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Community Research Extension Continuum in Urban Agriculture in an Urban Barangay of Northern Philippines

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Abstract

Urban Agriculture has always been an important part of society as it is responsible for producing essential food crops, which are essential in maintaining food security and nutrition. It also provides livelihood opportunities to many people. An important factor in farming and gardening is soil quality. Soils supply the essential nutrients, water, oxygen, and root support that our food-producing plants need to grow and flourish. This study aimed to analyze the chemical properties of the soil in Barangay Lucnab, Baguio City, as well as the presence of macronutrients and micronutrients. This research is important as it aims to assist the residents of Lucnab, given their present predicament of the low harvest and seemingly acidic soil, to maximize the nutrients already present in the farm and recommend the right amount of fertilizer and crops to plant to enhance productivity. And it is, therefore, the aim of this study to educate the community on how to maximize the potential of their farm. The research design used in this study was descriptive and experimental. The descriptive and experimental types of research sought to determine the characteristics of the soil sample in Barangay Lucnab through the manipulation of variables. They compared the results to a standard value. The sampling method used in collecting the soil was the zigzag sampling pattern. This method is adopted from the work of Ackerson (2018). Significant findings of this research revealed that the soil has low moisture content at values ranging from 27.26% to 33.60%. The soil is strongly acidic as the pH reading ranged from 4.1 to 4.83. Furthermore, the two sampling sites in Lucnab show a low organic matter with a value from 2.71% to 3.45%, while Purok 4A reveals a better nitrogen content. The levels of micronutrients such as phosphorous and potassium are above the optimum level, with the presence of micronutrients like zinc, copper, iron, and manganese. The results imply that the soil's acidity in Barangay Lucnab may affect the availability and solubility of some plant's nutrients as minerals are insoluble in acidic soil. This will greatly affect the harvest and productivity of the farmers. Therefore, it is recommended to correct the soil's pH and constantly irrigate the farms to help sustain the growth and development of the crops being grown in the said barangay. In the context of the results and analyses of the soil samples gathered in Barangay Lucnab, the researchers organized and conducted training and seminar to the community to correct the pH of the soil by adding lime and applying fertilizer before planting. Appropriate seeds were also distributed to the barangay.

Keywords: *Baguio City; micronutrients; moisture content; PH; soil analysis*

Introduction

Agriculture has always been an important part of society as it is responsible for producing essential food crops, which are essential in maintaining food security and nutrition. It also provides livelihood opportunities to many people.

Soil analysis, which is a component of soil health management, has been done in 42 countries worldwide, where soils were collected, extracted, and integrated into a database of soil health measurements conducted in the field across the globe (Jian, 2020). In the Philippines, there is no consensus on the current state of soil health, but there is an upsurge in soil science publications from 1970 onwards, and indicators show that there is no trend in slowing down (Navarrete & Asio, 2014). In the Cordillera Region, the soil chemical properties were analyzed under different

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elevations. Results show that phosphorus, soil organic matter, and pH in soils of Benguet and Mountain Province were higher in lower altitudes than upper altitudes (Paing & Gomez, 2021).

Lucnab is one of the barangays in Baguio City, and has established integrated urban agriculture, which relies heavily on farming and gardening as its sole source of livelihood. The usual vegetables and crops planted every year are pechay, squash, lettuce, tomatoes, beans, onion leeks, ginger, camote tops, and sayote mixed with flowering plants.

The Department of Education (DepEd) has two programs that work side-by-side to be implemented in schools: the Gulayan sa Paaralan Program established through DepEd Memorandum No. 293, s. 2007, and the School Inside a Garden (SIGA) launched through DECS Memo No. 77, s. 1995.

In November 2018, the Agricultural Training Institute – Cordillera Administrative Region (ATI-CAR) implemented a program titled "Glamorizing Farming through Urban Agriculture," advocating urban agriculture partnered with the City Government of Baguio, barangays, and schools (Velasco, 2018).

There were 28 participants, one of which is Lindawan National High School, located in Lucnab. As one of the participating schools, they are supposed to include urban farming in the school activities of their students. The ATI-CAR conducted training for teachers, schools, and other concerned officials who will serve as co-implementers of the program on urban gardening. The training is composed of basic practical urban farming technologies emphasizing organic agriculture.

In addition, in September 2020, the "Baguio Urban Garden Hopping" program was launched. It was spearheaded by the City Veterinary and Agriculture Office (CVAO) in partnership with the Department of Agriculture (DA) Regional Office and the Bureau of Fisheries and Aquatic Resources (BFAR) at Lindawan National High School again. According to Comanda (2020), the project aims to encourage residents and tourists to visit urban organic gardens and fishponds for tourism purposes and educate and invite the people to become urban farmers.

An important factor in farming and gardening is soil quality. Soils supply the essential nutrients, water, oxygen, and root support that our food-producing plants need to grow and flourish.

Soil analysis is a process used to determine the nutrients present in the soil. It is an important tool for farmers that should be done every five years to ensure harvest productivity.

Thus, this study aims to make a chemical analysis of the soil in Lucnab given their present predicament of the low harvest and seemingly acidic soil to maximize the nutrients already present in the farm and recommend the right amount of fertilizer and crops to plant to enhance productivity.

Literature Review

A study conducted by Navarrete (2013) indicates very little research productivity in soil science in the Philippines. If there are available studies about soil in the country, it would be geared more towards rice research, but very few publications about plant nutrition and soil chemistry. This is probably why farmers would rely on hindsight in evaluating the condition of their farm or soil condition. This is corroborated by Lima, Hoogmoed, Brussard, & Sacco dos Anjos (2011), revealing that farmers would use three indicators useful in assessing the condition of the soil such as spontaneous vegetation, rice plant development, and soil color.

Nevertheless, using science to analyze the chemical properties of the soil is an important tool for farmers to determine the presence of nutrients in the soil that can be maximized for crop production. This is corroborated by Usman & Kundiri (2016), stating that soil science plays a role in the global ecosystem for sustainable economic development. It is important to note that the right understanding of soil and its functions will lead to great productivity and yield of crops. In fact, according to Neina (2019), soil pH affects the growth of plants and biomass yield. This is why pH is often referred to as the master soil variable.

According to Bunemann et al. (2018), soil management should be used as an educational tool for farmers and a monitoring program. Target users of research related to soil should be involved from the beginning to increase the adoption of soil assessment. In fact, according to Pauli, Abott, & Andres (2016), farmers are rarely consulted by researchers on their existing knowledge about soil.

A deeper understanding of how farmers use and value soil life can lead to more effective collaborative extension programs and management initiatives to maintain healthy, living soils.

One available research about soils in Luzon was conducted by Calubaquib (2016). He sampled soils from Bolinao, Bantay, and Cervantes, and he revealed that soils from these sites have a high clay content, it is acidic, has very low organic matter, low nitrogen, and phosphorous. These data can lead to the impediment of the cultivation of the soil in Luzon due to farmers' low harvest yield. Moreover, according to Kanianska (2016), the use of fertilizers, the number of livestock, release of ammonia, and greenhouse gases from agriculture greatly affect the soil quality.

There is no published research about soil analysis in Lucnab, Baguio City, and it is, therefore, the aim of this study to offer a scientific basis of the chemical properties present in the soil sample of Lucnab, Baguio City to educate the community on how to maximize the potential of their farm.

Conceptual Framework

Contrary to the idea that plants are just passive receivers of environmental conditions in which they thrive, there is a two-way interaction between plants and soil. Soil plays an important role in the life of a plant. It can either hamper or support the growth and development of a plant. Soil provides mineral nutrients and

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anchorage for plants, while the latter provides the organic substrate that dictates the prevailing biological activity in the soil (Ehrenfield, 2013). Therefore, soil management is an important aspect of the agricultural activity of any farmer. According to Lal (2015), soil management indicates thorough planning of all inputs and outputs in the soil to achieve an appropriate balance of nutrients that forms the basis of the soil's life-support system. One of the aspects of soil management is soil testing. Soil testing dates its origin way back a hundred years ago, where scientists develop methods for determining the level of plant-available nutrients in soils. The first quick soil test done in 1845 was called Daubeny, where active nutrients were tested using carbonated water.

On the other hand, the first known fertilizer recommendations based on a soil test were given by Dr. Dyer in 1894 (Nathan 2011). Since then, the methods and procedures in analyzing the nutrients present in soil have greatly evolved in time.

One of the newest theories regarding soil testing is called the "Baker Soil Test." It is a new way of examining the intensive and extensive quantity of elements and nutrients present in a land (Baker, 2008).

Another approach in soil analysis is called the "Soil Health Tool." It is utilized in commercial soil testing because it is fast and cost-effective.

It provides information into the myriad and complex interactions between the soil and the plant, educating producers regarding the plant-available nutrients and estimating the soil health status of the land (Haney et al., 2018). There should be the right amount of macronutrients and micronutrients in the soil to be qualified as healthy.

Macronutrients are substances taken up in large amounts by plants, and they are constituents of proteins and nucleic acids, which are important components of plant tissue. Examples of macronutrients in soil are carbon, phosphorus, and potassium. Low amounts of macronutrients will hamper the growth of plants and will produce low yields (Agrocares, 2021). On the other hand, micronutrients are trace elements taken up in small quantities by plants. Examples of micronutrients are copper, iron, zinc, and manganese. They play an important role in photosynthesis, respiration, protein synthesis, and growth hormone production (University of Hawaii, 2021). Low micronutrients in the soil are affected by highly acidic and alkaline soils and depletion caused by farming. Low levels of trace elements such as Zinc will affect plant growth, while high concentrations will be toxic to the plant (Haes et al., 2012).

The frequency of soil testing is normally done every three years or whenever there is a change in crop to be grown to optimize crop production and apply the right amount of fertilizer needed by the plants (MSU, 2021). Applying the right amount of fertilizer is seen in the value of electrical conductivity. Most fertilizers are salts, and when placed in a solution, they will conduct electricity; therefore, the electrical conductivity of soil will indicate the amount of fertilizer available to plant roots (University of Massachusetts Amherst, 2021). Furthermore, soil pH affects the growth of the plants and biomass yield. This is why pH is often referred to as the master soil variable (Neina,2019). Most nutrients in the soil are available to plants when the pH is neutral, while acidic soils can result in poor plant growth. On the other hand, alkaline soils show a deficiency in zinc, copper, boron, and manganese. Therefore, it is important to achieve a pH between 5.5 to 7.5 to prevent long-term nutrient deficiencies (Queensland Government, 2016).

Given now the importance of soil testing and management of any tilled land, this research aims to offer help to the community of Lucnab, Baguio City, by analyzing the soil present in the area and coming up with a comprehensive report on the available macronutrients, trace elements, pH, and electrical conductivity of their land to propose the right crops to be grown and the optimum quantity of fertilizer to be applied. It has been noted that the soil in this barangay has not yet undergone soil analysis. Thus, this study's goal is to continue the partnership with this adopted barangay of the University of Baguio.

Significance of the Study

Community outreach plays an integral part in any Institution in giving back services to the community and building the character of selflessness among students. Based on CHED Memo #52, series of 2016 titled, "Pathways to equity, relevance, & advancement in research, innovation, & extension in Philippine Higher Education," Universities should establish a structured partnership with a community to integrate formal research and innovation. Similarly, UB Science High School believes in the importance of community involvement, as evident in its Philosophy and co-curricular activities such as outreach activities. Science High has been very consistent in visiting communities before the pandemic by offering programs such as academic, health and sanitation, security and safety, literacy, and livelihood. But with the impact of the pandemic, the outreach activity has been put on hold.

One of the adopted barangay of UB is Lucnab, Baguio City. A Memorandum of Agreement (MOA) was made in 2015, citing that Lucnab will be UB's adopted barangay. However, the MOA ended in 2018, but an extension of one year weaning period was made to further evaluate and assess other details that need to be done or correct for improvement and benefit of the barangay before finally exiting the community. Furthermore, based on the Institutional Sustainability Assessment (ISA) report made by the accreditors, a continuous partnership with the barangay should always be a part of UB's Corporate Social Responsibility. Moreover, it has also been noted during Level III accreditation of UB Science High School that the institution should aim for more sustainable forms of outreach programs by revisiting our chosen communities now and then.

It is, therefore, the goal of this research to continue the partnership with Lucnab to satisfy the role of the University in offering help in the area of livelihood, as one of the parameters of ECOS, even during the pandemic.

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Thus, this study aims to make a chemical analysis of the soil in Lucnab given their present predicament of the low harvest and seemingly acidic soil to maximize the nutrients already present in the farm and recommend the right amount of fertilizer and crops to plant to enhance productivity. The research results will be disseminated to the community via webinar, and a hard copy of the research will be given as an archive that can be stored in their library.

Objectives of the Study

This study aims to analyze the chemical properties and substances of the soil in Baguio City for potential farming. Specifically, it seeks to answer the following objectives:

General Objective

To determine the amount of some essential nutrient elements, present in the soil of Lucnab, Baguio City.

Specific Objectives

1. To determine the moisture content of the soil collected from Lucnab, Baguio City.
2. To determine the pH of the soil collected from Lucnab, Baguio City.
3. To identify the presence of the following macronutrients of the soil collected from Lucnab, Baguio City:

a. Organic matter/nitrogen
b. Phosphorus
c. Potassium

4. To determine the presence of the following trace element of the soil collected from Lucnab, Baguio City:

a. Copper
b. Zinc
c. Iron
d. Manganese

Methodology

Study Design

The research design used in this study is descriptive. Descriptive research seeks to determine the characteristics of certain phenomena (Mc Combes, 2020). On the other hand, experimental is a method that follows the scientific process. It includes a variable that can be manipulated, measured, calculated, and compared (Harland,n.d.). In this case, the soil of Lucnab will be measured in terms of its chemical properties, macronutrients, and trace elements. There will be no control variable in this study since the values generated from the soil analysis will be compared to a reference value. Therefore, the dependent variable will be the reference value adopted from Oerter (2019), Department of Agriculture, Reddy (2021), and Datta (2018). The independent variable is the soil sample gathered from Lucnab, Baguio City. It sought to determine the chemical properties of the soil and the presence of macro and micronutrients.

Location of the Study

Purok 2 is part of the watershed of the barangay. This area has a flat terrain with sandy clay loam. Purok 2B is going up the Disciples for Christ Independent School Foundation, Inc., a Korean school. It has sloppy terrain with sandy clay loam. Purok 4A is in Acapulco, where the Bugtong family resides. The area has flat terrain with sandy clay loam. Purok 2 is part of the watershed of the barangay. This area has a flat terrain with sandy clay loam.

The sampling method used in collecting the soil was the zigzag sampling pattern. This method is adopted from the work of Ackerson (2018). A zigzag sampling pattern collects a sample from locations randomly distributed across the representative portion of the field in a zigzag manner. Around 10 sampling points were marked in each field about 1 meter apart from each point. The ten samples were then mixed thoroughly to create a homogenous mixture. A kilo sample of soil was collected and submitted to the Department of Agriculture from the mixed soil samples. A certified agriculturist administered a collection of the soil samples to ensure the soundness of the method, and it was done during the fallow period.

Population of the Study

The participants of this study were from Lucban, Baguio City, particularly the officials of the Barangay, farmers, and other residents who willingly participated in the said research. The determination of the participation of the said population was based on the inclusion criteria that they should be a bonafide resident of the said community while the exclusion criteria will be nonresidents of Lucnab, Baguio City. The sampling method was purposive as farmers were chosen by the barangay officials and invited to participate in this research.

Data Gathering Tool

A consent form was distributed to the Barangay officials of Barangay Lucnab to seek their approval of the said research. The consent form is based on UBRDC document #21, version #1 from the responsible conduct of research.

Moreover, the following materials used in the collection of the soil is adopted from TNAU (2013), and they are the following: spade to cut the soil, sampling bags where the undisturbed soil was placed, meter stick used to measure the distances between points, paper, and pen to mark the sampling bags.

Data Gathering Procedure

A. Community Consultation

The following were the steps undertaken by the researchers in the conduct of the community consultation: A letter of endorsement from RDC and ECOS was sought by the researchers to allow them to conduct community consultation with the residents of Lucnab, Baguio City regarding the aims of the research. After which, the researchers presented to the community the research goals and the

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expected output of the study. After the presentation, consultation followed to allow the residents to ask questions about the research. A consent letter was distributed to the attendees of the forum to seek their approval of their soil sampling. Upon the approval of the said research by the Barangay officials, an ocular of the soil collection site was done together with the residents and farmers who were willing to participate in the said undertaking.

B. Collection of soil samples

The procedure in getting soil samples was adopted from TNAU (2013), and they are as follows: The field was divided into 10 homogenous units, and litters were removed in the sampling spot. A "V" shape cut was made to a depth of 15cm for each unit, and thick slices were gathered from top to bottom of the exposed face of the "V" shaped cut and placed in a container. The collected soil samples were thoroughly mixed, and one kilo of soil was collected. The soil samples were placed in a bag properly labeled, such as the name of the farmer, location of the farm, name of the sampler, a previous crop is grown, and crop to be grown. The three collected soil samples from Purok 2, Purok 2B, and Purok 4A were submitted to the Department of Agriculture CAR–Regional Soil Laboratory at BPI Compound, Guisad, Baguio City soil analysis.

C. Soil Analysis

The method in analyzing the soil was based on the procedures and guidelines of DA CAR, and they are following. However, an overview of the procedure is discussed below:

The pH was measured using the potentiometric method. The potentiometric method is a procedure by which the amount of a given test substance is found by adding a titrant until the entire test substance undergoes a chemical reaction (BYJU, n.d.).

Moisture content was analyzed using the gravimetric method. The gravimetric method involves weighing a moist sample at 105 degrees Celsius for 24 to 48 hours. Reweighing and calculating the mass of water lost as a percentage of the mass of the dried soil (Soil Lab Modules, n.d.).

The organic matter or nitrogen was calculated using the Walkley & Black spectrophotometric. This method measures oxidizable organic carbon present in the soil by adding potassium dichromate solution in concentrated sulfuric acid. Any heat produced in the reaction of substances will raise the temperature enough to induce substantial oxidation (Food & Agriculture Organization of UN, 2019).

The available phosphorous will be determined using Bray No. 1 Method. This method combines the collected soil with an extractant and is shaken for 5 minutes.

The amount of extracted phosphorous is determined by measuring the intensity of the blue color evident in the filtrate (University of Minnesota, 2021).

The available potassium was measured using cold sulfuric extraction. This procedure theoretically provides a way to release a constant amount of non-exchangeable potassium due to the breakdown of the primary and secondary minerals and the exchangeable potassium from a particular soil (Hunter, 1957 as cited in Foster, 2015).

Lastly, the trace elements were evaluated using the DTPA extraction. DTPA stands for diethylenetriaminepentaacetic acid. It is a non-equilibrium extraction method for the presence of zinc, copper, iron, and manganese. The extracts will be examined by inductively coupled plasma optical emission spectroscopy because this method yields low-cost analysis and great concentration ranges needed for soil testing (Kulikov, 2015).

Treatment of Data

Mean was used for objectives number 1 to 4 in computing the soil samples' average chemical property, macronutrients, and trace elements. Mean is determined by adding all the numbers and dividing them by the number of items in a set (Glen, 2021). This study will compute the average amount of the chemical properties, macronutrients, and trace elements of the three samples.

Moisture Content	Optimum value
Sandy clay loam	35% to 45%
Chemical Properties	
pH	6.2-7.2
Macronutrients	
Organic matter	3.6 – 4.5%
Phosphorous	11- 15 mg/Kg or ppm
Potassium	56-75 mg/Kg or ppm
Trace Element	
Copper	>0.40 mg/Kg or ppm
Zinc	>1.50 mg/Kg or ppm
Iron	>7.50 mg/Kg or ppm
Manganese	>4.00 mg/Kg or ppm

Table 1: Reference Value for chemical properties, macronutrients, & trace elements.

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The reference values for the following chemical properties, macronutrients, and trace elements are based on Oerter (2019), Department of Agriculture (n.d.), Reddy (2021), and Datta (2018). They were used as standard values in analyzing the gathered data from the soil analysis.

Ethical Consideration

The following ethical considerations were regarded in the conduct of the research: a letter was given to the Barangay Captain to seek approval of the research through community consultation, and the objectives of the research were thoroughly explained. The participation of the community was purely voluntary, and they could withdraw their participation anytime.

The collection of soil samples was done with the supervision of a farmer, the Barangay Captain, and other stakeholders. The researcher ensured that no other plants or animals were harmed during the collection method. All wastes generated from the sampling were properly disposed of and segregated not to contaminate other living organisms. The community was informed of the study results through a seminar, and they have furnished a hard copy of the research.

Result and Discussion

This section showcases relevant results gathered from testing the chemical properties and substances of the soil in Lucnab, Baguio City.

Moisture content of the soil in Lucnab, Baguio City

The first objective of this study was to assess the moisture content of the soil in Lucnab. Soil moisture is essential because it acts as a solvent and carrier of nutrients necessary for plant growth. The moisture content of the three soil samples from the three different sites in Lucnab, Baguio City, is presented in **Table 2**.

Field I.D. (Site)	Moisture Content (%)
Purok 2	27.54
Purok 2B	27.26
Purok 4A	33.60

Table 2: Moisture content of Soil in Lucnab, Baguio City.

Based on **Table 2**, the moisture content of the soil collected from Purok 2 is 27.54, Purok 2B is 27.26, and Purok 4A is 33.60, respectively. Although Purok 4A's moisture content is slightly higher than the two sites, all of these values are still below the optimum level of 35% to 45% moisture for a sandy clay loam type of soil. This means that water is available to plants only for a short period, around one to three days, after which it will be lost to drainage (Datta, 2018). Since soil moisture determines how vegetation and crops grow, less water for plants will mean less harvest for farmers.

A study on the moisture content of the soil in La Trinidad Benguet, where coffee is usually planted, shows an average of 68.34% to 55.38% (Calama & Fiegalan, 2021). This means that the soil is wet and saturated. Another study measuring the soil moisture of an experimental farm in Baguio City reveals an average between 19.38% to 21.82% if treated with mulch. Still, without mulch, the moisture content of the soil from the said site shows an average of 17.84% (Castillo, 2016). The latter study is similar to the values recorded in this research. This means that the moisture content of the soil in Baguio City falls below the field capacity at which the water content of the soil is considered ideal for crop growth (Datta, 2018).

pH of the soil in Lucnab, Baguio City

The second objective of this study was to assess the chemical properties of the soil in Lucnab according to pH. Hydrogen power is an important variable in the soil as it is related to nutrients in the soil. The pH level of the three soil samples from the three different sites in Lucnab, Baguio City, is presented in **Table 3**.

Field I.D. (Site)	pH
Purok 2	4.83
Purok 2B	4.65
Purok 4A	4.1

Table 3: pH Level of Soil in Lucnab.

Based on **Table 3**, the pH level of Purok 2 is 4.83, Purok 2B is 4.65, and Purok 4A is 4.1. All of the three pH readings are below the optimum level of 6.2 -7.2, according to Oerter (2019). Similarly, based on the interpretation provided by the Department of Agriculture, a pH less than 4.6 is considered low, and a pH of 4.6 to 5.0 is moderately low. This implies that Lucnab, Baguio City, is strongly acidic.

A pH below the optimum level means that nutrients leach out more quickly, plant nutrients are not readily available, and the presence of aluminum may become toxic to plant growth in soils

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with a pH below 5.0. Moreover, the structure of the soil is very much affected by pH. For instance, clay soils are normally granular under a pH of 5.5 to 7.0, but they become sticky or hard to cultivate if they are below the optimum level (Perry, n.d.).

A similar study was conducted in Benguet and Mountain Province by Paing (2021). The soil pH in these areas was measured, and it showed a reading of 6.79. This pH reading is within the optimum level, which means that nutrients are more readily available than acidic soil. Another research is done in Mankayan, Benguet by Delos Angeles (2018) reveals that the agricultural soil in this place had a pH of 4.9 which means that the soil is acidic. This result is similar to the values recorded in Lucnab, Baguio City.

Macronutrients of the soil in Lucnab, Baguio City

The third objective of this study was to assess the macronutrients of the soil in Lucnab. Macronutrients are essential in the growth of a plant because of their role in energy metabolism and protein synthesis. **Table 4** presents the macronutrients present in the soil of Barangay Lucnab.

Field I.D. (Site)	Organic Matter (%)	Phosphorous (mg/Kg or ppm)	Potassium (mg/kg or ppm)
Purok 2	3.45	84.85	260
Purok 2B	2.71	52.22	120
Purok 4A	4.27	204. 58	240

Table 4: Macronutrients of the Soil in Lucnab, Baguio City.

Organic Matter

Based on **Table 4**, Purok 2 has 3.45% organic matter or nitrogen, Purok 2B has 2.71%, and Purok 4A has 4.27%. Purok 2 and 2B are below the optimum level of organic matter, according to Oerter (2019), which is 3.6 - 4.5%, while Purok 4A is within the optimum level. According to the interpretation given by the Department of Agriculture, a value of 2.1 to 3.5 mg of organic matter or nitrogen means that it is low. In comparison, the range of 3.5 to 4.5 mg means that the presence of nitrogen is moderately high. A good amount of nitrogen promotes rapid vegetative growth in plants (DA, n.d.).

This implies that plants that are sown in Purok 2 and 2B grow slowly, and leaves exhibit a yellowish-green color, as evident in the sayote plant growing in Purok 2B during the time of data gathering. Organic matter or nitrogen is considered the building block of plant proteins and an integral part of the chlorophyll molecule that is essential in photosynthesis. The role of nitrogen in plants is to promote rapid vegetative growth and improve the quality of leaves (Nathan, 2021). Therefore, the lack of nitrogen or organic matter in the soil will greatly affect the growth of a plant and the quality of its leaves.

Nevertheless, in Purok 4, the amount of nitrogen is within the optimum level and can therefore help the farmers produce healthy and abundant crops.

A study conducted in Mankayan, Benguet, where soil samples were tested for organic matter, revealed that it contains nitrogen ranging from 0.03 to 2.2%, which means the soil is below the optimum level (Cuevas, 2020). Another soil analysis study made in Baguio before planting and at harvest showed a 2% amount of organic matter (Castillo, 2016). These researches corroborate the findings gathered in Lucban regarding the low amount of organic matter present in the soils samples from Purok 2 and 2B.

Phosphorous

Based on **Table 4**, Purok 2 has an amount of 84.85 mg of phosphorous, Purok 2B has 52.22 mg, and Purok 4A has 204.58 mg of phosphorous. These values exceed the optimum level, from 11 to 15 mg/Kg of phosphorous. This means that the soil samples in Barangay Lucnab reveal a considerable amount of phosphorous at the time of data gathering.

In normal instances, many soils test above optimum for phosphorous because of previous fertilizer and manure in the soil. This is true for all the soil samples gathered in Barangay Lucban. Purok 4A exhibits the highest amount of phosphorous out of the three sites due to a recent addition of fertilizer in preparation for planting crops. Purok 2 shows some residue of the manure as the soil was gathered after the harvest of crops, while Purok 2B has the lowest amount of phosphorous due to the presence of sayote plants at the time of data gathering. This further implies that the farmers in Lucban, Baguio City, can benefit economically by reducing the addition of fertilizer in their farms (Heckman, n.d.).

A similar result was recorded by Castillo (n.d.) in the soil samples gathered from Buguias and Baguio City. The phosphorous level of the soil samples with mulch and without mulch were from an average of 71 to 230 ppm of phosphorous, all of which are above the optimum level. An opposite observation was documented by Cuevas (2020) in a research done in Mankayan, Benguet, where all three sites exhibited below the optimum level of phosphorous, which is from 1.85 mg to 10.00 mg/Kg. This indicates that the soil lacks fertilizer essential for the growth of plants.

Potassium

Based on **Table 4**, Purok 2 has 260 mg of Potassium, Purok 2B has 120 mg, and Purok 4A has 240 mg/Kg of Potassium. These values exceed the optimum level, from 56 to 75 mg/Kg of Potassium. This means that the soil samples in Barangay Lucnab

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reveal a considerable amount of Potassium at the time of data gathering. Although Purok 2B indicates the lowest potassium value during the soil sampling, this is because sayote plants were currently growing at the time of data gathering. Crops normally remove larger amounts of Potassium from the soil during a growing season which explains why Purok 2B has the lowest value of Potassium among the three sites. Nevertheless, the value of 120 mg/Kg of Potassium is still above the optimum level. However, Potassium may still be applied to soils testing above optimum to maintain the fertility level in the optimum range (Heckman, n.d.).

Previous research by Castillo (n.d.) in Guisad, Baguio City, recorded the potassium levels of an experimental farm with mulch and without mulch. Results show that the potassium level of all the soil samples was from 374 to 672 ppm of Potassium, all of which are above the optimum level. This finding corroborates the result of this research. It implies that Baguio soil generally demonstrates a good amount of Potassium due to the 40% clay component, which can take up macronutrients through adsorption (Nathan, 2021).

Micronutrients of the soil in Lucnab, Baguio City

The fourth objective of this study was to assess the micronutrients of the soil in Lucnab. Micronutrients play a critical role in enzymatic reactions such as photosynthesis and respiration (Nair, 2016). **Table 5** presents the macronutrients present in the soil of Barangay Lucnab.

Field I.D. (Site)	Zinc (mg/Kg or ppm)	Copper (mg/Kg or ppm)	Iron (mg/Kg or ppm)	Manganese (mg/Kg or ppm)
Purok 2	4.65	1.48	14.76	16.15
Purok 2B	1.51	0.43	16.06	9.56
Purok 4A	0.56	0.42	14.7	17.31

Table 5: Micronutrients of the Soil in Lucnab, Baguio City.

Zinc

Based on **Table 5**, Purok 2 has a value of 4.65 mg/Kg, Purok 2B has 1.51.mg, and Purok 4A has 0.56 mg/Kg of zinc. Purok 2 and 2B values are in the optimum level, which is above 1.50 mg/Kg, while Purok 4A falls below the adequate level.

Zinc is one of the most important micronutrients in a plant. Although it is needed in minute amounts, it plays an essential role in plant development. **Table 5** implies that Purok 2 and 2B has a sufficient amount of zinc to prevent leakage of sugar onto the surfaces of plants and can prevent the invasion of fungus and bacteria (DA, n.d.). However, for Purok 4A, zinc deficiency can substantially lose crop yields and quality, as observed by the farmer who owns the said garden (Smart, 2020).

Research conducted in Cagayan corroborates the findings of this study by revealing that the soil sample with *Tetrastigm*a species planted on it shows an above the optimum level of zinc with a value of 3.46 mg/Kg (Opena, 2021). Another study done in Nueva Ecija regarding the presence of zinc was also conducted, and results show that the level of zinc is above the optimum level with a value of 3.64 mg/Kg (Javier, n.d.). However, there is no published research regarding assessing the presence of micronutrients in soils in Benguet.

Copper

Based on **Table 5**, Purok 2 has a value of 1.48 mg/Kg, Purok 2B has 0.43.mg, and Purok 4A has 0.42 mg/Kg of copper. The values of Purok 2, 2B, and 4A are at the optimum level, which is above 0.40 mg/Kg. This means that the soils in Barangay Lucnab have sufficient copper to help sustain the metabolic activities of plants being grown there, such as carrots.

Copper is an important activator of enzymes in plants, and deficiencies of this micronutrient are not common in soils as against zinc. This, therefore, corroborates the result of this research revealing that all soil samples from the three sites indeed are above the optimum level of copper. Furthermore, research is done in Benguet by Cuevas (2020) demonstrates that the soil samples from this area have an average copper content from 90.64 mg/Kg to as high as 220.73 mg/Kg. Another study was done in the soils of Cagayan by Opena (2021) also reveals values of copper above optimum, ranging from 1.76 mg/Kg to 3.90 mg/Kg. This means that it is not unusual for soils to run out of copper regardless of area.

Iron

Based on **Table 5**, Purok 2 has a value of 14.76 mg/Kg, Purok 2B has 16.06.mg, and Purok 4A has 14.7 mg/Kg of iron. The values of Purok 2, 2B, and 4A are above the optimum level, which is 7.50 mg/Kg. This means that the soils in Barangay Lucnab have a sufficient amount of iron to help maintain chlorophyll in plants (DA, n.d.). However, it may also mean that iron may not be available to plants since the soil's pH level in this Barangay is strongly acidic. The high presence of iron may become toxic to the development of crops.

Generally, lack of iron in the soil is not a common problem in farms, especially if the pH of the soil is below 7. This is corroborated by the studies of Cuevas (2021) and Javier (n.d.), where all the soil samples tested in Cagayan and Nueva Ecija, respectively, do not fall below the optimum level of 7.50 mg/Kg. These findings support the result of this research whereby a good amount of copper is recorded in all three sites of Lucnab, Baguio City. This implies that iron is enough to help the plant perform its metabolic processes such as respiration and photosynthesis.

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Manganese

Based on **Table 5**, Purok 2 has a value of 16.15 mg/Kg, Purok 2B has 9.56 mg, and Purok 4A has 17.31 mg/Kg of manganese. The values of Purok 2, 2B, and 4A are above the optimum level, which is 4.00 mg/Kg. This means that the soils in Barangay Lucnab have a sufficient amount of manganese to help plants perform protein synthesis (DA, n.d.). However, it may also imply that manganese may not be available since the soil's pH level in this Barangay is strongly acidic. The high presence of manganese may become toxic to the growth of some plants.

Manganese, like iron, is essential in forming chlorophyll and ascorbic acid in plants. Manganese deficiency is also not common in soils but can happen in sandy soils with a pH of 8 (Nathan, 2021). This is supported by the research made by Javier (n.d.) and Cuevas (2021), where manganese levels in Cagayan range from 6.20 mg/Kg to 37.60 mg/Kg of manganese, while in Nueva Ecija, manganese level is 171.15 mg/Kg. These findings support the values analyzed by the Department of Agriculture in the soil samples of Barangay Lucnab, which are all above the optimum level. This means that the soils in Lucnab can sustain the growth of plants such as beans or potatoes.

Conclusion and Recommendation

The soil in Barangay Lucnab, Baguio city, is composed of forty percent clay and sixty percent sand, giving it a gritty feeling. Therefore, the soil texture of this barangay is considered sandy clay loam. It is strongly acidic, affecting the solubility of minerals or nutrients such as phosphorous.

Moreover, the soil moisture is below the optimum level. This implies that water necessary for plant growth and development is available only for a short period; thus, constant watering of the garden in this barangay is needed.

Consequently, the soil has high amounts of macronutrients and micronutrients. This means that farmers or residents of this barangay can benefit from it since it will lessen their expenses in fertilizer use. However, the acidic soil of this area may inhibit the availability of some nutrients important for plant growth. Therefore, it is necessary to correct the pH of the soil in Barangay Lucnab for the minerals to be readily available to crops planted in the said area.

In the context of the results and analyses of the soil samples gathered in Barangay Lucnab, the following are recommended:

1. For Farmers to correct the pH of the soil by adding 20 pounds of lime per 100 square feet during the dry season, not to wash off the lime, it should be incorporated into the soil three weeks before applying fertilizer.
2. For farmers to use 261 kg/ha of 46-0-0 fertilizer material for cabbage, 98 kg/ha of 46-0-0 fertilizer material for radish, and 174 kg/ha of 46-0-0 fertilizer material for cucumber.
3. For Farmers to constantly irrigate the vegetable garden, about one inch of water per week as soil moisture is not enough for the growth and development of plants.

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