

Water Analysis of School Canals along Muralla Street, Intramuros, Manila, Philippines

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ABSTRACT

This study analyzed the physical and bacterial composition of canals on Muralla Street in Intramuros, Manila, Philippines. Canal samples were collected from five schools: Colegio de San Juan de Letran (CSJL), Lyceum of the Philippines University (LPU), Mapua University (MU), Pamantasan ng Lungsod ng Maynila (PLM), and Manila High School (MHS). Physical properties were analyzed following the APHA 1985 methods. Bacterial enumeration used serial dilution and spread plate techniques to obtain the total viable count (TVC). Analysis of Variance (ANOVA) was used to discover similarities and differences in water canal conditions between the studied locations. Results showed significant differences in pH and Dissolved Oxygen (DO) levels, with CSJL exhibiting the highest water quality. However, Total Suspended Solids (TSS) showed no significant difference, suggesting consistent water quality in suspended solids across locations, likely due to similar factors. Bacterial contamination also varied, with PLM showing the highest bacterial counts.

Keywords: *water analysis; pH level; dissolved oxygen; total suspended solid; bacteria*

INTRODUCTION

Floods are natural calamities that occur when the water levels of rivers, lakes, or canals rise due to heavy rains or the failure of dams and levees (Sholihah et al., 2020; Valijonovich et al., 2021). Consequently, floodwater disrupts ecosystems, alters water quality, and contaminates water sources, resulting in significant changes in physical properties such as pH level, dissolved oxygen (DO), and total suspended solids (TSS) as well as bacterial content. Water quality drastically changes by carrying sewage, industrial waste, stormwater, and agricultural runoff, along with floods.

Previous studies, such as that of Medallon & Garcia (2021), evaluated the physical and chemical properties of Taal Lake, finding that changes in pH levels and the total suspended solids (TSS),

dissolved oxygen (DO), and biological demand oxygen (BOD) indicated pollution. Similar to this study, Caidoy et al. (2024) analyzed the water quality of the Burayan River in Tacloban City across the three sampling sites: upstream, midstream, and downstream, using an Environmental Management Bureau's (EMB) water quality checker. Their findings revealed that all samples failed to meet the pH standard of DENR (pH = 6.5 – 9.0). However, for total dissolved solids (TDS), all samples complied with the EMB limit of ≤ 500 mg/L. In contrast, only sample B recorded a DO level of 4.08 mg/L, failing below the 5.00 mg/L standard. Taken together, these findings suggest that the Burayan River does not fully meet the EMB Standards, underscoring the need for continuous monitoring.

Furthermore, according to the National Oceanic and Atmospheric Administration (NOAA) (2025), water does not always have a pH of exactly 7, but rather, it tends to be slightly acidic due to the carbon dioxide (CO_2) in the atmosphere that dissolves in water, forming carbonic acid (H_2CO_3).

Building on these insights, this study focuses on Muralla St. Intramuros, the heart and historic walled city of Manila, Philippines. Muralla Street is lined with several schools and universities and serves hundreds of students from elementary to tertiary level. At the same time, institutions are surrounded by different canals that are part of the city's drainage system. Thus, avoiding exposure to these canals is inevitable. These pose health risks to students and are heightened during rainy seasons when flooding can greatly increase harmful bacteria such as *Salmonella*, *Vibrio cholerae*, and *Leptospira* that thrive in flood-affected areas, leading to foodborne infections, cholera outbreaks, and leptospirosis, particularly in unsanitary conditions (Mueller et al., 2023; Naing et al., 2019). School canals in Muralla St. eventually drain into the Pasig River, a major waterway that has been classified as a Class C body of water by the Department of Environment and Natural Resources (DENR) (2016).

Despite the existing research, there remains a gap in the aforementioned literature specifically addressing the canals near school zones. To fill this gap, this study analyzed the school canals along Muralla Street in terms of their physical properties using the water analysis method and enumerated the bacterial content using serial dilution and spread plate technique.

METHODS

Sample Collection. The location of the study is Muralla Street, Intramuros, Manila, Philippines. Muralla Street spans approximately 1.24 kilometers, connecting landmarks such as Baluarte de San Diego and Colegio de San Juan de Letran (CSJL). Sampling stations were established at five specific locations, as shown in Figure 1. Site 1 is the canal near the CSJL gate, 50 meters from the school entrance; the canal appears clear but emits an unpleasant odor. Site 2 is a drainage canal 20 meters away from Lyceum of the Philippines University (LPU), where the water is slightly clear, but floating plastic wrappers are visible. Site 3, located at the motorcycle parking area of Mapua University (MU), contains canal water that appears white, thick, and almost coagulated. Site 4 is a canal in front of Manila High School (MHS) that is clear in color and has no strong foul odor. Site 5 is situated beside Pamantasan ng Lungsod ng Maynila (PLM), where overflowing water was observed during sampling. Samples were collected in September 2024, during a period when low-pressure areas (LPAs) within the Philippine Area of Responsibility (PAR) brought continuous rainfall to Metro Manila. Further details of the sampling sites are provided in Table 1.

Materials and Equipment. The study analyzed a 500 mL canal water sample from schools along Muralla Street to determine its physical properties. Equipment used included a pH meter for pH level and a centrifuge to determine total suspended solids. Dissolved oxygen was performed using Biochemical Oxygen Demand (BOD) bottles, manganese (II) sulfate solution, alkaline potassium iodide solution, potassium permanganate solution, Concentrated sulfuric acid, sodium thiosulfate titrant (0.025 N or a similar concentration), starch indicator solution, as well as pipettes and a

burette. The serial dilution technique was used along with Nutrient Agar (NA), Mannitol Salt Agar (MSA), and Eosin Methylene Blue Agar (EMB) to facilitate bacterial colony counting.

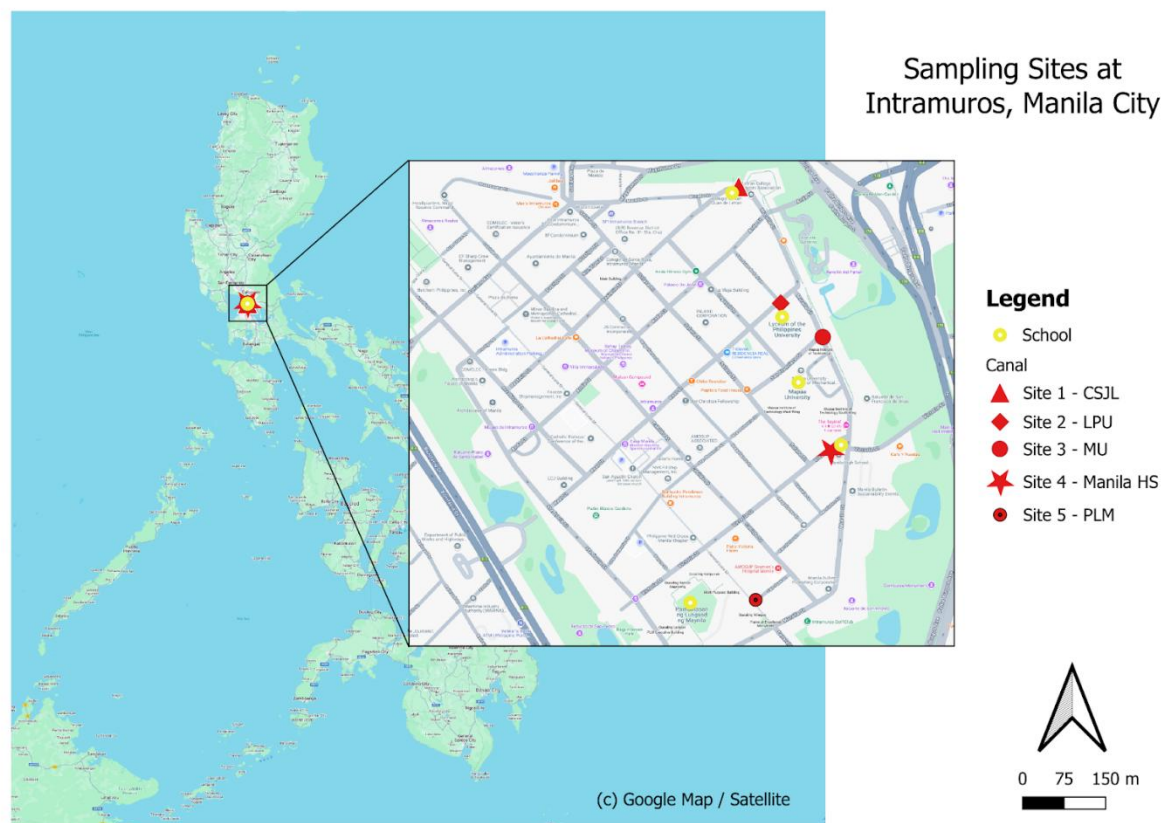


Figure 1. Map of the sampling sites in Muralla St., Intramuros Manila

Physical Properties. The study employed a comparative research design with statistical analysis to compare and examine the water canal conditions near schools along Muralla Street. Physical properties such as pH levels, Dissolved Oxygen (DO), and Total Suspended Solids (TSS) were analyzed using methods from APHA (1985), as adopted in the study by Okechukwu & Obire (2024).

pH Level. A pH meter was used to measure the canal's pH levels. Before testing, the meter was calibrated by dipping it into distilled water and a pH 7 buffer solution, and then into the sample in a 100 mL beaker to ensure accuracy.

Dissolve Oxygen (DO). For dissolved oxygen analysis, 2 mL of manganese (II) sulfate solution was added to a 300 mL canal sample in a Biochemical Oxygen Demand (BOD) bottle. Then, 2 mL of alkaline potassium iodide (KI) and potassium permanganate solution were added. The sample was gently inverted until a brown precipitate formed, indicating the presence of oxygen. The precipitate was allowed to settle halfway down the bottle, signifying the reaction between oxygen and manganese to form manganese (IV) oxide. Next, 2 mL of concentrated sulfuric acid was added to dissolve the precipitate, producing a yellow-brown iodine solution. A portion of this sample was transferred to a clean flask for titration. Sodium thiosulfate was added until the color faded to pale yellow, followed by a few drops of starch indicator, which turned the solution blue. Titration continued until the blue color disappeared, indicating the endpoint.

The analysis followed the principle of Winkler titration, in which the volume of sodium thiosulfate used is directly proportional to the amount of dissolved oxygen in the original sample (Flinn Scientific Biofax, 2017).

Total Suspended Solids (TSS). To measure suspended solids, canal samples were centrifuged at 2000 rpm for 20 minutes. The sediment was then filtered using filter paper, which was dried and weighed. The difference in weight before and after drying represented the mass of the suspended solids.

Table 1: Description of Sampling Sites in Muralla St. Intramuros Manila, Philippines

Sampling Site	Location	Description	Coordinates in Decimal degrees (DD)
1	Colegio de San Juan de Letran (CSJL)	The canal is located near the gate of CSJL, right beside the sidewalk, and runs along the campus perimeter. It is approximately 50 meters or a 1-minute walk from the school entrance. The canal has a lid or cover that can be opened. Upon closer observation, the water appears clear but emits a foul and unpleasant odor. The flow of the water is very noticeable, likely due to the pipe inside the canal that releases water continuously.	14.5939618, 120.9769674
2	Lyceum of the Philippines University (LPU)	A narrow roadside drainage canal is located beside the sidewalk near the wall of LPU, approximately 20 meters away from the school entrance. Water flows from a small circular opening in the concrete wall into the canal, but the movement is barely noticeable, suggesting stagnant or slow-flowing water. The canal water is slightly clear, but floating debris, such as plastic wrappers, is visible on the surface. The odor is present but not too strong or overpowering.	14.592003, 120.9776743
3	Mapua University (MU)	It is a canal with a lid, but it has an opening where the flow of water is visible. It is located at the end of the Mapúa building, beside a tree and an area where motorcycles are usually parked. The water is noticeably white, with a thick, almost coagulated appearance. It also emits a very foul odor. The canal is approximately 100 meters away from the school entrance. Small patches of algae can be seen along the concrete sides.	14.5914355, 120.9783791
4	Manila High School (MHS)	It is located at the front gate of MHS and has a lid that can be opened. It is approximately 90 meters from the school entrance. The water is clear in color and does not have a strong odor. The flow of water is not visible.	14.5895248, 120.9785147
5	Pamantasan ng Lungsod ng Maynila (PLM)	It is located beside the PLM building and is covered with a steel grating that cannot be easily opened. At the time of sample collection, the water was overflowing. It is approximately 30 meters away from the school entrance. The water was slightly clear and had a very foul odor.	14.5870254, 120.9772525

Microbial Analysis: To count the Total Viable Count (TVC) of bacteria, 28.0 grams of Nutrient Agar (NA), 35.96 grams of Eosin Methylene Blue (EMB), and 111 grams of Mannitol Salt Agar (MSA) were each suspended in 1000 mL of distilled water. The mixture was heated until completely dissolved, then sterilized by autoclaving at 120°C and 16 psi for 1 hour, followed by cooling to 45–50°C. A serial dilution was performed up to 1×10^{-9} using 9 mL of diluent with 1 mL of the water sample. Aseptic techniques were used throughout the plating procedure,

ensuring surfaces were disinfected before and after use. Plates were incubated at 37°C for 24 hours—the optimal temperature for bacterial growth. For counting, five samples were used, each multiplied by one dilution factor and three replicates, resulting in 15 plates. Colonies were manually counted. If the count was fewer than 300, the actual number was recorded; if more than 300, it was marked as “too many to count” (TMTTC).

RESULTS AND DISCUSSION

Water Quality of Canals. The parameters measured were pH, total suspended solids (TSS), and dissolved oxygen (DO). The water quality classification of the canals along Muralla Street is assumed to align with the Pasig River’s Class C classification, as the canals serve as drainage channels. Canals in Intramuros are likely connected to the Pasig River, either directly or indirectly, through drainage systems or other water flow connections. Class C waters are suitable for the propagation and growth of aquatic life, and recreational activities such as boating and fishing, and can be used for industrial purposes after proper treatment (DENR, 2016). The collected water from five sampling sites was assessed using the standards outlined in DENR Administrative Order 2016-08. As highlighted in Morata et al. (2019), Class C rivers across the Philippines face increasing pollution due to industrial activities, resulting in increased levels of TSS, low pH, and DO. The same concerns apply to the canals in Intramuros, as presented in Table 2, which shows the water quality parameters found in the canals along Muralla Street under Class C standards.

In the study conducted in Taal Lake (Medallon & Garcia, 2021), pH and TSS were found within the standard limits, with slightly elevated DO. One site was highly contaminated with waste and fertilizer use. pH and DO varied across sites, while TSS remained consistent. Similarly, in Burayan River, Tacloban City, Philippines, the pH levels across three stations were found to be below the acceptable range, while DO levels were mostly within the standards. TSS varied but remained within the standard limit (Caidoy et al, 2024).

In comparison, the water quality parameters measured from the canal surrounding CSJL, LPU, MU, MHS, & PLM recorded pH levels where only CSJL, LPU, and MHS, afforded pH levels of 7.2, 7.0, and 7.1, respectively, which were within the acceptable pH range of 6.5 - 9.0 according to the DAO 2016-08 standard set by the Philippine Department of Environment and Natural Resources (DENR). MU and PLM showed pH levels below the minimum threshold, making the water more acidic than acceptable. These can favor certain bacteria that produce foul odors. In terms of TSS levels, the data collected exceeds the DAO 2016-08 standard of 0.00008 g/mL, with CSJL having the highest TSS level at 0.08 g/mL. These high TSS levels can include organic matter, and when this organic matter accumulates and decomposes, it can release foul-smelling gases, contributing to the unpleasant odor. The DO values across all schools were also unusually high compared to the minimum standard of 3.0 mg/L, ranging from 26 to 58.5 mg/L. These suggest contamination or unnatural chemical processes, possibly from untreated wastewater.

Table 2. Water quality parameters of school canals along Muralla St., Intramuros, Manila, Philippines

Parameter	CSJL	LPU	MU	MHS	PLM	DAO ¹ 2016-08
pH	7.2 ±0.2 ²	7.0 ±0.1	5.1 ±0.2	7.1 ±0.2	5.4 ±0.7	6.5-9.0
TSS (g/ml)	0.08 ±0.02	0.07 ±0.03	0.07 ±0.05	0.07 ±0.01	0.07 ±0.03	0.00008
DO (mg/L)	58.5	28.0	46.0	30.0	26.0	3.0

¹DENR Administrative Order 2016-08

² ± data is the standard deviation of three trials

pH Levels of Canal Samples. Table 2 showed CSJL had the highest pH, indicating alkalinity, followed by MHS, LPU, PLM, and MU. MU had the lowest pH and was the most acidic. The pH levels across the three trials from five different schools showed notable differences in both the mean values and the consistency of the data. CSJL had the highest mean of 7.2, followed by MHS and LPU, which demonstrated low standard deviations ranging from 0.1 to 0.2. In contrast, MU and PLM exhibited lower mean values of 5.1 and 5.4, respectively. PLM had the highest standard deviation of 0.7, indicating less consistency across the trials.

A higher pH level may be caused by the presence of soap residues or chemical runoff originating from nearby school facilities, such as laboratories and restrooms. These institutions often use detergents and chemical substances in their daily operations, which may be discharged into the canal through wastewater systems, thereby increasing pH levels.

Table 3 showed no significant difference in pH levels between CSJL, LPU, and MHS (p -Tukey = 0.953 and 0.996). However, CSJL's canal was more alkaline than MU and PLM ($p < 0.001$, mean differences: 2.100 and 1.800, respectively). LPU's pH was also higher than MU and PLM ($p < 0.001$ and 0.002, mean differences: 1.900 and 1.600, respectively). MHS had a higher pH than MU's ($p < 0.001$, mean difference = -2.000) and PLM ($p = 0.001$, mean difference = 1.700), but no significant difference between MU and PLM ($p = 0.830$).

Table 3. Post-Hoc Test for pH Levels of school canals

Comparison		Mean Difference	t	p-Tukey
CSJL	LPU	0.200	0.696	0.953
	MU	2.100	7.304	<.001
	MHS	0.100	0.348	0.996
	PLM	1.800	6.260	<.001
LPU	MU	1.900	6.608	<0.001
	MHS	-0.100	-0.348	0.996
	PLM	1.600	5.565	0.002
MU	MHS	-2.000	-6.956	<0.001
	PLM	-0.300	-1.043	0.830
MHS	PLM	1.700	5.913	0.001

Note: Comparisons are based on estimated marginal means

pH level is vital in canal water quality since pH influences the behavior of chemicals in the water. When the pH level falls outside the normal range, it may indicate the presence of pollution from sources such as industrial waste or decaying matter. This imbalance can pose environmental and health risks to nearby communities through exposure to contaminated water.

Total Suspended Solids of Canal Samples. The results indicate no significant difference in total suspended solids (TSS) levels, suggesting consistent water quality in suspended solids is consistent across the areas.

Based on Table 2, the total suspended solids (TSS) of canal samples from five locations showed variations in the amount of particulate matter present in the water. CSJL showed the highest consistency across trials with a mean TSS of 0.08 g/mL and a low standard deviation (SD) of 0.02, indicating minimal variation among its trials. In contrast, MU had the highest with an SD of 0.05, despite having a similar mean of 0.07 g/mL, suggesting notable differences in suspended solids during sampling. LPU and PLM both had a mean TSS of 0.07 g/mL with a moderate variation (SD = 0.03), while MHS had the most stable results, with a mean of 0.07 g/mL and the lowest SD at 0.01. These differences in TSS may be influenced by environmental factors such as water flow or nearby human activity.

A high total suspended solids (TSS) levels are likely due to trash and solid waste improperly disposed of by students or vendors, which contribute to the suspended solids in the water. These materials, such as plastic, paper, and food wrappers, can accumulate in the canal, leading to increased levels of fine and coarse particles.

Table 4. Anova Test for Total Suspended Solids of school canals

Mean Difference	df	Mean Square	F	p
Location	6.67e-4	1.67e-4	0.184	0.942
Residuals	0.00907	9.07e-4		

Note: Comparisons are based on estimated marginal means

Table 4 showed no significant difference in Total Suspended Solids (TSS) levels among the schools on Muralla Street $F(4,10) = 0.184$, $p = 0.942$, as the p-value exceeded 0.05. These findings suggest that the water quality in terms of suspended solids is consistent across these areas, likely pointing to similar environmental factors or sources contributing to TSS levels in the floodwater. High TSS levels can significantly impact aquatic ecosystems by reducing sunlight penetration, which is essential for photosynthesis. Moreover, solid particles carry toxic compounds, which contribute to less interaction and penetration of sunlight to water, which only indicates that it disrupts aquatic life and ecosystem balance. However, in this study, the TSS levels were observed to remain clear and well-maintained across all schools along Muralla Street, indicating proper management in these areas, minimizing environmental impacts from suspended solids and supporting better water quality.

Dissolved Oxygen of Canal Samples. The DO concentrations (Table 2), measured based on the volume of sodium thiosulfate dispensed, revealed that CSJL had the highest DO level at 58.5 mg/L, followed by MU with 46 mg/L, while LPU, MHS, and PLM had relatively lower concentrations at 28 mg/L, 30 mg/L, and 26 mg/L, respectively. The volume of sodium thiosulfate dispensed closely corresponds to the DO concentration, which affirms the accuracy of the titration-based method used. Results showed that CSJL had the highest dissolved oxygen (DO), indicating better water quality, while PLM, LPU, and MHS had lower DO levels than MU, suggesting potential pollution. The findings suggest that CSJL and MU have relatively better water oxygenation compared to the other sites, possibly due to the differences in their pollution levels or the presence of organic matter.

High levels of DO could be attributed to constant water agitation or open-air flow, which promotes more oxygen to dissolve in water. Additionally, the presence of organic materials like fallen leaves or mild algae growth might enhance photosynthesis, temporarily increasing oxygen levels during sunlight.

Table 5 revealed that CSJL had significantly higher DO levels than LPU, MU, MHS, and PLM. (p-value of $< .001$, mean differences: 30.500, 12.500, 28.500, and 29.167, respectively), consistently showing CSJL's higher DO levels. LPU had significantly lower DO levels than MU ($p < 0.001$, mean difference = -18.000) but showed no significant differences with MHS and PLM, indicating similar DO levels. MU had higher DO levels than MHS and PLM ($p < .001$, mean differences = 16.000 and 16.667, respectively), while MHS and PLM showed no significant difference.

Table 5. Post-Hoc Test for Dissolved Oxygen in school canals

Comparison		Mean Difference	t	p-Tukey
CSJL	LPU	30.500	15.104	$< .001$
	MU	12.500	6.190	$< .001$
	MHS	28.500	14.113	$< .001$
	PLM	29.167	14.444	$< .001$
LPU	MU	-18.000	-8.914	< 0.001

	MHS	-2.000	-0.990	0.854
	PLM	-1.333	-0.660	0.961
MU	MHS	16.000	7.923	<0.001
	PLM	16.667	8.253	<.001
MHS	PLM	0.667	0.330	0.997

Note: Comparisons are based on estimated marginal means

Dissolved Oxygen (DO) is important in assessing canal water quality as it supports the life of aquatic organisms. High DO levels are normally sufficient to maintain healthy biotic assemblages in unpolluted, free-flowing streams. Subsequently, low dissolved oxygen levels may indicate pollution and have severe effects on aquatic life. It can also create foul odors and allow harmful bacteria to thrive.

Microbial Analysis of Canal Samples. CSJL and LPU tested positive on NA assay but negative on EMB and MSA assays (Table 6). MU tested positive on all three, while MHS tested positive only on EMB assay. PLM showed positive results on NA and EMB assays but negative on MSA assay.

Table 6. Bacteria Count in school canals

Media	CSJL	LPU	MU	MHS	PLM
Nutrient Agar (NA)	5	3	8	0	TMTC ¹
Eosin-methylene Blue (EMB) Agar	0	0	24	1	TMTC ¹
Mannitol Salt Agar (MSA)	0	0	5	0	0

¹ too many to count

These results suggest the presence of bacteria such as *Escherichia coli*, *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Yersinia pestis* in CSJL, LPU, MU, and PLM. Positive EMB results from MU, PLM, and MHS indicate potential *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Escherichia coli*, and *Salmonella typhimurium*. MSA positivity in MU suggests *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Micrococci*.

The health implications of these bacterial isolates are significant. For instance, *E. coli* causes gastrointestinal (GI) tract infections, urinary tract infections (UTIs) (Liu et al., 2021). While *S. aureus* causes severe skin infections, pneumonia, and sepsis (Cheung et al., 2021). Likewise, *S. pyogenes* is associated with group A streptococcus (GAS) disease (Avire et al., 2021), and *P. aeruginosa* causes asthma, chronic obstructive pulmonary disease (COPD), cystic fibrosis (CF), and bronchiectasis (Garcia-Clemente et al., 2020). Meanwhile, *K. pneumoniae* affects lower gastrointestinal tract (Zaki et al, 2023), and *Y. pestis* causes plague, a zoonotic disease (Barbieri et al., 2020).

Moreover, *E. aerogenes* causes lower respiratory tract infections, UTIs, surgical site infections, and intravascular device-associated infections (Ramirez & Giron, 2023). *P. mirabilis* is a known pathogen in the urinary tract infections (Wasfi et al., 2020), while *S. epidermidis* contributes to the development of common skin diseases (Severn & Horswill, 2022). Lastly, *M. luteus* has been identified as a cause of *M. luteus* bloodstream infection (BSI) (Zhu et al., 2021).

These findings align with the study of Naing et al. (2019) on the meta-analysis, which emphasized the increased risk of zoonotic infections such as leptospirosis in flood exposure, particularly among males, individuals with open wounds, and those in contact with contaminated water. The study highlighted the urgent need for flood control and sanitation improvements to reduce health risks associated with flood-related bacterial exposure.

When canals are poorly maintained, it can significantly impact both the environment and the health of students. Similar to the study of Le et al (2024) in Ho Chi Minh City, the presence of polluted canals near institutions can serve as a breeding ground for harmful bacteria such as *E. Coli*, and other coliforms, increasing the risk of waterborne diseases, particularly during a flood or heavy rain when students may come in contact with contaminated water. The accumulation of solid waste and the discharge of untreated wastewater into canals can degrade water quality, emit foul odors, and contribute to the spread of infections, while also disrupting the local ecosystem.

CONCLUSIONS

The study concluded that CSJL had the highest pH and DO levels, indicating better water quality, while LPU showed a lower DO level, indicating potential pollution, which is not compliant with the guidelines set by the DENR. The study also found harmful bacteria, including *E. coli*, *S. typhi*, and *K. pneumoniae* in the canal water near the schools on Muralla Street. Bacterial contamination varied, with LPU and PLM showing the highest bacterial content. The findings suggest significant differences in both physical properties and bacterial content of the canals between the schools. Bacterial contamination varied in the PLM, showing the highest bacterial counts. The presence of polluted canals near institutions can increase the risk of waterborne diseases, particularly during a flood or heavy rain when students come in contact with contaminated water.

RECOMMENDATIONS

Future researchers are recommended to conduct at least three trials when measuring dissolved oxygen (DO) to ensure accuracy and data reliability. Multiple trials help minimize experimental errors and strengthen the validity of the results. It is also suggested to include water quality assessments of the Pasig River for cross-verification, considering the potential connection between the river and the sampled canals. Lastly, future studies should consider analyzing additional parameters such as temperature, turbidity, and the presence of heavy metals (e.g., copper, lead, and cadmium), as well as oil and grease. This would provide a comprehensive understanding of the water quality and environmental impact of the canals.

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