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RESEARCH PAPER

Sediment and Water Analysis In Tinorian River, Iloilo, Philippines: Basis For Understanding The River's Health and Quality

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Abstract

The Tinori-an River is located in the 4th district of Iloilo, specifically in the municipalities of Barotac Nuevo and Anilao. The study aimed to assess the sediment conditions of the river. For site selection, 12 sampling sites were selected within the river and 15 for the ponds. The Total Organic Matter (TOM) and Moisture were determined using the loss-on-ignition (LOI) technique, and grain size was assessed using wet and dry sieving. For water parameters, a multiparameter water meter was used. Results showed that the highest TOM was 12.60% in Pond A. The highest moisture was 62.83% in Pond L. High sand-silt fractions were present in all sampling sites. Water parameters showed that the water was basic and low-fair DO concentrations for both sites. For salinity, upstream was considered freshwater and the other three sites were brackishwater. Temperature was constant in all the study sites. The water was mostly turbid in all sampling sites. The results indicated high TOM and moisture in all sites, which could be traced to slow water movement and the shallowing of the river due to fisheries and anthropogenic activities. The water parameters recorded showed that the river needs attention in areas where DO was less than 5 mg/L. The current study provided baseline data on the health and condition of the Tinori-an River, and the contributing factors to this should be known to have a scientific-based approach to managing the river.

Introduction

Water indicates the quality of life in oceans, rivers, lakes, and creeks alongside the terrestrial areas where life grows and develops (Uddin et al., 2014). The water in rivers offers a living environment for humans and other organisms;

because of this, the ecosystem is prone to anthropogenic activities (Karr, 1991; Karr, 1999). Aside from water availability, environmental and ecological balance are also considered problems. The rise of industrialization, urbanization, and advancement in all fields generates pollution, and water sources are affected by it. In some cases, the pollutant itself is not toxic, but its presence leads to deterioration of water quality. For instance, biodegradable organic matter in water is not lethal. However, its degradation consumes oxygen, leading to low dissolved oxygen levels, which hinder it from supporting fish and aquatic life (Trivedi, 1992). The Environmental Management Board (2006) has set a threshold of 5 mg/L for dissolved oxygen as their standard of compliance for Class C water bodies (DAO 2016-08). Section 2 of the Philippine Clean Water Act of 2004 (Republic Act 9275) promotes awareness, education, and active public participation in monitoring and managing water quality.

Sediments have been proven to be a sink for organic matter, nutrients, and contaminants in aquatic ecosystems (Xu et al., 2016). They also provide insights into the pollutants present compared to the water body itself (Tao & Lu, 2020), which serves as the basis for maintaining the ecosystem stability of aquatic environments. Sediments are comprised of particle accumulation that has different physical and chemical properties and is made up of inorganic and organic material. Water, air, erosion, and weathering processes transport these particles and disperse them to different parts of the river (Mudroch & MacKnight, 1994; Schorer & Eisele, 1997). The presence of numerous microbes combined with continuous loads of organic and inorganic matter makes sediments biogeochemically active (He et al., 2019; Kumwimba et al., 2017). Sediment movement and quality are partially affected by anthropogenic activities that can extensively alter the aquatic environment. Freshwater and marine sediments hold huge concentrations of contaminants coming from local urban and industrial sources and anthropogenic activities within the area (Bloesch, 2009).

Sources of organic matter can come from external sources (allochthonous) or within the aquatic ecosystem itself (autochthonous) (Brailsford et al., 2019; Kindler et al., 2011). Eutrophication of rivers is caused by too much loading of nutrients, which often leads to the intensification of organic matter in an aquatic ecosystem (Nixon, 1995). Domestic sewage discharges from homes, industrial effluents, and agricultural runoffs are the primary sources of these nutrients (Smith et al., 2014; Kubo & Kanda, 2020). External organic matter sources of coastal waters originate from domestic sewage, agriculture, and aquaculture runoffs, excreted in rivers, and airborne loading (Bonsdorff et al., 1997). In freshwater and marine sites like streams, lakes, estuaries, and coastal areas, sediments should be evaluated to know the impact of “contaminated” sediments on the ecosystem and formulate remedial actions (Mudroch & MacKnight, 1994). High organic matter in sediments boosts oxygen consumption through decomposition, which harms aquatic flora and fauna (Duarte, 1995). A considerable amount of organic matter is stored in sediments, which impact bottom oxygen concentration (Werner et al., 2003; Koho et al., 2013).

The National Water Quality Status Report (2006-2013) of the DENR-EMB (2013) reported that in the Philippines, there are 18 major river basins, 421 principal rivers, about 79 natural lakes, and an extensive coastline that is 17 460 km2 long. The Environmental Management Bureau of Western Visayas (Region 6) identified 61 rivers, 15 marine waters, and five unclassified water bodies (Environmental Management Bureau, 2025). The Tinori-an River, located in the 4th district of Iloilo and encompasses barangays in the municipalities of Barotac Nuevo and Anilao, is not included in the listing of the Region 6-EMB. The Tinori-an River serves as livelihood and income for people engaged in fisheries like capture and aquaculture. Different active and passive fishing gears are used to capture aquatic organisms; aquaculture ponds that rely on the river as a water source. Some bivalves, like oysters and green shells, are cultured using the hanging method, which utilizes bamboo rafts and ropes (binder nylon).

The river is surrounded by mangroves, which makes it a mangrove ecosystem. A tropical mangrove ecosystem’s sediment, in terms of textural and geochemical features, has an abundance of silt and sand with little clay (Badarudeen et al., 1996). Mangrove forests serve as a “pump” of fine-grained sediments from coastal edges to the inner parts of the forest (Furukawa & Wolanski, 1996). Around 40% of the sediment load from the river is settled in the estuary, mostly in and seaward. The residual sediment goes off-shore during flood seasons, but subsequent storms usually re-suspend and carry the sediment back (Brookes, 1994). The study of Golez et al. (2010) in the Jalaur River and Palla et al. (2013) in the Iloilo River are some studies that conducted sediment analysis to determine the health and condition of rivers in Iloilo Province. This study was done to give baseline data and to know the condition of the Tinori-an River by assessing water parameters and sediment quality, which gave insights into the impacts of fisheries and anthropogenic activities conducted within the river.

Materials and Methods

Study Site

This study was conducted in the Tinori-an River, which serves as a “boundary” between the municipalities of Barotac Nuevo and Anilao in Iloilo Province (Figure 1). Based on informal interviews with filter net operators, the river covers barangay Tinori-an in Barotac Nuevo and barangays Serallo, Badiang, Sambag-Culob, and Pantalan in Anilao. Three sampling sites were randomly selected (starting from the bridge), representing the upstream, midstream, downstream, and river mouth. The sampling sites in the river were 100-150 m away from each other. In total, twelve sampling sites were identified and were labeled Sites 1 to 12. Fifteen sampling sites were chosen for the earthen aquaculture ponds and were labeled Ponds A to O (Figure 1). The main gate of the earthen aquaculture connected to the river served as the water inlet and outlet. All of the sites mentioned were marked using a handheld GPS (Garmin GPSMAP 64s) and were sampled for sediment and water quality analysis. Sampling was done in September-November 2023 and February-March 2024 which represented the wet and dry seasons of the country respectively. All sampling activities were conducted during the low tide period. Inset maps include the map of the Philippines (lower left) wherein Region 6 (Panay region) is highlighted in a red square and the location of the municipality of Barotac Nuevo and Anilao were highlighted in black (lower right); the sampling sites were emphasized using Google Earth Pro. Base maps were obtained from PhilGIS and projected to WGS 84 using QGIS 2.18.23.

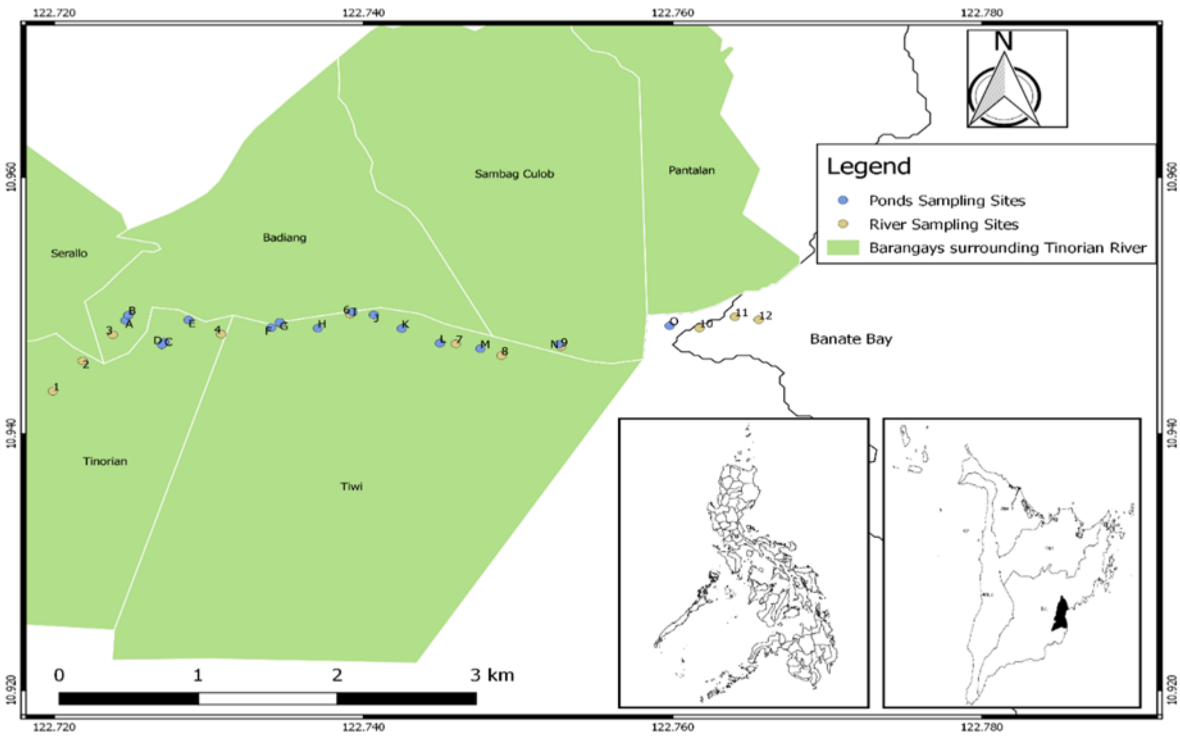

Figure 1. The location for the extraction of sediments and water parameters for river sampling sites (Sites 1-12) and ponds sampling sites (Ponds A-O) in Tinori-an River, Iloilo, Philippines.

Sediment extraction and analysis

Surface sediments were extracted in each sampling station using an improvised sediment corer. Approximately 5-7 cm of the surface sediments were extracted; however, this depth could vary depending on the type of sediments. Around 150 g of samples were taken from each sampling station and stored in pre-labeled Ziplock bags. Sediment samples were then stored in a cooler filled with ice to prevent sample degradation and were kept in a refrigerator for continuous preservation. At the laboratory, the processing of sediment samples was first defrosted through air-drying. The methods of Holme & Mcintyre (1971) were used for analysis of sediments

Approximately 5 g of sediment sub-samples were measured using an analytical balance (brand) for moisture content analysis. The measured sub-samples were placed in Petri dishes and covered with aluminum foil. It was subjected to oven-drying for 24 h at 100℃. The oven-dried petri dishes were allowed to cool down by placing them in a desiccator for 1h. The oven-dried sediments were reweighed, which gave the sediment "dry weight". The percentage moisture content was obtained using the formula:

$$Percent\ Moisture\ content = \frac{Sediment\ wet\ weight - Sediment\ dry\ weight}{Sediment\ wet\ weight}\ x\ 100$$

For Total Organic Matter (TOM) analysis, a modified loss-on-ignition of Holme & Mcintyre (1971) was used. The crucibles were first pre-weighed, and approximately 5 g of sediment samples were loaded and oven-dried for 80℃ for 24 h to constant dry weight. The pre-combusted crucibles were cooled down inside a desiccator for 1h. The oven-dried weight and sediment-dry weight were determined. After that, the crucibles were placed inside a furnace (brand) and were combusted again for 500℃ for 8h. The combusted crucibles were once again cooled inside a desiccator for 1h. The crucibles were reweighed which gave the after-furnace weight and ash weight. The total organic matter was calculated using the formula:

$$Percent\ Total\ Organic\ Matter = \frac{Sediment\ dry\ weight - Ash\ weight}{Sediment\ dry\ weight}\ x\ 100$$

Dry Sieving

The grain size composition was processed using the methods based on Holme & Mcintyre (1971) and Kenny & Sotheran (2013). Sediment samples were continuously oven-dried in an oven at 100℃ until it was thoroughly dried. Dry sieving was used for samples that were composed of mostly gravel and pebbles. For dry sieving, ~25 g of samples were loaded on the sieve stack and passed on different mesh-size sieves. Table 1 shows the classification of each mesh size sieve in which samples were classified as gravel, sand, and silt based on the Wentworth scale grade (Wentworth, 1922). The samples in each sieve stack were briskly shaken until grains were retained by diameters greater in size while smaller grains were passed to the following sieve stack. The retained sediments in each sieve were weighed and recorded. The sediment composition percentage was calculated using the formula:

$$Sediment\ composition = \frac{Weight\ of\ retained\ sediment}{Initial\ total\ weight\ of\ the\ sediment\ sample}\ x\ 100$$

Table 1. Sieve mesh sizes used for categorization of sediments based on the Wentworth scale grade classification (Wentworth, 1922).

Sediment classification	Sieve mesh size
Gravel	5.660 mm
	4.760 mm
	3.360 mm
	2.830 mm
	2.000 mm
Sand	1.410 mm
	0.840 mm
	0.350 mm
	0.250 mm
	0.210 mm
	0.149 mm
	0.063 mm
Silt-Clay	0.053 mm

Wet sieving

For silty sediment samples, rapid partial analysis by wet sieving was done using Buchanan's methods (Buchanan, 1984). This required an initial splitting of the sediment into a sand fraction (grains >0.063 mm) and a silt-clay fraction (grains <0.063 mm). The silty oven-dried sediment samples were used, and a sub-sample of ~25 g was weighed. The sub-samples were placed in a beaker filled with 250 ml of tap water and 10 ml of aqueous sodium hexametaphosphate ($NaPO_3$). A glass stirring rod was used to break the sediment, and it was continuously stirred for 10-15 minutes; the sediment was soaked overnight and re-stirred for 10-15 minutes. The suspended sediments were washed (using tap water) in a 0.062 mm sieve and placed in a white basin until the sieve surface was fully submerged and sieved by "puddling" the sieve into the water basin. The material passing through the sieve was discarded, and this was repeated until no material passed through and the water in the basin was clear with no particles present. The contents of the sieve were transferred to another container, and it was rapidly oven-dried at 100°C. The oven-dried sediments were transferred to two different mesh-size sieve stacks, which are 2 mm and 0.063mm. The retained sediments in the 2 mm sieve stack were classified as gravel; the 0.063mm was classified as the sand fraction. After that, the initial splitting was completed. The percent sediment composition was computed using the formulas:

$$Percent\ Gravel = \frac{Initial\ weight - Retained\ Gravel\ weight}{Initial\ weight}\ x\ 100$$

$$Percent\ Sand = \frac{Initial\ weight - Retained\ Sand\ weight}{Initial\ weight}\ x\ 100$$

$$Percent\ Silt - Clay = \frac{Initial\ weight - (Retained\ Gravel\ weight + Retained\ Sand\ weight)}{Initial\ weight}\ x\ 100$$

Physicochemical Characteristics of the Water

A multiparameter water meter (Hanna Technologies, HI9829 Multiparameter) was used to measure the surface water. Different physicochemical properties of the water, like temperature (in °C), pH, Dissolved oxygen (mg/L), and Salinity (ppt), were determined. A secchi disc was used to measure water transparency. The disc was slowly submerged in the water until it was not visible. The depth at which the disc was not visible was recorded. The depth was measured using a rope with markers (in meters) and a sinker to ensure stability.

Data Processing and Analysis

The gathered data was tabulated using Microsoft Excel 2013. Descriptive statistics like bar graphs and mean (with standard deviations) were used. The Statistical Package for Social Sciences (v.25) software was used for statistical analyses. The data on the river and ponds were analyzed using two-way ANOVA and for the post-hoc test, simple main effects was used to determined significant differences. If two-way ANOVA is not possible, a non-parametric test (Kruskal-Wallis test) was used.

Results and Discussion

Total Organic Matter (TOM)

Figures 2a and 2b showed the Total Organic Matter (TOM) of sampled sediments from the river and ponds respectively during the wet and dry season. The highest TOM recorded in the river was on site 11 which was 11.39%. The highest TOM recorded in the pond was on pond A which was 12.60%. The TOM of the river during the wet season ranged from 4.56-10.40% and for the dry season, it ranged from 4.23-11.39%. Figures 2c showed the various interactions between the season and sites. The mean TOM during the wet season and dry season was 8.41%(±1.88%) and 7.01%(±2.05%), respectively. For the sites, the mean TOM of the river and ponds were 7.65%(±2.13%) and 7.76%(±2.07%), respectively. A significant difference was observed in the TOM between seasons ($p = 0.019$; $\alpha = 0.05$) and the interaction of the sampling sites (both river and ponds) and the season ($p = 0.005$; $\alpha = 0.05$). For the post hoc tests, the significance difference between seasons and interaction between seasons and sites was displayed in Figure 2d. The mean TOM of the ponds during the wet and dry season were 9.12%(±1.64%) and 6.40%(±1.49%), respectively. For the river sites, the mean TOM during the wet and dry season were 7.53%(±1.86%) and 7.77%(±2.45%), respectively. The simple main effects showed that there is a significant difference between the TOM of ponds during the wet and dry season ($p = 0.0002$; $\alpha = 0.05$) which means that the TOM load of pond sediments are affected by the wet and dry season.

The obtained TOM obtained for the river and pond sampling sites showed a high organic matter content during the wet and dry season. A significant difference showed that the organic matter loading in the sediments was affected based on what season the country experiences. High TOM values were observed in sites 9-12 during the dry season which is located in the river mouth. The reason for this could be the deposition of sediment which is caused by household wastes, fishery (river filter nets, aquaculture), and anthropogenic activities that limits water exchange and movement. Organic matter deposition is affected by the topography of the river; bends/loops inhibit complete removal of saltwater and promotes deposition which is related to the case of Fatibello lagoon in Italy (Frascari et al. 2002). Another source of organic matter are the aquaculture ponds that relies on the river for its water source. In an informal interview with aquaculture operators, majority of them are culturing milkfish in their ponds. The operations of brackish milkfish aquaculture in the Philippines are usually year-round, in which fry collection and culture occurring between November to April because these are also the months of high abundance in milkfish fry (FAO, 2025a). However, pond preparation of brackish water ponds are usually done during the dry season, 1-2 months before stocking; this will allow appropriate draining, drying and fertilization because of low water neap tides (FAO, 2025b). In the study of Debnath and Haira (1972), environmental factors like moisture content, temperature and microbial diversity affects decomposition of soil organic matter; wherein, an increase in temperature in soil often leads to increased microbial activity and rate of decomposition of organic matter (Yadav et al. 2021). The pond preparation occurring during the dry season could be the reason why TOM in the ponds during the dry season was significantly low as compared to the wet season (Figure 2d). Based on the grain size analysis for the ponds, majority of the percent composition is silty-clay sand which are considered as fine grained sediments. Organic matter tends to accumulate with clay minerals resulting to its enrichment (Yu et al., 2009). Fine sediments are often correlated with high TOM because of its compact characteristics that tend to preserve organic matter. High TOM often leads to hypoxia and build-up of toxic by-products like ammonia and hydrogen sulphide (Nilsson & Rosenberg, 2000; Gray et al., 2002; Belley et al., 2010). The study of Tomasseti et al. (2009) presented reduced diversity of microbenthic communities and increased dominance of opportunistic species in mariculture sites.

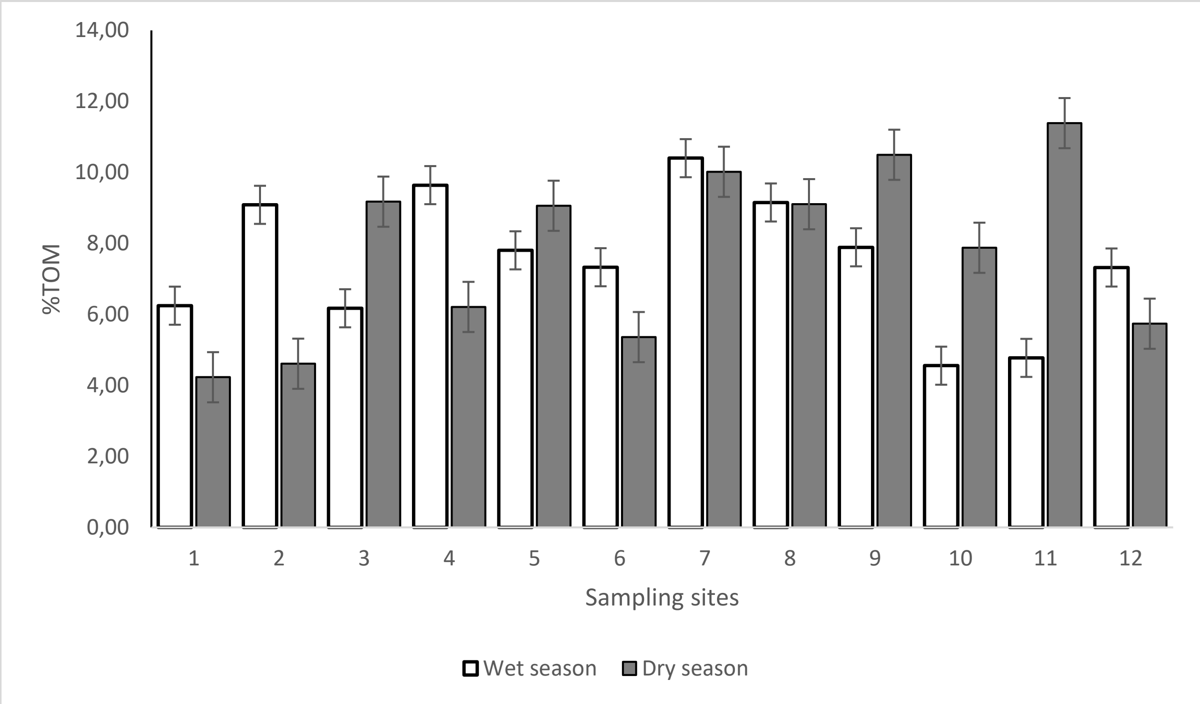

Figure 2a. TOM of sediments extracted from river sampling sites during the wet and dry season.

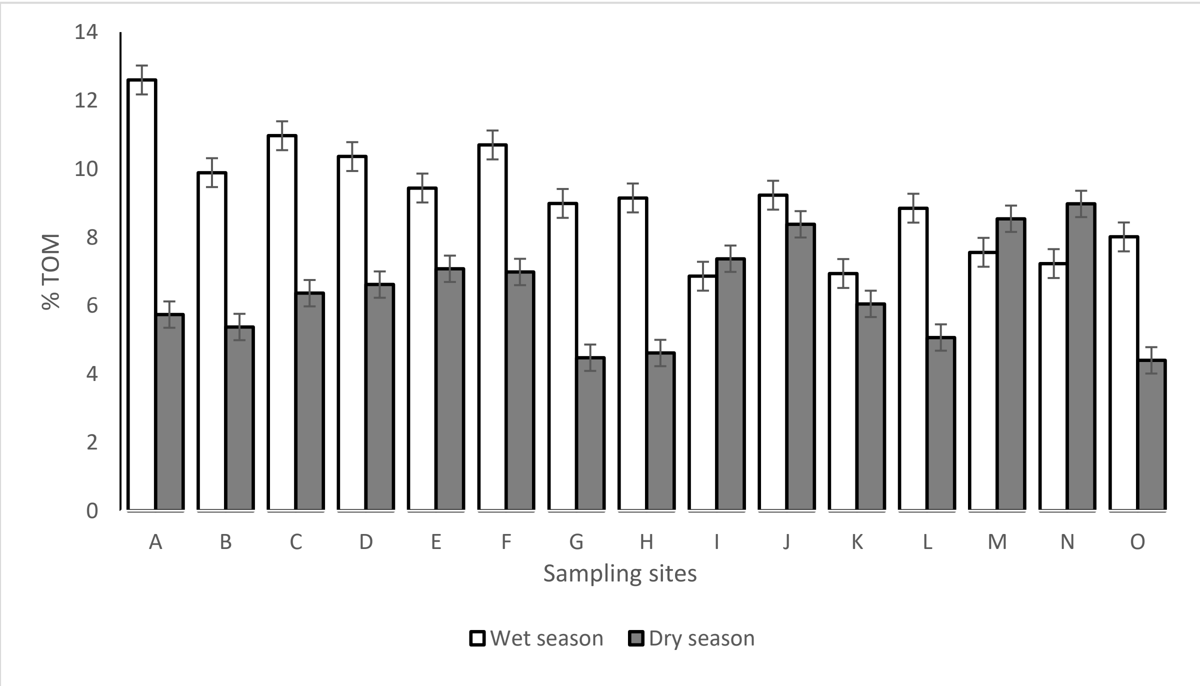

Figure 2b. TOM of sediments extracted from pond sampling sites during the wet and dry season.

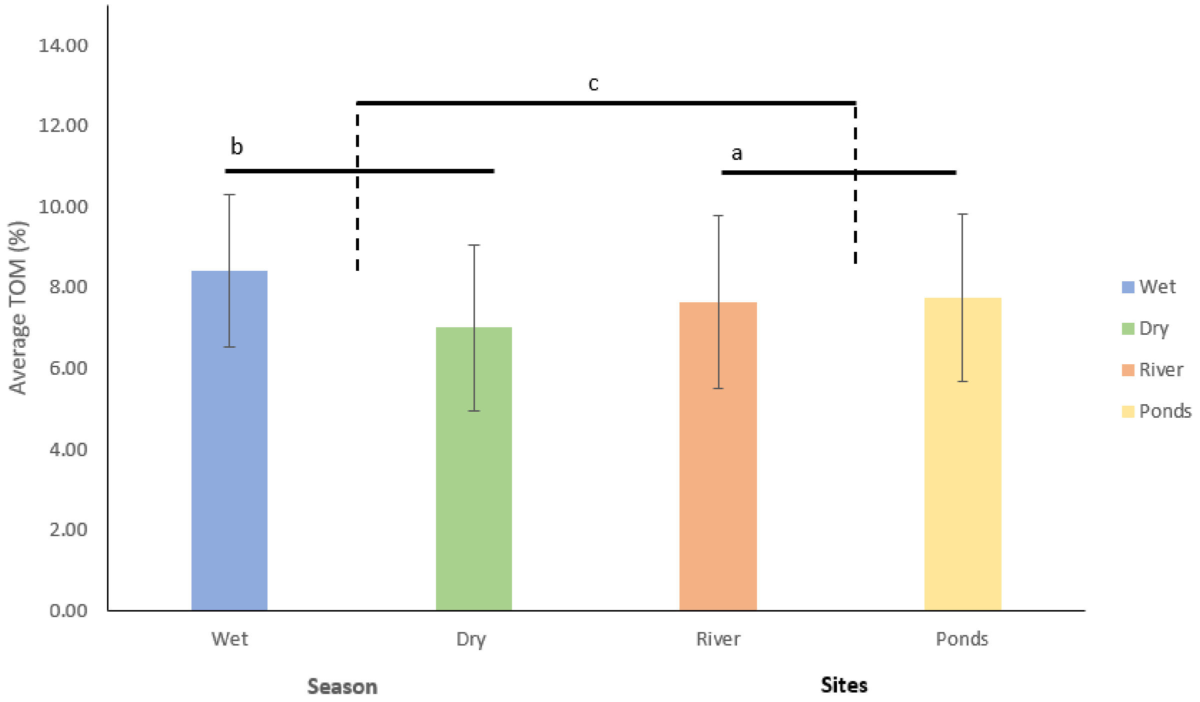

Figure 2c. Mean TOM (±SD) for season and sites showing various interactions and significant differences
**a: not significant; p-value = 0.832 at α = 0.05*
***b: significant; p-value = 0.019 at α = 0.05*
****c = significant; p-value = 0.005 at α = 0.05*

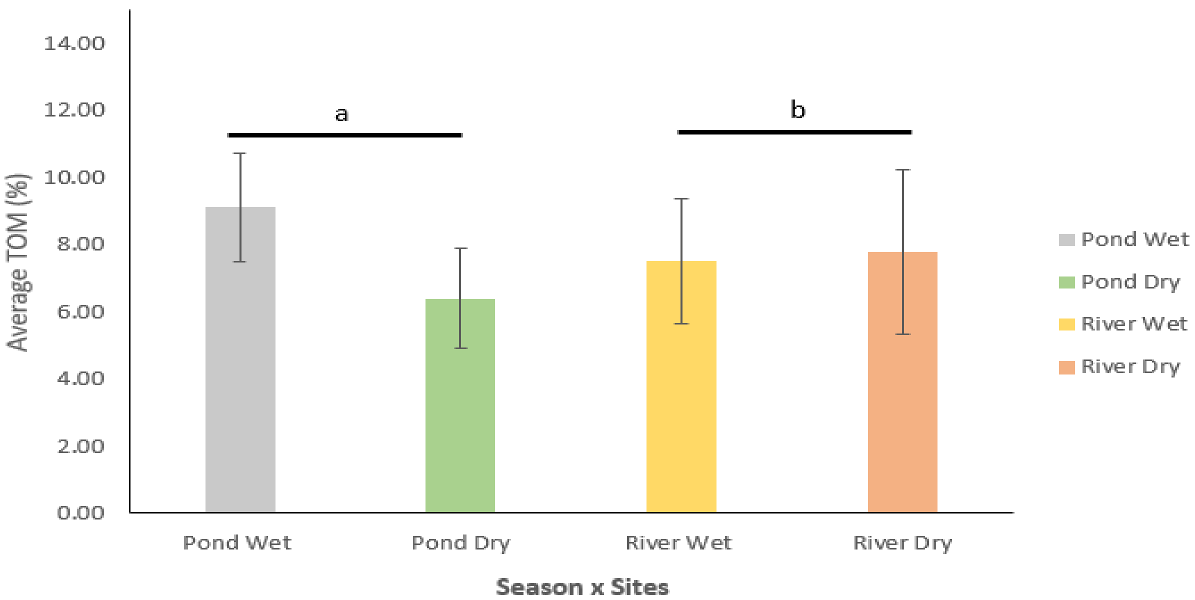

Figure 2d. Mean TOM (±SD) for the interaction of season and sites with its significant differences
**a: significant; p-value = 0.0002 at α = 0.05*
***b: not significant; p-value = 0.750 at α = 0.05*

Moisture Content

Figures 3a and 3b presented the percent moisture content of sampled sediments from the river and ponds respectively during the wet and dry season. The highest percent moisture content recorded in the river was on site 11 which was 60.82%. The highest percent moisture content recorded in the ponds was on pond L which was 62.83%. The percent moisture content of the river during the wet season ranged from 30.11-53.41% and for the dry season, it ranged from 23.38-60.82%. The percent moisture content of the ponds during the wet season ranged from 41.51-58.40% and for the dry season, it ranged from 28.19-62.83%. A significant difference was observed in the percent moisture content between the river and ponds (p = 0.009; α = 0.05) which means that percent moisture was affected by the sampling sites and not the season.

The high moisture content of the sediments of the river and pond sampling sites could be related to the TOM and sediment composition. According to the study of Gao et al. (2023) in tidal flats, sediment moisture content (SMC) is measured as the amount of seawater present within the sediment per unit weight. The SMC value in tidal flats affected the formation, migration, and exchange of material (Smit et al., 2019). Vegetation zones experiences reduced flow velocities which leads to lower sediment transport that is dominated by finer particles with inferior grain sorting (Gao et al. 2023). The river, dominated by fine sediments stores TOM and huge amounts of water because of its compact structure. The high percent moisture promotes bacterial growth.

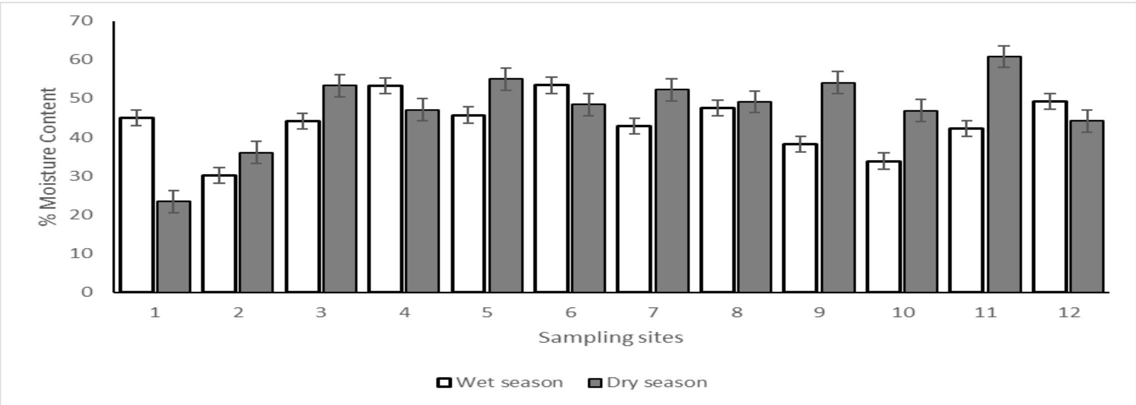

Figure 3a. Percent moisture content of sediments extracted from river sampling sites during the wet and dry season.

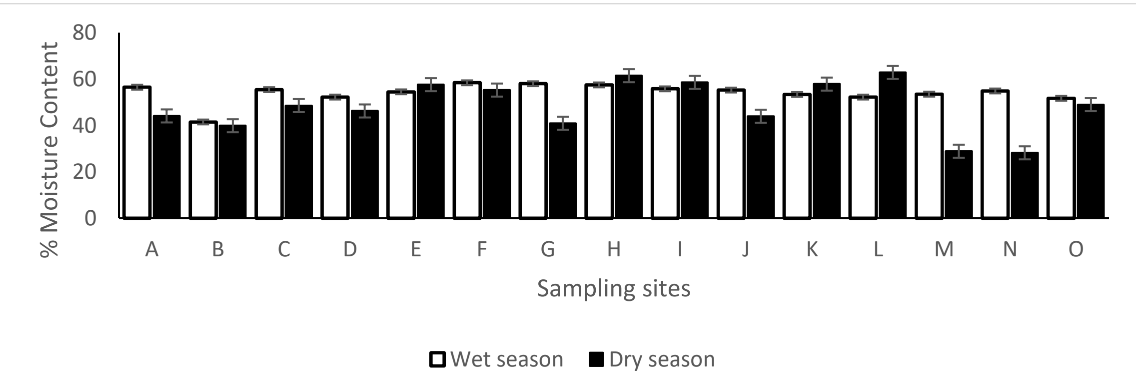

Figure 3b. Percent moisture content of sediments extracted from pond sampling sites during the wet and dry season.

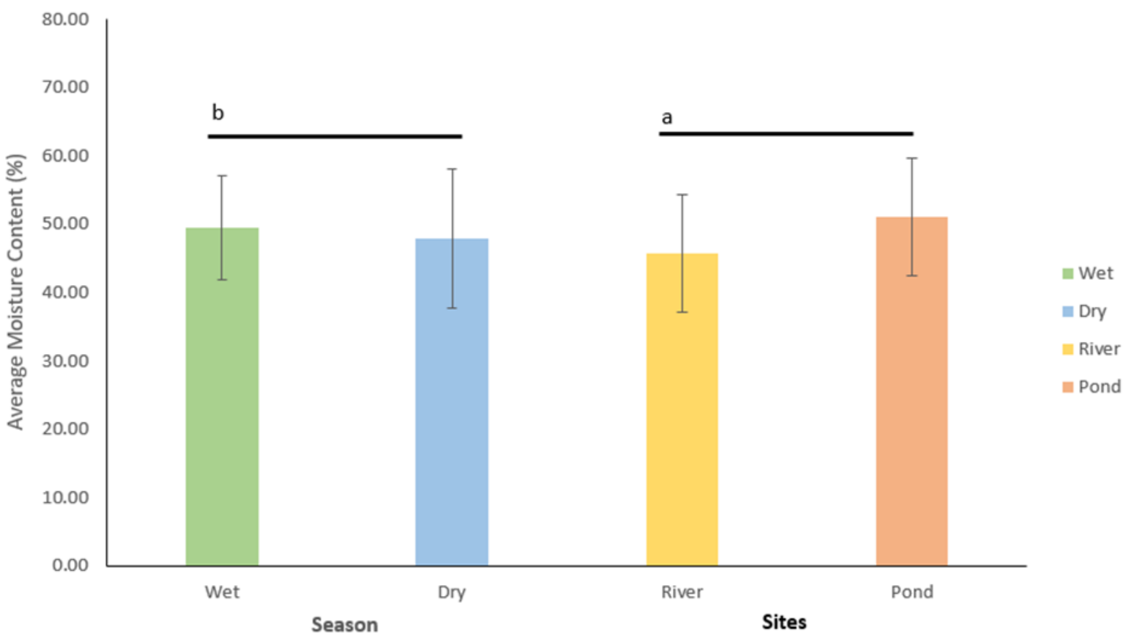

Figure 3c. Mean Percent moisture content (±SD) for season and sites showing significant differences.
**a: significant; p-value = 0.009 at α = 0.05*
***b: not significant; p-value = 0.653 at α = 0.05*

Grain Size Composition

Figures 4a and 4b revealed that the mean percent grain size composition of sampled sediments for the river and ponds respectively during the wet and dry season. The sediments in the river sampling sites showed that sand and silty-clay are dominant for the majority of the sites (Sites 2-11) and in the upstream part of the river (site 1), gravel is abundant. For the pond sampling sites, sand and silt-clay dominate all sampling sites. Gravel from sites 2-11 was mostly tiny pieces of broken oyster shells that could not be sorted using the mesh sizes for sand and silt-clay. It was observed that the samples taken from all sampling sites (except for Site 1 in the river) was black and had a thin brown layer on the surface.

The river is mainly composed of sand and silty-clay sediment, with the exception of site 1 wherein huge percent of gravel is present. Gravel dominates the river in the upstream part, specifically in river site 1. According to Fondriest Environmental Learning Center (2025a), sediment transport is directly affected by water flow. If the water flow is strong, it can suspend particles in the water column as it moves towards the downstream; or push them along the bottom. Sediment that rolls, slides, or bounces along the bottom is called bedload transport. It usually happens during high flow rate (for larger particles) or low flow rate (smaller particles). Smaller grain particles are often classified as suspended load (amount of sediment carried downstream) and its subset is called wash load wherein finest suspended sediments (<0.00195 mm in diameter) are usually present. Based on the studies of Postma (1954), and Semeniuk (1981) on Mississipian tidal rivers and Wadden coastal areas of the North Sea, the average grain size of sediments tend to increase starting from the tidal inlet towards tidal rivers to the upstream, with clay usually present towards tidal flats. It is possible that river site 1 is the last area in the river that experiences high water flow since this is the only site where coarse sediments are present. Water flow from river site 2 towards the river mouth is probably reduced due to the presence of fine silty sediments. Because of this, dry sieve analysis was applied in river site 1 because majority of the extracted sample was coarse grained sediments (gravel-sand classification), whereas sites 2-12 were subjected to wet sieving because majority of the sediments are silty (Figure 4a). As for the pond sampling sites, all of them were classified as silty sediments because the flushing in and out of aquaculture ponds are controlled by outlet structures (monks) which hinders water flow depending on the duration of the aquaculture operation and frequency of water change (FAO, 2025c). Based on a sediment quality perspective, fine-grained sediments (specifically the <0.063 mm fraction) that is loaded in many rivers exhibit increased concentrations of nutrients and contaminants, and these concentrations often have an implication to the sediment quality guidelines (Owens & Walling 2002; Blake et al. 2003). Because of this, it has an effect on the river ecology which is eutrophication and impacts human health (i.e., excessive levels of pathogens and radionuclides). Fine-grained sediments usually come from the topsoil of agricultural fields (Collins et al., 1997; Walling & Q et al., 1998; Owens et al., 1999), disturbed forestry (Motha et al. 2003), and construction and mining activities Grain-size distribution is often related to the Organic Matter content and distribution (Bergamaschi et al. 1997) and this study showed that sites which were dominated with fine sediments have high TOM.

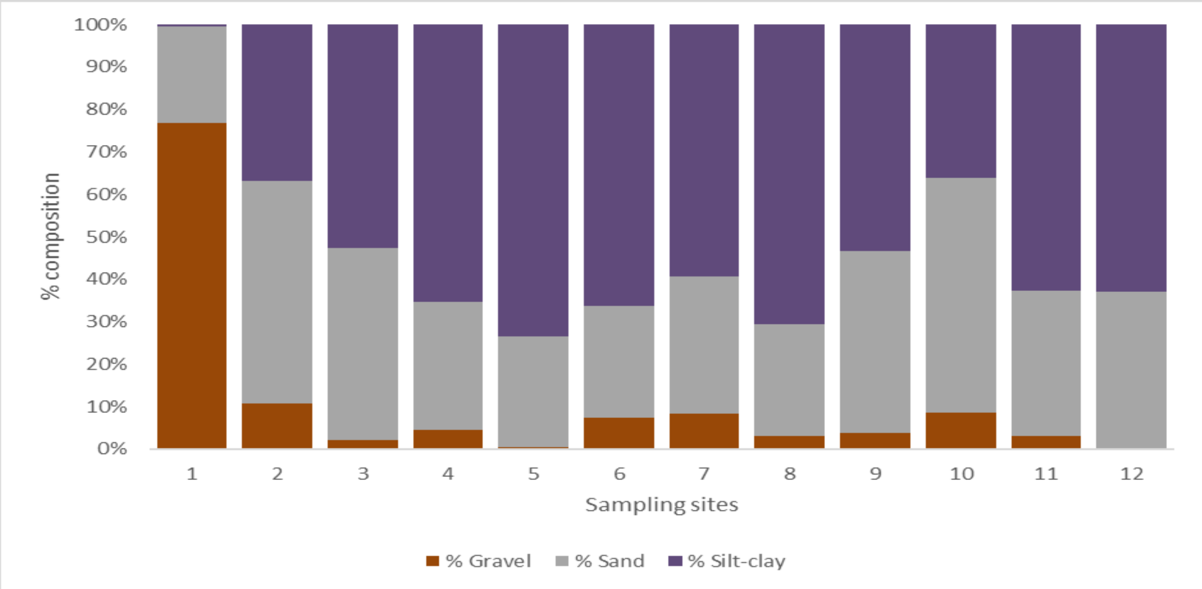

Figure 4a. Mean percent grain size composition of sediments extracted from river sampling sites during the wet and dry season

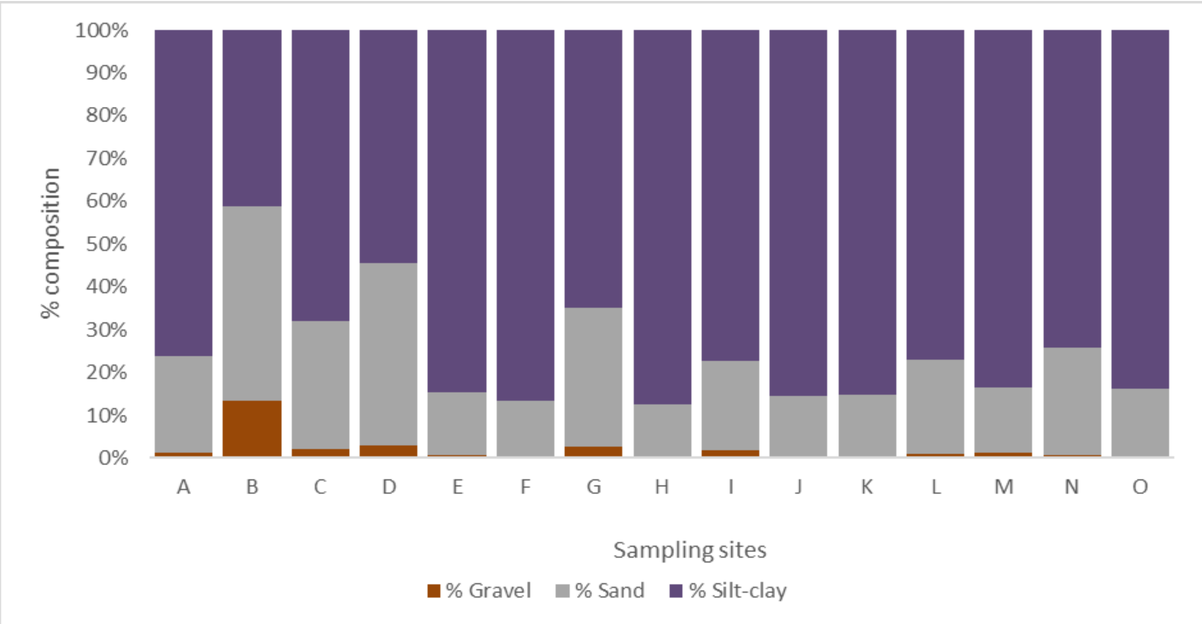

Figure 4b. Mean percent grain size composition of sediments extracted from pond sampling sites during the wet and dry season.

Water Parameters

Figures 5a and 5b shows the effects of water temperature to the TOM of sediments from the river sampling sites during the wet and dry season. The water temperature for the river sampling sites ranged from 28.29-32.53°C (mean = 30.23±1.37°C) and for the ponds, it ranged from 27.83-30.28°C (mean = 29.09±0.99°C) during the wet season. For the dry season, water temperature from the river sampling sites ranged from 26.31-28.72°C (mean = 27.8±0.82°C) and for the ponds, it ranged from 27.4-29.7°C (mean = 28.56±0.86°C). Tables 2A and 2B displays the other water parameters obtained during the wet and dry season. The salinity of the river during the wet and dry season ranged from 0.24-11.60 ppt (mean = 6.20±4.32 ppt) and 1.00-40.93 ppt (mean = 28.24±15.42 ppt), respectively; for the ponds, it ranged from 0.98-30.73 ppt (mean = 9.51±9.31 ppt) during the wet season and 18.89-44.37 ppt (mean = 36.04±8.06 ppt) during the dry season. The dissolved oxygen (DO) from the river sampling sites during the wet and dry season ranged from 2.55-4.07 mg/L (mean = 3.28±0.49 mg/L) and 2.50-6.67 mg/L (mean = 4.50±1.24 mg/L), respectively; for the ponds, it ranged from 1.36-2.81 mg/L (mean = 1.93±0.41 mg/L) during the wet season and 2.01-5.43 mg/L (mean = 3.23±0.95 mg/L) during the dry season. The pH for the river sampling sites during the wet and dry season ranged from 9.34-10.27 (mean = 9.80±0.29) and 7-38-8.28 (mean = 7.76±0.25), respectively; for the ponds, it ranged from 9.32-10.16 (mean = 9.80±0.23) during the wet season and 7.38-8.11 (mean = 7.70±0.21) during the dry season. The water clarity and depth for the river sampling sites during the wet season were 26-78 cm (mean = 61±14 cm) with a depth ranging from 73-276 cm (mean = 141±65 cm); for the dry season, it ranged from 20-44 cm (mean = 31±7 cm) with a depth ranging from 30-228 cm (mean = 146±62 cm). The ponds sampling sites obtained a water clarity and depth which ranged from 23-43 cm (mean = 33±6 cm) with a depth ranging from 27-235 cm (mean = 123±44 cm); for the dry season, it ranged from 21-43 cm (mean = 31±6 cm) with a depth ranging from 39-210 cm (mean = 134±49 cm).

Water temperature determines the removal of Total Organic Matter (TOM) from Micro polluted source water (Nengzi et al., 2023). A decrease in temperature (<22.4°C) limits the activity of heterotrophic bacteria and removal rate of CODMn (Acid Potassium Permanganate). Ammonia-N concentration and nitrifying bacteria showed high activity and oxidation rate at low temperatures (Nengzi et al., 2023). Elevated water temperature results in increased microbial activity which leads to rapid degredation of organic carbon in sediments (Gudasz et al., 2015) and is associated with reduced TOM. Increased water temperature also dictates plant respiration and photosynthesis wherein algal photosynthesis; this also leads to increase in sediment organic matter when these algae decompose (Arina et al., 2023). A decreased light availability, often affected by seasons (or time of the year) affects terrestrial dissolved organic matter (tDOM) in which reduced light availability promotes growth of heterotrophic bacteria which leads to absence in phytoplankton bloom; hence, maximum productivity often occurs during warmer months where river discharge is at minimum (Drakare et al., 2002; Figueroa et al., 2016). This could mean that water temperature has a direct effect on TOM load in Tinori-an river (Figures 5A-5B; 6A-6B) The salinity in the study showed that starting in site 1 towards the upstream, the water is freshwater and brackishwater in the areas approaching the river mouth (sites 2-12). Different organisms thrive based on their tolerances to salinity; oyster culture which is abundant in the river prefer a high range of salinity which is 2-30 ppt (NOAA, 2025a). Salinity has an effect on DO concentrations, osmosis regulation, and TDS toxicity (Fondriest Environmental Learning Center, 2025b). The high salinity range that is experienced by the river and ponds during the dry season (Table 2A) could be associated with high temperatures during summertime which elevates evaporation in estuaries; whereas during wet season, salinity range is low(Table 2B) due to the amount of freshwater flows from mountains and lower upstream (NOAA, 2025b). The recorded pH for both river and ponds during the wet and dry season is above pH 7 which means that the water is basic, wherein the higher it is to 7, the greater the alkalinity. The wet season recorded a higher pH as compared to the dry season which could be related to algae abundance, wherein they remove CO_2 (during photosynthesis) in the water which makes it basic (reduced carbonic acid) (NOAA, 2025b). This shows that phytoplankton abundance in Tinori-an river occurs during the wet season. The river and pond recorded low surface dissolved oxygen levels which could support oyster culture and some crustaceans (2-3 mg/L) but not of large fishes (~5 mg/L) (NOAA, 2025a). The Environmental Management Bureau (2006) has set an optimum water quality standard for Dissolved Oxygen (DAO 2016-08) which is 5 mg/L for Class C rivers. Unfortunately, Tinori-an River is not included in the classification of DENR at the moment. The results for water clarity and depth showed that the river has turbid waters. Turbidity determines the clarity of water and particles that makes the water cloudy or murky are silt, mud, algae, other plant materials, minerals and metals, and runoffs. Increased erosion causes excessive sediment loading to rivers also cause turbidity problems in the water column and sedimentation in channels, reservoirs, and estuaries.

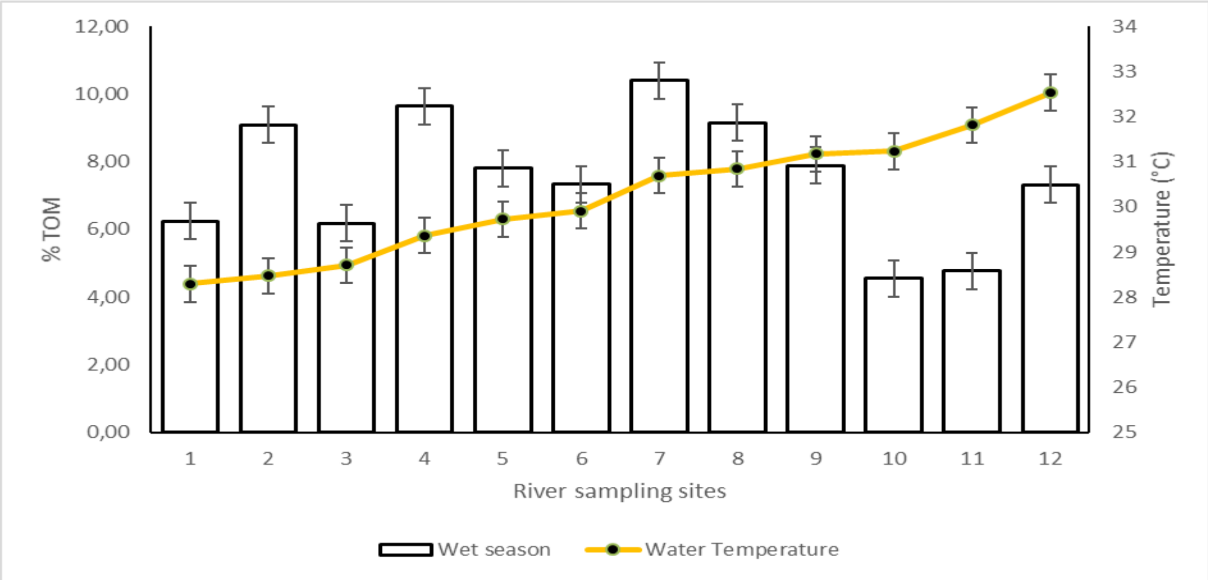

Figure 5a. TOM and water temperature of river sampling sites during wet season.

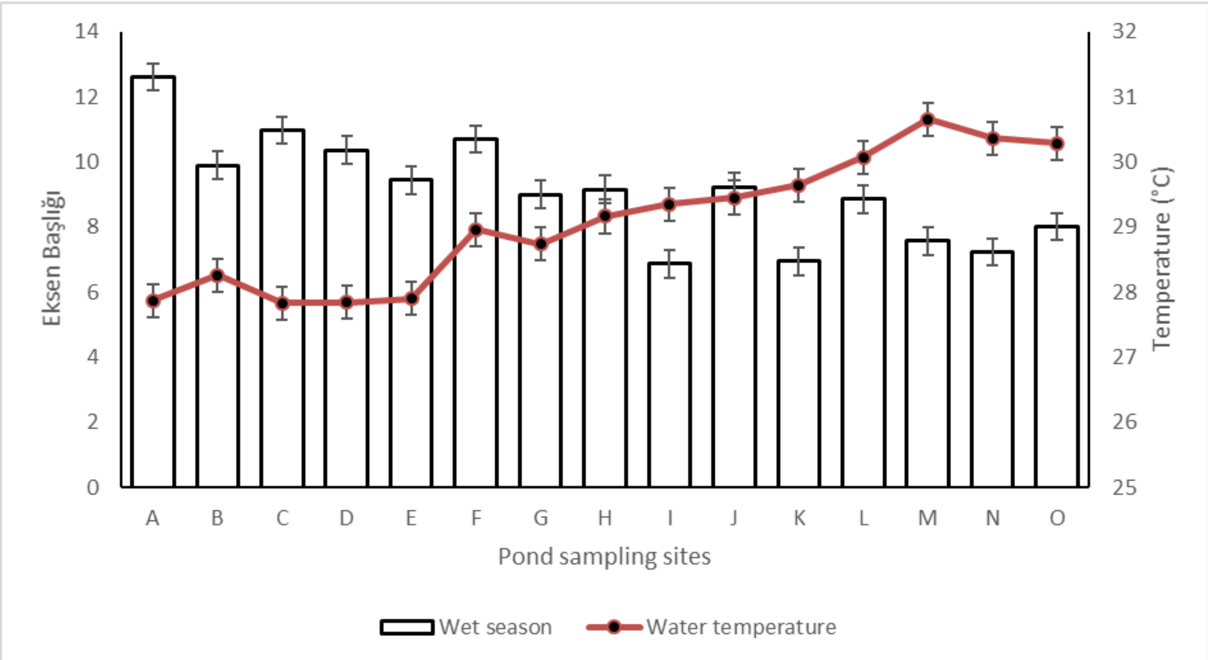

Figure 5b. TOM and water temperature of pond sampling sites during wet season.

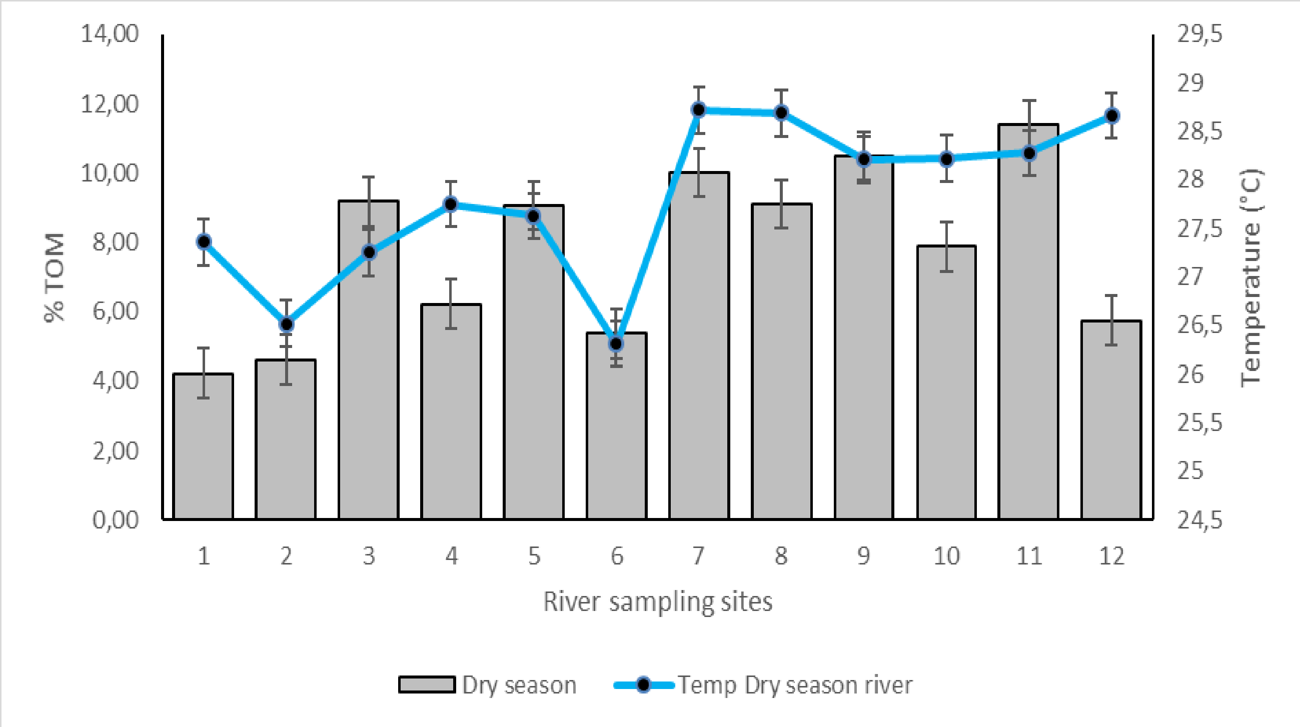

Figure 6a. TOM and water temperature of river sampling sites during dry season

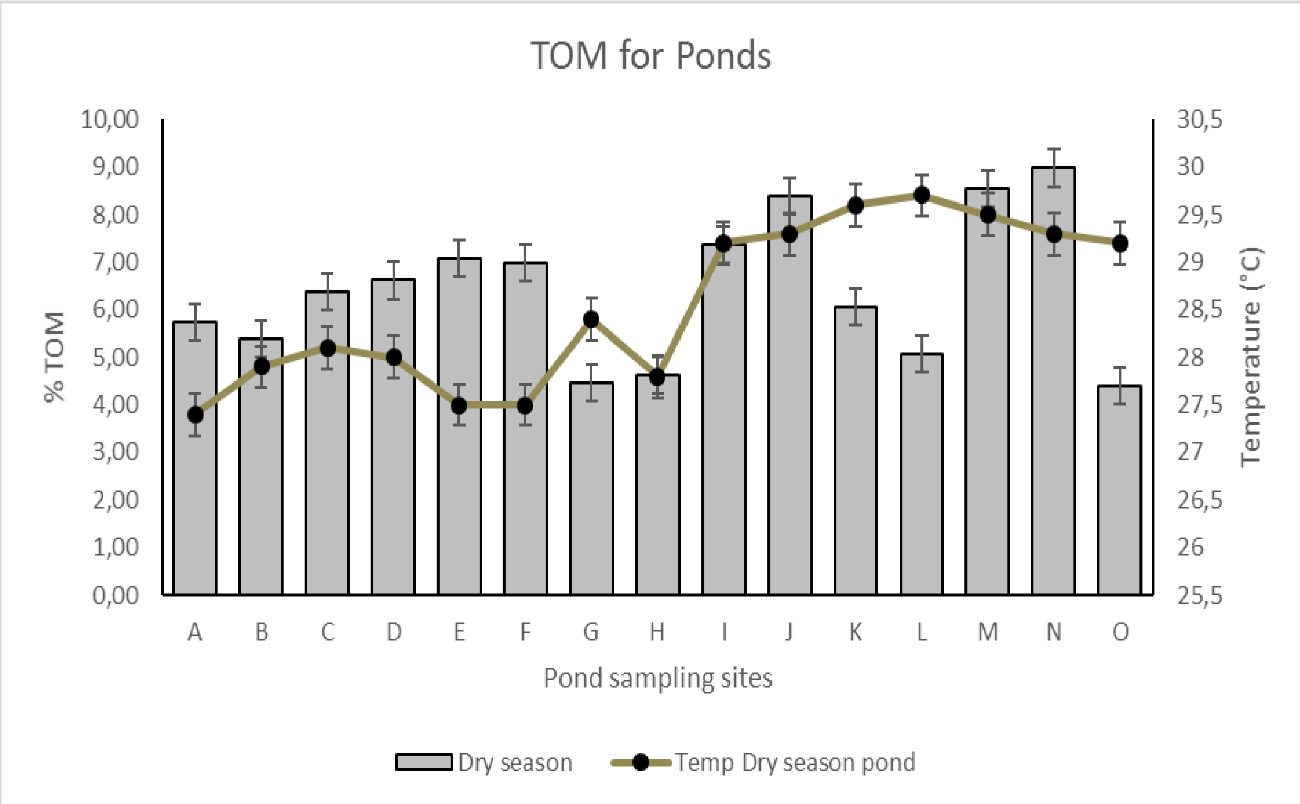

Figure 6b. TOM and water temperature of pond sampling sites during dry season

Table 2a. Mean water parameters from river sampling sites during the wet and dry season (mean±SD).

RIVER SAMPLING SITES										
WET SEASON						***DRY SEASON***				
Site	*Salinity (ppt)*	*Dissolved Oxygen (mg/L)*	*pH*	*Water clarity (cm)*	*Depth (cm)*	*Salinity (ppt)*	*Dissolved Oxygen (mg/L)*	*pH*	*Water clarity (cm)*	*Depth (cm)*
1	0.24±0.07	3.59±0.53	9.34±0.10	26±6	73±5	1.00±0.12	4.54±0.46	7.75±0.35	23±2	30±3
2	0.27±0.03	3.62±0.44	9.47±0.18	52±5	94±5	5.33±0.60	5.19±0.28	8.10±0.42	26±4	110±8
3	0.41±0.09	3.80±0.59	10.04±0.12	58±3	99±6	7.33±0.33	4.50±0.33	8.28±0.36	30±4	123±6
4	3.09±0.30	2.81±0.23	9.58±0.16	74±4	100±3	22.60±1.10	4.92±0.89	7.38±0.18	34±3	130±5
5	5.38±0.51	3.05±0.20	9.70±0.20	72±3	141±10	31.56±0.47	4.60±0.43	7.56±0.27	43±3	218±5
6	6.17±0.39	2.66±0.48	9.76±0.24	78±3	109±7	29.50±0.55	4.48±0.41	7.81±0.21	44±5	152±10
7	8.43±0.41	4.07±0.19	9.49±0.34	70±3	173±5	40.22±0.97	5.54±0.42	7.77±0.25	29±2	228±7
8	8.27±0.31	2.55±0.34	10.27±0.23	62±2	109±7	40.47±0.09	5.44±0.48	7.81±0.17	35±4	227±6
9	8.61±0.53	3.11±0.20	10.17±0.25	64±4	257±10	39.32±0.79	6.67±0.35	7.52±0.46	34±4	193±16
10	10.41±0.45	2.95±0.18	9.81±0.27	65±5	276±5	40.07±0.09	2.50±0.56	7.61±0.40	24±3	86±7
11	11.53±0.76	3.50±0.62	9.62±0.22	50±3	105±5	40.52±0.70	3.02±0.45	7.84±0.28	27±3	105±7
12	11.60±0.47	3.70±0.50	9.83±0.24	67±2	161±4	40.93±0.95	2.65±0.44	7.74±0.60	20±4	150±8

Table 2b. Mean water parameters from pond sampling sites during the wet and dry season (mean±SD).

POND SAMPLING SITES										
	WET SEASON					***DRY SEASON***				
Pond	*Salinity (ppt)*	*Dissolved Oxygen (mg/L)*	*pH*	*Water clarity (cm)*	*Depth (cm)*	*Salinity (ppt)*	*Dissolved Oxygen (mg/L)*	*pH*	*Water clarity (cm)*	*Depth (cm)*
A	1.34±0.46	1.98±0.18	9.32±0.39	27±3	95±4	18.89±0.40	2.94±0.08	7.62±0.26	21±3	39±4
B	1.59±0.37	2.55±0.13	10.16±0.42	27±2	112±8	32.42±0.63	2.86±0.11	7.64±0.28	43±2	146±5
C	0.98±0.05	1.99±0.15	9.93±0.25	36±4	116±5	23.34±0.80	2.71±0.51	7.39±0.32	27±2	106±5
D	1.03±0.04	1.89±0.13	9.78±0.29	23±3	27±4	28.94±1.19	2.75±0.49	7.48±0.46	40±3	141±5
E	2.46±0.51	1.85±0.13	9.86±0.16	30±3	75±5	28.39±0.50	2.72±0.55	7.81±0.25	30±3	112±9
F	8.58±0.10	1.92±0.11	9.93±0.24	40±4	140±4	34.43±0.69	2.52±0.34	7.75±0.18	23±3	160±6
G	7.56±0.34	1.79±0.14	9.80±0.05	39±2	130±2	38.13±0.70	2.65±0.25	7.65±0.18	25±3	62±5
H	8.49±0.42	1.41±0.23	9.90±0.15	43±3	127±4	36.56±0.64	3.00±0.25	7.78±0.19	34±2	121±8
I	7.13±0.16	1.36±0.12	9.53±0.26	33±3	118±4	44.37±0.70	2.01±0.22	7.38±0.28	35±3	192±11
J	6.65±0.36	1.38±0.12	9.69±0.19	30±2	129±2	43.45±0.48	2.80±0.33	7.83±0.21	35±2	106±7
K	6.57±0.45	1.67±0.19	9.68±0.20	30±3	119±2	42.46±0.48	3.27±0.12	7.63±0.39	30±2	210±5
L	12.11±0.54	1.84±0.09	9.95±0.30	28±3	143±3	42.18±0.46	3.53±0.41	7.76±0.16	27±3	107±6
M	23.57±0.94	2.04±0.10	9.53±0.19	39±3	131±5	43.54±0.53	4.40±0.19	7.64±0.35	35±2	131±7
N	23.90±1.17	2.41±0.18	9.88±0.04	33±2	154±5	41.49±0.32	4.90±0.14	8.01±0.18	35±3	205±4
O	30.73±1.55	2.81±0.19	10.11±0.18	42±2	235±11	42.07±0.39	5.43±0.33	8.11±0.18	30±2	166±6

Conclusions

The present study provided a baseline information on the sediment and water quality of Tinori-an River which gave an insight on its health and condition. Based on the TOM that was obtained on the ponds, aquaculture ponds are one of the sources of Organic Matter which is loaded directly to the river. Aquaculture ponds should have a settling/treatment pond before they discharge their effluents into the river. The high TOM and low DO concentrations indicates the lack of management on activities conducted directly to the river. Furthermore, the DENR should include the Tinori-an river in list of classification of water bodies since fishery and anthropogenic activities are present. Studies on microbenthic fauna as bio-indicators could support the study. Additional studies on presence of heavy metals, impacts of aquaculture production in the vicinity, productivity of water, and total suspended and total dissolved solids could give additional baseline data on the overall health and condition of the river

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Ethical approval

To the extent of our knowledge, no conflict of interest exists.

Informed consent

Not available

Conflicts of interest

There is no conflict of interests for publishing their study

Data availability statement

The authors declare that data are available upon reasonable request

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Author contribution

Gaudiel RM: Conceptualization, Writing original draft, Methodology, Investigation, Data curation, Formal analysis, Supervision, Validation, Review, Editing

Bito-onon JB: Funding acquisition, Validation, Review, Data curation

Villanueva CJ: Validation, Review, Data curation

Perrera VE: Validation, Review, Data curation

Solivio KA: Validation, Review, Data curation

Belgira KS: Validation, Review, Data curation

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