CHARACTERIZATION OF WATER QUALITY IN BITAN-AG CREEK, CAGAYAN DE ORO CITY, PHILIPPINES: A PHYSICOCHEMICAL INVESTIGATION

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ABSTRACT: *This study aimed to evaluate the water quality of Bitan-ag Creek in Cagayan de Oro City by assessing its physicochemical properties and comparing them to the standards set by DENR-DAO 2016-08 for Class C fresh surface water. The results showed that the levels of nitrates, phosphates, potassium, and temperature did not exceed the standard limits. However, the presence of solid and liquid waste contributed to increased phosphate and lead levels, with significant differences observed in two sampling sessions across the three sampling stations. The p-value for nitrates was greater than 0.05, indicating no significant difference in levels among the three stations. Potassium levels also did not show any significant difference, with a p-value of 0.18. On the other hand, the phosphate result revealed a significant difference, with a p-value of 0.01, indicating that the presence of solid and liquid waste contributed to phosphate substances along Bitan-ag Creek. The highest average concentration of nitrates (7.56 mg/L), phosphate (2.56 mg/L), and temperature (30˚C) was observed at Station 2 (near the University of Science and Technology of Southern Philippines). The trace of lead was below the standard set by DENR-DAO 2016-08 for Class C fresh surface water, but there was a significant difference in lead levels among the three sampling stations due to the discharge of household and liquid waste in the area.*

Keywords: Water Quality Assessment, Bitan-ag Creek, Characterization, Heavy metals

1. INTRODUCTION

The recognition of access to clean and safe water as a fundamental human right by the United Nations General Assembly Report in 2016 [1] underscores the importance of ensuring that individuals have access to high-quality water for their consumption. However, it is increasingly evident that both climate change and human activities are significantly impacting the hydrological cycle, leading to growing concerns about the degradation of water quality and its implications for human well-being.

One key aspect highlighted in the study by Jin et al. [2] is the pollution resulting from human involvement and improper agricultural discharge from rivers. This poses a significant challenge to water resources as these pollutants can contaminate water bodies, making them unsafe for human use. Such pollution can originate from various sources, including industrial activities, sewage systems, and agricultural practices.

Furthermore, the studies conducted by Uddin et al. [3] and Hasan et al. [4] provide valuable insights into the causes and consequences of surface water pollution and the deterioration of water quality, highlighting the predominant role of anthropogenic factors. Specifically, they identify untreated industrial effluents, inadequate disposal of domestic waste, and agricultural runoff as major contributors to water pollution. Industrial activities are known to release a wide range of harmful chemicals and pollutants into water bodies.

This can occur through direct discharge of untreated wastewater or accidental spills, leading to the contamination of nearby water sources. The presence of these pollutants compromises the quality of water and poses significant health risks to humans who rely on it for drinking, bathing, and other daily activities. Moreover, these pollutants can accumulate in the environment and have long-lasting effects on aquatic ecosystems, disrupting the balance of the ecosystem and endangering various species.

Improper disposal of domestic waste and inadequate wastewater treatment systems also play a significant role in water pollution. When domestic waste, including sewage and other household chemicals, is not disposed of properly or treated appropriately, it can find its way into water sources. This introduces contaminants such as bacteria, viruses, pharmaceuticals, and toxic substances into the water, further degrading its quality. In regions or communities lacking sufficient infrastructure for wastewater treatment, the problem of water contamination becomes even more severe, as untreated sewage is discharged directly into rivers, lakes, or coastal areas.

Agricultural runoff is another critical contributor to water pollution. Excess fertilizers, pesticides, and sediment from agricultural activities can be carried away by rain or irrigation water and end up in nearby water bodies. The accumulation of these substances in water sources can lead to eutrophication, a process where excessive nutrients promote the growth of harmful algal blooms. These blooms can deplete oxygen levels in the water, harming aquatic life and disrupting the natural balance of ecosystems. Additionally, pesticides can directly harm aquatic organisms, while sedimentation can negatively impact water clarity and alter aquatic habitats.

Additionally, a study conducted by Vega et al. [5] and Barakat *et al*. [6] examined how seasonal variations, including anthropogenic and natural processes such as temperature and precipitation, affect river water quality, leading to distinct characteristics in different seasons. Urban areas with high levels of urbanization are particularly susceptible to contamination due to both direct and indirect pollution sources. However, rural surface waters are also negatively impacted by farming, animal production, and other activities in the food sector that release organic contaminants into the water system. The consequences of inadequate sewerage and the resulting pollution have far-reaching environmental impacts, adversely affecting terrestrial and aquatic life as well as humans. When bodies of water, such as rivers, streams, and

lakes, become polluted due to wastewater discharge or accidental spills, both the human population and the surrounding ecosystem face significant risks and dangers.

According to Cabral [7], these bodies of water contaminate the local groundwater, exposing individuals to environmental illnesses and diseases, which can lead to death and morbidity. The urbanization of Cagayan de Oro is having a detrimental effect on the city's rivers and streams. Limited local data is available on the current condition of the water in Bitan-ag Creek, despite its extensive coverage within the city. This can be attributed, in part, to a lack of resources, professional interest, and dedicated efforts to investigate the creek's water quality alongside rehabilitation initiatives, as mentioned by Del Rosario and Palmes [8]. The city's population continues to grow, resulting in an increasing number of vehicles on the roads. Another significant environmental concern is the city's pollution caused by vehicles emitting excessive smoke and the high volume of garbage present.

The Bitan-ag Creek is a significant waterway in Cagayan de Oro City, alongside four other major creeks, namely Binono-an, Indolong, Kolambog, and Sapong Umalag. Although the Bitan-ag Creek is classified as Class C inland water, suitable for various purposes such as agriculture, irrigation, livestock watering, and industrial water supply, there is a limited amount of published research available on its condition.

To address this gap, Maglaque [9] and Kiamco [10] conducted a study and survey focusing on the health hazards caused by pollution in the creek, as well as the solid waste management practices of the communities residing along its banks. Their research aimed to characterize the quality of the creek's water, shedding light on its physical and chemical characteristics. The ultimate goal of the study is to raise awareness among the general public about the current state of the creek in terms of waste management practices.

2. METHODOLOGY

The study used a descriptive-comparative type of research it aims to determine the physicochemical properties of water in terms of temperature, nitrogen (N), phosphorous (P), potassium (K), and lead (Pb) concentration levels. The collection of samples was done between 0800 to 1600 with two months intervals to compare with the standard set DENR-DAO34 for Class C fresh surface water.

The Bitan-ag Creek extends from the Kahulugan watershed, situated in the upper part of Barangay Camaman-an, Cagayan de Oro City, to its endpoint in Macajalar Bay near Barangay Macabalan in Cagayan de Oro City. For the purpose of the study, multiple stations were selected along Bitan-ag Creek in Cagayan de Oro City. These stations include the upper station near Maria Reyna, the middle station near the University of Science and Technology of Southern Philippines-USTP, and the down station at Agora. The study employed a transect line measuring 30 x 10 meters at each of these stations.

Sampling Locations

At Station 1, which is situated near Maria Reyna Hospital, a notable observation is that households in the area discharge their liquid waste directly into the Bitan-ag Creek. The proximity of Station 1 to the mountainous region of Camaman-an, Cagayan de Oro City indicates the presence of anthropogenic activities along the creek. These activities contribute to the accumulation of solid waste and potentially lead to elevated levels of nitrates, phosphates, and potassium in the water. Moving to Station 2, located near the University of Science and Technology of the Southern Philippines (USTP), there are various food establishments situated along the creek within this station. Additionally, households in the vicinity also contribute to solid waste accumulation in Bitan-ag Creek. The combined effect of these factors can further contribute to the degradation of water quality in this section of the creek.

Finally, Station 3, positioned near the JETTI gasoline station at Agora, is notable for the generation of diverse forms of liquid waste. Moreover, households in the area discharge their waste directly into the creek. Consequently, pollutants such as nitrates, phosphates, potassium, and even lead may be directly disposed of in the creek, posing significant risks to the water quality and ecosystem. These distinct stations along Bitan-ag Creek demonstrate the diverse sources and types of pollution

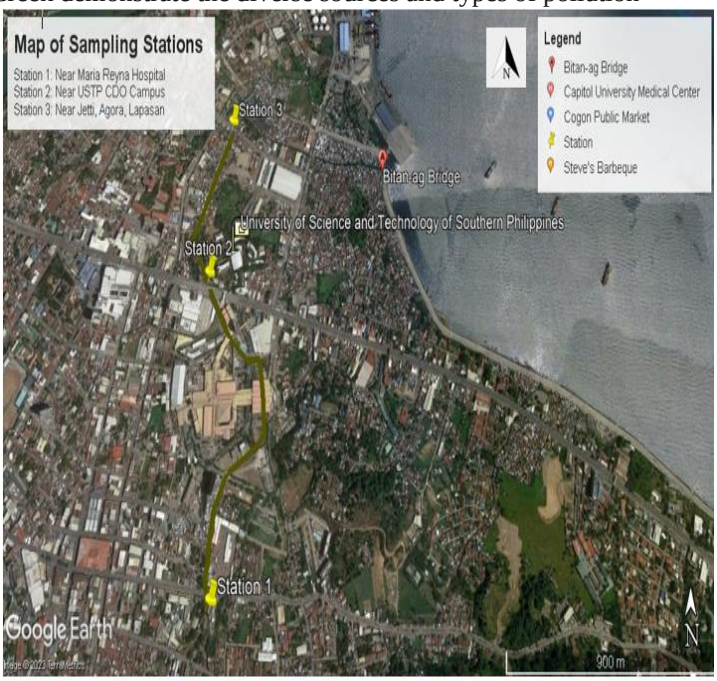

Fig. Map of Bitan-ag Creek showing three sampling stations: near Maria Reyna Hospital, near USTP, and near JETTI (Agora).

present in the water. The discharge of liquid waste from households, the accumulation of solid waste from various establishments, and the direct disposal of pollutants contribute to the degradation of water quality in different sections of the creek. It is crucial to address these issues through effective waste management practices, community awareness, and sustainable initiatives to mitigate the negative impacts on the

creek's ecosystem and the health of surrounding communities.

Sampling Techniques

1. Selection of Study Sites

There were three (3) sampling sites established along the Bitan-ag Creek namely: station 1 (near Maria Reyna Hospital), station 2 (near the University of Science and Technology of Southern Philippines), and Station 3 (near JETTI Agora). Station 1 is near Maria Reyna Hospital where households are in minimal numbers. Station 2 near the University of Science and Technology of Southern Philippine CDO Campus is surrounded by malls, fast food chains, and schools. Station III near JETTI Agora which is a household community area and a gasoline station is present.

Research Sampling

Three (3) 1.5L of water sample was collected in every station and lead (Pb) was sampled only once frequency in random grabbing points.

Data Collection and Procedures

Samples were collected in three sampling sites along Bitan-ag Creek through a random sampling technique. Station 1 (near Maria Reyna), Station 2 (near USTP), and Station 3 (Agora) with a 30 x 10 transect line. The sample was brought to the laboratory for analysis.

Inferential analysis was used to test if there are significant differences between the three-sampling station namely the nitrogen (N), phosphorous (P), potassium (K), and lead. One-way ANOVA was used to compare the means of the chemical parameters in each station along Bitan-ag Creek. With this, the hypothesis is that there is a significant difference in the three mean values or concentrations of the chemical parameters between the three sampled sites. A significant difference at a p-value of or less than 0.05 is to accept the hypothesis otherwise null hypothesis is accepted. The null hypothesis is that there is no significant difference in the three mean values or concentration of the chemical parameters between the three sampled sites.

3. RESULTS AND DISCUSSION

Bitan-ag Creek is found in the heart of Cagayan de Oro City. It stretches from barangay Camaman-an to barangay Macabalan. It was classified as a class C freshwater surface according to the Department of Environment and Natural Resources- DENR Administrative Order 2016-08 (DENR-DAO 2016-08).

Table 1. The physicochemical properties and p-values

Parameters	Stations			F-value	P value	DENR DAO 2016-08
	Station 1	Station 2	Station 3			
Nitrates (mg/L)	6.39	7.56	7.24	0.28	0.76	10(j)
Phosphate (mg/L)	1.17	2.76	2.55	17.8	0.01	0.4(k)
Potassium (mg/L)	8.84	8.48	12.89	1.96	0.18	NS
Lead (ppm)	0.0041	0.03	0.03	25.92	0.01	0.05
Temperature(˚C)	27	30	28			26-31

Legend:
DENR-DAO- Department of Environment and Natural Resources-DENR Administrative Order 2016-08

The findings of the study indicate that the physicochemical properties measured in the three sampling stations along Bitan-ag Creek do not exceed the standards set by DENR DAO 2016-08. The analysis of nitrate levels reveals a p-value of 0.76, which is greater than the significance level of 0.05. This indicates that there is no significant difference in the nitrates level among the three sampling stations. Similarly, the p-value for potassium is 0.18, also greater than the significance level of 0.05, suggesting that there is no significant difference in potassium levels among the sampling stations. The minimal levels of nitrates and potassium observed along Bitan-ag Creek can be attributed to the climatic patterns that occur during heavy rains, resulting in runoff from upstream areas. This dilutes the concentration of these substances downstream. However, phosphate levels show a significant difference among the sampling stations, with a p-value of 0.01, indicating that the presence of solid and liquid waste contributes to the phosphate content in Bitan-ag Creek. This difference can also be attributed to the specific characteristics of each sampling station, such as the type of area and the prevailing climatic conditions.

Notably, the sampling station near the University of Science and Technology of the Southern Philippines (USTP) exhibits the highest average concentration of nitrates (7.56 mg/L), phosphate (2.56 mg/L), and temperature (30°C). This can be attributed to the presence of various types of solid waste and a combination of liquid waste that contribute to increased nitrates, phosphorus, and temperature levels in this area.

Regarding lead levels, it is important to highlight that the traces of lead detected in the water are below the standard set by DENR DAO 2016-08 for Class C fresh surface water. However, there is a significant difference in lead levels among the three sampling stations. This difference may be attributed to the generation of different liquid wastes and the discharge of waste from households into the creek.

Overall, the study reveals that the physicochemical properties measured in Bitan-ag Creek generally meet the standards set by regulatory bodies. However, there are variations in phosphate and lead levels among the sampling stations, indicating the influence of solid and liquid waste, as well as the specific characteristics and activities occurring in each area. These findings emphasize the importance of proper waste management practices to minimize the potential negative impacts on water quality and to preserve the integrity of Bitan-ag Creek as a valuable natural resource.

Weather conditions play a crucial role in altering the distribution patterns of nitrogen, phosphorus, potassium, and lead in Bitan-ag Creek. These compounds are influenced by both natural processes and human activities. The anthropogenic activities occurring predominantly in the upper stream portion of the creek contribute to the release of biodegradable materials and other compounds. During rainfall events, these substances are carried downstream, leading to an accumulation of biodegradable materials and other compounds in the creek. This phenomenon can result in eutrophication, which refers to the excessive nutrient enrichment of water bodies. The occurrence of eutrophication in Bitan-ag Creek highlights the impact of human activities

and weather conditions on water quality and ecosystem health. Excess nutrients, particularly nitrogen, and phosphorus, promote the growth of algae and other aquatic plants, disrupting the natural balance of the ecosystem and potentially leading to harmful algal blooms.

To further investigate the variations in the distribution of these compounds, a one-way analysis of variance (ANOVA) was conducted. ANOVA is a statistical technique used to assess if there are significant differences between the means of multiple groups or sampling stations in this case. It allows for the examination of the differences in nitrogen, phosphorus, potassium, and lead levels among the various sampling stations along Bitan-ag Creek.

The results of the ANOVA analysis provide insights into the significance of these differences. For instance, the p-values obtained for nitrogen and potassium were greater than the predetermined significance level of 0.05. This suggests that there are no significant differences in the levels of nitrogen and potassium among the sampling stations. On the other hand, the p-value for phosphorus was found to be less than 0.05, indicating a significant difference in phosphorus levels among the sampling stations. This implies that the presence of solid and liquid waste, combined with the specific characteristics of each sampling station and the prevailing weather conditions, influences the distribution of phosphorus in the creek.

Additionally, the analysis revealed a significant difference in lead levels among the sampling stations. This difference can be attributed to the specific areas where different sources of liquid waste are generated and discharged into the creek. While the lead levels detected are below the regulatory standards set by relevant authorities, the findings underscore the importance of ongoing monitoring and effective waste management practices to prevent potential health and environmental risks.

In summary, weather conditions play a key role in altering the distribution patterns of nitrogen, phosphorus, potassium, and lead in Bitan-ag Creek. Human activities, particularly in the upper stream portion, contribute to the release of biodegradable materials and compounds. These substances, along with weather-induced runoff, can lead to eutrophication and impact the water quality of the creek. The one-way ANOVA analysis provides valuable insights into the differences among the sampling stations, highlighting the influence of solid and liquid waste, as well as specific environmental factors. This knowledge is crucial for implementing appropriate measures to mitigate pollution, preserve water quality, and ensure the long-term health and sustainability of Bitan-ag Creek and its surrounding ecosystem.

4. CONCLUSIONS

The concentration levels of nitrate, phosphate, and potassium in all three sampling stations across multiple sampling sessions were found to be within the standard limits set by DENR DAO 2016-08. Similarly, the trace lead concentration was below the specified standard. These results indicate that, overall, the water quality in Bitan-ag Creek meets the regulatory guidelines for these parameters. However, there was a significant difference observed in the level of phosphate between the two sampling sessions conducted at the three sampling stations. This finding suggests that the phosphate levels vary between different sampling sessions, indicating potential fluctuations in the presence of solid and liquid waste and other contributing factors. Weather conditions play a crucial role in altering the distribution patterns of nitrogen, phosphorus, potassium, and lead in Bitan-ag Creek. These compounds, influenced by both natural processes and human activities, originate from anthropogenic activities primarily occurring in the upper stream portion of the creek. As a result, during periods of rainfall, these substances are carried downstream, leading to an accumulation of biodegradable materials and other compounds. This process can contribute to eutrophication, which is characterized by an excessive nutrient load in bodies of water.

The excessive presence of nutrients, such as nitrogen and phosphorus, can stimulate the growth of algae and other aquatic plants, disrupting the natural balance of the ecosystem and potentially leading to harmful algal blooms. In summary, the concentration levels of nitrate, phosphate, and potassium in Bitan-ag Creek across multiple sampling sessions were found to be within the regulatory limits. However, there was a significant difference observed in the phosphate levels between different sampling sessions. The presence of trace amounts of lead was also found to be below the specified standard. Weather conditions play a vital role in the distribution patterns of these compounds, which are influenced by anthropogenic activities in the upper stream portion of the creek. The combined effects of these factors can contribute to eutrophication, highlighting the importance of ongoing monitoring and management practices to maintain the water quality and ecological balance of Bitan-ag Creek.

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