IOP Conference Series: Earth and Environmental Science

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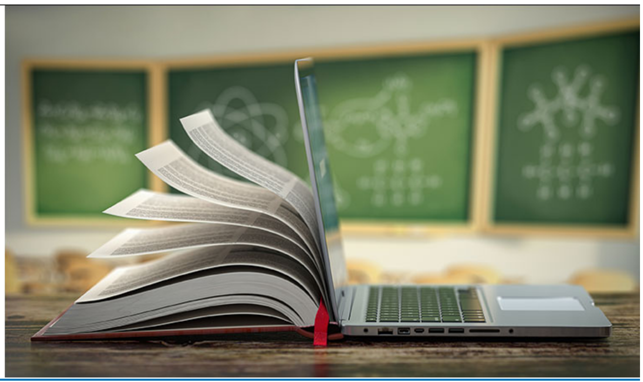
To cite this article: M Amin *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **807** 032095



IOP Conf. Series: Earth and Environmental Science **807** (2021) 032095 doi:10.1088/1755-1315/807/3/032095

Role of labile fraction of carbon for soil quality assessment (A Review)

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Abstract. Labile organic carbon fraction (LOC) response as a sensitive indicator of changes in soil quality. Changes in land management, use, and land cover significantly affect the total soil organic carbon. Organic forms such as the labile carbon fraction are still very rarely studied and affect soil quality. Soil quality is defined as the soil's capacity to perform various functions and can be accessed by measuring the physical, chemical, and biological properties of the soil. Organic carbon of various forces has a major role in soil function. It is important to know the labile fraction of soil carbon because this fraction is a food source and greatly affects the nutrient cycle and other soil properties.

1. Introduction

Soil organic carbon (SOC) is one of the carbon stores [1], which is called the main indicator of soil health and soil quality [2],[3]. Decreased SOC leads to a zone of air holding, soil fertility, enzyme activity, and soil biology [4]. Maintenance and improvement of SOCs are essential for a sustainable system [5].

Land use is a major factor affecting the dynamics of SOC [6], [7]. Continuous agricultural cultivation practice shows SOC depletion by increasing SOC mineralization [8]. Less intensive, untreated agricultural systems have been shown to increase SOC and aid in climate change mitigation [9], [10]. Increasing SOC without tillage can be done with cropping systems [11], [12], soil types [13], climate [6], [14] and other agronomic management practices [15], [16].

Change in organic soil carbon is relatively slow; therefore, the total SOC does not reflect a sensitive change in land-use soil quality [4], [17]. Labile organic carbon (LOC) is a SOC component that can be used as an indicator of sensitivity. Labile organic carbon is very sensitive to land-use change [4], [17], [18]. LOC changes in the soil are established by specific conditions, residue management, and land-use intensity [19]. Lack of soil organic carbon, nitrogen and no adverse impact on soil quality by reducing SOC and of course, on plant growth [20].

Labile carbon is a collection of soil organic carbon which is directly available for microbial activity and approaches it as the main energy source of microorganisms [21], [22]. The addition of organic matter as fertilizer and soil countermeasures can increase soil labile carbon [23]. Soil labile carbon has a major role as an indicator of soil function, especially nutrient cycling, soil aggregate formation, carbon sequestration, and habitat provision for biodiversity [24]. However, there are still lots of people who do not know about labile organic carbon.

There are still few studies on SOC that can be obtained. Agricultural cultivation practices are still being carried out, and further studies or literature studies are needed to increase our understanding of SOC dynamics.

2. Discussions

2.1. SOC content and its group

SOC is distributed in various ways among soil cells (soil compartment), and the quality, availability, and stability also vary widely. The properties of the compounds which make up SOC are very diverse, ranging from SOC compounds that degrade very easily to compounds that are physically resistant to decomposition or very stable molecular structures [25]. This is because the soil C cycle interacts with water and the nutrient cycle and soil biota [26]. Based on the size, chemical, and physical properties, the type/fraction (pool) of C or SOM is generally divided into three types (fast, slow, and passive), which describe how quickly it breaks down and be replaced by new ones [27].

Maintaining and improving soil properties are becoming increasingly important considering which agriculture is currently required to conserve biodiversity and environmental quality. Increasing the land's capacity to withstand climate change such as drought, floods, heavy rain, and heatwaves is a priority. SOC management through optimized management practices is one way to improve soil ecosystems. Increasing the C stock in the soil absorbs C in the atmosphere and improves the physical, chemical, and biological properties of the soil [28].

SOC consists of several simples to more complex compounds and has different stability [29]. Due to changes caused by agricultural practices, it is often difficult to detect measurements of total SOC content [22], measuring of changing SOC deposits such as labile carbon [30], [31].

Based on its function, organic material is composed of labile and stable components. The labile component consists of material that is very quickly decomposed at the beginning of the mineralization process. The accumulation of recalcitrant residue (residue resistant to weathering) is the residue from the previous mineralization process. The half-lives of this labile and stable fraction vary from a few months to thousands of years. [32].

Labile fraction, another SOC group that has an important role in the soil, maintains soil fertility as a source of plant nutrients because the chemical composition of the original material comes from materials that can decompose quickly. The labile fraction consists of easily decomposed material, ranging from several days to several years [33].

2.2. Labile Carbon Fractions

SOC affects many soil characteristics, including colour, nutrient holding capacity (cation and anion exchange capacity), nutrient turnover, and nutrient stability, which influences water interactions, aeration, and utility. Changes in organic soil carbon are relatively slow; therefore, total SOC does not reflect soil quality changes due to land use [17]. Labile carbon is a SOC component, used as an indicator of soil quality and is sensitive to land-use changes [17], [18]. Labile carbon fraction affects the organic matter stock of soil quality change at the labile fraction is an early indicator to predict the effect of soil management [34].

Labile organic carbon in soil comes from a plant root, root exudates, and microbial biomass [13]. Labile C is a SOC collection, which is directly available for microbial activity and as the main energy source for microorganisms in the soil [22]. The addition of organic fertilizers [28] and minimizing tillage practice can increase labile C in the soil [35]. Labile C has functions including nutrient cycling, soil aggregate formation, C sequestration, and habitat provision for biodiversity, which can be seen from high microbial biomass and abundance of soil fauna groups [24].

The labile C fraction, such as microbial biomass, a light fraction of C, extractable C, mineralized C is one of the components used as an indicator of soil quality and is influenced by soil and plant management [36], [37]. The light fraction is a reserve of organic C and energy source for microorganisms [38], [39]. Labile organic carbon fraction greatly affects SOM reserves, and changes that occur in the labile fraction are used as early indicators to determine the effect of soil management [40]. Soils with high labile C have more microbial biomass and the potential to release greater nutrients through soil decomposition with less labile carbon.

2.3. Land Use in Carbon Management on Agricultural Land

Soil carbon management strategy aims to increase plant residues and bio-solids of solid organic matter recycled from the waste treatment process. Soil carbon is used primarily as fertilizer at the soil surface by minimizing soil disturbance, maintaining sustainable land cover, strengthening nutrient cycling, creating positive nutrient balance, increasing biodiversity, and reducing the loss of water and nutrients from ecosystems. Recommended management practices for building C stores in the soil are essentially those that increase the supply of organic matter to the soil or decrease the decomposition rate of SOM [41].

These practices of SOM generally include a combination of the following: residual processing and management methods such as conservation cultivation, cover crops, mulch farming; soil fertility and nutrient management; erosion control (managing runoff with a terraced system, vegetative barriers, adding fertilizers to the soil surface, and mulching farming); water management such as auxiliary irrigation, surface and subsoil drying, groundwater management, water harvesting; and crop selection and rotation. Agricultural soils have been identified to have the lowest labile fraction [34] due to intensive tillage and harvesting of crop residues [42].

Several studies have been conducted on applying manure to agricultural land to increase microbial diversity by increasing the storage of labile C in the soil, thereby increasing life and providing an energy source for microbial growth [43, 44]. If more and more C is stored in the soil as organic carbon, it will reduce the amount of C in the atmosphere. It helps to reduce the problem of global warming and climate change. Still, it can also improve soil quality assessed from soil fertility, namely chemical, physical, and biological [45].

A labile fraction's biological functions are to provide nutrients and habitat for organisms that live in the soil, provide energy for biological processes, and contribute to soil security. The chemical function affects nutrient retention capacity, provides resistance to pH changes, and major stores of many important nutrients, especially nitrogen and potassium. And lastly, the physical function is binding soil particles into the aggregate is to increase the stability of the soil structure, increase the water holding capacity of soil changes, and control soil temperature [46, 47].

Land use gives different yields of labile fraction C. Agricultural soils have been identified as having the lowest labile fraction [48], due to high disturbance by tillage practices and crop residues harvesting. However, land uses such as forests, grasslands and shrubs have a high fraction of volatility due to high litter input and controlled soil temperature. The grazing activity appears to increase labile C by activating microbial activity by enzymes found in saliva and livestock manure, especially at warm temperatures [49].

Wijanarko & Purwanto's research (2017) show that the use of peanut and maize biomass in planted land can increase the water-soluble labile carbon fraction (DOC) by 60% compared to without biomass. This showed that using a cover crop can increase SOC through the decomposition of organic matter and increase plant residue [40]. DOC content generally describes the composition of SOM and is an indicator of soil quality. Changes in soil and crop management such as organic and inorganic fertilization and crop rotation affect DOC content C. The application of organic matter increases DOC to be higher than N fertilization alone. This suggests that plant residues contain more DOC content [50, 51].

In Jasinga Ultisols, which have been degraded, maintenance of the labile carbon fraction's quality is carried out by providing organic matter continuously throughout the year so that biomass is maintained. Applying organic matter can be done by mixing it in the soil and will increase the availability of soil nutrients. The research results by Nurida et al. (2007) were carried out; applying organic materials by mixing could increase the total N-content in the soil, K-available and C content in the soil [52]. Manure on Molisol can increase the total N and improve the soil N supply capacity in eroded soil with a depth of 5-10 cm [53].

Table 1. Management of tillage to increase the long-term labile fraction of soil carbon [45, 54].

Increase Inputs	Decrease Losses
Maximize crop and pasture cultivation by overcoming existing constraints such as compaction, soil acidity, and disease, and optimizing nutrient management.	Reduce intensive tillage, because intensive tillage can accelerate the decomposition of organic matter and promote erosion loss
In grazing, include legumes or nuts in the animal feed mixture	Minimize fallow because it can accelerate the decomposition of organic matter
Return of manure and organic matter to the soil	Avoid overgrazing as it reduces productivity and increases erosion
Good irrigation to increase biomass production	

3. Conclusion

Soil carbon management strategies are needed to increase carbon storage in the soil. Management that is easy to apply is the use of cover crops, erosion control, and organic fertilizers. The more C stored in the soil as organic carbons will improve the soil quality, judged from soil physical, chemical, and biological properties. Based on its function, organic material is divided into labile and stable components. The labile fraction is a SOC group, which has an important role in the soil, namely maintaining soil fertility as a plant nutrient source. Its composition comes from degradable materials.

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