Hypothesis

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ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN RIVERINE ECOSYSTEM KAWIT, CAVITE, PHILIPPINES

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Hypothesis

Environmental Parameters and Carbon Sequestration Potential of Mangrove Forest in Kaingen Riverine Ecosystem, Kawit, Cavite, Philippines

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Abstract: Mangroves play an important role as a carbon sink and in mitigation of climate change. This study aimed to assess the anthropogenic activities, water and soil quality, mangrove diversity, and carbon sequestration potential of mangrove trees in the Kaingen River, Kawit, Cavite. The sampling period was conducted from November 2022 to March 2023 with the established three sampling sites. The DENR Administrative Order (DAO)- 2016-08 was used as a standard for water quality parameters, except for phosphates whichused DAO-2021-19. The soil parameters were identified using the soil test kit from the Bureau of Soil and Water Management (BSWM) and at the BSWM laboratory. Mangrovespecies were identified using The Field Guide for Philippine Mangroves and were verifiedby experts. The carbon sequestration potential was obtained using an allometric equation for Southeast Asian mangroves. There are three mangrove species found in Kaingen Riverine such as *Rhizophora mucronata*, *Avicennia alba*, and *Xylocarpus granatum*. Based on species importance value *Rhizophora mucronata* is the dominant mangrove species. The result for carbon sequestration of each mangrove species showed that *Rhizophora mucronata* yielded the highest carbon stored (35.16 tC/ha) and carbon sequestered (128.92tCO_2/ha). Among all the sampling sites, site 3 yielded the highest carbon stored (30.76 tC/ha) and carbon sequestered (112.81 tCO_2/ha) in Kaingen River. Overall, the results of the study showed that Kaingen River can potentially store carbon at 71.89 tC/ha and CO_2 sequestered at 263.62 tCO_2/ha. This urges to practice conservation and protection measuresfor the mangroves forest of Kaingen River.

Keywords: kaingen river; mangrove; carbon stored; carbon sequestration; allometric equation

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Chapter I

INTRODUCTION

The rising demand for agricultural expansion, industrialization, and urbanization have significantly increased the concentrations of atmospheric pollutants, specifically the atmospheric Carbon dioxide (CO_2), which put pressure on the world's mangrove ecosystems to reduce the problem brought by climate change. Because of this, the extensive impact of climate change on the environment and to society has become a worldwide concern such as rising sea level, unpredictable weather patterns, weather extremes like intense precipitation and higher surface temperatures which contributes to global warming. Among the countries that are most vulnerable to the repercussions of global warming is the Philippines. The Philippines is one of the several countries in Southeast Asia that has a diverse mangrove forest ecosystem, in which 46 out of 70 known species of salt-tolerant mangrove species that have been accounted for in the world are found in the country. Mangroves live and thrive in transition zones where land and ocean meet. They play a significant role in the ecosystem, serving as the natural barrier against storm surges, promote marine biodiversity by acting as a nursing ground for small marine animals, and help in mitigating the effects of climate change.

One way to mitigate the effect of climate change is by reducing the concentration of greenhouse gases such as CO_2 in the atmosphere. Carbon sequestration is the term used in reducing CO_2 in the air, which the role is fulfilled by the forests. And unlike other types of forests, mangroves are known as powerful carbon sinks and sequester a significant amount of CO_2 in the atmosphere and store it in their roots, branches, the soil beneath them, and to the biomass.

Carbon sink refers to the natural ecosystem, both aquatic and terrestrial, that is capable of absorbing carbon emitted into the atmosphere. The Blue Carbon Initiative as an organization stated that protecting the aquatic ecosystem comprising mangrove forests will remove and store more carbon from the air. However, if the mangrove ecosystem is destroyed or degraded, the carbon dioxide stored can be released back into the air. Mangrove trees are beneficial in many ways such as raw materials for building and construction and block the waves that will hit the seaside coast. Aside from that, mangroves help in mitigating the negative effects brought by climate change and global warming by storing and sequestering carbon from the atmosphere that mainly comes from the increasing demand of anthropogenic activities which opted the researchers to conduct the study.

In this research study, the mangrove forest present in Kaingen River was assessed, and its potential in storing and sequestering CO_2 from the atmosphere.

Objectives of the Study

This study aimed to determine the species diversity, carbon sequestration potential of the mangrove ecosystem, and environmental quality of Kaingen River, Kawit, Cavite, Philippines.

Specifically, the study attempted to determine:

1. The anthropogenic activities in the Kaingen River,
2. The water quality of Kaingen River in terms of:
    - 2.1 temperature,
    - 2.2 turbidity,
    - 2.3 total dissolved solids (TDS),
    - 2.4 salinity,
    - 2.5 conductivity,
    - 2.6 pH,
    - 2.7 dissolved oxygen,
    - 2.8 phosphates, and
    - 2.9 nitrates
3. The soil quality of Kaingen River through physicochemical parameters in terms of:
    - 3.1 soil texture,
    - 3.2 water holding capacity,
    - 3.3 soil temperature,
    - 3.4 soil pH,
    - 3.5 organic matter,
    - 3.6 organic carbon,
    - 3.7 nitrogen, phosphorus, and potassium (NPK)
4. The species diversity of mangroves present in the Kaingen Riverine ecosystem
5. The amount of carbon dioxide stored and sequestered by the mangrove trees using allometric equations.
6. If there is a significant difference in the water and soil quality collected in:
    - 6.1 three sampling sites per sampling month, and;
    - 6.2 each site across the five-month sampling period.
7. If there is a significant relationship in the water and soil quality with the abundance of mangroves.

Significance of the Study

The study focused on mangrove diversity and its potential in storing and sequestering CO_2 in the Kaingen Riverine ecosystem. The study also served as a baseline for quantifying how anthropogenic activities affect the mangrove forest.

This study serves as a reference for the Local Government Unit (LGU) of Cavite, the National Government Unit (NGU), advocates, and educators to provide public awareness on protecting,

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managing, and conserving the mangrove ecosystem. It shall deepen the understanding of the significant role of mangrove forests in mitigating the impacts of climate change.

Furthermore, this study also serves as a reference for further research which aims to conduct a similar study about the mangrove ecosystem in the Philippines.

Scope and Limitations

The major focus of this study is to determine the mangrove species diversity, the amount of carbon stored and sequestered by the mangrove community, and environmental quality limited to water quality and soil quality only, of the Kaingen River, Kawit, Cavite, Philippines in five (5) months. Other environmental parameters, particularly air quality, and other anthropogenic activities such as electrical consumption, vehicle emission, and carbon footprint were not included in the study.

The collection of representative mangrove species in each of the three established vegetated sites was done using the continuous line transect method measuring 100 meters in length and 27.62 meters in width, equivalent to 2,762 m2 using a 100-m measuring tape. The mangrove species were identified using the manual Field Guide to Philippine Mangroves (2009) and (2022). It was verified by the Jose Vera Santos Memorial Herbarium, Institute of Biology in the University of the Philippines - Diliman, and Dr. Jurgenne H. Primavera for professional certification. In terms of carbon-storing and sequestration, the estimation for the amount of carbon stored and sequestered is only exclusive for the three established sampling sites within Kaingen River, given that the amount of carbon stored and sequestered was computed separately per site using a non- destructive method of data gathering. In quantifying the species identified, species abundance was calculated using the Shannon-Wiener Index, Simpson Diversity Index, and Sorensen's Similarity Index.

The method of water collection was conducted using grab sampling for parameters including temperature, turbidity, total dissolved solids (TDS), salinity, conductivity, pH level, and dissolved oxygen, while phosphates and nitrates were collected using composite sampling method. The assessment of the quality of water only focuses on measuring the concentration of the physicochemical parameters following the standard procedure of Department of Environment and Natural Resources Administrative Order (DAO) No. 2016-08 entitled "Water Quality Guidelines and General Effluent Standards of 2016" and the updated guidelines of the DAO-2021-19 for phosphates. It does not include the assessment of other parameters such as the concentration of trace metals and the amount of microbiological activity, as they do not relate to the growth of mangrove trees.

The soil sampling method was adopted from the Bureau of Soils and Water Management (BSWM) and only focuses on the following parameters including the soil texture, water holding capacity, soil temperature, soil pH, organic matter, organic carbon, and NPK (nitrogen, phosphorus, and potassium). Additionally, parameters such as soil pH and NPK were tested using the BSWM Soil Test Kit; therefore, results were compared based on the standard classification indicated in the manual wherein tests for available potassium do not include numerical values for the results. Qualitative analysis was used for NPK and its qualitative data was quantified through ranking for statistical analysis under the IBM SPSS version 26 software. Interpretation of results for NPK was based solely on the soil test kit manual, while further interpretation was not readily available on the official site of BSWM. In addition, the results of each parameter in each site were compared monthly of three sampling sites based on the Kruskal Wallis test and the five sampling periods per site based on the Friedman test. While the relationship between water and soil quality parameters with the abundance of mangroves was determined using Pearson's r Correlation.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

2.1. *Kaingen Riverine Ecosystem*

Kaingen is one of 23 barangays in the municipality of Kawit, in the province of Cavite, belonging to Region IV-A (CALABARZON), with an estimated elevation above the sea level of 7.5 meters (24.6

feet). According to the 2020 census, the population in the area was 1,723, which represents 1.60% of the municipality's total population. The researchers examined three sites within the mangrove community, measuring an area of 2,762 m2 for each site, using a 100-m field tape measure – Site 1 (14°26'55" N 120°54'26" E) is located near the aquaculture site of barangay Kaingen and residential area, Site 2 (14°27'16" N 120°54'32" E) is located near the aquaculture sites along Kaingen River, and Site 3 (14°27'21" N 120°54'33" E) is located next to Site 2 and end of Kaingen River.

Figure 1. Location map of Kaingen River in Kawit, Cavite, Philippines with the three (3) sampling sites.

Figure 2. Sampling Site 1 is located near the aquaculture site of barangay Kaingen and the residential area.

Figure 3. Sampling Site 2 is located in between the aquaculture sites along the Kaingen River.

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Figure 4. Sampling Site 3 is located next to Sampling Site 2 and end of the Kaingen River.

2.2. *Mangrove Ecosystem*

Mangroves are considered taxonomically diverse and salt-tolerant species. They grow in transition or intertidal zones, a part of the ocean where it meets the land, and on the fringing tropical and subtropical coastlines. Mangroves are known for their relationships within terrestrial and marine habitats due to their physical, biochemical, and biological interactions in the environment. They serve as a breeding ground, shelter, and feeding habitat for various aquatic animals (Primavera et al., 2018). Mangroves are distinguishable from other plant species due to their ability to withstand changes in salinity and allow oxygen exchange in sediments (Feller, 2018). Furthermore, mangroves have two categories: true and associate mangroves (Pototan et al., 2020).

In the Philippines, there are 42 mangrove species representing 18 families with a rich number of true mangrove species (Abino et al., 2013). In the study by Thomas et al. (2017), Southeast Asia accounted for the most mangrove deforestation per year between 2000 and 2012. The mangrove diversity's pronounced loss was due to the conversion of aquaculture (30%) and rice agriculture (22%) (Primavera et al., 2018).

Garcia et al. (2014) found that, quantitatively and qualitatively, the Philippines possess a high level of biodiversity. Due to its remote location, varied ecosystems, and high endemism rates, it is considered one of the seventeen countries with "mega biodiversity." Out of roughly 65 species of mangroves in the world, at least half can be found in the Philippines. However, the country is gradually losing its rich biodiversity resources, including mangroves, because of anthropogenic and natural disturbances.

2.3. *Carbon Sequestration*

Carbon sequestration is a process done by aquatic and terrestrial trees in capturing and storing CO2 in the atmosphere. Among different forests, mangroves comprised most of the carbon-rich ecosystems due to their ability to store five times more carbon per unit area, as Ahmed et al. (2022) studied. Quantifying the potential storage sequestered by the mangrove ecosystem is crucial, especially in reducing the effects of climate change, as supported by Nesperos et al. (2021).

Mangrove forests rapidly lost the carbon stored in their tree biomass due to cutting, human consumption, decomposing, and carbon export to neighboring ecosystems. Alongi (2014) stated that most carbon sequestered for future use is underground. The quadrat technique is a non-destructive method used to determine a mangrove tree's carbon sequestration at a specific sampling location.

Species were determined, and baseline measurements were taken, including height and the circumference of a tree's base. Komiyama's allometric equations were used to determine a tree's aboveground and belowground biomass. Biomass above ground consists of stems, branches, and leaves. All individual biomass values were added together to arrive at the total biomass. The calculated mean total biomass was then multiplied by the carbon conversion factor for mangroves (0.50 for woody and dry biomass matter) from the Intergovernmental Panel on Climate Change. Nesperos et al. (2021), reported that the amount of carbon sequestered was calculated by multiplying the amount of carbon stored by 3.667 to obtain the number of carbon dioxide (CO2) emissions.

2.4. *Water Quality*

Mangroves are good indicators of water quality. It is known to provide good water quality by filtrating harmful pollutants in water through its aboveground roots and providing a habitat for aquatic species. The following physicochemical parameters were quantified to determine the water quality in Kaingen Riverine.

2.4.1 . Temperature

Water temperature is a physical property that can influence how well mangroves thrive in their natural environment. The study of Ward et al. (2016) showed that the increase in Temperature influenced the mangroves, specifically in the form of shifts in species composition and phenological patterns such as the timing of flowering. At the same time, the fluctuations in the temperature of water were attributed to various factors such as air temperature, sediment thermal conductivity, wind speed, solar radiation, and artificial heat (Chen & Fang, 2015). However, it was noted that the water temperature must not surpass the upper threshold as it may cause the mangrove range to expand in higher latitudes, where more mangrove species are distributed. As supported by Collins et al. (2013), anthropogenic activities contributed to the increase of greenhouse gas levels attributed to the global temperature in which bodies of water store substantial amounts of additional heat.

2.4.2 . Turbidity

The turbidity scale evaluates the visibility of water. It is a sign that light is making its way through the water. When turbidity is high, the scattered light is bright; otherwise, the turbidity is low. The presence of inorganic and organic matter, clay, silt, algae, plankton, and other microorganisms can cause water to appear turbid, making it appear cloudy or opaque (Water Science School, 2019). Water turbidity is a measure of how clear the water is. High turbidity is an indicator of dissolved solids and soil erosion. Increased turbidity, as mentioned by Sari and Soeprobowati (2021) suggests that waste and pollution in water are being disturbed due to anthropogenic activities, which stresses the mangrove population and reduces its abundance and diversity. Climate change and human activity are two additional causes of turbidity changes. Runoff from the surface, movement of streams, surface flow, and waves and turbulence caused by the waves and winds cause excessive turbidity in natural waters (Pawar, 2013).

2.4.3. Total Dissolved Solids

Total dissolved solids, also known as TDS, are a measurement that can be used to determine the number of various substances dispersed in water. These substances include metals, principal minerals, organic matter, and salts. Total dissolved solids, like total suspended solids, contribute to the cloudiness or murkiness of water. Hence, higher concentrations of TDS decrease the clarity of the water. When this occurs, a limited amount of sunlight can pass through the water bodies that aquatic plants can utilize for their photosynthetic activities. Changes in concentrations of TDS threaten the sensitive mangroves in the mangal community due to the change in salinity and ionic composition, as well as their corresponding toxicity ion (Sari & Soeprobowati, 2021).

Additionally, TDS increases the risk of combining heavy materials and metals that can elevate water temperature. According to Chen et al. (2021), the rise in TDS concentrations was caused by emissions from homes and businesses in the bay's vicinity, which released inorganic salts like potassium, calcium, bicarbonate, sulfates, and so on. High organic salt content or effluent inflow from sewage plants or industries was also responsible for a high TDS value, as stated by Pawar (2013).

2.4.4 . Salinity

Salinity is the dissolved salt content in the bodies of water. It is one of the physical characteristics of water, wherein its concentrations are highly valuable for aquatic life. It can determine whether a study site is categorized as freshwater or marine water. As supported by Liu et al. (2020), low salinity level in the water is caused by precipitation.

One of the characteristics of mangroves is their ability to adapt to the salinity of water. Thus, mangroves are categorized as salt secretors and non- secretors. Salt secretors (halophytes) are mangroves that rid their tissue of salt, while non-secretors (glycophytes) do not allow the salt of seawater to enter their tissue (Reef & Lovelock, 2015). According to Feller of Smithsonian Ocean (2018), mangrove species such as Kacang-kacang (Aegiceras corniculata), Api-api (Avicennia species), and Jeruju (Acanthus species) were categorized as salt secretors. They excrete salt through the salt glands of leaves and become salt crystals that can be washed away with seawater. Mangroves categorized as non- secretors avoid high salts in their tissue through ultrafiltration in plant roots. A red mangrove (Rhizophora) and oriental mangroves (Bruguiera) that possess a stilt root system create a barrier that excludes 90% of salts by not allowing the seawater to pass through to its roots (impermeable) or vascular system. Hence, the roots acted as a filtration system, and the barrier was created against osmosis, whereas a species whose salt accumulated at their shoot excreted salt using their older leaves and bark prone to shedding.

On the other hand, mangroves thrive in bodies of water with oligohaline to weak mesohaline salinity that ranges from 0.5 to 35 parts per thousand (ppt). Saltwater intrusion in the coastal area could also affect the salinity level (Halder, 2023). In addition, saltwater intrusion could happen through sea level rise and excessive pumping of groundwater, which could be observed where a water pump is present or when the groundwater recharge reduces (Bayabil et al., 2021).

Anthropogenic pressure, which causes an increase in water's conductivity, directly affects freshwater's salinization. A high conductivity caused by agricultural activities, mining, de-icing roads, and wastewater discharge disrupts the temporal dynamics of salinity in the water. It deteriorates its ability to sustain aquatic organisms (Salcedo et al., 2022).

2.4.5 . Conductivity

Conductivity, as stated by Alsumaiti and Shahid (2018), is a significant factor in the condition of water and an indirect indicator of salinity. The electrical conductivity of water varies with the concentration of salt in it. The electrical conductivity was also measured with an EC meter calibrated against a standard, and the results were given in micro siemens per centimeter (S/cm). According to Kluáková (2018), organic compounds like oil and humic acid, derived from decaying organic materials, contribute to the monthly variation in conductivity and are directly correlated with TDS and salinity.

High conductivity was observed in a river system heavily impacted by agriculture, mining, de-icing roads, and wastewater discharge (Salcedo et al., 2022). Water quality needed to be maintained since elevated conductivity increased freshwater salinization.

2.4.6 . pH

The pH indicates the basicity or acidity of bodies of water. Strongly acidic water ranges from 0 to 4, while strongly basic water ranges from 9 to 14 pH. Mangrove trees' most optimum value for their growth responds to pH ranging from 6.7 to 7.3. The acidity and alkalinity of water are both influenced by the pH balance of water. Calcium, magnesium, and potassium levels decrease when water has excessive acidity. Calcium is essential for cellular expansion, magnesium for chlorophyll synthesis, and potassium to produce proteins. Calcium deposit occurs when the water has a pH that

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is too alkaline; it essentially blocks the uptake of nutrients by plant roots. As stated by Rugebregt and Nurhati (2020), There is an inverse relationship between the pH of the water and its temperature, with higher temperatures causing a lower pH in a given water sample.

2.4.7. Dissolved Oxygen

The level of oxygen in the water, known as dissolved oxygen (DO), is crucial for the survival of aquatic organisms. In a well-established mangrove ecosystem, the DO in the water increases due to oxygen exchanged at the mangrove roots. According to Pawar (2013), higher DO increases photosynthetic activity at lower temperatures due to wind velocity and monsoon influence. Several anthropogenic activities, such as effluent from treatment plants, agricultural runoff, and industrial wastes, resulted in lower dissolved oxygen. Low dissolved oxygen levels harm aquatic life and reduce water quality (US EPA, 2023).

2.4.8. Phosphates and Nitrates

Nitrogen and phosphorus are limiting nutrients to the growth of mangroves. Nitrogen and phosphorus do not directly meet mangrove needs as they are used by symbiotic organisms competing with one another. Nitrates are usually denitrified by bacteria, supported by mangrove roots that convert ammonium into nitrate. The natural process of denitrification, in which microorganisms convert nitrates into nitrogen gas, is the primary cause of low nitrate levels in the river, as stated by Singh and Singh (2022). Microorganisms are detectable, as even a faint green tint in the water. Phosphates, however, can be immobile and unavailable for mangroves. Thus, organisms capable of solubilizing phosphorus are essential for plants, especially in a nutrient-limited environment.

Both nitrates and phosphates determine the stability of vegetation growth of mangrove trees, such as the species of Rhizophora, as mentioned in the study conducted by Santoso and Soenardjo (2018). Low levels of nitrates and phosphates could result in low density of mangroves. In contrast, high levels of nitrates and phosphates could lead to eutrophication. In their same study, it was highlighted that nitrates and phosphate have a direct relationship with anthropogenic activities, especially in once-aquaculture sites where there was a presence of fertilizers with rich nitrogen and phosphorus content.

2.5. Soil Quality

Soil is known as the largest terrestrial carbon sink; it can supply significant amounts of nutrients for the growth and development of plants, as well as mangroves. Mangroves are known to store more carbon than any terrestrial forests. Due to the carbon sequestration ability of mangroves, it increases soil productivity, hence, improves the soil quality by increasing the volume of soil and adding its organic matter such as leaves, woody material, and roots. The following soil quality was quantified to calculate the potential of mangroves in the Kaingen Riverine to store carbon.

2.5.1. Soil texture

Soil texture is another factor that affects the growth of mangroves. According to Ghosh et al. (2018), it is found in the Indian Sundarbans Tiger Reserve that a high concentration of sand is found in soil covered with the amount of clay, making the soil texture loamy. Since mangroves are commonly found near the shore, the composition and texture of the soil in the mangrove zone, like that of the study, according to the study, is likely to be observed. Among the soil textural compositions, loamy soil is the best medium for more diverse mangrove species.

According to Alsumaiti and Shahid (2018), the physical property of soil that holds tremendous significance is its texture, as it could impact the potential for water flow, water retention capacity, and fertility potential. In addition, the biological stability of organic matter can be affected by soil texture due to its impact on factors such as water and oxygen availability and the accumulation and isolation of organic matter from decomposition.

2.5.2. Water Holding Capacity

The ability of soil to retain water in a saturated state or without evaporation is measured by its water-holding capacity. The soil's power to store water largely depends on its texture and the amount of decaying matter in it. Percentages can be used to express its significance. Soil texture and organic matter content are the two most essential factors in determining water-holding capacity. Human-induced activities, such as land-use change, altered soil texture and, in turn, the soil's ability to retain water, as Dror et al. (2021) reported. However, agricultural practices increased the soil's organic matter content, increasing the soil water holding capacity; this is because agricultural practices have increased biological activity, which has led to an increase in macropores responsible for transporting dissolved nutrients and micropores accountable for regulating capillary water distribution in the soil (Easton & Bock, 2016). The water-holding capacity of the earth is a measurement of the soil's ability to store water for later use by plants; a higher value indicates a greater capacity to store water (Zhang et al., 2021). Enhanced soil water holding capacity means more available water for mangroves to use in their development and maintenance. Therefore, better water storage is suitable for the proliferation of mangrove trees of various species.

2.5.3. Soil Temperature

Ward et al. (2016) found that mangrove productivity, phenology, composition, and latitudinal range of distribution are all impacted by rising temperatures. Due to constraints in biochemical reactions, it reduces mangroves' capacity to take in atmospheric carbon. Plant cover and solar radiation absorption are two factors that affect soil temperature (Onwuka & Mang, 2018).

Soil temperature has a weak direct correlation with the carbon flux of mangrove forests in Southwestern Japan, which is greatest during the warm season. The study also demonstrated how seasonal changes in Temperature and the tides would influence the carbon flux. Thus, to learn more about the mangrove forest's role as a carbon sink, it is crucial to consider the relationship between soil temperature and the amount of carbon exchange from the forest floor (Tomotsune et al., 2018).

Another factor affecting the soil temperature was anthropogenic activities that resulted in land with disrupted vegetation cover and plowing. As supported by Kiselev et al. (2019), disrupted vegetation cover and plowing caused an increase in the soil thawing, warming the soil to its 320 cm depth. The soil warmed up faster during the warm period, increasing the soil temperature to 2-5 °C. Whereas, during the cold period surface level of soil tends to have a minimum temperature of 11.3 °C and -1.2 °C at a depth of 320 cm. On the other hand, there was no increase in soil temperature in the undisrupted land with more vegetation cover. These showed that land with vegetation cover has a much-controlled temperature during the warm period because trees and other plants use the energy from the sun in their photosynthetic reaction.

2.5.4. Soil pH

Soil pH is a significant environmental physicochemical variable that affects the nutrient composition of soils, which is essential for the growth of mangroves. It is a chemical indicator where pH level can determine mangrove soil's acidity and geochemical process. In the study of Jimenez et al. (2022), geochemical processes within mangrove soil may reveal whether the mangroves are thriving or degrading. The study revealed that mature mangroves thrive with pH levels ranging from 6.3 to 7.7. Hence, they are typical for mangrove soils and plausible for mangrove ecosystems. Is supported by Alsumaiti and Shahid (2018), in which it was claimed that mangroves could not withstand soils with extreme pH that are not within the 5.16 to 7.72 pH range. The study also found that tides, excrement from roots, fermentation, natural carbonate, and redox fluctuation affect mangrove soil pH ranging from 6.5 to 7.0.

Aside from that, anthropogenic activity, such as improper garbage dumping in the soil, could affect the soil pH. The leachate from the garbage was composed of inorganic contaminants, soluble organic compounds, suspended solids, or even heavy metals seeping down the ground pores affecting the chemical composition of the soil (Wdowczyk & Szymańska-Pulikowska, 2021). In terms

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of natural occurrence, the low soil pH could be attributed to acid deposition in fog, rain, smog, or any particulate matter that is acidic. Chen et al. (2020) found that acid rain occurred during periods of high atmospheric concentrations of sulfur dioxide (SO2) and nitrogen oxide (NOx), two pollutants known to acidify the environment. Soil pH will be lowered when precipitation containing these compounds occurs.

2.5.5. Organic matter

Carbon-based organic matter is a storehouse of nutrients for plants, and it can be derived from the wastes, residues, or decomposition of any living matter. Soil organic matter deposits determine how well mangroves store carbon and how well they can withstand rising sea levels (Arnaud et al., 2020). The capacity of soil to hold and retain water is crucial for the growth of mangroves. The study by Fukumasu et al. (2020) demonstrated a positive correlation between soil organic carbon and pore size distribution in soil. In addition, Wei et al. (2014) cited that organic matter rates increase as the clay increases. Hence, the conservation of carbon stocks for adult mangroves revealed that it depends on the accumulated complex soil organic matter (Jimenez et al., 2021). On the other hand, the accumulation of organic matter yielded by mangroves is apparent in soil and may be transferred to neighboring bodies of water. Studies conducted in seagrass meadows near mangrove communities also showed that most organic carbon comes from the organic matter of mangroves (Azkab et al., 2017).

Clearing mangroves or allowing them to degrade could make the organic carbon stored in their soils more amenable to mineralization, which could release carbon dioxide emissions. Even small changes in the size of the soil's pool of organic carbon can result in significant carbon dioxide emissions into the atmosphere, especially in mangrove ecosystems. Soil organic carbon pools are particularly susceptible to mineralization following disturbance, but it is unclear how much of this vulnerability can be attributed to the depth of disturbance (Santos- Andrade et al., 2021).

2.5.6. Organic Carbon

Organic carbon is a form of carbon obtained from living or dead matter (Hancock et al., 2022), such as livestock and plants, animal bones, and dry leaves, and maintains the quality of soil as well as the inorganic carbon produced by soil formation (Gangopadhyay et al., 2021). As supported by Yang et al. (2021), soils with higher organic carbon are associated with finer soil grain size and higher water content. Soil organic carbon (SOC) is essential to the biogeochemical cycles that can counteract the organic carbon loss brought on by deforestation (Bonner et al., 2019). In addition, mangrove ecosystems have the potential to store 5-10.4 Pg of SOC worldwide; this accounts for 71-98% of total carbon storage in estuarine areas and 49-90% in marine mangrove areas (Wang et al., 2021).

On the other hand, the long-term impact of organic carbon stocks in soils can be influenced by both natural processes and anthropogenic disturbances. The impact of severe weather phenomena such as hurricanes, heat waves, and droughts on mangrove ecosystems can lead to substantial modifications, causing a reduction in both above and belowground carbon reserves and raising carbon dioxide emissions (Santos-Andrade et al., 2021).

2.5.7. Nitrogen, Phosphorus, and Potassium (NPK)

Nutrients like nitrogen, phosphorus, and potassium are crucial to a plant's development and growth. Mangrove forests almost entirely cover the world's tropical and subtropical coastlines. Mangrove forest structure and productivity are affected by nutrient availability, similarly to other plant communities. According to Pradipta et al. (2021), nitrogen and phosphorus are nutrients that influence mangrove development. As supported by Geng et al. (2017), soil nutrients respond directly to temperature, with a higher temperature causing a faster rate of nutrient accumulation. Nitrogen influences the number of photosynthetic processes that occur in mangroves. Increasing the leaf's nitrogen concentration improves electron transport during photosynthesis. Although plants contain less phosphorus than nitrogen, the latter is more widely recognized as essential to plant growth.

Reduced phosphorus uptake can reduce plant tissue volume and darken leaf color. Reduced soil nitrogen and phosphorus levels may lead to mangrove tree dwarfism, according to research by Alhassan et al. (2021).

Potassium is essential for regulating osmotic pressure, activating enzymes, protein synthesis, and photosynthesis in plant cells. Lack of potassium causes a decline in chlorophyll and photosynthetic activity in mangroves. According to Sofawi et al. (2017), potassium is used for fertilizers, increasing soil fertility and acting as an indicator of healthy plants. A lack of potassium in soil may lead to unhealthy plant growth.

For the interpretation of soil phosphorus (P) and potassium (K) levels, four soil classifications are used to determine how concentrated the amount of P and K are in the soil sample, namely as low, medium, optimum, and excessive having soil test values (in FIV) of 0-25 (low), 26-50 (medium), 51-100 (optimum), and > 100 (excessively), respectively. Low P and K concentrations are categorized as inadequate nutrients to support plant growth. However, medium concentrations in soils that have adequate P and K nutrients can support plant growth, but there is a need to increase in optimum level to secure stable plant production. On the other hand, optimum concentration levels of P and K are the recommended range to support plants. Excessive P and K concentration in soil endangers water quality, resulting in soil erosion, runoff, and leaching of P and K to the bodies of water. Furthermore, the result of the study shows that as the amount of P increases, the productivity of the soil increases. Like P, the productivity of soil increases as the amount of K increases. According to Lal and Kumar (2022), soil temperatures directly correlate with the potassium concentration in the soil's nutrient availability. However, excessive P and K could adversely affect the environment, disrupt soil quality, and negatively affect water quality.

2.6. *Related Studies*

The following are studies reviewed to serve as the basis of the study.

2.6.1. Local Studies

Abino et al. (2013) conducted a study in Botoc, Pinabacdao, Samar, Philippines, to analyze the species composition and carbon storage of a native mangrove. The chosen sampling site was based on the accessibility and safety of

the natural mangrove stand. As a result, data was collected using a non-destructive approach known as quadrat sampling. Samples of mangrove stems and branch bark were also taken into a research laboratory to test the carbon content. Therefore, comparing mangrove tree diversity in different environments is reasonable using the Shannon-Weiner and allometric equations index using a 47% carbon conversion value, or 0.47, to obtain the carbon stock recommended by the Intergovernmental Panel on Climate Change (IPCC). Also, twelve (12) plots spanning approximately 10 m × 10 m were used in the analysis. The Shannon-Wiener index yielded a value of 1.6365 for species diversity, indicating an insufficient variation in species of nearby mangrove stands. As a result, 74% of the biomass was derived from growth above ground, whereas 26% was derived from the roots of the plants. Further, the biomass and carbon density can store up to 188.50 t C ha-1 of carbon sequestration and storage. Climate change and unsustainable anthropogenic activities could hurt the assessed value.

On the other hand, Pototan et al. (2020) researched Banaybanay, Davao Oriental, Philippines, to investigate the diversity of mangrove tree species and their composition and structural properties. The standard procedure for evaluating mangroves was developed as a foundation, with Canizares and Seronay (2016) contributing their changes. In addition, the mangrove species samples were collected in three (3) quadrats measuring 10 m × 10 m each. The Shannon-Weiner, Peilou's Index of Evenness, Simpson's Index of Dominance, and Simpson's Index of Diversity indices were utilized to ascertain each species' richness, diversity, evenness, and dominance under the mangrove family. The evaluations of the mangroves were based on the sampling area, which had a total of 33 plant species spanning 14 groups. The 33 plant species were divided into two groups: true mangroves (94% of the total) and mangrove associates (6%). The study was utilized to ascertain whether the mangroves are classified as true or associated species. The Shannon-Wiener Index of Diversity was found to have a value of 3.145, Pielou's Index of Evenness has a value of 0.89, which indicates that there is high species evenness in the area, Simpson's Index of Dominance has a value of 0.05, which suggests that there is low dominance, and Simpson's Index of Diversity has a value of 0.11, which indicates that there is a low diverseness of species in the area. It showed that no species predominated over other mangrove species in the area.

In the study conducted by Cañizares and Seronay (2016), both the composition and diversity of tree species of mangrove in Barangay Imelda, located in Dinagat Island, Philippines, were assessed to promote the protection as well as the conservation status of the mangrove community. Methods used in the study include the line transect sampling and measurements of the mangroves' basal diameter in two appointed sampling stations, each with five (5) 10 m x 10 m plots. The procedure was adopted in the mentioned study for the diameter at breast height. At the same time, mangrove species were identified using the Philippine Mangroves, a manual field guide by Dr. Jurgenne H. Primavera. Mangrove regeneration included the construction of 1 m x 1 m subplots to count samplings and seedlings, and plant maturity was also identified. The data analysis in the study included the use of diversity indices with species richness, relative abundance, and the inclusion of Shannon-Weiner diversity index and evenness. The mangrove community's vegetation was also analyzed using the following parameters: frequency, relative frequency, population density, relative density, dominance, relative dominance, and importance value for each mangrove species. The habitat assessment of the area was analyzed by calculating the crown cover percentage, regeneration for every m^2, and average height. The findings revealed that the mangrove diversity of Barangay Imelda in Dinagat Island was shallow, which falls under the category H' equivalent to 1.856, wherein ten mangrove species belong to six families of the taxonomic classification. Three species were recorded to have the highest population density, relative frequency, relative dominance, and importance value indices, while one species had the lowest among those values. The crown cover of the site was classified as "fair" at 40.16%. In the same year, Dolorosa et al. (2016) investigated the mean height and regeneration per m^2 of mangroves having values of 5.87 and 3.6, respectively, and were classified as "excellent."

The study of Nesperos et al. (2021) presented the determination of the amount of carbon dioxide (CO2) sequestered by multiplying the weight of C by the value of 3.667. The value was obtained by computing the ratio of Carbon dioxide (CO2) to Carbon C by dividing the weight of carbon dioxide, which is 44 by 12, resulting in 3.667 as presented by the United States Environmental Protection Agency (US EPA) based from Greenhouse Gases Equivalencies Calculator - Calculations and References (2022).

2.6.2. Foreign Studies

The study by Chunkao et al. (2012) aimed to assess the water quality treated by the mangrove forest in Phetchaburi Province, Thailand. The sampling site chosen by the researchers is known for its wastewater dumping by the municipality of Phetchaburi Province. The study used six parameters to monitor the water quality: pH, water temperature, dissolved oxygen (DO), phosphate, nitrate, and ammonia. The experimental setup of this study was divided into three (3) sampling sites: (A) a tideland located between the pond and mangrove forest; (B) an area of mangrove forest; and (C) a sea area. According to the study, the mangrove forest chosen as a site has a mono-dominant species named Avicennia marina. The density of the tree, average height in meters, diameter at breast height (DBH), biomass, and sapling density are among the measured parameters within the forest.

Furthermore, they used the grab and composite sampling method to collect water samples for the three sampling sites. The result of the study shows that mangrove forests can improve the quality of water in Phetchaburi Province, Thailand, by increasing the dissolved oxygen (DO) by 32.39% and lowering phosphates (88.23%), ammonia (73.77%), and nitrates (64.28%). The roots caused the increase in dissolved oxygen—the mechanism of the Avicennia marina where it exchanges oxygen to allow it to breathe and prevent drowning. Furthermore, the decrease in water's phosphates, nitrates, and ammonia content was caused by three abiotic processes: sedimentation, absorption, and

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precipitation, as well as the exchange process between soil and water. The pH of water also decreased in sites B and C due to fermentation of organic matter, and the Temperature of water at site

B was observed to be lower compared to sites A and C, as mangroves covered it and a limited amount of sunlight can reach the water surface.

Alsumaiti and Shahid (2018) conducted a study whose main goal was to understand the critical characteristics of soils in the Eastern Lagoon Mangrove National Park in Abu Dhabi, UAE. The study also evaluated the variability of soil properties, which was accomplished by testing soil physicochemical properties such as pH, Temperature, Nitrogen, Phosphorus, Potassium, Organic Carbon, Organic Matter, and Soil Texture. Soil samples were collected using a combination of randomness and stratification with a frequent interval in which a hole with a depth of 0-50 cm and 50-100 cm was dug in the swaps. A kilogram of samples was also collected from each sample site, then placed in a clean plastic bag and labeled. The samples were sent to the lab for analysis to determine their essential physical and chemical properties.

In determining the amount of carbon stored and sequestered in a tree, the girth (GBH) of each species of mangrove tree was obtained by measuring the circumference of a trunk 1.37 m from the ground, which pertains to the tree's breast height (Harishma et al. 2020). The circumference of each tree was measured using a tape measure in centimeters (cm) as the standard unit, then divided the value obtained by the value of pi (π), 3.1416, which converted the GBH into diameter at breast height (DBH). The DBH was used to measure a tree's aboveground and belowground biomass using allometric equations established by Komiyama et al. for species of mangroves particular to the Southeast Asian region. The study used an equation of wagb=0.251ϱD2.46 in kilogram (kg) to estimate aboveground biomass.

In contrast, wr=0.199ϱ0.899D2.22 (kg) was used to estimate belowground or root biomass, where ϱ pertains to the wood density of specific mangrove species. At the same time, D indicates the diameter measured at 1.37 m from the ground of each tree. While the wood density required to compute the estimated aboveground and belowground biomass was obtained as provided by the database of the World Agroforestry Center (2017). The total carbon biomass was then obtained by taking the sum of computed aboveground and belowground biomass of each tree. After that, the total biomass of each tree per plot for all plots was summed up before being divided into the average area of all plots used to obtain the average total carbon biomass, then converting the unit into t/ha. Hence, to obtain the carbon stock, the average total carbon biomass was multiplied by the carbon conversion factor at the 0.5 value, as proposed by the Intergovernmental Panel on Climate Change IPCC (2006). The study also excluded herbs and seedlings for the estimation of carbon stocks. The results revealed that the mean mangrove biomass in the study location was 117.12 ± 1.02 t/ha; the highest biomass belonged to the species Avicennia marina with a 108.23 t/ha biomass. Kerala's average aboveground biomass (AGB) revealed an estimation of 80.23 ± 15.95 t/ha, while mean biomass for belowground (BGB) showed 36.90 ± 6.23 t/ha. The carbon stock for vegetation was also recorded and revealed to be 58.56 ± 0.51 t C/ha, and soil carbon stock resulted in an average of 81.26 ± 10.16 t C/ha. In comparison, the carbon stock of the site's ecosystem was estimated at 139.82 ± 10.67 t C/ha. Hence, results revealed that the location, Kerala, India, can sequester 139.82 t C/ha of carbon.

According to the study of Sahu and Kathiresan (2019), significant variations of the carbon sequestration potential of mangroves of varying ages were observed from age 7 with a carbon sequestration potential of 143.62 ± 36.08 to the natural plot, which sequestered approximately 282.72 ± 23.62 gCm-2a-1. It can be deduced from the results obtained from this study that the age and carbon sequestration potential of mangroves were directly proportional to each other; that is, as the age of mangroves increased, the carbon sequestered also increased.

Indrayani et al. (2021) also used allometric equations presented by Komiyama et al. (2005); however, the study referred to multiple references for specific allometric equations for estimating aboveground and belowground biomass per individual species of mangroves. A non-destructive data collection method was also used to measure the diameter of the mangrove's breast height. In contrast, the wood density for mangrove species was acquired from the World Agroforestry Center (2017). Total biomass was obtained by adding aboveground and belowground biomass and then

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taking the average to get the mean biomass of mangroves. The carbon factor value 0.50 study also referenced the Intergovernmental Panel on Climate Change. The results showed that five total species of mangrove trees were found in the study location. The results also showed that the average aboveground biomass obtained in the area was estimated to be 117.62 ± 45.68 t/ha.

In comparison, the average belowground biomass was 56.58 ± 22.49 t/ha, making aboveground biomass higher compared to the belowground biomass. Among the mangrove species, the mangrove biomass was highest in Rhizophora apiculata and lowest in Sonneratia caseolaris. Lastly, the average carbon stock of the location's ecosystem revealed an estimation of 87.10 ± 34.07 tC/ha.

The study conducted by Pawar (2013), in the mangrove ecosystem located in Uran, Navi Mumbai, on the western coast of India, evaluated the impact of human activities on the quality of water in mangrove ecosystems concerning tidal and seasonal variability. The study selected two sites, Sheva Creek and Dharamtar Creek, sites 1 and 2, with three stations each at 1 km apart, and was conducted for two years — from April 2009 to March 2011. On the other hand, four true mangrove species, representing three genera and 3 families, were dominant in the area. According to the resulting data, the coastal ecosystem of Uran was significantly strained due to industrialization, urbanization, and reclamation in the area. Disposing of untreated domestic waste and industrial effluents contributed to the destruction of the coastal ecosystem, public health risks, and reduced marine and coastal biodiversity. Furthermore, the water quality parameters from the mangrove ecosystem are intensely polluted.

Mangroves have unique root systems that adapt well to changing environmental conditions. It includes changes in salinity – through fluctuation of tides, soil compaction, and natural phenomena such as storm surges, storms, and strong winds, as cited in the study of Chen et al. (2015). Some mangrove species have developed modified root systems for their changing environment. It includes propping, stilt, or buttress roots, which vary in their morphological structure and function. In addition, the adaptation also helped mangrove trees, in terms of stability, especially for species that stood along the shoreline composed of soft soil.

Furthermore, the thigmomorphogenetic response of a modified root system of mangroves helped in resisting the tension inflicted by strong winds to the crown, which made mangroves able to withstand the destructive force that some tree species might not be able to endure. Rhizophora mangle and Rhizophora apiculata were observed to have prop roots descending from their trunks and branches, which provided the mangroves with a robust support system. Moreover, The submerged prop roots anchored the trees and accumulated debris and silt, which formed the soil beneath the tree per se. Further, the root system of Rhizophora mangle, containing prop roots or buttress roots from trunks, was proven to help mitigate the damages the storm surges may inflict and was higher than that of what other mangrove species can sustain. It only showed that mangroves were well adapted to their varying environment; otherwise, they will be prone to destruction.

The growth rate of mangroves is affected by salinity in a way that their growth pattern decreases as the mangroves approach more saline regions according to the values obtained for different variables such as tree basal area, average tree height, and diameter at breast height (DBH), except the stand density. Moreover, the lowest value for these variables was found in strong saline areas (Ahmed et al., 2022). The study of Basyuni et al. (2014) to the comparison of the growth rate of two species, Avicennia marina and Rhizophora stylosa seedings, one of which is salt-secretor species – the Avicennia marina, while the latter is not, it was shown that the said species have only certain level of salinity can be tolerated, that is, 2.00% salt concentration (equivalent to 75% natural seawater) was the maximum salt content for Avicennia marina to thrive, while 0.50% was the maximum for

Rhizophora stylosa. Further increase in salinity level will result in a decrease in the growth rate of these two species. Thus, although mangroves could tolerate varying salinity levels, their growth will still be affected by the changes in salt concentration.

As the 21st century approaches, mangrove forests have been threatened by deforestation for land conversion and timber, overexploitation of resources, and pollution. Climate change induces biophysical pressure on mangroves by affecting the following environmental factors — soil erosion, cyclones, sea-level rise, and salinization. The salinity of water may change due to a rise in sea level; an increase in salinity will increase the vulnerability of mangroves in tropical regions.

2.6.3 . Synthesis

Measurement for carbon sequestration, mainly in mangroves, could vary depending on their environment. Specifically, factors such as location, anthropogenic activities, soil quality, and water quality could affect mangroves' growth, which further affects their capacity to sequester and store atmospheric carbon.

This study shared similarities to the study of the following researchers: The studies of Abino et al. (2013), Harishma et al. (2020), and Indrayani et al. (2021) in terms of carbon storage and use of allometric equations to determine the CO2 sequestered and stored, as well as utilizing World Agroforestry Center database (2017) for the species' wood density and using 0.50 value as a conversion factor for

carbon in attaining the carbon stocks; The use of Simpson's index of dominance and Peilou's index of evenness in the study of Pototan et al. (2020); The study of Basyuni et al. (2014) which focused on the salt-secretor species of mangrove namely Avicennia marina and Rhizophora stylosa which can tolerate maximum salinity level of 2.00% and 0.50% respectively. On the other hand, this study differs from the study of the following researchers: The use of the Cray-Curtice equation in the study of Dolorosa et al. (2016); Chunkao et al. (2012) includes six water quality parameters, namely water pH, water temperature, dissolved oxygen (DO), phosphates, nitrates, and ammonia; Pawar (2013) considered tidal and seasonal variability together with anthropogenic activities in assessing water quality in mangrove ecosystem; And the study of Chen et al. (2015) which discussed the ability of root system of mangroves to adapt in a changing environmental condition such as changes in salinity level.

In addition, the study by Sahu and Kathiresan (2019) discussed the ability of mangroves to sequester carbon which varies from their age. Mangroves increase CO2 sequestration and storage as they mature, resulting in a direct relationship.

Chapter III

METHODOLOGY

3.1. Administration of Anthropogenic Activities Questionnaire

Anthropogenic activities in Kaingen River, Kawit, Cavite, Philippines, were determined through interviews and survey forms handed to the residents of Barangay Kaingen, Kawit, Cavite. Written consent was provided to the residents to ensure that the data obtained would remain confidential and intended only for academic purposes following Republic Act No. 10173 or the Data Privacy Act of 2012. The total number of respondents was determined using Slovin's formula.

Slovin's Formula

$$n = \frac{N}{1 + Ne^2}$$

where:

N = the size of the population

e = the desired margin of error

3.2 Water Quality Analysis

The samples of water were collected using grab and composite sampling methods following the standard procedure of Department of Environment and Natural Resources Administrative Order (DAO) No. 2016-08, entitled "Water Quality Guidelines and General Effluent Standards of 2016" and DAO No. 2021-19, entitled "Updated Water Quality Guidelines (WQG) and General Effluent Standards (GES) for Selected Parameters". Grab

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samples of some physicochemical parameters were measured in-situ such as temperature, turbidity, total dissolved solids (TDS), salinity, pH, and dissolved oxygen. At the same time, composite samples of phosphates and nitrates were sent to the laboratory for analysis. The water body classification of the three sites in the sampling location was categorized as Class C, which is intended for beneficial use for fish growth and propagation, including other aquatic resources as well as Recreational Water Class II.

3.2.1 . Temperature

The temperature was measured on-site using a laboratory thermometer. It was done in triplicates and the average was computed and recorded.

3.2.2 . Turbidity

The turbidity of the sample was measured using a calibrated Secchi disk. The Secchi disk was submerged in water until it was barely visible. The measured turbidity in centimeters (cm) was converted into Nephelometric Turbidity Unit (NTU). The NTU measurement for turbidity was obtained using the turbidity conversion chart from cm to NTU wherein there was a designated NTU measurement for a certain depth range in cm (Irvine, 2017). On the other hand, the total depth was calculated using a tape measure.

3.2.3. Total Dissolved Solids (TDS)

Total Dissolved Solids or TDS represented the concentration of the dissolved organic and inorganic substance that was presented in water with a unit of milligrams per liter (mg/L). Using a TDS Meter, the tester probes were submerged in the water until the meter was stabilized, then the results were recorded. The concentration for TDS was calculated using the measured value of conductivity in μS/cm with a formula: TDS = 0.65 x EC.

3.2.4 . Salinity

The sample's salinity was measured with the HRS28-T salinity meter. It was calibrated with distilled water based on the instructions provided in the manual. 2- 3 drops of the liquid sample were placed on the prism, and covered with the cover plate to spread the sample until no air bubbles were present. After 30 seconds, the results were seen through the eyepiece of the salinity meter. The initial value from the salinity was calculated using the measured value of conductivity in μS/cm with a formula: Salinity = 0.50 x EC.

3.2.5 . Conductivity

The conductivity of the water samples was determined using a probe and a meter. The water sample was tested by submerging the probe with two electrodes, wherein a voltage was applied across them. In addition, micro-Siemens per centimeter (μS/cm) is the fundamental unit of conductivity measurement. According to Rusydi (2018), the measured value for conductivity was used to determine the value of salinity and TDS.

3.2.6 . pH

The pH of water indicates the basicity or the acidity of the aquatic environment. The scale ranges from 0 to 14, with pH 7 being neutral. A pH below 7 infers that the sample is acidic, while a pH above 7 indicates the basicity of the sample. The pH is an essential indicator of a chemical change occurring in water because chemicals in water can affect it.

The pH meter was calibrated using three buffer solutions (4.0, 6.86/7.00, and 9.18/10.0). The pH was determined using a pen-type pH meter. The cap of the meter was removed before its usage, then turned on. The probe was dipped into the samples for two minutes, then the hold button was pressed when the reading stopped. The procedure was repeated for two (2) more trials.

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3.2.7. Dissolved Oxygen (DO)

A bottle covered with black cartolina paper and the electrical tape were used for the DO/BOD bottle. The DO meter was used to measure the dissolved oxygen concentration present in the water, then was recorded.

3.2.8. Phosphates and Nitrates

The water samples for Nitrate and Phosphate testing were transported and analyzed at the Mach Union Laboratory. The reference material for laboratory testing was the Standard Methods for Water and Wastewater, 23rd edition, and Methods for Chemical Analysis of Water and Wastes.

The standard method used for nitrates was the Brucine Method of Colorimetric Method, and nitrates (NO3-) concentration was analyzed using UV- Vis Spectrophotometer. On the other hand, the standard phosphates (PO_4^{3-}) method was the Stannous Chloride Method of the Colorimetric Method and was analyzed using UV-Vis Spectrophotometer.

For nitrates, the pH sample was changed with acetic acid (pH 6.7) or sodium hydroxide (pH 6.8) to get it to about 7. Then, 10 mL of standards and water samples were added to the sample tube with a pipette. After that, a 10.0 mL solution of sulfuric acid was added with a pipette into the tube and swirled. 0.5 mL of brucine- sulfanilic acid reagent was poured into each tube and carefully swirled it. The tube rack was put into a 25-minute water bath reaching 100°C. Afterward, the tube rack was taken out of the water bath and was put in a cold-water bath and waited until the temperature reaches the thermal equilibrium of 20–25°C. Lastly, a 1 cm square cuvette was used to measure the absorbance with the blank reagent measuring at 410 nm.

For the preliminary treatment of the sample, a 100 mL sample containing Phosphorus not exceeding 200g was added with 0.05 mL of phenolphthalein indicator. The color development was determined upon the addition of a molybdate

reagent I measuring 4.0 mL and a stannous chloride reagent measuring 0.5 mL into the sample accompanied by careful mixing every time a reagent was added. Samples, standards, and reagents were held within 2°C of one another at the temperature that ranged from 20°C to 30°C. For color measurement, it was measured photometrically at 690 nm after 10 minutes upon positioning into the spectrometer but not exceeding 12 minutes. The result was compared with a calibration curve, using a distilled water blank. (Baird et al., 2017)

3.3. Determining the Water Quality Index

The Water Quality Index (WQI) was calculated with the use of the Weighted Arithmetic Method (Banaag & Velasco, 2021) using Microsoft Excel. The unit weight (Wn) factor of each of the water parameter was :

$$W_n = \frac{K}{Sn}$$

where:

K = Proportionality constant; is obtained using the following formula:

$$K = \frac{1}{\frac{1}{S_1} + \frac{1}{S_2} + \frac{1}{S_3} + \cdots \frac{1}{S_n}} \; or \; \frac{1}{\sum S_n}$$

S_n = Standard desirable value of the nth parameters

On the totality of all chosen parameters' unit weight factor, Wn = 1 (unity). After calculating the proportionality constant (K), the Sub-Index (Qn) value was computed using the formula as follows:

$$Q_n = \frac{[V_n - V_o]}{[S_n - V_o]} \times 100$$

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where:

V_n = monthly data of each site per nth parameter

S_n = Standard acceptable value of the nth parameter

V_O = The parameters' ideal value in pure water

Generally, most of the parameters have actual values equivalent to zero (V_O = 0),except for certain parameters such as pH (**V_O = 7**) and DO (**V_O = 14.6**). Therefore:

$$Q_{pH} = \frac{[(V_n - 7)]}{[(S_{pH} - V_o)]} \times 100; \qquad \text{where } S_{pH} = 8.5$$

and

$$Q_{pH} = \frac{[(V_n - 14.6)]}{[(S_{pH} - V_o)]} \times 100; \qquad \text{where } S_{DO} = 5$$

After obtaining the sub-index (Qn) for each parameter, the unit weight per parameter (Wn) was multiplied by the Qn, where the total WnQn of all parameters was calculated before dividing it by the summation of unit weight (Wn) of all parameters

$$Overall\ WQI = \frac{\sum W_n Q_n}{\sum W_n}$$

3.4. *Soil Quality Analysis*

Following the Bureau of Soils and Water Management (2020) in soil sampling, a soil probe, a meter stick, a plastic, and a pail were prepared for the soil sample collection in the area. The soil samples' temperatures were analyzed in-situ. The ex-situ analysis used a test kit to analyze the sample's pH, nitrogen, phosphorus, and potassium. In addition, water holding capacity and soil texture were analyzed by the laboratory. The area was divided based on the sampling site, and three soil samples were taken on each site without any trials being conducted. These samples were taken at 10 points in a zigzag pattern and placed in a separate container. Afterward, organic matter and trash from the soil sample collected were removed. The soil sample was collected directly using a soil probe at a depth of 25 to 30 cm below the rim of the crown of the mangrove, wherein the sample was a composite soil sample. The soil sample was air-dried away from any contaminants. The sample used for the analysis was crushed and sorted away from the remaining organic matter in the soil sample and divided into four sides where two opposite sides were used, placed in the plastic bag upon obtaining one kilo of the sample and labeled before being sent to the Bureau of Soils and Water Management Laboratory for analysis. Testing methods for each soil quality parameter varied according to the current standard methods of BSWM. Soil pH and NPK were tested using a Soil Test Kit from the Bureau of Soils and Water Management.

In contrast, soil texture was examined using a Bouyoucos Hydrometer. The tapping method was used to determine the values of the samples' soil water holding capacity, while the organic matter used Walkey and Black Method. On the other hand, the test for soil organic carbon was obtained by multiplying the analysis result for soil organic matter by 1.72.

3.4.1. Test for Soil Texture

Soil texture was analyzed in the Bureau of Soils and Water Management using the Bouyoucos Hydrometer method of analysis.

The soil sample was initially weighed at 25 grams before the same quantity of Calgon was added to dissolve it. The mixture was transferred into a 1L or 1000 mL sedimentation cylinder, filled up

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until the 1000 mL mark using distilled water, and immersed to mix. After the soil had settled, the soil particles were measured with a hydrometer at the 40-second time stamp and repeated after two hours. For each of the subsequent soil samples, three replicates of each test and analysis were conducted. Using the following formula shown below, the percentage of particulate size for soil, silt, and clay was calculated.

$$\%\,sand = \frac{100 - soil\ sample\ at\ 40\ seconds}{weight\ of\ sample} \times 100$$

$$\%\,clay = \frac{soil\ sample\ at\ 2\ hours}{weight\ of\ sample} \times 100$$

$$\%silt = 1 - (\%\,sand + \%\,clay) \times 100$$

3.4.2. Test for Water Holding Capacity

The soil samples were sent to the laboratory for testing the water-holding capacity of the soil sample using the tapping method.

A filter paper was used to line the bottom of the Keen Raczkowski box. The soil sample was packed by tapping the box on a wooden bench 20 times. A small amount of soil was added to the box and tapped as before. With that, the top of the box was leveled by striking off the excess soil with the use of a straight-edged spatula. The box was then placed in a petri dish filled with water and left overnight. The saturated box was removed from the petri dish, weighed, and dried in an oven at 105°C and weighed again.

WHC (%) = fresh mass - dry mass fresh mass 100

3.4.3. Test for Soil Temperature

The soil temperature was obtained in-situ by thrusting the thermometer into the soil measuring at least 4 inches below. The thermometer was left to settle into the soil for 1 minute before the result was read and recorded.

3.4.4. Test for Soil pH

Soil pH was tested with the Soil Test Kit from the BSWM. The test tube was filled with the CPR indicator up to the second line mark and swirled gently about 20 times, then let it rest. The procedure was repeated after 2 minutes then let it rest for 5 minutes. The result was compared with the pH color chart included in the test kit's manual. A soil pH that is greater than 5.8 requires another test by repeating the same steps mentioned using the BTB indicator. The soil pH equal to or less than 5.4 also requires another test by repeating the same steps using the BCG indicator. When the color did not match the color present in the BTG or the BCG color chart, the CPR color chart will be used as a reference. The same steps were repeated for other soil samples from other sites before washing and rinsing the test tube using distilled water.

3.4.5. Test for Soil Organic Matter

The soil samples were sent to the laboratory for testing of Organic Matter (OM). The method used was the Walkey and Black Method which according to the Department of Sustainable Natural Resources of Australia, the first method is to identify the moisture content of the soil sample, ground and sieved through a 0.42 mm sieve. Afterward, 0.5-1.0 g topsoil was weighed and mixed with 2.0-4.0 g subsoil into a dry-tared 250 mL conical flask. 10 mL of 1N Potassium dichromate (K2Cr2O7) was added to the sample before mixing gently. After that, a 20 mL measurement of concentrated Sulfuric acid (H2SO4) was added to direct the stream towards the suspension before the flask was until the sample and reagent were mixed. A 200°C thermometer was placed and heated while the flask was swirled on a hot plate. The thermometer was set aside upon reaching 135°C, letting the mixture cool down on an asbestos sheet inside the fume hood. Once cooled, the mixture was diluted in 200 mL of deionized water and titrated it using ferrous sulfate (F2SO4) with a ferroin indicator. After that, organic matter can be calculated using the following formula/computation:

From the equation: $2Cr_2O_7^{2-} + 3C + 16H^+ \rightarrow 4Cr^{3+} + 8H_2O + 3CO_2$

A 1 mL of 1 N Dichromate solution is equivalent to a measurement of 3 mg of carbon. Both quality and normality of the dichromate mixture used are as stated in the method, the percentage of carbon was determined from the formula:

$$Organic\ Carbon\ (\%) = \frac{0.03\ g\ N\ \times 10\ mL\ \times \left(1 - \frac{T}{S}\right) \times\ 100}{ODW} = \frac{3(1 - \frac{T}{S})}{W}$$

where:

N=Normality of K2Cr2O7 solution
T=Volume of FeSO4 used in the sample titration (mL)
S=Volume of FeSO4 used in the blank titration (mL)
OSDW=Oven-dry sample weight (g)

3.4.6. . Test for Soil Organic Carbon

The soil organic carbon (SOC) was obtained through the calculation of SOC from the Soil Organic Matter (SOM). According to Australia's Department of Food and Agriculture, there is a total of 58% of the carbon exists as the mass of organic matter. Hence, soil organic matter can be computed by multiplying the percent total organic carbon by the conversion factor of 1.72, which is derived from 100 (organic matter) divided by 58 (organic carbon). By reconstructing the formula, the amount of soil organic carbon was determined by dividing the soil organic matter by the 1.72 conversion factor.

3.4.7. Test for Nitrogen (N)

The test tube inclusive of the BSWM Soil Test Kit was filled with the soil sample up until the first line mark followed by the Nitrogen solution up until it reached the second line mark. The test tube was swirled gently about 30 times and let rest for 5 minutes. The process was repeated and let it rest for 30 minutes. The resulting solution on the soil sample was compared to the nitrogen color chart of the manual before washing and rinsing the test tube. The steps were then repeated for the other soil samples.

3.4.8. Test for Phosphorus (P)

The test tube of the Soil Test Kit was filled with the soil sample up until the first line mark followed by the Phosphorus solution up until the second line mark and 4 drops of P1 solution which contained a high concentration of strong acid. The solution was swirled gently for 1 minute and let rest for 3 minutes. It was swirled again for another minute and let it rest for about 5 minutes. The tin foil strip that is included in the test kit was wrapped firmly on one end of a plastic stick. The stick wrapped in tin foil was used to stir the solution in the test tube for 1 minute without causing any disturbance to the soil. After two minutes, it was stirred again for the same amount of time. The resulting blue color solution was compared against the manual's color chart for phosphorus before washing and rinsing the test tube. The same steps were repeated for other soil samples using the same plastic stick and foil as it can be used up to 5 times.

3.4.9. . Test for Potassium (K)

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The Soil Test Kit test tube was filled with the soil sample up until the first line mark followed by adding the Potassium solution up to the second line mark and 8 drops of the K1 solution. The test tube was gently swirled for about 1 min. and let it rest for 3 min. The test tube was swirled again for another 1 min. and left to rest for 5 min. After that, the 12 drops of K2 solution were added dropwise in an inclined test tube without stirring or shaking the test tube. The appearance of a cloudy yellowish-yellow layer sitting above the orange solution was observed and compared to the picture provided in the manual after 5 min. of rest.

The sufficiency level was determined according to the level of thickness of the cloudy yellowish layer as presented in the picture. The test tube is washed and rinsed before repeating the same steps for the other soil samples.

3.5. . Aboveground Biomass, Belowground Biomass, and Total Carbon Biomass of Mangrove Trees

The Allometric equations used were established by Komiyama et al. (2005), as referenced by Abino et al. (2013), in the estimation of the aboveground and belowground biomass per mangrove tree. With the use of measuring tape, the girth of individual mangrove trees was obtained by measuring the circumference of mangrove trees not less than 10 cm, at the standard breast height of 1.37 m above the ground in centimeters.

The girth was divided by π at the value of 3.1416 to obtain the diameter (cm). The diameter of each tree was used in allometric equations along with the wood density for each mangrove species as follows:

Aboveground biomass

$$w_{agb} = 0.251\rho D^{2.46} \text{ (kg)}$$

Belowground biomass

$$w_{bgb} = 0.199\rho^{0.899} D^{2.22} \text{ (kg)}$$

where:

ρ = wood density in g/cm^3 of each species of mangroves based on the database ofWorld of Agroforestry for Wood Density (2017)

D = diameter of each tree in cm

After the biomass for the aboveground and belowground of an individual tree wasobtained, the two are summed to obtain the total biomass.

$$total\ biomass = w_{agb} + w_{bgb}$$

The mean total biomass was obtained by taking the sum of the total biomass of each mangrove tree per site. Then it was divided by the site's total area before converting it to tons per hectare (t/ha).

$$mean\ total\ biomass = \frac{(w_{agb} + w_{bgb})_1 + (w_{agb} + w_{bgb})_2 \ldots (w_{agb} + w_{bgb})_N}{A}$$

where:

N = number of trees per site

A = Area per site = 2,762 m^2

Whereas the area was determined by multiplying the measured width of 27.62 m by the established length of 100 m using field measuring tape.

3.6. Carbon Stored and Carbon Sequestered by Mangrove Trees

In determining the amount of carbon stored, the computed mean total biomass was multiplied by the carbon conversion factor for mangroves at 0.50 value based on the Intergovernmental Panel on Climate Change's default carbon fraction value for woody and dry biomass matter. In contrast, the amount of carbon sequestered was obtained by converting the amount of carbon stored to carbon dioxide (CO2) emissions by multiplying it by 3.667, according to Nesperos et al. (2021) and US EPA.

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Amount of Carbon Stored (tC/ha)	Amount of Carbon dioxide Sequestered (tCO_2/ha)
(Mean total carbon biomass) (0.50)	(tC/ha) (3.667)

3.7. Mangrove Species Inventory

The Continuous Line Transect Method was used to measure the population of mangrove species in three sites within the area measuring 100 meters in length and 27.62 meters in width. The book Field Guide to Philippine Mangroves by J.H. Primavera (2009 & 2022) could serve as the standard reference for mangrove species identification. A sample of each mangrove species was collected for the herbarium, measuring a length of 12 inches which includes the bud, flower, leaves, and fruits. The sample was sent to the

University of the Philippines - Diliman Quezon City Institute of Biology and Dr. Jurgenne

H. Primavera, a marine scientist known for verification and authentication. The collected sample species of mangroves were photographed as part of the photo documentation method.

3.8. Species Diversity Indices

The evenness, richness, and diversity of species were used to compare a variety of biological populations.

3.8.1. Shannon-Wiener Index

The Shannon-Wiener Index was used to quantify the measurement wherein it considered the number of various species and the evenness of the species distribution in the population. The richness of species refers to the number of species present in a given habitat. Having a high richness of species infers that the habitat shows both complexity and, at the same time, stability.

Species richness is calculated using the formula:

$$H = \sum p_i \ln p_i$$

where:

H = depicts the symbol for the Shannon Index of Diversity,

p_i = pertains to the individual's proportion based on the ith species; and

ln = refers to the natural logarithm

According to Kiernan (2021), evenness refers to the relative abundance of individual species that composes the area's abundance, and was calculated using the formula as follows:

$$E = \frac{H}{total\ number\ of\ species}$$

where:

E = depicts the symbol for species evenness; and

H = pertains to the calculated species richness

According to Moutsambote et al. (2016), the typical range for Shannon diversity ranges between 1.5 and 3.5 while a 4.5 index is rarely achieved.

3.8.2. Simpson's Diversity Index

Another diversity index is Simpson's Diversity Index, which measures diversity by considering the number of present species and the individual species' relative abundance. The principle in Simpson's diversity is a linear relationship between species richness and evenness and diversity. Hence, diversity increases when richness and evenness increase. In Simpson's Diversity Index, species dominance is measured wherein a dominating species infers to a less diverse community compared to a community with similar measures of abundance.

The formula for dominance is as follows:

$$D_s = \sum n_i (\frac{n_i - 1}{N(N-1)})$$

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where:

n_i = refers to the number of individuals in species i; and

N = sum of individuals

Once diversity is calculated, Ds can be substituted to obtain the species diversity in the formula as follows:

$$Simpson's\ Dominance = 1 - Ds$$

The value of a component closer to zero (0) indicates higher diversity while the value of a component that is distant from the zero (0) value indicates lower diversity. Hence, higher dominance is calculated to result in a lower calculated diversity.

The Simpson's Reciprocal Index is used to compare communities and reveal their unique characteristics. It is common practice to use the Reciprocal Index to quantify the diversity of a given habitat in terms of the species present and the abundance of each species.

$$Simpson's\ Reciprocal\ Index = \frac{1}{D_s}$$

3.8.3. Sorensen Index of Similarity

The Sorensen Index of Similarity was used in comparing the diversity of the two species involved. The index of similarity is equal to two (2) multiplied by the quantity of the species found in both communities divided by the number of species that are present in the first community and the number of species present in the second community multiplied by 100. In formula form, the Sorensen Index of Similarity is:

$$Index\ of\ Similarity\ (IS) = \frac{2C}{S_1 + S_2} \times 100$$

where:

C = species present in both communities

S_1 = number of species found in the community I

S_2 = number of species found in the community II

Determining the similarity index evaluates the range of variation of species and their composition.

3.9. Species Importance Value

The Species Importance Value, often known as the SIV, is a metric utilized to acquire the general significance of individual species within the community. The total of the percentage values of relative frequency, relative density, and relative dominance is what is referred to as the SIV.

$$SIV = Relative\ Frequency + Relative\ Density + Relative\ Dominance$$

3.9.1. Relative Frequency

The term "Relative Frequency" (Rf) refers to the degree to which different species are dispersed across an area that is relative to the total count of occurrences of all present species.

$$Rf = \frac{Frequency\ Value\ of\ Species}{Total\ Frequency\ of\ individual\ of\ all\ species} \times 100$$

3.9.2. Relative Abundance

The concept of relative abundance (RA) pertains to the numerical strength of individual species proportional to the sum of the quantity of all present species.

3.9.3. Relative Dominance

Relative Dominance (RDo) is the species coverage value corresponding to the total sum of the species' scope or coverage in an area.

$$RDo = \frac{Dominance\ of\ Species}{Total\ Dominance\ of\ all\ species} \times 100$$

3.10. Statistical Treatment

Statistical tests used in the study are Kruskal-Wallis, Friedman, and Pearson's r Correlation Test. These were done using the IBM SPSS version 26 Software.

3.10.1. Kruskal-Wallis

Kruskal Wallis non-parametric analysis is the statistical analysis used to identify whether there is a significant difference in the water quality and soil quality during the five months of the sampling period per site.

3.10.2. Friedman Test

Friedman Test is a non-parametric test that is an alternative to the one-way Analysis of Variance (ANOVA) that is used to determine if there is a significant difference between the water quality and soil quality of the three sites in between each month during the five-month sampling period; and

3.10.3. Pearson's r Correlation

Pearson's correlation, also known as Pearson's r, is a test statistic used to determine if there is a correlation between soil quality to mangroves, as well as the correlation between water quality to mangroves concerning the abundance of mangroves in three sampling sites.

Chapter IV

RESULTS AND DISCUSSION

4.1. . Anthropogenic Activities in Kaingen River

Anthropogenic activities can directly affect the condition of thriving bodies of water; hence, assessing the respondent's daily activities near the Kaingen River is important in determining how it can affect the water quality of the Kaingen River. There were 336 total survey questionnaires distributed to the residents of Barangay Kaingen, Kawit, Cavite.

Table 1. Anthropogenic activities in the Kaingen River.

Anthropogenic Activities	Mean	Remarks
Fishing	1.87	Seldom
Bathing	1.82	Seldom
Washing of clothes	1.45	Never
Throwing garbage	1.67	Never
Disposing of chemical waste	1.28	Never
Excreting	1.41	Never

Bathing of Animals	1.31	Never

Range: **Always** 3.26-4.00 **Often** 2.51-3.25 **Seldom** 1.76-2.50 **Never** 1.00-1.75.

Based on Table 1, the anthropogenic activities near Kaingen River are fishing and bathing which occurred rarely. These activities were observed during the five months of sampling, wherein residents of Brgy. Kaingen, mostly kids were bathing or swimming in the river. The throwing of garbage in the river was also observed. Most soil samples per site have evidence of thrown plastic residues and pieces of clothing. However, the result of the survey showed this activity has never occurred in the river, this meant that the collected garbage residues were resident wastes thriving in the river for a long time. Fishing activities can be observed since most residents residing nearby the Kaingen River were local fishermen. Kaingen River has situated nearby Bacoor Bay and Manila Bay. It serves as an estuary, rich in diverse aquatic species such as fishes and mollusks. On the other hand, anthropogenic activities such as washing clothes, disposing of chemical wastes, excreting, and bathing animals were never done by the residents due to precautions implemented by the management of Brgy. Kaingen Kawit, Cavite.

4.2. *Protection and Conservation Measures of Kaingen River*

Protection and conservation measures are necessary for the controlling and monitoring of the river's water quality to mitigate the deteriorating effects of harmful anthropogenic activities on the thriving aquatic species in Kaingen River. The perspicacity of Brgy. Kaingen's residents in protection and conservation measures for the Kaingen River were asked and assessed through survey questionnaires. Table 2 showed the administered response of the residents for the protection and conservation of the Kaingen River.

Table 2. Protection and conservation measures of Kaingen River.

Protection and Conservation Measures	**Mean**	**Remarks**
Preventing people from committing unlawful behavior in the river	3.58	Strongly Agree
Taking part in environmental groups	3.50	Strongly Agree
Creating groups and organizations	3.45	Strongly Agree
River conservation guidelines	3.54	Strongly Agree
Promoting sustainable methods	3.52	Strongly Agree
River management	3.42	Strongly Agree
Preventing depositing wastes	3.72	Strongly Agree
Supporting environmental programs	3.67	Strongly Agree

Range: Strongly Agree 3.26-4.00 Agree 2.51-3.25 Disagree 1.76-2.50 Strongly Disagree 1.00-1.75.

As presented in Table 2, the respondents strongly agreed with all of the conditions for the protection and conservation efforts of the Kaingen River such as preventing people from committing unlawful behavior in the river, taking part in environmental groups, creating groups and organizations, river conservation guidelines, promoting sustainable methods, preventing the depositing of wastes, river management, and supporting environmental programs. The result

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revealed that residents recognized the value of the river; its living thing components, beauty, and purpose as commercial rivers that most fishermen were relying on for their living. Residents are willing to exert extra effort to protect the river from the harmful effects of pollution by preventing unlawful behavior and depositing waste. Respondents were open to new knowledge and willing to join with environmental groups or create groups that will manage the river. A willingness to have river conservation guidelines, policies, and ordinances was observed in the interviews conducted during the distribution of survey questionnaires. The respondents wanted to promote sustainability and support environmental programs that seek to protect the Kaingen River and improve the Barangay's current approach to the protection and conservation of the river. Furthermore, respondents also agreed to have proper river management, which seeks to control the collection and extraction of fish and other aquatic resources in the river, as well as creating groups or organizations whose sole purpose is to oversee, manage, and monitor the condition of Kaingen River.

4.3. Water Quality Parameters of the Three Sampling Sites in Kaingen River, Kawit, Cavite during the Sampling Period

Water quality parameters were measured in-situ using different multi-tester for each designated parameter and conducting three trials per site. The data and results obtained from the tests were tabulated as presented in Table 3.

Table 3. Water quality of Kaingen River, Kawit, Cavite during the five-month sampling period.

Parameters	Site	November	December	January	February	March	DENR Standardfor ClassC Water
Temperature (°C)	1	32.20	30.07	29.23	32.00	32.80	25-31
	2	31.00	30.00	30.37	31.73	32.33	
	3	32.73	26.53	31.40	30.2	34.83	
Turbidity (NTU)	1	11.00	8.000	15.00	8.000	15.00	-
	2	8.000	15.00	24.00	24.00	15.00	
	3	15.00	15.00	15.00	11.00	24.00	
Total DissolvedSolid (mg/L)	1	910.5	2491.6	1047.3	2602.1	3087.5	-
	2	896.5	5507.6	2715.7	2695.4	3436.4	
	3	911.8	6029.9	3437.7	2665.0	3555.5	
Salinity (mg/L)	1	700.3	1916.7	805.7	2001.7	2375.0	-
	2	689.7	4236.7	2089.0	2073.4	2643.4	
	3	701.4	4638.4	2644.4	2050.0	2735.0	
Conductivity(μS/cm)	1	1400.7	3833.3	1611.3	4003.3	4750.0	-
	2	1379.3	8473.3	4178.0	4146.7	5286.7	
	3	1402.7	9276.7	5288.7	4100.0	5470.0	
pH	1	7.540	7.560	7.470	7.830	8.150	6.5-9.0
	2	7.890	7.710	7.600	7.740	8.150	
	3	7.800	7.680	7.540	7.590	7.750	
Dissolved Oxygen (mg/L)	1	2.970	5.400	3.500	4.600	9.500	≥ 5
	2	5.130	6.530	4.200	4.000	7.800	
	3	4.170	5.570	4.200	3.900	9.500	
Phosphates(mg/L)		0.6140	0.8150	0.7270	0.7180	0.4630	≤ 0.025
Nitrates (mg/L)		0.1230	0.2900	0.1700	0.1000	0.1400	≤ 7

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4.3.1. Water Temperature

Temperature is a crucial factor that affects different parameters specifically in water. The water temperature is important as it can determine the sudden change in the measurement of such parameters. Figure 5, it showed the fluctuation of measurement of the temperature in the three sampling sites during the five-month sampling period.

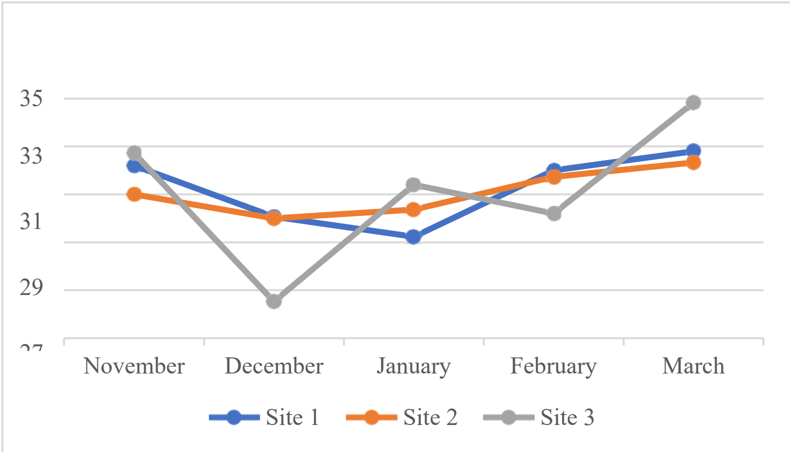

Figure 5. The temperature of water of the three Sites in the Kaingen River.

Among the three sampling sites, it was observed that the highest and lowest temperature was measured in Site 3 during March that ranged from 34.83°C and 26.53°C, respectively. The temperature for Site 1 ranged from 30.07 to 32.8°C, 30 to 32.33°C for Site 2, and 26.53 to 34.83 for Site 3. The fluctuation that occurred during the sampling months may have been attributed to a variety of factors including air temperature, sediment thermal conductivity, wind speed, solar radiation, and artificial heat according to the study of Chen and Fang (2015). In addition to this, the country experienced warm and dry seasons from March to May which can be attributed to the high average recorded temperature, based on Figure 5, in March due to intense solar radiation. Consequently, it may have also been drastically increased due to the artificial heat brought by anthropogenic activities in the area, in which according to the same publication, artificial heat is one of the factors that causes higher temperature inputs in streams and river bodies. This is supported by Collins et al. (2013), claiming that anthropogenic activities have also contributed to the increase in greenhouse gas levels attributing to the rise in global temperature in which bodies of water store substantial amounts of the additional heat. Moreover, the average depth during March was the lowest among the months included in the sampling period. The shallow depth of the river increases the amount of solar radiation that is absorbed by the water. The upper surface of the water absorbs and reflects most of the incoming sunlight; thus, the increase in temperature is attributed to shallow depths of water showing an inverse relationship between the two parameters. Meanwhile, the month of December garnered the lowest average water temperature due to heavy rains that were experienced on the day of the sample collection, with the addition of significantly higher depth compared to March. Based on the water quality guideline set by DAO-2016-08 for temperature, the data obtained complied with the standard for class C water.

According to the Kruskal-Wallis Test, the temperature has a significant difference among the three sites during November ($p = 0.023$) and January ($p = 0.038$). The distinction of measurements of temperature for November is observed between Site 2 and Site 3 ($p = 0.006$), while no significant difference is observed between Site 1 and Site 2 ($p = 0.169$), and Site 1 and Site 3 ($p = 0.169$). The disparity of measurement during January is observed between Site 1 and Site 3 ($p = 0.011$), while a marginal difference is observed between Site 1 and Site 2 ($p = 0.134$) and Site 2 and Site 3 ($p = 0.295$). On the other hand, the p-value of temperature during December ($p = 0.066$), February ($p = 0.054$), and March ($p = 0.193$) are observed to be insignificant.

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According to the Friedman Test, the temperature in Site 1-3 shows that there is no similarity between the five-sampling period as the results of the p-value (p = 0.31) of each month differ from one another. In comparison, temperature is directly proportional to the turbidity of water; as the turbidity increases, the water temperature increases as high turbidity increases the water temperature due to the particles absorbing sunlight. As studied by Mandal (2014), turbidity affects the water temperature as the suspended particles in the water column absorbed and scattered the sunlight.

4.3.2. Turbidity

Turbidity is the number of suspended solids present in water. It determines how clear the water is, which also affects other parameters. Figure 6 showed the measurement of the turbidity in the three sampling sites during the five-month sampling period.

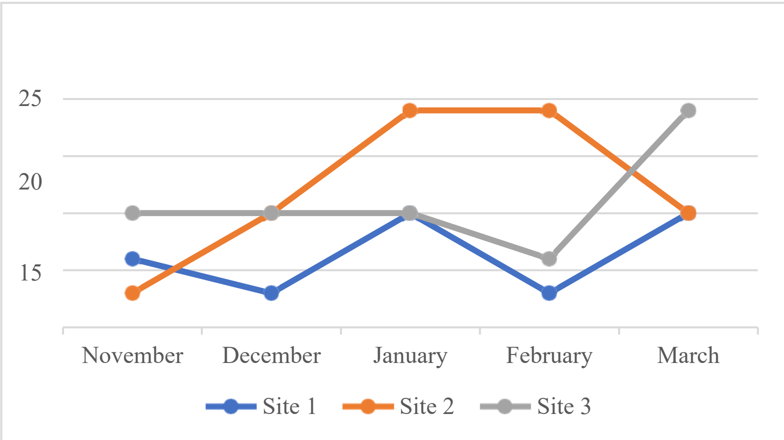

Figure 6. The Turbidity of water of the three sites in the Kaingen River.

Based on the data collected during the sampling period, shown in table 3, it was observed that the result for turbidity during the five-month sampling period ranges from 8 to 24 NTU.

The turbidity was highest during January with values ranging from 15.00 to 24.00 NTU from Site 1 to Site 3. An environmental phenomenon was observed during the sampling, wherein heavy precipitation occurred; thus, one possible factor that caused high turbidity was the run-off. The surface area, especially the soil with less vegetation, is more exposed to rainfall washing organic and inorganic materials off the surface increasing the load of sediment in the river (Liu et al., 2023). On the other hand, turbidity was lowest at 8.000 NTU in Site 2 in November, and Site 1 in December and February. The result can be inferred from the result of temperature where the low temperature was measured in Site 2 in November and Site 1 in December. According to the study of Shi et al. (2022), when water temperature becomes high, the turbidity increases, thus, a low-temperature results in low turbidity.

According to the Kruskal-Wallis Test, there is a significant difference in turbidity among the three sites during the five-month sampling period – November to March (p = 0.018). A significant difference in turbidity for November is observed between Site 2 and Site 3 (p = 0.005), while an insignificant distinction is observed between Site 1 and Site 2 (p = 0.157) and Site 1 and Site 3 (p = 0.157). During December, a significant difference is ascertained between Site 1 and Site 2 (p = 0.014) and Site 1 and Site 3 (p = 0.014), while no significance is depicted between Site 2 and Site 3 (p = 1.000). The significant distinction of turbidity measurement in January is observed between Site 1 and Site 2 (p = 0.014) and Site 2 and Site 3 (p = 0.014), while the insignificant difference is observed between Site 1 and Site 3 (p = 1.000). During February, a significant difference in turbidity value is observed between Site 1 and Site 2 (p = 0.005), while no significant difference is observed between Site 1 and Site 3 (p = 0.157) and Site 2 and Site 3 (p = 0.157). Lastly, a significant distinction of measurement of turbidity during March sampling is observed between Site 1 and Site 3 (p = 0.014) and 2 and Site 3 (p = 0.014), while no significant difference is observed between Site 1 and Site 2 (p = 1.000).

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According to the Friedman Test, there is a significant difference in the measurement of turbidity in Sites 1 to 3 across the five sampling months (p = 0.017). Site 1 showed significant differences between December and January (p = 0.020), December and March (p = 0.020), February and January (p = 0.020), and February and March (p = 0.020). In Site 2, there are significant differences depicted in November and January (p = 0.007), and November and February (p = 0.007). On the other hand, no significant differences were observed between the five-sampling months for Site 2. Moreover, significant differences for Site 3 were observed between February and March (p = 0.002). Argenal and Gomez (2016) said that turbidity and dissolved oxygen are inversely related as the less dissolved oxygen was present in the water sample, the more turbid the water is. One factor that influences the relationship between dissolved oxygen and turbidity is anthropogenic activities as it plays an extensive role in keeping the turbidity level high in the water sample.

4.3.3. Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are the measurement of both inorganic and organic substances present in water. In addition, the TDS measurement is commonly expressed in milligrams per liter (mg/L). Figure 7 showed the measurement of the TDS in the three sampling sites during the five-month sampling period.

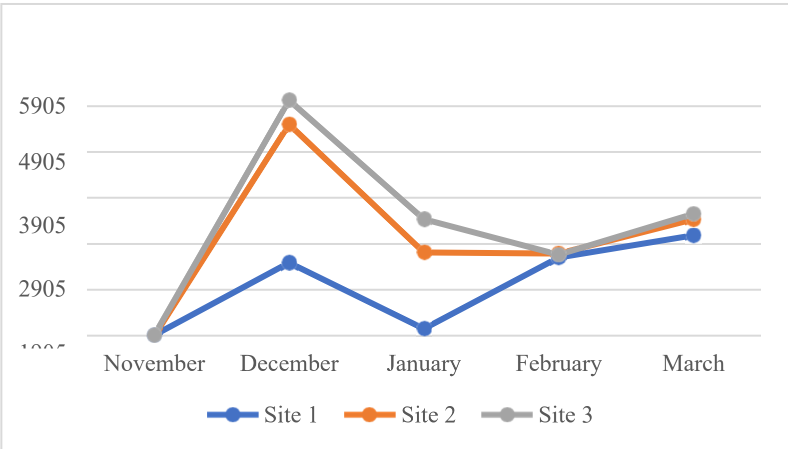

Figure 7. The total dissolved solids of water of the three Sites in the Kaingen River.

Based on the results obtained from total dissolved solids (TDS) analysis during the five-month sampling period, the concentration of TDS ranged from

896.5 to 6029.9 mg/L. Among the five-month sampling period, TDS was observed to be highest in Site 3 in November, December, January, and March having concentrations of 911.8, 6029.9, 3437.7, and 3555.5 (in mg/L), respectively, while the TDS in February sampling was observed to be highest in Site 2 at 2695.4 mg/L. Whereas the highest concentration of TDS was observed in Site 2 (5507.6 mg/L) and Site 3 (6029.9 mg/L) in December. The high TDS concentration was caused by soil erosion, runoff, suspended particles from decayed plants or animals, and wastewater effluent by households or the agricultural sector near the Kaingen River that settled in on the bottom part of the river. In contrast, the TDS concentration in Site 3 was highest due to emissions from households/establishments near the bay that might have emitted inorganic salts such as potassium, calcium, bicarbonate, sulfates, and such (Chen et al., 2021). On the other hand, the lowest concentration of TDS was observed in Site 2 in November at 896.5 mg/L. It appeared to be lowest due to few human activities occurring on the site as well as it was far from other sources of pollution, specifically heavy metal pollution (Kadarsah et al., 2020).

According to the Kruskal-Wallis Test, the measurement of total dissolved solids (TDS) has a significant difference among the three sites during December (p = 0.027), January (p = 0.027), February (p = 0.05), and March (p = 0.027). During December, significant distinction in TDS measurement is depicted between Site 1 and Site 3 (p = 0.007), while insignificant differences are observed between

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Site 1 and Site 2 (p = 0.178) and Site 2 and Site 3 (p = 0.178). During January, it was noticeable that a significant difference in measurement is found between Site 1 and Site 3 (p = 0.007), while no significant distinction is observed between Site 1 and Site 2 (p = 0.178) and Site 2 and Site 3 (p = 0.178). For February, a significant difference is observed between Site 1 and Site 2 (p = 0.017), while there is a negligible difference in TDS measurements between Site 1 and Site 3 (p = 0.100) and Site 2 and Site 3 (p = 0.454). Moreover, it was discernable that there is a significant difference in TDS value between Site 1 and Site 3 (p = 0.007), while a negligible difference is observed between Site 1 and Site 2 (p = 0.178) and Site 2 and Site 3 (p = 0.178) during March. On the other hand, no significant difference in TDS measurement among the three sites is observed during November (p = 0.414).

According to the Friedman Test, the distribution of total dissolved solids (TDS) in sites 1-3 showed that there is no similarity between November 2022 to March 2023. The significant differences, based on pairwise comparison, were observed in the months of November-February (p = 0.020), November-March (p = 0.002), and January-March (p = 0.020) for Site 1, and the months of November- March (p = 0.020), November-December (p = 0.002), and February-December for sites 2 and 3. This may be attributed to several environmental factors such as phosphates, nitrates, and conductivity in which TDS is directly proportional. According to Rusydi (2018), TDS and conductivity have a direct relationship which is used to describe salinity level expressed with an equation: TDS = 0.65 × conductivity (in 25 °C). Moreover, TDS can also be affected by certain anthropogenic activities such as the dumping of organic wastes.

4.3.4.Salinity

Salinity is the measurement of dissolved salt in water which then affect the circulation of ocean current due to variation in density in different region. Moreover, salinity measurement is expressed in milligrams per liter (mg/L). Figure 8 showed the measurement of the salinity in the three sampling sites during the five-month sampling period.

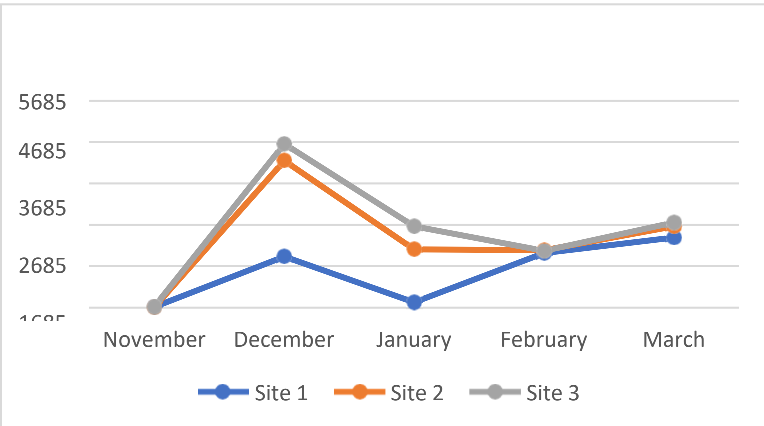

Figure 8. The salinity of water of the three Sites in the Kaingen River.

Based on the results of salinity during the five-month sampling period, the salinity of Site 1 to Site 3 ranged from 689.7 to 4638.4 mg/L. During the five-month sampling period, high salinity concentration was observed in Site 3 in November, December, January, and March at 701.4, 4638.4, 2644.4, and 2050.0 (mg/L), respectively, while the highest accounted salinity was observed in Site 2 and Site 3 in December with a concentration at 4236.7 mg/L and 4638.4 mg/L. The data also showed a low salinity concentration in Site 2 in November at 689.7 mg/L. The factors that affect the salinity level are conductivity and total dissolved solids (TDS) having a directly proportional relationship, as shown in table 3, that as the conductivity increases, the total dissolved solids and salinity increase resulting in salty water, thus a more concentrated salinity level. The low salinity level is caused by precipitation wherein it dilutes the salt concentration in water (Liu et al., 2020). As observed in the data, November has the lowest salinity among all the sampling months ranging from 689.7 to 701.4 mg/L, unlike December to March where salinity ranged from 805.7 to 4638.4 mg/L. According to the

PAG-ASA weather forecast in November 2022, low pressure (LPA) will bring heavy rains and thunderstorms within CALABARZON. Hence, when the sampling was conducted in November, the water is affected by the precipitation, thus low salinity level. Aside from that, saltwater intrusion in the coastal area could also increase the salinity level (Halder, 2023) in the sampling area specifically on the riverbank during a certain period. Saltwater intrusion could happen through sea level rise, excessive pumping of ground water which can be observed in the area where a water pump is present, or when the groundwater recharge reduces (Bayabil et al., 2021).

According to the Kruskal-Wallis Test, the measurement of salinity has a significant difference among the three sites during December ($p = 0.027$), January ($p = 0.027$), February ($p = 0.050$), and March ($p = 0.027$). During December, a significant distinction in salinity values is observed between Site 1 and Site 3 ($p = 0.007$), while a negligible difference is observed between Site 1 and Site 2 ($p = 0.178$) and Site 2 and Site 3 ($p = 0.178$). For January, it was observed that salinity has a significant difference between Site 1 and Site 3 ($p = 0.007$), while no significant distinction is observed between Site 1 and Site 2 ($p = 0.178$) and Site 2 and Site 3 ($p = 0.178$). A significant difference in salinity during February sampling is observed between Site 1 and Site 2 ($p = 0.017$), while a negligible difference was observed between Site 1 and Site 3 ($p = 0.100$) and Site 2 and Site 3 ($p = 0.454$). Lastly, the difference in salinity measurement during March is observed between Site 1 and Site 3 ($p = 0.007$), while a negligible distinction is observed between Site 1 and Site 2 ($p = 0.178$) and Site 2 and Site 3 ($p = 0.178$). Conversely, the salinity of the three sites during November showed no significant difference ($p = 0.414$).

The Friedman Test for the distribution of salinity in sites 1-3 showed that there is a significant difference between November 2022 to March 2023. The pairwise comparison for the months of November-March ($p = 0.020$), November- December ($p = 0.002$), and February-December ($p = 0.039$) for sites 2 and 3, and the months of November-March ($p = 0.020$), November-February ($p = 0.020$), and January-March ($p = 0.020$) for Site 1 showed that there were differences in distributions of salinity. This can be attributed to several environmental factors such as saltwater intrusion, wherein nearby coastal areas affect the salinity of freshwater (Halder, 2023). In addition, the temperature has a direct relationship with salinity. The highest temperature for all sampling sites was recorded in March, which explained why the salinity level highly increased compared to previous months.

4.3.5. Conductivity

Conductivity measures the ability of water to conduct electric current. It determines the number of substances dissolved in water, chemicals, and mineral content. Measurement of conductivity is expressed by micro siemens per centimeter (µS/cm). Figure 9 showed the measurement of the conductivity in the three sampling sites during the five-month sampling period.

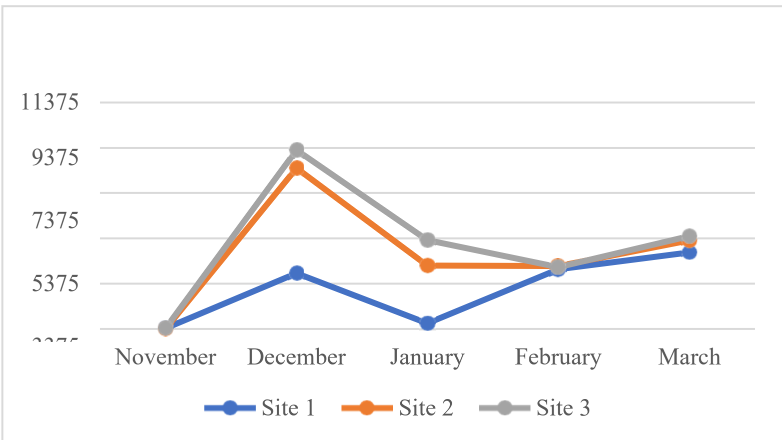

Figure 9. The conductivity of water of the three Sites in the Kaingen River.

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Based on the results of conductivity during the five-month sampling period, the conductivity of Site 1 to Site 3 ranged from 1400.7 to 9276.7 µS/cm. During the five-month sampling period, high conductivity was measured in Site 3 in November, December, January, and March at 1402.7, 9276.7, 5288.7, 5470.0, respectively, while the highest measured conductivity was observed in Site 2 (8473.3 µS/cm) and Site 3 (9276.7 µS/cm) in December. Whereas, low conductivity was measured in Site 2 in November at 1379.3 µS/cm. As observed in table 3, conductivity, TDS, and salinity have a directly proportional relationship, as the conductivity increased, TDS and salinity increased. Conductivity can be used to determine the total dissolved solids (TDS) and both parameters can be used as indicators of salinity level in studying seawater intrusion. Thus, as both total dissolved solids and salinity increase, the conductivity also increases (Rusydi, 2019).

According to the Kruskal-Wallis Test, the conductivity values measured have a significant difference among the three sites for December ($p = 0.027$), January ($p = 0.027$), February ($p = 0.050$), and March ($p = 0.027$). For December, a significant difference in conductivity measurement is observed between Site 2 and Site 3 ($p = 0.007$), while an insignificant difference is observed between Site 1 and Site 2 ($p = 0.178$) and Site 1 and Site 3 ($p = 0.178$). A significant distinction of measurement is observed in January between Site 1 and Site 3 ($p = 0.011$), while a negligible difference is observed between Site 1 and Site 2 ($p = 0.178$) and Site 1 and Site 3 ($p = 0.178$). Further, it is observed during February that there is a significant difference in conductivity values between Site 1 and Site 2 ($p = 0.017$), while it is insignificant between Site 1 and Site 3 ($p = 0.100$) and Site 2 and Site 3 ($p = 0.454$). Subsequently, it is observed during March that there is a significant difference between Site 1 and Site 3 ($p = 0.007$), while no significant distinction is observed between Site 1 and Site 2 ($p = 0.178$) and Site 2 and Site 3 ($p = 0.178$). On the other hand, no significant difference in conductivity is observed during November sampling ($p = 0.414$).

According to the Friedman Test, the distribution of conductivity in Sites 1 to 3 showed that there are significant differences between November 2022 to March 2023. The significant differences, based on pairwise comparison, were observed in the months of November-February ($p = 0.020$), November-March ($p = 0.002$), and January-March for Site 1, the months of November-March ($p = 0.002$), December- March ($p = 0.020$), and November-January ($p = 0.039$) for Site 2, and the months of November-March ($p = 0.020$), November-December ($p = 0.002$), and February- December ($p = 0.020$) for Site 3. Aside from water quality parameters where conductivity has a direct relationship with such as TDS and salinity, dissimilar distribution between months can be attributed to the presence of organic compounds such as oil and humic acid which came from decaying organic materials as discussed in the study of Klučáková (2018).

4.3.6. Water pH

The pH is a chemical parameter that determines the basicity or acidity of water. It is important as it can alter the compositions of different parameters in water. Figure 10 showed the measurement of the pH in the three sampling sites during the five-month sampling period.

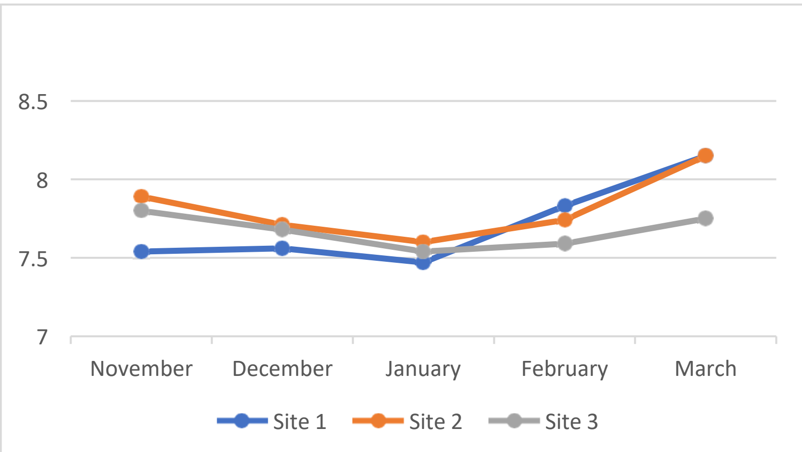

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Figure 10. The pH of water of the three Sites in the Kaingen River.

Based on the data collected, it was shown in table 3 that the pH was highest in March for sites 1 and 2 with similar pH recorded, that is, 8.150, while it was observed to be highest in Site 3 during November with a pH value of 7.800. The average pH of Sites 1 to 3 from November 2022 to March 2023 ranged from 7.540 to 8.020, with which the highest average pH was recorded in March 2023, while the lowest average pH was recorded in January 2023. However, all five sampling months displayed pH levels that are higher than the neutral pH of 7 which indicates that the water pH of the Kaingen River in Kawit, Cavite has basic pH properties. The occurrence of fluctuations in pH can be attributed to factors including natural and man-made influences. The month of March 2023 garnered the highest average pH of 8.020 despite the same month having the highest recorded average temperature. On the contrary, January 2023 had the lowest recorded average pH, but still basic, which is attributed to its slightly higher temperature - inversely proportional to pH - that reached 30.33°C despite being the second lowest average temperature that was recorded during the 5-month sampling period. Based on the water quality guideline set by DAO-2016-08 for pH in class C water, it was observable that the values obtained complied with the standard ranging from 6.5 to 9.0.

According to the Kruskal-Wallis Test, it was observed that the pH has a significant difference among the three sites for November ($p = 0.026$), January ($p = 0.026$), and February ($p = 0.027$). During November, a significant difference in pH is observed between Site 1 and Site 2 ($p = 0.007$), while a negligible difference is depicted between Site 1 and Site 3 ($p = 0.176$) and Site 2 and Site 3 ($p = 0.176$).

A significant difference in pH during January is observed between Site 1 and Site 2 ($p = 0.007$), while an insignificant difference is depicted between Site 1 and Site 2 ($p = 0.176$) and Site 2 and Site 3 ($p = 0.176$). Subsequently, a significant distinction in pH measurement among the three sites for February is observed between Site 1 and Site 3 ($p = 0.007$), while no significant discrepancy in measurement is shown between Site 1 and 2 ($p = 0.178$) and Site 2 and Site 3 ($p = 0.178$). In contrast, the pH in three sampling sites during December ($p = 0.106$) and March ($p = 0.063$) showed no significant difference.

According to Friedman's test, there is a significant difference in pH measurement across the five-month sampling period ($p = 0.022$). The findings showed significant differences in pH in Site 1 observed between January and February ($p = 0.020$), January and March ($p = 0.002$), and November and March ($p = 0.39$). Further, there is a significant difference in the measurement of pH across the five sampling months at Site 2 ($p = 0.017$). The data collected revealed a significant difference in pH between January and March ($p = 0.020$), January and November ($p = 0.002$), and February and November ($p = 0.020$) for Site 3. According to Rugebregt and Nurhati (2020), the temperature can contribute to significant errors in the pH of water. The pH level of water is inversely proportional to the temperature of the water, an increase in temperature results in a lower pH level of the water sample.

4.3.7. Dissolved Oxygen

Dissolved oxygen is one of several indicators of water quality. It is the amount of oxygen present in water that was produced by aeration. Figure 11 showed the measurement of the DO in the three sampling sites during the five- month sampling period.

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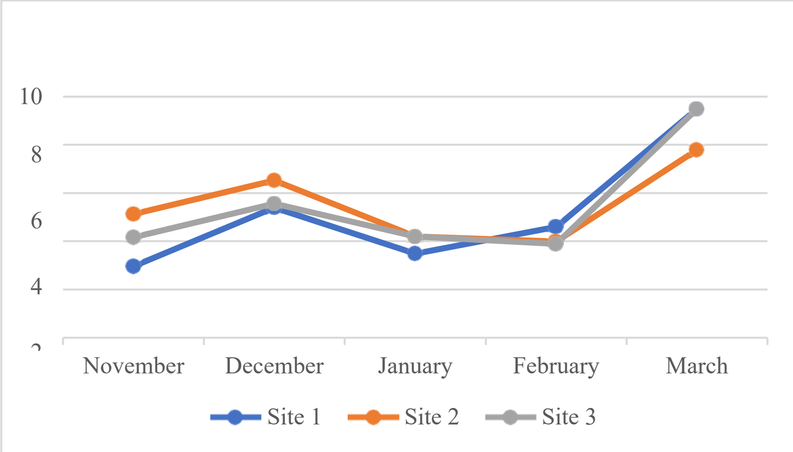

Figure 11. The dissolved oxygen of water of the three Sites in the Kaingen River.

The dissolved oxygen (DO) level ranged from 2.970 to 9.500 mg/L for Site 1, 4.000 to 7.800 mg/L for Site 2, and 3.900 to 9.500 mg/L for Site 3. The DO was observed to be highest in March sampling for Sites 1 to 3 measuring 9.500, 7.800, and 9.500 mg/L, from Sites 1 to 3, respectively. On the other hand, the lowest DO concentration for Site 1 was observed during November sampling at 2.970 mg/L, while during February sampling, both sites 2 and 3 were measured to have the lowest DO level having values of 4.000 and 3.900 mg/L, from Site 1 to 2, respectively. Based on figure 10, the month of March has the highest mean DO concentration at 8.933 mg/L, followed by December at 5.830 mg/L. While low DO was observed in February, November, and January with mean DO (in mg/L) of 4.167, 4.090, and 3.967, respectively. The variation in the DO measurement can be attributed to (1) temperature – having an inverse relationship, wherein the DO level decreases as the temperature increases; vice-versa, (2) industrial and household waste including waste water and high nutrients present which directly reduces the DO concentration in water, (3) and water turbulence increasing the amount DO as it gets higher adding aeration in water (US EPA, 2022). Based on the water quality guideline set in DAO-2016-08 for dissolved oxygen in class C water, it was found that during November, January, and February, the DO concentration did not comply with the minimum DO concentration of ≥ 5.0 mg/L, while during December and March, the concentrations of DO from the two sampling months were above and complied to the standard.

According to the Kruskal-Wallis Test, the dissolved oxygen (DO) has a significant difference among the three sites for November ($p = 0.026$) and February ($p = 0.048$). A significant difference in DO for November is observable between Site 1 and Site 2 ($p = 0.007$), while there is no significant difference between Site 1 and Site 3 ($p = 0.176$) and Site 2 and Site 3 ($p = 0.176$). In February sampling, a significant distinction in DO concentration is observed between Site 1 and Site 3 ($p = 0.016$), while no significant difference is observed between Site 1 and Site 2 ($p = 0.098$) and Site 2 and Site 3 ($p = 0.452$). In contrast, there is no significant difference in DO level across the three sampling sites in December ($p = 0.063$), January ($p = 0.053$), and March ($p = 0.063$).

According to the Friedman Test, the distribution of dissolved oxygen (DO) in Sites 1 to 3 showed that there is a significant difference between November 2022 to March 2023 ($p = 0.18$). Major differences in measurement, based on the pairwise comparison, were observed for the months of November-December ($p = 0.028$), November-March ($p = 0.003$), and January-March ($p = 0.014$) for Site 1; February- December ($p = 0.020$), February-March ($p = 0.002$), and January-March ($p = 0.020$) for Site 2; and February-December ($p = 0.020$), February-March ($p = 0.002$), and November-March ($p = 0.039$) for Site 3. This can be attributed to several environmental factors such as salinity, temperature, and anthropogenic activities as they have an indirect relationship to DO. The level of DO for November was significantly lower compared to December due to temperature where higher temperature was recorded in November. Although both January-March and November-March have lower DO records despite having lower temperatures and salinity, anthropogenic activity may contribute since in November and January, the water was more turbid which is due to the release of aquaculture waters.

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4.3.8. Phosphates and Nitrates

Phosphates and Nitrates are essential for mangroves' regenerative health and overall growth. Phosphates are a vital nutrient that helps the mangroves convert sunlight into usable energy essential for their cellular growth and reproduction, while nitrates help in synthesizing proteins. Phosphates play a major role in the formation of DNA and cell wall membranes for plants. High levels of phosphate in water can cause eutrophication or algal bloom which produce toxins lethal for both plants and animals. On the other hand, nitrates are essential to aquatic life but can cause significant problems in excessive amount. This could affect other water parameters such as DO, pH, and temperature. High levels of nitrates found in water can cause hypoxia which is a low level of DO in water and toxic to warm-blooded marine animals. Figure 12 showed the measurement of the Phosphate and Nitrate in the three sampling sites during the five-month sampling period.

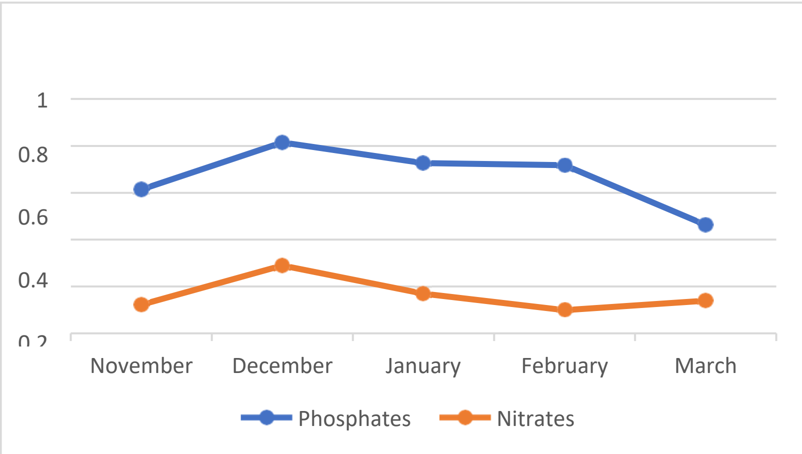

Figure 12. The phosphates and nitrates of water of the three Sites in the Kaingen River.

The tabulated result presented in Table 3, showed that the phosphate level gathered from November 2022 to February 2023 were 0.6140, 0.8150, 0.7270, and 0.7180 mg/L, respectively. Whereas the concentration of phosphates for March measures 0.4630 mg/L, the result was lower than obtained results of phosphates from November 2022 to February 2023. As set in DAO-2016-08, the standard concentration of phosphates in Class C water is ≤ 0.5 mg/L. Based on the results, only March complied with the standard concentration of phosphates at 0.4630 mg/L, or, below level to the standard set through DAO-2016-08. However, DAO- 2021-19 was issued amending the standard level for some parameters for WQG of DAO-2016-08, including phosphates. The result showed that the phosphates concentration of Kaingen River during the five-month sampling period exceeds the standard level of 0.025 mg/L for Water Quality Guidelines (WQG) of Class C water. The main cause for the high phosphate level in the river was active aquaculture in the area, wherein local fishermen use fertilizers that contain high levels of phosphates, and the discharge directly goes into the river's bodies of water. Furthermore, the concentration of nitrates gathered from November 2022 to March 2023 was 0.1230, 0.2900, 0.1700, 0.1000, and 0.140 mg/L, respectively. During the five- month sampling period, the nitrates level of Kaingen River was lower than the standard level for nitrates of 7 mg/L as set in DAO-2016-08 for Class C water. According to Singh and Singh (2022), the main cause for low nitrates levels in the river was the natural process of denitrification wherein microorganisms convert nitrates into nitrogen gas. The presence of microorganisms is observable due to the slightest green coloration in water.

According to Friedman's Test, it was observed that there is no significant difference in the measurement of phosphates across the five sampling months ($p = 0.406$). The same result occurred in nitrates, wherein no significant difference was observed during the five- month sampling period. Therefore, pairwise comparisons were not shown.

4.4. *Water Quality Index*

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Table 4 summarizes the water quality index of Kaingen River per site during the five-month sampling period using the Weighted Arithmetic Method.

Table 4. Water Quality Index Report of Kaingen River, Kawit, Cavite.

Sampling Periods	Sampling Sites 1 WQI	2 WQI	3 WQI	Average WQI	Remarks
November	117.7	116.53	125.64	119.96	Unsuitable
December	146.91	159.44	158.12	154.82	Unsuitable
January	141.11	155.91	142.43	146.48	Unsuitable
February	131.15	154.24	134.48	139.96	Unsuitable
March	110.97	108.45	124.32	114.58	Unsuitable
Average WQI	**129.57**	**138.91**	**137.00**	**-**	**Unsuitable**

Range Quality: 0 – 25 = Excellent; 26 – 50 = Good; 51 – 75 = Poor; 76 – 100 = Very Poor;. **>100** = Unsuitable

Based on the results depicted in Table 4, the water quality index in all sites during the sampling period from starting from November 2022 to March 2023 ranged from 108.45 to 159.44 which implied that the water quality in Kaingen River is unsuitable and deteriorated, which means that it is unfit or unsuitable for human consumption.

The water quality index of the three sites throughout the sampling period all exceeded the 100 range which indicated that all sites were under the unsuitable category. The highest water quality index in November was recorded in Site 3 having a WQI value of 125.64 which was significantly affected due to the high values of turbidity, biological oxygen demand, and phosphates. The highest WQI for December, January, and February was recorded in Site 2, which was mainly caused by the high WnQn of the parameter's turbidity and phosphates. Lastly, the month of March showed that the highest water quality index was recorded in Site 3 showing a significant difference from the WQI recorded in sites 1 and 2. The high WQI in March was attributed to its high total coliform and turbidity and showed that the phosphate levels in March have significantly dropped in value compared to the preceding months. In a comparison of all the months included in the sampling period, the highest average water quality index was recorded in December 2022, which is equivalent to 154.82, followed by January 2023 with 146.48, February 2023 with an average WQI of 139.96, then November 2022 with 119.96 and March 2023 with 114.58 which was slightly lower than November and all fall under the unsuitable category which indicated that the water in Kaingen River throughout the sampling period was unfit for human consumption. In addition, the average WQI per site including all five months revealed that Site 2 has the highest WQI equivalent to 138.91, followed by Site 3 equivalent to 137.00, while Site 3 garnered the least average WQI equivalent to 129.57. It can be observed that the water quality index was mainly affected by the WnQn values of the parameters including turbidity and phosphates which contributed a lot to the dark and murky appearance of the water in the Kaingen River. However, the most notable water parameter that contributed to the increase in the WQI was the phosphates which have exceedingly high values compared to the other parameters especially starting from December 2022 to February 2023. The increased phosphate levels resulted from anthropogenic activities present in the area (Indicators: Phosphorus | US EPA, 2022). Anthropogenic activities present in the Kaingen River such as fishing have caused the water quality index to appear high. In addition, precipitation runoff and other natural phenomena like tides, weathering, and erosion, as well as the decomposition of debris and leaves may have contributed to its increase. Specifically, phosphate levels tend to increase due to the presence of septic systems in which, according to the survey conducted, at least 65.88% of the total population in Barangay Kaingen have proper sewage systems in their households. In addition to this, frequent occurrence of

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precipitation runoff from urban areas may have been directed into the river which was also responsible for the river's increase in phosphate levels.

4.5. Soil Texture and Water Holding Capacity of the Three Sampling Sites in Kaingen River, Kawit, Cavite during the Sampling Period.

The determination of soil texture was done at the Bureau of Soils and Water Management. The texture of the representative soil samples in total sand, silt, and clay, were analyzed using the Bouyoucos Hydrometer whereas the water holding capacity of the soil samples was measured using the Tapping method of testing. The data and results obtained from the tests are tabulated in Table 5.

Table 5. Soil Texture and Water Holding Capacity of the Three Sampling Sites in Kaingen River, Kawit, Cavite during the Sampling Period.

Soil Parameters	**Site**	**Sampling Period**				
		November	**December**	**January**	**February**	**March**
Total Sand	1	20.10	18.10	8.800	17.70	12.80
	2	80.80	33.90	30.90	29.00	31.50
	3	-	24.00	16.10	16.10	11.70
Total Silt	1	33.50	49.70	58.00	51.10	53.00
	2	8.200	30.30	27.60	25.50	25.70
	3	-	24.00	37.30	41.90	44.10
Total Clay	1	46.40	33.80	33.30	31.20	34.20
	2	11.00	35.80	41.50	45.50	42.80
	3	-	42.20	46.60	42.00	44.20
Texture Class	1	Clay	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam
	2	Sandy Loam	Clay Loam	Clay	Loam	Clay
	3	-	Clay	Clay	Silty Clay	Silty Clay
Water Holding Capacity (WHC)	1	38.10	87.20	85.70	95.90	94.60
	2	84.10	75.50	88.30	98.50	77.60
	3	98.40	97.70	121.4	107.2	96.50

Pore Size Distribution: **Sand:** 0.006 mm – 2.0 mm; **Silt:** 0.05 mm – 0.002 mm; **Clay:** < 0.002 mm.

4.5.1. Soil Texture

Soil texture is the physical characteristic of soil that summarizes the sand, clay, and silt content of the soil. Based on the table depicted above, the textural class of soil in Site 1 for November was classified as clay which was dominated by 46.40% of total clay content. From December to March, the textural class of Site 1 was consistently classified as silty clay loam dominated by the total silt content that ranged from 33.50% to 53.00% over the five months. Site 2 on the other hand, was categorized as sandy loam during November in which the soil was dominated by 80.80% of total sand, followed by clay loam, clay, loam, and clay loam respectively from December to March which was dominated by total clay and loam interchangeably. While Site 3 was classified from clay to silty clay from December to March often dominated by the total clay content that ranged from 42.00% to 46.60%.

The physical properties of the soil vary depending on the site from where the soil samples were taken and showed differences in results between months. The difference in structure of the soil between the three sites caused significant differences in water-holding capacity, and nutrients such as nitrogen, phosphorus, and potassium. On the other hand, other chemical properties of soil such as organic matter influence the overall soil structure. According to Easton and Bock (2016), the structure of the soil influences the rate of elements such as water and air that can pass through the soil, root penetration, and nutrient availability. Single-grained soils such as sand allow water to percolate at a

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higher rate compared to structure- less soils such as silt and clay. Thus, clay and silt that are less porous than sand indicate a higher ability to hold moisture in the soil.

4.5.2. Water Holding Capacity

Water holding capacity pertains to the moisture content of the soil that persists in the soil after the water is exuded. Figure 13 depicted the water-holding capacity of the three sampling sites during the five-month sampling period.

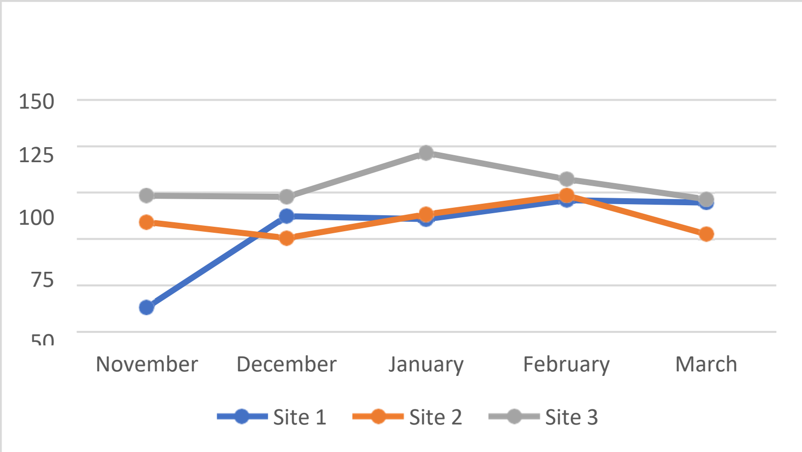

Figure 13. The soil water holding capacity of the three Sites in the Kaingen River.

The water-holding capacity of soil was dependent on the soil's structure and texture in which less porous soils have higher water-holding capacities compared to porous soils. From November to March, the water holding capacity of all three sites ranged from 38.10% to 121.40%. During the sampling period, Site 1 has a water-holding capacity ranging from 38.10% to 95.90%, comparatively, the textural class of Site 1 during the sampling period was classified as either clay or silty clay loam which indicated the dominance of clay and silt content. On the other hand, Site 2 ranged from 75.50% to 98.50% from November to February in which the water holding capacity values are higher compared to Site 1. However, Site 2 showed a textural class of sandy loam despite having a higher water-holding capacity value in November. This is due to the higher organic matter in Site 2 in November equivalent to 3.85% which is higher compared to the 0.660% of organic matter in Site 1 in the same month.

Based on the Kruskal Wallis Test, it shows that there is a significant difference ($p = 0.027$) in the distribution of the soil's water-holding capacity across the sites of the five sampling months. This may be attributed to the increase in organic matter due to more presence of macropores that transport the dissolved nutrients, and micropores that oversee water capillary distribution, thus, contributing to the increase in soil water holding capacity as stated by Easton and Bock (2016). The pairwise comparison also showed that Site 1 and Site 2 ($p = 1.000$) have no significant difference, while Sites 1 and 3 ($p = 0.020$), as well as Sites 2 and 3 ($p = 0.020$), showed significant differences. This explains why Site 3 has a higher water holding capacity than sites 1 and 2 despite the contrast in textural classes. The highest water capacity values were recorded in Site 3 ranging from 97.70% to 121.40%. This indicates that the soil in the area has higher water retention due to the soil being less porous as indicated by the textural class of Site 3 ranging from Clay to Silty Clay which is dominated by high clay content in the soil. In addition, several factors such as natural occurrences and anthropogenic activities present in the area caused the increase in organic matter. Comparatively, Site 3 has the highest organic matter values compared to the other two sites which is directly proportional to the soil's ability to hold water.

The Friedman test also showed that there is no significant difference ($p = 0.189$) in the distribution of water holding capacity from November to March of the three sites. This may be

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attributed to the amount of clay and loam that consistently dominated the soil texture of the three sites from November to March.

4.6. *Soil Physicochemical Characteristics of the Three Sampling Sites in Kaingen River, Kawit, Cavite.*

The physicochemical properties of the soil along the Kaingen River were determined through a series of in-situ and ex-situ soil testing from November 2022 to March 2023. Table 6 shows the parameters for soil analysis include temperature, which was tested in-situ using a laboratory thermometer while soil pH, nitrogen, phosphorus, and potassium were tested using the colorimetric method from the Bureau of Soils and Water Management (BSWM) Soil Test Kit. Soil Organic Matter was tested in the laboratory using the Walkley and Black Method while Soil Organic Carbon was obtained by dividing the organic matter to 1.72. The data and results obtained from the tests are tabulated as presented in Tables 6 and 7.

Table 6. Soil pH, Temperature, and Soil Nutrients of the Three Sampling Sites in Kaingen River, Kawit, Cavite during the Sampling Period.

Parameters	**Sampling Period**	**Sampling Sites**		
		1	**2**	**3**
Temperature (°C)	November	31.00	29.50	30.20
	December	27.00	26.00	28.00
	January	27.50	26.50	26.80
	February	29.50	27.00	26.00
	March	29.00	29.50	27.00
pH	November	5.800	5.800	5.800
	December	5.800	5.800	5.800
	January	5.800	5.800	5.800
	February	5.800	5.800	5.800
	March	5.800	5.800	5.800
Organic Matter (%)	November	0.6600	3.850	10.50
	December	3.990	2.020	12.28
	January	5.320	2.840	9.400
	February	6.380	6.300	11.05
	March	5.300	1.760	10.03
Organic Carbon (%)	November	0.3800	2.240	6.100
	December	2.320	1.170	7.140
	January	3.090	1.650	5.470
	February	3.710	3.660	6.420
	March	3.080	1.020	5.830

4.6.1. Soil Temperature

Soil temperature is a significant environmental factor that influences the physical and chemical processes occurring in soil. Figure 14 presents the soil temperature of the three sampling sites during the five-month sampling period.

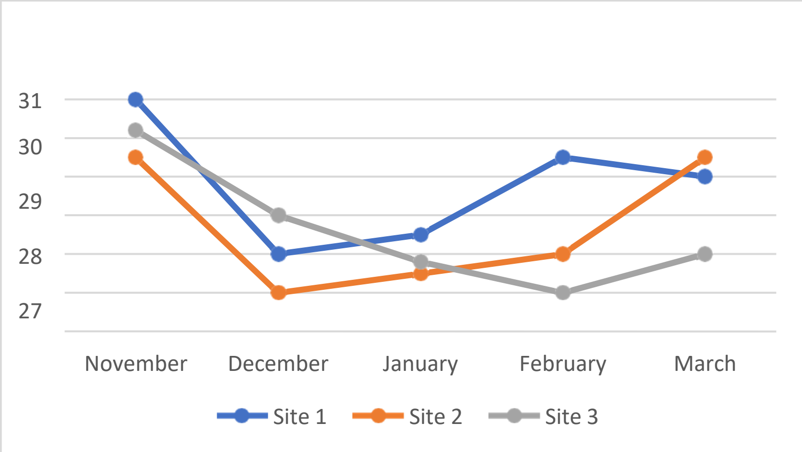

Figure 14. The soil temperature of the three Sites in the Kaingen River.

Based on the data gathered and presented in Figure 14, the soil temperature of all three sites from November 2022 to March 2023 ranged from 26.00°C to 31.00°C. The highest recorded temperature in sites 1 and 3 were recorded in November which are 31.00°C and 30.20°C respectively, while the highest soil temperature in Site 2 were recorded in November and March which both reached 29.50°C. On the other hand, the lowest soil temperature recorded for Sites 1 and 2 was in November and Site 3 was in January. The difference in the range of soil temperature from each site across varying months can be attributed to different factors such as the amount of solar radiation that is absorbed by the soil, and the vegetative cover (Onwuka & Mang, 2018). The amount of solar radiation absorbed is dependent on the moisture content of the soil as heat is directly proportional to the moisture content caused by the difference in soil texture of each site. Heat travels at a higher rate in soils with higher moisture content compared to soils with low moisture content because of the pockets of air present in drier soils. The textural class of the soil in Site 1 in November was classified as clay which has high water retention while Site 3 was unidentified, however, has a 98.40% water-holding capacity. Site 2 on the other hand, has a textural class of sandy loam but has a water holding capacity of 84.10% in November which is still high, thus the difference in the soil moisture content is associated with heat dissipation rate contributing to the contrast in temperature between sites.

According to the Kruskal Wallis Test, there is no significant difference ($p = 0.398$) in the soil temperature across the sites of the five sampling months. Change in soil temperature in an area is also associated with the variation in weather conditions that occurred from November 2022 to March 2023. The Friedman Test showed that there is no significant difference ($p = 0.137$) in the distribution of temperature from November to March of the three sites. Heavy precipitation was evident during the sampling period which caused slight fluctuations in soil temperature. However, provided that all three sites are in the same area, each site may have received the same amount of rainfall and shade caused by the monsoons throughout the months. Moreover, each site from which the soil samples were taken is slightly covered by the sunlight provided by the population of present mangrove trees, thus, contributing to a marginal difference in the recorded temperature of the soil samples.

4.6.2. Soil pH

Soil pH measures how acidic or alkaline the soil is, which is essential to identify the availability of nutrients that can be dissolved in the soil. Figure 15 showed the soil pH of the three sampling sites during the five-month sampling period.

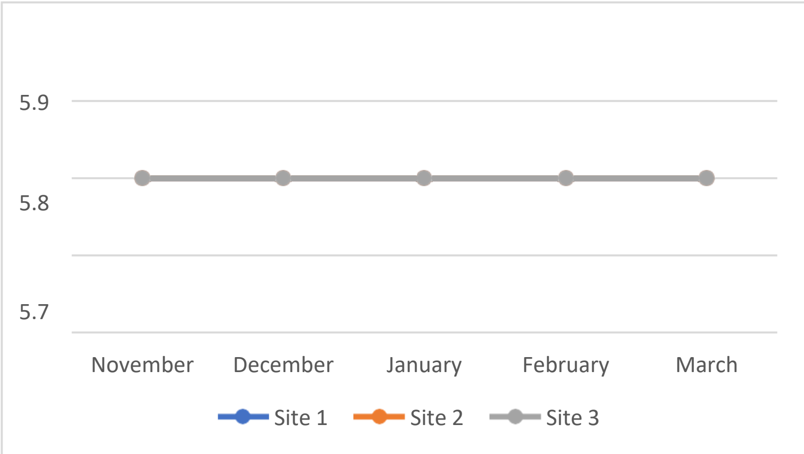

Figure 15. The soil pH of the three Sites in the Kaingen River.

The recorded soil pH of sites 1, 2, and 3 for November, December, January, February, and March are all the same at 5.800 which indicated that the soil samples for the four consecutive months were moderately acidic based on the standard classification in the Bureau of Soils and Water Management Manual that adopted the same classification in from the United States Department of Agriculture. The 5.800 pH levels recorded from November 2022 to March 2023 indicated that the soil is still tolerable for the survival of mangrove trees. This is supported by Alsumaiti and Shahid (2018), in which it was claimed that mangroves cannot withstand soils with extreme pH that are not within the 5.16 to 7.72 pH range. One cause of low soil pH is the amount of precipitation an area is experiencing; thus, greater precipitation indicates that there is a higher intensity of leaching and weathering of basic alkaline minerals in soil which leads to the acidification of the topsoil.

According to the Kruskal Wallis Test, the soil pH shows no significant difference ($p = 1.000$) in the soil pH between sites 1, 2, and 3 over the five-month sampling period. This can be attributed due to the presence of anthropogenic activities that are evident in all three sites. Site 1 is the area closest to residential spaces and is more accessible to the public. Site 2 and 3 on the other hand, although slightly farther than Site 1, face the open Bacoor Bay wherein anthropogenic activities such as fishing are present. In addition to this, the Friedman Test showed that there is no significant difference ($p = 1.000$) in the distribution of pH from November to March of the three sites. Soil pH differs in varying locations because of an area's climate. Dry or arid climates have higher soil pH, thus, are basic whereas humid or wet climates have lower soil pH, making them acidic (Zhang et al., 2019). The Philippines, being a tropical country, experiences intense precipitation most especially during October to late March due to monsoons, thus explaining the consistent acidic nature of the soil of all three sites.

4.6.3. Organic Matter

Organic matter is the main source of carbon in the soil that supports the soil by improving its chemical, physical, and biological functions. Figure 16 depicted the soil organic matter of the three sampling sites during the five-month sampling period.

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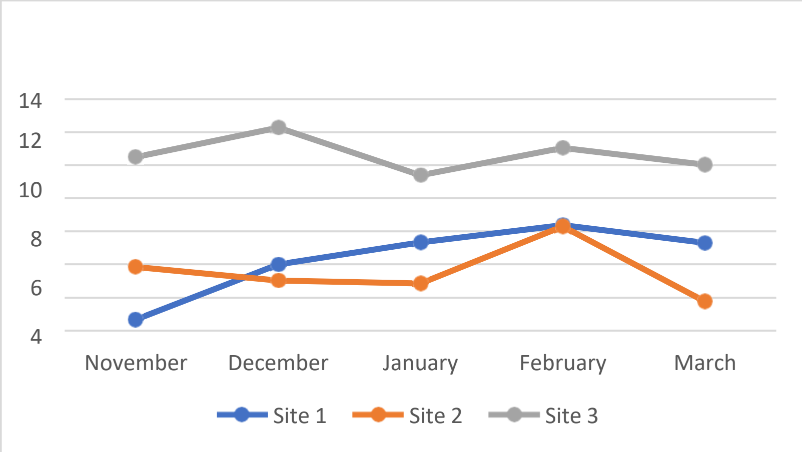

Figure 16. The soil organic matter of the three Sites in the Kaingen River.

Soil organic matter of all sites from November to December ranges from 0.6600% to 12.28%. The soil organic matter of Site 1 and 2 was highest during February which is equivalent to 6.380% and 6.300%. Site 3 on the other hand has the highest recorded organic matter among all the months which was recorded in December, equivalent to 12.28%. Climatic conditions such as soil temperature and precipitation affect the organic matter content of the soil. This was evident in the heavy precipitation that occurred during December which garnered the highest recorded organic matter of 12.28% compared to all sites and sampling months. The values of organic matter from November to March in Site 3 were significantly higher compared to the range of OM in the other two sites. The factors that change the amount of organic matter in soil are attributed to climatic conditions and increasing clay content. As seen in the table of results of the soil's physical test, Site 3 has a textural class ranging only from Silty clay to clay and has a clay content that ranges from 42.00% to 46.60%, which was significantly higher than the other sites, contributes as a factor as to why Site 3 has higher organic matter compared to the other two sites.

According to the Kruskal-Wallis Test, there is a significant difference ($p = 0.008$) in the soil organic matter between the three sites across the five sampling months which can be attributed to the different soil texture between Sites 1 to 3. In addition, several anthropogenic factors such as the presence of decomposed leaves occur in the area because of the survey conducted with residents. The significant difference between sites also produced a pairwise comparison wherein sites 1 and 2 showed no significant difference ($p = 0.525$) in the amount of organic carbon due to both sites having a high percentage of loam other than clay content. Both soil particles are less porous and therefore, the presence of both textures increases the amount of organic matter in the soil. While sites 1 and 3 ($p = 0.003$) and sites 2 and 3 ($p = 0.020$) showed significant differences in soil organic matter between the three sites during the five-month sampling period due to their comparative differences in soil texture. The bonds that occur between the surfaces of clay particles delay the decomposition process of organic matter. This is supported by Wei et al. (2014) in which it was stated organic matter rates increase as the clay increases as well. Soil organic matter also increases the water- holding capacity of soil which contributes to the dark coloration of the soil and increases the soil's ability to absorb temperature. Based on the results, Site 3 which holds the highest OM values and clay content during the five sampling months also displayed the highest values of water-holding capacity ranging from 97.70% to 121.40%, with January being the highest. In addition, based on the Friedman Test it showed that there is no significant difference ($p = 0.308$) in the distribution of organic matter between November to December of all three sites which may be attributed to the consistent textural class of each site from November to March that affects the organic matter content of the soil.

4.6.4. Organic Carbon

Organic carbon is the main component of organic matter. It is responsible for determining the quality and fertility of the soil by providing improvements to the soil's physic-chemical properties.

Figure 17 presented the soil organic carbon of the three sampling sites during the five-month sampling period.

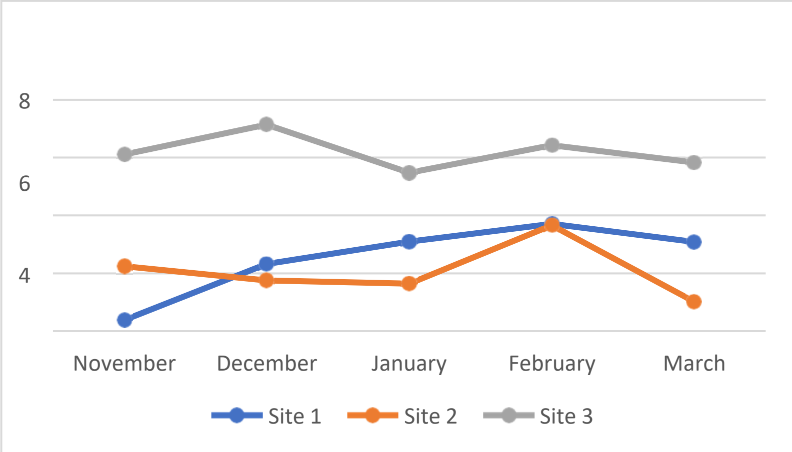

Figure 17. The soil organic carbon of the three Sites in the Kaingen River.

The soil organic carbon in all three sites across five sampling months ranged from 0.380% to 7.140%. Site 1 ranged from 0.3800% to 3.710% wherein the highest was recorded in February sampling. Organic carbon in Site 2 ranges from 1.020% to 3.660% wherein the highest organic carbon was recorded in February as well. Site 3 on the other hand, has the highest recorded organic carbon among all the months which was recorded in December, equivalent to 7.140%. Changes in soil organic matter carbon are attributed to several physical factors including the textural class of soil wherein a higher percentage of clay plays an important role in maintaining the amount of organic carbon in the soil while the temperature is responsible for affecting plant productivity which affects the organic carbon directly.

According to the Kruskal-Wallis Test, there is a significant difference ($p = 0.008$) in the organic carbon content of soil across the three sites in all five sampling months. Factors that affect soil organic carbon content include the physical composition of the soil, wherein soils with higher organic carbon are associated with finer soil grain size and higher water content (Yang et al., 2021). This explained why Site 3 with the highest clay content and water-holding capacities has the highest organic carbon values, ranging from 96.50% to 121.4%, compared to the other two sites. However, the pairwise comparison showed that sites 1 and 2 ($p = 0.525$) do not have a significant difference in organic carbon content due to both sites having a closer range of values. On the other hand, a comparison between sites 1 and 3 ($p = 0.020$) and sites 2 and 3 ($p = 0.003$) showed a significant difference in the amount of organic carbon because of the higher range of values of organic matter recorded in Site 3. The change in soil organic carbon can be attributed to the amount of organic matter present in the soil. Organic carbon is dependent on the amount of organic matter since organic carbon is computed by simply dividing the organic matter value by the 1.72 conversion factor. In addition, based on the Friedman Test showed that there is no significant difference ($p = 0.308$) in the organic carbon content in soil between the sampling months of the three sites. This is due to the additional factors including precipitation and temperature wherein the organic matter is inversely proportional due to the increased evaporation rate and decreased plant productivity (Zhao, et. al). Temperature, which showed no significant difference between months of all sampling sites explains why there is also no observable difference in organic carbon.

Table 7. Nitrogen (N), Phosphorus (P), and Potassium (K) of the Three Sampling Sites in Kaingen River, Kawit, Cavite during the Sampling Period.

Parameters	**Sampling Period**	**Sampling Sites**		
		1	**2**	**3**
Nitrogen (N)	November	Low	High	Very High
	December	Low	Low	Very High
	January	Very High	Low	High
	February	Very High	Very High	Very High
	March	Very High	Low	Very High
Phosphorus (P)	November	High	Very High	Very High
	December	Very High	Very High	Very High
	January	Very High	Very High	Very High
	February	Very High	Very High	Very High
	March	Very High	Very High	Very High
Potassium (K)	November	Sufficient ++	Sufficient	Sufficient +
	December	Sufficient +	Sufficient	Sufficient +
	January	Sufficient ++	Low	Sufficient
	February	Low	Sufficient	Sufficient
	March	Sufficient	Sufficient	Low

Nitrogen Range**: Low:** 0 – 2 **High**: 3.6 – 4.5 **Very High**: > 4.5Phosphorus Range**: High:** 16 – 20 mg/L **Very High**: > 20 mg/L.

4.6.5. Nitrogen (N)

Based on the data shown in Table 7, the available Nitrogen of Sites 1 to 3 from November to March ranges from Low (0 to 2) to Very High (>4.5%). The highest available Nitrogen recorded in Site 1 was in January 2023, February 2023, and March 2023 in which all were classified as Very High (> 4.5%), Site 2 shows Very High available Nitrogen in February whereas Site 3 has Very High available Nitrogen for November, December, February, and March. However, the slight difference in available Nitrogen is dependent on several factors such as the soil pH, temperature and precipitation, organic carbon, and soil moisture.

According to the Kruskal-Wallis Test, there is no significant difference (p = 0.135) in the distribution of Nitrogen availability across the three sites during the five months of sampling. The result can be attributed to the consistent value of soil pH (pH 5.8) which has an insignificant difference between the three sites from November to March. Low nitrogen availability in soil indicates that the soil has low organic carbon, which is the main component of organic matter. This explains why sites 1 and 2 have low nitrogen content in the soil as both sites have significantly lower organic matter and organic matter throughout the months that ranged from 0.6600% to 6.380% and 1.760% to 6.300% respectively. On the other hand, Site 3 is interchangeably categorized with high and very high nitrogen content due to the high values of organic matter ranging from 10.03% to 12.28% throughout the months. In addition, temperature has a directly proportional relationship with the available nutrients in soil such as nitrogen wherein the increase in temperature increases the rate of nutrient accumulation in the soil (Geng et al., 2017). This is proved by the result obtained wherein the amount of temperature of the three sites also showed no significant difference and therefore, explained the absence of a significant difference in the available nitrogen between the three sites from November to March. In addition, based on the Friedman Test it also showed that there is no significant difference (p = 0.406) in nitrogen availability in soil between the sampling months of the three sites. This can be attributed to the soil moisture content and amount of organic carbon present in soil which were also both found insignificant between the sampling months of the three sites. Soil organic carbon and available nitrogen are directly proportional according to Wibowo and Kasno (2021), however, organic carbon showed no significant difference between the sampling months and therefore, does not affect the amount of available nitrogen in the soil. The same case also applies to soil moisture which is directly proportional to the soil's nitrogen availability. The amount of rainfall affects the balance of soil nitrogen, which also includes the processes of the nitrogen cycle, where the decrease in total nitrogen was caused by nitrogen leaching, hence, it explains the low availability of Nitrogen in those months (Zhang et al., 2020). However, the temperature accelerates the accumulation of nitrogen availability in soil, which the result was also found insignificant across the months of the three sampling sites. Therefore, it does not affect the amount of nitrogen in the soil.

4.6.6. Phosphorus (P)

The measured value of soil phosphorus is identical throughout November 2022 to March 2023 within the sampling period. All five months fall into the Very High (more than 20 mg/L) range except for Site 1 of November 2022 which was classified as High (16 to 20 mg/L). This indicated that the soil consistently contained 16 mg/L to more than 20 mg/L of phosphorus in the following months of the period. Factors that affect available phosphorus in the soil can be attributed to the soil's pH levels and organic matter content between the sampling months and across each site. In terms of pH, acidic soils are proportional to the availability of soil phosphorus. On the other hand, organic matter indirectly increases the available phosphorus by increasing the acidity levels of soil. Phosphorus is one of the main soil nutrients that determine the growth of plants.

According to the Kruskal-Wallis Test, there is no significant difference ($p = 0.368$) in the available Phosphorus of soil from November to March is the same across the three sites. One of the factors that affect phosphorus availability in soil is the soil pH. This may be due to the consistent value of soil pH (pH 5.8) that has an insignificant difference between the three sites from November to March. In this regard, the data presented show that the monthly pH of 5.8 in each site is one of the factors that may have affected the presence of phosphorus in the soil. The 5.8 pH is close to the maximum soil phosphorus availability ranging between 6 and 7 on the pH scale, as reported by Prasad and Chakraborty (2019). This explains why the Phosphorus in all sites for the entire five consecutive months falls under High to Very High. Consequently, Phosphate forms very strong bonds with aluminum and iron, both of which are abundant in acidic soils. The excretion of waterbirds is another factor that affects the availability of phosphorus in soil in the area. Mangrove soils and vegetation, where phosphorus availability was significantly higher than in typical soil, benefit greatly from the nutrient contributions of waterbirds, as stated by McFadden et. al. (2016). In addition, the Friedman Test showed that there is no significant difference ($p = 0.406$) in the availability of phosphorus in soil across the sampling months for the three sites. Organic matter content in soil has a directly proportional relationship to the phosphorus availability by providing acidic compounds. Thus, the insignificant difference in phosphorus availability between months of all sampling sites is attributed to the irrelevance in the organic matter content of the soil between months of all sampling sites as resulted of the statistical analysis.

4.6.7. Potassium (K)

Soil productivity increases in proportion to the amount of potassium present. The available Potassium of Sites 1 to 3 from November 2022 to March 2023 ranges from Low to Sufficient++. In Site 1, the highest available Potassium was recorded in November and January equivalent to Sufficient ++ in which several factors, including rainfall, moisture content, textural class, and temperature may be responsible for this. Precipitation was evident during January, however, despite the presence of rainfall, November and January have temperatures of 31.00°C and 27.50°C respectively which are still considerably high compared to the other recorded temperatures of other sites and months and textural class during those months' fall under Clay and Silty Clay Loam respectively with clay content values of 46.40% and 33.30%. The combination of different factors contributed to the Sufficient ++ potassium content in the soil.

According to the Kruskal-Wallis Test, there is no significant difference ($p = 0.323$) in the distribution of soil potassium between the three sites of all sampling months. The concentration of potassium in the soil's nutrient availability increases proportionally to the increasing temperature of the soil (Lal & Kumar, 2022). However, previous data suggested that the difference in soil

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temperature was negligible between sites in all months. Thus, the temperature being insignificant across the sites during the five-month sampling period is attributed to the minimal difference or shows no significant difference at all in the potassium availability across sites of all sampling months. Studies indicate that the difference in the total clay content in the soil at each site causes a difference in the nutrient availability of soil. Soil with higher clay content, due to its compact soil particles, holds onto plant nutrients better than the sand particles. However, according to the Friedman Test showed that there is no significant difference (p = 0.322) in the amount of phosphorus between months of all sampling sites. The availability of potassium in the soil rises as the amount of water in the soil rises wherein increasing soil moisture also boosts potassium's movement to the roots, which increases the nutrient's availability to the plant as stated by the University of Minnesota (2018). In this regard, the moisture content of soil with the presence of high loam and clay content percentage increases the ability of the soil to hold more moisture which increases the uptake of potassium availability. However, water holding capacity has no significant difference between months of all three sites and therefore, may be attributed to the marginal difference of phosphorus across months in all sites.

4.7. Relationship of Water Quality to the Abundance of Mangrove Trees Found in Kaingen River, Kawit, Cavite

Pearson's r Correlation is a test statistic used to identify the relationship between the water quality and abundance of mangroves in Kaingen River. Table 8 showed the summarized results of the abundance of mangrove trees for each water parameter.

Table 8. Relationship of Mangrove trees to the Physicochemical parameters of water in Kaingen River, Kawit, Cavite.

Parameters	*r*-value	*p*-value	Remarks
Temperature	-0.032	0.911	Negligible Correlation/ Not Significant
Turbidity	-0.298	0.28	Negligible Correlation/Not Significant
Total Dissolved Solids	0.16	0.568	Negligible Correlation/ Not Significant
Salinity	0.16	0.568	Negligible Correlation/ Not Significant
Conductivity	0.16	0.568	Negligible Correlation/ Not Significant
pH	0.054	0.849	Negligible Correlation/Not Significant
Dissolved Oxygen	0.021	0.987	Negligible Correlation/Not Significant

Based on Pearson's r Correlation Test, the temperature (r = -0.032; p = 0.911), turbidity (r = -0.298; p = 0.28), total dissolved solids (r = 0.16; p = 0.568), salinity (r = 0.16; p = 0.568), conductivity (r = 0.16; p = 0.568), pH (r = 0.288; p = 0.299) and dissolved oxygen (r = 0.054; p = 0.849) were observed to have negligible correlation and has no significant relationship with the abundance of mangroves as the p-values obtained were above the significance level of 0.05 (two-tailed).

Temperature is an indicator of the absence and presence of mangroves, a sudden fluctuation can negatively affect the ability of mangroves to photosynthesize, hence, distorting their ability to flourish. Mangroves only survived at temperatures above 19° C and not exceeding 10 ° C (Noor et al., 2015). Although Table 3 showed that the temperature of water in Kaingen River is accepted for mangrove habitat, the result of Pearson's r correlation resulted in a negligible correlation and was not significant in mangrove abundance (r = -0.032; p = 0.911).

Turbidity measures the clarity and affects the amount of light passing through the water. When water is turbid, it appeared to be cloudy caused by inorganic and organic matter, silt, clay, algae, plankton, and other microbes (Water Science School, 2019). Based on the correlation between the mangrove abundance and turbidity, there is no significant relationship between the two variables (r = 0.16; p = 0.568).

Dissolved oxygen is an indicator of healthy water bodies. According to the study of Chunkao et al., (2012), mangrove communities increase the amount of DO concentration in water. However, the correlation obtained depicted that the DO has a negligible correlation with the mangrove abundance (r = 0.054; p = 0.849).

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Salinity is a key environmental factor that controls the growth of mangroves. The study of Basyuni et al., (2019) showed that Avicennia alba can resist high salinity, while Rhizophora and Xylocarpus only grow within a specific range, due to their characteristic as non-salt secretors (ultrafiltration). Hence, the growth response of mangroves differs according to the response of mangrove species to a change in salinity concentration. On the other hand, total dissolved solids and conductivity are driving factors to salinity level (Rusydi, 2018), wherein table 3 accounted for a direct relationship within the three parameters. Although the result of Pearson's r correlation showed that salinity, TDS, and conductivity yielded the same r and p-value (r =0.16; p = 0.568), all three parameters have negligible correlation, and therefore, not significant in the abundance of mangroves in Kaingen River.

The pH of water quantifies the limit of distribution of species in aquatic habitats, it indicates whether an aquatic species can thrive at a certain pH level. Mangroves in Kaingen River have been found to thrive within the pH level of 7.540 to 8.150. The result of Pearson's r correlation for pH resulted in a negligible correlation and was not significant in mangrove abundance (r = -0.054; p = 0.849).

Overall, the correlation results showed that the physicochemical parameters of the water measured were not related to the abundance of mangroves in the Kaingen River.

4.8. Relationship of Soil Quality to the Abundance of Mangrove Trees Found in Kaingen River, Kawit, Cavite

Pearson's r Correlation is a test statistic used to identify the relationship between the soil quality and abundance of mangroves in Kaingen River. Table 9 showed the summarized results of the abundance of mangrove trees for each soil parameter.

Table 9. Relationship of Mangrove trees to the Physicochemical Parameters of Soil in Kaingen River, Kawit, Cavite.

Parameters	*r-value*	*p-value*	Remarks
Water HoldingCapacity	-0.132	0.639	Negligible correlation/Not significant
Soil Temperature	-0.187	0.504	Negligible correlation/Not significant
pH	a	a	Cannot be computed (variable isconstant)
Organic Matter	-0.452	0.090	Low negative correlation/Not Significant
Organic Carbon	-0.452	0.090	Low negative correlation/Not Significant
N	-0.414	0.127	Low negative correlation/Not Significant
P	0.226	0.417	Negligible correlation/ Not Significant
K	-0.384	0.158	Low negative correlation/Not Significant

According to Pearson's r Correlation Test, there is a low negative correlation and has no significant relationship between organic matter (r = -0.452; p = 0.090), organic carbon (r = -0.452; p = 0.090), available nitrogen (r = -0.414; p = 0.127), and available potassium (r = 0.226; p = 0.417) with the abundance of mangroves in all sites from November to March. Whereas a negligible correlation and no significant relationship occur between water holding capacity (r = -0.132; p = 0.639), soil temperature (r = -0.187; p = 0.504), and available phosphorous (r = 0.226; p = 0.417), with the mangrove abundance found in all sites during the 5-month sampling period. On the other hand, the soil pH showed that the correlation (r) coefficient cannot be computed because one or more variables of soil pH were constant and therefore, cannot describe its relationship with the abundance of mangrove trees.

Organic matter indirectly affects the growth of mangroves by influencing the soil structure in which it binds and forms stable soil aggregates, thus, improving the soil structure to increase the water-holding capacity of soil which is beneficial for the growth and distribution of mangroves. A decrease in soil organic matter corresponds to a decrease in the soil's porosity and turn decreases the soil's capacity to hold water (Jiao et al., 2020) which is an essential factor that supports mangal abundance in an area. However, Pearson's r Correlation indicated that there is a low negative correlation (r = -0.452) which infers that as organic matter increases, the abundance of mangroves slightly decreases. It also showed that the relationship between the two is not significant (p = 0.090); therefore, there is no significant relationship that exists between organic matter and the abundance of mangroves in Kaingen River, Kawit, Cavite.

Soil organic carbon affects the physical property of soil in terms of the soil's pore structure. The study conducted by Fukumasu et al. (2020), showed that there is a positive correlation between soil organic carbon and pore size distribution in soil which then contributes to the capacity of soil to hold and retain water that is essential for the growth of mangroves. Pearson's correlation revealed a low negative correlation (r = -0.452) which presents that as organic carbon increases, a slight abundance of mangroves occurs. However, the statistical treatment also presented that the relationship between the two parameters is not significant (p = 0.090). Hence, this indicates that there is no relationship between organic carbon and the abundance of mangroves.

Nitrogen availability in soil is considered one of the most important nutrients that affect plant growth. According to Pradipta et al. (2021), nutrients such as nitrogen affect the number of photosynthetic processes occurring in mangroves wherein the concentration of nitrogen found in leaves increases the electron transport in the photosynthesis process. However, most mangrove forests thrive even in nutrient-limiting soils, and that nitrogen availability only enhances the mangrove's growth but not its abundance in an area. Thus, the difference in the abundance of mangroves at each site despite the values of nitrogen availability shows that there is a low negative correlation (p = -0.414) which means that as nitrogen availability increase, the abundance of mangroves sightly decrease in Kaingen River, Kawit, Cavite but also shows that it is not significant (r = 0.127). Therefore, the result indicates the absence of a significant relationship between available nitrogen in soil with the abundance of mangroves.

Potassium availability in the soil is an internal factor that influences the abundance of mangroves in an area. Potassium is utilized in fertilizers, boosting soil fertility, and serving as an indicator of healthy plant growth. A lack of potassium in the soil may result in unhealthy plant development (Sofawi et al., 2017). Several variables, including precipitation, moisture content, textural class, and temperature, may have contributed to the highest Potassium availability at each site. The statistical test revealed that there is also a low negative correlation (r = -0.384) which means that as potassium increases, a slight decrease in the abundance of mangroves occurs. However, it also showed that it is not significant (p = 0.158) which indicates that there is no significant relationship between soil potassium availability and mangrove abundance.

The water-holding capacity of soil is the ability of soil to retain moisture. It pertains to the moisture content of the soil that persists in the soil after the water is exuded. A higher water holding capacity estimates the highest volume of water that is stored by the soil that will be utilized by plants for growth and survival (Zhang et. al, 2021). However, results showed a negligible correlation (r = -0.132) between the two variables which also showed that it is not significant (p = 0.639). In conclusion, there is no existing significant relationship between water-holding capacity and mangrove abundance.

Soil temperature is one of the main factors that influences the spread of mangroves in the ecosystem. Higher density of mangrove populations tends to grow in sheltered tropical and subtropical temperatures which have higher temperatures which are commonly abundant along the Southern and Northern Hemispheres (Ward et al., 2016). The soil temperature varies according to the fluctuations in atmospheric and solar temperature, hence, an increase in solar and atmospheric temperature also increases the temperature of the soil. The increase in the temperature increases the rate of evaporation in soil, thus increasing the soil salinity. The increase in salinity affects mangroves by slowing their growth rates. Comparing the three sites, Site 2 with the slightly lower range of soil temperatures garnered the highest number of total mangroves found in the site whereas Site 1 having the highest range of temperatures from November to December shows the least number of total mangroves found within the site. However, the results indicate a negligible correlation (r = -0.187) between soil temperature and the abundance of mangroves which is also not significant. Therefore,

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there is no significant relationship between the temperature of the soil and the mangrove abundance in the Kaingen River.

The amount of phosphorus present in the area is one factor that influences the growth and abundance of mangroves. Throughout the entirety of the sampling period, the value of the phosphorus that was measured was consistently between 16 and more than 20 milligrams per liter (mg/L). Insufficient levels of phosphorus and potassium in soil are classified as inadequate nutrients that cannot sustain plant growth. It has been suggested by Alhassan et al. (2021) that because of the decreased levels of nitrogen and phosphorus in the soil, it may cause dwarfism in mangrove trees. Additionally, the concentration of phosphorus in the soil may have been influenced by various factors, including the soil's pH level and the presence of avian fauna in the area. This shows a negligible correlation ($p = 0.226$) between the abundance of mangroves and the availability of phosphorus in the soil, as evidenced by the consistent levels of phosphorus across various sites but also showed that it is not significant which concludes that the relationship occurred between available phosphorus and mangroves abundance is not significant.

Moreover, soil pH is another external factor that affects the growth and abundance of mangroves in an area. According to Alsumaiti and Shahid (2018), it was claimed that mangroves cannot withstand soils with extreme pH that are not within the 5.160 to 7.720 pH range. Based on the results of the tests for soil pH, all three sites from November 2022 to March 2023 have a consistent soil pH of 5.800 which falls under moderately acidic pH for soil, thus, showing that the soils in all three sites are within the tolerable range of soil pH for the survival of mangroves. However, consistency in soil pH values indicates constant variables and therefore cannot identify both the relationship between soil pH and mangrove abundance, as well as their significance in their relationship.

Overall, the correlation results showed that the physicochemical parameters of the soil measured are not related to the abundance of mangrove in Kaingen River, except for the soil pH where its relationship to mangrove abundance was not determined since the value of the variable was constant.

4.9. Mangrove Trees Inventory in Kaingen River, Kawit, Cavite, Philippines

The species of mangrove trees present along the river of Kaingen were initially identified using Dr. J.H. Primavera's manual Field Guide to Philippine Mangroves (2009) and (2022) and were then verified by Dr. Primavera as well as Jose Vera Santos Memorial Herbarium, Institute of Biology in the University of the Philippines – Diliman. The percentage occurrences quantify the population of mangrove trees found in each sampling site and determine the abundant mangrove species within the Kaingen Riverine ecosystem. The result for the percentage occurrences of mangrove trees was presented in Table 10.

Table 10. Percentage (%) Occurrence of Identified Mangrove Trees in Kaingen River, Kawit,Cavite.

Mangrove Species	Site 1	Site 2	Site 3	Total No. ofSpecies	% Occurrences
Acanthaceae					
Avicennia alba	15	8	1	24	9.38
Meliaceae					
Xylocarpus granatum	-	14	-	14	5.47
Rhizophoraceae					
Rhizophora mucronata	6	170	42	218	85.16

Based on the tabulated data presented in Table 10, Avicennia alba was observed to be dominant in Site 1, while Rhizophora mucronata of family Meliaceae became dominant in sites 2 and 3. Among all three identified mangrove species present in three sites, Rhizophora mucronata was the most abundant having 218 total trees and an occurrence of 85.16%, followed by Avicennia alba with an abundance of 24 and a total occurrence of 9.380%. On the other hand, the least abundant mangrove species was Xylocarpus granatum with only 14 total trees and a total occurrence of 5.470%.

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The biodiversity and conservation status of mangrove trees is necessary to monitor their biological status and whether the trees were categorized in the International Union for Conservation of Nature (IUCN) Red List or known as the list of threatened, endangered, and critically endangered flora and fauna across the world. Table 11 showed the biological and IUCN status of Mangrove trees found in the Kaingen River.

Table 11. Biodiversity and Conservation Status of Mangrove trees found in Kaingen River, Kawit, Cavite.

Family Name	Scientific Name	Common Name	Biological Status	IUCN Status
Acanthaceae	*Avicennia alba*	Bungalon	Introduced	Least Concern
Meliaceae	*Xylocarpus granatum*	Tabigi	Native	Least Concern
Rhizophoraceae	*Rhizophora mucronata*	Bakhaw babae	Native	Least Concern
Malvaceae	*Thespesia populneoides*	Banago	Introduced	Least Concern

Note: *Thespesia populneiodes* is an accessory tree found alongside mangrove trees in the Kaingen River.

Based on tabulated data presented in the table, the biodiversity and conservation status of mangrove species found in three sampling sites of Kaingen River showed that only Avicennia alba commonly known as Bungalon was introduced in the Philippines. All three species of mangroves were categorized as least concerned according to the International Union for Conservation of Nature (IUCN). Moreover, an accessory tree was found in Site 2 alongside mangrove trees of Kaingen River called Thespesia populneoides of the family Malvaceae or commonly known as Banago. It is a flowering plant native to terrestrial (coastal forest) and shorelines where mangroves are thriving. This accessory tree has introduced biological stats and is usually found in tropical regions of the world, including the Philippines.

The Species Importance Value of the mangrove species was determined by calculating the relative frequency (Rf), relative abundance (RA), and relative dominance (RD), and were ranked from highest to lowest species importance value as summarized in Table 12.

Table 12. Mangrove Species Importance Value Index found in Site 1, 2, and 3 in Kaingen River, Kawit, Cavite.

	Site								
Species	**1**	**2**	**3**	***f***	**R*f***	**RA**	**RD**	**IV**	**Rank**
Rhizophora mucronata	6	170	42	218	85.16	1.172	1.172	87.50	1
Avicennia alba	15	8	1	24	9.375	1.172	1.172	11.72	2
Xylocarpus granatum	0	14	0	14	5.469	1.172	1.172	7.813	3

The table illustrated that Rhizophora mucronata exhibited the highest species importance value, as indicated by its 87.50 IV. Rhizophora mucronata, which held the highest Importance Value (IV) ranking, exhibited abundance within Site 2 of the mangrove forest. The study of Rastegar and Gozari (2017) has reported that Rhizophora mucronata, commonly referred to as Asiatic mangrove, is distributed in tropical and sub-tropical regions along coastal areas. Rhizophora mucronata is a crucial constituent of the mangrove ecosystem, as this species plays an essential part in safeguarding the adjacent terrestrial regions from the deleterious impacts of the marine environment. Specifically, Rhizophora mucronata contributes to shoreline stabilization and serves as a protective barrier against high-velocity winds and storms.

Ranked as the species with the second highest importance was Avicennia alba showing an importance value of 11.72. This species was found in all three sites of the riverine system and the most abundant species of mangrove in Site 1. Avicennia alba is a woody type of mangrove species that is known to have a high salt tolerance and can adapt to extreme saline conditions. In addition, Avicennia alba is an important species of mangrove because of its salt exclusion abilities. The species of Avicennia ranked as first among the salt-secretor species of mangroves. Salt secretors allow the species to exclude excess amounts of salts through their leaves and root systems, thus, not only tolerating salt but also maintaining salt concentration in its system (Basyuni et al., 2019). Furthermore, Avicennia species are also known to have thinner leaves containing fewer chemicals such as lignin – species with a higher decomposing rate than other mangrove species, such as Rhizophora mucronata, which contributes more nutrients to the environment (Muliawan & Bengen, 2020).

The mangrove species that ranked third and has the least species importance was the Xylocarpus granatum with an importance value of 7.813. Unlike the other two species, Xylocarpus granatum was found only in Site 2 which accounted for a total of 14 trees. The root system of Xylocarpus granatum is composed of stanniferous cells which it contains the chemical 'tannin', a derivative of phenolics that prevents infestation of bacteria and fungi as well as reduces the damages caused by excess ions, hydrogen sulfides, and salts (Chorchuhirun, 2020). According to Siddique et al. (2017), although Xylocarpus granatum was able to thrive better in non-saline conditions, the species can still adapt in areas with up to 25 PSU (Practical Salinity Unit). This characteristic of mangroves allowed them to perform carbon sequestration and provide other environmental benefits even in moderately saline conditions.

4.10. Diversity Indices of Mangrove Trees Found in Kaingen River

To determine the diversity of mangrove trees found in three sampling sites in Kaingen River, Kawit, Cavite, two diversity indices were used to quantify the mangrove trees such as Shannon-Wiener and Simpson's Diversity Index. Table 13 showed the summarized results of Shannon-Weiner and Simpson's Diversity Index of mangrove trees found in Sites 1, 2, and 3 of Kaingen River.

Table 13. Shannon-Weiner and Simpson's Diversity Index for Mangrove Trees found in Sites 1,2, and 3 of Kaingen River, Kawit Cavite.

Diversity Indices		Site 1	Site 2	Site 3
Shannon-Weiner Index				
	Diversity (H)	0.5983	0.4311	0.1105
	Evenness (E)	0.1994	0.1437	0.0368
Simpson's Index				
	Diversity (D_s)	0.5714	0.7899	0.9318
	Dominance (1-D_s)	0.4286	0.2101	0.0682
	Reciprocal (1/D_s)	1.750	1.266	1.073

Simpson's Diversity Index: D_s = 0 (High Diversity); 1= (Low diversity). 1-Ds = 0 (Low diversity); 1 (High diversity) 1/Ds = >1 (High diversity). **Shannon-Weiner Diversity Index:** 1.99 and below (Very Low); 2.0-2.49 (Low); 2.50-2.99 (Moderate); 3.00-3.49 (High); 3.50 and above (Very High)

The depicted data from above showed the result of computed value for Shannon- Weiner Diversity Indices of mangroves in the three sampling sites of Kaingen River. The Shannon-Weiner Diversity (H) results were 0.5983 (Site 1), 0.4311 (Site 2), and 0.1105 (Site 3).

In Shannon-Weiner Diversity Index, H with a value of 1.99 and below represents very low diversity. Based on the result, all sampling sites were categorized as having very low diversity. However, among the three sampling sites, Site 1 has the higher computed value for Shannon-Weiner diversity (H = 0.5983) and evenness (E = 0.1994). The result for the Shannon-Weiner diversity index can be inferred from the outcome of Simpson's Diversity Index (Ds) such as 0.5714 (Site 1), 0.7899 (Site 2), and 0.9318 (Site 3). According to the principle of Simpson's index, the diversity value ranges from 0 to 1, the higher the value corresponds to the lower diversity. On the other hand, as the dominance (1-Ds) approaches 1, a high diversity of species is found in sampling sites. Hence, among the three sampling sites, mangrove species were diverse (Ds = 0.5714) and dominant (1-Ds = 0.4286) in Site 1. In addition, it also had high diversity in Simpson's index reciprocal (1/Ds = 1.750). The result suggested that Site 1 possessed a more favorable habitat for mangroves than Site 2 and Site 3.

The difference in quantified mangrove species per sampling site was caused by the uneven distribution of mangrove species driven by the following factors such as human inhabitants near the

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sampling sites, anthropogenic activities, and soil quality. Site 1 is located near the Kaingen River's entrance and is more likely inhabited by households, and on its other side, a river's flash flood barrier was constructed. Site 2 was usually affected by human activities such as fishing and pathway for boats. Since there were few households on this site, residents are likely to throw waste within the open bodies of water due to insufficient land areas. Furthermore, only one side of Site 3 is inhabited by mangrove trees,

while the other side is an open body of water separating Bacoor Bay from Manila Bay. Based on Table 10, only two mangrove species were found in Site 1 and Site 3, while three species were found in Site 2. The data showed that even though Site 1 was low in species richness, the site possessed much-distributed mangrove trees than other sampling sites. Both sites 2 and 3 have uneven mangrove distribution, hence, affecting the result of Shannon-Weiner and Simpon's indices. As supported by Cañizares et al., (2016), the result of their study showed, although Brgy. Imelda of Dinagat Island has a relatively high species richness of mangroves, the uneven distribution of its species resulted in low diversity.

Another factor that affected mangrove species distribution is the soil quality. During the five-month sampling period, different concentrations of nitrogen, phosphorus, and potassium (NPK) were observed. Nitrogen for Site 1 ranged from 0-2 to >4.5 mg/L which is likely to possess less range of nitrogen concentration than the other two sites with both ranging from 3.6 to >4.5 mg/L. On the other hand, phosphorus concentrations have been consistent for Site 1 which ranged from 16-20 to >20 mg/L, while sites 2 and 3 have been consistent at >20 mg/L. It showed that Site 1 can acquire less phosphorus concentration. Both nitrogen and phosphorus are limiting nutrients for the growth of mangroves, high concentrations can inflect thriving mangrove ecosystems, whereas moderate concentrations are best for mangrove trees. Subsequently, the concentration of potassium among the three sampling sites is as follows: Site 1 (low to sufficient ++), Site 2 (low to sufficient), and Site 3 (low to sufficient +). It can be inferred that during the five- month sampling period, Site 1 can potentially yield a substantial amount if potassium (sufficient++) suitable for mangrove trees. In the mangrove ecosystem, potassium is an essential nutrient that helps mangroves to regulate protein synthesis, osmotic pressure, and photosynthesis.

To determine the similarity of the three sampling sites in terms of mangrove species composition, Sorensen's Index of Similarity was used. Table 14 showed the summarized result of an index of similarity between Site 1 and Site 2, Site 2 and Site 3, and Site 1 and Site 3.

Table 14. Sorensen's Index of Similarity of each study site in Kaingen River, Kawit, Cavite.

Sites	Index of Similarity (%)
Sites 1 and Site 2	80.00
Site 2 and Site 3	80.00
Site 1 and Site 3	100.0

The highest similarity index was found between sites 1 and 3, at 100.0%, while the lowest was found between sites 1 and 2 and between sites 2 and 3 at 80.00%. Possible explanations include the changes in water salinity leading to the introduction of new species on each site. In addition, a few numbers of Xylocarpus granatum species in the area may be due to its competition with Avicennia alba since they are both exclusively pollinated by animals, while Rhizophora mucronata is wind or self-pollinated.

Moreover, the location of Site 1 and Site 3 could also be a factor that contributed to their similarity index. Both areas were affected by anthropogenic activities, creating large anthropogenic disturbances present in the area. Natural factors may have also contributed to the seed dispersal of the mangrove species since the mangrove forest is a sanctuary for waterbirds.

4.11. Amount of Carbon Stored and Sequestered Per Mangrove Species

The mangrove species were identified using Dr. Jurgenne H. Primavera's Manual Field Guide and verified by the Jose Vera Santos Memorial Herbarium Institute. Table 15 presented the total biomass of each mangrove species and their corresponding amount of carbon stored and sequestered in tons per hectare.

Table 15. Carbon Stored and Carbon Dioxide (CO_2) Sequestered of each Mangrove Species in all sampling sites in Kaingen River, Kawit, Cavite.

Mangrove Species	Abundance per Species	GBH Range (cm)	DBH Range (cm)	Mean Total Biomass (t/ha)	Carbon Stored (tC/ha)	CO_2 Sequestered (tCO_2/ha)
Avicennia alba	32	24.00 – 172.7	7.640-54.97	69.85	34.92	128.06
Xylocarpus granatum	11	10.00 – 47.00	4.270-14.96	3.367	1.683	6.173
Rhizophora mucronata	190	10.00 – 67.95	3.180-24.06	70.31	35.16	128.92

The calculated aboveground biomass (AGB) and belowground biomass (BGB) were summed to obtain the total biomass in tons per hectare (t/ha) and multiplied by the conversion factor of 0.50 to obtain the amount of carbon stored as referenced from the Intergovernmental Panel on Climate Change (Harishma et al., 2020). Among the three identified species present in the Kaingen River, Rhizophora mucronata has the highest total biomass calculated which yielded the highest carbon stored equivalent to 35.16 tC/ha, while the amount of carbon dioxide sequestered of the species, obtained by multiplying the carbon stored by 3.667, resulted to 128.92 tCO2/ha. This is followed by Avicennia alba which stored 34.92 tC/ha of carbon and sequestered 128.06 tCO2/ha carbon dioxide. Lastly, the least carbon stored, and carbon dioxide sequestered was yielded by Xylocarpus granatum which is equivalent to 1.683 tC/ha and 6.173 tCO2/ha.

The amount of carbon stored and sequestered were both influenced by the population of each mangrove species. As indicated in Table 15, Rhizophora mucronata garnered the highest total biomass, carbon stored, and carbon dioxide sequestered due to its dominance in terms of abundance equivalent to 190 individual trees. Diana et.al (2021) stated that the carbon absorption rate is higher in a few species, such as Rhizophora mucronata, in which many of its trees are scattered throughout sites 2 and 3. However, Avicennia alba yielded results with only a marginal difference in the same categories despite only having 32 individual mangroves in all three sites. This may be attributed to the diameter size of each mangrove species, in which the same publication stated, that trees with greater diameter at breast height have greater carbon-storing and accumulation capabilities. This explained why Avicennia alba is not far behind Rhizophora mucronata in terms of storing and sequestering carbon due to its massive diameter size ranging from 7.640-54.97 cm despite its small abundance. Lastly, Xylocarpus granatum yielded the least amount of carbon stored and sequestered due to the combination of both its low abundance in the area and smaller diameter size only ranging from 4.270-14.96 cm.

Based on these findings, the presence of Avicennia alba should be protected and conserved in the Kaingen River. Hence, plant more of this species since it can sequester more CO2 compared to other mangrove species.

4.12. Calculated Carbon Stored and Sequestered of Mangrove Trees found in Kaingen River

The Carbon Stored and Sequestered were calculated by determining first the Girth at Breast Height (GBH) and Diameter Breast Height (DBH) of individual species of mangroves present in 3 sampling sites of Kaingen River, Kawit, Cavite. After the verification of mangrove species, the Wood Density (WD) of each species was identified on the official website of the World Agroforestry Wood

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Density Database. The Aboveground Biomass (AGB) and Belowground Biomass (BGB) were calculated using the values from the Mean DBH per species of mangrove present per site. After that, the sum of AGB and BGB divided by the area of the sampling site was calculated to get the value of Mean Total Biomass (MTB) in Kilogram per square meter (kg/m2) which was then converted into Tons per hectare (tC/ha). Lastly, Carbon Stored was calculated by multiplying the value of MTB by 0.50, whereas Carbon Sequestered was calculated by multiplying the value of MTB by 3.667. Moreover, presented in Table 8 is the summary of the calculation of Carbon Stored and Sequestered.

Table 16. Carbon Stored and Sequestered of Mangrove Species of sites 1, 2, and 3 in Kaingen River, Kawit, Cavite.

Site	Aboveground Biomass (kg)	Belowground Biomass (kg)	Mean Total Biomass (tC/ha)	Carbon Stored (tC/ha)	CO_2 Sequestered (tCO_2/ha)
1	12145.35	4205.67	59.20	29.60	108.54
2	4276.35	2090.53	23.05	11.53	42.27
3	12277.50	4716.35	61.53	30.76	112.81
		TOTAL		**71.89**	**263.62**

Based on the results shown in Table 16, showed that Site 3 has the highest aboveground biomass (AGB) with a value of 12277.50 kg, followed by Site 1 with an AGB value of 12145.35 kg, and Site 2 with an AGB value of 4276.35 kg. For belowground biomass (BGB), Site 3 has the highest BGB value of 4716.35 kg, followed by Site 1 with a BGB value of 4205.67 kg, and Site 2 with a BGB value of 2090.53. For mean total biomass, Site 3 has the highest value with 61.53 tC/ha, followed by Site 1 with 59.20 tC/ha, and Site 2 with 23.05 tC/ha. For carbon stored, Site 3 has the highest value with 30.76 tC/ha, followed by Site 1 with 29.60 tC/ha, and Site 2 with 11.53 tC/ha. Lastly, for carbon sequestered, Site 3 has the highest CO2 stored with a value of 112.81 tCO2/ha, followed by Site 1 with 108.54 tCO2/ha, and Site 2 with 42.27 tCO2/ha.

The amount of carbon that can be stored by mangroves in their roots and leaves is proportional to the age of the mangroves. The high amount of carbon stored in sites 1 and 3 is due to the older age of mangrove trees in the two sites as referenced by greater diameter at breast height (DBH) measured, whereas the amount of carbon stored in Site 2 was relatively lower because of the smaller DBH. This is supported by Carnell et al. (2022), in which it was stated that the age of mangroves has a significant effect on the amount of carbon stocks, wherein mangroves with ages ranging from 17 to 35 years old double the carbon stored and sequestration rates. On the contrary, the amount of carbon sequestered by sites 1 and 3 is significantly lower than Site 2 despite having high carbon stocks because of the difference in mangrove abundance and spatial distribution. The mangrove trees in Site 2 are more condensed due to the smaller DBH which allows the mangroves to be relatively closer to each other and hence, give way to the growth of more mangrove trees which explains the site's higher abundance and more carbon sequestered. Mangrove trees in sites 1 and 3, on the other hand, are older and have greater DBH which explained why mangroves in the two sites are scattered and less in number – contributing to the lower amount of carbon sequestered. Lastly, Sites 1 to 3 which represented the mangrove ecosystem of Kaingen River, Kawit, Cavite yielded a total carbon stored of 71.89 tC/ha and a total carbon sequestered of 263.62 tCO2/ha.

The mangrove forest in Kaingen River has the potential to sequester CO2 in the environment since Site 3 alone can sequester 112.81 tCO2/ha. Accumulatively, sites 1-3 sum up approximately 35% of the entire Kaingen River. Therefore, 35% of the entire Kaingen River accumulated 71.89 tC/ha and sequestered 263.62 tCO2/ha. Even though Site 3 has a greater number of matured mangroves than Site 1, mangroves in Site 1 were able to store and sequester higher concentrations of carbon and carbon dioxide, respectively. Moreover, Site 2 has the highest number of mangroves that are currently in their 1-2 years of age. As concluded in the study of Wiarta et al. (2019) Rhizophora apiculata sequestered more carbon in their 5th year compared to the amount of carbon sequestered in their 1st and 3rd year. This meant that in another 3-4 years, all mangroves that are currently present in

Kaingen River, especially in Site 2, will reach their maturity stage and will allow them to maximize their potential to sequester CO2.

Chapter V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1. Summary

The study was conducted to determine the potential of mangrove trees present in Kaingen River, Kawit, Cavite, to store and sequester carbon from the environment, as well as identify both water and soil quality and its relationship with the abundance of mangroves throughout the five-month sampling period in three established sampling sites. The three sampling sites were located (1) near the aquaculture site and residential area of Barangay Kaingen, (2) between the aquaculture sites, and (3) the area located at the end of Kaingen River. Water quality was assessed by collecting and measuring physicochemical parameters such as water temperature, pH, turbidity, total dissolved solids, salinity, and dissolved oxygen through in-situ testing. Whereas phosphates and nitrates were sent to Mach Union Laboratories Inc. for testing. The soil quality on the other hand was tested by the researchers using the BSWM Soil Test Kit, while other parameters excluded from the test kit such as soil texture, water holding capacity, and organic matter were analyzed by the Bureau of Soils and Water Management (BSWM) laboratory. Mangrove species were identified using Dr. Jurgenne H. Primavera's Manual Field Guide (2009) and (2022) and were verified by the Jose Vera Santos Memorial Herbarium, Institute of Biology in the University of the Philippines – Diliman. Diversity indices including the Shannon-Weiner Index, Simpson's Diversity Index, as well as the Sorensen Index of Similarity, which was used to determine the abundance and diversity of mangroves found in Kaingen River. The amount of CO2 stored and sequestered by mangrove trees were obtained using a non-destructive method of collection by measuring the diameter at breast height (DBH) with the application of allometric equations introduced by Komiyama et al. (2006) for aboveground and belowground biomass. In addition, the use of 0.5 carbon conversion factor was used as referenced on Intergovernmental Panel on Climate Change (IPCC) which was indicated from the studies conducted by Harishma et al. (2020) and Indrayani et al. (2021).

The results for water quality of Kaingen River yielded results that were based on the DENR Standard for Class C Waters. This includes water temperature ranging from 26.53 C – 34.83 C, turbidity (8.000 NTU – 24.00 NTU), conductivity (1379.3 µS/cm – 9276.7 µS/cm), TDS (896.5 mg/L – 6029.9 mg/L), salinity (689.7 mg/L – 4638.4 mg/L), pH (pH 7.54 – 8.15), DO (3.0 mg/L – 9.5 mg/L), and phosphates 0.463 mg/L – 0.815, which exhibited negligible correlation but not significant. Nitrates (0.1 mg/L – 0.29 mg/L), however, exhibited a low negative correlation but also not significant. On the other hand, soil quality standard was based on the United States Department of Agriculture which yielded soil organic matter (0.66% - 12.28%), organic carbon (0.38% - 7.14%), nitrogen (Low – Very high) and potassium (Low to Sufficient++) which have low negative correlation and has no significant relationship. Phosphorus (High – Very High), water holding capacity (38.1% - 121.4%), and temperature (26.0°C - 31.0°C) yielded negligible correlation and no significant relationship whereas pH (pH 5.8) cannot be computed and therefore, cannot describe its relationship with the abundance of mangrove trees.

According to the Kruskal-Wallis Test, the water quality parameters that have a significant difference among the three sites with respective months are the following: temperature having a significant difference in November ($p = 0.023$) and January ($p = 0.038$); turbidity in November to March ($p = 0.018$); TDS, salinity, and conductivity on December ($p = 0.027$), January ($p = 0.050$), February ($p = 0.027$), and March ($p = 0.027$); pH on November to March ($p = 0.018$); and dissolved oxygen on November ($p = 0.026$) and February ($p = 0.048$). Whereas the Friedman test for water quality parameters shows no similarities among the three sites. Temperature on sites 1 ($p = 0.031$) and 3 ($p = 0.017$) while Site 2 showed a significant difference at ($p = 0.189$); TDS in sites 1 ($p = 0.017$), 2 ($p = 0.022$), and 3 ($p = 0.017$); salinity in sites 1 ($p = 0.017$), 2 ($p = 0.022$), and 3 ($p = 0.017$); conductivity in

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sites 1 ($p = 0.017$), 2 ($p = 0.022$), and 3 ($p = 0.017$); pH in sites 1 ($p = 0.022$), 2 ($p = 0.017$), and 3 ($p = 0.017$); and DO in sites 1 ($p = 0.018$), 2 ($p = 0.017$), and 3 ($p = 0.022$). However, the Friedman test shows having a significant difference in turbidity for sites 1-3 ($p = 0.017$), phosphates ($p = 0.406$), and nitrates ($p = 0.406$).

According to the Kruskal-Wallis Test, the following soil parameters were observed to have no significant differences in the measurement across the three sampling sites during the five-sampling period: temperature ($p = 0.398$), soil pH ($p = 1.000$), nitrogen ($p = 0.135$), phosphorus ($p = 0.368$), and potassium ($p = 0.323$). On the other hand, the water-holding capacity ($p = 0.027$), organic matter ($p = 0.008$), and organic carbon ($p = 0.008$) were observed to have significant differences in the measurements. There were significant differences in the measurement of water holding capacity across the three sampling sites between sites 1 and 3 ($p = 0.020$) and sites 2 and 3 ($p = 0.020$), while no significant difference was observed between sites 1 and 2 ($p = 1.000$). For organic matter, significant differences were observed between sites 1 and 3 ($p = 0.003$) and sites 2 and 3 ($p = 0.020$), while no significant difference was observed between sites 1 and 2 ($p = 0.525$). On the other hand, the differences in the measurement of organic carbon across the three sampling sites were observed between sites 1 and 3 ($p = 0.020$) and sites 2 and 3 ($p = 0.003$), while no significant difference between sites 1 and 2 ($p = 0.525$). The Friedman test shows that there is no significant differences in the measurement of the following parameters for Sites 1 to 3 across the five-month sampling period: water holding capacity ($p = 0.189$), temperature ($p = 0.137$), pH ($p = 1.000$), organic matter ($p = 0.308$), organic carbon ($p = 0.308$), nitrogen ($p = 0.406$), phosphorus ($p = 0.406$) and potassium ($p = 0.322$).

According to the inventory of mangroves, Rhizophora mucronata (Bakhaw babae) was the most abundant mangrove species among all identified mangrove species present in the three sites of the Kaingen River. This is followed by Avicennia alba (Bungalon), while the least abundant mangrove species is Xylocarpus granatum (Tabigi).

Among the three identified species of mangroves present in the three established sites of Kaingen River, Rhizophora mucronata has the highest total biomass calculated which also yielded the highest carbon stored and amount of carbon dioxide sequestered. This is followed by Avicennia alba then, the least carbon stored and carbon dioxide sequestered was yielded by Xylocarpus granatum. Accumulatively, all three established sites sum up approximately 35% of the entire Kaingen River. Therefore, 35% of the entire Kaingen River was able to accumulate 71.89 tC/ha of carbon stored and sequester 263.62 tCO_2/ha of carbon dioxide. The results of the study urge the residents and authorities of Barangay Kaingen to practice conservation and protection measures for the mangrove ecosystem and its benefits.

5.2. Conclusion

Based on the result of the study, the following conclusions were drawn:

1. Different anthropogenic activities in the area may affect the Kaingen Riverine system. Some of these activities include but are not limited to bathing, washing clothes, disposal of household and chemical waste, excretion, and bathing of animals.
2. There are varying trends in the result of water quality in terms of temperature, turbidity, pH, DO, phosphate, and nitrates based on the DENR Standard for Class C Waters and TDS, salinity, and conductivity.
3. There are varying trends in the result of soil quality in terms of soil texture, water holding capacity, soil temperature, soil pH, organic matter, organic carbon, and NPK.
4. Three species of mangroves were identified in the Kaingen River: Avicennia alba, Rhizophora mucronata, and Xylocarpus granatum.
5. A total of 71.89 tC/ha stored, and 263.62 tCO_2/ha sequestered by the mangrove trees in Kaingen River were calculated using allometric equations.
6. There is no significant relationship between water and soil quality collected in three (3) sampling sites per sample month and five (5) sampling periods per site.

7. The results show no correlation between water quality and the abundance of mangroves, but there was a correlation between soil quality and the abundance in distribution of mangrove trees species in the Kaingen River.

5.3. Recommendations

Based on the results and discussion obtained, the following recommendations were made:

1. Use of mangrove plant parts such as leaves and seedlings to determine concentrations of pollutants.
2. Include a survey on threats to mangroves based on the activities in the Kaingen River.
3. Include carbon footprint and/or carbon emission in terms of carbon generated by vehicles, electricity consumption, and use of fuel of the entire barangay Kaingen, Kawit, Cavite, Philippines.
4. Conduct air quality monitoring in the Kaingen River.
5. Conduct a survey of Avifauna species in Kaingen River.
6. Analyze heavy metals of mangrove roots and water in Kaingen River.
7. Test for organophosphates and their relationship to mangroves.
8. Conduct economic valuation of the mangrove ecosystem in Kaingen River.

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Appendix

Appendix A. Sampling Site/Station

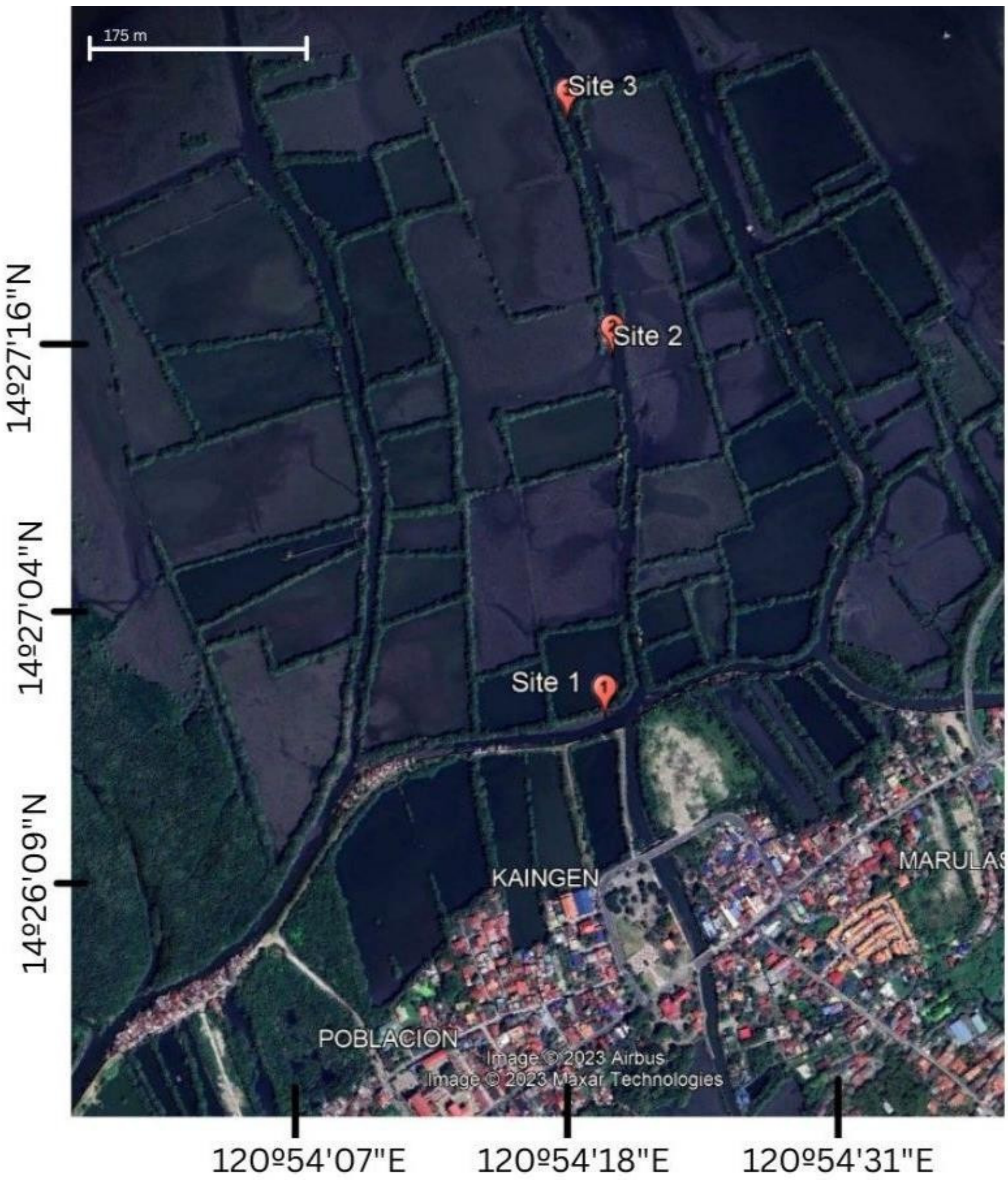

Figure A1. Location map of Kaingen River in Kawit, Cavite, Philippines with the three (3) sampling sites.

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Figure A2. Sampling Site 1 is located near the aquaculture site of barangay Kaingen and the residential area.

Figure A3. Sampling Site 2 is located in between the aquaculture sites along the Kaingen River.

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Figure A4. Sampling Site 3 is located next to Sampling Site 2 and end of the Kaingen River.

Appendix B. Schematic Diagram

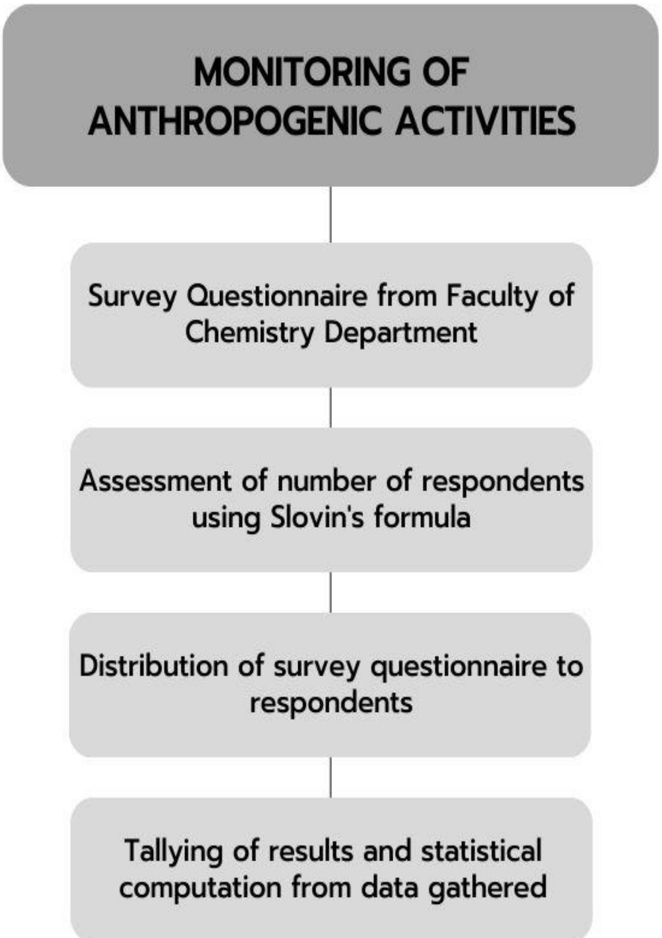

Figure B1. Diagram Showing the Process of Monitoring the Anthropogenic Activities Occurring in the Kaingen River.

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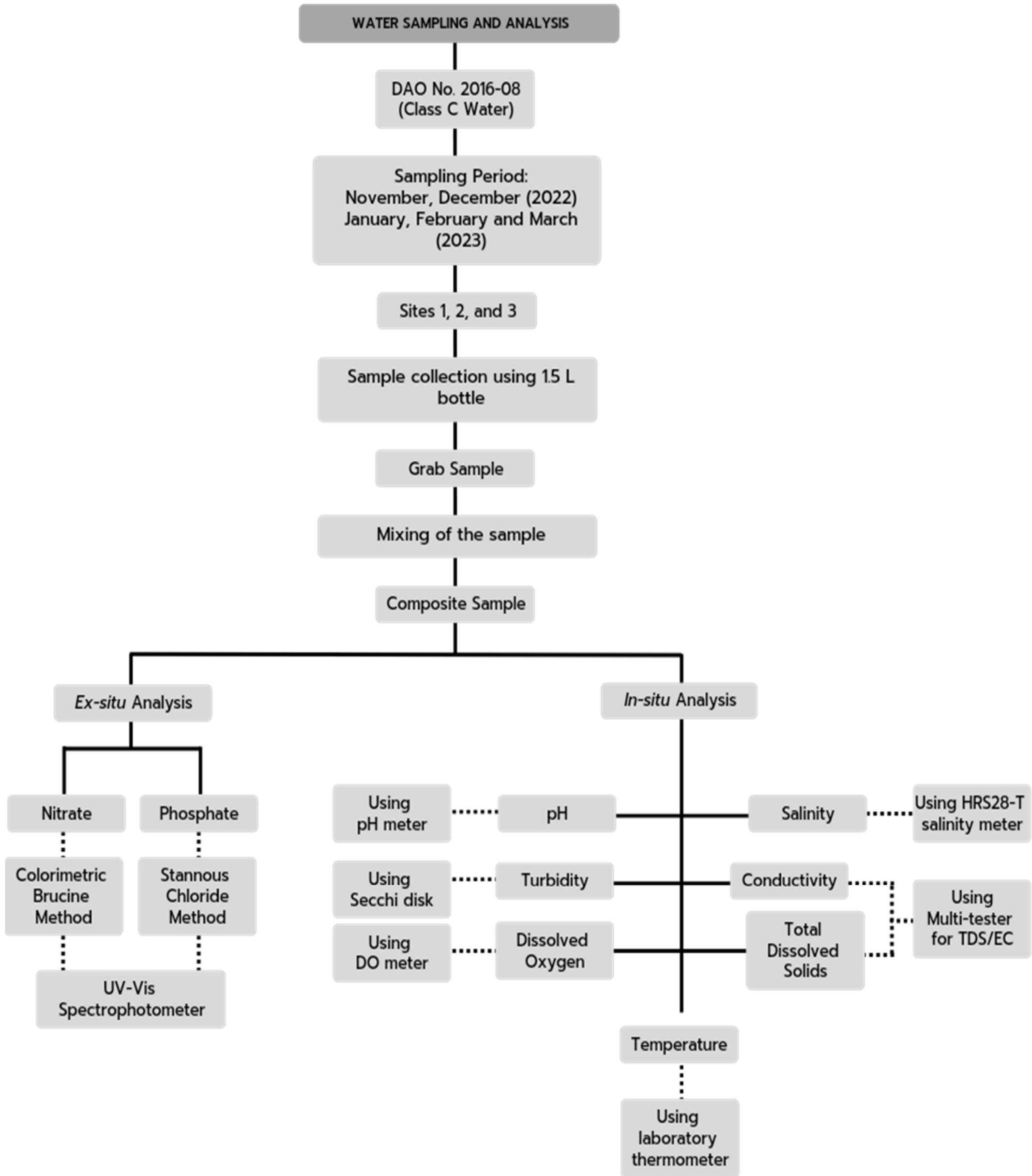

Figure B2. Diagram Showing the Process of Water Sampling and Analysis Done in Kaingen River.

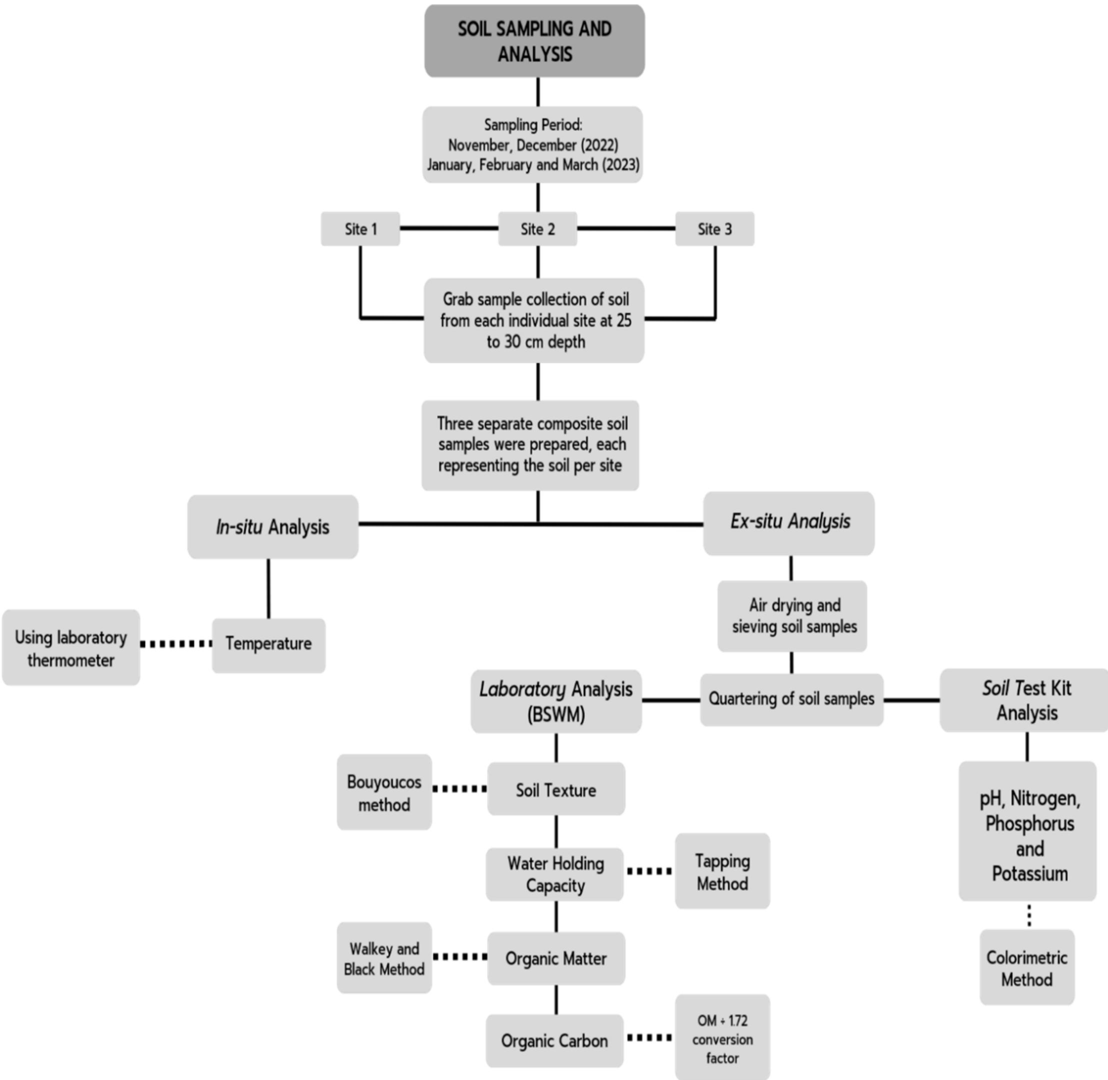

Figure B3. Diagram Showing the Process of Soil Sampling and Analysis Done in Kaingen River.

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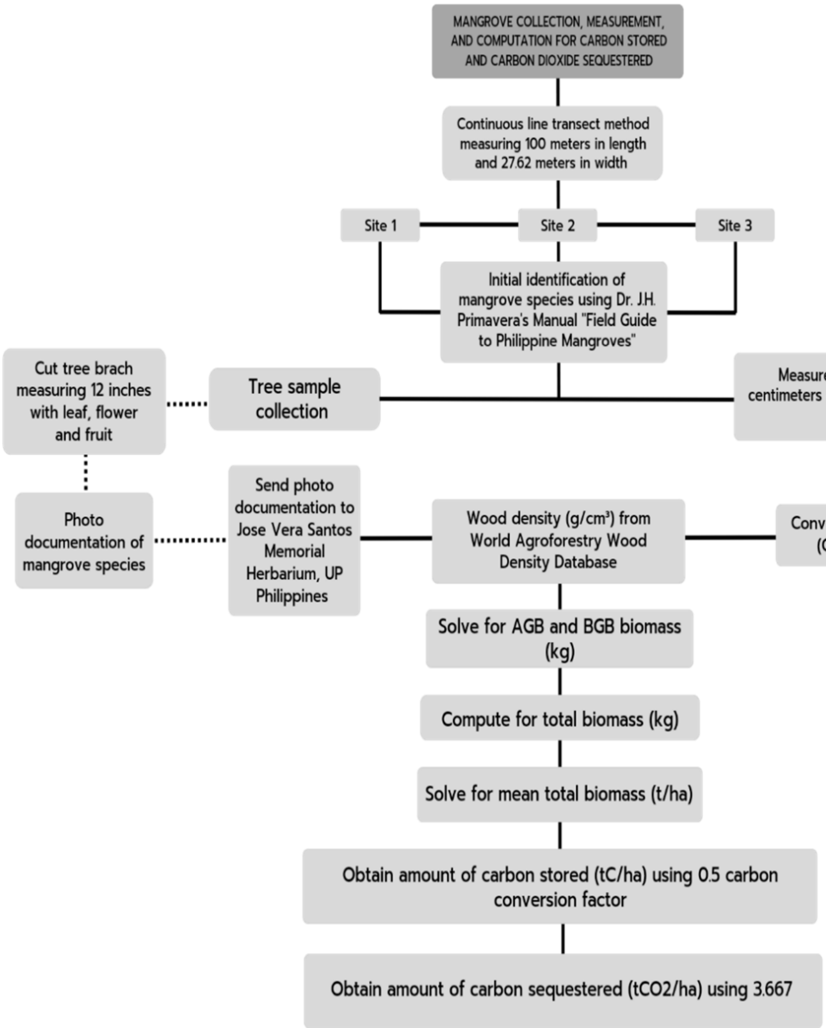

Figure B4. Diagram Showing the Process of Mangrove Collection, Measurement and Computation for Carbon Stored and Carbon Dioxide Sequestered Done in Kaingen River.

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Appendix C. Survey Questionnaire

Survey Questionnaire

Numerical Control: Date:

Location: Time:

I. Demographic Profile (Impormasyong Katanungan)

Name (Pangalan): ☐ ☐

Gender (Kasarian): Male (Lalaki) Female (Babae)

Age (Edad): ☐ 18 – 30 ☐ 31-40

☐ 41-50 ☐ 51 above

Civil Status (Kalagayang Sibil):

☐ Single (Walang asawa) ☐ Widowed (Biyuda o Biyuda)

☐ Married (May asawa) ☐ Separated (Hiwalay sa asawa)

Educational Attainment (Natapos):

☐ Elementary (Elementarya) ☐ College (Kolehiyo)

☐ Highschool (Sekundarya) ☐ Vocational (Bokasyonal)

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Occupation (Trabaho):

Members of the family (Bilang ng miyembro ng pamilya):

☐ 2-4 ☐ 5-7 ☐ 8-10 ☐ 11 or more

Do you have a proper sewage system of your household?

☐ Yes ☐ No

II. Anthropogenic Activities near the Kaingen River (Mga karaniwang gawain malapit sa Ilog ng Kaingen)

Direction: Kindly check the number, which corresponds to your practices near Kaingen River.

(Panuto: Maari lamang pong pakicheck-an and bilang na aangkop sa inyong gawain malapit sa Ilog)

4 – Always (Palagi)

3 – Often (Malimit)

2 – Seldom (Bihira)

1 – Never (Hindi kailanman)

	1	**2**	**3**	**4**	**Location**
1. Fishing (Pangingisda)					
2. Bathing (Paliligo)					
3. Washing of clothes (Paglalaba ng damit)					

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4. Throwing garbage (Pagtatapon ng basura)					
5. Disposing of chemical waste (Pagtatapon ng kemikal)					
6. Excreting (Pagdumi / Pagpapadumi ng hayop)					
7. Bathing of animals (Pagpapaligo ng alagang hayop)					

III. Protection and Conservation Measures of Kaingen River (Pangangalaga at mga bagay na makatutulong na pagyamanin ang Ilog)

Direction: Check the number which corresponds your honest answer.

(Panuto: Pakicheck-an ang bilang na naangkop sa inyong kasagutan)

4 – Strongly agree (Lubos na sumasang-ayon)

3 – Agree (Sumasang-ayon)

2 – Disagree (Hindi sumasang-ayon)

1 – Strongly Disagree (Lubos na hindi sumasang-ayon)

Protection and Consultation Measures	External Occurrence

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	1	2	3	4
1. Preventing people from unlawful behavioral that would result in the rivers erosion and deterioration. (Pagbabawal sa mga tao hindi kaaya-ayang gawain na resulta sa pagkasira ng Ilog ng Kaingen)				
2. Taking part in community and environmental groups in order to save the river (Pagsali sa mga pangkat – pangkalikasan na tumutulong sa pangangalaga ng Ilog ng Kaingen)				
3. Creating groups and organizations that will oversee the river's management. (Pagbuo ng mga pangkat at samahan na patuloy na mangangalaga ng Ilog ng Kaingen)				
4. Putting in place River conservation guidelines, policies, and ordinances. (Pagpapatupad ng mga batas at alituntunin ukol sa pangangalaga ng Ilog ng Kaingen)				
5. Utilizing environmentally friendly sustainable fishing and farming methods. (Paggamit ng mga ligtas at naangkop na pamamaraan sa pangingisda at iba pang gawaing pang-agrikultura)				
6. Planning, River managament in collecting fishes and other resources. (Pagplaplano ukol sa pangunguha ng isda at iba pang panglikas na yaman)				
7. Garbage and other wastes must not be deposited on the river. (Pag-iwas sa				

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pagtatapon ng basura sa Ilog ng Kaingen)				
8. Supporting environmental programs to maintain and conserve the river's flora and fauna. (Pagsuporta sa mga programang pang-turismo upang mapangalagaan ang mga halaman at hayop sa Ilog ng Kaingen)				

IV. Natural Occurrences (Natural na Pangyayari)

Directions: Please identify the extent of the following natural occurences near or within Kaingen River. (Pakitukoy ang lawak ng mga sumusunod na natural na pangyayari malapit o mismo sa Ilog ng Kaingen)

5 – Always (*Palagi*)

4 – Frequent (*Madalas*)

3 – Often (*Malimit*)

2 – Seldom (*Bihira*)

1 – Never (*Hindi Kailanman*)

Natural occurrences (Mga natural na pangyayari)	**1**	**2**	**3**	**4**	**5**
Precipitation runoff (*Pagdaloy ng tubig mula sa pag-ulan*)					
Fishing (*pangingisda*)					
Tides (*Taas ng tubig*)					
Weathering and erosion (*Pagguho ng mga lupa o bato at pagbabago nito dulot ng panahon*)					
Debris and leaf composition (*Pagkabulok ng mga labi*)					

Appendix D. Survey Results

Table D1. Demographic Profile.

		Total No. of Respondents	%
Gender	Male	164	48.81
	Female	172	51.19
Age	18 – 30	172	51.19
	31 – 40	51	15.18
	41 – 50	39	11.61
	51 – above	74	22.02
Civil Status	Single	189	56.25
	Married	111	33.04
	Widowed	25	7.44
	Separated	11	3.27
Educational Attainment	Elementary	35	10.42
	High School	160	47.62
	College	133	39.58
	Vocational	8	2.38
Members of the Family	0 – 1	1	0.30
	2 – 4	135	40.18
	5 – 7	167	49.70
	8 – 10	24	7.14
	11 – more	9	2.68
Proper Sewage System	Yes	221	65.77
	No	115	34.23

Table D2. Anthropogenic Activities Near Kaingen River.

	1	2	3	4	Respondents	X	REMARKS
Fishing	194	44	46	52	336	1.87	Seldom
Bathing	202	45	38	51	336	1.82	Seldom
Washing of clothes	258	29	21	27	335	1.45	Seldom
Throwing garbage	220	46	27	42	335	1.67	Seldom
Disposing of chemical waste	286	22	12	16	336	1.28	Seldom
Excreting	263	29	23	21	336	1.41	Seldom
Bathing of Animals	276	30	16	14	336	1.31	Seldom

Range: Always 3.26-4.00 **Often** 2.51-3.25 **Seldom** 1.76-2.50 **Never** 1.00-1.75.

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Table D3. Protection and Conservation Measures of Kaingen River.

	1	2	3	4	Respondents	X	REMARKS
Preventing people	17	10	71	238	336	1.87	Strongly Agree
ronmentalgroups	16	14	91	215	336	1.82	Strongly Agree
Creating groups	16	15	106	198	335	1.45	Strongly Agree
River policies	17	8	88	223	336	1.67	Strongly Agree
ıstainable methods	17	14	81	224	336	1.28	Strongly Agree
River management	21	25	81	209	336	1.41	Strongly Agree
Deposits	9	8	52	266	335	1.31	Strongly Agree

Range: Strongly Agree 3.26-4.00 **Agree** 2.51-3.25 **Disagree** 1.76-2.50 **Strongly Disagree** 1.00-1.75.

Table D4. Natural Occurrences in the Kaingen River.

	1	2	3	4	5	Respondents	X	REMARKS
PrecipitationRunoff	53	42	68	71	102	336	3.38	Often
Fishing	73	36	59	60	108	336	3.28	Often
Tides	44	57	82	74	79	336	3.26	Often
Weathering and erosion	169	71	37	35	24	336	2.03	Seldom
Debris and leaf decomposition	144	61	56	36	39	336	2.30	Seldom
PrecipitationRunoff	53	42	68	71	102	336	3.38	Often
Fishing	73	36	59	60	108	336	3.28	Often

Range: Always 4.30-5.00 **Frequent** 3.50-4.20 **Often** 2.70-3.40 **Never** 1.00-1.80.

Appendix E. Physicochemical and Biological Properties of Water and Soil

Republic of the Philippines
Department of Environment and Natural Resources
Visayas Avenue, Diliman, Quezon City
Tel Nos. 929-6626 to 29; 929-6633 to 35
926-7041 to 43; 929-6252; 929-1669
Website: http://www.denr.gov.ph / E-mail: web@denrgov.ph

DENR Administrative Order
No. 2016 -08

MAY 2 4 2016

SUBJECT: **Water Quality Guidelines and General Effluent Standards of 2016**

Pursuant to Section 19e and 19f of Republic Act (RA) 9275, otherwise known as the Philippine Clean Water Act of 2004, and Executive Order 192 (Providing the Reorganization of the Department of Environment, Energy and Natural Resources; Renaming it as the Department of Environment and Natural Resources) dated 10 June 1987, the Department of Environment and Natural Resources (DENR) hereby adopts and promulgates these Water Quality Guidelines (WQG) and General Effluent Standards (GES).

SECTION 1.0 Basic Policy. It is the policy of the State to pursue a policy of economic growth in a manner consistent with the protection, preservation and revival of the quality of our fresh, brackish and marine waters.

SECTION 2.0 Objectives. This Administrative Order is issued to provide guidelines for the classification of water bodies in the country; determination of time trends and the evaluation of stages of deterioration/enhancement in water quality; evaluation of the need for taking actions in preventing, controlling, or abating water pollution; and designation of water quality management areas (WQMA). In addition, this Order is issued to set the General Effluent Standards (GES).

SECTION 3.0 Scope and Coverage. The WQG applies to all water bodies in the country: freshwaters, marine waters, and groundwater; and shall be used for classifying water bodies, determining time trends, evaluating stages of deterioration or enhancement in water quality, and as basis for taking positive actions in preventing, controlling, or abating water pollution. Moreover, this WQG shall be used in the process of designating WQMA.

The GES applies to all point sources of pollution, regardless of volume, that discharge to receiving body of water or land. The GES shall be used regardless of the industry category.

SECTION 4.0 Definition of Terms. For purposes of this Order, the following terms shall have the following meanings:

a) **"Annual Average"** means the sum of all values in one year divided by the number of values.

b) **"Assimilative Capacity"** refers to the amount of contaminant load that can be discharged to a specific water body without exceeding the water quality guidelines.

c) **"Discharge"** includes, but is not limited to, the act of spilling, leaking, pumping, pouring, emitting, emptying, releasing or dumping of any material into a water body or onto land from which it might flow or drain into said water.

d) **"Effluent"** means discharges from known source, which is passed into a body of water or land, or wastewater flowing out of a manufacturing plant, industrial plant including domestic, commercial, and recreational facilities.

e) **"Establishment"** refers to a recognizable economic unit under a single ownership or control, i.e., under a single legal entity, which engages in one or predominantly one kind of economic activity at a single physical location. This includes industrial, commercial, and institutional establishments.

f) **"Freshwater"** means water containing less than 500 parts per million dissolved common salt, sodium chloride, such as that in groundwater, rivers, ponds and lakes.

g) **"General Effluent Standards (GES)"** means any legal restriction or limitation on quantities, rates, and/or concentrations or any combination thereof, of physical, chemical or biological parameters of effluent which a person or point source is allowed to discharge into a body of water or land; that is applicable to all industry categories and defined according to the classification of the receiving water body.

h) **"Geometric Mean"** is the n^{th} root of the product of a series of n numbers. It is a calculation to determine an average when the set of numbers covers a wide range.

i) **"Groundwater"** refers to subsurface water that occurs beneath a water table in soils and rocks, or in geological formations.

j) **"Industry"** means the set of all production units engaged primarily in the same or similar kinds of productive economic activity.

k) **"Marine Waters"** refer to waters with salinity levels not less than 30 parts per thousand, at least 95 percent of the time.

l) **"Maximum Allowable Limit"** are values that should not be exceeded at any point in time.

m) **"Natural Background Concentration"** refers to the amount of naturally occurring chemical substances derived/originating from natural processes in the environment.

n) **"Navigable Waters"** means the waters of the Philippines, including the territorial sea and inland waters suitable for water transport.

o) **"Point Source"** means any identifiable source of pollution with specific point of discharge into a particular water body".

p) **"Pollutant"** refer to any substance, whether solid, liquid, gaseous or radioactive, which directly or indirectly:

(i) alters the quality of any segment of the receiving water body so as to affect or tend to affect adversely any beneficial use thereof;
(ii) is hazardous or potentially hazardous to health;
(iii) imparts objectionable odor, temperature change, or physical, chemical

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or biological change to any segment of the water body;or

(iv) is in excess of the allowable limits or concentrations or quality standards specified, or in contravention of the condition,limitation or restriction prescribed in RA 9275.

q) **"Potable Water"** means water suitable (both health and acceptability considerations) for drinking and cooking purposes.

r) **"Primary Contact Recreation"** refers to any form of recreation, where there is intimate contact of the human body with water, such as swimming, water skiing, or skin diving.

s) **"Primary Parameters"** are the required minimum water quality parameters to be monitored for each water body.

t) **"Protected Water"** refers to a watercourse or a water body, or any segment thereof, that is classified as a source of public water supply, harvesting of shellfish for direct human consumption, or that which is designated by competent a government authority or by legislation as a national marine park and reserve, including coral reef park and reserve.

u) **"Receiving Water Body"** refers to the water body into which surface water, wastewater, and effluent are discharged.

v) **"Secondary Parameters"** are other water quality parameters that shall be used in baseline assessments as part of the Environmental Impact Assessment and other water quality monitoring purposes.

w) **"Secretary"** means the Secretary of the Department of Environment and Natural Resources.

x) **"Significant Effluent Quality Parameters"** are parameters specific to the processes of an establishment.

y) **"Strong Wastewater"** refers to wastewater whose initial Biochemical Oxygen Demand (BOD) value before treatment is equal to or greater than 3,000 milligram per liter (mg/L).

z) **"Surface Waters"** refer to waters (e.g. rivers, lakes, bays, etc.) which are open to the atmosphere and subject to surface runoff.

aa) **"Treatment"** refers to any method, technique, or process designed to alter the physical, chemical, biological, or radiological character or composition of any waste or wastewater to reduce or prevent pollution.

bb) **"Water Body"** means both natural and man-made bodies of fresh, brackish, and saline waters, and includes, but is not limited to, aquifers, groundwater, springs, creeks, streams, rivers, ponds, lagoons, water reservoirs, lakes, bays, estuarine, coastal and marine waters. Water bodies do not refer to those constructed, developed and used purposely as water treatment facilities and/or water storage for recycling and re-use, which are integral to process industry or manufacturing.

cc) **"Water Pollution"** means any alteration of the physical, chemical or biological or radiological properties of a water body resulting in the impairment of its purity or quality.

dd) **"Water Quality Guidelines (WQG)"** refer to the level for a water constituent or numerical values of physical, chemical, biological, and bacteriological or radiological parameters which are used to classify water resources and their use, which do not result in significant health risk.

These are not intended for direct enforcement but only for water quality management purposes, such as determining time trends, evaluating stages of deterioration or enhancement of the water quality, and as basis for taking positive action in preventing, controlling, or abating water pollution.

ee) **"Water Quality Management Area (WQMA)"** are certain areas designated using appropriate physiographic units (i.e. watershed, river basins or water resources regions), having similar hydrological, hydrogeological, meteorological or geographic conditions which affect the physiochemical, biological and bacteriological reactions and diffusions of pollutants in the water bodies, or otherwise share common interest or face similar development programs, prospects or problems.

SECTION 5.0 Classification of Water Bodies. For purposes of maintaining water quality according to its intended beneficial usage, the following classification of water bodies shall be adopted (see Tables 1-2).

Table 1. Water Body Classification and Usage of Freshwater

Classification	Intended Beneficial Use
Class AA	Public Water Supply Class I – Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the latest PNSDW
Class A	Public Water Supply Class II – Intended as sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration and disinfection) to meet the latest PNSDW
Class B	Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, etc.)
Class C	1. Fishery Water for the propagation and growth of fish and other aquatic resources 2. Recreational Water Class II – For boating, fishing, or similar activities 3. For agriculture, irrigation, and livestock watering
Class D	Navigable waters

Note: For unclassified water bodies, classification shall be based on the beneficial use as determined by the Environmental Management Bureau (EMB).

Table 2. Water Body Classification and Usage of Marine Waters

Classification	Intended Beneficial Use
Class SA	1. Protected Waters – Waters designated as national or local marine parks, reserves, sanctuaries, and other areas established by law (Presidential Proclamation 1801 and other existing laws), and/or declared as such by appropriate government agency, LGUs, etc. 2. Fishery Water Class I – Suitable for shellfish harvesting for direct human consumption
Class SB	1. Fishery Water Class II – Waters suitable for commercial propagation of shellfish and intended as spawning areas for milkfish (*Chanos chanos*) and similar species 2. Tourist Zones – For ecotourism and recreational activities 3. Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, skin diving, etc.)

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Classification	Intended Beneficial Use
Class SC	1. Fishery Water Class III – For the propagation and growth of fish and other aquatic resources and intended for commercial and sustenance fishing 2. Recreational Water Class II – For boating, fishing, or similar activities 3. Marshy and/or mangrove areas declared as fish and wildlife sanctuaries
Class SD	Navigable waters

Note: For unclassified water bodies, classification shall be based on the beneficial use as determined by EMB.

SECTION 6.0 Water Quality Guidelines. The rules and regulations established in this section are intended to maintain and preserve the quality of all water bodies based on their intended beneficial usage and to prevent and abate pollution and contamination to protect public health, aquatic resources, crops, and other living organisms.

6.1 Guidelines for Water Quality (Freshwater and Marine Waters). The WQG provided for in Tables 3-6 shall be maintained for each water body classification. For purposes of this Order, the parameters defining the WQG are categorized as primary or secondary parameters.

Primary parameters (Table 3) are the required minimum water quality parameters to be monitored for each water body. Secondary parameters (Tables 4-6) are other water quality parameters to be used in baseline assessment as part of the Environmental Impact Assessment and other water quality monitoring purposes as defined in Table 3.1 (Recommended Parameters, Frequency and Duration of Sampling) of the Ambient Water Quality Monitoring Manual issued through EMB Memorandum Circular 2008-008.

Water quality monitoring procedures [i.e. water quality monitoring plan, sampling, quality assurance (QA), quality control (QC), etc.] shall also be in accordance with the above-mentioned EMB Memorandum Circular 2008-008.

Table 3. Water Quality Guidelines for Primary Parameters

Parameter	Unit	Water Body Classification								
		AA	A	B	C	D	SA	SB	SC	SD
BOD	mg/L	1	3	5	7	15	n/a	n/a	n/a	n/a
Chloride	mg/L	250	250	250	350	400	n/a	n/a	n/a	n/a
Color	TCU	5	50	50	75	150	5	50	75	150
Dissolved Oxygen[(a)] (Minimum)	mg/L	5	5	5	5	2	6	6	5	2
Fecal Coliform	MPN/100mL	<1.1	<1.1	100	200	400	<1.1	100	200	400
Nitrate as NO_3-N	mg/L	7	7	7	7	15	10	10	10	15
pH (Range)		6.5-8.5	6.5-8.5	6.5-8.5	6.5-9.0	6.0-9.0	7.0-8.5	7.0-8.5	6.5-8.5	6.0-9.0
Phosphate	mg/L	<0.003	0.5	0.5	0.5	5	0.1	0.5	0.5	5
Temperature[(b)]	°C	26-30	26-30	26-30	25-31	25-32	26-30	26-30	25-31	25-32
Total Suspended Solids	mg/L	25	50	65	80	110	25	50	80	110

Notes:
MPN/100mL – Most Probable Number per 100 milliliter
n/a – Not Applicable
TCU – True Color Unit
(a) Samples shall be taken from 9:00 AM to 4:00 PM.
(b) The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment.

Figure E1. DENR Water Quality Guidelines and General Effluent Standards of 2016.

 doi:10.20944/preprints202308.0371.v1

Table E2. Updated Water Quality Guidelines and General Effluent Standards for Selected Parameters.

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Department of Environment and Natural Resources
Visayas Avenue, Diliman, 1101 Quezon City
☎ (632) 927-6726; (632) 929-6626 loc. 2113; 2071; Fax (+632) 928-9732
E-mail: web@denr.gov.ph; Website: www.denr.gov.ph

JUN 30 2021

DENR ADMINISTRATIVE ORDER
No. 2021 - 19

SUBJECT: UPDATED WATER QUALITY GUIDELINES (WQG) AND GENERAL EFFLUENT STANDARDS (GES) FOR SELECTED PARAMETERS

Pursuant to Section 19e of Republic Act No. 9275, otherwise known as the *Philippine Clean Water Act of 2004,* which states that the Department of Environment and Natural Resources, as the lead agency, shall enforce, review and revise within twelve (12) months from the effectivity of this Act water quality guidelines after due consultation with the concerned stakeholder sectors; *Provided*, that the Department, in coordination with appropriate agencies shall review said guidelines every five (5) years or as need arises; and Section 19f states that the Department shall review and set effluent standards every (5) years from the effectivity of this Act or sooner as determined by the Department; and Sections 8 and 9 of the Department of Environment and Natural Resources Administrative Order (DAO 2016-08), otherwise known as the Water Quality Guidelines (WQG) and General Effluent Standards (GES) of 2016, which provides for the modification of WQG and GES and its periodic review, this Order is hereby issued.

Section 1. Basic Policy

It is the policy of the State to pursue a policy of economic growth in a manner consistent with the protection, preservation and revival of the quality of our fresh, brackish and marine waters.

Section 2. Objectives

This Order is issued to update the water quality guidelines for selected parameters based on the current classification of water bodies and on its beneficial use. In addition, the effluent standards for selected parameters are updated based on its perceived impact to the activities in the area and to the environment.

Section 3. Scope and Coverage

This Order covers the updating of WQG and/or GES for the following parameters:

3.1 Ammonia as NH_3-N
3.2 Boron
3.3 Copper as Dissolved Copper
3.4 Fecal Coliform
3.5 Phosphate as Phosphorus (Total, Reactive)
3.6 Sulfate

This also cover additional requirements on the use of GES for strong wastewater for BOD, requirements for modification of Significant Effluent Quality Parameter (SEQP), and amendment to Section 7.0 of DENR AO 2016-08.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 4 August 2023 doi:10.20944/preprints202308.0371.v1

Water Body Classification	Unit	WQG	GES
Class SB	mg/L	0.2	1
Class SC	mg/L	0.2	1
Class SD	mg/L	0.4	2

Note: *NDA – No Discharge Allowed*

4.4 Updated WQG and GES for Fecal Coliform

Table 4 presents the updated WQG and GES for Fecal Coliform for all water bodies.

Table 4. Updated WQG and GES for Fecal Coliform

Water Body Classification	Unit	WQG	GES
Class AA	MPN/100 mL	20	NDA
Class A	MPN/100 mL	50	100
Class B	MPN/100 mL	100	200
Class C	MPN/100 mL	200	400
Class D	MPN/100 mL	400	800
Class SA	MPN/100 mL	20	NDA
Class SB	MPN/100 mL	100	200
Class SC	MPN/100 mL	200	400
Class SD	MPN/100 mL	400	800

Note: *NDA – No Discharge Allowed*
MPN/100mL – Most Probable Number/100 ml of sample

4.5 Updated WQG and GES for Phosphate as Phosphorus (Total, Reactive)

Table 5 presents the updated WQG and GES for Phosphate as Phosphorus (Total, Reactive) for all water bodies.

Table 5. Updated WQG and GES for Phosphate as Phosphorus (Total, Reactive)

Water Body Classification	Units	WQG	GES
Class AA	mg/L	0.025	NDA
Class A	mg/L	0.025	1
Class B	mg/L	0.025	1.5
Class C	mg/L	0.025	4
Class D	mg/L	0.05	10
Class SA	mg/L	0.1	NDA
Class SB	mg/L	0.2	2
Class SC	mg/L	0.2	4
Class SD	mg/L	0.4	10

Note: *NDA – No Discharge Allowed*

4.6 Updated WQG and GES for Sulfate

Table 6 presents the updated WQG and GES for Sulfate for all water bodies.

Table 6. Updated WQG and GES for Sulfate

Water Body Classification	Units	WQG	GES
Class AA	mg/L	250	NDA
Class A	mg/L	250	500
Class B	mg/L	250	500
Class C	mg/L	275	550
Class D	mg/L	500	1,000
Class SA	mg/L	-	-

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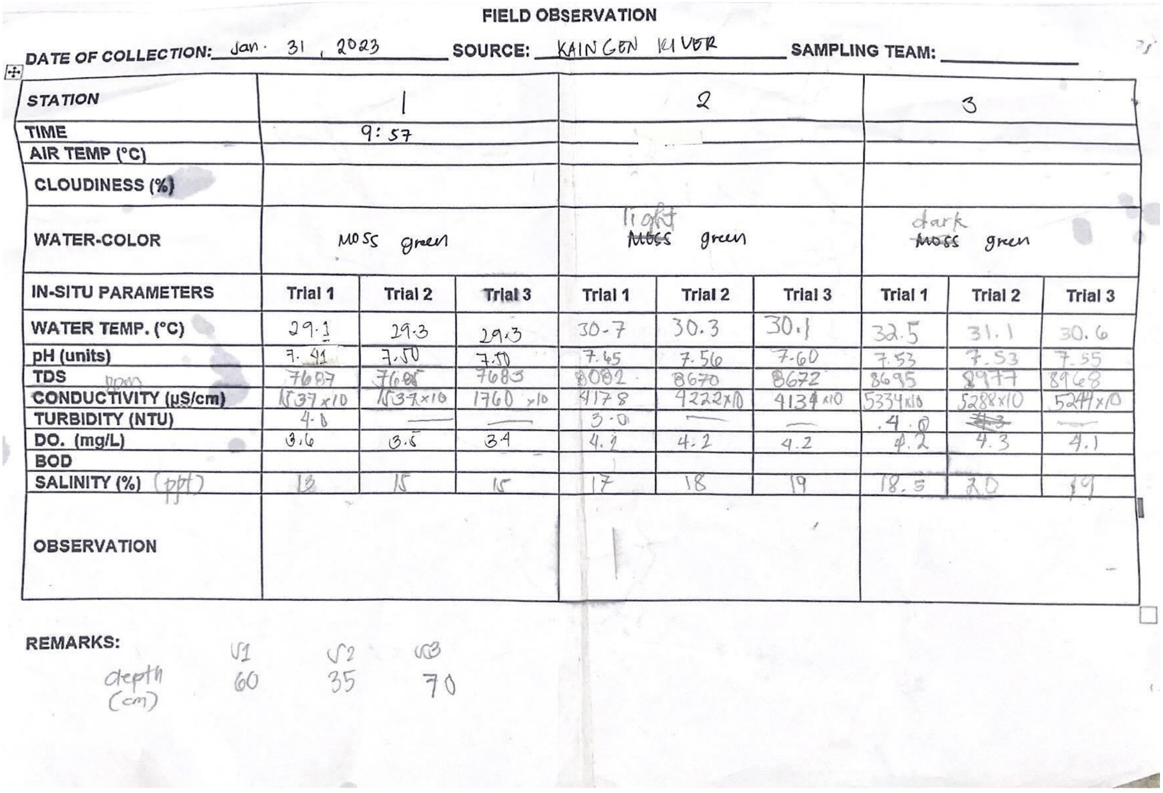
Table E3. Water Quality Index Report of Kaingen River, Kawit, Cavite with the Inclusionof All Water Quality Parameters.

Parameter	Sites	Sampling Period				
		November	December	January	February	March
Turbidity	1	16.5203	12.0147	22.5276	12.0147	22.5276
	2	12.0147	22.5276	36.0442	36.0442	22.5276
	3	22.5276	22.5276	22.5276	16.5203	36.0442
Conductivity	1	0.0234	0.0640	0.0269	0.0668	0.0793
	2	0.0230	0.1414	0.0697	0.0692	0.0882
	3	0.0234	0.1548	0.0883	0.0684	0.0913
Total Dissolved Solids	1	0.0360	0.0984	0.0414	0.1028	0.1219
	2	0.0354	0.2175	0.1073	0.1065	0.1357
	3	0.0360	0.2382	0.1358	0.1053	0.1404
Salinity	1	0.0263	0.0720	0.0303	0.0752	0.0892
	2	0.0259	0.1591	0.0784	0.0778	0.0992
	3	0.0263	0.1741	0.0993	0.0770	0.1027
pH	1	3.9183	3.9287	3.8819	4.0690	4.2353
	2	4.1002	4.0066	3.9495	4.0222	4.2353
	3	4.0534	3.9910	3.9183	3.9443	4.0274
Dissolved Oxygen	1	4.5055	8.1099	5.2564	6.9085	14.2675
	2	7.6594	9.7620	6.3077	6.0074	11.7144
	3	6.3077	8.4103	6.3077	5.8572	14.2675
Nitrates	1	0.0942	0.2222	0.1303	0.0766	0.1073
	2	0.0942	0.2222	0.1303	0.0766	0.1073
	3	0.0942	0.2222	0.1303	0.0766	0.1073
Phosphates	1	92.2131	122.40	109.184	107.832	69.5353
	2	92.2131	122.40	109.184	107.832	69.5353
	3	92.2131	122.40	109.184	107.832	69.5353
Total Coliform	1	0.3604	0.0020	0.0360	0.0036	0.0050
	2	0.3604	0.0020	0.0360	0.0036	0.0050
	3	0.3604	0.0020	0.0360	0.0036	0.0050
Ave. WQI in Five Months	1	129.57 (UNSUITABLE)				
	2	138.91 (UNSUITABLE)				
	3	137.00 (UNSUITABLE)				
Ave. WQI perMonth		**119.96(US)**	**154.82(US)**	**146.48(US)**	**139.96(US)**	**114.58(US)**

Range Quality: 0 – 25 = Excellent; 26 – 50 = Good; 51 – 75 = Poor; 76 – 100 = Very Poor; >100 = Unsuitable.



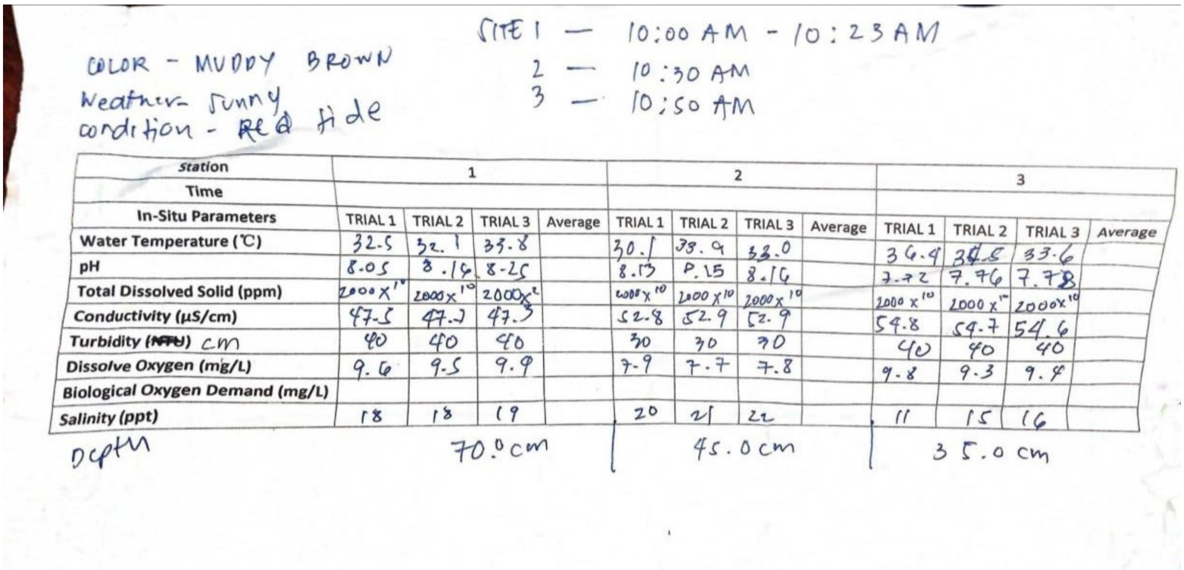
FIELD OBSERVATION

DATE OF COLLECTION: Jan. 31, 2023 SOURCE: KAINGEN RIVER SAMPLING TEAM:

STATION	1			2			3		
TIME	9:57								
AIR TEMP (°C)									
CLOUDINESS (%)									
WATER-COLOR	moss green			~~moss~~ light green			~~moss~~ dark green		
IN-SITU PARAMETERS	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
WATER TEMP. (°C)	29.1	29.3	29.3	30.7	30.3	30.1	32.5	31.1	30.6
pH (units)	7.41	7.50	7.50	7.65	7.56	7.60	7.53	7.53	7.55
TDS ppm	7687	7685	7683	8082	8670	8672	8695	8977	8968
CONDUCTIVITY (µS/cm)	1537×10	1537×10	1760 ×10	4178	4222×10	4134×10	5334×10	5288×10	5244×10
TURBIDITY (NTU)	4.0	—	—	3.0	—	—	4.0	~~4.3~~	—
DO. (mg/L)	3.6	3.5	3.4	4.2	4.2	4.2	4.2	4.3	4.1
BOD									
SALINITY (%) (ppt)	13	15	15	17	18	19	18.5	20	19
OBSERVATION									

REMARKS:

	V1	V2	V3
depth (cm)	60	35	70



COLOR - MUDDY BROWN
Weather - sunny
condition - Red tide

SITE 1 — 10:00 AM - 10:23 AM
2 — 10:30 AM
3 — 10:50 AM

Station	1				2				3			
Time												
In-Situ Parameters	TRIAL 1	TRIAL 2	TRIAL 3	Average	TRIAL 1	TRIAL 2	TRIAL 3	Average	TRIAL 1	TRIAL 2	TRIAL 3	Average
Water Temperature (℃)	32.5	32.1	33.8		30.1	33.9	33.0		34.4	34.5	33.6	
pH	8.05	8.14	8.25		8.13	8.15	8.16		7.72	7.76	7.78	
Total Dissolved Solid (ppm)	2000×10	2000×10	2000×2		2000×10	2000×10	2000×10		2000×10	2000×10	2000×10	
Conductivity (µS/cm)	47.5	47.2	47.3		52.8	52.9	52.9		54.8	54.7	54.6	
Turbidity (~~NTU~~) cm	40	40	40		30	30	30		40	40	40	
Dissolve Oxygen (mg/L)	9.6	9.5	9.9		7.9	7.7	7.8		9.8	9.3	9.4	
Biological Oxygen Demand (mg/L)												
Salinity (ppt)	18	18	19		20	21	22		11	15	16	

Depth 70.0 cm | 45.0 cm | 35.0 cm

Figure E4. Field Observation Record for Water.

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November

MACH UNION LABORATORIES INC.

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Accredited: Philippine Accreditation Bureau (DTI-PAB) • Department of Health • Food & Drug Administration
Recognized: Department of Environment & Natural Resources (DENR-EMB) • Bureau of Animal Industry (DA-BAI)

CERTIFICATE OF ANALYSIS

Job Number : MU22043314 **Laboratory Number:** MU22043314-001 **Date Reported:** 11/28/2022

Client ID : NCRMNL-000450
CUSTOMER : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Ayala Blvd., Corner San Marcelino St., Ermita, Manila

Attention : Jean Mherk B. Tapere
09567784687

PROJECT DETAILS: BSES - NS4A / BSES - 4A

SAMPLE INFORMATION

Sample Type : River Water
Identification : KAINGEN RIVER
Description : River Water Sample in 500 mL PET Bottle
Collection Date and Time : 11/22/2022 09:30 AM
Collected by : CUSTOMER

Storage Condition : Chilled
Received Date and Time : 11/22/2022 04:15 PM
Analyzed Start Date and Time : 11/22/2022 04:15 PM
Analyzed End Date and Time : 11/27/2022 10:50 AM

Comments:

1. *All sample information stated herein are based on the details provided by the customer. The results in this certificate of testing relates only to the samples submitted to and tested by the laboratory.*
2. *Sample(s) was/were analyzed under specific environmental conditions: Temperature: 20- 25°C & Relative Humidity: 45-50%RH.*

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MU22043314_FINAL_221128 181508 *Attention is drawn to the terms and conditions for the testing printed over leaf* Page 1 of 4

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Recognized: Department of Environment & Natural Resources (DENR-EMB) • Bureau of Animal Industry (DA-BAI)

PAB ACCREDITED TESTING LABORATORY
PNS ISO/IEC 17025:2017
LA-2012-215C
LA-2012-216C

CERTIFICATE OF ANALYSIS

Job Number: MU22043314 **Laboratory Number:** MU22043314-003 **Date Reported:** 11/28/2022
CUSTOMER : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Sample ID : KAINGEN RIVER

LABORATORY TEST RESULTS

PARAMETER	TEST METHOD	UNIT	RESULT
Total Coliform	9221 B. Multiple Tube Fermentation Technique	MPN/100 mL	24×10^4

ORIGINAL COPY

(*) Not PAB Accredited
Test Method Reference:
Standard Methods for Examination of Water and Wastewater, 23rd Edition, APHA, AWWA WEF, US-WA, 2017

Checked by:
Liza Louise B. Perez, RMT
Medical Technologist
PRC# 0096315

Victor Gregory Bede D. Garcia, RCh
Chemist III
PRC# 0013349

Certified by:
Luchiel S. Ignacio, RMT
Section Head - Water
PRC# 0047991

Marisa T. Manaor, RCh
Supervising Chemist
PRC# 0005460

Approved for Release by:
Aladino M. Abulencia, ChE
Technical Manager
PRC License No. 0008351

MU22043314_FINAL_221129181515H Page 4 of 4

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PAB ACCREDITED TESTING LABORATORY
PNS ISO/IEC 17025:2017
LA-2012-215C
LA-2012-216C

CERTIFICATE OF ANALYSIS

Job Number: MU22043314 **Laboratory Number:** MU22043314-001 **Date Reported:** 11/28/2022
CUSTOMER : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Sample ID : KAINGEN RIVER

LABORATORY TEST RESULTS

PARAMETER	TEST METHOD	UNIT	RESULT
Phosphate as P (Total, Reactive)	4500-P D. Stannous Chloride Method	mg/L	0.614

ORIGINAL COPY

(*) Not PAB Accredited
Test Method Reference:
Standard Methods for Examination of Water and Wastewater, 23rd Edition, APHA, AWWA WEF, US-WA, 2017.

Checked by:
Liza Louise P. Perez, RMT
Medical Technologist
PRC# 0096315

Victor Gregory Jude D. Garcia, RCh
Chemist III
PRC# 001[illegible]349

Certified by:
Luchie S. Ignacio, RMT
Section Head - Water
PRC# 0047991

Marisa T. Manaor, RCh
Supervising Chemist
PRC# 0005465

Approved for Release by:
Aladino M. Abulencia, ChE
Technical Manager
PRC License No. 0008351

MU22043314-FINAL_221128 1815H
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PAB ACCREDITED TESTING LABORATORY
PNS ISO/IEC 17025:2017
LA-2012-215C
LA-2012-216C

CERTIFICATE OF ANALYSIS

Job Number: MU22043314 **Laboratory Number:** MU22043314-002 **Date Reported:** 11/28/2022
CUSTOMER : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Sample ID : KAINGEN RIVER

LABORATORY TEST RESULTS

PARAMETER	TEST METHOD	UNIT	RESULT
Nitrate as N	352.1 Brucine - Colorimetric Method	mg/L	0.123

ORIGINAL COPY

(*) Not PAB Accredited
Test Method Reference:
Verified Method based on United States Environmental Protection Agency (US EPA)

Checked by:
Liza Louise P. Perez, RMT
Medical Technologist
PRC# 0096315

Victor Gregory Jude D. Garcia, RCh
Chemist III
PRC# 00[illegible]3349

Certified by:
Luchie S. Ignacio, RMT
Section Head - Water
PRC# 0047991

Marisa T. Manaor, RCh
Supervising Chemist
PRC# 0005465

Approved for Release by:
Aladino M. Abulencia, ChE
Technical Manager
PRC License No. 0008351

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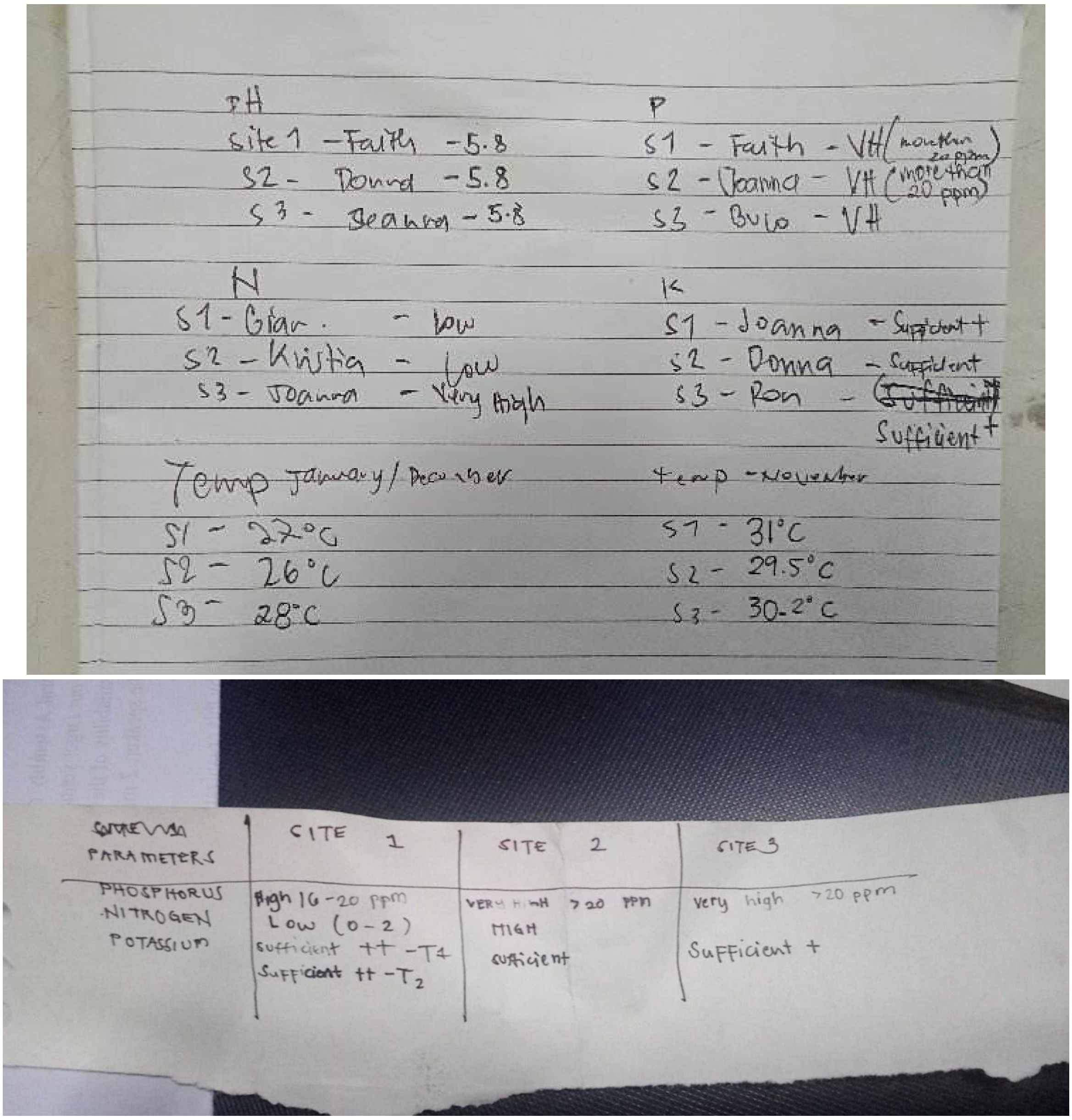
Page 3 of 4

Figure E5. Results of Phosphates and Nitrates For Water Quality.


pH
Site 1 – Faith – 5.8
S2 – Donna – 5.8
S3 – Jeanna – 5.8

P
S1 – Faith – VH (more than 20 ppm)
S2 – Joanna – VH (more than 20 ppm)
S3 – Buio – VH

N
S1 – Glar. – low
S2 – Kristia – Low
S3 – Joanna – Very High

K
S1 – Joanna – Sufficient +
S2 – Donna – Sufficient
S3 – Ron – Sufficient +

Temp January/December
S1 – 27°C
S2 – 26°C
S3 – 28°C

temp – November
S1 – 31°C
S2 – 29.5°C
S3 – 30.2°C

PARAMETERS	SITE 1	SITE 2	SITE 3
PHOSPHORUS	High 16–20 ppm	VERY HIGH > 20 ppm	very high > 20 ppm
NITROGEN	Low (0–2)	HIGH	
POTASSIUM	Sufficient ++ – T1 Sufficient ++ – T2	sufficient	Sufficient +

Figure E6. Results of Ex-situ Soil analysis.

 doi:10.20944/preprints202308.0371.v1

November

BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0003
SOIL CHEMICAL TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	15

CUSTOMER INFORMATION

Name of Customer:	KRISTIA MARIAE TUPAS	*To be filled out by the Laboratory*	
Contact Number:	09998453179	Test Report No.:	23-10-CHEM-S
Address:	Quiapo, Manila		
Date of Sampling:	22-Nov-22	Date of Analysis:	31-Jan-23
Sampling Site/Location:	Kaingen River, Kawit, Cavite		
Date Submitted:	11-Jan-23	Date Issued:	14-Feb-23

Determination	Test Method	Laboratory No.						
		S-14 1	S-14 2	S-14 3				
		Description						
		Site 1	Site 2	Site 3				
FERTILITY PARAMETERS		Test Result (Oven-dry Basis)						
*pH (H_2O, 1:1)	Potentiometric	-	-	-				
*Available Phosphorus (Avail. P), mg/kg	Olsen, UV-Vis	-	-	-				
	Bray 1, UV-Vis	-	-	-				
*Exchangeable Potassium (K), cmol/kg	Ammonium acetate, pH 7, AES	-	-	-				
*Organic Matter (OM), %	Walkley and Black/Colorimetric, UV-Vis (Calculation, OC X 1.72)	0.66	3.85	10.50				
Nitrogen (N), %	Calculation, OM x 0.05	-	-	-				
SPECIALIZED PARAMETERS								
pH (CaCl2, 1:2)	Potentiometric	-	-	-				
*Electrical Conductivity (EC), mS/cm	Potentiometric	-	-	-				
*Exchangeable Calcium (Ca), cmol/kg	Ammonium acetate, pH 7, AAS/AES	-	-	-				
*Exchangeable Magnesium (Mg), cmol/kg		-	-	-				
*Exchangeable Sodium (Na), cmol/kg		-	-	-				
Sum of Exchangeable Bases, cmol/kg	Calculation	-	-	-				
*Total Nitrogen (N), %	Kjelhdahl	-	-	-				
Exchangeable Acidity (EA), cmol/kg	$BaCl_2$-TEA Titration	-	-	-				
Extractable Aluminum (Extr.Al), cmol/kg	KCl-NaF Titration	-	-	-				
CEC Sum, cmol/kg	Calculation	-	-	-				
Base Satn % Sum, %	Calculation	-	-	-				
*Cation Exchange Capacity (CEC Direct), cmol,/kg	NH_4OAc, pH 7, Distillation-Titration Method	-	-	-				
Base Satn % on CEC, %	Calculation	-	-	-				
*Copper (Cu), mg/kg	DTPA-TEA Extraction-AAS	-	-	-				
*Zinc (Zn), mg/kg		-	-	-				
*Manganese (Mn), mg/kg		-	-	-				
*Iron (Fe), mg/kg		-	-	-				
Moisture Content (MC), %	Gravimetric	-	-	-				

Nothing Follows

Certified and Approved by:

FLORFINA P. SANCHEZ
Head, Soil Chemistry Section
Professional Identification Card No. 0006889

Noted by:

MARIBEL R. JALALON
Chief, Laboratory Services Division

Notes:
*1) *These parameters are ISO/IEC 17025:2017 accredited.*
2) The test results apply to the samples as received.
3) The test results relate only to the samples tested.
4) This test report shall not be reproduced except in full, without the written approval and authorization of Laboratory Services Division Management.

BUREAU OF SOILS AND WATER MANAGEMENT
SRDC Bldg., Elliptical Rd., Corner Visayas Ave., Diliman, Quezon City
Customer Center contact info: 8332-9534 / 8273-2474 loc. 3202 ; customers.center@bswm.da.gov.ph
Laboratory email add: laboratory@bswm.da.gov.ph

Page 1 of 1

BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0002
SOIL PHYSICAL TEST REPORT	Effective Date:	May 16, 2022
	Revision No.:	13

Name of Customer:	KRISTIA MARIAE TUPAS		
Contact Number:	09998453179		
Address:	Quiapo, Manila	Date of Analysis:	25-Jan-23
Date of Sampling:	22-Nov-22		
Sampling Site/Location:	Kaingen River, Kawit, Cavite	Test Report Number:	23-10-PHY-S(b)
Date Submitted:	11-Jan-23	Date Issued:	27-Jan-23

Determinations	Test Method	Laboratory No.						
		S14-1	S14-2	S14-3				
		Description						
		SITE 1	SITE 2	SITE 3				
***Percent Particle Size Distribution (mm) USDA**		Test Result						
Total Sand (0.006-2.0)	Bouyoucos Hydrometer	20.1	80.8	Insufficient Sample				
Silt (0.05-0.002)		33.5	8.2					
Clay (less 0.002)		46.4	11.0					
Textural Class		Clay	Sandy Loam					
Sand Fractions	Sieve	–	–	–				
Bulk Density (g/cc)	Core	–	–	–				

Nothing Follows

Certified and Approved by:

MARJORIE JEAN E. TAO
Agriculturist II

Noted by:

MARIBEL R. JALALON
Chief, Laboratory Services Division

Notes:
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BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0014
SOIL MOISTURE TEST REPORT	Effective Date:	May 16, 2022
	Revision No.:	8

Name of Customer: KRISTIA MARIAE TUPAS
Contact Number: 09998453179
Address: Quiapo, Manila
Date of Sampling: 22-Nov-22
Sampling Site/Location: Kaingen River, Kawit, Cavite
Date Submitted: 11-Jan-23

Date of Analysis: 23-25-Jan-23
Test Report Number: 23-10-PHY-S(a)
Date Issued: 27-Jan-23

Determination	Test Method	Laboratory No.						
		S14-1	S14-2	S14-3				
		Description						
		SITE 1	SITE 2	SITE 3				
Moisture Retention Capacity, %		Test Result						
Water Holding Capacity	Tapping	38.1	84.1	98.4				
Field Capacity 1/3 BAR	Pressure Extraction	-	-	-				
Permanent Wilting Point 15 BAR	Pressure Extraction	-	-	-				
Hydraulic Conductivity (cm/sec)	Constant Head	-	-	-				
Moisture Content	Gravimetric	-	-	-				
Nothing Follows								

Certified and Approved by:
BEATRIZ C. MAGNO
Head, Soil Physics Section

Noted by:
MARIBEL R. JALALON
Chief, Laboratory Services Division

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BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0003
SOIL CHEMICAL TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	15

CUSTOMER INFORMATION
Name of Customer: KRISTIA MARIAE TUPAS - TUP MANILA
Contact Number: 09998453179
Address: Quiapo, Manila
Date of Sampling: 6-Jan-23
Sampling Site/Location: Kaingen River, Kawit, Cavite
Date Submitted: 27-Jan-23

To be filled out by the Laboratory
Test Report No.: 23-29-CHEM-S
Date of Analysis: 27-Feb-23
Date Issued: 1-Mar-23

Determination	Test Method	Laboratory No.						
		S-40 1	S-40 2	S-40 3				
		Description						
		Site 01	Site 02	Site 03				
FERTILITY PARAMETERS		Test Result (Oven-dry Basis)						
*pH (H_2O, 1:1)	Potentiometric	-	-	-				
*Available Phosphorus (Avail. P), mg/kg	Olsen, UV-Vis	-	-	-				
	Bray 1, UV-Vis	-	-	-				
*Exchangeable Potassium (K), cmol/kg	Ammonium acetate, pH 7, AES	-	-	-				
*Organic Matter (OM), %	Walkley and Black/Colorimetric, UV-Vis (Calculation, OC X 1.72)	3.99	2.02	12.28				
Nitrogen (N), %	Calculation, OM x 0.05	-	-	-				
SPECIALIZED PARAMETERS								
pH (CaCl2, 1:2)	Potentiometric	-	-	-				
*Electrical Conductivity (EC), mS/cm	Potentiometric	-	-	-				
*Exchangeable Calcium (Ca), cmol/kg	Ammonium acetate, pH 7, AAS/AES	-	-	-				
*Exchangeable Magnesium (Mg), cmol/kg		-	-	-				
*Exchangeable Sodium (Na), cmol/kg		-	-	-				
Sum of Exchangeable Bases, cmol/kg	Calculation	-	-	-				
*Total Nitrogen (N), %	Kjelhdahl	-	-	-				
Exchangeable Acidity (EA), cmol/kg	$BaCl_2$-TEA Titration	-	-	-				
Extractable Aluminum (Extr.Al), cmol/kg	KCl-NaF Titration	-	-	-				
CEC Sum, cmol/kg	Calculation	-	-	-				
Base Satn % Sum, %	Calculation	-	-	-				
*Cation Exchange Capacity (CEC Direct), $cmol_c$/kg	NH_4OAc, pH 7, Distillation-Titration Method	-	-	-				
Base Satn % on CEC, %	Calculation	-	-	-				
*Copper (Cu), mg/kg	DTPA-TEA Extraction-AAS	-	-	-				
*Zinc (Zn), mg/kg		-	-	-				
*Manganese (Mn), mg/kg		-	-	-				
*Iron (Fe), mg/kg		-	-	-				
Moisture Content (MC), %	Gravimetric	-	-	-				
Nothing Follows								

Certified and Approved by:
FLORFINA P. SANCHEZ
Head, Soil Chemistry Section
Professional Identification Card No. 0006889

Noted by:
MARIBEL R. JALALON
Chief, Laboratory Services Division

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BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0002
SOIL PHYSICAL TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	14

CUSTOMER INFORMATION

Name of Customer: KRISTIA MARIAE TUPAS - TUP MANILA
Contact Number: 09998453179
Address: Quiapo, Manila
Date of Sampling: 6-Jan-23
Sampling Site/Location: Kaingen River, Kawit, Cavite
Date Submitted: 27-Jan-23

To be filled out by the Laboratory

Test Report Number: 23-29-PHY-S(b)
Date of Analysis: 16-Feb-23
Date Issued: 8-Mar-23

Determinations	Test Method	Laboratory No.						
		S40-1	S40-2	S40-3				
		Description						
		SITE 1	SITE 2	SITE 3				
*Percent Particle Size Distribution (mm) USDA		Test Result						
Total Sand (0.006-2.0)	Bouyoucos Hydrometer	18.1	33.9	24.0				
Silt (0.05-0.002)	Bouyoucos Hydrometer	49.7	30.3	33.8				
Clay (less 0.002)	Bouyoucos Hydrometer	32.2	35.8	42.2				
Textural Class		Silty Clay Loam	Clay Loam	Clay				
Sand Fractions	Sieve	-	-	-				
Bulk Density (g/cc)	Core	-	-	-				

Nothing Follows

Certified and Approved by:
MARJORIE JEAN E. TAO
Agriculturist II

Noted by:
MARIBEL R. JALALON
Chief, Laboratory Services Division

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BUREAU OF SOILS AND WATER MANAGEMENT Laboratory Services Division	Reference Code:	BSWM_LS_RE_0014
SOIL MOISTURE TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	9

CUSTOMER INFORMATION

Name of Customer: KRISTIA MARIAE TUPAS - TUP MANILA
Contact Number: 09998453179
Address: Quiapo, Manila
Date of Sampling: 6-Jan-23
Sampling Site/Location: Kaingen River, Kawit, Cavite
Date Submitted: 27-Jan-23

To be filled out by the Laboratory

Test Report No.: 23-29-PHY-S(a)
Date of Analysis: 20-Feb-23
Date Issued: 8-Mar-23

Determination	Test Method	Laboratory No.						
		S40-1	S40-2	S40-3				
		Description						
		SITE 1	SITE 2	SITE 3				
Moisture Retention Capacity, %		Test Result						
Water Holding Capacity	Tapping	87.2	75.5	97.7				
Field Capacity 1/3 BAR	Pressure Extraction	-	-	-				
Permanent Wilting Point 15 BAR	Pressure Extraction	-	-	-				
Hydraulic Conductivity (cm/sec)	Constant Head	-	-	-				
Moisture Content	Gravimetric	-	-	-				

Nothing Follows

Certified and Approved by:
for: BEATRIZ C. MAGNO
Head, Soil Physics Section

Noted by:
MARIBEL R. JALALON
Chief, Laboratory Services Division

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SOIL CHEMICAL TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	15

CUSTOMER INFORMATION

Name of Customer: KRISTIA MARIAE G. TUPAS/TUP Manila
Contact Number: 09662084939
Address: Quiapo Manila
Date of Sampling: 31-Jan-23
Sampling Site/Location: Kaingen, Kawit, Cavite
Date Submitted: 23-Feb-23

To be filled out by the Laboratory

Test Report No.: 23-59-CHEM-S
Date of Analysis: 8-Mar-23
Date Issued: 21-Mar-23

Determination	Test Method	Laboratory No.						
		S-83 1	S-83 2	S-83 3				
		Description						
		Site 1	Site 2	Site 3				
		Test Result (Oven-dry Basis)						
FERTILITY PARAMETERS								
*pH (H_2O, 1:1)	Potentiometric	-	-	-				
*Available Phosphorus (Avail. P), mg/kg	Olsen, UV-Vis	-	-	-				
	Bray 1, UV-Vis	-	-	-				
*Exchangeable Potassium (K), cmol/kg	Ammonium acetate, pH 7, AES	-	-	-				
*Organic Matter (OM), %	Walkley and Black/Colorimetric, UV-Vis (Calculation, OC X 1.72)	5.32	2.84	9.40				
Nitrogen (N), %	Calculation, OM x 0.05	-	-	-				
SPECIALIZED PARAMETERS								
pH ($CaCl_2$, 1:2)	Potentiometric	-	-	-				
*Electrical Conductivity (EC), mS/cm	Potentiometric	-	-	-				
*Exchangeable Calcium (Ca), cmol/kg	Ammonium acetate, pH 7, AAS/AES	-	-	-				
*Exchangeable Magnesium (Mg), cmol/kg		-	-	-				
*Exchangeable Sodium (Na), cmol/kg		-	-	-				
Sum of Exchangeable Bases, cmol/kg	Calculation	-	-	-				
*Total Nitrogen (N), %	Kjelhdahl	-	-	-				
Exchangeable Acidity (EA), cmol/kg	$BaCl_2$-TEA Titration	-	-	-				
Extractable Aluminum (Extr.Al), cmol/kg	KCl-NaF Titration	-	-	-				
CEC Sum, cmol/kg	Calculation	-	-	-				
Base Satn % Sum, %	Calculation	-	-	-				
*Cation Exchange Capacity (CEC Direct), $cmol_c$/kg	NH_4OAc, pH 7, Distillation-Titration Method	-	-	-				
Base Satn % on CEC, %	Calculation	-	-	-				
*Copper (Cu), mg/kg	DTPA-TEA Extraction-AAS	-	-	-				
*Zinc (Zn), mg/kg		-	-	-				
*Manganese (Mn), mg/kg		-	-	-				
*Iron (Fe), mg/kg		-	-	-				
Moisture Content (MC), %	Gravimetric	-	-	-				

Nothing Follows

Certified and Approved by:

FLORFINA P. SANCHEZ
Head, Soil Chemistry Section
Professional Identification Card No. 0006889

Noted by:

MARIBEL R. JALALON
Chief, Laboratory Services Division

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SOIL MOISTURE TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	9

CUSTOMER INFORMATION

Name of Customer: KRISTIA MARIAE G. TUPAS/TUP Manila
Contact Number: 09662084939
Address: Quiapo Manila
Date of Sampling: 31-Jan-23
Sampling Site/Location: Kaingen, Kawit, Cavite
Date Submitted: 23-Feb-23

To be filled out by the Laboratory

Test Report No.: 23-59-PHY-S(a)
Date of Analysis: 4-Apr-23
Date Issued: 5-Apr-23

Determination	Test Method	Laboratory No.						
		S83-1	S83-2	S83-3				
		Description						
		SITE 1	SITE 2	SITE 3				
Moisture Retention Capacity, %		Test Result						
Water Holding Capacity	Tapping	85.7	88.3	121.4				
Field Capacity 1/3 BAR	Pressure Extraction	-	-	-				
Permanent Wilting Point 15 BAR	Pressure Extraction	-	-	-				
Hydraulic Conductivity (cm/sec)	Constant Head	-	-	-				
Moisture Content	Gravimetric	10.6	10.7	23.4				

Nothing Follows

Certified and Approved by:

BEATRIZ C. MAGNO
Head, Soil Physics Section

Noted by:

MARIBEL R. JALALON
Chief, Laboratory Services Division

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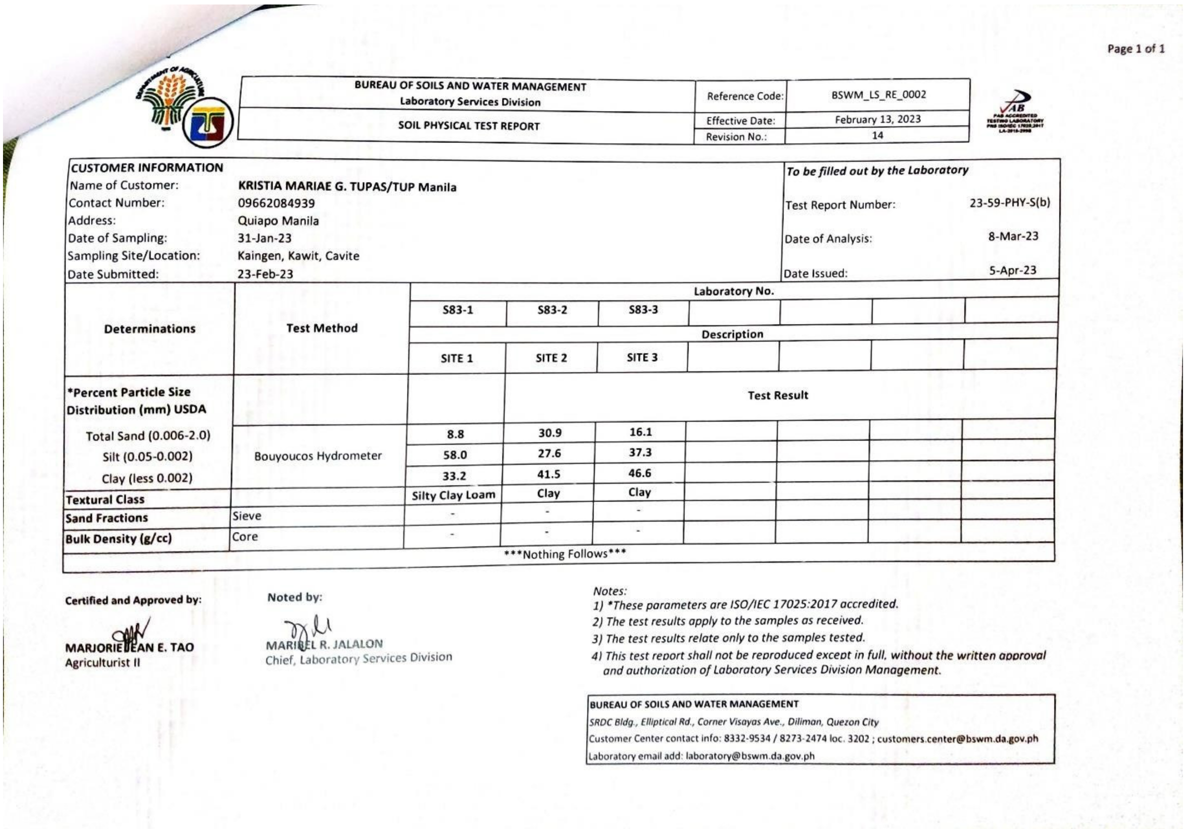

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SOIL PHYSICAL TEST REPORT	Effective Date:	February 13, 2023
	Revision No.:	14

CUSTOMER INFORMATION

Name of Customer:	KRISTIA MARIAE G. TUPAS/TUP Manila	*To be filled out by the Laboratory*	
Contact Number:	09662084939	Test Report Number:	23-59-PHY-S(b)
Address:	Quiapo Manila		
Date of Sampling:	31-Jan-23	Date of Analysis:	8-Mar-23
Sampling Site/Location:	Kaingen, Kawit, Cavite		
Date Submitted:	23-Feb-23	Date Issued:	5-Apr-23

Determinations	Test Method	Laboratory No.						
		S83-1	S83-2	S83-3				
		Description						
		SITE 1	SITE 2	SITE 3				
*Percent Particle Size Distribution (mm) USDA		Test Result						
Total Sand (0.006-2.0)	Bouyoucos Hydrometer	8.8	30.9	16.1				
Silt (0.05-0.002)		58.0	27.6	37.3				
Clay (less 0.002)		33.2	41.5	46.6				
Textural Class		Silty Clay Loam	Clay	Clay				
Sand Fractions	Sieve	-	-	-				
Bulk Density (g/cc)	Core	-	-	-				

Nothing Follows

Certified and Approved by:
MARJORIE JEAN E. TAO
Agriculturist II

Noted by:
MARIBEL R. JALALON
Chief, Laboratory Services Division

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Figure E7. Results of Soil Quality Soil Texture, WHC and Organic Matter November.

Appendix F. Abundance of Species

Table F1. Amount of Carbon Stored and Carbon dioxide Sequestered of Mangrove Trees in Site 1.

TreeNo.	Scientific Name	Local name	GBH (cm)	DBH (cm)	Wood Density (g/cm^3)	AGB (kg)	BGB (kg)	Total Biomass(kg)
1	*Avicennia alba*	Bungalon	91.9	29.25261013	0.6987	709.1358437	259.2721792	968.4080229
2	*Avicennia alba*	Bungalon	162.6	51.75706646	0.6987	2886.222521	920.2018123	3806.424333
3	*Avicennia alba*	Bungalon	35.6	11.33180545	0.6987	68.79237045	31.58017106	100.3725415
4	*Avicennia alba*	Bungalon	61	19.41685765	0.6987	258.752571	104.3825053	363.1350764
5	*Avicennia alba*	Bungalon	80.8	25.71937866	0.6987	516.660461	194.8268028	711.4872638
6	*Avicennia alba*	Bungalon	172.7	54.9719888	0.6987	3347.437138	1051.924262	4399.3614
7	*Avicennia alba*	Bungalon	71.1	22.63177998	0.6987	377.2007064	146.6715887	523.8722952
8	*Avicennia alba*	Bungalon	128.3	40.8390629	0.6987	1611.42781	543.824363	2155.252173
9	*Avicennia alba*	Bungalon	62.7	19.95798319	0.6987	276.8544	110.9505408	387.8049408
10	*Avicennia alba*	Bungalon	56.4	17.9526356	0.6987	213.3633765	87.70716907	301.0705455
11	*Avicennia alba*	Bungalon	94.7	30.14387573	0.6987	763.4739581	277.1356756	1040.609634
12	*Avicennia alba*	Bungalon	68.6	21.83600713	0.6987	345.4065781	135.4674699	480.874048
13	*Avicennia alba*	Bungalon	38.1	12.1275783	0.6987	81.29217058	36.71545619	118.0076268
14	*Avicennia alba*	Bungalon	30.5	9.708428826	0.6987	47.02739088	22.40480281	69.4321937
15	*Avicennia alba*	Bungalon	26.7	8.498854087	0.6987	33.89931968	16.67441027	50.57372995
16	*Rhizophora mucronata*	Bakhaw babae	45.7	14.54672778	0.8483	154.3923777	65.45729277	219.8496705
17	*Rhizophora mucronata*	Bakhaw babae	48.3	15.37433155	0.8483	176.9057483	74.01277804	250.9185264
18	*Rhizophora mucronata*	Bakhaw babae	26.4	8.403361345	0.8483	40.02926939	19.35997504	59.38924442
19	*Rhizophora mucronata*	Bakhaw babae	33.02	10.51056786	0.8483	69.41024749	31.81479787	101.2250454
20	*Rhizophora mucronata*	Bakhaw babae	38.6	12.28673287	0.8483	101.9146865	44.99537666	146.9100632
21	*Rhizophora mucronata*	Bakhaw babae	32.3	10.28138528	0.8483	65.74613214	30.2951896	96.04132175
Total Biomass of Site 1 (kg)	**Total Biomass (t/ha)**		**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**				
	5.919992648	59.19992648		29.59996324	108.5430652			

Table F2. Amount of Carbon Stored and Carbon dioxide Sequestered of Mangrove Trees in Site 2.

Tree No.	Scientific Name	Local name	GBH (cm)	DBH (cm)	Wood Density (g/cm³)	AGB (kg)	BGB (kg)	Total Biomass (kg)
1	*Avicennia alba*	Bungalon	48.0	15.27883881	0.6987	143.4916811	61.31278305	204.8044641
2	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	51.93719759
3	*Avicennia alba*	Bungalon	24.0	7.639419404	0.6987	26.07912009	13.16025908	39.23937918
4	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	51.93719759
5	*Avicennia alba*	Bungalon	33.5	10.66335625	0.6987	59.23569727	27.59274798	86.82844524
6	*Avicennia alba*	Bungalon	33.0	10.50420168	0.6987	57.08441723	26.68679559	83.77121282
7	*Avicennia alba*	Bungalon	40.0	12.73236567	0.6987	91.63066919	40.9042716	132.5349408
8	*Avicennia alba*	Bungalon	32.0	10.18589254	0.6987	52.92272845	24.92461361	77.84734206
9	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334
10	*Xylocarpus granatum*	Tabigi	8.5	2.705627706	0.6721	1.952032252	1.268677365	3.220709617
11	*Xylocarpus granatum*	Tabigi	9.0	2.864782277	0.6721	2.246740971	1.440321844	3.687062815
12	*Rhizophora mucronata*	Bakhaw babae	16.0	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
13	*Rhizophora mucronata*	Bakhaw babae	39.0	12.41405653	0.8483	104.5324036	46.03705171	150.5694553
14	*Rhizophora mucronata*	Bakhaw babae	40.0	12.73236567	0.8483	111.2498879	48.69868745	159.9485753
15	*Rhizophora mucronata*	Bakhaw babae	37.8	12.03208556	0.8483	96.79698516	42.95125627	139.7482414
16	*Rhizophora mucronata*	Bakhaw babae	11.0	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
17	*Rhizophora mucronata*	Bakhaw babae	6.5	2.069009422	0.8483	1.27349974	0.862207363	2.135707103
18	*Rhizophora mucronata*	Bakhaw babae	12.0	3.819709702	0.8483	5.754636138	3.362996703	9.11763284
19	*Rhizophora mucronata*	Bakhaw babae	9.0	2.864782277	0.8483	2.835754152	1.775670772	4.611424924

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20	*Rhizophora mucronata*	Bakhaw babae	5.0	1.591545709	0.8483	0.667879655	0.48156785	1.149447504
21	*Rhizophora mucronata*	Bakhaw babae	7.0	2.228163993	0.8483	1.528175321	1.016393138	2.544568458
22	*Rhizophora mucronata*	Bakhaw babae	7.0	2.228163993	0.8483	1.528175321	1.016393138	2.544568458
23	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
24	*Rhizophora mucronata*	Bakhaw babae	9.0	2.864782277	0.8483	2.835754152	1.775670772	4.611424924
25	*Rhizophora mucronata*	Bakhaw babae	9.0	2.864782277	0.8483	2.835754152	1.775670772	4.611424924
26	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
27	*Rhizophora mucronata*	Bakhaw babae	5.5	1.75070028	0.8483	0.844353328	0.595044227	1.439397555
28	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
29	*Rhizophora mucronata*	Bakhaw babae	5.6	1.782531194	0.8483	0.882621596	0.619329113	1.501950709
30	*Rhizophora mucronata*	Bakhaw babae	8.0	2.546473135	0.8483	2.122429979	1.367111216	3.489541195
31	*Rhizophora mucronata*	Bakhaw babae	55.0	17.5070028	0.8483	243.5141598	98.75276082	342.2669206
32	*Rhizophora mucronata*	Bakhaw babae	7.0	2.228163993	0.8483	1.528175321	1.016393138	2.544568458
33	*Rhizophora mucronata*	Bakhaw babae	7.0	2.228163993	0.8483	1.528175321	1.016393138	2.544568458
34	*Rhizophora mucronata*	Bakhaw babae	21.0	6.684491979	0.8483	22.79772278	11.64852429	34.44624707
35	*Rhizophora mucronata*	Bakhaw babae	20.5	6.525337408	0.8483	21.48555129	11.04174331	32.5272946
36	*Rhizophora mucronata*	Bakhaw babae	10.5	3.342245989	0.8483	4.143407798	2.500255085	6.643662883
37	*Rhizophora mucronata*	Bakhaw babae	5.5	1.75070028	0.8483	0.844353328	0.595044227	1.439397555
38	*Rhizophora mucronata*	Bakhaw babae	21.5	6.84364655	0.8483	24.15631114	12.27318997	36.4295011
39	*Rhizophora mucronata*	Bakhaw babae	14.0	4.456327986	0.8483	8.408276237	4.735308897	13.14358513
40	*Rhizophora mucronata*	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866

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41	*Rhizophora mucronata*	Bakhaw babae	5.5	1.75070028	0.8483	0.844353328	0.595044227	1.439397555
42	*Rhizophora mucronata*	Bakhaw babae	6.0	1.909854851	0.8483	1.045885349	0.721838183	1.767723532
43	*Rhizophora mucronata*	Bakhaw babae	8.5	2.705627706	0.8483	2.463783603	1.564062453	4.027846056
44	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
45	*Rhizophora mucronata*	Bakhaw babae	15.0	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
46	*Rhizophora mucronata*	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
47	*Rhizophora mucronata*	Bakhaw babae	12.2	3.88337153	0.8483	5.993454143	3.488694169	9.482148312
48	*Rhizophora mucronata*	Bakhaw babae	14.0	4.456327986	0.8483	8.408276237	4.735308897	13.14358513
49	*Rhizophora mucronata*	Bakhaw babae	6.0	1.909854851	0.8483	1.045885349	0.721838183	1.767723532
50	*Rhizophora mucronata*	Bakhaw babae	8.0	2.546473135	0.8483	2.122429979	1.367111216	3.489541195
51	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
52	*Rhizophora mucronata*	Bakhaw babae	9.0	2.864782277	0.8483	2.835754152	1.775670772	4.611424924
53	*Rhizophora mucronata*	Bakhaw babae	6.7	2.13267125	0.8483	1.372069208	0.922210659	2.294279867
54	*Rhizophora mucronata*	Bakhaw babae	10.2	3.246753247	0.8483	3.858232774	2.344425609	6.202658383
55	*Rhizophora mucronata*	Bakhaw babae	8.0	2.546473135	0.8483	2.122429979	1.367111216	3.489541195
56	*Rhizophora mucronata*	Bakhaw babae	16.6	5.283931755	0.8483	12.78491662	6.911686493	19.69660311
57	*Rhizophora mucronata*	Bakhaw babae	15.8	5.029284441	0.8483	11.32213782	6.193880303	17.51601813
58	*Rhizophora mucronata*	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866
59	*Rhizophora mucronata*	Bakhaw babae	16.0	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
60	*Rhizophora mucronata*	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
61	*Rhizophora mucronata*	Bakhaw babae	18.0	5.729564553	0.8483	15.60279369	8.272733549	23.87552723

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62	*Rhizophora mucronata*	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
63	*Rhizophora mucronata*	Bakhaw babae	19.1	6.079704609	0.8483	18.05402697	9.437091167	27.49111813
64	*Rhizophora mucronata*	Bakhaw babae	16.2	5.156608098	0.8483	12.04034522	6.547377891	18.58772311
65	*Rhizophora mucronata*	Bakhaw babae	20.3	6.461675579	0.8483	20.97356501	10.80401751	31.77758253
66	*Rhizophora mucronata*	Bakhaw babae	14.9	4.742806213	0.8483	9.800996264	5.437729392	15.23872566
67	*Rhizophora mucronata*	Bakhaw babae	15.0	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
68	*Rhizophora mucronata*	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
69	*Rhizophora mucronata*	Bakhaw babae	19.4	6.175197352	0.8483	18.75962959	9.76931056	28.52894015
70	*Rhizophora mucronata*	Bakhaw babae	17.0	5.411255411	0.8483	13.55614951	7.28686428	20.84301379
71	*Rhizophora mucronata*	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536
72	*Rhizophora mucronata*	Bakhaw babae	15.0	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
73	*Rhizophora mucronata*	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
74	*Rhizophora mucronata*	Bakhaw babae	19.0	6.047873695	0.8483	17.82238667	9.327753688	27.15014035
75	*Rhizophora mucronata*	Bakhaw babae	20.6	6.557168322	0.8483	21.74429671	11.16167325	32.90596995
76	*Rhizophora mucronata*	Bakhaw babae	3.2	1.018589254	0.8483	0.222792697	0.178803916	0.401596613
77	*Rhizophora mucronata*	Bakhaw babae	5.3	1.687038452	0.8483	0.770815861	0.5480706	1.318886461
78	*Rhizophora mucronata*	Bakhaw babae	2.0	0.636618284	0.8483	0.070107712	0.062984062	0.133091774
79	*Rhizophora mucronata*	Bakhaw babae	5.0	1.591545709	0.8483	0.667879655	0.48156785	1.149447504
80	*Rhizophora mucronata*	Bakhaw babae	4.9	1.559714795	0.8483	0.635498252	0.460446709	1.095944961
81	*Rhizophora mucronata*	Bakhaw babae	3.7	1.177743825	0.8483	0.318425797	0.246803834	0.565229631
82	*Rhizophora mucronata*	Bakhaw babae	3.4	1.082251082	0.8483	0.258624783	0.204563088	0.463187871

83	*Rhizophora mucronata*	Bakhaw babae	4.5	1.432391138	0.8483	0.515388575	0.381132388	0.896520963
84	*Rhizophora mucronata*	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536
85	*Rhizophora mucronata*	Bakhaw babae	15.0	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
86	*Rhizophora mucronata*	Bakhaw babae	17.2	5.47491724	0.8483	13.95185592	7.478547001	21.43040292
87	*Rhizophora mucronata*	Bakhaw babae	16.0	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
88	*Rhizophora mucronata*	Bakhaw babae	19.2	6.111535523	0.8483	18.2874447	9.54712927	27.83457397
89	*Rhizophora mucronata*	Bakhaw babae	20.3	6.461675579	0.8483	20.97356501	10.80401751	31.77758253
90	*Rhizophora mucronata*	Bakhaw babae	16.7	5.315762669	0.8483	12.97521379	7.004459705	19.9796735
91	*Rhizophora mucronata*	Bakhaw babae	15.4	4.901960784	0.8483	10.62999295	5.851134422	16.48112737
92	*Rhizophora mucronata*	Bakhaw babae	19.0	6.047873695	0.8483	17.82238667	9.327753688	27.15014035
93	*Rhizophora mucronata*	Bakhaw babae	15.3	4.87012987	0.8483	10.46099328	5.767120844	16.22811413
94	*Rhizophora mucronata*	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
95	*Rhizophora mucronata*	Bakhaw babae	16.4	5.220269926	0.8483	12.40931673	6.728177154	19.13749389
96	*Rhizophora mucronata*	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866
97	*Rhizophora mucronata*	Bakhaw babae	18.9	6.016042781	0.8483	17.59251952	9.219116022	26.81163554
98	*Rhizophora mucronata*	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
99	*Rhizophora mucronata*	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
100	*Rhizophora mucronata*	Bakhaw babae	15.9	5.061115355	0.8483	11.49923447	6.281244391	17.78047886
101	*Rhizophora mucronata*	Bakhaw babae	16.7	5.315762669	0.8483	12.97521379	7.004459705	19.9796735
102	*Rhizophora mucronata*	Bakhaw babae	20.0	6.366182837	0.8483	20.21928494	10.45275246	30.67203741
103	*Rhizophora mucronata*	Bakhaw babae	17.0	5.411255411	0.8483	13.55614951	7.28686428	20.84301379

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104	*Rhizophora mucronata*	Bakhaw babae	14.9	4.742806213	0.8483	9.800996264	5.437729392	15.23872566
105	*Rhizophora mucronata*	Bakhaw babae	19.6	6.23885918	0.8483	19.23897538	9.994303962	29.23327934
106	*Rhizophora mucronata*	Bakhaw babae	21.8	6.939139292	0.8483	24.99395466	12.65661271	37.65056737
107	*Rhizophora mucronata*	Bakhaw babae	20.7	6.588999236	0.8483	22.00488246	11.28231555	33.28719802
108	*Rhizophora mucronata*	Bakhaw babae	24.2	7.703081232	0.8483	32.3160152	15.95931283	48.27532803
109	*Rhizophora mucronata*	Bakhaw babae	23.0	7.321110262	0.8483	28.51559776	14.25541521	42.77101297
110	*Rhizophora mucronata*	Bakhaw babae	25.1	7.98955946	0.8483	35.35325113	17.30691804	52.66016917
111	*Rhizophora mucronata*	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
112	*Rhizophora mucronata*	Bakhaw babae	22.7	7.22561752	0.8483	27.60931375	13.84590917	41.45522292
113	*Rhizophora mucronata*	Bakhaw babae	22.2	7.066462949	0.8483	26.1372758	13.17794463	39.31522043
114	*Rhizophora mucronata*	Bakhaw babae	21.7	6.907308378	0.8483	24.71285657	12.5280848	37.24094137
115	*Rhizophora mucronata*	Bakhaw babae	20.8	6.62083015	0.8483	22.26731267	11.40367099	33.67098366
116	*Rhizophora mucronata*	Bakhaw babae	25.0	7.957728546	0.8483	35.0077682	17.1542168	52.161985
117	*Rhizophora mucronata*	Bakhaw babae	24.3	7.734912147	0.8483	32.6455084	16.10608559	48.75159399
118	*Rhizophora mucronata*	Bakhaw babae	24.9	7.925897632	0.8483	34.66429701	17.00225893	51.66655595
119	*Rhizophora mucronata*	Bakhaw babae	20.9	6.652661064	0.8483	22.53159141	11.52574032	34.05733173
120	*Rhizophora mucronata*	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
121	*Rhizophora mucronata*	Bakhaw babae	16.4	5.220269926	0.8483	12.40931673	6.728177154	19.13749389
122	*Rhizophora mucronata*	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
123	*Rhizophora mucronata*	Bakhaw babae	20.0	6.366182837	0.8483	20.21928494	10.45275246	30.67203741
124	*Rhizophora mucronata*	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588

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125	*Rhizophora mucronata*	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
126	*Rhizophora mucronata*	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
127	*Rhizophora mucronata*	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
128	*Rhizophora mucronata*	Bakhaw babae	16.5	5.25210084	0.8483	12.59628581	6.81959261	19.41587842
129	*Rhizophora mucronata*	Bakhaw babae	19.1	6.079704609	0.8483	18.05402697	9.437091167	27.49111813
130	*Rhizophora mucronata*	Bakhaw babae	18.7	5.952380952	0.8483	17.13808748	9.00393688	26.14202436
131	*Rhizophora mucronata*	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
132	*Rhizophora mucronata*	Bakhaw babae	15.6	4.965622613	0.8483	10.97282658	6.021167151	16.99399373
133	*Rhizophora mucronata*	Bakhaw babae	17.7	5.634071811	0.8483	14.9708424	7.969750518	22.94059292
134	*Rhizophora mucronata*	Bakhaw babae	19.9	6.334351923	0.8483	19.97149479	10.33708066	30.30857544
135	*Rhizophora mucronata*	Bakhaw babae	23.6	7.512095747	0.8483	30.38054292	15.0941521	45.47469501
136	*Rhizophora mucronata*	Bakhaw babae	22.0	7.00280112	0.8483	25.56182152	12.91583317	38.47765469
137	*Rhizophora mucronata*	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
138	*Rhizophora mucronata*	Bakhaw babae	18.6	5.920550038	0.8483	16.91351396	8.89739377	25.81090773
139	*Rhizophora mucronata*	Bakhaw babae	22.6	7.193786606	0.8483	27.31107304	13.7108636	41.02193663
140	*Rhizophora mucronata*	Bakhaw babae	15.3	4.87012987	0.8483	10.46099328	5.767120844	16.22811413
141	*Rhizophora mucronata*	Bakhaw babae	16.5	5.25210084	0.8483	12.59628581	6.81959261	19.41587842
142	*Rhizophora mucronata*	Bakhaw babae	23.7	7.543926662	0.8483	30.69820165	15.23650658	45.93470823
143	*Rhizophora mucronata*	Bakhaw babae	25.2	8.021390374	0.8483	35.70074949	17.4603633	53.16111279
144	*Rhizophora mucronata*	Bakhaw babae	18.0	5.729564553	0.8483	15.60279369	8.272733549	23.87552723
145	*Rhizophora mucronata*	Bakhaw babae	23.0	7.321110262	0.8483	28.51559776	14.25541521	42.77101297

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146	*Rhizophora mucronata*	Bakhaw babae	24.7	7.862235803	0.8483	33.98337504	16.70057067	50.68394571
147	*Rhizophora mucronata*	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
148	*Rhizophora mucronata*	Bakhaw babae	23.0	7.321110262	0.8483	28.51559776	14.25541521	42.77101297
149	*Rhizophora mucronata*	Bakhaw babae	19.4	6.175197352	0.8483	18.75962959	9.76931056	28.52894015
150	*Rhizophora mucronata*	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
151	*Rhizophora mucronata*	Bakhaw babae	22.7	7.22561752	0.8483	27.60931375	13.84590917	41.45522292
152	*Rhizophora mucronata*	Bakhaw babae	24.6	7.830404889	0.8483	33.64591681	16.55083896	50.19675578
153	*Rhizophora mucronata*	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
154	*Rhizophora mucronata*	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
155	*Rhizophora mucronata*	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
156	*Rhizophora mucronata*	Bakhaw babae	24.9	7.925897632	0.8483	34.66429701	17.00225893	51.66655595
157	*Rhizophora mucronata*	Bakhaw babae	25.0	7.957728546	0.8483	35.0077682	17.1542168	52.161985
158	*Rhizophora mucronata*	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
159	*Rhizophora mucronata*	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536
160	*Rhizophora mucronata*	Bakhaw babae	21.6	6.875477464	0.8483	24.4336434	12.40027746	36.83392086
161	*Rhizophora mucronata*	Bakhaw babae	24.6	7.830404889	0.8483	33.64591681	16.55083896	50.19675578
162	*Rhizophora mucronata*	Bakhaw babae	23.8	7.575757576	0.8483	31.01782331	15.37959574	46.39741905
163	*Rhizophora mucronata*	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
164	*Rhizophora mucronata*	Bakhaw babae	22.3	7.098293863	0.8483	26.42785811	13.3100863	39.73794441
165	*Rhizophora mucronata*	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
166	*Rhizophora mucronata*	Bakhaw babae	26	8.276037688	0.8483	38.55373335	18.71478783	57.26852118

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167	*Rhizophora mucronata*	Bakhaw babae	22.4	7.130124777	0.8483	26.72034914	13.44295287	40.16330201
168	*Rhizophora mucronata*	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
169	*Rhizophora mucronata*	Bakhaw babae	17.0	5.411255411	0.8483	13.55614951	7.28686428	20.84301379
170	*Rhizophora mucronata*	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
171	*Rhizophora mucronata*	Bakhaw babae	23.7	7.543926662	0.8483	30.69820165	15.23650658	45.93470823
172	*Rhizophora mucronata*	Bakhaw babae	26.7	8.498854087	0.8483	41.15756818	19.85176272	61.0093309
173	*Rhizophora mucronata*	Bakhaw babae	18.8	5.984211867	0.8483	17.36442123	9.111177358	26.47559859
174	*Rhizophora mucronata*	Bakhaw babae	15.9	5.061115355	0.8483	11.49923447	6.281244391	17.78047886
175	*Rhizophora mucronata*	Bakhaw babae	23.3	7.416603005	0.8483	29.43930609	14.67148993	44.11079602
176	*Rhizophora mucronata*	Bakhaw babae	18.1	5.761395467	0.8483	15.8168974	8.375109839	24.19200724
177	*Rhizophora mucronata*	Bakhaw babae	16	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
178	*Rhizophora mucronata*	Bakhaw babae	18	5.729564553	0.8483	15.60279369	8.272733549	23.87552723
179	*Rhizophora mucronata*	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
180	*Rhizophora mucronata*	Bakhaw babae	20.5	6.525337408	0.8483	21.48555129	11.04174331	32.5272946
181	*Rhizophora mucronata*	Bakhaw babae	23.6	7.512095747	0.8483	30.38054292	15.0941521	45.47469501
182	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334
183	*Xylocarpus granatum*	Tabigi	15.5	4.933791698	0.6721	8.55721432	4.814792179	13.3720065
184	*Xylocarpus granatum*	Tabigi	47.0	14.96052967	0.6721	131.062112	56.50650169	187.5686137
185	*Xylocarpus granatum*	Tabigi	13.4	4.265342501	0.6721	5.981281409	3.485088643	9.466370052
186	*Xylocarpus granatum*	Tabigi	21.0	6.684491979	0.6721	18.06241835	9.448611899	27.51103024
187	*Xylocarpus granatum*	Tabigi	6.0	1.909854851	0.6721	0.828644988	0.585513553	1.414158541

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188	*Xylocarpus granatum*	Tabigi	39.5	12.5732111	0.6721	85.45653647	38.41375204	123.8702885
189	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334
190	*Xylocarpus granatum*	Tabigi	40.0	12.73236567	0.6721	88.14222522	39.50157001	127.6437952
191	*Xylocarpus granatum*	Tabigi	55.0	17.5070028	0.6721	192.9339465	80.10255099	273.0364975
192	*Xylocarpus granatum*	Tabigi	25.2	8.021390374	0.6721	28.28536336	14.16284092	42.44820427

Total Biomass of Site 2 (kg)	**Total Biomass (t/ha)**	**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**
2.305169919	23.05169919	11.52584959	42.26529046

Table F3. Amount of Carbon Stored and Carbon dioxide Sequestered of Mangrove Trees in Site 3.

Tree No.	Scientific Name	Local Name	GBH (cm)	DBH (cm)	Wood Density (g/cm^3)	AGB (kg)	BGB (kg)	Total Biomass (kg)
1	*Avicennia alba*	Tabigi	149	47.42806213	0.6987	2328.152905	757.9996385	3086.152544
2	*Rhizophora mucronata*	Bakhaw babae	35	11.14081996	0.8483	80.10126827	36.20554871	116.306817
3	*Rhizophora mucronata*	Bakhaw babae	37.6	11.96842373	0.8483	95.54195021	42.44837712	137.9903273
4	*Rhizophora mucronata*	Bakhaw babae	11	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
5	*Rhizophora mucronata*	Bakhaw babae	73	23.23656735	0.8483	488.6593796	185.1487672	673.8081468
6	*Rhizophora mucronata*	Bakhaw babae	74	23.5548765	0.8483	505.291548	190.8264157	696.1179638
7	*Rhizophora mucronata*	Bakhaw babae	32.5	10.34504711	0.8483	66.75212126	30.71320487	97.46532613
8	*Rhizophora mucronata*	Bakhaw babae	62	19.73516679	0.8483	326.9757612	128.8408633	455.8166245
9	*Rhizophora mucronata*	Bakhaw babae	55	17.5070028	0.8483	243.5141598	98.75276082	342.2669206
10	*Rhizophora mucronata*	Bakhaw babae	62.5	19.89432136	0.8483	333.5007739	131.1588843	464.6596582

11	*Rhizophora mucronata*	Bakhaw babae	37.2	11.84110008	0.8483	93.06098296	41.45237342	134.5133564
12	*Rhizophora mucronata*	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
13	*Rhizophora mucronata*	Bakhaw babae	57	18.14362108	0.8483	265.8790683	106.9021045	372.7811728
14	*Rhizophora mucronata*	Bakhaw babae	46.6 + 49.2	15.24700789	0.8483	173.3234665	72.65891613	245.9823826
15	*Rhizophora mucronata*	Bakhaw babae	25	7.957728546	0.8483	35.0077682	17.1542168	52.161985
16	*Rhizophora mucronata*	Bakhaw babae	59.4	18.90756303	0.8483	294.2704531	117.1520744	411.4225276
17	*Rhizophora mucronata*	Bakhaw babae	11	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
18	*Rhizophora mucronata*	Bakhaw babae	53.5	17.02953909	0.8483	227.5004747	92.87299935	320.373474
19	*Rhizophora mucronata*	Bakhaw babae	70.7	22.50445633	0.8483	451.6518165	172.4468135	624.0986301
20	*Rhizophora mucronata*	Bakhaw babae	40.4	12.85968933	0.8483	114.006644	49.78639791	163.7930419
21	*Rhizophora mucronata*	Bakhaw babae	42	13.36898396	0.8483	125.4368842	54.26970989	179.7065941
22	*Rhizophora mucronata*	Bakhaw babae	51.2	16.29742806	0.8483	204.1907702	84.24097577	288.431746
23	*Rhizophora mucronata*	Bakhaw babae	22.4	7.130124777	0.8483	26.72034914	13.44295287	40.16330201
24	*Rhizophora mucronata*	Bakhaw babae	33.7	10.72701808	0.8483	72.97961358	33.28759779	106.2672114
25	*Rhizophora mucronata*	Bakhaw babae	47	14.96052967	0.8483	165.4217968	69.66286313	235.08466
26	*Rhizophora mucronata*	Bakhaw babae	55.9	17.79348103	0.8483	253.4341007	102.3760311	355.8101318
27	*Rhizophora mucronata*	Bakhaw babae	42	13.36898396	0.8483	125.4368842	54.26970989	179.7065941
28	*Rhizophora mucronata*	Bakhaw babae	41.4	13.17799847	0.8483	121.0745441	52.56356743	173.6381116
29	*Rhizophora mucronata*	Bakhaw babae	60	19.09854851	0.8483	301.6366295	119.7953198	421.4319493
30	*Rhizophora mucronata*	Bakhaw babae	57.1	18.175452	0.8483	267.0280164	107.3189057	374.3469221
31	*Rhizophora mucronata*	Bakhaw babae	58	18.46193023	0.8483	277.5012013	111.1102746	388.6114759

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32	*Rhizophora mucronata*	Bakhaw babae	64.7	20.59460148	0.8483	363.1253211	141.628801	504.7541221
33	*Rhizophora mucronata*	Bakhaw babae	49.2	15.66080978	0.8483	185.1254623	77.1092721	262.2347344
34	*Rhizophora mucronata*	Bakhaw babae	75.6	24.06417112	0.8483	532.5932038	200.107083	732.7002868
35	*Rhizophora mucronata*	Bakhaw babae	58	18.46193023	0.8483	277.5012013	111.1102746	388.6114759
36	*Rhizophora mucronata*	Bakhaw babae	65.2 + 70.7	21.62910619	0.8483	409.654828	157.9081985	567.5630265
37	*Rhizophora mucronata*	Bakhaw babae	98.5	21.62910619	0.8483	409.654828	157.9081985	567.5630265
38	*Rhizophora mucronata*	Bakhaw babae	61	19.41685765	0.8483	314.1545814	124.2728645	438.4274459
39	*Rhizophora mucronata*	Bakhaw babae	28	21.62910619	0.8483	409.654828	157.9081985	567.5630265
40	*Rhizophora mucronata*	Bakhaw babae	68	21.64502165	0.8483	410.3967649	158.1662659	568.5630307
41	*Rhizophora mucronata*	Bakhaw babae	19	21.62910619	0.8483	409.654828	157.9081985	567.5630265
42	*Rhizophora mucronata*	Bakhaw babae	33	10.50420168	0.8483	69.30687152	31.77203423	101.0789058
43	*Rhizophora mucronata*	Bakhaw babae	40	21.62910619	0.8483	409.654828	157.9081985	567.5630265

Total Biomass of Site 3(kg)	**Total Biomass (t/ha)**	**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**
6.152733237	61.52733237	30.76366618	112.8103639

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Table F4. Amount of Carbon Stored and Carbon dioxide Sequestered of Avicennia alba.

TreeNo.	ScientificName	Local name	GBH (cm)	DBH (cm)	Wood Density (g/cm³)	AGB (kg)	BGB (kg)	Total Biomass (kg)
1	*Avicennia alba*	Bungalon	91.9	29.25261013	0.6987	709.1358437	259.2721792	968.4080229
2	*Avicennia alba*	Bungalon	162.6	51.75706646	0.6987	2886.222521	920.2018123	3806.424333
3	*Avicennia alba*	Bungalon	35.6	11.33180545	0.6987	68.79237045	31.58017106	100.3725415
4	*Avicennia alba*	Bungalon	61	19.41685765	0.6987	258.752571	104.3825053	363.1350764
5	*Avicennia alba*	Bungalon	80.8	25.71937866	0.6987	516.660461	194.8268028	711.4872638
6	*Avicennia alba*	Bungalon	172.7	54.9719888	0.6987	3347.437138	1051.924262	4399.3614
7	*Avicennia alba*	Bungalon	71.1	22.63177998	0.6987	377.2007064	146.6715887	523.8722952
8	*Avicennia alba*	Bungalon	128.3	40.8390629	0.6987	1611.42781	543.824363	2155.252173
9	*Avicennia alba*	Bungalon	62.7	19.95798319	0.6987	276.8544	110.9505408	387.8049408
10	*Avicennia alba*	Bungalon	56.4	17.9526356	0.6987	213.3633765	87.70716907	301.0705455
11	*Avicennia alba*	Bungalon	94.7	30.14387573	0.6987	763.4739581	277.1356756	1040.609634
12	*Avicennia alba*	Bungalon	68.6	21.83600713	0.6987	345.4065781	135.4674699	480.874048
13	*Avicennia alba*	Bungalon	38.1	12.1275783	0.6987	81.29217058	36.71545619	118.0076268
14	*Avicennia alba*	Bungalon	30.5	9.708428826	0.6987	47.02739088	22.40480281	69.4321937
15	*Avicennia alba*	Bungalon	26.7	8.498854087	0.6987	33.89931968	16.67441027	50.57372995
16	*Avicennia alba*	Bungalon	48.0	15.27883881	0.6987	143.4916811	61.31278305	204.8044641
17	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	51.93719759
18	*Avicennia alba*	Bungalon	24.0	7.639419404	0.6987	26.07912009	13.16025908	39.23937918
19	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	51.93719759
20	*Avicennia alba*	Bungalon	33.5	10.66335625	0.6987	59.23569727	27.59274798	86.82844524
21	*Avicennia alba*	Bungalon	33.0	10.50420168	0.6987	57.08441723	26.68679559	83.77121282
22	*Avicennia alba*	Bungalon	40.0	12.73236567	0.6987	91.63066919	40.9042716	132.5349408
23	*Avicennia alba*	Bungalon	32.0	10.18589254	0.6987	52.92272845	24.92461361	77.84734206
24	*Avicennia alba*	Bungalon	149	47.42806213	0.6987	2328.152905	757.9996385	3086.152544
25	*Avicennia alba*	Bungalon	48.0	15.27883881	0.6987	143.4916811	61.31278305	0.074150784
26	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	0.018804199
27	*Avicennia alba*	Bungalon	24.0	7.639419404	0.6987	26.07912009	13.16025908	0.014206872
28	*Avicennia alba*	Bungalon	27.0	8.59434683	0.6987	34.84401078	17.09318681	0.018804199
29	*Avicennia alba*	Bungalon	33.5	10.66335625	0.6987	59.23569727	27.59274798	0.031436801
30	*Avicennia alba*	Bungalon	33.0	10.50420168	0.6987	57.08441723	26.68679559	0.030329911
31	*Avicennia alba*	Bungalon	40.0	12.73236567	0.6987	91.63066919	40.9042716	0.047985134
32	*Avicennia alba*	Bungalon	32.0	10.18589254	0.6987	52.92272845	24.92461361	0.028185135

Total Biomass of Avicennia alba (kg)	**Total Biomass (t/ha)**	**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**
6.984794515	69.84794515	34.92397257	128.0662074

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Table F5. Amount of Carbon Stored and Carbon dioxide Sequestered of Xylocarpus granatum.

Tree No.	Scientific Name	Local Name	GBH (cm)	DBH (cm)	Wood Density (g/cm³)	AGB (kg)	BGB (kg)	Total Biomass (kg)
1	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334
2	*Xylocarpus granatum*	Tabigi	15.5	4.933791698	0.6721	8.55721432	4.814792179	13.3720065
3	*Xylocarpus granatum*	Tabigi	47.0	14.96052967	0.6721	131.062112	56.50650169	187.5686137
4	*Xylocarpus granatum*	Tabigi	13.4	4.265342501	0.6721	5.981281409	3.485088643	9.466370052
5	*Xylocarpus granatum*	Tabigi	21.0	6.684491979	0.6721	18.06241835	9.448611899	27.51103024
6	*Xylocarpus granatum*	Tabigi	39.5	12.5732111	0.6721	85.45653647	38.41375204	123.8702885
7	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334
8	*Xylocarpus granatum*	Tabigi	40.0	12.73236567	0.6721	88.14222522	39.50157001	127.6437952
9	*Xylocarpus granatum*	Tabigi	55.0	17.5070028	0.6721	192.9339465	80.10255099	273.0364975
10	*Xylocarpus granatum*	Tabigi	25.2	8.021390374	0.6721	28.28536336	14.16284092	42.44820427
11	*Xylocarpus granatum*	Tabigi	25.0	7.957728546	0.6721	27.73632089	13.91451251	41.6508334

Total Biomass of Xylocarpus granatum (kg)	**Total Biomass (t/ha)**	**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**
0.336665209	3.366652086	1.683326043	6.1727566

Table F6. Amount of Carbon Stored and Carbon dioxide Sequestered of Rhizophora mucronata.

Tree No.	Scientific Name	Local name	GBH (cm)	DBH (cm)	Wood Density (g/cm³)	AGB (kg)	BGB (kg)	Total Biomass (kg)
1	Rhizophora mucronata	Bakhaw babae	45.7	14.54672778	0.8483	154.3923777	65.45729277	219.8496705
2	Rhizophora mucronata	Bakhaw babae	48.3	15.37433155	0.8483	176.9057483	74.01277804	250.9185264

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3	Rhizophora mucronata	Bakhaw babae	26.4	8.403361345	0.8483	40.02926939	19.35997504	59.38924442
4	Rhizophora mucronata	Bakhaw babae	33.02	10.51056786	0.8483	69.41024749	31.81479787	101.2250454
5	Rhizophora mucronata	Bakhaw babae	38.6	12.28673287	0.8483	101.9146865	44.99537666	146.9100632
6	Rhizophora mucronata	Bakhaw babae	32.3	10.28138528	0.8483	65.74613214	30.2951896	96.04132175
7	Rhizophora mucronata	Bakhaw babae	16	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
8	Rhizophora mucronata	Bakhaw babae	39	12.41405653	0.8483	104.5324036	46.03705171	150.5694553
9	Rhizophora mucronata	Bakhaw babae	40	12.73236567	0.8483	111.2498879	48.69868745	159.9485753
10	Rhizophora mucronata	Bakhaw babae	37.8	12.03208556	0.8483	96.79698516	42.95125627	139.7482414
11	Rhizophora mucronata	Bakhaw babae	11	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
12	Rhizophora mucronata	Bakhaw babae	6.5	2.069009422	0.8483	1.27349974	0.862207363	2.135707103
13	Rhizophora mucronata	Bakhaw babae	12	3.819709702	0.8483	5.754636138	3.362996703	9.11763284
14	Rhizophora mucronata	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
15	Rhizophora mucronata	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
16	Rhizophora mucronata	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
17	Rhizophora mucronata	Bakhaw babae	55	17.5070028	0.8483	243.5141598	98.75276082	342.2669206
18	Rhizophora mucronata	Bakhaw babae	21	6.684491979	0.8483	22.79772278	11.64852429	34.44624707
19	Rhizophora mucronata	Bakhaw babae	20.5	6.525337408	0.8483	21.48555129	11.04174331	32.5272946
20	Rhizophora mucronata	Bakhaw babae	10.5	3.342245989	0.8483	4.143407798	2.500255085	6.643662883
21	Rhizophora mucronata	Bakhaw babae	21.5	6.84364655	0.8483	24.15631114	12.27318997	36.4295011
22	Rhizophora mucronata	Bakhaw babae	14	4.456327986	0.8483	8.408276237	4.735308897	13.14358513
23	Rhizophora mucronata	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866
24	Rhizophora mucronata	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573

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25	Rhizophora mucronata	Bakhaw babae	15	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
26	Rhizophora mucronata	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
27	Rhizophora mucronata	Bakhaw babae	12.2	3.88337153	0.8483	5.993454143	3.488694169	9.482148312
28	Rhizophora mucronata	Bakhaw babae	14	4.456327986	0.8483	8.408276237	4.735308897	13.14358513
29	Rhizophora mucronata	Bakhaw babae	10	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
30	Rhizophora mucronata	Bakhaw babae	10.2	3.246753247	0.8483	3.858232774	2.344425609	6.202658383
31	Rhizophora mucronata	Bakhaw babae	16.6	5.283931755	0.8483	12.78491662	6.911686493	19.69660311
32	Rhizophora mucronata	Bakhaw babae	15.8	5.029284441	0.8483	11.32213782	6.193880303	17.51601813
33	Rhizophora mucronata	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866
34	Rhizophora mucronata	Bakhaw babae	16	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
35	Rhizophora mucronata	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
36	Rhizophora mucronata	Bakhaw babae	18	5.729564553	0.8483	15.60279369	8.272733549	23.87552723
37	Rhizophora mucronata	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
38	Rhizophora mucronata	Bakhaw babae	19.1	6.079704609	0.8483	18.05402697	9.437091167	27.49111813
39	Rhizophora mucronata	Bakhaw babae	16.2	5.156608098	0.8483	12.04034522	6.547377891	18.58772311
40	Rhizophora mucronata	Bakhaw babae	20.3	6.461675579	0.8483	20.97356501	10.80401751	31.77758253
41	Rhizophora mucronata	Bakhaw babae	14.9	4.742806213	0.8483	9.800996264	5.437729392	15.23872566
42	Rhizophora mucronata	Bakhaw babae	15	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
43	Rhizophora mucronata	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
44	Rhizophora mucronata	Bakhaw babae	19.4	6.175197352	0.8483	18.75962959	9.76931056	28.52894015
45	Rhizophora mucronata	Bakhaw babae	17	5.411255411	0.8483	13.55614951	7.28686428	20.84301379
46	Rhizophora mucronata	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536

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47	Rhizophora mucronata	Bakhaw babae	15	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
48	Rhizophora mucronata	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
49	Rhizophora mucronata	Bakhaw babae	19	6.047873695	0.8483	17.82238667	9.327753688	27.15014035
50	Rhizophora mucronata	Bakhaw babae	20.6	6.557168322	0.8483	21.74429671	11.16167325	32.90596995
51	Rhizophora mucronata	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536
52	Rhizophora mucronata	Bakhaw babae	15	4.774637128	0.8483	9.963604971	5.51907976	15.48268473
53	Rhizophora mucronata	Bakhaw babae	17.2	5.47491724	0.8483	13.95185592	7.478547001	21.43040292
54	Rhizophora mucronata	Bakhaw babae	16	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
55	Rhizophora mucronata	Bakhaw babae	19.2	6.111535523	0.8483	18.2874447	9.54712927	27.83457397
56	Rhizophora mucronata	Bakhaw babae	20.3	6.461675579	0.8483	20.97356501	10.80401751	31.77758253
57	Rhizophora mucronata	Bakhaw babae	16.7	5.315762669	0.8483	12.97521379	7.004459705	19.9796735
58	Rhizophora mucronata	Bakhaw babae	15.4	4.901960784	0.8483	10.62999295	5.851134422	16.48112737
59	Rhizophora mucronata	Bakhaw babae	19	6.047873695	0.8483	17.82238667	9.327753688	27.15014035
60	Rhizophora mucronata	Bakhaw babae	15.3	4.87012987	0.8483	10.46099328	5.767120844	16.22811413
61	Rhizophora mucronata	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
62	Rhizophora mucronata	Bakhaw babae	16.4	5.220269926	0.8483	12.40931673	6.728177154	19.13749389
63	Rhizophora mucronata	Bakhaw babae	15.5	4.933791698	0.8483	10.80060245	5.935816207	16.73641866
64	Rhizophora mucronata	Bakhaw babae	18.9	6.016042781	0.8483	17.59251952	9.219116022	26.81163554
65	Rhizophora mucronata	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
66	Rhizophora mucronata	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
67	Rhizophora mucronata	Bakhaw babae	15.9	5.061115355	0.8483	11.49923447	6.281244391	17.78047886
68	Rhizophora mucronata	Bakhaw babae	16.7	5.315762669	0.8483	12.97521379	7.004459705	19.9796735

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69	Rhizophora mucronata	Bakhaw babae	20	6.366182837	0.8483	20.21928494	10.45275246	30.67203741
70	Rhizophora mucronata	Bakhaw babae	17	5.411255411	0.8483	13.55614951	7.28686428	20.84301379
71	Rhizophora mucronata	Bakhaw babae	14.9	4.742806213	0.8483	9.800996264	5.437729392	15.23872566
72	Rhizophora mucronata	Bakhaw babae	19.6	6.23885918	0.8483	19.23897538	9.994303962	29.23327934
73	Rhizophora mucronata	Bakhaw babae	21.8	6.939139292	0.8483	24.99395466	12.65661271	37.65056737
74	Rhizophora mucronata	Bakhaw babae	20.7	6.588999236	0.8483	22.00488246	11.28231555	33.28719802
75	Rhizophora mucronata	Bakhaw babae	24.2	7.703081232	0.8483	32.3160152	15.95931283	48.27532803
76	Rhizophora mucronata	Bakhaw babae	23	7.321110262	0.8483	28.51559776	14.25541521	42.77101297
77	Rhizophora mucronata	Bakhaw babae	25.1	7.98955946	0.8483	35.35325113	17.30691804	52.66016917
78	Rhizophora mucronata	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
79	Rhizophora mucronata	Bakhaw babae	22.7	7.22561752	0.8483	27.60931375	13.84590917	41.45522292
80	Rhizophora mucronata	Bakhaw babae	22.2	7.066462949	0.8483	26.1372758	13.17794463	39.31522043
81	Rhizophora mucronata	Bakhaw babae	21.7	6.907308378	0.8483	24.71285657	12.5280848	37.24094137
82	Rhizophora mucronata	Bakhaw babae	20.8	6.62083015	0.8483	22.26731267	11.40367099	33.67098366
83	Rhizophora mucronata	Bakhaw babae	25	7.957728546	0.8483	35.0077682	17.1542168	52.161985
84	Rhizophora mucronata	Bakhaw babae	24.3	7.734912147	0.8483	32.6455084	16.10608559	48.75159399
85	Rhizophora mucronata	Bakhaw babae	24.9	7.925897632	0.8483	34.66429701	17.00225893	51.66655595
86	Rhizophora mucronata	Bakhaw babae	20.9	6.652661064	0.8483	22.53159141	11.52574032	34.05733173
87	Rhizophora mucronata	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
88	Rhizophora mucronata	Bakhaw babae	16.4	5.220269926	0.8483	12.40931673	6.728177154	19.13749389
89	Rhizophora mucronata	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
90	Rhizophora mucronata	Bakhaw babae	20	6.366182837	0.8483	20.21928494	10.45275246	30.67203741

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91	Rhizophora mucronata	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
92	Rhizophora mucronata	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
93	Rhizophora mucronata	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
94	Rhizophora mucronata	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
95	Rhizophora mucronata	Bakhaw babae	16.5	5.25210084	0.8483	12.59628581	6.81959261	19.41587842
96	Rhizophora mucronata	Bakhaw babae	19.1	6.079704609	0.8483	18.05402697	9.437091167	27.49111813
97	Rhizophora mucronata	Bakhaw babae	18.7	5.952380952	0.8483	17.13808748	9.00393688	26.14202436
98	Rhizophora mucronata	Bakhaw babae	17.4	5.538579068	0.8483	14.35433753	7.672968345	22.02730588
99	Rhizophora mucronata	Bakhaw babae	15.6	4.965622613	0.8483	10.97282658	6.021167151	16.99399373
100	Rhizophora mucronata	Bakhaw babae	17.7	5.634071811	0.8483	14.9708424	7.969750518	22.94059292
101	Rhizophora mucronata	Bakhaw babae	19.9	6.334351923	0.8483	19.97149479	10.33708066	30.30857544
102	Rhizophora mucronata	Bakhaw babae	23.6	7.512095747	0.8483	30.38054292	15.0941521	45.47469501
103	Rhizophora mucronata	Bakhaw babae	22	7.00280112	0.8483	25.56182152	12.91583317	38.47765469
104	Rhizophora mucronata	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
105	Rhizophora mucronata	Bakhaw babae	18.6	5.920550038	0.8483	16.91351396	8.89739377	25.81090773
106	Rhizophora mucronata	Bakhaw babae	22.6	7.193786606	0.8483	27.31107304	13.7108636	41.02193663
107	Rhizophora mucronata	Bakhaw babae	15.3	4.87012987	0.8483	10.46099328	5.767120844	16.22811413
108	Rhizophora mucronata	Bakhaw babae	16.5	5.25210084	0.8483	12.59628581	6.81959261	19.41587842
109	Rhizophora mucronata	Bakhaw babae	23.7	7.543926662	0.8483	30.69820165	15.23650658	45.93470823
110	Rhizophora mucronata	Bakhaw babae	25.2	8.021390374	0.8483	35.70074949	17.4603633	53.16111279
111	Rhizophora mucronata	Bakhaw babae	18	5.729564553	0.8483	15.60279369	8.272733549	23.87552723
112	Rhizophora mucronata	Bakhaw babae	23	7.321110262	0.8483	28.51559776	14.25541521	42.77101297

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113	Rhizophora mucronata	Bakhaw babae	24.7	7.862235803	0.8483	33.98337504	16.70057067	50.68394571
114	Rhizophora mucronata	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
115	Rhizophora mucronata	Bakhaw babae	23	7.321110262	0.8483	28.51559776	14.25541521	42.77101297
116	Rhizophora mucronata	Bakhaw babae	19.4	6.175197352	0.8483	18.75962959	9.76931056	28.52894015
117	Rhizophora mucronata	Bakhaw babae	18.3	5.825057296	0.8483	16.25031127	8.581940408	24.83225167
118	Rhizophora mucronata	Bakhaw babae	22.7	7.22561752	0.8483	27.60931375	13.84590917	41.45522292
119	Rhizophora mucronata	Bakhaw babae	24.6	7.830404889	0.8483	33.64591681	16.55083896	50.19675578
120	Rhizophora mucronata	Bakhaw babae	20.1	6.398013751	0.8483	20.46889059	10.56913202	31.03802261
121	Rhizophora mucronata	Bakhaw babae	16.8	5.347593583	0.8483	13.16718194	7.097913145	20.26509508
122	Rhizophora mucronata	Bakhaw babae	19.7	6.270690094	0.8483	19.4813442	10.10785719	29.5892014
123	Rhizophora mucronata	Bakhaw babae	24.9	7.925897632	0.8483	34.66429701	17.00225893	51.66655595
124	Rhizophora mucronata	Bakhaw babae	25	7.957728546	0.8483	35.0077682	17.1542168	52.161985
125	Rhizophora mucronata	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
126	Rhizophora mucronata	Bakhaw babae	17.8	5.665902725	0.8483	15.17977062	8.070054737	23.24982536
127	Rhizophora mucronata	Bakhaw babae	21.6	6.875477464	0.8483	24.4336434	12.40027746	36.83392086
128	Rhizophora mucronata	Bakhaw babae	24.6	7.830404889	0.8483	33.64591681	16.55083896	50.19675578
129	Rhizophora mucronata	Bakhaw babae	23.8	7.575757576	0.8483	31.01782331	15.37959574	46.39741905
130	Rhizophora mucronata	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
131	Rhizophora mucronata	Bakhaw babae	22.3	7.098293863	0.8483	26.42785811	13.3100863	39.73794441
132	Rhizophora mucronata	Bakhaw babae	16.9	5.379424497	0.8483	13.36082565	7.192047707	20.55287336
133	Rhizophora mucronata	Bakhaw babae	26	8.276037688	0.8483	38.55373335	18.71478783	57.26852118
134	Rhizophora mucronata	Bakhaw babae	22.4	7.130124777	0.8483	26.72034914	13.44295287	40.16330201

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135	Rhizophora mucronata	Bakhaw babae	24.8	7.894066718	0.8483	34.32283387	16.85104377	51.17387764
136	Rhizophora mucronata	Bakhaw babae	17	5.411255411	0.8483	13.55614951	7.28686428	20.84301379
137	Rhizophora mucronata	Bakhaw babae	15.2	4.838298956	0.8483	10.29359862	5.683774517	15.97737314
138	Rhizophora mucronata	Bakhaw babae	23.7	7.543926662	0.8483	30.69820165	15.23650658	45.93470823
139	Rhizophora mucronata	Bakhaw babae	26.7	8.498854087	0.8483	41.15756818	19.85176272	61.0093309
140	Rhizophora mucronata	Bakhaw babae	18.8	5.984211867	0.8483	17.36442123	9.111177358	26.47559859
141	Rhizophora mucronata	Bakhaw babae	15.9	5.061115355	0.8483	11.49923447	6.281244391	17.78047886
142	Rhizophora mucronata	Bakhaw babae	23.3	7.416603005	0.8483	29.43930609	14.67148993	44.11079602
143	Rhizophora mucronata	Bakhaw babae	18.1	5.761395467	0.8483	15.8168974	8.375109839	24.19200724
144	Rhizophora mucronata	Bakhaw babae	16	5.092946269	0.8483	11.67796477	6.3692814	18.04724617
145	Rhizophora mucronata	Bakhaw babae	18	5.729564553	0.8483	15.60279369	8.272733549	23.87552723
146	Rhizophora mucronata	Bakhaw babae	19.8	6.302521008	0.8483	19.72551594	10.22211583	29.94763177
147	Rhizophora mucronata	Bakhaw babae	20.5	6.525337408	0.8483	21.48555129	11.04174331	32.5272946
148	Rhizophora mucronata	Bakhaw babae	23.6	7.512095747	0.8483	30.38054292	15.0941521	45.47469501
149	Rhizophora mucronata	Bakhaw babae	35	11.14081996	0.8483	80.10126827	36.20554871	116.306817
150	*Rhizophora mucronata*	Bakhaw babae	37.6	11.96842373	0.8483	95.54195021	42.44837712	137.9903273
151	*Rhizophora mucronata*	Bakhaw babae	11	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
152	*Rhizophora mucronata*	Bakhaw babae	73	23.23656735	0.8483	488.6593796	185.1487672	673.8081468
153	*Rhizophora mucronata*	Bakhaw babae	74	23.5548765	0.8483	505.291548	190.8264157	696.1179638
154	*Rhizophora mucronata*	Bakhaw babae	32.5	10.34504711	0.8483	66.75212126	30.71320487	97.46532613
155	*Rhizophora mucronata*	Bakhaw babae	62	19.73516679	0.8483	326.9757612	128.8408633	455.8166245
156	*Rhizophora mucronata*	Bakhaw babae	55.0	17.5070028	0.8483	243.5141598	98.75276082	342.2669206

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157	*Rhizophora mucronata*	Bakhaw babae	62.5	19.89432136	0.8483	333.5007739	131.1588843	464.6596582
158	*Rhizophora mucronata*	Bakhaw babae	37.2	11.84110008	0.8483	93.06098296	41.45237342	134.5133564
159	*Rhizophora mucronata*	Bakhaw babae	10.0	3.183091418	0.8483	3.674785579	2.243592995	5.918378573
160	*Rhizophora mucronata*	Bakhaw babae	57.0	18.14362108	0.8483	265.8790683	106.9021045	372.7811728
161	*Rhizophora mucronata*	Bakhaw babae	46.6 + 49.2	15.24700789	0.8483	173.3234665	72.65891613	245.9823826
162	*Rhizophora mucronata*	Bakhaw babae	25.0	7.957728546	0.8483	35.0077682	17.1542168	52.161985
163	*Rhizophora mucronata*	Bakhaw babae	59.4	18.90756303	0.8483	294.2704531	117.1520744	411.4225276
164	*Rhizophora mucronata*	Bakhaw babae	11.0	3.50140056	0.8483	4.645773248	2.772271986	7.418045234
165	*Rhizophora mucronata*	Bakhaw babae	53.5	17.02953909	0.8483	227.5004747	92.87299935	320.373474
166	*Rhizophora mucronata*	Bakhaw babae	70.7	22.50445633	0.8483	451.6518165	172.4468135	624.0986301
167	*Rhizophora mucronata*	Bakhaw babae	40.4	12.85968933	0.8483	114.006644	49.78639791	163.7930419
168	*Rhizophora mucronata*	Bakhaw babae	42.0	13.36898396	0.8483	125.4368842	54.26970989	179.7065941
169	*Rhizophora mucronata*	Bakhaw babae	51.2	16.29742806	0.8483	204.1907702	84.24097577	288.431746
170	*Rhizophora mucronata*	Bakhaw babae	22.4	7.130124777	0.8483	26.72034914	13.44295287	40.16330201
171	*Rhizophora mucronata*	Bakhaw babae	33.7	10.72701808	0.8483	72.97961358	33.28759779	106.2672114
172	*Rhizophora mucronata*	Bakhaw babae	47.0	14.96052967	0.8483	165.4217968	69.66286313	235.08466
173	*Rhizophora mucronata*	Bakhaw babae	55.9	17.79348103	0.8483	253.4341007	102.3760311	355.8101318
174	*Rhizophora mucronata*	Bakhaw babae	42.0	13.36898396	0.8483	125.4368842	54.26970989	179.7065941
175	*Rhizophora mucronata*	Bakhaw babae	41.4	13.17799847	0.8483	121.0745441	52.56356743	173.6381116
176	*Rhizophora mucronata*	Bakhaw babae	60.0	19.09854851	0.8483	301.6366295	119.7953198	421.4319493
177	*Rhizophora mucronata*	Bakhaw babae	57.1	18.175452	0.8483	267.0280164	107.3189057	374.3469221

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178	*Rhizophora mucronata*	Bakhaw babae	58.0	18.46193023	0.8483	277.5012013	111.1102746	388.6114759
179	*Rhizophora mucronata*	Bakhaw babae	64.7	20.59460148	0.8483	363.1253211	141.628801	504.7541221
180	*Rhizophora mucronata*	Bakhaw babae	49.2	15.66080978	0.8483	185.1254623	77.1092721	262.2347344
181	*Rhizophora mucronata*	Bakhaw babae	75.6	24.06417112	0.8483	532.5932038	200.107083	732.7002868
182	*Rhizophora mucronata*	Bakhaw babae	58.0	18.46193023	0.8483	277.5012013	111.1102746	388.6114759
183	*Rhizophora mucronata*	Bakhaw babae	65.2 + 70.7	21.62910619	0.8483	409.654828	157.9081985	567.5630265
184	*Rhizophora mucronata*	Bakhaw babae	98.5	21.62910619	0.8483	409.654828	157.9081985	567.5630265
185	*Rhizophora mucronata*	Bakhaw babae	61.0	19.41685765	0.8483	314.1545814	124.2728645	438.4274459
186	*Rhizophora mucronata*	Bakhaw babae	28.0	21.62910619	0.8483	409.654828	157.9081985	567.5630265
187	*Rhizophora mucronata*	Bakhaw babae	68.0	21.64502165	0.8483	410.3967649	158.1662659	568.5630307
188	*Rhizophora mucronata*	Bakhaw babae	19.0	21.62910619	0.8483	409.654828	157.9081985	567.5630265
189	*Rhizophora mucronata*	Bakhaw babae	33.0	10.50420168	0.8483	69.30687152	31.77203423	101.0789058
190	*Rhizophora mucronata*	Bakhaw babae	40.0	21.62910619	0.8483	409.654828	157.9081985	567.5630265

Total Biomass of Rhizophora mucronata (kg)	**Total Biomass (t/ha)**	**C. Stored (tC/ha)**	**CO_2 Sequestered (tCO_2/ha)**
7.031091513	70.31091513	35.15545757	128.9150629

able F7. Total Occurrence of Identified Mangrove spp. in Kaingen River, Kawit, Cavite.

Mangrove Species	Site 1	Site 2	Site 3	Total No. of Species	Total Occurrences(%)
Acanthaceae					
Avicennia alba	15	8	1	24	9.38
Meliaceae					
Xylocarpus granatum	-	14	-	14	5.47
Rhizophoraceae					
Rhizophora mucronata	6	170	42	218	85.16

doi:10.20944/preprints202308.0371.v1

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Appendix G. Statistical Treatment

Table G1. Kruskal Wallis Comparing the Water Quality of Three Sampling Sites PerSampling Month.

Parameters	November		December		January	
	p-value	Remarks	*p-value*	Remarks	*p-value*	Remarks
Temperature	0.023	S	0.066	NS	0.038	S
Turbidity	0.018	S	0.018	S	0.018	S
TDS	0.414	NS	0.027	S	0.027	S
Salinity	0.414	NS	0.027	S	0.027	S
Conductivity	0.414	NS	0.027	S	0.027	S
pH	0.026	S	0.106	NS	0.026	S
DO	0.026	S	0.063	NS	0.053	NS

Parameters	February		March	
	p-value	Remarks	*p*-value	Remarks
Temperature	0.054	NS	0.193	NS
Turbidity	0.018	S	0.018	S
TDS	0.05	S	0.027	S
Salinity	0.05	S	0.027	S
Conductivity	0.05	S	0.027	S
pH	0.027	S	0.063	NS
DO	0.048	S	0.063	NS

Table G2. Friedman Test One-Way ANOVA Comparison of Soil Quality across SamplingSites during the Five-Month Period.

Parameters	SITE 1		SITE 2		SITE 3	
	p - value	Remarks	*p - value*	Remarks	*p - value*	Remarks
Temperature	0.031	S	0.189	NS	0.017	S
Turbidity	0.017	S	0.017	S	0.017	S
TDS	0.017	S	0.022	S	0.017	S
Salinity	0.017	S	0.022	S	0.017	S
Conductivity	0.017	S	0.022	S	0.017	S
pH	0.022	S	0.017	S	0.017	S
DO	0.018	S	0.017	S	0.022	S
Nitrate	0.406	NS	0.406	NS	0.406	NS
Phosphate	0.406	NS	0.406	NS	0.406	NS

Table G3. Kruskal Wallis Comparing the Soil Quality of Three Sampling Sites PerSampling Month.

Parameters	*p* - value	Remarks
Soil Temperature	0.398	Not Significant
Soil pH	1.000	Not Significant

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Organic Matter	0.008	Significant
Organic Carbon	0.008	Significant
Water Holding Capacity	0.027	Significant
Nitrogen	0.135	Not Significant
Phosphorus	0.368	Not Significant
Potassium	0.323	Not Significant

Table G4. Friedman Test One-Way ANOVA Comparison of Soil Quality across SamplingSites during the Five-Month Period.

Parameters	*p* - value	Remarks
Soil Temperature	0.137	Not Significant
Soil pH	1.000	Not Significant
Organic Matter	0.308	Not Significant
Organic Carbon	0.308	Not Significant
Water Holding Capacity	0.339	Not Significant
Nitrogen	0.406	Not Significant
Phosphorus	0.406	Not Significant
Potassium	0.322	Not Significant

Appendix H. Species Diversity Computation

Table H1. Shannon-Weiner Diversity Index for Mangrove sp. found in Site 1,2, and 3 ofKaingen River, Kawit Cavite.

Species	n	pi	In(pi)	PiInPi
Site 1				
Avicennia alba	15	0.71429	-0.33647	-0.24034
Xylocarpus granatum	0	0	0	0
Rhizophora mucronata	6	0.28571	-1.25276	-0.35793
Total	**21**			
Shannon-Weiner (H)				**0.5983**
Shannon-Weiner Evenness (E)				**0.1994**

Species Richness(S)					**2**
Site 2					
Avicennia alba	8	0.04167	-3.17805		-0.13242
Xylocarpus granatum	14	0.07292	-2.61844		-0.19093
Rhizophora mucronata	170	0.88542	-0.12170		-0.10775
Total	**192**				
Shannon-Weiner (H)					**0.4311**
Shannon-Weiner Evenness (E)					**0.1437**
Species Richness (S)					**3**
Site 3					
Avicennia alba	1	0.02326	-3.76120		-0.08747
Xylocarpus granatum	0	0	0		0
Rhizophora mucronata	42	0.97674	-0.02353		-0.02298
Total	**43**				
Shannon-Weiner (H)					**0.1105**
Shannon-Weiner Evenness (E)					**0.0368**
Species Richness (S)					**2**

Table H2. Simpson Diversity Index of Mangrove sp. found in Site 1, 2, and 3 in KaingenRiver, Kawit Cavite.

Site 1 Species	n	n-1	n(n-1)	*Dominance (C)*	*Diversity (1-D)*	*Reciprocal (1/D)*
Avicennia alba	15	14	210			
Xylocarpus granatum	0	5	30	0.5714	0.4286	1.750
Rhizophora mucronata	6	0	40			

Site 2 Species	**n**	**n-1**	**n(n-1)**	***Dominance (C)***	***Diversity (1-D)***	***Reciprocal (1/D)***

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Avicennia alba	8	7	56			
Xylocarpus granatum	14	169	28730	0.7899	0.2101	1.266
Rhizophora mucronata	170	13	182			

Site 3 Species	**n**	**n-1**	**n(n-1)**	***Dominance (C)***	***Diversity (1-D)***	***Reciprocal (1/D)***
Avicennia alba	1	0	0			
Xylocarpus granatum	0	41	1722	0.9318	0.06818	1.073
Rhizophora mucronata	42	0	1722			

Appendix I. Photo-documentations

Table I1. Identified and Collected Tree Species in Kaingen River during the Five-MonthSampling Period.

Local Name	**Family Name**	**Scientific Name**	**No. of Trees per Species**
Bakhaw Babae	*Rhizophoreceae*	*Rhizophora mucronata Poir*	24
Bungalon	*Acanthaceae*	*Avicennia alba Blume*	14
Tabigi	*Meliaceae*	*Xylocarpus granatum* J.Koenig	218
Banago	*Malvaceae*	*Thespesia populneoides* (Roxb.)Kostel.	1

Note: *Thespesia populneoides* (Roxb.) Kostel is an associate species.

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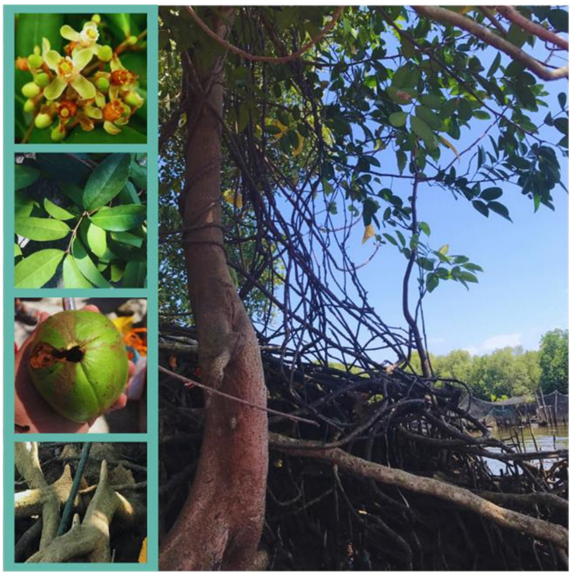
Local Name: Bakhaw Babae
Scientific Name: Rhizophora mucronata Poir
Description: It is an evergreen tree that grows on riverbanks. It produces seeds with elongated roots that reach a meter or more and still attached to the branch until it becomes well-developed.

Local Name: Bungalon, Api-api, Miapi
Scientific Name: Avicennia alba Blume
Description: Low, bushy and has a shallow aerial root known aspneumatophores. It is characterized by its silvery grey underside color and rough texture underneath its leaves.

Local Name: Tabigi
Scientific Name: Xylocarpus granatum J Koenig
Description: A native Philippine mangroves that can be found in estuaries. It has plank or ribbon roots. Some unique characteristics are smooth and brown colored bark, pinnate leaves, has 2-3 leaflets,with rounded tips.



Local Name: Banago
Scientific Name: Thespesia populneoides (Roxb.) Kostel
Description: It has cordate leaf blades,strong yellow twigs accompany with yellow flower that anthesis to color pink and red. It grows commonly in beach forests, tidal streams, and riverbanks.

Figure I2. Description of Identified and Collected Tree Species in the Kaingen River,Kawit, Cavite.

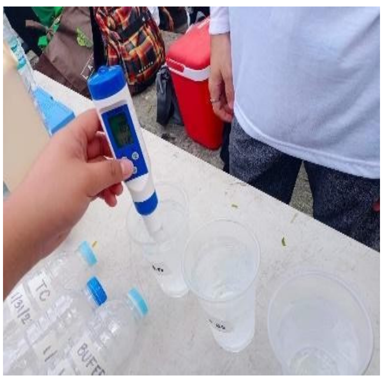


Figure I3. Instrument Calibration.

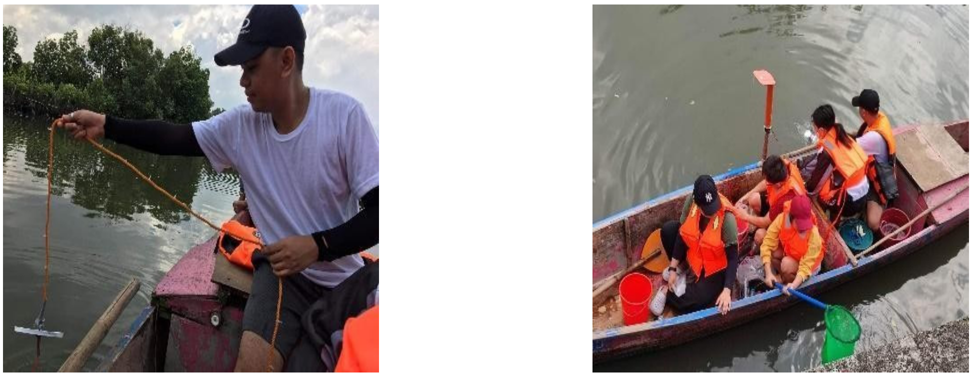


Figure I4. Water Samples Collection and Preparation.

Figure I5. In-situ Water Sample Analysis.

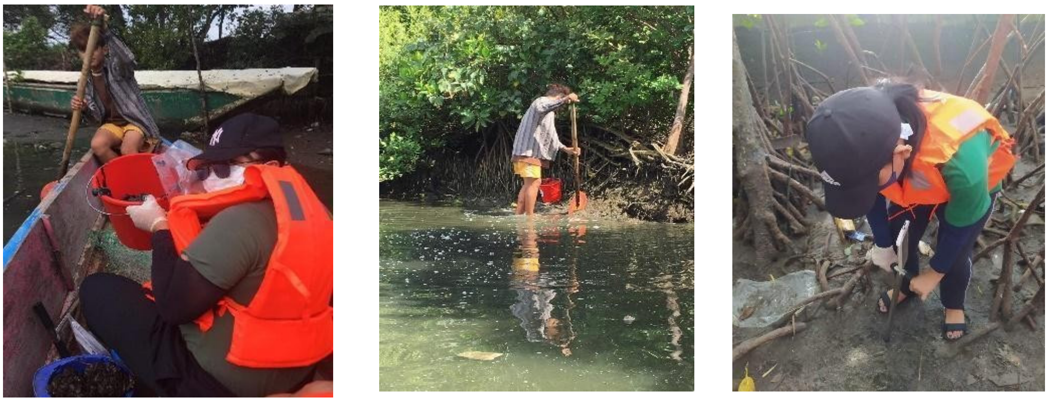


Figure I6. Soil Collection.

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Figure I7. Preparation of Soil Samples.

Figure I8. Ex-situ Soil Analysis.

Figure I9. Measuring of Girth at Breast Height (GBH) of Mangroves.

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Figure I10. Distribution of Survey Questionnaires.

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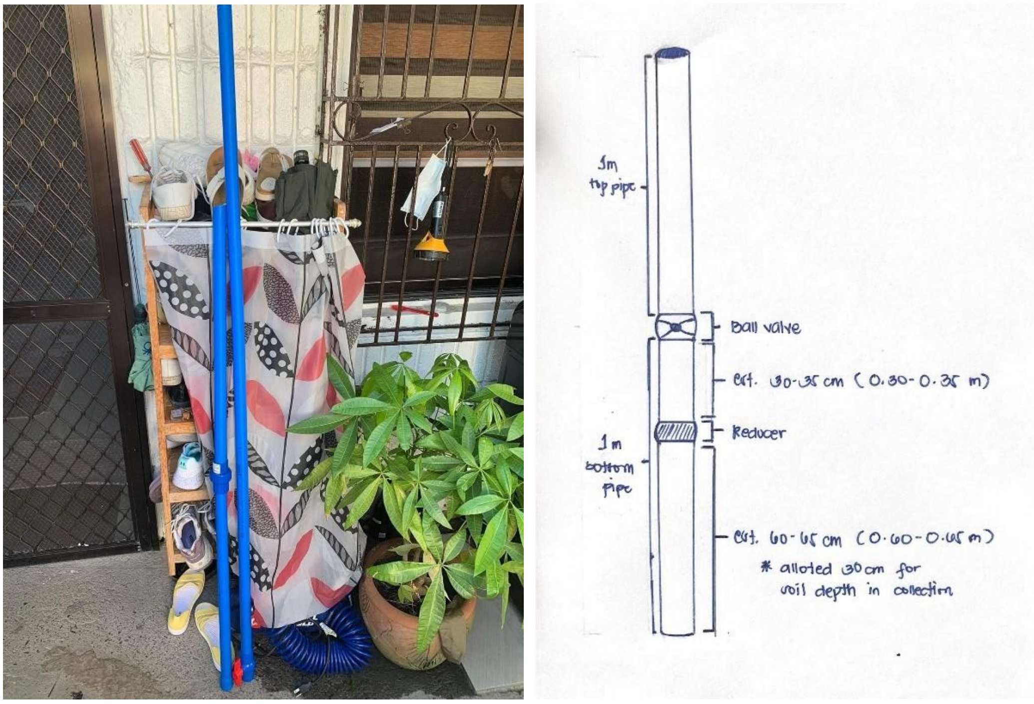

Figure I11. Soil collection instrumentation (used during high tide).

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Appendix J. Letters and Certifications

Republic of the Philippines
Technological University of the Philippines
COLLEGE OF SCIENCE
Department of Chemistry

THESIS PROPOSAL ENDORSEMENT

The undersigned certifies that he/she/they read the undergraduate thesis proposal which hereto attached entitled **"MANGROVE DIVERSITY, BLUE CARBON, WATER AND SOIL QUALITY ASSESSMENT OF MANGROVE ECOSYSTEM IN KAINGEN RIVER, KAWIT, CAVITE, PHILIPPINES"** prepared and submitted by **Mr. RONIEL B. BARRIOS, Ms. JHADE V. BUENAFE, Ms. JHIANNA LOU J. MADLA, Ms. KRISTIA MARIAE G. TUPAS, and Mr. GIAN CARLO G. VERANO**, and affirms that the same complies with the standards prescribed for the Thesis Program by Technological University of the Philippines – Manila, College of Science, in partial fulfillment for the degree Bachelor of Science in Environmental Science.

In view thereof, the undersigned endorses the said thesis proposal.

February 02, 2023.

Noted By:

PROF. ERWIN P. ELAZEGUI
Thesis Adviser

PROF. MARIA CARMELITA G. SAPINA
Department Head, College of Science

Recommending Approval:

PROF. MARIA CARMELA F. FRANCISCO
OIC-Dean, College of Science

Figure J1. Thesis Proposal Endorsement.

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Republic of the Philippines
Technological University of the Philippines
COLLEGE OF SCIENCE
Department of Chemistry

Date: February 06, 2023

For: Mr. Januel R. Peras
OIC, PENR Officer
Trece Martires City

RE: Application for Gratuitous Permit

Dear Mr. Peras,

Greetings!

We, Jhianna Lou J. Madla and Gian Carlo G. Verano, are the group representatives of the research entitled "Mangrove Diversity, Blue Carbon, Water and Soil Quality Assessment of Mangrove Ecosystem in Kaingen River, Kawit, Cavite, Philippines" as part of the program requirement of Bachelor of Science in Environmental Science of the Technological University of the Philippines.

May we respectfully apply for the gratuitous permit on the above-mentioned research project.

We hope that this request merits your kind consideration and approval.

Thank you very much for your immediate response to this matter.

Very truly yours,

GIAN CARLO G. VERANO
Group Leader

JHIANNA LOU J. MADLA
Group Representative

Noted By:

PROF. ERWIN P. ELAZEGUI
Thesis Adviser

PROF. MARIA CARMELITA G. SAPINA
Department Head, College of Science

Recommending Approval:

PROF. MARIA CARMELA F. FRANCISCO
OIC- Dean, College of Science

Figure J2. Application for Gratuitous Permit.

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TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
COLLEGE OF SCIENCE

San Marcelino St., Ayala Blvd., Ermita Manila

Date: 04 February 2023

For: **Mr. ERNESTO SOLIS JR.**
Barangay Captain
Barangay Kaingen, Kawit, Cavite, Philippines

Dear Sir,

Greetings of Peace and Goodwill!

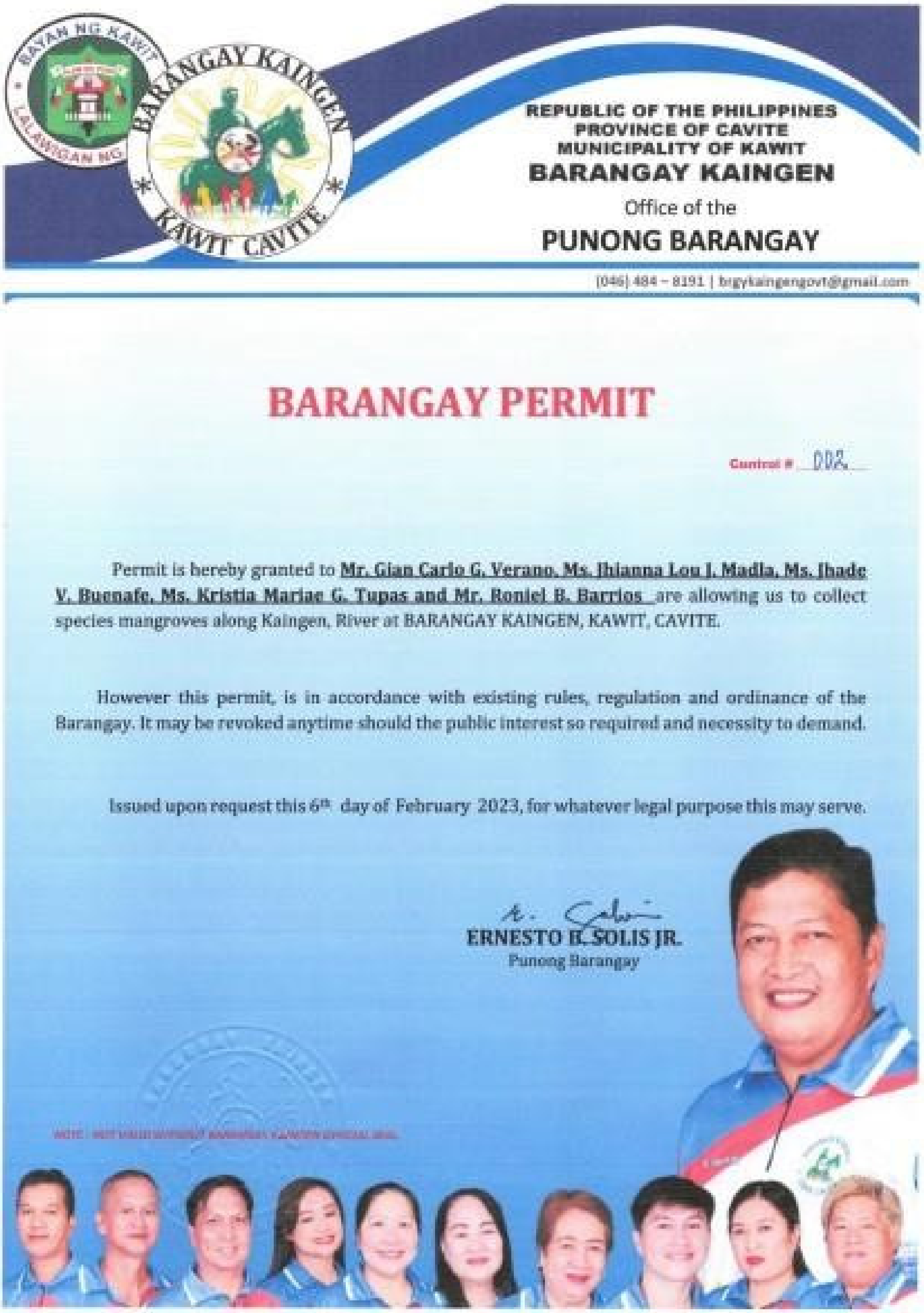
We, **Mr. GIAN CARLO G. VERANO, Ms. JHIANNA LOU J. MADLA, Ms. JHADE V. BUENAFE, Ms. KRISTIA MARIAE G. TUPAS,** and **Mr. RONIEL B. BARRIOS,** are the student-researchers of Bachelor of Science in Environmental Science at Technological University of the Philippines – Manila, currently conducting our research for our subject Thesis Writing 1 entitled **"MANGROVE DIVERSITY, BLUE CARBON, WATER AND SOIL QUALITY ASSESSMENT OF MANGROVE ECOSYSTEM IN KAINGEN RIVER, KAWIT, CAVITE, PHILIPPINES"**.

We would like to request a clearance form from your good office allowing us to collect species of mangroves along Kaingen River under your locality. The species of mangrove collected will be used to create herbarium and for species identification. Rest assured that we will take precautions in collecting these species.

Very truly yours,

Gian Carlo G. Verano
Group Leader

Figure J3. Letter of Request for Barangay Kaingen.



REPUBLIC OF THE PHILIPPINES
PROVINCE OF CAVITE
MUNICIPALITY OF KAWIT
BARANGAY KAINGEN
Office of the
PUNONG BARANGAY

(046) 484 – 8191 | brgykaingengovt@gmail.com

BARANGAY PERMIT

Control # 002

Permit is hereby granted to Mr. Gian Carlo G. Verano, Ms. Jhianna Lou J. Madla, Ms. Jhade V. Buenafe, Ms. Kristia Mariae G. Tupas and Mr. Roniel B. Barrios are allowing us to collect species mangroves along Kaingen, River at BARANGAY KAINGEN, KAWIT, CAVITE.

However this permit, is in accordance with existing rules, regulation and ordinance of the Barangay. It may be revoked anytime should the public interest so required and necessity to demand.

Issued upon request this 6th day of February 2023, for whatever legal purpose this may serve.

ERNESTO B. SOLIS JR.
Punong Barangay

Figure J4. Barangay Permit from Barangay Kaingen.

Republic of the Philippines
Department of Environment and Natural Resources
Regional Office No. IV-A, CALABARZON

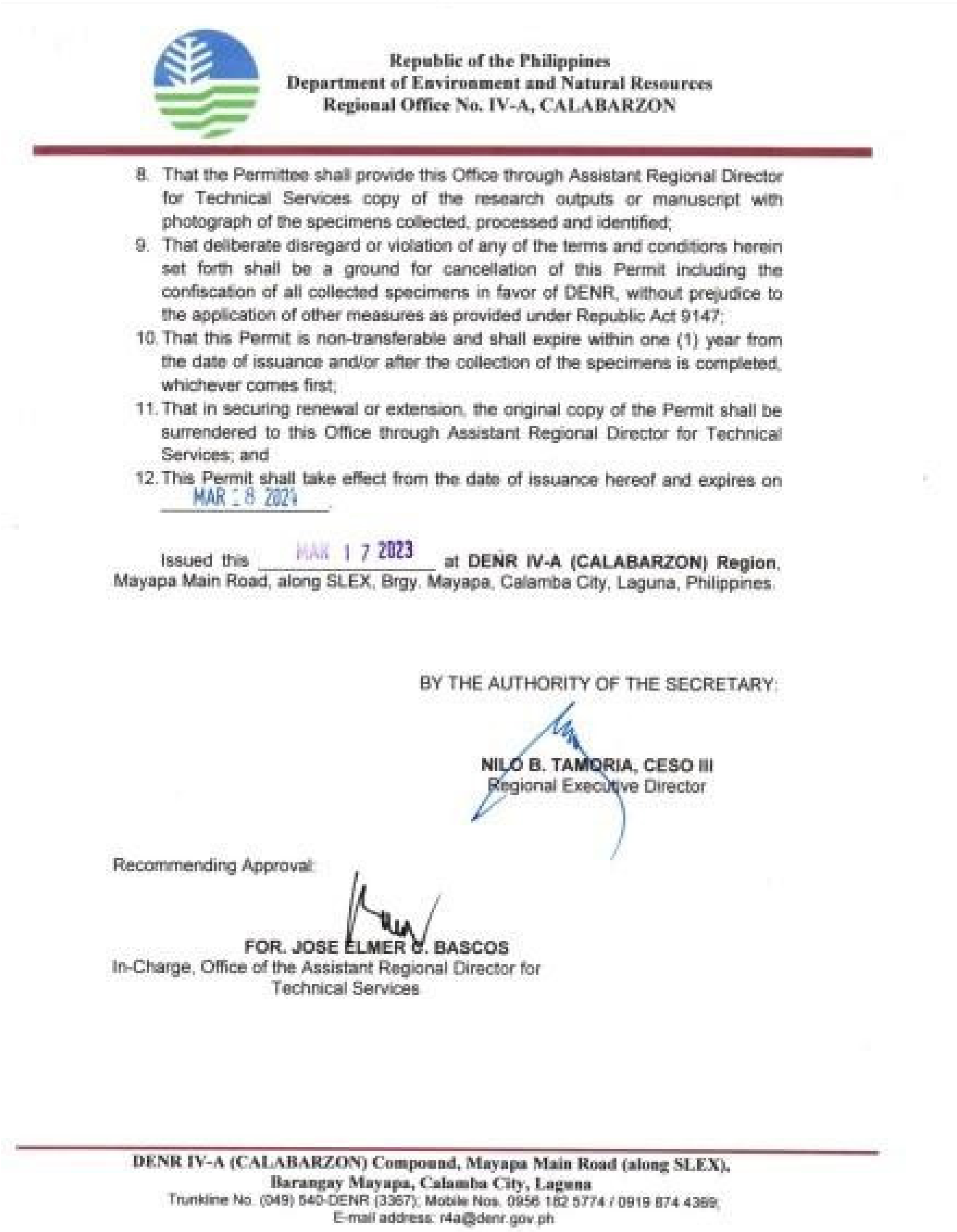
WILDLIFE GRATUITOUS PERMIT
NO. R4A-WGP-2023-CAV-009

Holder **Mr. Roniel B. Barrios, et. al.**
Department of Chemistry, College of Science
Technological University of the Philippines
San Marcelino St., Ayala Blvd., Ermita Manila

Pursuant to Republic Act 9147, otherwise known as the Wildlife Resources Conservation and Protection Act of 2001, in consonance with the provisions of Section 15 of the Joint DENR-DA-PCSD Administrative Order No. 01 dated May 18, 2004 and on the basis of the endorsement/clearances issued by the proper authorities relative to the research study entitled **"Mangrove Diversity, Blue Carbon, Water and Soil Quality Assessment of Mangrove Ecosystem in Kaingen River, Kawit, Cavite, Philippines"**, a **WILDLIFE GRATUITOUS PERMIT** is hereby granted to **Mr. Roniel B. Barrios, et. al.** of Technological University of the Philippines. This permit covers the following terms and conditions as herein specified:

1. That the Permittee shall be allowed to collect a sample of each mangrove species measuring a length of twelve (12) inches which consist of bud, flowers, and its fruit found within **Kaingen River** located in Kawit, Cavite including water and soil sample;
2. That the Permittee shall employ scientific collection method(s) that will not cause injury/disturbance to other wildlife species and damage to habitat/landscape ecosystem;
3. That the Permittee shall ensure that the specimens collected be used strictly for the research study and display and shall not in any manner be used for commercial purposes;
4. That the Permittee shall coordinate with PENRO Cavite prior to actual collection;
5. That all specimens collected shall not be transported from the site without the Wildlife/Local Transport Permit that will be issued by PENRO Cavite;
6. That the initial report shall be submitted by the Permittee to the DENR Regional Office through PENRO Cavite after collection activity and in case certain technology is developed from the research study, the same should be made available to Philippine Government through this Office;
7. That the DENR shall be acknowledged in all publications and/or Articles as a result of the research project. Further, the Permittee shall furnish this Office through the Assistant Regional Director (ARD) for Technical Services copies of all published or unpublished reports and articles about the research project;

DENR IV-A (CALABARZON) Compound, Mayapa Main Road (along SLEX),
Barangay Mayapa, Calamba City, Laguna
Trunkline No. (049) 540-DENR (3367); Mobile Nos. 0956 182 5774 / 0919 874 4369;
E-mail address: r4a@denr.gov.ph



Republic of the Philippines
Department of Environment and Natural Resources
Regional Office No. IV-A, CALABARZON

8. That the Permittee shall provide this Office through Assistant Regional Director for Technical Services copy of the research outputs or manuscript with photograph of the specimens collected, processed and identified;
9. That deliberate disregard or violation of any of the terms and conditions herein set forth shall be a ground for cancellation of this Permit including the confiscation of all collected specimens in favor of DENR, without prejudice to the application of other measures as provided under Republic Act 9147;
10. That this Permit is non-transferable and shall expire within one (1) year from the date of issuance and/or after the collection of the specimens is completed, whichever comes first;
11. That in securing renewal or extension, the original copy of the Permit shall be surrendered to this Office through Assistant Regional Director for Technical Services; and
12. This Permit shall take effect from the date of issuance hereof and expires on MAR 18 2024.

Issued this MAR 17 2023 at **DENR IV-A (CALABARZON) Region**, Mayapa Main Road, along SLEX, Brgy. Mayapa, Calamba City, Laguna, Philippines.

BY THE AUTHORITY OF THE SECRETARY:

NILO B. TAMORIA, CESO III
Regional Executive Director

Recommending Approval:

FOR. JOSE ELMER C. BASCOS
In-Charge, Office of the Assistant Regional Director for Technical Services

DENR IV-A (CALABARZON) Compound, Mayapa Main Road (along SLEX), Barangay Mayapa, Calamba City, Laguna
Trunkline No. (049) 540-DENR (3367); Mobile Nos. 0956 182 5774 / 0919 874 4369;
E-mail address: r4a@denr.gov.ph

Figure J5. Gratuitous Permit.

 doi:10.20944/preprints202308.0371.v1

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
COLLEGE OF SCIENCE
San Marcelino St., Ayala Blvd., Ermita Manila

March 27, 2023

Jose Vera Santos Memorial Herbarium
Institute of Biology
Ma. Regidor St., UP Diliman

To whom it may concern,

Greetings of peace and goodwill!

We, the Bachelor of Science in Environmental Science students from Technological University of the Philippines - Manila, would like to submit a photo of our herbarium specimens for Mangrove species identification as a requirement for Mangrove species inventory of our thesis entitled "Mangrove Diversity, Blue Carbon, Water and Soil Quality Assessment of Kaingen River, Kawit, Cavite, Philippines".

Attach herewith are the names and signatures of researchers, Thesis Writing Adviser, and Thesis Adviser. Thank you.

Respectfully,

RONIEL B. BARRIOS
Researcher

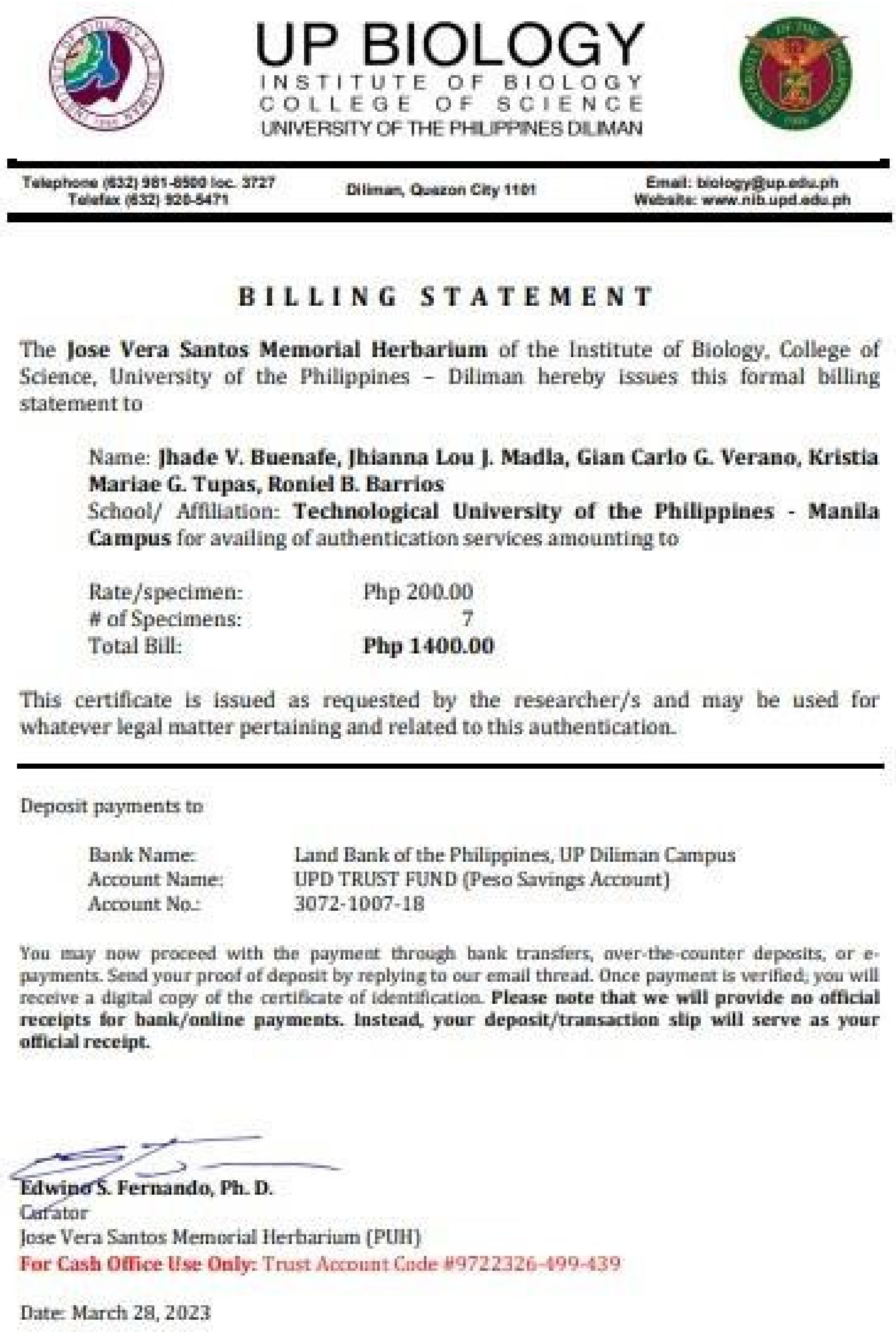
JHADE V. BUENAFE
Researcher

JHIANNA LOU J. MADLA
Researcher

KRISTIA MARIAE G. TUPAS
Researcher

GIAN CARLO G. VERANO

Figure J6. Letter of Request for Mangrove Species Identification.



UP BIOLOGY
INSTITUTE OF BIOLOGY
COLLEGE OF SCIENCE
UNIVERSITY OF THE PHILIPPINES DILIMAN

Telephone (632) 981-8500 loc. 3727
Telefax (632) 920-5471
Diliman, Quezon City 1101
Email: biology@up.edu.ph
Website: www.nib.upd.edu.ph

BILLING STATEMENT

The **Jose Vera Santos Memorial Herbarium** of the Institute of Biology, College of Science, University of the Philippines – Diliman hereby issues this formal billing statement to

Name: **Jhade V. Buenafe, Jhianna Lou J. Madla, Gian Carlo G. Verano, Kristia Mariae G. Tupas, Roniel B. Barrios**
School/ Affiliation: **Technological University of the Philippines - Manila Campus** for availing of authentication services amounting to

Rate/specimen:	Php 200.00
# of Specimens:	7
Total Bill:	**Php 1400.00**

This certificate is issued as requested by the researcher/s and may be used for whatever legal matter pertaining and related to this authentication.

Deposit payments to

Bank Name:	Land Bank of the Philippines, UP Diliman Campus
Account Name:	UPD TRUST FUND (Peso Savings Account)
Account No.:	3072-1007-18

You may now proceed with the payment through bank transfers, over-the-counter deposits, or e-payments. Send your proof of deposit by replying to our email thread. Once payment is verified, you will receive a digital copy of the certificate of identification. **Please note that we will provide no official receipts for bank/online payments. Instead, your deposit/transaction slip will serve as your official receipt.**

Edwino S. Fernando, Ph. D.
Curator
Jose Vera Santos Memorial Herbarium (PUH)
For Cash Office Use Only: Trust Account Code #9722326-499-439

Date: March 28, 2023

Figure J7. Billing Statement.

UP BIOLOGY
INSTITUTE OF BIOLOGY
COLLEGE OF SCIENCE
UNIVERSITY OF THE PHILIPPINES DILIMAN

Telephone (632) 981-8500 loc. 3727
Telefax (632) 920-5471
Diliman, Quezon City 1101
Email: biology@up.edu.ph
Website: www.nib.upd.edu.ph

CERTIFICATE OF IDENTIFICATION

This is to certify that the accepted scientific name of the specimens by **Jhade V. Buenafe, Jhianna Lou J. Madla, Gian Carlo G. Verano, Kristia Mariae G. Tupas, Roniel B. Barrios** from **Technological University of the Philippines - Manila Campus** are

Family Name	**Scientific Name**
Rhizophoraceae	*Rhizophora mucronata* Poir.
Malvaceae	*Thespesia populneoides* (Roxb.) Kostel.
Acanthaceae	*Avicennia alba* Blume
Meliaceae	*Xylocarpus granatum* J.Koenig
Meliaceae	*Xylocarpus granatum* J.Koenig
Meliaceae	*Xylocarpus granatum* J.Koenig
Meliaceae	*Xylocarpus granatum* J.Koenig

These specimens were identified using materials at the Institute of Biology, Jose Vera Santos Memorial Herbarium (PUH), College of Science, University of the Philippines, Diliman, Quezon City.

This certificate is issued as requested by the researchers and may be used for whatever legal matter pertaining and related to this authentication.

Edwino S. Fernando, Ph. D.
Curator
Jose Vera Santos Memorial Herbarium (PUH)

Date: March 29, 2023

Figure J8. Certificate of Plant Identification.

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Technological University of the Philippines
Ermita, Manila
COLLEGE OF LIBERAL ARTS
Department of Languages

CERTIFICATE OF PROOFREADING

This is to certify that the thesis herein was reviewed and edited for proper English language, punctuation, spelling, composition and grammar by the undersigned. The research content was never altered in any way during the editing process.

ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN RIVERINE ECOSYTEM, KAWIT CAVITE, PHILIPPINES

AUTHORS

Barrios, Roniel B.
Buenafe, Jhade V.
Madla, Jhianna Lou J.
Tupas, Kristia Mariae G.
Verano, Gian Carlo G.

Prof. Mary Ann A. Misa
Faculty, Department of Languages

1278755
PRC License

June 26, 2023
Date

Figure J10. Certificate of Proofreading.

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-301-3001 local 711 Email: urds@tup.edu.ph | Website: www.tup.edu.ph	Index No.	F-URD-4.1-CSI
		Issue No.	01
		Revision No.	00
		Date	06202023
VRE-URD	**CERTIFICATE OF SIMILARITY INDEX USING TURNITIN**	Page	1 / 1
		QAC No.	CC-06202023

This is to certify that the manuscript entitled

"ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN RIVERINE ECOSYSTEM KAWIT, CAVITE, PHILIPPINES"

Authored by

RONIEL B. BARRIOS
JHADE V. BUENAFE
JHIANNA LOU J. MADLA
GIAN CARLO G. VERANO
KRISTIA MARIAE G. TUPAS

College of Science

has been subjected to similarity check on June 22, 2023
using Turnitin with generated similarity index of **7%**.

Processed by:

Assoc. Prof. FRANCIS A. ALFARO, Ed.D., LPT
Faculty, University Research
and Development Services

Certified correct by:

Assoc. Prof. FRANCISCO D. ESPONILLA II, Ed.D.
Director, University Research
and Development Services

Transaction ID	URD-TCERT-ELGB-10032022
Signature	

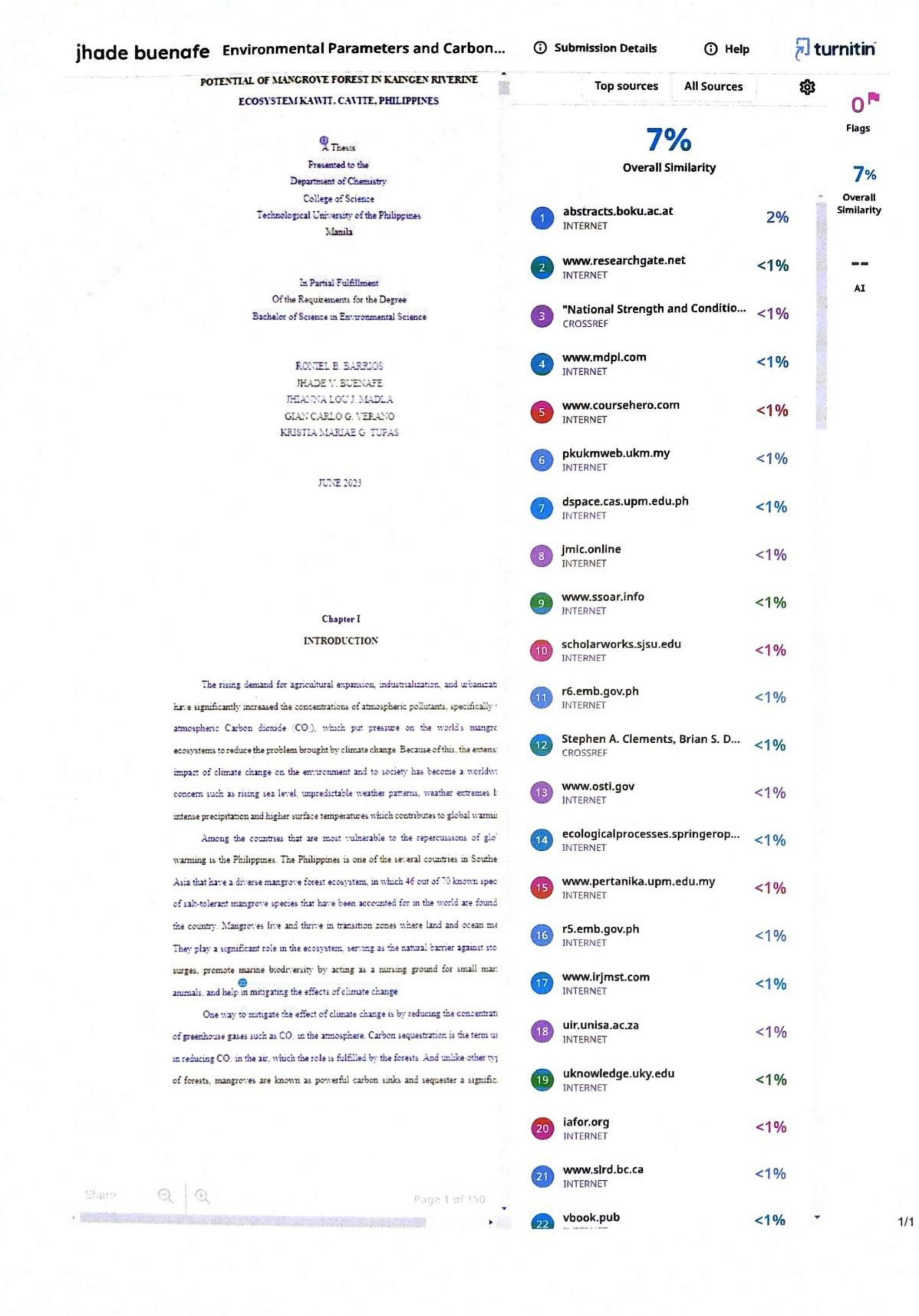

Figure J11. Certificate of Similarity Index Using Turnitin.

 doi:10.20944/preprints202308.0371.v1

Republic of the Philippines
Technological University of the Philippines
TECHNOLOGY LICENSING OFFICE
INNOVATION and TECHNOLOGY SUPPORT OFFICE
Manila

WAIVER

I/We, GIAN CARLO G. VERANO, JHIANNA LOU J. MAOLA, KRISTIA MARIAE G. TUPAS, JHADE V. BUENAFE, AND RONIEL B. BARRIOS; of legal age, single, with residence and postal address at MANILA CITY, after being duly sworn in accordance with law hereby depose and say:

1. That I/we am the creator / author of the work entitled ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN RIVERINE ECOSYSTEM, KAWIT, CAVITE, PHILIPPINES., subject of the application for copyright filed for and on behalf of the TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES;

2. That I/we are waiving my right as creator / author of said work in favor of TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES and we hereby expressly agree that the copyright registration certificate therefore be issued in favor of TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES.

IN WITNESS THEREOF, I/we have hereunto set my signature on this ______ day of ___________, ______, in Manila, Philippines.

CONFORME:

by:

GIAN CARLO G. VERANO
KRISTIA MARIAE G. TUPAS
JHIANNA LOU J. MAOLA
JHADE V. BUENAFE
RONIEL B. BARRIOS

SUBSCRIBED AND SWORN to before me this JUN 23 2023 day of ___________, ______, in ________________, affiant exhibiting to me his Community Tax Certificate No. ________________ issued on __________ at ______________, ____________________.

NOTARY PUBLIC

ATTY. MARY ANN RIVERA SAGAN
Notarial ... Dec. 31, 2023
... City
PTR No. ... Manila
... April 14, 2025
3rd Flr. Villaroman Bldg. No. ... Cor. España, Manila

Doc. No. 436
Page No. 88
Book No. XVII
Series of 2023

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T.M. Kalaw Street, Ermita, Manila, 1000 Philippines

AFFIDAVIT

(IMPORTANT- This affidavit must be executed by **individual** (an official of a corporation or firm may act) and must be under the seal of an officer authorized to administer oaths within the Philippines. In case of published works, the execution must be **subsequent** to the date of publication. The affiant must fill in the required statements to accord with the fact concerning the work named, and draw pen through statements not intended to be made.)

REPUBLIC OF THE PHILIPPINES
Municipality of ______________________
Province or City of ______________________ S.S.

I GIAN CARLO G VERANO, KRISTIA MARIAE G. TUPAS, JHIANNA LOU J. MAOLA, JHADE V. BUENAFE, RONIEL B. BARRIOS being duly sworn, depose do solemnly affirm and say:
That I am the (a) person claiming copyright (b) printer who printed (c) duly authorized agent or representative residing in the Philippines of the claimant of copyright in the Work named herein;
That (d) I am a resident of the municipality of Manila City Province of Manila and (e) Technological University of the Philippines of Manila claim/s
(name of claimant if other than affiant) (municipality, province)
ownership of copyright in the said work (f) as (g) by assignment (h) by inheritance from the author hereof, that said work is (i) original, not copied from any work whether published or unpublished (j) a work falling under Sec. 172 of R.A. 8293 of which consent of the copyright owner has been secured **of which 2** complete copies **have been deposited**, is entitled ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN
(Title as it appears on the front part or title page (if book)
RIVERINE ECOSYSTEM KAWIT, CAVITE, PHILIPPINES
(of the work, edition number if any; author's name if he is different from claimant)
and have been (k) completed (l) printed or reproduced in copies at ______________________
(Municipality, Province)
by ______________________, the work or its printing or reproduction having been completed on the ________ day of ____________, ________, and the said work was first published or sold to the public in the Philippines on the _____ day of ________________, ________,
(same date given in the application)
at ______________________ by ______________________
(Municipality; Province) (Name of person in the application)

GIAN CARLO G. VERANO JHADE V. BUENAFE
KRISTIA MARIAE G. TUPAS
JHIANNA LOU J. NADULA RONIEL B. BARRIOS
(Signature of person making affidavit)

Subscribed and sworn to before me this ________ day of JUN 23 2023, ________. The deponent in the foregoing affidavit exhibited to me his Community Tax Certificate No. ____________ Issued at the Municipality of ____________, Province of ____________ Philippines , on ____________, ________.

NOTARIAL P30.00 Documentary Stamp SEAL

ATTY. MARY ANN RIVERA SAGAN
Notary Public
My commission expires on ________

3rd Flr. Villaroman Bldg. No. 873 P.Campa St. Cor. España, Manila

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Page No. ________
Book No. ________
Series of ________

1. Of the lines number (a) to (1) use the ones which apply and cross out lines not used.
2. See footnote** on the reverse back side hereof.
3. In case of periodicals the title includes the volume and number as well as the date of which issue separately registered. For example: Philippine Magazine, Vol. XXX, No. 2 July 1933.
4. In case of manuscripts or unpublished works, data regarding publication are not required and the corresponding blank spaces should be crossed out.

CLASS DESIGNATIONS OF COPYRIGHTABLE WORKS UNDER R. A. 8293

(a) Books, Pamphlets, articles and other writings; (b) Periodicals and newspaper; (c) Lectures, sermons, addresses, dissertations for oral delivery, whether or not reduced in writing or other material form; (d) Letters; (e) Dramatic or dramatico-musical compositions; choreographic works or entertainment in dumb shows; (f) Musical compositions with or without words; (g) Works of drawing, painting, architecture, sculpture, engraving, lithography or other works of arts, model or design for works of arts; (h) Original ornamental designs, or models for articles of manufacture, whether or not registrable as an industrial designs and other works of applied art; (I) Illustrations maps, plans, sketches, charts and three-dimensional works relative to geography, topography, architecture or science; (j) drawings or plastic works of a scientific or technical character, (k) Photographic works including works produced by a process analogous to photography, lantern slide; (l) Audiovisual works and cinematographic works produced by a process analogous to cinematography or any process for making audio-visual recordings; (m) Pictorial illustrations and advertisements; (n) Computer Programs; (o) Other literary, scholarly, scientific and artistic works; (P) Sound recordings, and (q) Broadcast recordings

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The Director, *The National Library of the Philippines* Date ____________

SIR: I have the honor to apply for the copyright registration of the (a) unpublished (b) Published work named herein of which **Two (2) complete copies** are herewith deposited compliance with the provisions of REPUBLIC ACT 8293. The amount of P200.00 for the registration fee and sixty pesos worth of documentary stamp to be affixed to the certificate and application form are also enclosed. The data required by the rules and regulations of that office are the following:

1. Name and address of copyright owner: Technological University of the Philippines
(Claimants full legal name)
Ayala Boulevard, Ermita, Manila
(Street number, municipality and province)
2. Name of author: Gian Carlo G. Verano, Kristia Mariae G. Tupas, Jhianna Lou J. Madla, Jhade V. Buenafe and Roniel B. Barrios
3. Country of which the author is a citizen: Philippines
(Country)
4. If alien author, state Alien Certificate No. and where domiciled in the Philippines: ____________
5. Title of the Work: ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE
(Title as it appears on the front part of the title page of the work followed by the edition number, if any)
FOREST IN KAINGEN RIVERINE ECOSYSTEM KAWIT, CAVITE, PHILIPPINES
6. Class to which the work belongs: O
7. If copyright is claimed upon a new matter in a reissued work, state new matter specifically: ______
(Additional chapters by numbers followed by inclusive pages in parenthesis; other more or less short but materials alterations)
8. (d) Completed (e) Printed or Reproduced in copies on the ____day of ____________, ______
(Date when the work or its printing was completed)
at Manila by ____________
(Municipality, Province) (Person or Establishment making the printing or reproduction in copies)
9. First published or sold to the public in the Philippines on the _____day of ____________, ____
(Day the work was placed on sale, sold or publicly distributed)
____________ by ____________
(Municipality, Province) (Person or Establishment)
10. Send certificate of registration to: ____________
(Name and address)
11. Unit price if reproduced in copies for sale: P____________

Very Respectfully,
GIAN CARLO G. VERANO
KRISTIA MARIAE G. TUPAS
JHIANNA LOU J. MADLA
JHADE V. BUENAFE
RONIEL B. BARRIOS
(Signature of Applicant)

Deposit received on ____________ Certificate issued on ____________
Application received on ____________ Signed by ____________
Affidavit received on ____________ Certificate mailed by ____________
Fee received P______ O.R. ____________ Certificate received by ____________
(Signature of receiver)
Date of Registration ____________ XXc____________

(Please Read Instructions Carefully Before Filling Blanks)

- Of the lines marked (a) to (e) use the ones which apply and cross out the lines not used

** The word author includes a translator, a composer, painter, sculptor or other artists, or a photographer or a producer of a cinematographic film or publisher of a periodical, or an editor of work without known authors.
+ In case of periodicals, the title should include the volume and number as well as the date of each issue separately registered e.g. Philippine Magazine Vol. XXX No. 2, July 1933.
++ See class designations at the bottom of the reverse or back side hereof. A representative may sign the application under the name of the claimant Accomplish this form in duplicate.

FORM SHOULD BE FILLED UP LEGIBLY
(THIS FORM IS NOT FOR SALE AND MAYBE REPRODUCED)

NLP-034 ***Application for Copyright Registration*** *1 of 2* *Rev. 1*

Figure J12. ITSO Documents.

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Technological University of the Philippines
Ayala Blvd., Ermita Manila
College of Science
Department of Chemistry

Mga iginagalang naming Ginoo at Ginang/Binibini:

Kami po ay mga estudyante na kasalukuyang nasa ika-apat na taong panuruan sa ilalim ng kursong Bachelor of Environmental Science sa Technological University of the Philippines, Kasalukuyan po naming ginagawa ang aming pag-aaral na pinangalanang "**Environmental Parameters and Carbon Sequestration Potential of Mangrove Forest in Kaingen Riverine Ecosystem Kawit, Cavite, Philippines**". Ang pag-aaral po namin ay naglalayong alamin ang kasalukuyang kalidad ng tubig, alamin ang epekto at kaugnayan nito sa dami ng palaka sa palayan. Ang pag-aaral ay nagnanais din alamin ang mga aktibidad ng mga residente na naninirahan malapit sa tabing ilog ng **Kaingen**. Ang resulta ng pag-aaral na ito ay magiging kapaki-pakinabang sa mga residente at sa mga susunod pa na mananaliksik sa lugar na ito.

Kalakip ng pag-aaral, maari po lamang na pakisagutan ang talatanungan naniniwala po kamina ang inyong matapat na opinyon sa pagsagot ay makakatulong sa ng aming pagsasaliksik. Maging Panatag na ang lahat ng mga opinyon at impormasyon na inyo pong ibibigay ay itinuturing na may ganap na pagiging kompidensyal, Ang inyo pong positibong tugon ay lubhang makakatulong sa tagumpay ng gawaing ito. Maraming salamat po.

Lubos na gumagalang,

Mga Mag-aaral :

Roniel B. Barrios.   Jhade V. Buenafe.   Jhiamna Lou J. Madla

Kristla Mariae G. Tupas.   Gian Carlo G. Verano

Assoc. Prof. Erwin P. Elazegui
Faculty-in-Charged, Thesis Writing

Figure J13. Letter of Request to Conduct Anthropogenic Survey.

 doi:10.20944/preprints202308.0371.v1

February 23, 2023

DR. GINA P. NILO
DIRECTOR
2nd Floor, SRDC Bldg., Visayas Ave.
Elliptical Rd., Diliman, Quezon City

Dear Dr. Gina Nilo,

Greetings!

We, fourth-year college students at the Technological University of the Philippines-Manila taking up a course of Bachelor of Science in Environmental Science, are conducting a thesis study entitled: ***"Mangrove Diversity and Blue Carbon, Water, and Soil Quality Assessment of Mangrove Community in Kaingen, River, Kawit Cavite Philippines"*** and ***"Freshwater Mollusk and Water Quality in Kaingen River, Kawit, Cavite, Philippines"*** as a partial fulfilment requirement in Thesis Writing I and Thesis Writing II.

Our studies thus include 5-month monitoring and analysis of soil in our research area. Currently, we are struggling when it comes to the financial situation as our study also scopes the soil and water analysis and the certification and identification of specimens. We are informed that your good office is offering a soil analysis discount. Regarding this, we are writing this letter as we would like to request a discount for soil analysis in your laboratory office for our future transactions and even with our past two transactions with the code **S-14-1-3** that was submitted on **January 12, 2023**, and **S-40-1-3** that was submitted on **January 27, 2023.**

Looking for your kind consideration regarding the discount. Thank you and God Bless!

Respectfully yours,

Kristia Mariae G. Tupas

Group Representative

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March 13, 2023

DR. GINA P. NILO
DIRECTOR
2nd Floor, SRDC Bldg., Visayas Ave.
Elliptical Rd., Diliman, Quezon City

Dear Dr. Gina Nilo,

Greetings!

We, fourth-year college students at the Technological University of the Philippines-Manila taking up a course of Bachelor of Science in Environmental Science, are conducting a thesis study entitled: ***"Mangrove Diversity and Blue Carbon, Water, and Soil Quality Assessment of Mangrove Community in Kaingen, River, Kawit Cavite Philippines"*** and *"**Freshwater Mollusk and Water Quality in Kaingen River, Kawit, Cavite, Philippines**"* as a partial fulfilment requirement in Thesis Writing I and Thesis Writing II.

Our studies thus include 5-month monitoring and analysis of soil in our research area. Currently, we are struggling when it comes to the financial situation as our study also scopes the soil and water analysis and the certification and identification of specimens. We are informed that your good office is offering a soil analysis discount. Regarding this, we are writing this letter as we would like to request a discount for soil analysis in your laboratory office for our future transactions and even with our past transaction with the code **S-83-1-3** that was submitted last **February 22, 2023.**

Looking for your kind consideration regarding the discount. Thank you and God Bless!

Respectfully yours,

kristiatupas

Kristia Mariae G. Tupas

Group Representative

 doi:10.20944/preprints202308.0371.v1

March 31, 2023

DR. GINA P. NILO
DIRECTOR
2nd Floor, SRDC Bldg., Visayas Ave.
Elliptical Rd., Diliman, Quezon City

Dear Dr. Gina Nilo,

Greetings!

We, fourth-year college students at the Technological University of the Philippines-Manila taking up a course of Bachelor of Science in Environmental Science, are conducting a thesis study entitled: ***"Mangrove Diversity and Blue Carbon, Water, and Soil Quality Assessment of Mangrove Community in Kaingen, River, Kawit Cavite Philippines"*** and *"**Freshwater Mollusk and Water Quality in Kaingen River, Kawit, Cavite, Philippines**"* as a partial fulfilment requirement in Thesis Writing I and Thesis Writing II.

Our studies thus include 5-month monitoring and analysis of soil in our research area. Currently, we are struggling when it comes to the financial situation as our study also scopes the soil and water analysis and the certification and identification of specimens. We are informed that your good office is offering a soil analysis discount. Regarding this, we are writing this letter as we would like to request a discount for soil analysis in your laboratory office for our future transactions and even with our past transaction with the code **S-98-1-3** that was submitted last **March 13, 2023.**

Looking for your kind consideration regarding the discount. Thank you and God Bless!

Respectfully yours,

Kristia Mariae G. Tupas

Group Representative

 doi:10.20944/preprints202308.0371.v1

May 19, 2023

DR. GINA P. NILO
DIRECTOR
2nd Floor, SRDC Bldg., Visayas Ave.
Elliptical Rd., Diliman, Quezon City

Dear Dr. Gina Nilo,

Greetings!

We, fourth-year college students at the Technological University of the Philippines-Manila taking up a course of Bachelor of Science in Environmental Science, are conducting a thesis study entitled: ***"Mangrove Diversity and Blue Carbon, Water, and Soil Quality Assessment of Mangrove Community in Kaingen, River, Kawit Cavite Philippines"*** and ***"Freshwater Mollusk and Water Quality in Kaingen River, Kawit, Cavite, Philippines"*** as a partial fulfilment requirement in Thesis Writing I and Thesis Writing II.

Our studies thus include 5-month monitoring and analysis of soil in our research area. Currently, we are struggling when it comes to the financial situation as our study also scopes the soil and water analysis and the certification and identification of specimens. We are informed that your good office is offering a soil analysis discount. Regarding this, we are writing this letter as we would like to request a discount for soil analysis in your laboratory office for our future transactions and even with our past transaction with the code **S-129-1-3** that was submitted last **March 31, 2023.**

Looking for your kind consideration regarding the discount. Thank you and God Bless!

Respectfully yours,

Kristia Mariae G. Tupas

Group Representative

Figure J14. Discount Letter for Laboratory Soil Analysis in BSWM.

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Appendix K. Line of Budget

LINE-ITEM BUDGET

Title of Proposal: ENVIRONMENTAL PARAMETERS AND CARBON SEQUESTRATION POTENTIAL OF MANGROVE FOREST IN KAINGEN RIVERINE ECOSYSTEM, KAWIT, CAVITE, PHILIPPINES

Proponents: Barrios, Roniel B., Buenafe, Jhade V., Madla, Jhianna Lou J., Tupas, Kristia Mariae G., and Verano, Gian Carlo G.

	Unit (PHP)	Quantity	Total (PHP)
I. Material/s			
Life Vest	200	5 pcs	1000
Nylon Rope	200	2 pcs	400
Sola Bottle	21	2 pcs	42
Electrical Tape	110	1 pc	110
Black Cartolina	25	2 pcs	50
Waterproof Phone Case	150	5 pcs	750
Field Tape Measure	250	2 pcs	500
Meter Stick	42	1 pc	42
Zip Lock Bags	88	1 pack	88
Masking Tape	30	3 pcs	90
Clear Packaging Tape	100	1 pc	100
Raincoat	100	5 pcs	500
Pail	26	1 pc	26
Clearbook	53	2 pcs	106
Metal Soil Probe	877	1 pc	877
DIY Soil Probe (PVC)	676	1 pc	676
Field Guide Book	700	5 pcs	3500
Binder Clip	228/box	2 boxes	456
Folder	7	7 pcs	49
Puncher	190	1 pc	190
Expanding Folder	252	1 set	252
Fastener	59	7 pcs	49
SUBTOTAL			**9853**
II. Acquired In-Situ Device and Other Equipment			
DO Analyzer	3365	1	3365
Salinity Refractor	537	1	537
Portable pH Meter with TDS	774	1	774
5-in-1 pH Meter Water Quality Tester	1560	1	1560
BSWM Soil Test Kit	1500	1	1500
SUBTOTAL			**7736**
III. Laboratory Expenses			
Mangrove Species ID	200	7	1400
1st Soil Parameter Testing BSWM	2250	1	2250
2nd Soil Parameter Testing BSWM	2250	1	2250
3rd Soil Parameter Testing BSWM	2250	1	2250

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4th Soil Parameter Testing BSWM	2250	1	2250
5th Soil Parameter Testing BSWM	2250	1	2250
Laboratory Expenses for Nitrates (Mach Union Laboratories Inc.)	2500	1	2500
Laboratory Expenses for Phosphates (Mach Union Laboratories Inc.)	2500	1	2500
SUBTOTAL			**17650**
IV. Transportation			
1st Ocular Inspection	350	2	700
2nd Ocular Inspection	300	3	900
3rd Ocular Inspection	300	5	1500
November Sampling	300	5	1500
December Sampling	300	5	1500
January Sampling	300	5	1500
February Sampling	300	5	1500
March Sampling	300	5	1500
Total Travel Expense for Gratuitous Permit (4 days)	300/day	3	3600
January Thesis Survey	300	5	1500
February Thesis Survey	300	5	1500
Boat Rent (November Sampling)	2000	1	2000
Boat Rent (December Sampling)	2000	1	2000
Boat Rent (January Sampling)	2000	1	2000
Boat Rent (February Sampling)	2000	1	2000
Boat Rent (March Sampling)	2000	1	2000
Travel expense to BSWM Laboratory (November)	250	1	250
Travel expense to BSWM Laboratory (December)	250	1	250
Travel expense to BSWM Laboratory (January)	250	1	250
Travel expense to BSWM Laboratory (February)	250	2	500
Travel expense to BSWM Laboratory (March)	250	1	250
Travel expense to BSWM Laboratory (April)	250	1	250
Travel expense to BSWM Laboratory (May)	250	2	500
June Travel Expenses	4800	4	19200
July Travel Expenses	4800	4	19200
SUBTOTAL			**67850**
V. Other Expenses	**Unit (PHP)**	**Quantity**	**Total (PHP)**
TURNITIN Account	300	1	300
Gratuitous Permit	200	1	200
November Printing Expenses	470	1	470
December Printing Expenses	585	1	585

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January Printing Expenses	380	1	380
February Printing Expenses	440	1	440
March Printing Expenses	270	1	270
April Printing Expenses	300	1	300
May Printing Expenses	2574	1	2574
Food for Panel	143	5	715
June Printing Expense	2500	1	2500
July Printing Expense (For book bind)	800	10	8000
Grammarian	1500	1	1500
Notary	50	4	200
Book bind	250	10	2500
Tarpaulin Printing	300	1	300
CD Burn	80	5	400
SUBTOTAL			**21634**
		TOTAL	**PHP 124,723.00**