Journal of Ecosystem Science and Eco-Governance (JESEG)

Vol. 7, No. 1 | June 2025
PRINT ISSN 2704 4394 | ONLINE ISSN 2782 8522
DOI: https://doi.org/10.54610/jeseg.v7i1.132

SHORT COMMUNICATION

Gastropod Community and Coliform Contamination in Langihan Lagoon: A Call for Improved Sanitation Management

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Received: September 24, 2024
Revised: May 14, 2025
Accepted: June 13, 2025
Available Online: June 16, 2025

Cite this article: Dollano, A.O., Libot, A., & Jumawan, J.C. (2025). Gastropod Community and Coliform Contamination in Langihan Lagoon: A Call for Improved Sanitation Management, *Journal of Ecosystem Science and Eco-Governance*, 7(1):14-23.DOI: https://doi.org/10.54610/jeseg.v7i1.132

ABSTRACT

Freshwater ecosystems in urban areas are increasingly threatened by biological contamination and declining water quality, posing risks to biodiversity and public health. Survey and inventory of gastropods in Langihan Lagoon, Butuan City, Philippines and the examination of snail's coelomic contents were conducted. Total coliform counts and basic physico-chemical features of the lagoon were also assessed. Results revealed a total of 1,389 freshwater snail individuals from five species (*Pomacea canaliculata, Gyraulus* sp., *Melanoides maculata,* and *Mieniplotia scabra*) from four families. Artificial shedding and dissection of the snails' body cavity showed the absence of any cercaria. However, sporocysts, hookworm eggs and two species of bdelloid rotifers (*Rotaria* sp. and *Philodina* sp.) were isolated from *P. canaliculata.* Physico-chemical parameters from all study stations were within the standard limits except the high salinity and low DO levels during dry season and the low pH during wet season assessment. Total coliform tests indicate the highest probable presence of coliform (>1,6000 MPN/100mL) from all stations across seasons which imply high risk of exposure to coliform-associated diseases when in contact with the lagoon water. Improved management of the lagoon to improve water quality and reduce the coliform contamination in the area is recommended.

Keywords: *Man-made lagoon, pollution, public market, bioindicators, invasive species, Caraga*

Aquatic ecosystems play a critical role in maintaining ecological balance, supporting biodiversity, and providing essential services such as food supply, water filtration, and recreation. However, these systems are increasingly threatened by anthropogenic pressures, including pollution, habitat modification, and resource overexploitation. The discharge of pollutants into freshwater environments can disrupt biotic integrity by altering community structure and function, often resulting in disease, behavioral anomalies, and the loss or migration of sensitive species (Emmanuel et al. 2008). These disruptions may cascade through trophic levels, affecting not only microorganisms and invertebrates but also fish and other higher aquatic organisms.

Lagoons, particularly those situated in urban landscapes, serve as transitional aquatic systems that are vulnerable to these stressors. Freshwater lagoons—whether natural or artificial—are typically shallow and influenced by variable hydrological and salinity regimes, precipitation-evaporation dynamics, and inputs from surrounding land use (Boadella et al. 2021, Kjerfve 1994). While man-made lagoons are often constructed for flood control, sewage retention, or water stabilization (Boadi & Kuitunen 2002), their bio-physicochemical health is frequently neglected. Due to their enclosed nature,

they are especially prone to siltation, eutrophication, salinity fluctuations, and oxygen depletion (Esteves et al. 2008, Rodrigo et al. 2013), making them potential hotspots for environmental degradation and public health risks.

Langihan Lagoon, located in the heart of the public market in Butuan City, Philippines, exemplifies such a scenarioConstructed in the 1970s as part of flood mitigation efforts for the lowland areas of Langihan, Bading, Pagatpatan, and Poyohon (Magcuro et al. 2024), the lagoon has since evolved into a multipurpose waterbody used for fishing, livestock grazing, bathing, and informal waste disposal (personal observation). In its early years, the lagoon supported a diverse community of freshwater fish, which were harvested and sold by residents of nearby communities. Today, however, only a few non-native species tolerant of turbid and oxygen-poor conditions—such as *Channa striata, Pterygoplichthys* sp., and *Oreochromis niloticus*—are occasionally captured through electrofishing (BarangaynCaptain, personal communication).

Growing concerns over the lagoon's declining water quality are further exacerbated by its continued exposure to human and animal waste from surrounding establishments. This raises the potential risk of waterborne diseases, especially through contact with lagoon water during recreational or domestic activities. Yet, despite its socio-ecological importance, Langihan Lagoon remains poorly studied, par-ticularly in terms of biological indicators and microbial contamination.

Gastropods are key bioindicators in freshwater ecosystems due to their sensitivity to environmental changes and their ecological role in nutrient cycling, food webs, and disease transmission (Estaño & Jumawan 2023, Gianelli et al. 2016). They also serve as intermediate hosts for parasites that can affect both humans and animals, making them important for understanding zoonotic disease risks. Depending on their species and abundance, gastropods may indi-cate ecosystem productivity, pollution levels, or the presence of parasitic infections (Fitria et al. 2023).

This study aims to assess the ecological and public health condition of Langihan Lagoon by examining the diversity and parasitic potential of its gastropod community, alongside key physicochemical parameters and indicators of water contamination. The findings are intended to provide a scientific basis for improving lagoon management, pollution mitigation, and community awareness in urban freshwater settings.

The study was conducted through a single intensive sampling effort, carried out over three consecutive days for each index season—dry (June) and wet (December) of 2018. Permission to collect for gastropod samples were secured from Barangay Obrero key officials. Three cluster stations were established in the Langihan Lagoon based on anthro-pogenic activity were established, each with three substations 30 m apart (Figure 1). Cluster 1 station is nearest to Tabuan Market and Bus Terminal. This area is most often cleared from aquatic macrophytes. The Cluster 2 station is situated across the bridge crossing S. Calo St. and has the least number of households fronting the lagoon with the banks stabi-lized by concrete. Cluster 3 station is nearest the dense population of houses fronting the lagoon. A belt transect with triplicate 30-m distances was established within each cluster station to assess the biophysico-chemical features of the lagoon. Extensive sampling was done for three consecutive days for a representative month for two index seasons (May for southwest monsoon/dry season; December for northeast monsoon).

Routine physico-chemical parameters (salinity, temperature, conductivity, total dissolved solids (TDS), pH, and dissolved oxygen (D.O.) concentration) were measured (Hanna HI98194) multi-meter tester in each cluster station every morning (7am-10am) for three consecutive days for every index season. Water samples for microbial analyses were collected for each cluster station from 7:00 am-9:00 am. Multiple tube fermentation technique (MTFT) was used to identify the most probable number (MPN) of bacteria present in the sample following APHA (1992). The presumptive test for coliform bacteria was done initially on single strength lauryl sulfate tryptose (LST) broth. The most probable number (MPN) of coliform bacteria per 100 mL sample were determined from the MPN table for 100, 10^{-1} and 10^{-2} dilutions.

Prior to collection of snails, permission was secured from the local government of Barangay 18, Obrero, Butuan City. Gastropods were collected along the 30 meter stretch of each sampling station with five jabs/kicks using 0.3 m wide D-frame dip net, with a 500-µm mesh size. The collected snails were stored individually in vials with lagoon water and brought to the laboratory and were documented and identified using standard keys (Brown 1994, DBL-WHO 1998). For each species per station, at least ten individuals were viewed and examined

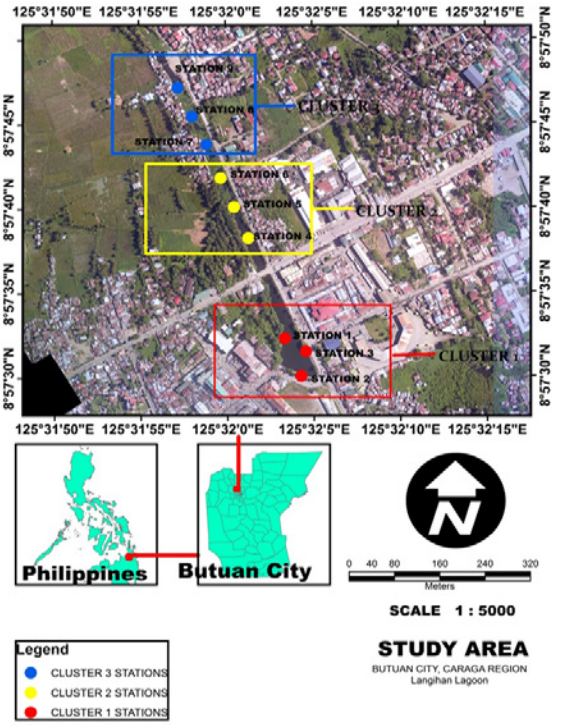

Figure 1. Map of study stations in Langihan Lagoon, Butuan City, Philippines

in the laboratory to survey the coelomic contents of their body tissues following Opisa et al (2011). Indices of biodiversity such as species richness, abundance, dominance, evenness and Shannon's diversity of gastropods from each cluster station, as well as multivariate analyses were computed using PAST software. Comparison of physico-chemical data between index seasons was done using T-test, while difference between cluster stations was done using One-way ANOVA. Principal Component Analyses (PCA) and Bray Curtis index of similarity were performed to compare possible relationships between physico-chemical and abundance of gastropods across cluster stations and seasons.

Based on DAO 08-2016, lagoons are classified as Class C-mainly for growth of fish, fishing, and irrigation. Following the standards for this classification, the water collected from all the study stations was within the standard limits except for the high salinity (0.52 mg/L) and low DO (1.29 mg/L) for both dry and wet seasons and low pH during the wet season (Table 1). By PCA, temporal influence can be seen affecting parameters such as D.O., salinity, pH, temperature and conductivity as these were higher during the dry season except for TDS which was observed higher during the wet season (Figure 2).

Typical of freshwater lagoons, the low elevation of Langihan Lagoon often experiences altered freshwater inflows, with estuarine water from Butuan Bay often seeping into the area and this may have contribute to the rather higher salinity which exceeded the standard limit (<0.5 ppt) for freshwaters and is observed during months with low precipitation. Although Langihan Lagoon is not an estuary, several factors may explain its slightly elevated salinity. Effluents from nearby markets likely in-troduce salts from food waste and cleaning agents, a common source of salinity in urban freshwater systems (Kida et al 2024). Evapoconcentration during dry seasons can further concentrate dissolved salts due to high evaporation rates (America et al. 2020). Additionally, while not directly connected to the sea, saltwater intrusion from rising sea levels or hydrological shifts may also contribute, as seen in similar coastal lagoons (Su et al 2025).

Salinity acts as a limiting factor in the distribution of organisms as dilution and evaporation influences faunal distribution through increased stress, decrased reproduction and survival rates (Palmer et al. 2008). The dissolved oxygen in all stations was

Table 1. Water Physico-chemical parameters and Most Probable Number (MPN) coliform index using MTFT of Langihan Lagoon from both dry and wet season of 2018

Physico-chemical Parameters	DAO 08-2016 Standard Class C water	Cluster 1		Cluster 2		Cluster 3		Overall Mean
		Dry	Wet	Dry	Wet	Dry	Wet	
pH	6.5-9.0	7.41±0.39	5.08±0.21*	7.38±0.16	5.16±0.08*	7.10±0.26	5.20±0.03*	6.22 mg/L
Temperature	32-350C	29.31±1.18*	27.14±0.46	29.24±1.30*	27.47±0.37	28.47±0.51*	27.37±0.46	28.17°C
Conductivity	<1,500 µs/cm	1103.55±23.03*	632.67±29.25	1094.11±26.6*	724.41±70.4	1072.85±10.7*	823.44±149.46	908.505 µs/cm
TDS	< 1,000 mg/L	240.26±31.80	326.15±30.9*	309.94±60.05	377.67±31.6*	342.04±76.90	439.00±58.53*	339.18 mg/L
Salinity	< 0.5 ppt	0.55±0.17*	0.31±0.02	0.72±0.28*	0.36±0.02	0.78±0.30*	0.43±0.07	0.525 ppt
DO	5 mg/L	3.55±2.52*	0.26±0.13	3.06±2.32*	0.30±0.18	0.33±0.24*	0.25±0.10	1.29 mg/L
MPN coliform index	APHA 1992							
Total Coliform	1000 MPN/100 mL	>1,6000	>1,6000	>1,6000	>1,6000	>1,6000	>1,6000	>1,6000MPN/100mL **

*P≤ 0.05. ; **Highest probable presence of total coliform; Data presented as Mean± SEM

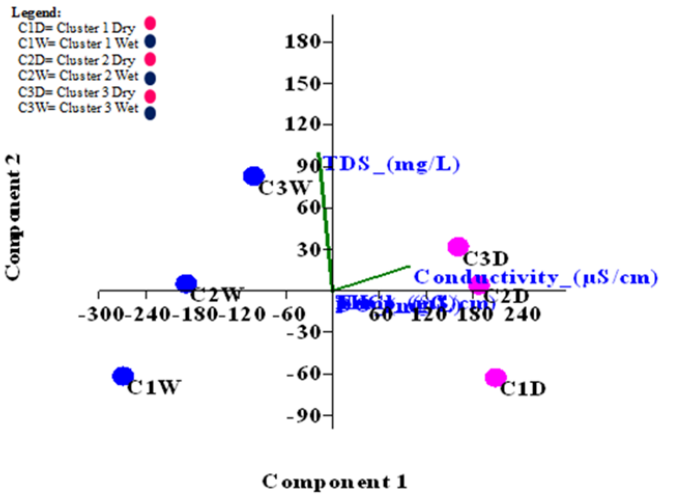

Figure 2. Principal components analysis (PCA) of physico-chemical parameters for both dry and wet seasons

below the standard limit of minimum of 5 mg/L). T-test analyses show that DO is significantly low, even critically lower during the wet season. Low DO levels could lead to low species diversity as very few organisms have tolerance to low DO often resulting in the disruption of reproductive cycle and even the dominance of certain species which best tolerate certain poor water quality parameters. The sparse vegetation and shade surrounding the lagoon could also be an important consideration as it also increases water temperature and consequently decreases DO. The high level of pH may be due to geographical location of Langihan lagoon as receiver of sewage wastes from the local public market, bus terminals, and homes through a system of pipes. Conversely, industrial discharges containing alkaline substances, such as detergents or lime, can raise the pH, making the water more basic. These alterations in pH can have detrimental effects on aquatic ecosystems, affecting the health and diversity of aquatic organisms (Baker et al. 1990).

Freshwater gastropods, such as *Pomacea canali-culata*, exhibit remarkable resilience to low dissolved oxygen (DO) levels and polluted conditions due to several physiological and behavioral adaptations. Notably, *P. canaliculata* possesses a dual respiratory system comprising both gills and a lung-like structure, enabling it to utilize atmospheric oxygen when aquatic oxygen levels are insufficient. This adaptation allows the species to thrive in hypoxic or stagnant waters where other organisms may not survive (Wang et al. 2025, Qin et al. 2022).

Water samples from both dry and wet seasons showed extremely high total coliform levels (>16,000 MPN/100 mL), exceeding safe limits for human use (APHA, 1992). Although the study did not distinguish thermotolerant or fecal coliforms, such high counts strongly suggest fecal contamination, likely due to direct discharge of domestic, livestock, and market waste into the lagoon. Total coliforms, while not all pathogenic, serve as indicators of microbial pollution and signal compromised water quality (UNEP/WHO, 1996; AS/NZS 4276.6, 2007).

This level of contamination poses serious public health risks. Communities using the lagoon for bathing, washing, or fishing may be exposed to waterborne diseases, especially vulnerable populations like children and the elderly. Persistent microbial pollution can also disrupt aquatic life and food safety, threatening both ecological and human health. The findings underscore the urgent need to assess and mitigate contamination in water bodies within urban settlements.

Addressing coliform contamination requires immediate and long-term interventions. In the short term, public awareness and restricted use of contaminated lagoon water should be prioritized. In the long term, improvements in sanitation infrastructure, proper waste disposal, and regular water quality monitoring are essential. These actions are vital not only for reducing health risks but also

for sustaining the lagoon as an urban ecological resource.

A total of 1,389 freshwater snail individuals represented by five species from four families were identified (Table 2). These five snail species were known vectors of zoonotic diseases and were notorious for tolerance under stressful water conditions. The golden apple snail, *Pomacea canaliculata* was the most abundant snail collected from the lagoon. Interestingly, this species also had the widest spectrum of commensals and parasites surveyed from its digestive cavity with *Angiostrongylus cantonensis* that causes eosinophilic meningitis (angiostrongyliasis) being the most important (Damborenea et al. 2017, Lv et al. 2009). Moreover, *P. canaliculata* is also reported as a passive host for *Mycobacterium ulcerans* that cause chronic skin ulcers such as Buruli ulcer disease (Marsollier et al. 2004). *Gyraulus* sp. is a hermaphroditic planorbid snail which mostly prefer habitats with slow moving or stagnant waters like ponds, lakes and swamps (Beran & Horsák 2011). *Melanoides maculata* is known pathogenic member of family Thiaridae with long periods of survival and was also found to harbor *A. cantonesis* (Tujan et al. 2016). *Radix rubiginosa* are known to survive long periods of time without oxygen and various fluctuations in water temperatures and is found to be a vector for *Schistosoma incognitum* (Bunnag et al. 1983) and Fasciola gigantica (Corea et al. 2010). The horny operculum of *Mieneplotia scabra* enables it to close its shell for protection against drought and predators. It is also a known vector for *Haplorchis taichui* causing haplorchiasis (Chontananarth & Wongsawad 2010), paragonimiasis, and echinostomiasis (Sriaroon et al. 2015).

Species richness in sampling stations was rather uniform for the two index seasons of collection, nonetheless, there is low dominance value while evenness is approaching 1.0 in all stations (Table 3). Shannon_H values were low and comparable between the dry and wet seasons for each cluster, probably because very few species (five only) were observed and are consistently observed across seasons. *Pomacea canaliculata* was found abundantly and was consistently observed in all of the stations during the dry and wet season of the year. T-test comparison indicates that gastropods were significantly abundant during the dry season in Clusters 1 ($p=0.024$) and 2 ($p=0.035$) whereas gastropods were significantly abundant in Cluster 3 ($p=0.023$) during the wet season probably due to the heavy growth of water hyacinth in the area. Clusters 1 and 2 obtained a high index of similarity (Figure 3) and are closely related due to its overall high density of population.

Out of five species, only three species (*P. canaliculata, M. maculata,* and *R. rubiginosa*) were further examined in the laboratory due to viability of live samples for the assay. Of the three snails examined, only one gastropod (*P. canaliculata*) was found harboring unidentified eggs of trematodes but

Table 2. Gastropods identified from Langihan Lagoon, Butuan City, Philippines

Family	Snail species	Common Name	Medical importance
Ampullariidae	*Pomacea canaliculata*	Apple snail	Vector for angiostrongyliasis; Passive host for *Mycobacterium ulcerans*
Planorbidae	*Gyraulus* sp.	Ram horn snail	----
Thiaridae	*Melanoides maculata*	Mahogany trumpet snail	Vector for angiostrongyliasis
Lymnaeidae	*Radix rubiginosa*	Big ear radix	Vector for echinostomiasis, cercarial dermatitis, vector of *Schistosoma incognitum* and *Fasciola gigantica*
Thiaridae	*Mieniplotia scabra*	Thiara	Vector for haplorchiasis, Paragonimiasis, and echinostomiasis

Table 3. Diversity indices of gastropod collected in the area from both dry and wet season of 2018

	Cluster 1		Cluster 2		Cluster 3	
	Dry	Wet	Dry	Wet	Dry	Wet
Taxa_S	3	3	3	3	3	3
Dominance_D	0.357	0.383	0.340	0.336	0.353	0.384
Simpson_1-D	0.643	0.616	0.659	0.663	0.646	0.616
Shannon_H	1.063	1.025	1.088	1.094	1.067	1.016
Evenness_e^H/S	0.95	0.939	0.989	0.995	0.968	0.920
Abundance	336*	236	306*	245	36	230*

no mature cercaria were observed (Table 4; Figure 4). An unidentified species of hookworm egg was isolated from *P. canaliculata* only during the dry season from the Cluster 1 station. The presence of ho-okworm eggs indicates the presence of parasitic nematode adults.

The presence of hookworm eggs and sporocysts confirm that *P. canaliculata* could harbor a wide spectrum of organisms that by facultative or obligate manner, could cause diseases of medical importance (Damborenea et al. 2017). No known snail vector for schistosomiasis (i.e. *Oncomelania quadrasi*) was collected from Langihan Lagoon.

The findings of this study reveal that Langihan Lagoon is experiencing significant ecological stress, as evidenced by persistently low dissolved oxygen levels, elevated salinity, acidic conditions during the wet season, and extremely high total coliform counts across all stations. These conditions indicate both chemical and microbial pollution, largely stemming from unregulated waste disposal and untre-ated effluents entering the lagoon from nearby markets, households, and livestock areas.

The abundance of pollution-tolerant gastropods such as *Pomacea canaliculata*, coupled with the presence of hookworm eggs and sporocysts, further underscores the potential of this ecosystem to act as a reservoir for zoonotic pathogens. These biological and physico-chemical indicators provide a compelling picture of a degraded aquatic environment with immediate and long-term implications for public health and biodiversity.

Given its location and multifaceted use by surrounding communities, Langihan Lagoon represents a critical urban ecosystem that requires urgent attention. The results of this study underscore the need for integrated lagoon management strategies that include the establishment of proper sanitation infrastructure, regulation of waste disposal, and continuous water quality monitoring. Public health interventions—such as awareness campaigns about the risks of direct contact with lagoon water—should be prioritized.

Future research should include the identification of thermotolerant coliforms and pathogenic parasites to further clarify the lagoon's role in disease transmission. Additionally, ecological restoration efforts, such as the reintroduction of aquatic vegetation and bioremediation, may help improve water quality and ecological function. Sustainable management of Langihan Lagoon is not only vital for environmental protection but also

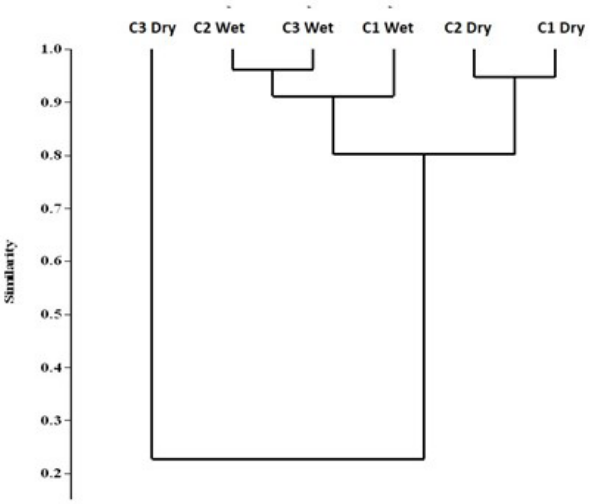

Figure 3. Cluster Analysis using Bray Curtis index of similarity for gastropods collected in cluster stations (C1,C2,C3) in Langihan Lagoon for two index (Dry and wet) seasons of 2018.

Table 4. Survey of coelomic inhabitants in gastropods of Langihan Lagoon

	Dry Season	**Wet Season**
Pomacea canaliculata	Unidentified hookworm egg, unidentified sporocyst, *Rotaria* sp., *Philodina* sp.	*Rotaria* sp., *Philodina* sp.
Melanoides maculata	none	none
Radix rubiginosa	none	none

for safeguarding the health and well-being of the communities that surround it.

Acknowledgement

The authors would like to acknowledge the local government of Barangay 18, Obrero, Butuan City for their assistance during fieldwork.

Statement of Conflict of Interest

To ensure impartiality in the evaluation of this article, one of the authors, J.C. Jumawan, who serves as the Editor-in-Chief of JESEG, had no involvement in the review process or editorial decision-making for this submission.

Author Contribution

A.A. Dollano and A.A. Libot conducted the study, collected data, performed the analysis, and contributed to the original draft. J.C. Jumawan conceptualized the study design, supervised the project, and handled manuscript editing. J.C. Jumawan and A.A. Libot co-wrote the manuscript draft for the journal. All authors reviewed and approved the final version of the article.

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