



Assessing soil mineral content and its agricultural and environmental implications in Mandaluyong city

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Abstract

The study aimed to assess the soil mineral content in Mandaluyong City and its implications for agriculture and the environment. Soil tests were conducted to determine the presence and level of nitrogen, phosphorus, and potassium, addressing the issue of carbon dioxide pollution and the potential for urban agriculture in the city. The research process involved ocular inspections, soil sample collection, and testing using a Soil Test Kit (STK). The findings of the study are expected to provide valuable information for urban agriculture and environmental management in Mandaluyong City.

Soil testing using the STK, and one-way ANOVA was conducted to analyze the data. The results revealed differences in pH, nitrogen, phosphorus, and potassium levels in soil samples from different areas in Mandaluyong City. However, the statistical analysis using one-way ANOVA indicated no significant difference in the overall nutrient content among the soil samples. The study concluded that while statistically non-significant, the unique characteristics of certain samples could hold agricultural significance, and targeted fertilizer application could enhance the soil's suitability for cultivation. The study recommended future pursuits to consider a larger and more diverse sampling area within Mandaluyong City.

Keywords: NPK (nitrogen, phosphorus, potassium), soil test kit, BTB, BCG, CPR

Introduction

Background of the Study

Soil is a fundamental and important agricultural resource (Why BSWM? n.d.). It is an essential resource that provides us with most of our needs, from wood for houses to food for people and the land we stand upon. The researchers need to conduct tests to fully utilize the most out of our soil for planting. We test the soil to identify what type of fertilizer will be used and what nutrient sources should be provided to produce an excellent yield (Hochmuth *et al.*, n.d.).

Utilizing the soil to its fullest potential is necessary to make the most of it, but this only applies to rural settings with farmlands and crops. In an urban setting, most soil is being utilized as support and ground for new establishments and houses (R. Dungca, 2017) [14].

In addition, carbon dioxide pollution has been at an all-time high due to the ever-increasing population of the Philippines, adding to the production factories and innumerable private and public vehicles on the road daily (Ritchie *et al.*, 2020).

Due to the recent pandemic, households in urban areas, such as Mandaluyong City, have been dabbling in house plants and crops inside their households (Leslie, 2021) [6]. This recent trend in keeping houseplants has been of great benefit to the residents and is even environmentally beneficial due to the increasing carbon storage of the plants.

Numerous empty soil plots exist around urban areas, specifically in Mandaluyong City. Untouched soil plots with no plants and no purpose as of now. These soil plots could be utilized not only for décor but also for aiding in the ever-increasing carbon pollution in urban areas.

Statement of the Problem

Studies about soil science have been on the rise for the past ten years, but most are biased toward rice research

(Navarrete & Asio, 2013) [10]. There were fewer studies regarding plant nutrition and soil chemistry. In Mandaluyong City, there is still a lack of studies that aim to assess the soil nutritional content of the land. The residents of Mandaluyong City are unaware of the quality of their soil and the feasibility of growing crops on it. Thus, this study aims to determine the presence and level of specific minerals vital to plant growth.

Objectives of the Study

This research aims to determine the presence and level of nitrogen, phosphorus, and potassium in the soil found in the sampling sites in Mandaluyong City and signify its possible effect on the environment, agriculture, and the residents' health.

Significance of the Study

This research primarily aims to determine the presence and level of nitrogen, phosphorus, and potassium in the soil collected from different sampling areas within Mandaluyong City. Giving a general quantification of the amount of minerals present within the soil can give way to further developments in urban agriculture and possibly prevent health risks that might appear due to the overabundance of these minerals.

Scope and Limitations of the Study

This study focuses only on the soil samples from specific areas within Mandaluyong City. This study does not explore the type of soil collected because the soil samples from each respective sampling area will be mixed. Furthermore, the soil collected is limited to soils found in public places and soils within the researchers' property. Lastly, only the presence of nitrogen, phosphorus, and potassium will be

tested for each of the soil samples due to the limitations of the soil test kit.

Review of related literature

Soil

Most of the landmass is covered in soil. Soil comprises organic and inorganic compounds that serve as a source of water and nutrients and a structural support for plants. Soils are made by the numerous interactions of various environmental processes (Leeper & Uren, 2023).

The soil is separated into horizons: O Horizon is the decomposed organic matter above the soil, A Horizon is the topmost soil layer where plant roots develop and seeds germinate, B Horizon, also known as the subsoil, holds the clay with minerals such as calcium carbonate, iron oxides, and aluminum oxides, C Horizon, also known as the regolith, is made up of damaged bedrocks and the bedrocks itself (Soil Science, n.d.).

Soil Nutrients

The main nutrient components to be tested for are Nitrogen, Phosphorus, and Potassium. Each of these nutrients serves a primary function in overall plant growth. According to Revoredo (2021) [16], nitrogen helps plants boost their growth and productivity; phosphorus prolongs plant life. It maximizes root development, and potassium provides better and more significant maturation of fruits, tubers, stems, grains, and pods.

Nitrogen in the soil exists in three forms: nitrogen compounds, ammonium (NH₄⁺) ions, and nitrate (NO₃⁻) ions. Not all the nitrogen in the soil is available to plants, the nitrogen available to plants is mainly limited to inorganic compounds NH₄⁺ and NO₃⁻, commonly referred to as mineral nitrogen (Nitrogen: Key Nutrients 2023). Nitrogen is a vital component of chlorophyll; the compound plants utilize sunlight to produce glucose and water from carbon dioxide (Nitrogen: Key Nutrients 2023). Despite their use, excess amounts of nitrogen in the soil can cause nitrous oxide and ammonia emissions, contributing to climate change and atmospheric pollution (Girkin & Cooper, 2023) [4].

Phosphorus is another essential nutrient for plants. It mainly helps in capturing sunlight to convert it into beneficial plant compounds (Role of Phosphorus in Plants 2023). It is essential for the growth of plants, especially young seedlings (Lines-Kelly, 1970) [7]. Phosphorus is associated with the plant's growth in root development, stalk and stem strength, earlier crop maturity, and resistance to plant diseases (Role of Phosphorus in Plants 2023). Phosphorus deficiency in plants is hard to spot compared to when plants are deficient in nitrogen or potassium. Due to this, there are occurrences when it is already too late for the plant when phosphorus deficiency is observed (Role of Phosphorus in Plants 2023).

Potassium is involved in almost all the processes necessary for the plant to sustain growth, survive, and reproduce (Potassium: Nutrient Management 2023). Potassium increases the yields of crops and plants due to its root growth and improved drought tolerance, aids in photosynthesis, increases the protein contents of plants, and reduces water loss and wilting (Potassium: Nutrient Management 2023). Potassium only occurs in the soil in inorganic form (Potassium management in crops n.d.).

All soil nutrients are vital to the growth of plants (Gebrehiwot, 2022) [3]. But with each of their importance comes the danger they pose when an excess of them is present in the soil.

Soil Test Kit

The Bureau of Soils and Water Management (BSWM) under the Department of Agriculture developed a way for rural farmers and field technicians to test and monitor the nutrient soil content of their respective fields. The Soil Test Kit (SKT) determines the quality level of the primary nutrients for plants (Nitrogen, Phosphorus, and Potassium) and tests the soil for pH level to determine whether the soil is acidic, basic, or neutral (Bureau of Soils and Water Management, 2022). This enables the farmers to focus on what type of fertilizer they must focus on when cultivating the land.

The Soil Test Kit contains a variety of solutions aimed at testing the pH level of the soil and the level of nitrogen, phosphorus, and potassium. The kit contains BTB, BCG, and CPR indicator dyes to determine the pH level of the soil, K₁, K₂, and a K solution to determine the general amount of potassium in the soil, a P solution to determine the phosphorus level, a N solution to determine the amount of nitrogen in the soil, a small bottle of distilled water, and 5 test tubes with markings for testing the soils (Bureau of Soils and Water Management, 2022).

Carbon Dioxide Pollution

Carbon dioxide (CO₂) is a colorless gas with a sour taste and faint odor. It is a greenhouse gas that is mostly linked to global warming. It is formed from the combustion of organic materials, fermentation, and respiration of animals, which is then utilized by plants in photosynthesis (Rafferty, 2023) [15]. The harms of carbon dioxide are not limited to global warming but to us humans too.

Carbon dioxide emission has never been higher than before, according to the Manila Air Quality Index (AQI) and Philippines Air Pollution (2023), the rampant rise of CO₂ levels in the Philippines has never been higher due to rising population and production factories in the Philippines. Additionally, the main local transportation in the Philippines uses diesel as its fuel undeniably contributing to the CO₂ emission in the Philippines, taking into account the extra emission by very old and run-down jeepneys that are still in commission (Ritchie *et al.*, 2020).

As a solution to this, the most effective way to reduce atmospheric CO₂ levels is through plants' photosynthesis. A few calculations prove that agriculture's ability to assimilate CO₂ can lead to greater carbon capture and storage that could potentially address the problem of carbon dioxide pollution (Clay *et al.*, 2012) [2].

Methodology

Flow of Research Process

Figure 1 shows a schematic diagram of the research process that was performed for each of the selected sampling sites. Each of the locations was found in Mandaluyong City. Three separate tests will be conducted on a mixture of two samples from each sampling area.

Ocular Inspection

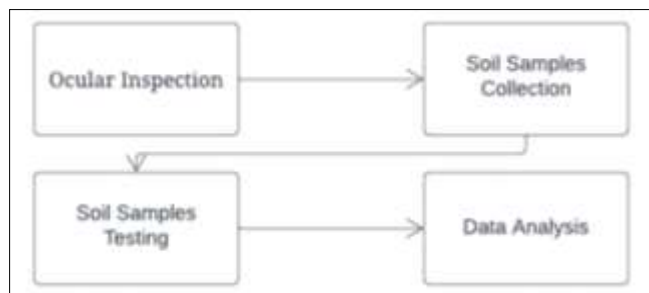


Fig 1: Schematic Diagram of the Research Process

Three separate ocular inspections were conducted in the sampling sites, namely in (3) Barangay Daang Bakal, (1) Barangay Hulo, and (2) Barangay Pleasant Hills. The study determined the exact localities of the sampling site by determining the addresses. Next, a visual inspection was done by describing the sites according to the abundance of plants and greenery that are easily locatable. After the ocular inspection follows the sampling.

Two separate samplings were done on each of the three sampling sites. The type of soil collected was not determined because purposive sampling was done, wherein only the nutrient content of each sample was determined, and the type of soil was not necessary. Each sample was stored in plastic containers to be transported to the laboratory for testing. After conducting an ocular inspection, the collection of soil samples followed.

Soil Samples Collection

The Soil Sample Collection method is adapted from the instruction manual provided by the Bureau of Soils and Water Management (2022). In each sampling area, specific areas were chosen to collect the samples from. Before collecting, the soil was cleared of any vegetation, debris, or litter. Using a digging tool pit with a depth of 20 cm – 30 cm was dug. Using a knife or a trowel, the sides of the pits were trimmed by about 3 cm – 4 cm and then placed in plastic containers. This was repeated in another area from the same location to collect 2 samples from each sampling area. The two samples were mixed thoroughly to represent the general soil condition of their respective sampling area. The method was repeated for the other 4 locations to collect 5 soil samples.

Soil pH Level Testing

The Soil Testing was done using a Soil Test Kit (STK). The soil testing method was adapted from the instruction manual provided by the Bureau of Soils and Water Management (2022). For the Soil pH test, first, the test tube was filled with a soil sample up to the first mark (Appendix B). 1 mL of the test tube was filled with the solution CPR pH indicator dye (Appendix B) up to the second mark (Appendix B). The test tube was gently swirled to mix the contents. It kept on swirling for about 2 minutes, and the test tube was allowed to stand for 5 minutes. To get the pH of the soil, the test tube with the resulting solution was inclined, and the color of the pH indicator was matched with the provided color chart (Appendix B). If the soil pH was greater than 5.8, steps 1 to 5 were repeated using the BTB pH indicator dye (Appendix B) instead of CPR. However, if the soil pH was less than or equal to 5.4, steps 1 to 5 were

repeated using BCG indicator dye (Appendix B) instead of CPR. If there is no color matched on BTB or BCG, refer to the results on CPR for the final reading.

Soil Nitrogen Level Testing

Soil Testing was conducted using a Soil Test Kit (STK). The soil testing method was adapted from the instruction manual provided by the Bureau of Soils and Water Management (2022). For the Nitrogen test, the test tube was filled with soil samples up to the first mark. 1 mL of the test tube was filled with solution N up to the second mark, with the awareness that the N solution contained a high concentration of strong acid, and precautions were taken to avoid inhalation and skin contact. The test tube was then gently swirled to mix the contents. It kept on swirling for 5 minutes, and the test tube was allowed to stand for 30 minutes. The color of the resulting solution on top of the soil was matched with the color chart provided (Appendix B).

Soil Phosphorus Level Testing

The Soil Testing was conducted using a Soil Test Kit (STK). The soil testing method was adapted from the instruction manual provided by the Bureau of Soils and Water Management (2022). For the Phosphorus test, the test tube was filled with soil samples up to the first mark. 1 mL of the test tube was filled with solution P up to the second mark, with the awareness that the P solution contained a high concentration of strong acid, and precautions were taken to avoid inhalation and skin contact. The test tube contents were mixed well by gently swirling, and it was kept on swirling for 3 minutes. Subsequently, the test tube was allowed to stand for 5 minutes. A foil or tin strip was taken, wrapped firmly at one end of a plastic stick, and used to stir the solution slowly without disturbing the soil for one minute. This process was repeated after about two minutes. The color of the resulting solution on top of the soil was matched with the color chart provided (Appendix B).

Soil Potassium Level Testing

The Soil Testing was conducted using a Soil Test Kit (STK). The soil testing method was adapted from the instruction manual provided by the Bureau of Soils and Water Management (2022). For the Potassium test, the test tube was filled with soil samples up to the first mark. 1 mL of the test tube was filled with solution P up to the second mark, followed by 8 drops of K1 solution. The contents were mixed well by gently swirling the test tube for about 1 minute. It kept on swirling for 3 minutes, and the test tube was allowed to stand for 5 minutes. After mixing, the test tube was inclined, and 12 drops of K2 solution were slowly added, one drop at a time. There was no mixing or shaking of the solution, and it was allowed to stand for 2 minutes. The appearance of a cloudy yellowish layer on top of the orange solution was observed. The level of sufficiency was determined based on the thickness of the cloudy yellowish layer, as provided in the reference picture (Appendix B).

One-way ANOVA

The researchers used one-way ANOVA to analyze data from studies involving more than two groups with one independent variable and one dependent variable. This statistical method was employed to determine if there were statistically significant differences between the means of

three or more groups. One-way ANOVA was particularly useful in various types of studies, including field studies, experiments, and quasi-experiments. This statistical method was employed to determine whether there were statistically significant differences between the means of three or more groups. Due to the results being a range instead of a specific number, the researchers took the average of the range and applied it to the statistical analysis. For potassium levels with no numerical representation, we substituted counting numbers to represent each level of increase.

Results and Discussions

Ocular Inspection

For the first phase of the study, an ocular inspection was conducted at each of the sampling sites, namely (1) Barangay Hulo; (2) Barangay Pleasant Hills; and (3) Barangay Daang Bakal. Based on preliminary visual inspection, all sampling sites had plant life within proximity.

Upon further inspection, the researchers observed that there was more flora around (1) Barangay Hulo and (2) Barangay Pleasant Hills as compared to (3) Barangay Daang Bakal, which were mostly dominated by weeds and trees.

Upon collection of samples, there were earthworms in the soil collected from (1) Barangay Hulo and (2) Barangay Pleasant Hills, but none from (3) Barangay Daang Bakal. This could be attributed to the fact that the soil from (3) Barangay Daang Bakal is under a broken segment of the road, while the soil collected from (1) Barangay Hulo and (2) Barangay Pleasant Hills has a more abundant flora.

Sampling

An estimated 500 grams of soil were collected in total per sampling area. The sampling area was first dug up to 20–30 cm before taking soil samples to ensure that the researchers tested the soil that the plant may use. The soil from each sampling area was mixed, followed by the removal of coarse objects such as rocks and leaves. Sample 1 from (1) Barangay Hulo was moist, grainy, and moldable. Sample 2 from (2) Barangay Pleasant Hills was grainy and dry with pebbles. Sample 3 from (3) Barangay Daang Bakal was moist with many clumps of soil.

pH Level Testing

The samples were tested by following the instructions provided by the Bureau of Soils and Water Management.

The first sample yielded a dark hue of purple after testing with CPR pH indicator dye, which indicated that its pH was higher than 5.8. Sample 1 was then tested again using BTB pH indicator dye, which showed that the pH level of the first sample was 7.6. The second sample yielded the same result as the first sample, which resulted in the pH level being 7.6. The third sample only needed the CPR pH indicator dye due to its tested pH being 5.8. The results yielded show that the first and second samples were a bit higher than neutral, while the third sample is more acidic compared to others, which could be because of high hydrogen ion content from the presence of ammonia in the soil (Girkin & Cooper, 2023)^[4].

Soil Nitrogen Level Testing

Samples 1 and 2 yielded an almost identical result of dark green. This means that they have a very high nitrogen content. Sample 3, on the other hand, yielded a yellow shade, which shows that it has a low nitrogen content. The high nitrogen content of both samples 1 and 2 could be related to the presence of flora, which contributes to the abundance of nutrients for the plants to utilize. In contrast, sample 3 has less flora around it and is located under cement roads. This result contradicts the pH level test for sample 3 because nitrogen is the most common nutrient to cause acidity in soils (Girkin & Cooper, 2023)^[4].

Soil Phosphorus Level Testing

Samples 1 and 3 both yielded a dark blue solution, which means that both samples had very high levels of phosphorus of at least 20 parts per million. Sample 2 yielded a lighter shade of blue, which constitutes high levels of phosphorus of at least 16 parts per million but at most 20 parts per million.

Soil Potassium Level Testing

All 3 samples yielded different levels of potassium throughout the tests. Sample 1 produced a dark cloudy layer at the top, which, when compared to the provided diagram, shows that it has a sufficient+ amount of potassium. Sample 2 yielded a completely hazy solution with no visible cloudy layer; therefore, it had a low amount of potassium. Sample 3 has a very visible and tall cloudy layer, which signifies a sufficient++ amount of potassium present within the sample.

Table 1: Results of pH, Nitrogen, Phosphorus, and Potassium Level Testing

Location	Sample	pH Level	Nitrogen Level	Phosphorus Level	Potassium Level
Barangay Hulo	1	7.6	Very High (>4.5)	Very High (> 20 ppm)	sufficient+
Barangay Pleasant Hills	2	7.6	Very High (>4.5)	High (16 to 20 ppm)	low
Barangay Daang Bakal	3	5.8	Low (0 to 2)	Very High (> 20 ppm)	sufficient++

Table 2: Results of One-way ANOVA Statistical Analysis

Sample	Ph Level	N Level	Phosphorus Level	Potassium Level		$(x_1 - \bar{x}_1)^2$	$(x_2 - \bar{x}_2)^2$	$(x_3 - \bar{x}_3)^2$	$(x_4 - \bar{x}_4)^2$
1	7.6	4.6	21	3		0.36	1.44	81	0.16
2	7.6	4.6	18	1		0.36	1.44	144	2.56
3	5.8	1	21	4		1.44	5.76	81	1.96
$\bar{x} =$	7	3.4	30	3.6	Total	2.16	8.64	306	4.68
SSW	SSB	dfw	dfb	MSB	MSW	Fstat	Fcrit		
321.48	505.16	3	8	72.16	40.185	0.001	4.07		

Fstat < Fcrit

The table reveals the results of the soil components in terms of nutrients. Regarding the level of nutrients in the soil from Mandaluyong, there is no significant difference in nitrogen, phosphorus, and potassium. The F-stat represents the analysis results to determine if there is a significant difference in means between the samples, but it is less than the F-critical. Through the result of the One-way Anova, it can be concluded that there is no significant difference between the three samples.

The findings presented in Table 1 reveal the result that there is a significant difference between the samples from Mandaluyong. Conversely, as illustrated in Table 2, no statistically significant difference was observed among the samples. The researcher further determined no correlation between the qualitative and quantitative analyses.

Conclusions

The findings from the one-way ANOVA analysis, indicating no significant difference in the overall nutrient content among soil samples, are intriguing when contrasted with qualitative observations. Despite the statistical insignificance, a consistently noticeable difference in specific nutrient tests suggests a nuanced perspective. The conditional disparities highlight the diverse composition of individual soil samples, emphasizing the need for a more detailed analysis of nutrient distribution. While statistically non-significant, the unique characteristics of certain samples could hold agricultural significance, potentially influencing crop growth. These soils, exhibiting variability in nutrient levels, present an opportunity for cultivation. Furthermore, the cultivation of crops in these soils carries economic potential. As the crops mature, they may serve as a source of sustenance, potentially reducing the daily cost of living. The observed lack of specific nutrients in certain samples can be addressed through targeted fertilizer application, allowing for precision in nutrient management and enhancing the soil's suitability for cultivation.

Due to the lack of samples from multiple areas around Mandaluyong City, the results could not be used to formulate a concrete conclusion encompassing the entirety of Mandaluyong City. It is recommended for future studies to consider a larger sampling site and a more diverse and spread-out sampling area within Mandaluyong City. Through this, future researchers could create a more inclusive and concrete conclusion that will apply to the City of Mandaluyong.

Additionally, collaboration with local government authorities, research institutions, and community organizations is crucial for future studies in Mandaluyong City. Such collaborations can provide researchers with access to valuable resources, expertise, and support. Researchers can ensure that their studies align with the city's priorities and address relevant issues by working closely with local stakeholders. This collaboration will enhance the credibility and applicability of the research findings.

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