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Drinking Water Quality of Selected Tap Water Samples in Cagayan de Oro (District II), Philippines

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Abstract

This study was conducted to preliminarily determine present drinking water quality of selected District II communities in Cagayan de Oro, Philippines. Five community stations (total twenty stations) were established covering three months tap water monitoring. All samples were analyzed using portable meters determining the pH, dissolved oxygen (DO), temperature, conductivity, salinity, turbidity, and total dissolved solids (TDS) Overall, all studied tap water samples from selected stations passed the drinking water regulations except for conductivity (Risk quotient>1). Similarly, both pH and turbidity analyses showed a sampling date specific variations ($p<0.05$) while the analyses of temperature and salinity showed station specific variations ($p<0.05$). A strong correlation of studied parameters was also found between conductivity-salinity ($r = 0.98$); conductivity-TDS ($r = 0.90$); and salinity-TDS ($r = 0.92$). Extrapolating from this it can be concluded that the tap water samples were safe to drink. The study was preliminary and further analyses incorporating metals, pathogens, and organics may be needed.

Keywords: Drinking water, water quality parameters, ground water.

I. Introduction

The millennium development goal under environmental sustainability states the need for ensuring drinking water quality. The case is significant for the Philippines which are heavily affected by typhoons annually. Consequently typhoons commonly affect the water pipelines and services, inevitably contaminating the water upon restoration. Ensuring safe drinking water in the city of Cagayan de Oro is essential considering that it has become a typhoon hotspot recently.

Although there were no direct studies to extrapolate potential drinking water contamination in Cagayan de Oro, few studies however states contamination of adjacent water bodies (Alvarez *et al*., 2008; Besagas *et al*., 205; Lago, 2013). The reviewed studies present the arising need of ensuring water quality locally as a need prior to typhoons and other environmental externalities (e.g. anthropogenic activities from dumpsites (Galarpe and Parilla, 2012; Sia Su, 2008)).

Locally, the drinking water provider is the Cagayan de Oro Water District (CDOWD). The water is being analyzed prior to release as part of the monitoring system, however the water quality are not evaluated onsite/consumers pipelines. This in return presents a concern owing to potential contamination along the pipeline systems. This in return requires household water storage and treatment with point-of-use water quality monitoring (Wright *et al*., 2004). Often water pipelines are located within domestic wastewater drainage/sewerage, alarmingly posing public health concern. Owing to the potential concern this study was conducted given the following objectives:

1. To determine the physicochemical parameters of tap water samples in selected District II communities (Zone 8, Cugman, Zone 10, Cugman, Baloy, Tablon, and Bugo) in Cagayan de Oro, Philippines;
2. To determine whether the studied parameters passed the water quality guidelines (PNSDW, 2007; WHO, 2008);

3. To determine the risk quotient brought by the studied physicochemical parameters;
4. To determine if there is a significant difference among studied stations and sampling dates; and lastly
5. To determine if there is correlation among studied physicochemical parameters.

2. Materials and Methods

2.1 Study site

The water samples were collected from five stations under District II of Cagayan de Oro. These stations included Zone 8 Cugman, Zone 10, Cugman, Baloy, Tablon, and Bugo. Each station was composed with four other substations (approximately 5 m-10 m apart) as sources of tap water analyzed in the laboratory (refer to Figure 1).

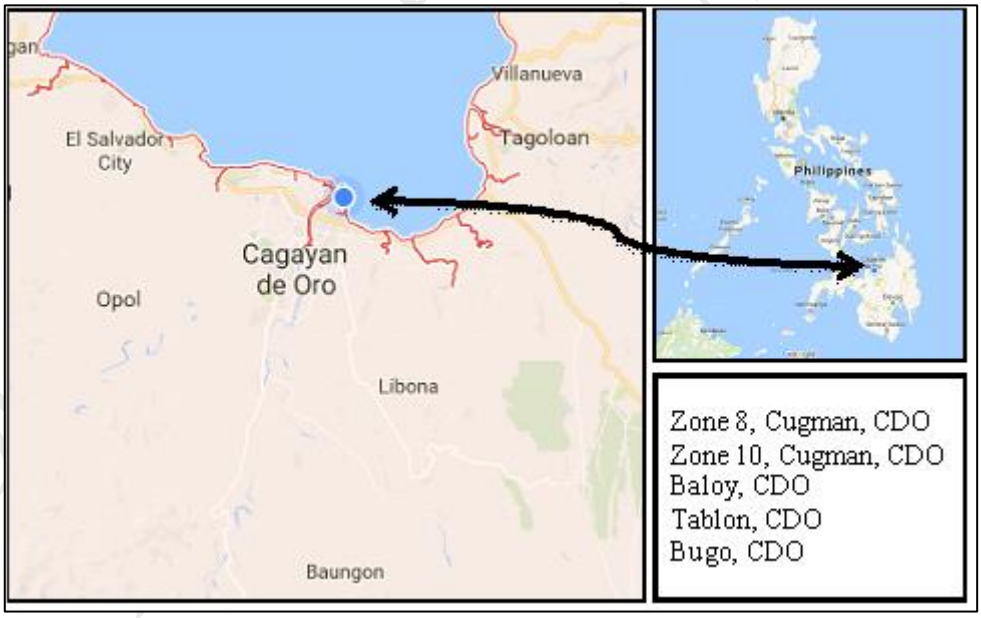


Figure 1. Map of the studied tap water stations in District II, Cagayan de Oro

2.2 Sampling

Sampling was carried on December Dec 16, 2016, Jan 11, 2017, Jan 14, 2017, Jan 30, 2017, and Feb 4, 2017 daytime to minimize weather factors. All samples were contained in pre-cleaned polyethylene (PET) bottles with distilled water. Upon sampling the bottles itself were prewashed by the samples prior to collecting water as final sample for analysis. All samples were analyzed in triplicates in the University of Science and Technology of Southern Philippines (USTP)-Environmental Science/Material Science Laboratories.

2.3 Physicochemical analyses

Each physicochemical parameter was analyzed using probe meters. The DO determination was carried using DO 6+ Oakton Eutech (manufactured in Singapore). The TDS, conductivity, salinity, and pH were all determined using Oyster series Extech instram (manufactured in Taiwan). Turbidity on the other hand was analyzed using Lamotte model 2020we (manufactured in USA).

2.4 Data analysis

All results were expressed descriptively as mean with standard deviation. The difference between stations and sampling dates were determined using Two Way-ANOVA (0.05 level of significance). To determine the association among studied parameters the Pearson correlation was employed. The risk quotient (RQ) was also determined adopted from (Galarpe and Parilla, 2014). The RQ was calculated as the ratio between the determined concentration and the available standard (GEF/UNDP/IMO, 2014). The calculated RQ of >1 can gauge the parameter to likely pose environmental risk. The standard reference for calculated RQ is shown in Table 1.

Table 1. Different Standards of water quality

Standards	Ph	Conductivity (μs)	Turbidity (NTU)	TDS (ppm)
PNDSDW	6.5-8.5		5 NTU	500 mg/L
WHO	6.5-8.5	250 us/cm	<5 NTU	
US EPA	6.5-8.5		1-5 NTU	500 mg/L

3. RESULTS AND DISCUSSION

3.1 Summary of the physicochemical properties

Overall, the pH of tap water samples from Zone 8, Cugman ranged from 6.23-7.83 (see Table 2). Considerably, a lower pH results were recorded during the last sampling (February 4, 2017) in both stations, namely, Zone 8, Cugman and Baloy, Cagayan de Oro. Despite the lowest recorded pH (5.94) in Zone 10, Cugman on January 30, 2017 (see Table 3) sampling other stations showed comparable result about the neutral pH range (see Table 2-6). Similarly the determined temperature and DO values were normal at room temperature conditions. The ranged levels of conductivity were 351-460 uS/cm and TDS were 237-297 ppm in all stations, respectively. The high levels of TDS can be associated to presence of carbonates in water samples (Pip, 2000). Further, conductivity may indicate potential levels of ions (Galarpe and Parilla, 2014; Achas *et al*., 2016; Chapman, 1996). The salinity concentrations ranged from 141 ppm to 347 ppm with the highest mean concentration in Bugo station (264 ppm) (see Table 6) and the lowest mean concentration in Zone 8, Cugman station (167 ppm) (see Table 2). The recorded levels of turbidity posed no health concern although small presence can be associated to either sample contamination or exposure to particulate matter to the water pipes (Jafari *et al*., 2008; Omezuruike *et al*., 2008).

Table 2. Physicochemical properties of tap water in Zone 8, Cugman

Sampling period	pH	Temp (℃)	DO (ppm)	Conductivity (µs)	Turbidity (NTU)	Salinity (ppm)	TDS (ppm)
Dec 16, 2016	7.72	24.5	6.24	349	0.27	176	231
Jan 9, 2017	7.71	23.5	3.81	356	0.54	174	251
Jan 14, 2017	7.61	23.5	5.41	351	0.13	143	234
Jan 30, 2017	7.83	23.5	4.35	342	0.49	170	235
Feb 4, 2017	6.23	23.0	4.69	359	0.28	176	256
Mean	7.42	23.6	4.9	351	0.34	167	237
SD	0.67	0.55	0.94	6.58	0.16	14.1	7.83

Table 3. Physicochemical properties of tap water in Zone 10, Cugman

Sampling period	pH	Temp (℃)	DO (ppm)	Conductivity (µs)	Turbidity (NTU)	Salinity (ppm)	TDS (ppm)
Dec 16, 2016	7.83	24.3	6.73	347.33	0.38	173.6	255
Jan 9, 2017	7.83	24.5	6.78	351.67	0.13	174.63	279
Jan 14, 2017	7.63	25.8	6.13	404.67	0.06	200	268
Jan 30, 2017	5.94	27.4	5.54	444.67	0.14	221.83	297
Feb 4, 2017	7.31	23.5	5.91	403.7	0.10	212	271
Mean	7.31	25.1	6.22	390.41	0.16	196.27	278
SD	0.71	1.36	0.44	33.29	0.10	19.54	13

Table 4. Physicochemical properties of tap water in Baloy

Sampling period	pH	Temp (℃)	DO (ppm)	Conductivity (µs)	Turbidity (NTU)	Salinity (ppm)	TDS (ppm)
Dec 16,2016	7.71	23.6	4.46	347	0.32	185	236
Jan 9, 2017	7.71	23.5	3.81	356	0.54	174	251
Jan 14, 2017	7.61	23.5	5.41	351	0.13	143	234
Jan 30, 2017	7.83	23.5	4.35	342	0.49	170	235
Feb 4, 2017	6.23	23..0	4.69	359	0.28	176	256
Mean	7.41	23.4	4.54	351	0.35	170	242
SD	0.67	0.24	0.58	6.82	0.17	15.9	10.3

Table 5. Physicochemical properties of tap water in Tablon

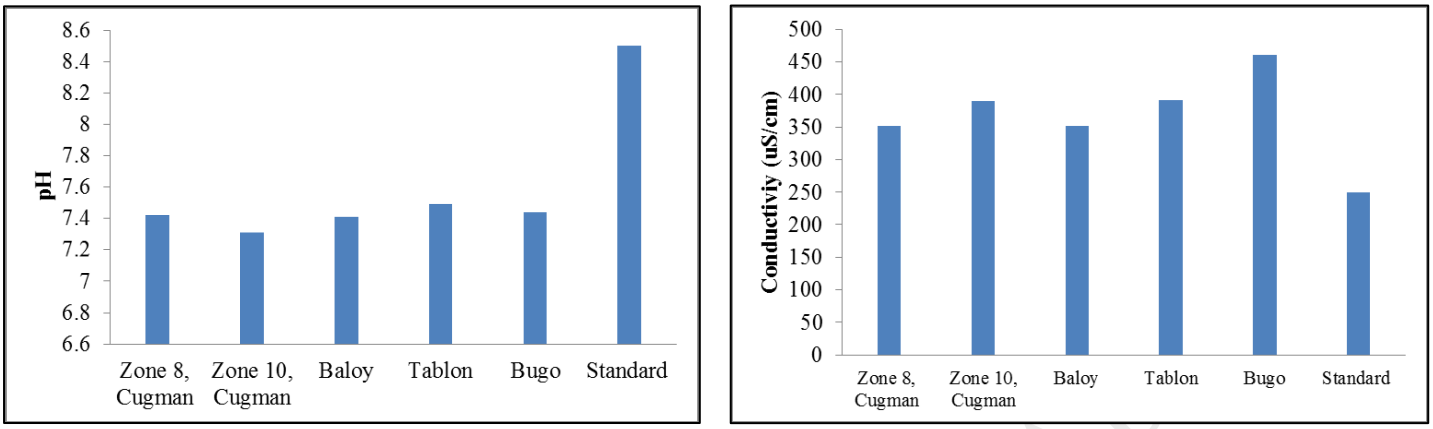
Sampling period	pH	Temp (℃)	DO (ppm)	Conductivity (µs)	Turbidity (NTU)	Salinity (ppm)	TDS (ppm)
Dec 16, 2016	7.71	23.6	4.46	347	0.32	185	231
Jan 9, 2017	7.71	24.5	6.25	485	0.54	218	282
Jan 14, 2017	7.30	27.3	5.73	389	0.22	194	259
Jan 30, 2017	7.36	27.9	3.31	337	0.23	168	228
Feb 4, 2017	7.36	27.8	3.29	394	0.18	168	233
Mean	7.49	26.0	4.61	391	0.29	186	246
SD	0.20	2.27	1.36	58.5	0.15	20.8	23.3

Table 6. Physicochemical properties of tap water in Bugo

Sampling period	pH	Temp (℃)	DO (ppm)	Conductivity (μs)	Turbidity (NTU)	Salinity (ppm)	TDS (ppm)
Dec 16,2016	7.45	24.6	6.43	377	0.36	189	253
Jan 9, 2017	7.50	24.6	6.40	377	0.36	189	251
Jan 14, 2017	7.44	23.0	6.53	387	0.28	260	260
Jan 30, 2017	7.41	23.0	4.53	445	0.40	324	253
Feb 4, 2017	7.38	23.0	4.31	716	0.31	357	470
Mean	7.44	23.6	5.64	460	0.34	264	297
SD	0.04	0.87	1.12	0.05	76.67	145.65	96.55

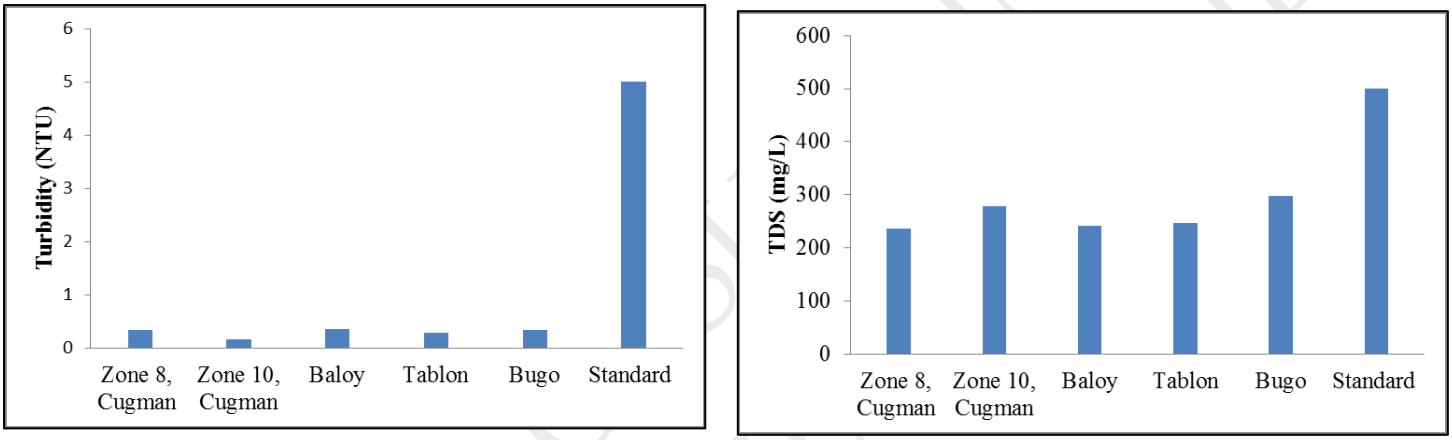
3.2 Physicochemical properties of tap water compared to standards and RQ

Three standards (PNSDW, WHO, and US EPA) served as reference on studied selected physicochemical properties of tap water samples (see Table 1). The pH (Figure 2a), turbidity (Figure 3a), and TDS (Figure 3b) were within the drinking water standards. The considerably lower concentrations in return showed no potential risk in all studied stations (see Table 7). However, conductivity exceeded the drinking water regulations (Figure 2b). The conductivity calculated RQ>1 in all stations may indicate potential risk (Galarpe and Parilla, 2014) (see Table 7).



a b

Figure 2. Tap water samples per station compared to standard (a) pH (b) conductivity



a b

Figure 3. Tap water samples per station compared to standard (a) turbidity (b) TDS

Table 7. Corresponding RQ of the selected physicochemical properties

Sampling station	pH	Turbidity	TDS	Conductivity
Zone 8, Cugman	1.14-0.87	0.07	0.47	1.4
Zone 10, Cugman	1.12-0.86	0.03	0.56	1.56
Baloy	1.14-0.87	0.07	0.48	1.4
Tablon	1.15-0.88	0.06	0.49	1.56
Bugo	1.14-0.88	0.07	0.59	1.84

3.3 Statistical comparisons

The summary of ANOVA is shown in Table 8. Both pH and turbidity analyses showed a sampling date specific variations ($p<0.05$) while the analyses of temperature and salinity may indicate station specific variations ($p<0.05$).

Table 8. ANOVA of the selected physicochemical properties

Parameter	F critical	P value	Description
pH			
Sampling date	3.892254	**0.029844**	Significant difference
Station	0.039166	0.989121	No significant difference
Temperature			
Sampling date	0.080233	0.986942	No significant difference
Station	5.290437	**0.014826**	Significant difference
DO			
Sampling date	2.677078	0.083388	No significant difference
Station	1.653439	0.229503	No significant difference
Turbidity			
Sampling date	1.069437	**0.003159**	Significant difference
Station	2.003515	0.943358	No significant difference
Conductivity			
Sampling date	1.069437	1.069437	No significant difference
Station	2.003515	2.003515	No significant difference
Salinity			
Sampling date	0.522899	0.720974	No significant difference
Station	5.360752	**0.014202**	Significant difference
TDS			
Sampling date	1.288589	0.328424	No significant difference
Station	1.55464	0.25146	No significant difference

Further analysis using Pearson correlation showed strong association between the following parameters, conductivity-salinity (r = 0.98); conductivity-TDS (r = 0.90); and salinity-TDS (r = 0.92) (see Table 9). The strong correlation of these parameters may indicate presence of ions. Present findings was in agreement with the specific results shown in Table 2-7 where an increase in TDS corresponds to increase in both salinity and conductivity.

Table 9. Correlation of the selected physicochemical properties

Parameters	pH	Temp	DO	Conductivity	Turbidity	Salinity	TDS
pH	1	0.09	-0.73	0.15	0.71	0.088	-0.30
Temp		1	0.09	0.076	-0.62	-0.11	-0.02
DO			1	0.53	-0.71	0.54	0.81
Conductivity				1	-0.06	**0.98**	**0.90**
Turbidity					1	0.03	-0.33
Salinity						1	**0.92**
TDS							1

4. Conclusion

Overall, all studied tap water samples from selected stations/communities in District II, Cagayan de Oro passed the drinking water regulations except for conductivity (RQ>1). Similarly, both the pH and turbidity analyses showed a sampling date specific variations ($p<0.05$) while the analyses of temperature and salinity may indicate station specific variations ($p<0.05$). A strong correlation of studied parameters was also found between

conductivity-salinity, conductivity-TDS, and salinity-TDS. Extrapolating from this it can be concluded that the tap water samples were fit to drink. The study was initially preliminary and further analyses incorporating metals, pathogens, and organics may be needed.

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