Analysis of the physical and chemical properties of soils in the agroecosystems of the Tunshi experimetal station

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SUMMARY

In Ecuador, about 49 per cent of land is degraded and 22 per cent is in the process of desertification. Taking into account these data and because the studies on this problem of degradation at the national or regional level have been minimal, in search of possible solutions this issue has been raised as a research project. The Tunshi Experimental Station (TSE) was divided into 3 zones known as high, middle and low zone. The study was supported with the use of geographic information systems (GIS) and chemical and physical analyses were performed in the TotalChem laboratory located in the Ambato canton.

The parameters analyzed were the hydrogen potential (pH) in which the following data were obtained: high zone = 7.38, middle zone = 7.60 and low zone = 7.24. In the texture, for the 3 zones a textural class of a sandy loam soil was obtained. Stop the content of organic matter (OM) we have for the high zone = 3.0%, medium zone = 2.9% and low zone = 4.0%. While in the electrical conductivity (EC) the following data were obtained: high zone = 0.21mmhos/cm, middle zone = 0.22mmhos/cm and low zone = 0.20mmhos/cm.

Considering the data obtained through the analysis of both physical and chemical soils, it is possible to propose proposals to improve the quality of soils at the Tunshi Experimental Station through the implementation of different agroecological or soil conservation practices.
In the middle and lower zone there are no soils that are in degradation processes since they have percentages of 4.3% and 4.0% of organic matter respectively, that is, they maintain a biological activity within the established parameters.

The pH being an indicator of the availability of nutrients, the values for the middle and low zone are 7.38 and 7.24 respectively, that is, they are soils with practically neutral pH. While in the high zone the value is 7.60, which makes it a soil with a slightly alkaline pH, according to Cartagena, this area presents a possible excess of Ca, Mg and carbonates, low solubility microelements and a possible need to treat the soil with amendments such as gypsum because the development of several crops is inhibited.

Key words: <Degradation>, <Soils>, < Agroecological practices>, < Agroforestry>, <Silvopastoral > system, < GIS>.

1. INTRODUCTION

Soil is an essential part of the ecosystem and is therefore extremely important for the services it provides, but the global degradation of this resource is increasing. Soil erosion is the main process of anthropogenic degradation affecting soils worldwide. This process modifies the main physical, chemical and biological properties of the soil, which affects the productivity of the agroecosystem. Of particular importance are the occurrence of extreme events, their high probability of occurrence due to climate change and impacts on arable land (Winschel, 2017, p. 24).

Over time, human activities have been shown to drastically change the earth's natural cover patterns across the planet. As Europeans arrived in the Americas, the structural characteristics of landscapes began to change, mainly in relation to disturbance systems, including changes in patterns of use of basic resources. Large areas of natural forests have been cleared and converted to make way for agriculture (Hernández R, et al, 2014).

With the emergence of the Green Revolution in agriculture after World War II, these soil erosion processes increased. It has been shown that during the period 1945–1990, the world's soils were reduced by 17%, compared to only 6% during the period 1900–1945. This was the core of the concepts of sustainable agriculture, organic agriculture, etc. These changes in soil properties have been studied in greater detail since the presentation of these results in 1990, and are still included today as an element of soil classification in global and national classifications (Hernández, et al., 2017, p. 51).

Globally, ice-free land covers a total of 13 billion hectares, of which 11% is cultivated, 24% is permanent pasture and 31% is forest. Of the total 3.2 billion hectares of arable land, about 1.475 billion hectares are currently cultivated. But despite pressure in developing countries to increase food production, progress has been slow: between 1977 and 1988, the area of arable land increased by only 4%, the area of permanent pasture remained almost unchanged, and the area of forests decreased by 3.5% (Winschel, 2017, p. 24).

Ecuador is characterized by the great diversity of its natural resources, among which the presence of soils with great agricultural potential stands out. However, erosion and anthropogenic processes have been affecting agricultural soils (De Noni & Trujillo, 1986, p. 384). Soil fertility is considered of great importance for plant growth and is defined as the potential of a soil to supply the nutrients in the forms, quantities and proportions required to achieve good plant development and yield. Its evaluation for agricultural purposes is the process by which nutritional problems in soils are diagnosed and based on them fertilization plans are developed (Domínguez et al., 2019, p. 52).

Given this background, it was identified that the natural resources in the Tunshi Experimental Station haveproblems due to the indiscriminate use of pesticides, fungicides and fertilizers. In the case of soil, it provides important environmental goods and services such as sustenance of food for plants, stores nutrients, is the habitat of an infinity of organisms and houses all the natural ecosystems that exist on the planet. This makes the study, conservation and recovery of degraded soils very important activities that must be implemented continuously. Since this resource has been one of the most overexploited both in the agricultural, livestock, forestry or urban fields (Reinoso, 2018, p. 23).

In the present research we will try to estimate the processes of degradation, and the processes derived from it, using multicriteria analysis techniques and to be able to establish predictions of the advance of the agricultural frontier of the Tunshi Community. To this end, the following research question was posed that will guide this entire study: What are the soil degradation processes of the Tunshi Experimental Station today?

Soil is a mixture of mineral and organic materials; able to support plant life. The interest of this research focuses on evaluating the quality of the soil, therefore, the determination of physical and chemical characteristics allows to assess its productive aptitude. One of the main elements for agricultural sustainability is the determination of soil quality, effectively directing its use and management (Quintero, 2002).

Studies on the problem of erosion at the national or regional level have been minimal, rather these are carried out in localized areas which does not allow us to understand the impact of this problem. To carry out this research we take into account the advanced degradation of the soil, that is, in the country, around 49% of the lands are degraded and 22% are in the process of desertification (Alarcón, 2018, p. 1).

2. MATERIALS AND METHODS

Research design

According to the manipulation or not of the independent variable

Because the study variables were not manipulated during the research, a non-experimental design was chosen. In a non-experimental study, no situations arise, but the researcher observes existing conditions without intentional provocation. In non-experimental research, the independent variables are there and cannot be manipulated; there is no direct control over these variables, and it is not possible to influence them, as has already been done, such as their effects (Hernández, et al., 2014, p. 152).

Data collection

The method used in the present study was observation. Observation is a process of attention, collection, selection and recording of information, for which the researcher uses his senses (sight, hearing, kinetic and kinetic senses, smell, touch, etc.). Observation is the integral openness of the individual (internal and external senses, experiences, perception, intellect), with respect to what surrounds him, as well as the selection, systematic recording and codification of all facts, situations or behaviors (Hurtado, 2010 p. 833).

The research technique used was documentary review. This technique is a process of locating, collecting, selecting, examining, analyzing, extracting and recording the information contained in the documents. The documentary review technique can be used for a variety of purposes, in fact, it serves to build the noological foundation of the research and, in this case, of the search for information oriented to the configuration of the theoretical, conceptual, historical, legal and contextual starting point (Hurtado, 2010, p. 851).

Experimental units

Three soil analyses will be carried out within the study area, which are: high, medium and low zone, for which the following parameters will be evaluated:

- Hydrogen potential (pH).

- Texture.
- Structure.
- Macronutrients.
- Micronutrients.
- Organic matter content.
- Electrical conductivity

Figure 1. Location of sampling points

To begin with the selection of points, a community mapping is carried out where3 agroecosystems known as: high zone, middle zone and low zone are identified.

Table 1. Extension of study areas.

ZONE	AREA (Ha)
Loud	18,37
Media	29,68
Casualty	23,51

Methodological development

According to the manipulation or not of the independent variable

Because the study variables were not manipulated during the research, a non-experimental design was chosen. In a non-experimental study, no situations arise, but the researcher observes existing conditions without intentional provocation. In non-experimental research, the independent variables are there and cannot be manipulated; there is no direct control over these variables, and it is not possible to influence them, as has already been done, such as their effects (Hernández, et al., 2014, p. 152).

According to the interventions in the fieldwork

According to the interventions in the fieldwork, a transversal design has been used. Cross-sectional research designs collect data at the same time. Its purpose is to describe the variables in a given period of time and analyze their effects and interrelationships. It's like "taking a picture" of something happening (Hernandez, et al., 2014, p. 154).

Dot marking

The points were marked by using GPS using their coordinates. The sampling area was established from transects. Transect sampling includes greater soil variability, which implies greater sampling units or soil clustering.

In the transects, it is possible to appreciate the spatial distribution of the soil by catenas in the relief. Likewise, if the profiles are located in homogeneous areas, they can be represented on maps, and used for territorial planning (Mendoza, et al., 2017 p. 23).

Soil sample for determination of soil texture and chemical properties

At each sampling point a hole was made at the different points marked by the transect and the extracted soil was placed in a sack to mix the sub-samples, once mixed approximately one kilogram was extracted and sent to the laboratory for analysis.

Sample preparation and identification

Once the sampling has been carried out, according to the plan, and prior to its analysis in the laboratory, it is important to ensure good preparation and labeling, that it is not erased in transport and that it contains the information of the sampling site. The subsamples are deposited on canvas or plastics, mixed, and large clods, trunks, stones, among others, are removed. A part of this mixture should be separated and placed in a well-identified container (bag, box, etc.).

Analysis of information

With the zoning and results of the physical and chemical analysis of the soils of the Tunshi Experimental Station, we proceeded to compare with the data of the scientific literature to generate the current state of the soils of the station. In addition, it was complemented with information obtained in field practices.

3. RESULTS

Chemical analysis

Next, the chemical analyses of the soils of the Tunshi-ESPOCH Experimental Station are presented, which will help us to have a reference regarding the current situation of the soils of this study site.

The values obtained for each of the analyzes performed are qualified considering the nomenclature according to the parameters A High, M Medium and B Low as follows:

Table 2. Range of the values obtained.

MACRONUTRIENTS					
Batch data	**%**	**Ppm**	**meq/100ml**		
Calicata	**N. Assimilable**	**P**	**K**	**Like**	**Mg**
Upper Zone	37 M	69 A	2,1 A	1,5 M	0,4 M
Middle Zone	45 M	68 A	0,7 A	1,9 M	0,8 A
Lower Zone	31 M	47 A	0,5 A	1,1 M	0,6 M

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Graphically, the macronutrients are represented according to the study areas:

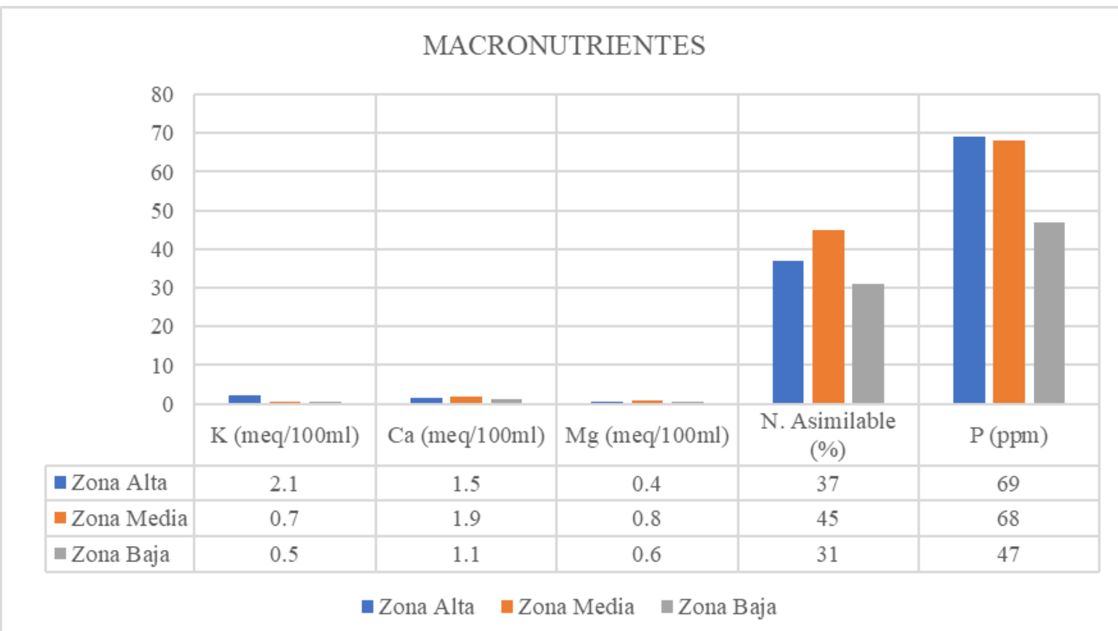

Figure 2. Macronutrients in the study areas

Phosphorus (P) is one of the 17 essential nutrients for plant growth. In general terms, we can say that values below 5 ppm are very low, between 5 and 10 ppm are low, between 10 and 20 ppm average and above 20 to 25 ppm, can be considered adequate (Quintero, 2002, p. 1)

In this study we have high values of Phosphorus for the three zones corroborating the information mentioned above.

The amounts of potassium (K) present are high for the three zones (high, medium and low), the plant absorbs potassium from the soil solution only as potassium ion. This is very mobile in the plant. Potassium is essential for the plant, because it influences multiple tasks of plant metabolism (K + S Minerals and Agriculture, 2019).

Interchangeable bases largely define soil fertility. (Arcos, 2022, p. 25) state that the high contents of Ca and Mg represent fertile soil. The total concentration of Ca of 0.7-1.5%, up to 10% in soils of arid zones. Arid and alkaline soils generally contain high levels of calcium (Garcia, 2008, p. 38). Having medium and high values for the three zones it can be said that these soils are practically fertile.

Table 3. Micronutrient values

MICRONUTRIENTS			
Batch data	**Ppm**		
Calicata	**With**	**Mn**	**Zn**
Upper Zone	6,0 A	2,0 B	1,0 B
Middle Zone	9,0 A	3,0 B	1,0 B
Lower Zone	3,0 M	1,0 B	1,0 B

Graphically the macronutrients by zones are represented:

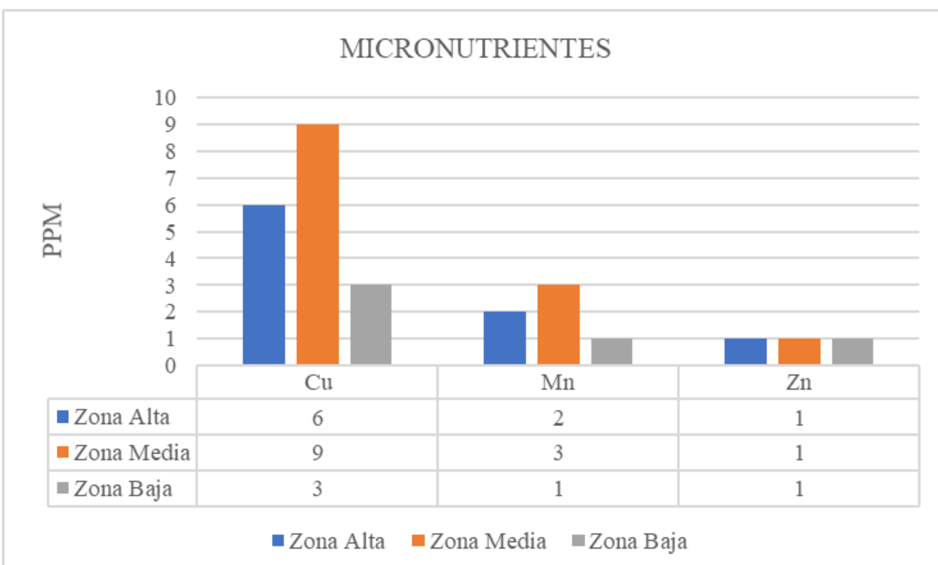

Figure 3. Soil micronutrients.
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Copper exists in soils as Cu^{2+} and most of it is absorbed by the plant in this form. Once absorbed, it accumulates mainly in the roots. Its concentration in plant tissue varies between 5 and 20 ppm and in soil from 2 to 100 ppm. However, most of the copper in the soil is not available to plants (Sele, 2019, p. 1).

Mn is considered immobile within the plant (phloem) and its availability to crops is influenced by soil factors involved in the oxidoreduction process, particularly pH, organic matter content, soil water status and microbial activity. Its availability is higher in acidic soils due to the solubilization of Mn-containing compounds (Gómez, et al., 2006 p. 341).

The availability of zinc is strongly influenced by pH and its total content in the soil. The amount of exchangeable zinc decreases with increasing pH and is very low from pH 6. With increasing pH the affinity of zinc increases considerably against iron and manganese oxides.

In soils this micronutrient is poorly mobile and its total content normally varies from 10–300 ppm with an average of 50 ppm (Castellanos and Rodríguez, 2014, p. 1).

Corroborating with the previous information, in the study areas (high, medium and low) we have very low levels of this micronutrient as we have values of 1.0 ppm for the three areas.

Table 4. pH values

SOIL PH		
Calicata	**Amount of pH**	**Level**
Upper Zone	7,60	Slightly ALKALINE
Middle Zone	7,38	Virtually NEUTRAL
Lower Zone	7,24	Virtually NEUTRAL

The graphical representation of the pH values is shown in the following figure

Figure 4. pH of the soil of the zones: high, medium and low.
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The pH of the soil solution is a good indicator of nutrient availability. This is because the presence of aluminum ions (Al3+, Al(OH)2 +), H+ and OH- are determinants of the solubility of nutrients in the soil (phosphate, sulfate, molybdates, iron, manganese, copper, zinc) or are indicators of the scarcity of the available forms of some of them in the soil (calcium, magnesium, potassium, sodium).

In this case, for the middle and low zone we have pH data close to neutrality 7.38 and 7.24 respectively, that is, according to Cartagena (2002, p. 42) these areas have a good availability of Ca and Mg; moderate availability of P and low availability of microelements, while for the high zone the pH is slightly alkaline with a value of 7.60, according to Cartagena (2002, p. 42) this area presents a possible excess of Ca, Mg and carbonates, low solubility of P and microelements; Possible need to treat the soil with amendments such as gypsum. The development of various crops is inhibited.

Table 5. Electrical conductivity and presence of organic matter.

Calicata	**Electrical conductivity**	**Presence of M. Or**
Batch data	**mmhos/cm**	**%**
Upper Zone	0,21	2,9
Middle Zone	0,22	4,3
Lower Zone	0,20	4,0

Graphically theelectrical conductivity and presence of organic matter are presented as follows:

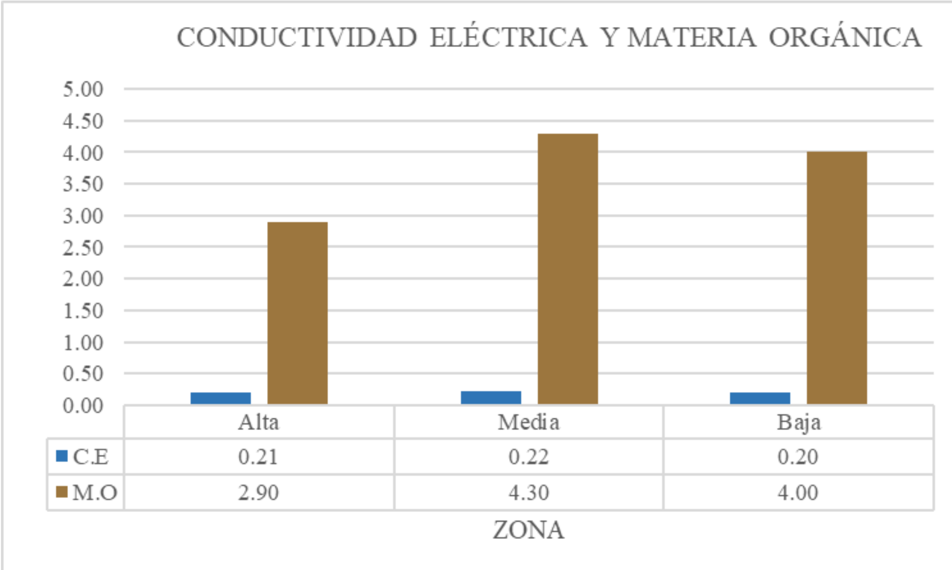

Figure 5. Electrical conductivity and presence of organic matter.

The electrical conductivity (E.C) has a similar value in the three zones: 0.21 for the upper zone, 0.22 for the middle zone and 0.20 for the low zone. This means that the soils studied in the three zones are in the "non-saline" category.

The value of electrical conductivity presented by the soil greatly influences the effort that the root of the plant has to make to absorb the nutrients of the fertilizer solution provided. Therefore, if it is above the optimal value for the crop, the plant will have to work harder to extract the nutrients. This entails an additional expenditure of energy that will negatively influence the productive performance. A value <0.8 means that soil salinity is low (Rucks, 2004, p. 1).

On the other hand, the content of organic matter (M.O) has a value of 2.9% for the upper zone, 4.3% for the middle zone and 4% for the lower zone, this means that the upper zone presents a deficiency in organic matter, while in the middle and low zone it presents a normal percentage in organic matter.

The organic matter of the soil regulates chemical fertility, from the amount of nutrients it will provide for plants, as well as the maintenance of biodiversity and the physical structure of soils, being desirable that the value is greater than 5% (Romero, 2012).

Physical analysis

For the physical analysis of the soil, a calicata was carried out, which allowed a visual inspection of the soil moisture content in the root zone of the crop, allows us to determine the degree of compaction of the land, depth of the soil, presence or not of impermeable layers, see structure and texture.

Table 6. Thickness of horizons and colour of soils in TSE.

HORIZONS	THICKNESS (cm)			COLOR		
	Upper Zone	Middle Zone	Lower Zone	Upper Zone	Middle Zone	Lower Zone
Or	6	8	8	2,5Y 3/3	2,5Y 4/2	10YR 3/1
A	24	15	27	2,5Y 4/3	2,5Y 5/2	10YR 2/2
B	22	28	35	2,5Y 3/3	2,5Y 5/2	10YR 2/2
C	18	19		10YR 4/3	2,5Y 5/2	

Graphically the thickness of the soil horizons is presented as follows:

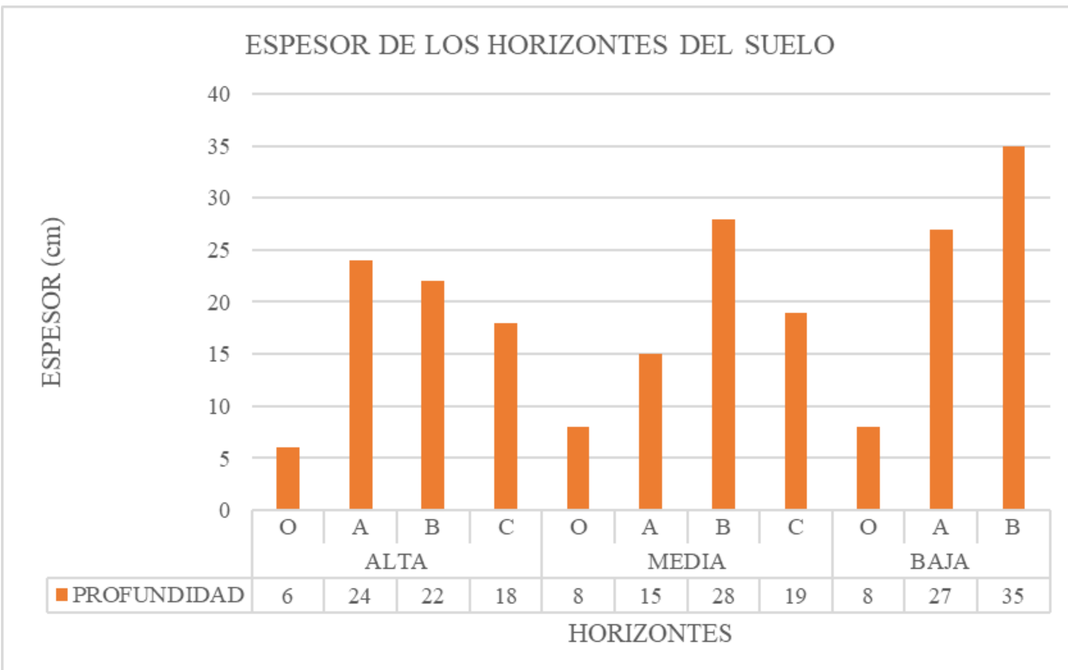

Figure 6. Thickness of the soil horizons of the zones: high, medium and low.

When performing the corresponding analysis of each of the calicatas carried out in the three zones, it was observed that in the calicata of the upper zone there are 4 horizons:

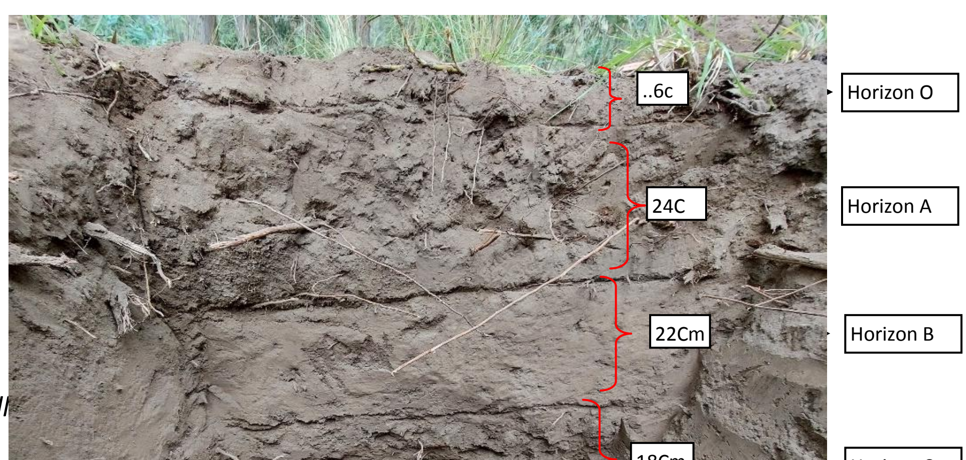

Figure 7. Soil horizons of the upper zone.

Horizon O: Which is located in the first 6 cm of the soil, formed by leaves, branches and decomposing plant remains. Especially the leaf litter from eucalyptus trees.

Horizon A: This horizon composed of minerals, located below the O horizon, with a thickness of 42 cm, in it we can observe roots and partially decomposed organic matter.

Horizon B: With a thickness of 22 cm, composed mainly of fine mineral elements and has a granular structure.

Horizon C: With a thickness of 18 cm, partially decomposed parent material, in which we find fragments of bedrock in weathering processes.

In the calicata of the middle zone we find 4 horizons:

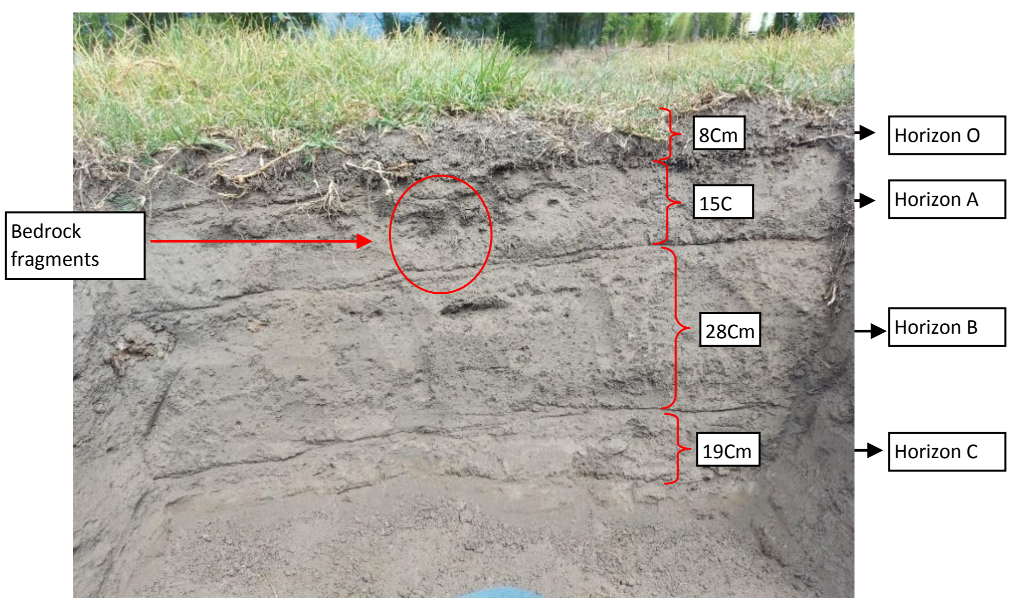

Figure 8. Soil horizons of the middle zone.

Horizon O: Located in the first 8 cm, in this horizon we find remains of decomposing plants

Horizon A: This horizon composed of minerals, located below the O horizon, with a thickness of 15, in it we can observe roots and partially decomposed organic matter.

Horizon B: With a thickness of 28 cm, composed mainly of fine mineral elements and has a granular structure.

Horizon C: With a thickness of 19 cm, partially decomposed parent material, in which we find fragments of bedrock in weathering processes.

In the calicata of the lower zone we find 3 horizons:

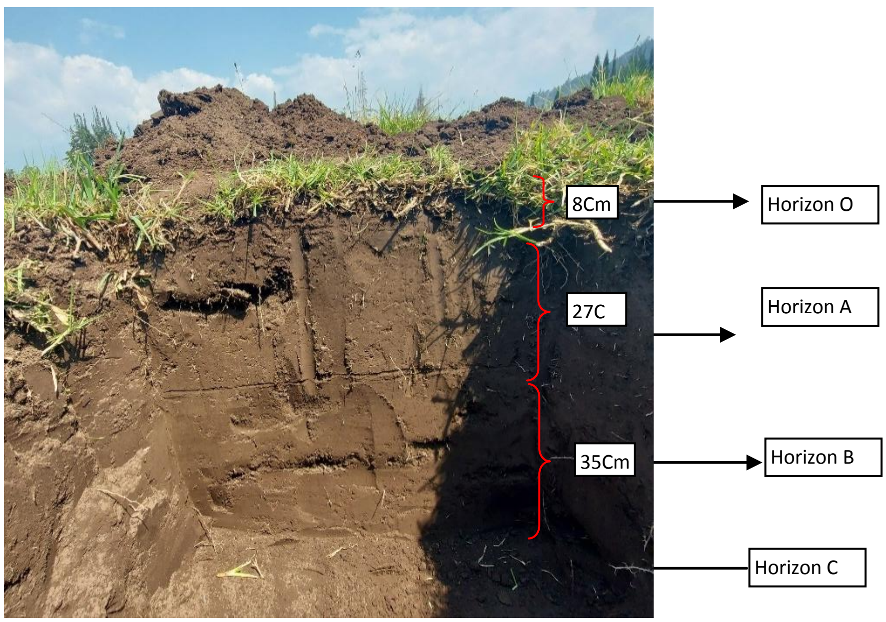

Figure 9. Ground horizons of the lower zone.

Horizon O: Located in the first 8 cm, this area is characterized by the presence of pastures, which is why in this horizon we find grasses and pastures, and there is also organic matter (manure) from cows.

Horizon A: Located below horizon O, with a thickness of 27 cm, in which the presence of roots is observed.

Horizon B: With a thickness of 35 cm, concentration of residues, which cause this horizon to have a darker color than the previous ones.

Table 7. Texture.

CALICATA	CLASE TEXTURAL
Upper Zone	Sandy loam
Middle Zone	
Lower Zone	

In the texture we have a sandy loam textural class, its structure is usually granular of soft consistency, although in virgin soils not worked the structure can be laminar with a slightly hard consistency.
Ciancaglini (2009, p. 9) states that, in dry soils, it breaks easily, at first the texture appears soft, but as it rubs, a sandy sensation begins to dominate. While in wet soils a ball is formed that allows careful handling without breaking, it forms a ribbon up to 3 cm long and when rubbed between the thumb and index finger it is soft at first, but when rubbed a rougher sensation dominates.

4. DISCUSSION

The Experimental Tunshi E station being located in the Tunshi San Nicolás Community of the parish Licto, are affected by a degradative process due to the inadequate exploitation of the soils, which has caused a decrease in the yields of several crops, has similar characteristics in terms of the type of soil called inceptisol (USDA, 1999).

Table 8. Type of soil of the community.

ACRONYM	ORDER	SUBORDER	LARGE GROUP	SUBGROUP
Hq	Inceptisol	Andepts	Eutrandepts	Duric Rup

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The type of soil in the territory of the TSE of Order INCEPTISOLS and Suborder ANDEPTS, silt-sandy soil on a hard-Duripan layer in discontinuity with black coatings and calcium carbonate at 40/50 cm. depth (PDOT, 2015).

Order Inceptisol
Inceptisols are immature soils that have a profile with less expressed features than mature soils and that are still related to the nature of the original material. In addition, this type of soil can be found in subhumid to humid climates from equatorial regions to the tundra (Torres, 2010).

This order is very heterogeneous, ranging from very poorly drained to well-drained soils, so that its physical and chemical properties are very varied. However, the fitness of inceptisols is diverse.

Suborder Andepts

This order is very heterogeneous, ranging from very poorly drained to well-drained soils, so that its physical and chemical properties are very varied. However, the aptitude of Inceptisols is diverse (Muñoz, 2016).

Land cover

The soil cover in the process of erosion is 4.16 km2, due to the use of chemical fertilizers, poor management of fertilizer, pollution by organic and inorganic garbage and the burning of garbage. The coverage of shrub vegetation (not moorland), is 1.76 km2, has been affected by the increase of the agricultural frontier

Worldwide, soils have become very important in the coexistence of human beings, integrated management must be carried out to enhance their productive capacity for the benefit of man and achieve sustainable development, contributes to providing food security for a place. This situation demands that technical professionals and those responsible for agricultural production expand their knowledge related to the management and conservation of this resource, so that an adequate use is made that contributes to a balance between soil, plant and animals say that it makes it possible to improve the environment, achieve more ecological productions and obtain greater economic benefits for man and the country.

In Ecuador, soils have not been managed in an adequate way, contributing to reduce agricultural production, for this reason actions have begun to be carried out aimed at improving the quality of these to obtain better productions and supply national markets.

5. CONCLUSIONS

In the middle and lower zone there are no soils that are in degradation processes since they have percentages of 4.3% and 4.0% of organic matter respectively, that is, they maintain a biological activity within the established parameters. Meanwhile, in the upper zone the content of organic matter is 2.9%, due to the presence of the eucalyptus forest and the slope of the land, there is degradation of the soil resource, manifested by the scarce coverage of this and by the outcrop of cangahua.

The pH being an indicator of the availability of nutrients, the values for the middle and low zone are 7.38 and 7.24 respectively, that is, they are soils with practically neutral pH. While in the high zone the value is 7.60, which makes it a soil with a slightly alkaline pH, according to Cartagena, this area presents a possible excess of Ca, Mg and carbonates, low solubility microelements and a possible need to treat the soil with amendments such as gypsum because the development of several crops is inhibited.

It is recommended to perform other types of soil analysis for the upper zone, an analysis of the soil biota can be considered since the biota is an indicator of soil health, and this is modified positively or negatively quickly according to changes in the use of the agroecosystem. And thus know what is happening in the upper area of the Tunshi Experimental Station.

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