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Analysis of Water Quality in Burayan River Tacloban City, Eastern Philippines

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ABSTRACT: The study used both descriptive and quantitative research design which aimed to determine and compare the different physico-chemical parameters of the three stations in Burayan River. The researcher chose Burayan River as the research locale and selected three different sampling stations according to its upstream (Brgy 83-A Burayan San Jose), midstream (Brgy. Taguictic, San Jose) and downstream (Villa Dolina, Marasbaras). Two sets of parameters were used in gathering the different samples: physical (temperature, turbidity) and chemical (pH, alkalinity, total dissolved solids, nitrate and dissolved oxygen). Water quality checker from Environmental Management Bureau (EMB) was used to test all parameters except for alkalinity and nitrate which were conducted by the Leyte Metropolitan Water District (LMWD). Based on the analysis and interpretation, it was found out that the water temperature of all the sampling stations were high compared to the standard which is 24.9 ◦C. The three sampling stations of the turbidity rate exceeded from the standards which is ≤5 NTU. For conductivity, all samples were within the standard which is ≤500µS. All samples did not meet the standards for pH level which is 6.5- 8.5 range. All samples exceed the standard for the alkalinity which is ≤150 @ pH=4.8. For nitrate, all samples were within the standard which is ≤50mg/L. For the total dissolved solids all results from the three samples meet the standard which is ≤500mg/L. For dissolved oxygen, all samples were within the standards except for sample B which has 4.08mg/L because the standard was 5.0 mg/L as its minimum.

KEYWORDS: physico-chemical parameters, alkalinity, nitrate, turbidity, total dissolved solids, upstream, downstream, midstream, DO, EMB, LMWD, Burayan

I. INTRODUCTION

Water is a source of life and regarded as the most essential of natural resources. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Thus, it is important to verify that the quality of water meets the standards of safe water. However, due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity, water becomes highly polluted with different harmful contaminants. Water pollution, as described by Miller (2001), is any chemical, biological or physical change in water that has harmful effects on organisms or makes water unsuitable for desired users. Industrial and municipal solid wastes have emerged as one of the leading causes of pollution. Contamination of water resources with toxic chemicals and harmful microorganisms is one of the serious health problems worldwide.

The industrial and agricultural revolutions discharging chemical wastes to the water resources add to the problems of water pollution. As cited by Ahmed et al. (2010), a report by Time Magazine revealed that over 4,000 chemicals have been found in our drinking water. Diseases by the contamination of water include skin lesions, vascular and cardiac problems, cancer of the bladder, lungs or skin, liver and kidney damage, damage to the nervous system, suppression of the immune system, and birth defects. Lokhande et al. (2011) mentioned in their study, that convenient access to water and trash disposal, the majority of Indian factories are located along riverbanks. Numerous different pollutants, including petroleum hydrocarbons, are frequently included in these wastes. Various acids, alkalis, colors, heavy metals, chlorinated hydrocarbons, and other compounds that significantly alter the physico-chemical characteristics of water. Kumar Reddy and Lee (2012) reported that a growing number of contaminants are entering water supplies from industrialization and human activity like heavy metals, dyes; pharmaceuticals; pesticides, fluoride, phenols, insecticides, pesticides and detergents. The increased use of metalbased fertilizer in agricultural revolution of the government could result in continued rise in concentration of metal pollutions in freshwater reservoir due to the water run-off (Adefemi and Awokunmi, 2010). Having mainly excessive amounts of heavy metals such as Pb, Cr and Fe, as well as heavy metals from industrial processes produce water or chronic poisoning in aquatic animals (Dixon 1994). Some other diseases associated with water contamination are caused by pathogens which arise from animal and human feces and from insufficient water supply. These include cholera (Cholera vibrio), shigellosis (dysentery caused by Shigella spp.), typhoid (Samonella typhi), paratyphoid (Samonella paratyphi), diarrhea (Escherichia coli), hepatitis (Hepatitis virus) and poliomyelitis (Polio virus).

On a survey conducted by the World Health Organization (WHO) in 2004, as cited by Shittu, et al (2008), diseases contacted through drinking water kill about 5 million children annually and make 1/6th of the world population sick. The largest recorded outbreak of waterborne disease in the United States dates back to 1993 in Milwaukee, Wisconsin—an outbreak of cryptosporidiosis, a pathogen, infected more than 400,000 people and lead to at least 50 deaths. A study in Nigeria revealed that majority of the rural populace do not have access to potable water and therefore, depend on well, stream and river water for domestic use. The bacterial qualities of groundwater, pipe borne water and other natural water supplies in Nigeria, have been reported to be unsatisfactory, with coliform counts far exceeding the level recommendation by

WHO.

The susceptibility of water from harmful chemicals and pathogens poses an extreme importance for extensive studies about water quality. One way is through frequent testing and monitoring of the water resources. Patil et al., (2012) suggested that it is also necessary to know the details about the different physico-chemical parameters in determining the water quality. It was also explained that the reason for elucidation of important parameters in water quality assessment may be attributed to the fact that in the overall potability of water, such parameters should not be ignored (Shittu et al, 2008). Therefore, on the basis of knowing the impact of water pollution on human health and the environment poses significance in conducting water assessment and analysis from which this study is derived. Expectedly, the result of this study intends to raise sense of awareness and action among people for the protection of rivers and other water resources and promote habitable communities.

II. OBJECTIVES OF THE STUDY

The main purpose of this study is to determine and compare the different physicochemical parameters of the three stations of Burayan River in Tacloban City. Specifically, to answer the following questions;

- identify the physico-chemical parameter values in terms of:
- Physical
  - water temperature
  - turbidity
- Chemical
  - pH
  - alkalinity
  - nitrate
  - total dissolved solids
  - dissolved oxygen
- compare the water quality of Burayan River to the standard quality
- determine the variations of the physico-chemical values among the different stations of Burayan River.

Significance of the Study : The reduction of water quality of a water source has impacted negatively the stakeholders all over the world. Research, according to WHO, showed that 80% of diseases are water-related and children under 5 years of age are more vulnerable. Water pollution is also related to the continuous crisis of water shortage especially in developing countries which limits supply of water in the community. It was also found out that poor water quality can affect aquaculture in terms of fish production, product quality and profit. Production is reduced when the water contains contaminants impairing development and reproduction thus results to low quality and low profit (PHILMINAQ). The findings of the study may serve as a framework for environmentalists to understand the physico-chemical parameters of Burayan River and analyze results of whatever this study may produce. Furthermore, this study may help environmentalists to devise a plan for water treatment and preventive measures for water pollution. From this research, environmentalists may do advance researches and studies that will benefit the community. Furthermore, this study may serve as a calling for the residents of Tacloban City to have a sense of action for the safeguarding of the rivers and develop discipline within themselves. This study may serve also as a campaign to promote the protection of water bodies and the environment. In addition, the agencies for the protection of the environment, the government, and with the involvement of the community can impose and devise programs and activities for water treatment.

Scope and Limitation : This research focused only on the physico-chemical parameters indicating the water quality of Burayan River in Tacloban City. The parameters are limited and divided into two major categories: physical and chemical parameters. The scope under the physical factors includes water temperature and turbidity while the scope under the chemical factors were pH, alkalinity, nitrate, total dissolved solids, and dissolved oxygen. The water sampling and analysis were conducted by the chemical analysts from the Environmental Management Bureau (EMB) in Palo, Leyte and the Leyte Metropolitan Water District (LMWD).

III. RELATED STUDIES AND LITERATURE

The design of troubleshooting and developing a concept for treating water and wastewater require water analysis. Analyzing "all" contaminants would be extremely expensive and impractical. The cost of a water analysis increases with the number of requested items. It is of extreme importance that the water quality of a water supply be tested through consistent and constant monitoring especially that the degradation of water quality has ill effects to human health and the environment. A manner in which to know the quality of water is by determining the physico-chemical parameters with their respective values and comparing them from the standard values set by environmental agencies.

Classification for Water Quality : It is very essential and important to test the water with physico-chemical parameters before it is used for drinking, domestic, agricultural or industrial purpose. Selection of parameters for testing of water solely depends upon for what purpose we are going to use that water and what extent we need its quality and purity. For this reason, the elucidation of the classification of water quality determines the beneficial use of the water body monitored based on the water quality standards met. According to Simpi et al. (2011), the fact that one of the most vital elements of the ecosystem is water, the use of fertilizers in agriculture, the industrialization of the world's economies, and other human-made activities.

Data from the EMB show that as of 2005, it has classified 525 water bodies in terms of best usage and water quality, representing 62.5 percent of the inventoried water bodies in the Philippines. Among these water bodies, 263 are principal rivers, 213 are minor rivers, seven are lakes, and 42 are coastal and marine waters. Based on DENR Memorandum Circular No. 2013-03, additional 51 water bodies were officially classified according to their beneficial use comprising a total of 671 principal and small water bodies.

Table 1 below shows the classification of water quality for both inland surface water and coastal and marine waters, the beneficial use under which the water is classified, and the number of water bodies classified in the Philippines.

Table 1. Classification of Water Quality and its Distribution in the Philippines

Classification		Beneficial Use	Number
	Inland Surface Water		
Class AA		Waters intended as public water supply requiring only approved disinfection to meet the Philippine National Standards for Drinking Water (PNSDW)	5
Class A		Waters suitable as water supply requiring conventional treatment to meet the PNSDW	203
Class B		Waters intended for primary contact recreation (e.g. bathing, swimming, skin diving, etc.)	149

Class C		Waters for fishery, recreation/boating, and supply for manufacturing processes after treatment	231
Class D		Waters intended for agriculture, irrigation, livestock watering, etc.	23
	Coastal and Marine Waters		
Class SA		Waters suitable for fishery production, tourism, marine parks, coral reef parks, and reserves	4
Class SB		Waters intended for recreation such as bathing, swimming, skin diving, etc., and as spawning areas for Bangus and similar species	20
Class SC		Waters intended for recreation /boating, and as mangrove areas for fish and wildlife sanctuaries	27
Class SD		Waters used for industrial purposes such as cooling	3

(Source: EMB National Water Quality Status Report, 2006)

There are still unclassified important coastal and marine water bodies. These are Manila Bay in NCR; Nasugbu Bay, Tayabas Bay and Balayan Bay in Region 4A; Albay Gulf in Region 5; Panay Gulf in Region 6; Leyte Gulf and Cancacao Bay in Region 8; Macajalar Bay in Region 10; and Malaglag Bay in Region 11.

Other countries have employed different systems of classification for water quality. For the designation of the classification of waters, the ASEAN members other than Philippines have been using a Class Designator system that also specify limit metrics for pollutant levels and biophysical conditions for specific ecosystems and water body types. These Class Designator systems can be transparently related to Beneficial Uses for estuarine and marine areas. The application of a graduated series of guidelines encompassing a series of Class Designators support an adaptive management of water quality and coastal systems. For marine waters, to cite one, Thailand classifies water quality from Class I-Class VI classification according to the Beneficial Use of a water body as Class I is intended for natural resource preservation; II for coral reef conservation; III for aquaculture; IV-recreation; IV for industry or ports; and VI as residential districts. The implementation of a Class Designators framework offers a useful approach that can help integrate and summarize national data and be readily input into a regional reporting system about water pollutants in the form of compliance and status.

Standard values for Water Quality: A number of standards for determining water quality have been formulated by the Department of Environment and Natural Resources (DENR). Enclosure to the DENR Administrative Order 34, as of 1990, are the water quality criteria for each classification based on their beneficial use. As described by the EMB, water quality criteria defined in the parameters used for testing water quality serve as benchmark against which monitoring data are compared to assess the quality of water bodies based on established classifications.

The table below shows the standard water quality in both freshwater and marine water environments in different countries.

Table 2. Standard Water Quality in Different Countries

Parameter	Country							
	Philippine (DAO, 1990-34)		India		Malaysia		Australia (ANZECC, 2000)	
	Fresh Water	Marine	Fresh Water	Marine	Fresh water	Marine	Fresh water	Marine
pH	6.5-8.5	6.5-8.5		6.5-8.5	6.5-9.0	6.5-9.0	5.0-9.0	6.0-9.0
Alkalinity (mg/L)							≥ 20	
DO	5.0	5.0	N.D.	5.0	3.0-7.0	3.0-7.0	> 5.0	> 5.0
TSS	≤ 30% (increase)	≤ 30% (increase)			25-150		< 40	< 10
TDS					500-1000			
Ammonia					0.3 (TAN)		<0.03	< 0.01
Nitrite					0.4		0.10	< 0.10
Nitrate	10				7.0		50	100
Phosphorous	0.050.10(P) (lakes and reservoir) 0.20 (P) (all others)	Nil (as organo Phosphate)			0.100.20 (P)		< 0.10 (PO4)	<0.05 (PO4)
Mercury	2.0	2.0		1.0			< 1.0	< 1.0
Lead	50	50		1.0			< 1-7.0	< 1-7.0
Cadmium	10	10		1.0			< 0.2-1.8	< 0.5-5.0
Nickel	NA	NA						

(Source: PHILMINAQ)

The table below shows the Water Quality Monitoring of Three Rivers in Region 8 from 2014-2015.

Table 3. Water Quality Monitoring of Three Rivers in Region 8 from 2014-2015

River	Station	Parameter											
		Average pH		Average Temperature				Average DO (mg/L)			Average BOD		
		2014	2015	2014		2015		2014	2015		2014	2015	
			1	2		1	2		1	2		1	2
Burayan	Brgy. Fatima	6.96	7.5	No data	27.85	28.04	No dat	11.05	5.5	9.4	10.12	20	19

	Burayan Bridge	7.11	7.27		28.12	27.5	a	8.74	5.07	11.5	10.49	12	7
	Fronting STI College	7.39	7.13		27.64	27		9.90	4.12	10	10.85	9	9
Mangon-bangon River	Fronting LNHS	7.65	7.85	No data	24.18	29	No data	14.9	12.2	14.76	1.53	9	0
	Quarry	7.82	7.14		23.75	29.24		15.38	11.32	12.38	3.07	11	-
	Fronting Leyte Progressive HS	7.69	7		24.53	30.05		15.35	11.23	12.39	7.17	12	230
Calbayog River	1-upstream Aguit-itan	7.71	6.11	No data	29.61	24.5	No data	11.74	12.17	10.38	3.55	3.9	10
	2-midstream Rosales Bride	7.4	6.45		29.31	25.1		12.31	12.11	10.26	3.53	4.8	10
	3-midstream Jasmines Bridge	5.61	7.12		30.13	26.8		14.21	10.0		7.98	4.8	
	4-Payahan Bridge	7.91	7.11		30.63	26.0		10.93	10.14	10.40	4.65	5.7	10

Dissolved oxygen (DO) is the amount of oxygen that is dissolved in water and is essential to healthy streams and lakes. A higher dissolved oxygen level usually indicates better water quality. If dissolved oxygen levels are too low, some fish and other organisms may not be able to survive. Low DO levels may be found in areas where organic material is decaying, as bacteria require oxygen to decompose organic waste, thus, depleting the water of oxygen. A steady supply of dissolved oxygen (DO) is required for all higher aquatic organisms. The difficulties linked with low DO concentrations in rivers have been recognized for over a century (Cox, 2003). Low DO concentrations or, in extreme cases, anaerobic conditions in a generally well-oxygenated river system result in an unbalanced ecology with fish mortality, smells, and other aesthetic nuisances. When DO concentrations drop, aquatic animals are forced to change their breathing habits or lessen their level of activity. Areas near sewage discharges sometimes have low DO levels due to this effect (Stevens Institute of Technology, The Global Water Sampling Project 2007).

Biochemical oxygen demand (BOD) is a frequently used and useful indicator for measuring biodegradable organic compounds and contaminants in water (Kwok et al., 2005). It measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD parameter measures the organicstrength of wastes in water; the greater the BOD, the greater the degree of organic pollution. BOD also directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are similar as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

Total suspended solids (TSS) is one of the most critical metrics for assessing wet-weather pollution in urban sanitation systems. Rossi et al., (2005) stressed the pollutants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), phosphorus, and organic substances are adsorbed onto these particles, indicating that a high TSS load may have an influence on the receiving waters. The researchers offer a stochastic model to estimate the TSS load and its dynamics during rain events. Additionally, it measures the amount of undissolved solid particles in water such as level of siltation, decaying plant and animal matter, and domestic and industrial wastes. According to EMB, the presence of a high percentage of TSS confirms the effects of sand and gravel quarrying activities and runoff from denuded forests and agricultural lands.

Total dissolved solids (TDS) is generally used as an aggregate indicator of the presence of a broad array of chemical contaminants. Meanwhile, Rusydi, (2018) described this as used to characterize salinity level. The primary sources of TDS in receiving waters are agricultural runoff, leaching of soil contamination, and point source water pollution from industrial or domestic sewage (EMB, 2006).

Heavy metals are parameters included in monitoring activities only for receiving water bodies where mining, electroplating, tanning, and other similar activities are operating. As mentioned by Sharma and Agrawal (2005) in their study, heavy metals are predominantly present in scattered states within rock formations. The increase in industrialization and urbanization has augmented the human-made input of heavy metals into the biosphere. These metals are most abundantly available in soil and aquatic environments, with a less r presence in the atmosphere in the form of particles or vapors. These metals become pollutants when they occur in concentrations large enough to have an adverse effect on the ecosystem and public health. In concentrations higher than those specified to maintain healthy waterways, heavy metals can become toxic to aquatic life and harmful to people who consume contaminated seafoods. Other important parameters measured for water quality as discussed by the PHILMINAQ include the following:

pH affects the toxicity of many substances in the water. Natural waters range between pH 5.0 and pH 10.0 while seawater is near pH 8.3. For most freshwater species, a pH range between 6.5-9.0 is ideal, but most marine species cannot tolerate as wide range pH as freshwater animals, thus the optimum pH is usually between 7.5-8.5. At pH 4.0 or below and pH 11 or above, most species die. According to Saalidong (2022), pH stands out as likely the most crucial physicochemical factor governing the behavior of various water quality parameters, including metal concentrations, within aquatic environments. pH levels not only impact bacterial activity but also the accessibility of other pollutants in water. Broadly speaking, extremely high or low pH values can render water unsuitable for specific uses. In highly alkaline conditions, metals tend to precipitate, and substances like ammonia can become harmful to aquatic organisms, resulting in water with undesirable odor and taste.

Alkalinity acts as a stabilizer for pH. In aquaculture, it is the measure of the capacity of water to neutralize or buffer acids using carbonate, bicarbonate ions, and in rare cases by hydroxide, thus protecting the organisms for major fluctuations in pH. Without a buffering system free carbon dioxide will form large amounts of weak acid that may potentially decrease the nighttime pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and as a result, drive the pH levels above 10.0. In the study conducted by Colt and Kroeger (2013), they found out that the levels of alkalinity and carbon dioxide play a crucial role in pH regulation via carbonate chemistry reactions. Alterations in these factors can greatly influence the concentration of un-ionized ammonia. Not only alkalinity but also carbon dioxe concentration is contingent upon fish metabolism, water temperature, the type of aerator utilized, and the rates of gas flow.

Ammonia-Nitrogen (NH3-N) is the most frequent nitrogen-containing component in wastewater, with several sources of pollution and significant emissions as concurred by Li et al., (2024). It is the initial product of the decomposition of nitrogenous organic wastes and respiration. The main cause of eutrophication in water bodies is the excessive discharge of wastewater containing ammonia nitrogen into the water body without treatment or with insufficient treatment. High concentrations of ammonia cause an increase in pH and ammonia concentration in the blood of the fish damaging the gills, the red blood cells, affect osmoregulation, reduce the oxygen-carrying capacity of the blood, and increase the oxygen demand of tissues. NH3 levels usually increase as the temperature and pH increase.

Nitrite-Nitrogen (NO2-N) is a by-product of NH3 or NH4 into NO3 through nitrification completed by aerobic bacteria. If high levels occur, it can cause hypoxia or “brown blood disease” due to deactivation of hemoglobin in fish’ blood. The toxicity of nitrite is dependent on chemical factors such as the reduction of calcium-, chloride-, bromide- and bicarbonate ions. It is found out that increasing pH, low DO and high ammonia can increase its toxicity.

Nitrate-Nitrogen (NO3-N) is formed through nitrification process by the action of aerobic bacteria. Generally, it is stable over a wide range of environmental conditions and is highly soluble in water. Compared with other inorganic nitrogen compounds, it is also the least toxic. However high levels can affect osmoregulation, oxygen transport, eutrophication and algal bloom.

Phosphorous is found in the form of inorganic and organic phosphates (PO4) in natural waters. It is a limiting nutrient needed for the growth of all plants- aquatic plants and algae alike. However, excess concentrations especially in rivers and lakes can result to algal blooms. Digestive problems could occur from extremely high levels of phosphates.

Pesticides are chemicals used to control unwanted non-pathogenic organisms. These chemicals are designed to be toxic and persistent, thus it is also of concern in aquaculture, as well as the health of animals and humans.

Water Quality Monitoring in Local, National, and International Rivers : One of the agencies concerned about water quality in Region 8 is the Environmental Management Bureau (EMB) situated in Brgy. Luntad Palo, Leyte. The EMB monitors water quality of the region's rivers on a quarterly basis using physico-chemical parameters like dissolved oxygen (DO), biochemical oxygen demand (BOD), temperature, and pH.

In the study conducted by Crocker and Bartram (2014), they mentioned that the World Health Organization (WHO) Guidelines for Drinking-water Quality and the WSP manual propose that both operational monitoring and independent surveillance be carried out; both often involve testing for signs of fecal contamination. Operational monitoring informs decision making and corrective actions regarding control measures (e.g., source protection, water treatment), whereas drinking water quality surveillance involves an independent third party overseeing the water supply with the specific mandate of protecting public health. A study about physico-chemical and bacteriological analyses of water used for drinking and swimming purposes from four sampling sites conducted in Abeokuta, Nigeria by Shittu et al., (2008) revealed that Sokori stream and a well did not comply with turbidity and Mg2+ standards while all others were within the standards for pH, color, total solids, TDS, acidity, total hardness, Ca2+ hardness, chloride and iron. None of the samples complied with bacteriological standards as total coliform counts generally exceeded 1,600 MPN/ml, and pathogen count such as SalmonellaShigella counts and Vibrio cholera counts were very high. The data of the parameters were compared to the standards set by WHO and EPA.

Table 4. Water Quality Monitoring of Country's Rivers under the Sagip-Ilog Program from 2008-2012

Region	River	Class	Average DO (mg/L)					Average BOD (mg/L)				
			2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
III	Meycauayan	C	2.48	4.15	2.61	2.28	.05	35.55	48.95	59.00	45.10	47.49
	Marilao	C	2.39	4.98	3.55	2.97	.11	11.09	8.21	24.00	18.28	27.20
	Bocaue	C	4.96	7.92	5.78	3.62	3.54	11.84	6.311	11.00	6.72	10.26
IV-A	Imus	C	4.13	4.75	5.15	4.67	4.13	11.09	18.68	12.00	11.57	15.28
	Ylang-ylang	C	3.97	4.57	5.13	5.38	5.74	63.76	126.27	119.00	-	24.86
IV-B	Mogpog	C	-	8.02	5.89	6.83	7.96	-	-	-	-	
	Calapan	C	3.07	2.91	1.60	1.97	2.72	3.83	5.33	14.00	10.98	14.08
V	Anayan*	D	6.50	6.28	5.09			2.81	2.91	4.28	-	
	Malaguit **	C	7.43	7.49	6.88	6.78	5.90	Not monitored -Consistently registered w/in WQ criteria**				
	Panique***	C	6.87	7.37	6.92	7.17	.35	Not monitored - Consistently registered w/in WQ criteria***				
VI	Iloilo	C	4.47	3.91	4.01	3.36	4.40	4.35	6.40	12.00	6.99	14.20

VII	**Luyang***	**C**	**6.86**	**4.08**	**5.75**	**5.00**	**4.00**	**1.36**	**2.48**	**4.00**	**4.00**	**3.00**
	Sapangdaku*	**C**	**6.83**	**4.33**	**5.13**	**5.50**	**3.00**	**1.14**	**3.18**	**6.00**	**3.00**	**1.67**
X	**Cagayan de Oro***	**A**	**8.13**	**8.76**	**8.15**	**8.27**	**4.48**	**2.00**	**1.14**	**-**	**4.48**	**2.00**
CAR	**Balili**	**-**	**4.55**	**6.72**	**4.49**	**2.77**	**9.90**	**37.44**	**7.04**	**37.00**	**44.00**	
NCR	**Marikina**	**C**	**2.20**	**2.62**	**5.22**	**3.93**	**3.06**	**18.18**	**13.97**	**10.29**	**9.89**	
	San Juan	**C**	**1.85**	**1.28**	**1.93**	**1.17**		**44.19**	**44.7 3**	**35.38**	**48.50**	
	Paranaque	**C**	**1.57**	**0.36**	**0.29**	**-**	**1.90**	**38.20**	**53.31**	**38.00**	**29.16**	**47.6**
	Pasig	**C**	**3.15**	**3.10**	**3.18**	**3.39**		**20.49**	**33.29**	**29.01**	**31.71**	

One program formulated by the EMB is the Sagip-Ilog Program which aimed to improve water quality of the identified 19 priority rivers in the Philippines in terms of BOD and DO levels and comply with the DAO-34 or the Revised Water Quality Criteria by year 2016. Monthly water quality monitoring was required for these priority rivers and results indicated that 75% of the rivers monitored passed the water quality standards for DO while 25% failed to pass the standards. Moreover, out of the 19 priority rivers monitored in 2012, 6 rivers were already within BOD In the study conducted by Crocker and Bartram (2014), they mentioned that the World Health Organization (WHO) Guidelines for Drinking-water Quality and the WSP manual propose that both operational monitoring and independent surveillance be carried out; both often involve testing for signs of fecal contamination. Operational monitoring informs decision making and corrective actions regarding control measures (e.g., source protection, water treatment), whereas drinking water quality surveillance involves an independent third party overseeing the water supply with the specific mandate of protecting public health. A study about physico-chemical and bacteriological analyses of water used for drinking and swimming purposes from four sampling sites conducted in Abeokuta, Nigeria by Shittu et al., (2008) revealed that Sokori stream and a well did not comply with turbidity and Mg^{2+} standards while all others were within the standards for pH, color, total solids, TDS, acidity, total hardness, Ca^{2+} hardness, chloride and iron. None of the samples complied with bacteriological standards as total coliform counts generally exceeded 1,600 MPN/ml, and pathogen count such as Salmonella shigella counts and Vibrio cholera counts were very high. The data of the parameters were compared to the standards set by WHO and EPA.

IV. METHODOLOGY

This chapter presents the process and methods used in gathering and collecting data obtained from the study. This includes research design, research locale and research procedure.

Research Design : This study used both descriptive-quantitative research designs. The descriptive design presents the observation, collection and documentation of data, the description of the processes of the research procedure, and the discussion of the results of the water analysis. The quantitative design, on the other hand, provides measurement and analysis of the data gathered from the water analysis.

Research locale : This research was conducted in Burayan River in Tacloban City. The researchers purposely selected three different stations of Burayan River according to its upstream, midstream and downstream which were Brgy 83-A Burayan San Jose (upstream), Brgy. Taguictic (midstream) and, San Jose, and Villa Dolina, Marasbaras respectively (downstream). The researcher chosen this river as the research locale, in order to provide important information for conservation and management efforts, as well as help the LGU and the community by crafting an informed resource management relative to the appropriate consumption or usage of the water of the said river.

Research Procedure:

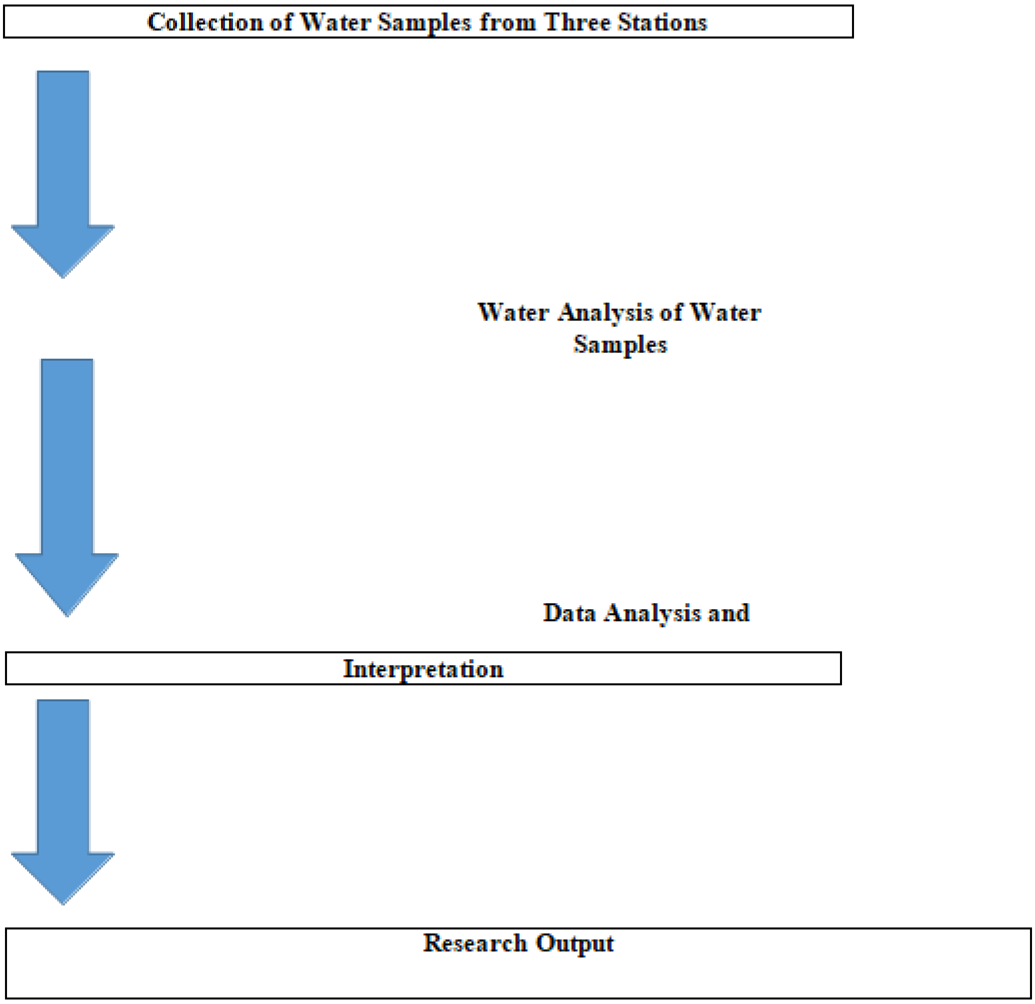

Figure 1. The Flow of Activities

Collection of Water Samples from Three Stations : The collection of water samples from three different stations of Burayan River was based on the instruction given by the EMB in Palo. The containers used for gathering the water samples were sterilized before dates of collection. Six containers (two for each station) were prepared; one to be submitted to EMB and the other to LMWD-Tacloban since EMB tests limited parameters only. The researchers directly gathered the water samples from the stations during a rainy day and a sunny day as instructed by the EMB. According to Ibrahim et al. (2009), the difference in the indicator transparency mean values of the wet and dry seasons may be explained by the absence of floodwater, surface runoffs, and the settling action of suspended materials after the end of precipitation. For every station, approximately 1.5 liters were collected. The containers were tightly sealed and labelled as Sample A (upstream), Sample B (midstream) and Sample C (downstream). The samples were immediately submitted to EMB and LMWD for water analysis after one to two hours of collection.

Water Analysis of Water Samples : The water analysis of the samples gathered was performed by the chemical analysts from the EMB and LMWD.

In EMB, water temperature, turbidity, conductivity, pH, total dissolved solids and dissolved oxygen were tested using a water quality checker- a device measuring multiple parameters together. The water quality checker was immersed on the samples for less than five minutes and it started reading. The analyst guided the researchers on how to read the results by letting the water quality checker reach first a hundred percent dissolve oxygen level. After reaching 100%, the water quality checker was stopped, and the final results of the water analysis were displayed.In LMWD, nitrate and alkalinity were tested in the laboratory. Nitrate analysis was done through distillation process and alkalinity by titration. It took four days before the tests were completed and the results were recorded.

V. RESULTS AND DISCUSSION

The results of the water analysis of the three samples were treated independently. The results were placed in Table 6 and Table 7 prior to the sampling date. Table 6 shows the water quality of Burayan River during the rainy day, while Table 7 shows the water quality during the sunny day. The EMB and WHO standards were utilized in comparing the water quality of the river from the set of standards. In determining whether the water quality passed the standard values of the physicochemical parameters of the three sampling sites, Table 8 was prepared. Table 8 shows the summary for the parameters that were recorded as favorable and unfavorable water quality. From the results, we derived the final decision if the water quality of the river passed the standard.

Table 5 Water Quality of Burayan River during Rainy Day

Parameter	Unit	Sampling Station			LMWD and DAO Standard
		Sample A (Villa Dolina, Marasbaras)	Sample B (Brgy. Taguictic Burayan, San Jose)	Sample C (Brgy. 83A Burayan, San Jose)	
Width		830 cm	458 cm	987 cm	
Water temperature	ºC	29.86	30.72	31.34	24.9
Turbidity	NTU	43.6	44.1	35.9	≤ 5
Conductivity	µS	0.735	3.02	16.4	≤ 500
pH	Range	9.31	9.53	9.24	6.5-8.5
Alkalinity	mg/L	160.00	162.00	190.00	≤ 150 @ pH=4.8
Nitrate	mg/L	1.443	1.828	2.369	≤ 50
TDS	mg/L	0.471	1.94	10.2	≤ 500
DO	mg/L	7.56	7.45	16.4	5.0 minimum

The water temperature of the three samples ranged from 29.86-31.34 ºC. From the three samples, Sample A has the lowest temperature which is 29.86 ºC while Sample C has the highest which is 31.34 ºC. The three samples have only little difference by their decimals, however; all samples were relatively high compared to the standard provided by LMWD which is 24.9 ºC. The turbidity of the three samples ranged from 35.9-44.1 NTU. Sample C has the lowest measure of turbidity which is 35.9 NTU while Sample B got the highest measure of 44.1 NTU. All samples exceeded from the standard, ≤ 5, given by LMWD.

The conductivity ranged from 0.735-16.4 µS. Sample A has the lowest conductivity of 0.735 µS. On the other hand, Sample C has the highest measure of 16.4 µS. All samples were conductive and within the standard provided by LMWD. The pH ranged from 9.24-9.53. All of the samples have only little differences. Sample C got the lowest pH of 9.24. Sample B was recorded highest with 9.53. However, all samples did not meet the standard by the DAO. This result was somehow nearly similar to the study of Adefemi and Awokunmi (2009), where in the physico-chemical parameters obtained from analysis of water samples from wells and Ona River in Itaogbolu were presented with the corresponding the pH values ranged between 6.87-7.45 with an average value of 7.22±0.35 The alkalinity of the three samples ranged from 160.00-190.00 mg/L. Sample A got the lowest measure of 160.00 mg/L while Sample C got the highest measure of 190.00 mg/L. All samples exceeded the standard set by LMWD. The nitrate of the samples ranged from 1.443-2.369 mg/L. Sample A got the lowest value of 1.443 mg/L while Sample C got the highest value of 2.369 mg/L. All samples were within the standard provided by the LMWD.

The total dissolved solids ranged from 0.471-10.2 mg/L. Sample A has the lowest value of 0.471 mg/L and Sample C has the highest value with 10.2 mg/L. All samples met the standard by

LMWD.

The dissolved oxygen ranged from 7.45-16.4 mg/L. Sample B got the lowest value of 7.45 mg/L while Sample C has the highest value with 16.4 mg/L. All samples passed the standard given by DAO which is 5.0 mg/L.

Table 6 Water Quality of Burayan River during Sunny Day

Parameter	Unit	Sampling Station			LMWD and DAO Standard
		Sample A (Villa Dolina, Marasbaras)	Sample B (Brgy. Taguictic Burayan, San Jose)	Sample C (Brgy. 83A Burayan, San Jose)	
Width		830 cm	458 cm	987 cm	
Water temperature	ºC	29.95	30.29	31.16	24.9
Turbidity	NTU	91.4	95.3	114	≤ 5
Conductivity	µS	0.404	0.624	8.49	≤ 500
pH	Range	7.71	6.86	6.44	6.5-8.5
Alkalinity	mg/L	168	155	137.5	≤ 150 @ pH=4.8
Nitrate	mg/L	1.438	0.873	0.765	≤ 50
TDS	mg/L	0.263	0.399	5.35	≤ 500
DO	mg/L	6.0	4.08	7.96	5.0 minimum

The temperature of the samples ranged from 29.95-31.16 ºC. Sample A has the lowest temperature which is 29.95 ºC while Sample C has the highest value of 31.16 ºC. All samples have slight differences compared to the samples in Table 6, but all samples were higher than the standard.

The turbidity of the samples ranged from 91.4-114 NTU. Sample A had its lowest measure of 35.9 NTU while Sample C got the highest measure of 114 NTU. Compared to the samples from Table 6, the three samples were much higher. All samples did not pass the standard.

The conductivity ranged from 0.404-8.49 µS. Sample A was the lowest with a value of 0.404 µS while Sample C was the highest with 114 µS. All samples were within the standard.

`The pH ranged from 6.44-7.71. All samples were quite lower than samples in Table 6. Sample C got the lowest pH of 6.44. On the other hand, Sample A was the highest with 7.71. All samples passed the standard.

The alkalinity ranged from 137.5-168 mg/L. Sample C got the lowest measure of 137.5 mg/L while Sample A got the highest measure of 168 mg/L. All samples did not meet the standard except Sample C.

The nitrate ranged from 0.765-1.438 mg/L. Sample C got the lowest value of 0.765 mg/L while Sample A got the highest value of 1.438 mg/L. All samples were within the standard.

The total dissolved solids ranged from 0.263-5.35 mg/L. Sample A has the lowest value of 0.263 mg/L and Sample C has the highest value with 5.35 mg/L. All samples met the standard.

The dissolved oxygen ranged from 4.08-7.96 mg/L. Sample B got the lowest value of 4.08 mg/L while Sample C has the highest value of 7.96 mg/L. All samples were within the standard except Sample B.

Table 7 Summary of Water Quality of Burayan River

Parameter	Sample A (Villa Dolina, Marasbaras)		Sample B (Brgy. Taguictic Burayan, San Jose)		Sample C (Brgy. 83A Burayan, San Jose)	
	Rainy	Sunny	Rainy	Sunny	Rainy	Sunny
Water temperature	U	U	U	U	U	U

Turbidity	U	U	U	U	U	U
Conductivity	F	F	F	F	F	F
pH	U	F	U	F	U	F
Alkalinity	U	U	U	U	U	F
Nitrate	F	F	F	F	F	F
TDS	F	F	F	F	F	F
DO	F	F	F	U	F	F

(F=Favorable; U=Unfavorable)

All samples whether during rainy day or sunny day were unfavourable for water temperature and turbidity tests. While the conductivity, nitrate, and total dissolved solids parameters for all samples of both rainy day and sunny day passed the water quality standard. For pH, samples for rainy day were all unfavourable compared to the samples for sunny day which were favourable. Only Sample C (Brgy. 83A Burayan, San Jose) for sunny day was favourable for alkalinity, while only Sample B (Brgy. Taguictic Burayan, San Jose) during sunny day was unfavourable for dissolved oxygen.

VI. CONCLUSION

There were significant differences on the physicochemical parameters of the three sampling stations in Burayan River. Alkalinity value in Brgy 83A Burayan San Jose was favorable only during sunny day. However, all other sampling stations, Villa Dolina, Marasbaras and Brgy. Taguictic Burayan San Jose were unfavorable both during sunny and rainy days. Dissolved oxygen level in Brgy. Taguictic, Burayan San Jose was unfavorable only during sunny day. Whereas, the two sampling stations, Brgy. 83A Burayan San Jose and Villa Dolina Marasbaras, were favorable for both sunny and rainy days. Nevertheless, there were also uniformity on the physicochemical parameters on the three sampling stations. Water temperature and turbidity of the three sampling stations did not pass the permissible limits indicated by DAO and EMB. Conductivity, nitrate and total dissolved solids of the three sampling stations were not within the water quality standards. The pH levels of the three sampling stations were unfavorable during rainy day contrary to the results during sunny day. Brgy. Taguictic, Burayan San Jose incurred most unfavorable water quality for all parameters both rainy and sunny day. The results of the water analysis clearly determine that water quality of Burayan River did not pass the water standard quality set by LMWD and EMB.

IV. RECOMMENDATION

Environmental agencies of the concerned city should conduct regular examination of water quality of its all bodies of water to maintain the natural quality of water as well as to reduce it from contamination. They should also need to conduct action plans in renewing the water quality of the Burayan River. Then for the community officials, they should impose policies in maintaining and sustaining the natural quality of Burayan River. They should impose clean-up drive activities in cleaning Burayan River. Since collaboration has become a popular approach to environmental policy, planning, and management (Koontz et al., 2010). Also, a further study that could shed light on the current water quality of all rivers in Tacloban City and help in formulating strategies for its conservation Lastly, by participating in clean-up drive activities mandated by various government agencies, the residents of the barangay who live close to the river should work hand in hand with the community officials to strictly follow the necessary ordinance of the local government for the complete recovery of the river's water body. To keep the river from becoming polluted, and by avoiding throwing trash into it.

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