Coliform Assessment of Sewage Water Flowing into Cagayan River

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Abstract*— Cagayan River is considered to be the main source of livelihood in the Cagayan Valley region. Emission of untreated wastes from residential buildings was found to be among the major contributors to contamination of the river. Moreover, untreated wastewater or sewage is a source of microorganisms which cause waterborne diseases. This study assessed coliform bacteria count in sewage water that is directly flowing in the Cagayan River in three flood-prone barangays of Tuguegarao City. Multiple tube fermentation technique (MTFT) and Heterotrophic Plate Count (HPC) method were employed to determine the total coliforms, fecal coliforms, and heterotrophic plate counts of the different sewage samples collected. The findings showed a significantly increased fecal and total coliform count of >1600 MPN/mL in all the samples that exceeded the standard limit set by the Department of Environment and Natural Resources (DENR), and World Health Organization. Moreover, the heterotrophic plate count (HPC) of all the sampling sites did not fall within the allowable limits. The results therefore indicate a high bacterial content or concentration as well as high level of fecal matter contamination of the sewage waters from the barangays which are sources of sewage water effluent flowing into the Cagayan River. The results indicate the lack of treatment of sewage water flowing directly into the Cagayan River. Moreover, the results imply the need for continuous monitoring and strict compliance to general effluent standards and sewage treatment and sewage management system of wastewater in these areas before discharge into a particular water body.

Keywords*— *sewage water, total and fecal coliform count, heterotrophic plate count (HPC), standard level

I. Introduction

Water sewage is defined as a subset of wastewater, but it contains everything that wastewater does (Delaware Health and Social Services, 2014). It is divided into rainwater runoff, which comes from streets and open grounds and flows through sewers after rainfall, industrial or liquid waste from industrial sites, and domestic wastewater generated by households, institutions, and commercial sites (Amoatey & Bani, 2011). Wastewater, especially domestic wastewater, may contain high concentrations of pathogens. It consists of black water (excreta, urine, fecal sludge) and greywater (kitchen, laundry, bathing wastewater) (Corcoran et al., (2010), and if left untreated or only partially treated and reached the rivers and other water sources via sewage, leakage or flooding, the outcomes are not good. Water pollution, the depletion or death of aquatic organisms, and the widespread of water-borne diseases caused by waterborne pathogens (such as coliform bacteria) are more serious consequences (Environmental Technology, 2016).

Coliform bacteria encompass a broad range group of gram-negative, rod-shaped bacteria that display several features (Whitlock et al., 2002). They are usually found in the environment, the digestive tract, and the feces of warm-blooded animals and humans (Pal, 2014) and have been widely used as water quality indicators. Coliform bacteria are unlikely to cause disease, but they are indicators of contamination of the water system by disease-causing or pathogenic organisms and may pose potential health risks. Diarrheal disease caused by fecal contamination of water sources (Wolf et al., 2014) can lead to a high mortality rate among children (Liu et al., 2012). Gastrointestinal illness (GI) causes symptoms such as diarrhea, nausea, vomiting, fever, abdominal pain (Wade et al., 2006; Arnone & Walling, 2007). Typhoid fever, influenza, dysentery, ear infections, and gastroenteritis can be transmitted in water with elevated fecal coliform counts (Oram, 2014). Escherichia coli (*E. coli*) is considered to be the main species of fecal coliforms (Department of Health [DOH], 2017). Although some strains of these bacteria are harmless, they have obtained virulence factors through transposons, phages, plasmids, and/or pathogenic islands and have developed into pathogenic *E. coli* strains (Lim et al., 2013). Severe cases caused by *E. coli* include bloody diarrhea, dehydration, kidney failure (Pietrangelo, 2019), and even death (Bhat & Danek, 2011). These diseases may be transmitted not only through the ingestion of water contaminated by pathogens, but also through skin contact during recreational activities or by ingestion of raw crops irrigated with contaminated water (Edokpayi et al., 2015) and through ingestion of contaminated fish and shellfish. Agricultural runoff, wastewater sewerage discharge or septic systems' effluents and domestic sewerage, building's untreated waste emission, and animal fecal matter discharge were noted by Ancog & Mayor (2005) as known sources of coliform bacteria in groundwater.

In 2015, the Greenpeace Philippines reported that wastewater sewerage is considered as the major source of pollution of the Philippines' rivers, at which 48% comes from inadequately treated domestic wastewater or sewerage while the remaining 37% and 15% comprised of agricultural and industrial wastewater, respectively (Borgen Magazine, 2016). Edokpayi et al. (2017) affirm that wastewater effluents are the major sources of the numerous water pollution problems. In Cagayan Valley, residential and building's untreated wastes' emission was among the major contributors to contamination of the Cagayan River (Ancog & Mayor, 2005). The Cagayan River, also known as Rio Grande de Cagayan, is considered to be the main source of livelihood in the region. It is the largest river in the country, with a basin area of 75, 753 sq. km. and a river length of 520 km. Ilagan river, Siffu-Mallig river, Magat river, and Chico river are considered to be the main tributaries of the Cagayan River. The river's headwaters are found in the Caraballo Mountains of Central Luzon at an elevation of about 1,524 meters. This river flows northward for about 520 km to the entrance of the Babuyan Channel in Aparri, Cagayan (Balderama, 2018). In 2013, the DOST-PAGASA had classified the Cagayan River as a category III climate zone and is considered to have no obvious maximum rainfall period and short dry period. It is comparatively dry during November and May, while wet for the remaining year. Aside from that, the Cagayan River is rich in water and is mainly used for irrigation systems of region II aside from fishery, transport, recreation, and tourism (Water Environment Partnership in Asia (WEPA), 2017). It also supports the lives of many endangered and endemic species such as the Philippine eagle (*Pithecophaga jefferyi*), Luzon bleeding-heart pigeon (*Gallicolumba luzonica*), and riverine (*Gallicolumba luzonica*)- locally known as Ludong (*Cestreaus plicatilis*).

The water quality of the Cagayan River Basin was reported to be good as of 2000. Most of its sections are classified as 'uncontaminated' and 'slightly contaminated' for the 2 sections. This shows that the Cagayan River has no major source of water pollution and can be used for public water supply, recreational, fishery, and industrial water supply. However, due to the sudden boom of population densities every year and the birth of gradual industrialization, and the intensification of agricultural activities in the country, the quality of the Cagayan River may change (Villena & Rimando, 2005). Japan International Cooperation Agency (JICA) reported in 2004 that the quality of the Cagayan River Basin is increasingly affected and subjected to pollution by untreated sewage, residential sewage, industrial wastewater sewage, livestock and poultry manure, agro-chemicals, and sediments that directly enter the river and aquatic ecosystems (Balderama, 2018). In addition, domestic sewage containing pathogens also ended up in the above-mentioned river, which may pose a threat to human health and life. The inadequate facilities for wastewater treatment, collection and disposal of sewage wastewater in the region further adding to the river's degradation and can result in water-borne outbreaks (Edokpayi et al., 2017).

Given that waterborne diseases remain as the major public health concern in the country caused by the untreated wastewater or sewage, it is also the major source of pollution in the Philippines' rivers. Therefore, this study sought to assess the presence of coliform bacteria in the sewage water from three barangays in Tuguegarao City directly flowing to the Cagayan river. The sewage water was tested for total coliform, fecal coliform and Heterotrophic Plate Count (HPC).

II. Methods

This research study utilized a descriptive quantitative approach to establish the numerical relationship among the coliform bacteria populations recovered at the three locations, namely Caggay, Cataggaman Viejo, and Pallua Sur. Further, no controls were utilized. The study was conducted in three barangays of Tuguegarao City which are the direct sources of sewage water effluents flowing into the Cagayan River. These barangays are found in the southern and northeastern portion of the city. Moreover, these barangays are identified among the flood-prone barangays of the city by the Department of Public Works and Highways (DPWH) Tuguegarao Flood Hazard Map. Residential sewage may pollute the Cagayan River, especially when it overflows due to flooding, and may cause water-borne diseases. Multiple Tube Fermentation Tests (MTFT) and Heterotrophic Plate Count (HPC) were utilized to determine the coliform bacteria present in sewage flowing directly to the Cagayan River, which was conducted at the Department of Science and Technology Regional Office No. II, Regional Government Center, Carig Sur, Tuguegarao City. The researchers performed the collection of water samples with the assistance of a water analyst from the Department of Science and Technology Regional Office No. II.

A. Collection and Handling of Water Samples

The researchers followed the U.S. Environmental Protection Agency's Science and Ecosystems Support Divisions' Standard Operating Procedure for water sewage collection (2017). Meanwhile, the sample handling, preservation, storage, and transportation requirements were based on APHA-AWWA-Standard Methods for the Examination of Water and Wastewater, 22nd Edition (2012).

B. Testing of the Water Samples

The collected samples were sent to the Department of Science and Technology Regional Office No. II, Regional Government Center, Carig Sur, Tuguegarao City for coliform bacteria count in water sewage recovered at the three locations, namely Caggay, Cataggaman Viejo, and Pallua Sur, Tuguegarao City. The tests performed are based on APHA-AWWA-Standard Methods for the Examination of Water and Wastewater, 23nd Edition (2017).

a) Multiple Tube Fermentation Test (MTFT): The standard test for the coliform group can be performed using the multiple tube fermentation technique or the presence-absence process (through the presumptive-confirmed phases or completed test). The fermentation method can be used to identify and quantify coliforms in both potable and non-potable water. When multiple tubes are used, the coliform density is determined using a most probable number (MPN) table. This number represents an estimate of the sample's mean density of coliforms, calculated using specific probability formulas. When combined with other data from engineering or sanitary surveys, coliform testing results provide the most accurate assessment of water-treatment performance and sanitary quality of source water (Baird & Bridgewater, 2017).

b) Presumptive Coliform Test: This test is performed in fermentation tubes containing inverted Durham fermentation gas detection tubes and a specific enrichment procedure for coliform bacteria, which are filled with a selected growth medium (MacConkey lactose broth). Inoculate the water sample to be examined into a series of lactose broth tubes. A series of tubes can be divided into three or four groups of three, five, or more tubes. Count must be used to record observations.

c) Completed Total and Fecal Coliform Test: The completed test is presented here as a quality control recommendation and to be used when the test findings are uncertain. Positive coliform tests require additional testing for thermotolerant (fecal) coliforms and/or *E. coli*. Therefore, testing with EC and/ or EC-MUG broths is considered the completed test. Every quarter, perform the completed test on at least one positive sample to confirm the presence of coliform bacteria and provide QC data for non-potable water sample analysis (Baird & Bridgewater, 2017).

d) Heterotrophic Plate Count (HPC): This method, previously known as the standard plate count, was used to determine the amount of live, culturable heterotrophic bacteria in water and to identify changes in swimming pools or during water treatment and distribution. Colonies can be formed from pairs, chains, clusters, or single cells, all of which are colony-forming units (CFU) (Baird & Bridgewater, 2017).

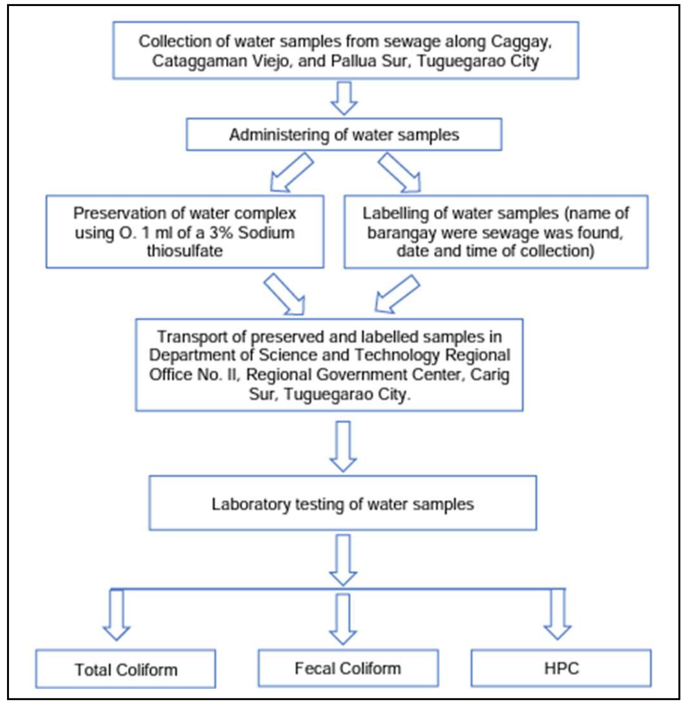

Fig. 4. Methodological framework of the study

C. Waste Disposal Management

The Department of Science and Technology Regional Office No. II, Regional Government Center, Carig Sur, Tuguegarao City was responsible for the overall disposal of the materials used in the laboratory tests, such as the tested water samples and their containers, as well as the disposal of the tested media. The overall waste disposal was based on Policy, Procedure, and Guideline: Bio-Waste and Sharps Disposal of University of Idaho Institutional Biosafety Committee (2018).

D. Data Analysis

The data from the tests performed on the sewage water samples from the different barangays were presented in tabular format. The mean of the total coliform, total fecal coliform and HPCs were also computed. The mean values were then compared to the standards of the Department of Environment and Natural Resources (DENR) and WHO.

TABLE I. DENR AND WHO STANDARDS FOR TOTAL COLIFORM, FECAL COLIFORM AND HPC

Standard	**Coliform Test**	**Classification of Water Supply**			
		Class A (Public Water Supply)	***Class B (Recreational Water Supply I)***	***Class C (Fishery Water; Recreational Water Supply II and Industrial Water)***	***Class D (Agricultural and industrial water supply)***
DENR	Total Coliform Count (MPN/100 mL)	1,000(m)	1,000(m)	5,000(m)	N/A
	Fecal Coliform	100(m)	200(m)	N/A	N/A

Standard	Coliform Test	Classification of Water Supply			
		Class A (Public Water Supply)	***Class B (Recreational Water Supply I)***	***Class C (Fishery Water; Recreational Water Supply II and Industrial Water)***	***Class D (Agricultural and industrial water supply)***
	Count (MPN/100 mL)				
WHO	HPC (CFU/mL)	1.0 x 102			

The table above presents the standards set by DENR for the allowable limit of coliform present in different classes of surface water. Cagayan River belongs to Class A. This classification includes bodies of water having watersheds which are uninhabited and otherwise protected.

E. Ethical Considerations

The researchers asked for permission from the Dean of the Health and Allied Sciences, University Ethics Board, Vice President for Academics, and President of University. All protocols that were used in conducting this study were subjected to approval by the ethics committee of the University of Saint Louis (USL).

The researchers also asked for permission from the Captains of the barangays before proceeding to the conduct of the study in the respective barangay. This is done to guarantee the safety of the residents. The researchers also sought assistance from a licensed water analyst in collecting water samples from the sewage of the aforementioned barangays. Lastly, the research underwent ethical review and clearance from the University Research Ethics Board.

III. Results

TABLE II. Total Coliform Count Sewage Water Samples Collected

Barangay	Total Coliform Count (MPN/100 mL)			Mean	Qualitative Interpretation
	R1	***R2***	***R3***		
A	>1600	>1600	>1600	>1600	Exceeds allowable limit
B	>1600	>1600	>1600	>1600	Exceeds allowable limit
C	>1600	>1600	>1600	>1600	Exceeds allowable limit

The table above shows the total coliform of the different sewage water samples from the three barangays. It shows that all sewage water samples exceeded the allowable limit set by DENR. The findings of the table imply high concentration of possibly pathogenic bacteria of the sewage waters from the three barangays that are directly flowing into the Cagayan River.

TABLE III. Total Coliform Count Sewage Water Samples Collected

Barangay	Fecal Coliform Count (MPN/100 mL)			Mean	Qualitative Interpretation
	R1	***R2***	***R3***		
A	>1600	>1600	>1600	>1600	Exceeds allowable limit
B	>1600	>1600	>1600	>1600	Exceeds allowable limit
C	>1600	>1600	>1600	>1600	Exceeds allowable limit

The table above shows the fecal coliform of the different sewage water samples from the three barangays. It shows that all sewage water samples exceeded the allowable limit set by DENR. The findings of the table further imply high fecal matter contamination of the sewage waters from the three barangays that are directly flowing into the Cagayan River.

TABLE IV. Biochemical Characteristics of Pathogenic Bacteria Identified in the Food Samples

Barangay	Fecal Coliform Count (MPN/100 mL)			Mean	Qualitative Interpretation
	R1	***R2***	***R3***		
A	7.3 x 10^5	8.0 x 10^5	9.3 x 10^5	8.2 x 10^5	Exceeds allowable limit
B	7.0 x 10^5	6.5 x 10^5	5.2 x 10^5	6.2 x 10^5	Exceeds allowable limit
C	7.4 x 10^5	6.1 x 10^5	7.6 x 10^5	7.0 x 10^5	Exceeds allowable limit

The table above shows the HPC results of the different sewage water samples from the three barangays. It shows that all sewage water samples exceeded the allowable limit set by WHO for coliform content. Moreover, the table reveals that barangay A has the highest HPC count among the barangays where the sewage water samples were collected. The findings of the table also imply high fecal matter contamination of the sewage waters from the three barangays that are directly flowing into the Cagayan River.

IV. Discussion

Wastewater effluents that contain pollutants are frequently discharged into surface water. The pathogens in the environment may be aided by these effluents (Oram, 2014). A group of bacteria called coliforms (total coliforms and fecal coliforms) are the most commonly used bacterial indicators in wastewater and are also used to monitor the microbial quality of water (Aslan et al., 2011; Vecchia et al., 2012; Spilki et al. 2013; Meals, Harcum, & Dressing, 2013; Osuolale & Okoh, 2015). The presence of non-pathogenic fecal coliforms in water could suggest the presence of pathogenic microorganisms that are of fecal origin. Studies have shown that gastrointestinal and respiratory diseases are related to polluted wastewater discharged into water bodies where the number of indicator bacteria has increased. Effective treatment and application of appropriate wastewater treatment systems in wastewater reuse (Jaffar et al., 2017), as well as regulatory compliance of effluents from wastewater treatment plants (WWTPs), are critical in removing organic waste as well as deactivating microbial pathogens before discharge into the environment (Makuwa et al., 2020).

In this study, total and fecal coliforms were detected at a constant level in water sewage from all the sampling sites, indicating that there is a high concentration of bacteria in water sewage due to human and animal manure and there is high possibility of Cagayan River being contaminated with these effluent sites. This is congruent to the findings of Samie (2009) and Oram (2014) revealing that human excrement, animal manure, and commercial waste generated from households and businesses are carried out by sewage increases the number of bacteria in feces. High concentrations of coliforms are also attributed to the lack of adequate wastewater treatment facility in the region.

In addition, high concentrations of total coliforms and fecal coliforms present in all the water sewage samples could indicate that wastewater treatment plants (WWTPs) are ineffective at removing fecal bacteria and that compliance with general effluent standards and sewage treatment and sewage management systems is poor (Hedricks & Pool, 2012). The standard limit ranged from <1.1 to 400 MPN/100 mL for fecal coliforms and total coliforms for the wastewater effluent to be allowed to discharge into a particular water body. Consequently, these guidelines given by the Department of Environment and Natural Resources (DENR) shown to be not in accordance with the findings of this study where total and fecal coliform counts were substantially higher, as their population exceeded >1,600 MPN/100 mL. These findings are consistent with data from research in South Africa, which found that fecal coliform counts were above the general limit of 1000 counts/100 mL and the specific limit of 0 counts/100 mL in 1.91 % and 96.43 % of the samples analyzed, respectively, indicating non-compliance in this regard (Makuwa et al., 2020). This significant increase indicates that sewage has received manure from one source to another (Oram, 2014; Department of Health (DOH), 2016). However, studies have revealed that other properties also play a role in wastewater treatment. Conductivity, pH, dissolved oxygen, nitrogen, and phosphate content may affect the bacterial community in wastewater (Samie et al., 2010). In 2013, Sanders, Yuan, & Pitchford evaluated the fecal coliform and *E. coli* concentrations in effluent-dominated streams of the Upper Santa Cruz Watershed in Arizona, which revealed that 13%-15% of the wastewater samples discharged with high concentrations of fecal coliform (maximum) exceeded the 800 colony forming units (CFU) per 100 mL, and 29% of samples exceeded the full-body contact standard of 235 CFU/100 mL established for *E. coli*. According to Asfaw et al. (2017), the high microbial contamination of treated wastewater indicates that the wastewater treatment plant may not be able to effectively eliminate the bacteria in the final effluent discharged into the environment. In South Africa, a study of sewage treatment plants in the Western Cape found that the presence of fecal bacteria in raw wastewater and treated sewage effluents from certain sewage treatment plants exceed recommended levels, except for treatment 3 (tertiary treatment), which uses chlorination, resulting in the reduction of total and fecal coliforms (Hedricks & Pool, 2012). In another study by Brandt et al. (2017), their findings revealed that any coliform bacteria present in treated water implies either treatment process flaws or some form of post-treatment contamination. In contrast to the findings of other studies, Bhat & Danek (2011) found that the average concentration of fecal coliforms in canal operation was 537 MPN/100 mL, but is reduced to 218 MPN/100 mL following the operation of a wastewater treatment facility (WWTF), indicating a 59 percent reduction. Similarly, the average concentration of fecal coliforms in the sewage flowing directly into the river dropped from 170 MPN/100 mL before WWTF to 86 MPN/100 mL after WWTF, a decrease of about 50% (Bhat & Danek, 2011). In another study by Gungal (2010), the fecal coliforms in Western Turkey were reduced by 96% after the sewage treatment plant was operated.

Our results also show that positive wastewater tests of total coliforms, fecal coliforms, and *E. coli* indicate that there are leaks in the septic tank system and agricultural runoff containing animal manure. As explained by Gross (2010), when a septic tank leaks, the sewage will not be discharged to the drain field before treatment occurs, which may be a reason for the high coliform bacteria count. The high concentration of coliforms in wastewater is a principal public health concern, especially when it is discharged into the environment untreated. According to the water quality guidelines and effluent standards recommended by the Department of Environment and Natural Resources (2016), the concentration of fecal coliforms in the present study is higher. This indicates that the Cagayan River is contaminated and may suggest that its intended use is affected. In the studies conducted by Michigan State University Extension and Oram in 2013 and 2014, respectively, fecal coliform counts in rivers are high (above 200 colonies per 100 mL) and may pose a health risk, such as typhoid fever, leptospirosis, stomach cramps, fever, dysentery, ear infection, and gastroenteritis, when exposed to this water. The contraction of these diseases often occurs during flooding, such as overflow of sewer and pollution caused by failure of sewer infrastructure may increase (Olds et al., 2018). In addition, untreated fecal materials, for example, containing fecal coliforms, will add excessive organic materials to the water. The decay of this material depletes the oxygen in the water, as a result, fish and other aquatic life may be killed (Oram, 2014). To address this problem, the Department of the Interior and Local Government (DILG) issued memorandum circular no. 2019-62 or the Policy and Guidelines on Sewage Treatment and Sewage Management System, which establishes rules and regulations concerning public order and safety. This memorandum focuses on the role of Local Government Units (LGUs) in implementing sewage treatment and septage management systems in the region. This memorandum further states that all barangays, municipalities, provinces, and cities shall be provided with general hygiene and sanitation services, as well as infrastructure facilities for drainage and sewerage, flood control, and other similar facilities. In addition, LGUs ensure that all residents, institutions, industrial, commercial and government establishments have hygienic tanks, or adequate wastewater treatment facilities designed to remove materials that degrade water quality and pose a health safety risk when discharged into receiving streams or bodies of water. Furthermore, this policy strictly prohibits the dumping of sewage and untreated wastewater into the drainage, canals, rivers, and other natural or artificial waterways and other open areas. Failure to implement and comply with these policies and guidelines may raise the risk of sewage containing high coliforms being discharged into the environment untreated, endangering public health (Department of Interior and Local Government (DILG), 2019).

Followed by fecal and total coliform, heterotrophic plate counts (HPCs) were also significantly higher. Samples (particularly replicates 2 and 3) from barangay A have a higher HPC of 8.0 x and 9.3 x respectively, compared with barangay B and C. This means that there is more bacterial growth in the water sewage from barangay A. However, Table 1 also shows that levels of heterotrophic plate count (HPC) are significantly elevated in all barangays and did not fell within the standard values of WHO and EPA. This implies that sewage from these barangays should not be discharged in Cagayan River and must be treated. In general, the higher concentration of HPC in different wastewater samples was attributed to the stagnant part of the distribution system and the increase in sewage effluent, which led to the proliferation of bacteria (Hach, 2017). Also, based on the study of Mulamattathil, Bezuidenhout, & Mbewe (2015), high amounts of HPC in raw water and treated water from Modimola dam have received sewage effluent. These findings imply that the emergence of high levels of HPC means that the treatment process at the sewage treatment plant failed to lower the heterotrophic bacteria to an acceptable level before discharge. In addition, the high density of HPC in wastewater is also reflected in potable source waters, which have raised concerns because it contains opportunistic pathogens. The results of this study confirm data obtained in previous studies that have shown an increase in HPC in sewage above the standard value. This result could suggest a change in the water source's quality or a problem with water treatment before treatment occurs (Verhille, 2013). When the level of HPC is acceptable after leaving the treatment plant but is higher in the distribution system's level than the baseline level, regrowth in the distribution system may occur (Bartram et al. 2003; Verhille, 2013). With these, it can be justified that the high concentrations of coliform bacteria in water sewage from the different barangays in Tuguegarao denotes inadequate wastewater treatment facility, which increases bacterial growth.

Another factor that promotes the high HPC count is the season. Generally, a public water supply system with conventional treatment can limit the heterotrophic bacteria counts in the water distribution to less than 100 CFU/ml in the distribution system, although many systems experience increased heterotrophic populations (500–1000 CFU/ml) during the dry season (Allen, Edberg, & Reasoner, 2004). This finding corresponds to the present study to some extent because it was carried out in the dry season.

Several other factors need to be considered. Studies have suggested that the effective treatment of wastewater can reduce wastewater effluent discharge into the environment (Water Environment Federation, 2020; Jasim, 2020). To reduce the high concentration of coliform bacteria, multiple intervention measures can be applied by focusing on planning and installing a sustainable on-site wastewater system, as well as strict compliance and monitoring on wastewater treatment plants. It is also important to note that other factors, such as septic tank leakage, and physiochemical parameters, also contribute to bacterial growth. Hence, checking the design and performance of septic tanks can effectively reduce coliforms.

V. CONLUSION

The present study determined that the coliform bacteria present in sewage water directly flowing into the Cagayan River in Tuguegarao City were significantly higher than the allowable limits set by the Department of Environment and Natural Resources and World Health Organization. The results therefore indicate a high bacterial content or concentration as well as high level of fecal matter contamination of the sewage waters from the barangays. Moreover, as these barangays are the direct sources of sewage effluent to the Cagayan river, it may contribute significantly to the contamination of the river. This further implies the need to strictly monitor the compliance of the general effluent standards and sewage treatment and sewage management system of water sewage in these areas before discharge into a particular water body.

VI. RECCOMENDATIONS

Based on the findings and conclusion presented above, the researchers recommend conducting correlational analyses of the coliform bacteria count from water sewage during the dry and rainy seasons. Future researchers should also recommend to include physiochemical parameters to determine their relation to bacterial count and their distribution. In addition, it is advised to conduct isolation and identification of other pathogenic bacteria present in sewage water aside from coliform bacteria, which may pose a real impact on human health. The assessment of coliform bacteria in the Cagayan River is highly recommended.

The results of the study further imply the need to treat water sewage. This idea would ensure that quantity and quality of effluent to be discharged in the environment, particularly in water bodies, are treated first and within allowable limits. The Department of Health (DOH), Department of Environment and Natural Resources (DENR) and Department of Interior and Local Government (DILG) in coordination with Local Government Unit (LGU) and the Barangay Officials of the effluent sites must take into consideration the planning and installing of a sustainable and adequate on-site wastewater system in Tuguegarao City to effectively reduced the pathogens in its allowable limit.

Furthermore, it is recommended to conduct civic activities like the Student Learning Program (SLP), which can foster community participation and government involvement to raise awareness to the residents about the current situation of the water sewage flowing directly to the Cagayan River.

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