IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 11, Issue 5 Ver. IV (May. 2017), PP 53-58
www.iosrjournals.org

Analyses of Physicochemical Parameters of Selected Tap Water Samples in Cagayan de Oro (District I), Philippines

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Abstract: *This study was conducted to initially determined drinking water quality in Cagayan de Oro, Philippines. The objectives were to quantify selected physicochemical parameters among selected tap water samples on December, 2016-Feburary, 2017 in District 1 communities of the city. Analyses further included quantifying risk quotient and comparing findings to drinking water quality standard. Studied parameters were pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), salinity, conductivity, and turbidity using portable probe pre calibrated meters. Overall, determined concentrations passed reference standards for drinking water with sampling station and sampling period variation. Although no risk was determined on the studied parameters, it is however recommended to conduct further monitoring incorporating other water quality parameters.*

Keywords: *District 1; tap water; risk quotient*

I. Introduction

Ensuring its sustainable use and drinking water quality is a must to drive socio-economic growth locally in Cagayan de Oro, Philippines. Recently, water systems were affected due to heavy precipitation leading to urban flood. In return this presents a concern if poor monitoring on receiving water pipes or consumers is minimal. This consequently, results to a potential concern if unmonitored water pipelines or systems are flooded among other tributary factors. Locally, few studies revealed potential contamination of adjacent water bodies (Alvarez *et al*., 2008; Besagas *et al*., 205; Lago, 2013). The reviewed studies presents the arising need of ensuring water quality locally as urgent mitigating measures prior to typhoons and other environmental externalities (e.g. anthropogenic activities from dumpsites (Galarpe and Parilla, 2012; Sia Su, 2008)). 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 physicochemical parameters are not evaluated onsite/consumers pipelines. At the latter, requiring 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 when there is occurrence of flood. Given the pressing risk this study was conducted aiming to address the following objectives:

1. To determine the physicochemical parameters of tap water samples in selected District I communities in Cagayan de Oro, Philippines;
2. To determine whether the studied parameters passed the water quality guidelines (PNSDW, 2007; WHO, 2008; US EPA);
3. To determine the risk quotient of the studied physicochemical parameters;
4. To determine if there is a significant difference among studied stations and sampling period.

II. Materials and Methods

2.1 Study site

The water samples were collected from five stations under District I of Cagayan de Oro. These stations included Phase1, Kauswagan, Phase2, Kauswagan, Capisnon, Kauswagan, Regency, Iponan, and Kisanlu, Iponan in the city .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).

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 Analytical methods

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 Extechinstram (manufactured in Taiwan). Turbidity on the other hand was analyzed using Lamotte model 2020we (manufactured in USA).

Figure 1. Google earth map of the studied sites in Cagayan de Oro, Philippines

2.4 Statistical analyses

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. Drinking water quality standards

PARAMETER	WHO	US EPA	PNSDW
pH	6.5-8.5	6.5-8.5	6.5-8.5
Total Dissolved Solids	500 mg/L	500 mg/L	N/A
Turbidity	Less than 5 ntu	1-5 ntu	5 ntu

III. Results And Discussions

3.1 Summary of physicochemical parameters

Summary of results are shown in Table 2-6. The pH of the water samples were considerably within the range 7.16-7.45 with the first sampling period showing higher pH. Likewise, both DO and temperature were within the normal range. Results for TDS were within the range 171.33-403.82 ppm with the highest concentration during the fourth sampling period in all studied stations (see Table 5).The high levels of TDS can be associated with the presence of carbonates in water samples (Pip, 2000).

Further, present findings on salinity showed higher concentrations in Kisanlu, Iponan (287.26 ppm) during the first sampling period (Refer to Table 2). Succeeding sampling periods however revealed invariable pattern with other stations (e.g. Phase 1, Kauswagan; Phase 2, Kauswagan; Capisnon, Kauswagan) showing higher concentrations of salinity (Table 3-6). Determined conductivity concentrations were within the range

245-523.80µs with the highest mean concentration during the fourth sampling period (see Table 5). Similarly, the high conductivity concentrations were found to be comparable with those stations and sampling periods with higher TDS. Conductivity may indicate potential levels of ions in water (Galarpe and Parilla, 2014; Achas *et al*., 2016; Chapman, 1996). The studied water stations turbidity were within the range 0.53-1.03 ntu which may not directly indicate potential drinking water issues. Turbidity 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 on December 16, 2017

Location	Physicochemical parameters						
	pH	DO (mg/L)	Temp (°C)	TDS (ppm)	Salinity (ppm)	Conductivity (µs)	Turbidity (ntu)
Phase1, Kauswagan	7.47	4.90	23	210.52	150.86	284	0.81
Phase2, Kauswagan	7.51	5.21	23.2	278.38	176	312	0.70
Capisnon, Kauswagan	7.38	5.15	23	235.92	141.12	296	0.88
Regency, Iponan	7.46	5.50	23.8	273.26	177.46	311.2	1.02
Kisanlu, Iponan	7.33	4.84	23.14	323	287.26	323	1.58
Mean	7.45	5.12	23.48	264.21	187	305.24	1.03
SD	0.07	0.34	0.31	39	52.30	14	0.31

Table 3. Physicochemical properties of tap water on January 11, 2017

Location	Physicochemical parameters						
	pH	DO (mg/L)	Temp (°C)	TDS (ppm)	Salinity (ppm)	Conductivity (µs)	Turbidity (ntu)
Phase1, Kauswagan	7.63	6.41	23	275	220	412	0.79
Phase2, Kauswagan	7.05	6.04	23	268.46	216.52	419.72	0.94
Capisnon, Kauswagan	7.05	6.47	23	336	207.6	418.4	0.634
Regency, Iponan	7.16	4	23	61.62	46	91.56	1.12
Kisanlu, Iponan	7.38	5	23	257.4	190.86	387	0.75
Mean	7.43	5.66	23	239.70	176.20	345.74	0.85
SD	0.23	0.95	0	93.01	66	128	0.17

Table 4. Physicochemical properties of tap water on January 14, 2017

Location	Physicochemical parameters						
	pH	DO (mg/L)	Temp (°C)	TDS (ppm)	Salinity (ppm)	Conductivity (µs)	Turbidity (ntu)
Phase1, Kauswagan	7.47	3.61	23	302.2	225.4	453	1.19
Phase2, Kauswagan	7.18	4.75	23.1	231.84	186	108	0.57
Capisnon, Kauswagan	7.54	5.09	23	77.8	274.8	388.6	0.55
Regency, Iponan	7.42	3.90	23.1	154	88.52	177.76	0.55
Kisanlu, Iponan	6.31	4.78	23	90.82	67.86	95.3	1.04
Mean	7.18	4.42	23.4	171.33	169	245	0.78
SD	0.45	0.57	0.15	85.22	79.21	148.04	0.28

Table 5. Physicochemical properties of tap water on January 30, 2017

Location	Physicochemical parameters						
	pH	DO (mg/L)	Temp (°C)	TDS (ppm)	Salinity (ppm)	Conductivity (µs)	Turbidity (ntu)
Phase1, Kauswagan	6.69	8.27	23	496.6	361.8	547	0.6
Phase2, Kauswagan	7.09	5.78	23.5	445.8	333	668	0.78
Capisnon, Kauswagan	7.38	3.11	23	339.2	228.6	428	0.76
Regency, Iponan	6.44	9.51	23	506.4	372.18	692.2	0.90
Kisanlu, Iponan	7.38	6.47	23.5	232	142.2	284	1.25
Mean	7.16	5.43	23.2	403.82	287.56	523.80	0.86
SD	0.42	2.46	0.25	117	99.17	153	0.22

Table 6. Physicochemical properties of tap water on February 4, 2017

Location	Physicochemical parameters						
	pH	DO (mg/L)	Temp (°C)	TDS (ppm)	Salinity (ppm)	Conductivity (µs)	Turbidity (ntu)
Phase1, Kauswagan	7.32	5.52	23	414	313	547	0.47
Phase2, Kauswagan	7.71	6.03	23.5	426.6	360.2	592.4	0.55
Capisnon, Kauswagan	6.62	5.08	23	485	469	689	0.55
Regency, Iponan	7.74	5.60	23.46	141.94	105.98	212	0.18
Kisanlu, Iponan	7.05	7.87	23.1	271.2	202.4	284	0.92
Mean	7.28	4.96	23.21	348	290.11	452.28	0.53
SD	0.47	1.08	0.24	139.34	141	206.09	0.26

3.2 Water quality compared to standards and RQ

Overall, both pH and turbidity were within the standard set for drinking water (Figure 2 and 3). This was in agreement with the calculated RQ<1 indicating no potential risk (pH =0.86; turbidity =0.16).Likewise, the determined TDS were within the standard with pronounced results during the fourth sampling period (January 30, 2017). The RQ values (<1) of these three parameters showed no potential risk(see Table 7).

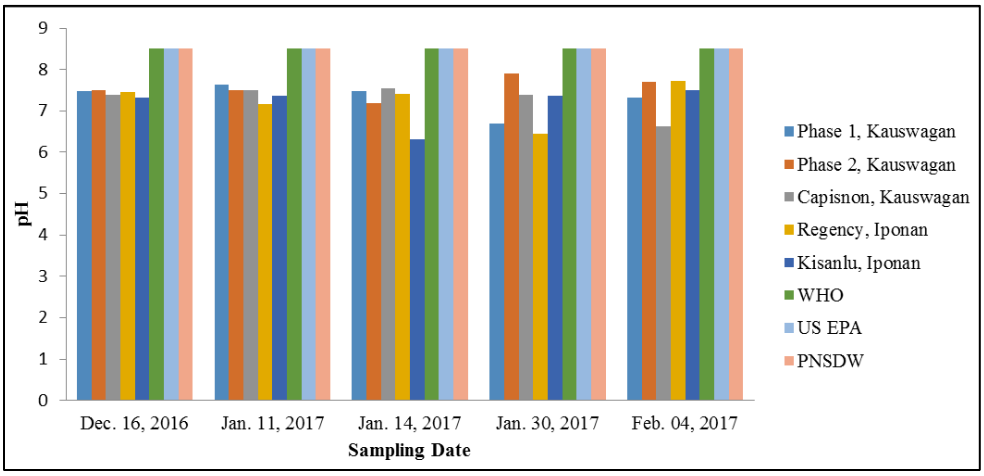

Figure 2.pH of the studied water samples compared to standards

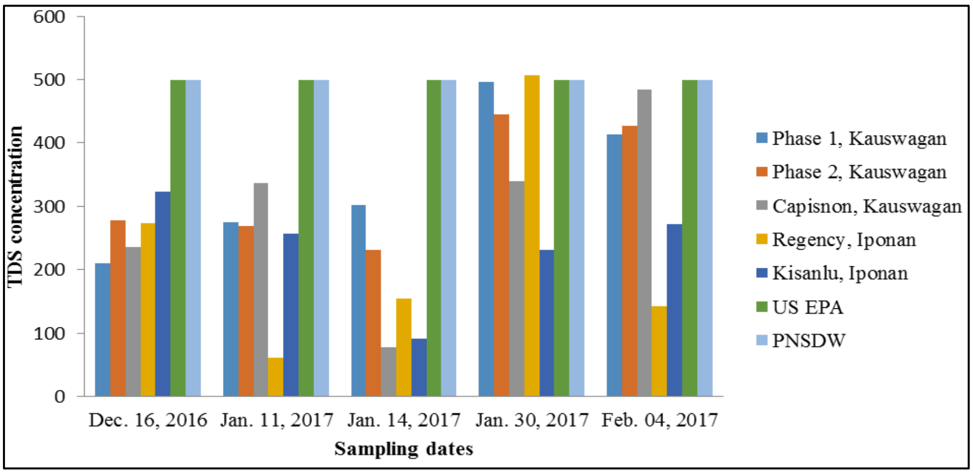

Figure 3. TDS of the studied water samples compared to standards

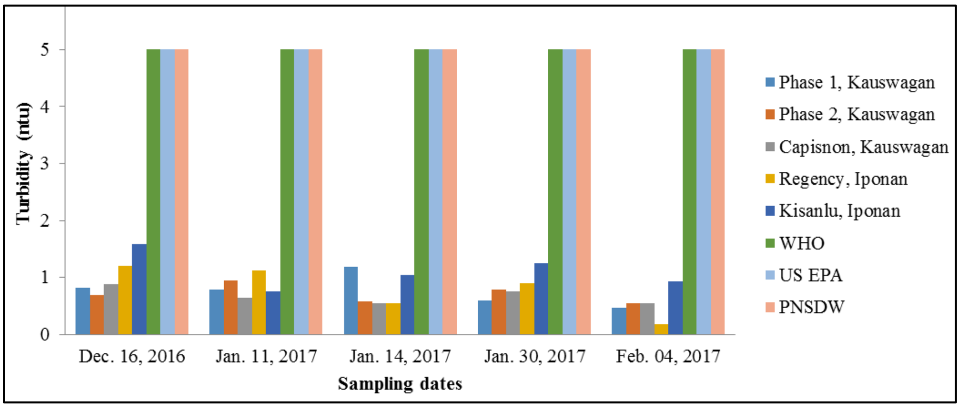

Figure 4. Turbidity of the studied water samples compared to standards

Table 7. Overall RQ of the studied parameter in every station

Parameter	pH	Turbidity	TDS
Phase1, Kauswagan	0.86	0.15	0.68
Phase2, Kauswagan	0.89	0.14	0.66
Capisnon, Kauswagan	0.86	0.13	0.59
Regency, Iponan	0.85	0.16	0.45
Kisanlu, Iponan	0.84	0.22	0.47
Mean	0.86	0.16	0.57

3.3 Statistical analyses of the physicochemical parameters

Notably, the parameter which showed significant variation was TDS, turbidity, and conductivity. The variation in TDS was sampling period specific ($p < 0{,}05$; see Table 8) as evidenced by higher concentrations in some sampling period. Similar condition was also revealed with conductivity analysis as sampling period specific difference ($p < 0.05$). Overall, both parameters were associated to be comparable. Turbidity on the other hand was both sampling station and sampling period specific ($p < 0.05$) supporting that different stations on every sampling period had varied results.

Table 8. Summary of results for ANOVA

Parameter	p-value	F-critical	Decision on null hypothesis
pH			
Sampling Period	0.75112	3.006917	Accept
Sampling Station	0.540129	3.006917	Accept
TDS			
Sampling Period	0.018354	3.006917	Reject
Sampling Station	0.300947	3.006917	Accept
DO			
Sampling Period	0.171508	3.006917	Accept
Sampling Station	0.94478	3.006917	Accept
Turbidity			
Sampling Period	0.050258	3.006917	Reject
Sampling Station	0.042843	3.006917	Reject
Salinity			
Sampling Period	0.111167	3.006917	Accept
Sampling Station	0.261381	3.006917	Accept
Temperature			
Sampling Period	0.137429	3.006917	Accept
Sampling Station	0.140474	3.006917	Accept
Conductivity			
Sampling Period	0.043501	3.006917	Reject
Sampling Station	0.202331	3.006917	Accept

IV. Conclusions

Overall studied physicochemical parameters were within the standard set for drinking water guidelines (PNSDW, WHO, and USEPA). Distinctively, TDS and conductivity showed higher concentrations on selected sampling period regardless of the study stations. Extrapolating from this, preliminarily the drinking water in District 1, Cagayan de Oro is fit for drinking. The study is preliminary and may require further monitoring to ensure safe drinking water access.

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