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Research Article

Monitoring and Baseline Profile Confluence of Kulaman and Tinanan Rivers in Arakan Valley Philippines

Simonette C. Villabeto[1], MST, Lourdes Simpol[2], Ph D
[1]Central Science Laboratory, Cotabato Foundation College of Science and Technology, Arakan, Philippines
[2]Chemistry Department, Ateneo de Davao University, Bolton St., Davao City, Philippines

***Corresponding author**
Simonette Villabeto
Email: nfr_uplb@yahoo.com

Abstract: The study aimed to determine a more intensive 5-month monitoring of Kulaman River, Tinanan River and determine the baseline profile of approximately 1500-m downstream of the confluence of both Kulaman and Tinanan Rivers. Samples were collected from the three sampling stations simultaneously and brought to Ateneo de Davao University Chemistry laboratory for analysis. Chemical parameters analyzed were pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), and total solids (TS). Using one-way ANOVA, it was found out that pH, DO, BOD, TSS, TDS and TS levels show no significant difference among the three sampling stations. It also shows that in temperature level, station 3 shows significant difference on stations 1 and 2 since sampling was done one sampling station after the other. Thus, time of sampling and distance are considered for the high temperature level of station 3. Lower temperature levels are attributed to the weather condition of the sampling area as the stream was shaded and no disturbance has been noticed before and during sampling. Using t-test, the researcher's data obtained from sampling stations 1 & 2 differ significantly with respect to parameters such as temperature (station 1), and DO and TDS (station 2). Other parameters such as pH (station 1 & 2), BOD (station 2), TSS (stations 1 & 2), TDS (station 1), and TS (stations 1 & 2) shows no significant difference. Based on the results, Station 3 may be classified according to DENR Administrative Order No. 34 as Class A Category.
Keywords: Dissolved Oxygen, Biochemical Oxygen Demand, Total Dissolved Solid, Total Suspended Solid, Total Solid

INTRODUCTION

Water is an indispensable component of the ecosystem and everyone knows that water is the key resource in the maintenance of sustainability. It plays a central role in the growth and environmental health of cities and town. It is also used as a source of aesthetic enjoyment; as a transporter of disease; as a container for nuisance; and finally, as the once unlimited area for disposal of society's waste products. Added to society's products are the waterborne toxic chemicals which may come from pesticides run offs from industrial lands, waste chemical dumps and landfills, treatment ponds and others. Thus, the understanding of water pollutants, its sources, interaction with the environment, and effects, are of critical concern of every citizen so as to preserve quality of human life and its environment[1].

One of the government agencies directly concerned with the determination of the quality of water in rivers, lakes, reservoirs and all other fresh surface waters is Environmental Management Bureau (EMB) - Department of Environment and Natural Resources (DENR). Analyses conducted by this office include pH, temperature, biochemical oxygen demand, dissolved oxygen, total suspended solids, total solids, and others which will also be used to classify or reclassify bodies of water according to its water quality and beneficial usage. This is in response to DENR Administrative Order No. 34 also known as Revised Water Usage and Classification/Water Quality Criteria [2]

EMB-DENR XII is currently intensifying its efforts in determining the water baseline profile of all areas covered by their office including rivers of Arakan Municipality. At present, two major rivers of Arakan were already classified based on DAO No. 34 [2].

Arakan is composed of various creeks and rivers that discharge to Pulangi River, the longest river in Mindanao, now known as the Mindanao River or also known as Rio Grande de Mindanao. Among these rivers are the Kulaman and Tinanan Rivers, which meet at Barangay Doroluman. The meeting point of these two rivers is called as "sabang" which means "tagbo" or confluence [5].

Arakan is considered an agricultural area in which continuous used of pesticides by banana plantations and other farm lands of neighboring barangays which indirectly dispose their wastes in bodies of water are expected. These activities could possibly cause degradation of the water environment. An anecdotal report that fish kill had occurred on nearby rivers along banana plantation particularly Barangay Meocan and residents had suspected that it was because of the chemicals coming from banana plantations. River of Meocan flows through Tinanan River. Upon consultation with the EMB-DENR XII [2], the need for intense monitoring of the two rivers arises. Thus, this study aimed to determine a more intensive 5-month monitoring of Kulaman River (station 1), Tinanan River (station 2) and to determine the baseline data of 1500-m downstream of the confluence of Kulaman and Tinanan Rivers (station 3). Specifically it aimed to determine the levels of pH, temperature, TS, TSS, TDS, DO and BOD of Kulaman River, Tinanan River and of the 1500-m downstream of the confluence of Kulaman and Tinanan Rivers; determine if there are significant differences among the three sampling stations as far as pH, temperature, TS, TSS, TDS, DO, BOD are concerned; determine [4-6] if there are significant differences on the results obtained from sampling station 1 and 2 with the existing data obtained by DENR XII as far as pH, temperature, TS, TSS, TDS, DO, BOD are concerned and establish an assessment as to what classification could be deduced on station 3 based on DAO # 34 guidelines.

MATERIALS AND METHODS

Sampling Period, Collection and Time

Water samples were collected from three sampling stations at around 6-11 am and were done every other week for a period of 5 months, which started last October 2009. Samples containers and BOD bottles were used but were washed and thoroughly rinsed with distilled water. Grab sampling procedure was used in the collection of water from sampling stations of Kulaman River, Tinanan River. It from 1500-m downstream of the confluence of Kulaman and Tinanan Rivers was taken from a single point of the rivers where thorough mixing of water was observed. It was done by immersing the containers in a depth just below the surface of the water. Samples were taken from the identified parts of the river and facing the opposite of the current flow. Two-liter volume of water per sampling stations was acquired for laboratory analysis. It was collected in plastic bottles, except for samples collected in BOD bottles for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD). Details on weather conditions two days before sampling, activities observed and sampling time were recorded. Temperature readings were done on site.

Preservation of Water Samples

Sample containers were stored in an ice box maintaining a temperature of 4°C to avoid decomposition before analysis at Ateneo de Davao Chemistry laboratory.

Methods of Analysis

Temperature and pH determination were done on site using calibrated alcohol thermometer and Orion 230A+ pH meter respectively.

Standard Methods for Examination of Water and Wastewater, 16th edition was used to determine Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Solids (TS), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS).

Interpretation of Data

One – way ANOVA was used to interpret if there are significant differences among the three sampling stations as far as pH, temperature, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), and biochemical oxygen demand (BOD) are concerned. The p-value is utilized as an alternative way of conducting tests of significance. It is being compared with the level of significance or alpha.

t – test was used to interpret if there are significant differences on the results obtained from sampling stations 1 and 2 with the existing data obtained by DENR XII as far as pH, temperature, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), and biochemical oxygen demand (BOD) are concerned.

RESULTS AND DISCUSSION

pH Analysis

As shown on Table-1, the highest pH values are 8.48 ± 0.02 (station 1), 8.49 ± 0.03 (station 2) and 8.47 ± 0.01 (station 3). Also shown on the table were the lowest pH values for the three sampling stations, 7.98 ± 0.03; 8.00 ± 0.03; and 7.99 ± 0.02 respectively. These lower values of pH may be due to prolonged absence of rain that was experienced from the later part of November up to the last schedule of sampling.

The mean pH for station 1 is 8.31 ± 0.13, 8.25 ± 0.18 in station 2 and 8.32 ± 0.10 in station 3. Each value falls within the standard limit set by DENR.

Using one-way analysis of variance (ANOVA), there is no significant difference in the pH levels among three sampling stations since the p-value (0.681) exceeds the significance level (α = 0.05) as validated by the result of comparing $F_{calc.}$ with that of the $F_{crit.}$ Since the value of F_{calc}. = 0.390 is less than F_{crit}. at 0.05 level of significance = 3.40, then, there is no significant difference in the pH levels among the three sampling stations.

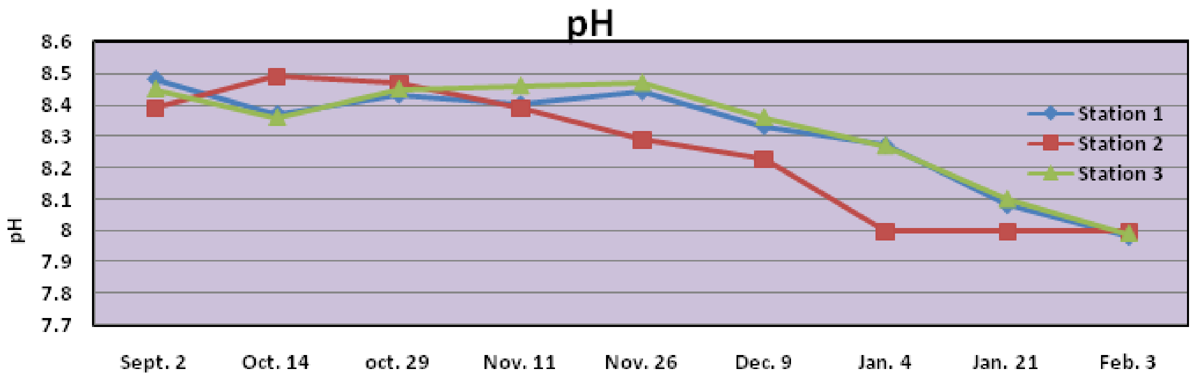

Figure -1: Graphical trend on the pH values obtained from three sampling stations.

Table -1. Data Summary of ANOVA Calculations for pH Analysis

Sources	**Sum of Squares (SS)**	**Deg. of Freedom (df)**	**Mean**	**Fcalc.**	**Fcrit.**	**p-value**
Between Groups	0.026	2	0.013	0.390	3.40	0.681
Within Groups	0.809	24	0.034			
Total	0.835	26				

Temperature Determination

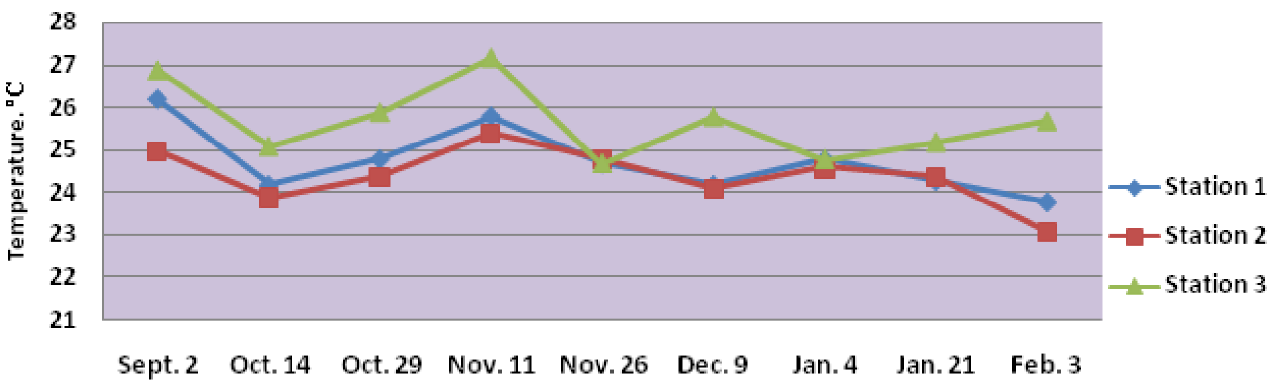

Fig-2: Changes in water temperature from three sampling stations during the 5-month monitoring.

The results reveal that high temperature readings were observed in the first day of sampling where it was conducted between 8:00 am to 9:00 am. But all throughout the duration of the study, there were low temperature readings on stations 1 and 2 since the sampling areas are shaded and no disturbances were noticed before and during samplings.

Station 3 gives high temperature readings since it is the last station being sampled and disturbances had already occurred upstream that includes ongoing construction of the bridge and sand and gravel extraction.

Table -2: Data Summary of ANOVA Calculations for temperature determination

Sources	Sum of Squares (SS)	Deg. of Freedom (df)	Mean Square (MS)	Fcalc.	Fcrit.	p-value
Between Groups	8.016	2	4.008	6.556	3.40	0.005
Within Groups	14.671	24	0.611			
Total	22.687	26				

As shown on table-2, p-value of 0.005 is less than α = 0.05, this means that there is significant difference in the temperature among three sampling stations since sampling was done one sampling station after the other that started with sampling station 2, followed by sampling station 1, then station 3.

The value for $F_{calc.}$ = 6.556 is greater than $F_{crit.}$ = 3.40, which means a significant difference among three sampling stations.

Dissolved Oxygen (DO)

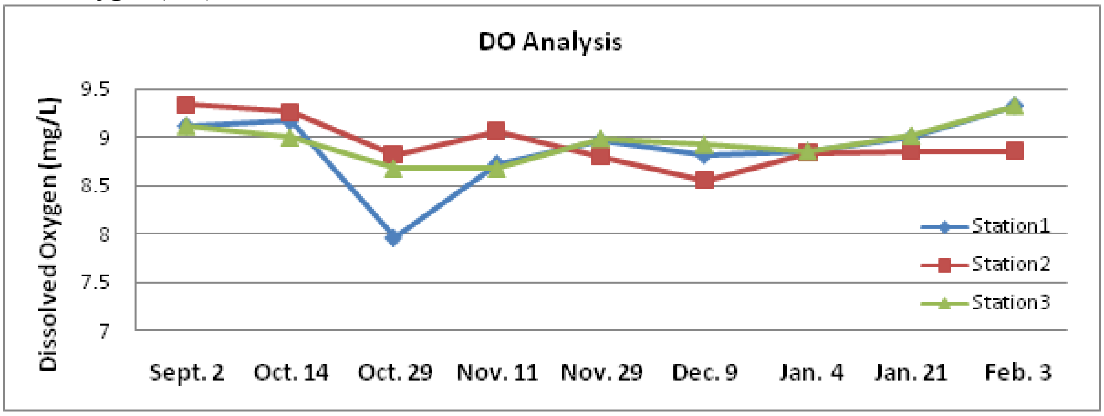

Fig-3. Graphical Trend of dissolved oxygen (DO) level obtained in three sampling stations

Higher value of DO was observed in the first and second sampling dated September 2 and October 14, 2009 because prior to these dates, heavy rainfall occurred , and during rainy seasons, oxygen concentration tend to be higher.

The mean level of Do for 5 – months intensive monitoring in all sampling stations fall within the standard limit set by DENR.

Table-3 Data Summary of ANOVA Calculations for dissolved oxygen analysis

Sources	Sum of Squares (SS)	Deg. of Freedom (df)	Mean Square (MS)	Fcalc.	Fcrit.	p-value
Between Groups	0.024	2	0.012	0.141	3.40	0.869
Within Groups	2.044	24	0.085			
Total	2.068	26				

Table -3 shows that the p-value of 0.869 is greater than α = 0.05, therefore, there is no significant difference in the dissolved oxygen in the three sampling stations.

It is also validated by the result obtained in the Fcalc.= 0.141 that is less than Fcrit.= 3.40 at α 0.05.

Biochemical Oxygen Demand (BOD)

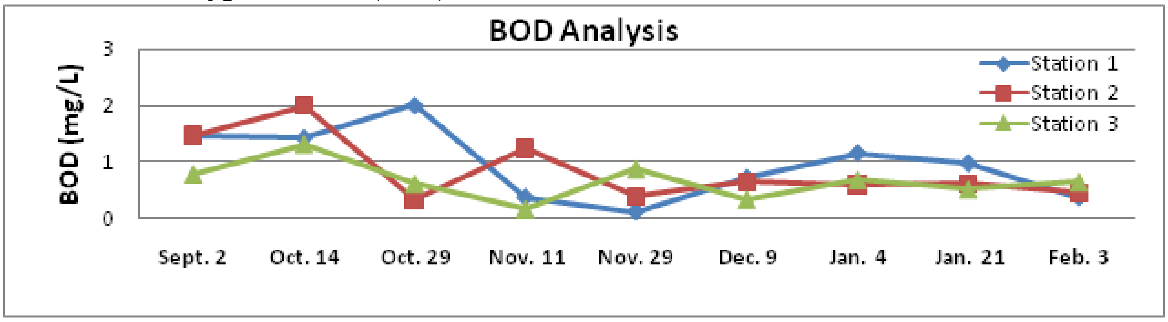

Fig-4: Graphical Trend of Biochemical Oxygen Demand (BOD) obtained from three sampling stations

Highest BOD values were taken October 14 and October 29 as shown by the graph. These higher values were attributed to the turbidity of water due to siltation and soil erosion activity that carry decomposed organic wastes of dead plants and leaves. These causes the increased levels of TSS levels, likewise increases the temperature and decreases the DO concentration as revealed by the results in temperature and DO. The decrease in DO might be due to organic wastes present in the body of water which eventually causes the higher demand for oxygen or simply the BOD (Water Quality Monitoring, Vol. 1, Feb. 2008). These higher BOD values still fall within the standard limit set by DENR for class A and B category, that is 5 mg/L.

Table-4:Data Summary of ANOVA Calculations for BOD analysis

Sources	Sum of Squares (SS)	Deg. of Freedom (df)	Mean Square (MS)	Fcalc.	Fcrit.	p-value
Between Groups	0.431	2	0.215	0.788	3.40	0.466
Within Groups	6.556	24	0.273			
Total	6.987	26				

As shown on the table-4, p-value is 0.466, greater than $\alpha = 0.05$, thus there is no significant difference in the BOD level of the three sampling stations. Also shown on the table that F_{calc}. of 0.788 is less than $F_{crit.}$ of 3.40, which means there is no significant difference.

Total Suspended Solids

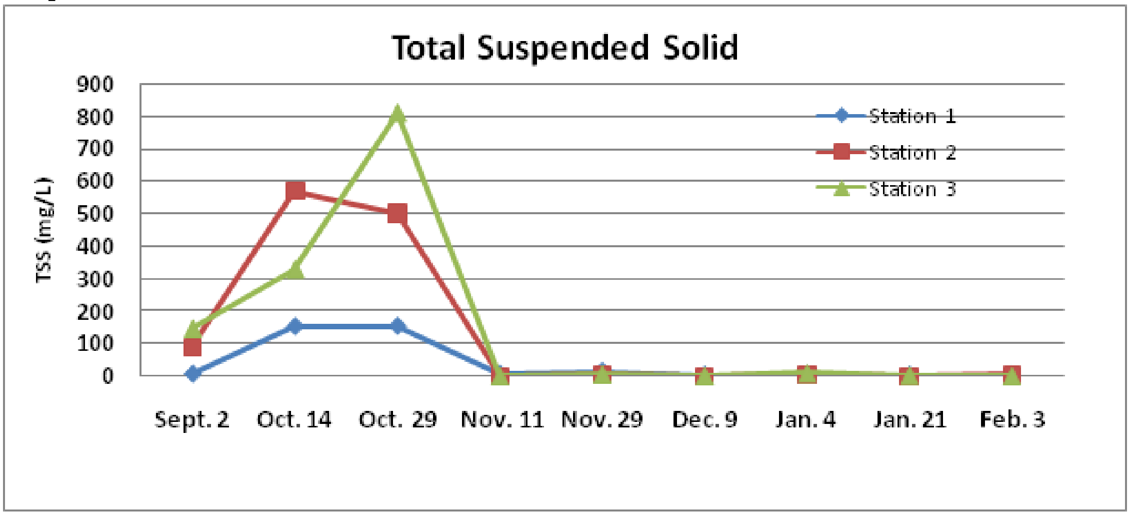

Fig-5: Graphical Trend on the Total Suspended Solids concentration (mg/L) obtained from three sampling stations

It shows that on October 14 and October 29, 2009, the concentrations of TSS from three sampling stations were observed to be on its highest level which made it fall way above the limit set by DENR to any category (Revised Water Usage and Classification of Fresh Waters). Higher TSS levels can be attributed to the heavy rainfall that occurred several days before sampling. All other levels of TSS on all sampling stations fall way below the standard limit set by DENR for class AA category.

Total Dissolved Solids (TDS)

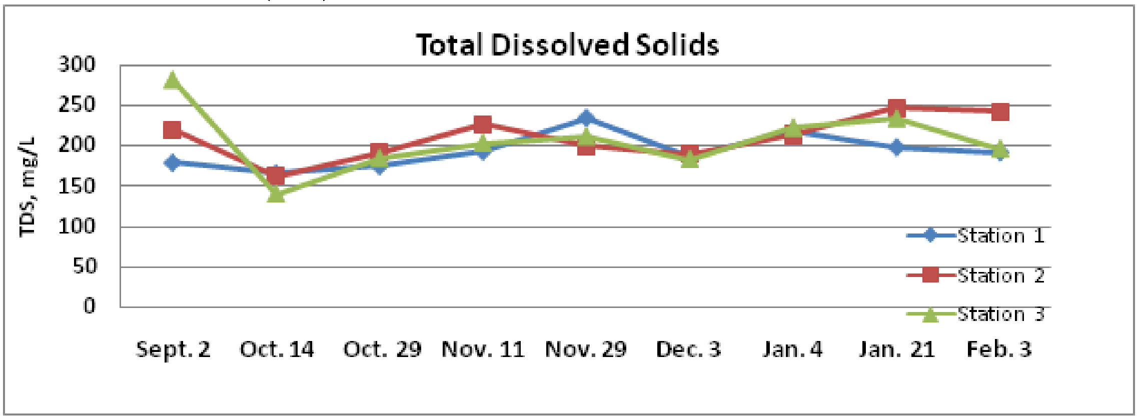

Fig-6 Graphical trend of total dissolved solid concentration in mg/L from three sampling stations

The graph reveals that all values were not very far apart from each other, these is so because all sampling stations were located near agricultural lands and runoff occurred in all sampling stations during heavy rainfall. Based on DAO No. 34, all sampling stations fall within the class AA category.

Total Solids (TS)

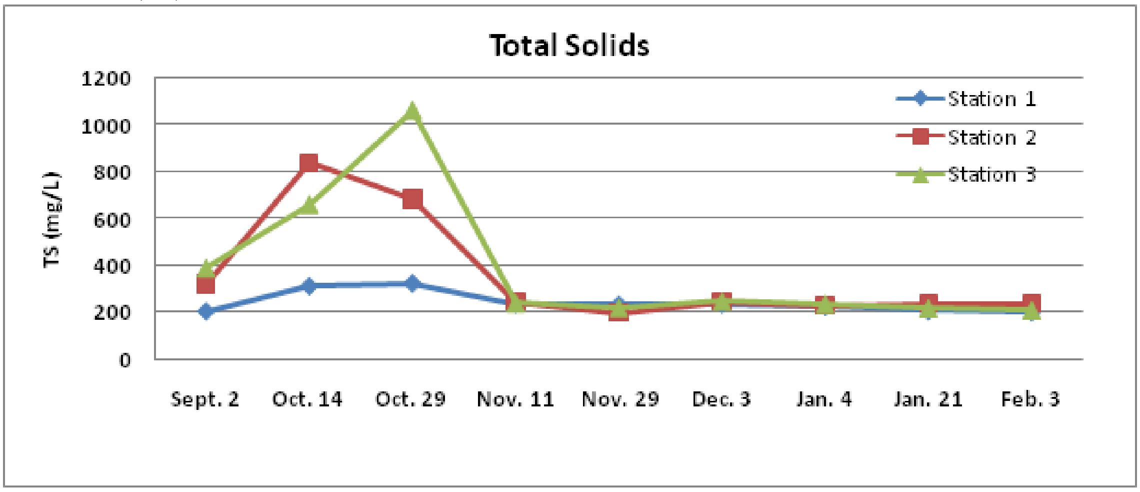

Fig-7: Graphical trend of Total Solid concentration in mg/L from three sampling stations

All TS levels from three sampling stations based on the graph, fall within the limit set by DENR for class A category. The basis for classification was the previous data obtained by EMB-DENR XII which was set as the baseline.

Comparison of the Results obtained from Sampling Stations 1 and 2 with the existing data of DENR XII

Summary of t-test Calculation (Independent Samples) for All Parameters

Parameters	Stations	Computed t-ratio	Critical Value	Degrees of Freedom (df)	Significance
pH	Station 1 Station 2	2.0338 1.4917	2.201 2.120	11 16	Not significant Not significant
Temperature	Station 1 Station 2	5.329 No data from DENR	2.201 -	11 -	Significant -
D.O.	Station 1 Station 2	0.497 3.634	2.201 2.120	11 16	Not significant significant
BOD	Station 1 Station 2	No data from DENR 1.008	- 2.120	- 16	- Not significant
Total Suspended Solids	Station 1 Station 2	0.583 1.529	2.201 2.120	11 16	Not significant Not significant
Total Dissolved Solids	Station 1 Station 2	1.928 3.744	2.201 2.120	11 16	Not significant Significant
Total Solids	Station 1 Station 2	0.875 0.414	2.201 2.120	11 16	Not significant Not significant

As shown on the table, the computed t-ratio of temperature (station 1), DO and TDS (station 2) are greater than their critical values at 0.05 level of significance. Thus, the null hypothesis which states that there is no significant difference between the data obtained from the two sampling stations and the data from DENR" is rejected, while the computed t-ratios of the remaining parameters are less than their critical values, thus, the null hypothesis is accepted.

The table above also implies that the significant difference on temperature levels of sampling station 1 and DENR is due to the time of sampling when temperature reading was taken. This is also the reason why there is a significant difference on the DO levels in station 2 of the researcher's data and the DENR.

No comparison was made on the BOD of station 1 and temperature of station2 since there was no available data from DENR XII.

CONCLUSION

Results of the study gave the following conclusions:

The average levels of pH, temperature, DO, BOD, TSS, TDS, and TS obtained from three sampling stations are.

Parameters	Sampling Stations		
	1	2	3
pH	8.31 ± 0.13	8.25 ± 0.18	8.32± 0.10
temperature, ºC	24.8 ± 0.4	24.4 ± 0.4	25.7± 0.6
DO, mg/L	8.89 ± 0.62	8.94 ± 0.66	8.96 ± 0.69
BOD, mg/L	0.96 ± 0.62	0.86 ± 0.57	0.65 ± 0.33
TSS, mg/L	40 ± 27	130 ± 130	147 ± 240
TDS, .mg/L	194 ± 53	211 ± 37	206 ± 40
TS, mg/L	244 ± 43	363 ± 62	391 ±98

1. There is no significant difference in the pH, DO, BOD, TSS, TDS and TS levels of the three sampling stations. For temperature level, station 3 shows significant difference on stations 1 and 2. However, temperature level does not differ from each other as revealed by the results obtained within a particular station.
2. There is a significant difference on the results obtained by the researcher and DENR data with respect to parameters such as temperature (station1), and DO and TDS (station 2). For other parameters such as pH (both stations 1 & 2), BOD (station 2), TSS (both stations 1 & 2), TDS (station 1) and TS (both stations 1 & 2) show no significant difference.
3. The recommended classification of sampling station 3 (approx. 1500-m downstream of the confluence of Tinanan and Kulaman Rivers) according to DENR Administrative Order No. 34 is Class A Category.

Recommendations:

Based on the results and findings of the study, the following are hereby recommended:

1. Include analysis on the levels of nitrates and phosphates among the three sampling stations considering the study area is an agricultural area.
2. Establish additional sampling stations upstream of sampling stations 1 and 2 to provide more information, which could be used as additional basis in the classification of the river, and to monitor other parts of the river especially those parts near agricultural area.
3. Analyze the possible metal contents of the three sampling stations.

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