8. SOIL ORGANIC MATTER

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LEARNING OBJECTIVES

After studying this chapter, a student should be able to:

- Define soil organic matter and discuss its formation.
- Describe the properties of humus and its role in plant nutrition.
- Outline the methods of studying decomposition of plant residues and formation of soil organic matter.
- Explain the role of soil microbial biomass in plant nutrition.
- Discuss the importance of maintaining organic matter in soil.

8.1 Introduction

The term **soil organic matter** includes all materials of either plant, animal, or microbial origin produced in the soil or added to it regardless of their degree of decomposition. When an organic residue is incorporated into the soil and environmental conditions are favourable, microorganisms immediately begin to utilize it as a source of food and energy. Readily available constituents, such as cellulose, peptides, and most simple organic components are rapidly used for energy and the synthesis of microbial tissue. More resistant components, especially lignin, are decomposed more slowly and tend to accumulate in the soil in partially degraded or microbially altered forms. Together with the products of microbial synthesis, they form a brown to black structureless soil organic polymer that is generally referred to as **humus** or stable soil organic matter. This process of humification is represented in Figure 8.1.

Soil does not exist in isolation of ecological factors but is in continual interaction with them, and must therefore be looked at as a dynamic biological system. Unlike its mineral parent material, soil has developed increased

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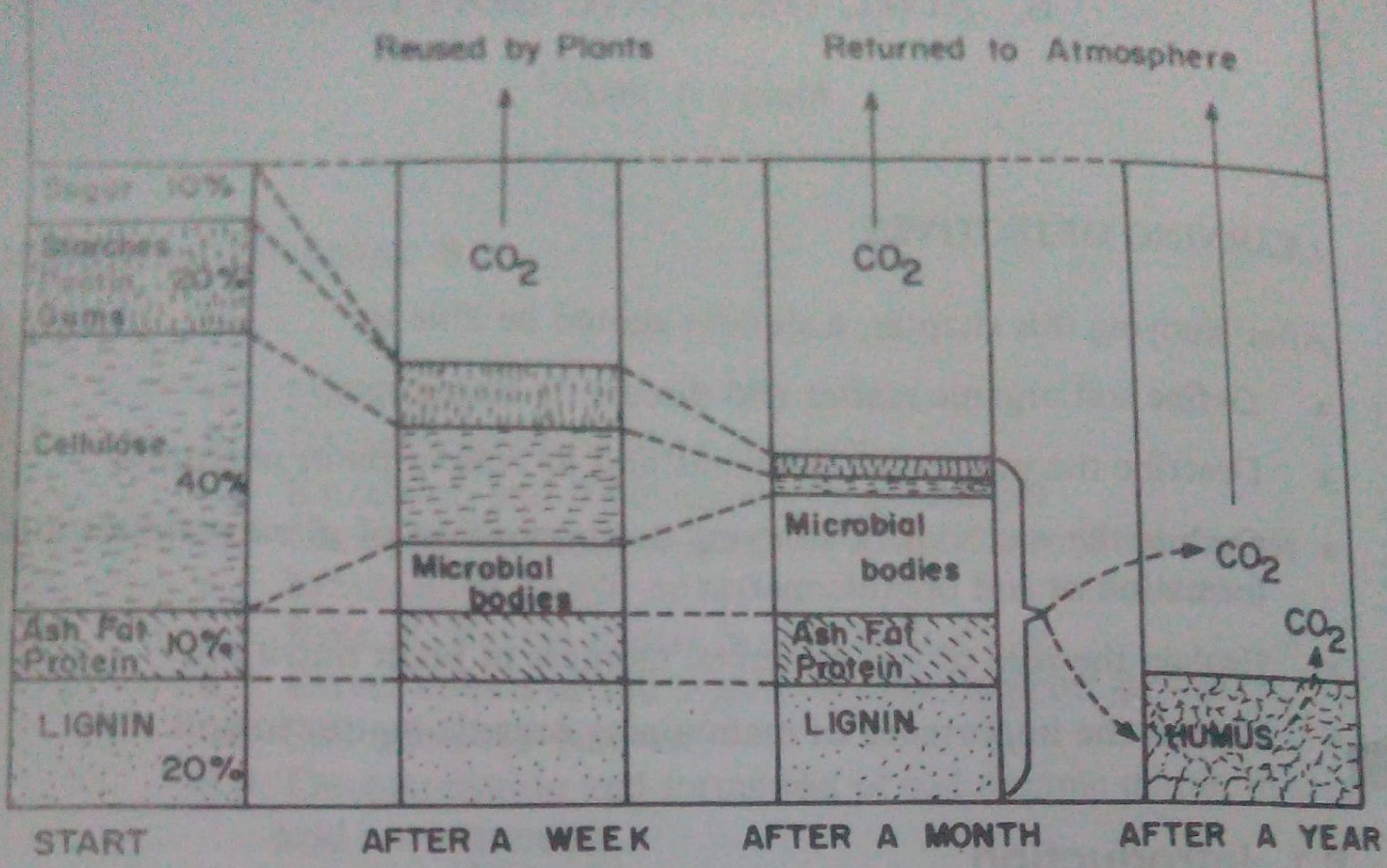

Figure 8.1 The progress of humus formation resulting from the microbial degradation of plants.

fertility which is responsible for producing crops and other vegetation. The evolution and maintenance of soil fertility depends upon organic matter being incorporated into the soil and its continued transformation under the influence of various biological, chemical, and physical factors.

8.2 Decomposition of plant residues

The decomposition process in soil starts with the breakdown of larger pieces of plant residues by soil fauna such as termites and earthworms. Reduction in size makes the residues more amenable to attack by different soil microorganisms. As indicated in Figure 8.1, different constituents of organic residues decompose at different rates. Simple sugars, amino acids, most proteins, and certain polysaccharides decompose very quickly and can be completely utilized in a matter of hours or days. Large macromolecules, which make up the bulk of plant residues, must first be broken down into simpler units before they can be further utilized for energy and cell synthesis. This is accomplished by enzymes excreted by microorganisms. Polysaccharides such as cellulose are cleaved into oligosaccharides (Gk. *oligo* 'few'),

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and finally into simple sugars. Proteins are broken down into peptides and amino acids.

Polysaccharides → oligosaccharides → simple sugars

Proteins → peptides → amino acids

Lignin decomposes very slowly (Fig. 8.1). In order to understand its decomposition and role in humus formation, a cursory look at the structural scheme of lignin will be useful. In different groups of plants, lignin is composed of three different phenolic monomers, which polymerize together to form a large polyphenolic polymer. The decomposition of lignin by microscopic fungi leads to the release of the phenylpropane units of which lignin is composed. These units are further broken down by various enzymes into simple phenolic compounds.

The rate of decomposition of plant residues depends on their chemical constituents. For example, a less lignified plant residue such as green manure legumes will decompose faster than lignified material such as wheat straw. In any case, plant residues reaching the soil are used by soil microflora as carbon sources and are thus transformed into CO_2, microbial bodies (microbial biomass), and humified or stable organic matter fraction.

It should be clear from the foregoing discussion that soil organic matter contains both decomposed and undecomposed organic residues. The latter is comprised of carbohydrates, fats, waxes, and proteins. In addition, all the products of microbial synthesis are components of organic matter

Humus generally refers to the decomposed organic residues which have undergone a series of degradation and synthesis cycles as explained earlier. The humic substances consist of a series of highly acidic, yellow to black-coloured, high molecular weight compounds — humic acid, fulvic acid, hymatomelanic acid, and humin — which can be separated using different extraction procedures.

8.3 Extraction and fractionation of soil humus

Extraction and separation of various humic substances can be carried out using 0.1–0.5 N NaOH. Many workers have also used neutral sodium pyrophosphate for extraction. The following fractions are obtained based on solubility characteristics (Fig. 8.2).

Humic acid: soluble in alkali, insoluble in acid
Fulvic acid: soluble in alkali, soluble in acid
Hymatomelanic acid: alcohol-soluble part of humic acid
Humin: insoluble in alkali

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