Treatment

Parameters / Indicators	DENR Standard for Domestic Water	Sample #2 Before Treatment	Sample #2 After Treatment
PH	6.5 – 8.5	7.1	7.6
Temperature, °C	30°C	30°C	29.2°C
Conductivity (μ S/°C) @ T = 20°C	None specified	654	928
Total Dissolved Solids (TDS), mg/L	500	580	85
Acidity (mg/L $CaCO_3$)	200 – 400 *	404	233
Alkalinity (mg/L $CaCO_3$)	300 desirable limit 600 permissible limit **	492	438
Biological Oxygen Demand (BOD)	4.0	2.0	2.0
Turbidity (NTU)	10 NTU **	4.0	1.26
Dissolved Oxygen, mg/li	Not less than 5 mg/li	7.44	4.46
Color (Color Units)	15 color units	3	3
Total Coliform, MPN/100ml	50	Nil	Nil
Faecal Coliform, MPN/100ml	20	Nil	Nil
Calcium (mg/li)	None specified	10	-
Sodium (mg/li)	None specified	30	-
Chlorides (mg/li)	250	12	-
Ammoniacal Nitrogen	1 mg/li	Nil	-
Sulfate, SO_4^-	400 mg/li	60	16
Mg	50 mg/li	41	<0.0005

*Philippine National Drinking Water Standard

** INTERNET

Quality of Drinking Water After Treatment

Table 7 shows the comparison of the quality of CPU drinking water obtained from sampling station # 12 before and after treatment with the quality of MIWD drinking water. Both pH and temperature results before and after treatment fall within the permissible limit of MIWD drinking water standard. Conductivity, alkalinity, and dissolved oxygen content increased while total dissolved solids, acidity, and turbidity decreased. Color results remained at 3 color units and total and faecal coliform tests both gave negative results for all drinking water sources. All results before and after treatment fall within the limit of MIWD drinking water standard.

Table 7. Comparison of the Quality of CPU Drinking Water From Sampling Station # 12 with MIWD Standard Permissible Values For Drinking Water Before and After Treatment

Parameters / Indicators	MIWD Standard for Drinking Water*	Sample #12 Before Treatment	Sample #12 After Treatment
pH	6.5 - 8.5	7.55	7.78
Temperature, °C	30°C	30°C	30°C
Conductivity (μ S/°C) @ T = 20°C	None specified	415	450
Total Dissolved Solids (TDS), mg/L	500	34	1
Acidity (mg/L $CaCO_3$)	200 - 400	22	8
Alkalinity (mg/L $CaCO_3$)	150 - 300	136	152
Turbidity (NTU)	5 NTU	1.5	1.02
Dissolved Oxygen, mg/li	None specified	3.35	4.7
Color (Color Units)	5 color units	3	3
Total Coliform, MPN/100ml	Nil	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil	Nil

* MIWD Quality of Drinking Water is based on the Philippine National Standard For Drinking Water 1993

Table 8 shows a comparison of the quality of CPU drinking water after treatment and the quality of bottled water. It also shows that the results for conductivity, calcium, sodium, chlorine, sulfate, and magnesium exceeded the values specified for the same parameters in the bottled water.

Parameters / Indicators	Bottled Water	Sample # 11 Drinking Fountain (Engineering Study Area)
pH	7.0	4.55
Temperature, °C	-	27°C
Conductivity (μ S/°C) @ T = 20°C	330 mg/li	415
Total Dissolved Solids (TDS), mg/L	500	34
Acidity (mg/L $CaCO_3$)	-	22
Alkalinity (mg/L $CaCO_3$)	-	136
Turbidity (NTU)	-	1.5
Dissolved Oxygen, mg/li	-	3.35
Color (Color Units)	-	3
Total Coliform, MPN/100ml	Nil	Nil
Faecal Coliform, MPN/100ml	Nil	Nil
Calcium (mg/li)	5	75
Sodium (mg/li)	40	200
Chlorides (mg/li)	10	250
Ammoniacal Nitrogen	1	-
Sulfate, SO_4^-	17	200
Mg	14	50

Based from the results, the drinking water sample from sampling station # 12 must undergo certain purification processes to compete with the bottled water quality requirements.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the results, the CPU's domestic and drinking water sources both met the requirements for domestic and drinking water standards and are safe for their specific uses. However, for drinking purposes, it is better that routine microbiological testing be conducted to make sure of the absence of pathogens.

It is further concluded that the number of samples to be taken and the time and exact place of sampling depends on the importance of the analysis, the accuracy required, and the resources available. The whole sampling technique will depend upon what is being sampled, why it is being analyzed, and what constituents are to be determined.

Recommendation

CPU should allocate considerable resources to monitor water quality so that its beneficial uses can be protected. Effective control over the quality of the raw water and over the quality of the treated water is only possible through continual routine examination. A regular survey of leaking pipelines and their immediate repair is highly needed to avoid contamination of drinking water supply.

It is recommended that CPU authorities should find ways and means to be able to construct the most centralized water treatment facility to treat the water coming from the different sources before allowing them to flow through pipelines.

Further research is recommended on the design of a water treatment facility system in CPU that will ensure the safety of water in all drinking faucets inside CPU campus.

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