monomers (either degradation products of lignin or of microbial origin) are polymerized into high molecular weight polymers (Stevenson 1986:15). Figure 8.4 schematizes this process.

The reaction between amino acids and polyphenols involves simultaneous oxidation of the polyphenol to the quinone form such as by polyphenol oxidase enzymes. The addition product readily polymerizes to form brown nitrogenous polymer according to the general sequence shown in Figure 8.5.

## 8.6 Role of organic matter in soil productivity

Fertile soils are characterized by their ability to support plant growth. This property depends on the presence of organic matter, which has a profound effect on all the soil functions related to its productivity. It has already been shown that soil organic matter serves not only as a reservoir of all the required plant nutrients, but it also gives structure to the soil and provides energy for the microbial activity which is essential for recycling of nutrients, thus maintaining the productivity of soil. Some of the effects of soil organic matter are described below.

**Nutrient availability.** This is one of the main functions of soil organic matter. Upon decomposition in soil, all plant and animal residues release N, P, S, and other nutrients essential for plant growth. However, these elements have to be in plant-useable form such as $SO_4$, $NH_4$, and

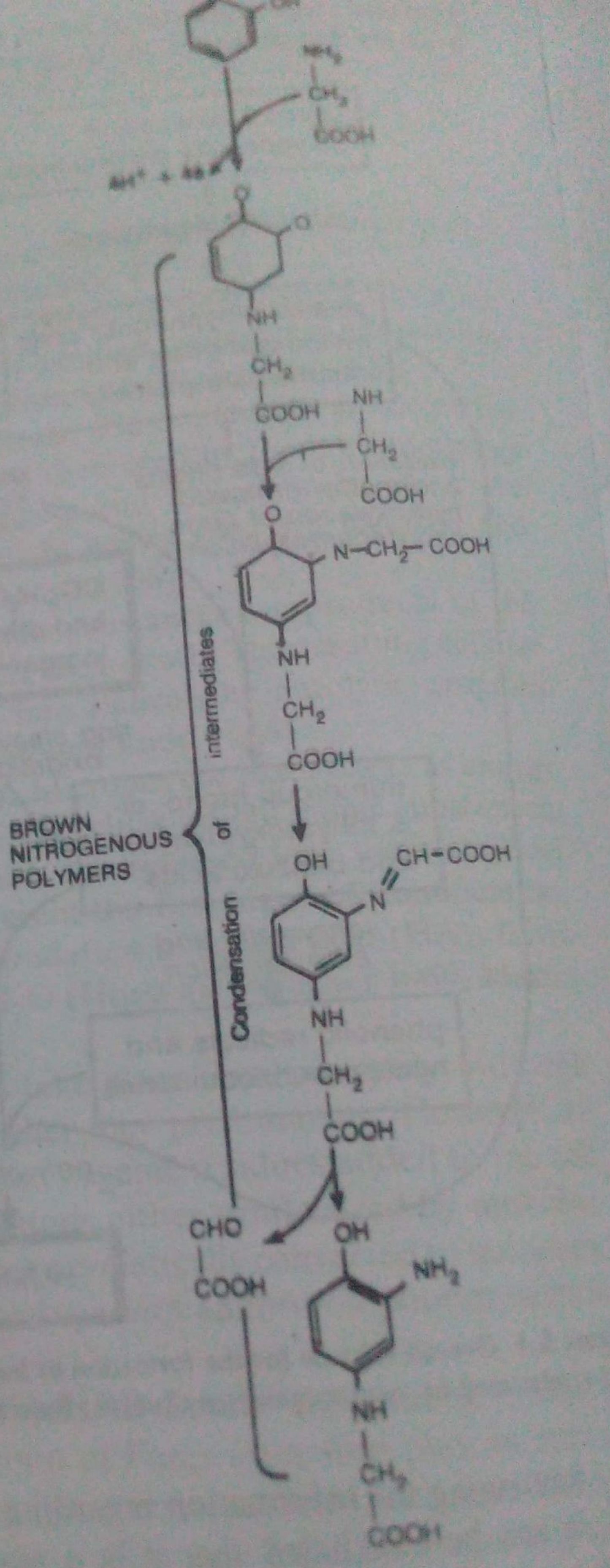


Figure 8.5 Formation of brown nitrogenous polymers in soil as depicted by the reaction between amino acids and polyphenols.

$PO_4$ which occur through the activity of microorganisms. Such plant-useable forms of elements are summarized in Table 8.2. This process of conversion of organic forms of the elements into inorganic ionic species (Table 8.2) is referred to as **mineralization.** The conversion of these mineral forms of nutrients into organic forms is called **immobilization**. Both these processes are mediated through microbial activity which is greatly influenced by factors like temperature, moisture, pH, and the C:N, C:P, and C:S ratios of the decomposing organic residues. The rates of mineralization/immobilization are dependent on these ratios. It is generally accepted that C:N, C:P, and C:S ratios of less than 20, 200, and 200, respectively, favour mineralization; whereas values of 30, 200, and 400, respectively, result in immobilization. In order to have sustainable use of soil nutrients, an equilibrium between mineralization and immobilization should be maintained (Stevenson 1986:68).

$$\text{Organic N, P, S} \underset{\text{immobilization}}{\overset{\text{mineralization}}{\rightleftharpoons}} NH_4^+, NO_3^-, PO_4^{3-}, SO_4^{2-}$$

**Table 8.2** Simple inorganic forms of plant nutrients produced during organic matter decomposition

| Nutrient | Ionic species (soil solution) | | | Gaseous species | | |
|---|---|---|---|---|---|---|
| Carbon | $CO_3^{2-}$ carbonate | $HCO_3^-$ bicarbonate | | $CO_2$ carbon dioxide | $CH_4$ methane | |
| Nitrogen | $NO_2^-$ nitrite | $NO_3^-$ nitrate | $NH_4^+$ ammonium | $NH_3$ ammonia | $NO_2$ nitrous oxide | $N_2$ nitrogen gas |
| Phosphorus | $H_2PO_4$ primary orthophosphate | $HPO_4^{2-}$ secondary orthophosphate | | | | |
| Sulphur | $SO_4^{2-}$ sulphate | $S_2O_3^{2-}$ thiosulphate | | $H_2S$ hydrogen sulphide | | |
| Metal cations | $K^+$ $Mg^{2+}$ | $Na^+$ | $Ca^{2+}$ | | | |
| Micronutrients | $H_2BO_3^-$ borate $Fe^{2+}$ $Mn^{4+}$, $Mn^{3+}$, $zN^{2+}$, $Cu^{2+}$ $Mn^{2+}$ | $MoO_4^{2-}$ molybdate $Fe^{3+}$ | | | | |

**Soil physical conditions.** Organic matter is regarded as the backbone of a productive soil, improving its structure and maintaining the life processes going on in soil which are essential for soil productivity. When the soil organic matter decreases below a critical level, soils tend to become hard, compact, and cloddy. Addition of easily decomposable organic residues is thus essential. It helps in the formation of soil aggregates which maintain soil porosity and thus allow downward movement of water in the soil (Stevenson 1986:69).

**Soil and water conservation.** The presence of soil organic matter has a strong binding effect on the soil particles, resulting in a decrease in erosion. Also, increased microbial activity due to the decomposition of organic residues results in the production of several polysaccharides which help in the conservation of soil structure and promote soil aggregate formation, resulting in reduction in soil runoff (Stevenson 1986:70).

**Buffering and exchange capacities.** This property of soil is crucial for plant nutrient availability as it stops the nutrients from leaching away from the root zone but keeps them in an exchangeable form. Humic substances, which are highly colloidal and amorphous in nature, represent large surface area which is available for adsorption. The specific surface area of well-developed humus may be as high as $900 \times 10^3$ $m^2/kg$, resulting in exchange capacities ranging from 1500–3000 mmol/kg. Because nutrients are retained in exchangeable form, humus also imparts buffering over a wide range of pH (Stevenson 1986:70).

**Interaction with organic chemicals.** Because of the sorptive property of soil organic matter, there is a direct interaction with most agrochemicals, especially pesticides and herbicides. Thus it strongly influences pesticide/herbicide behaviour in soil including its effectiveness against target species, phytotoxicity to succeeding crops, leaching ability, volatility, and biodegradability. Recommended application rates of agrochemicals are often higher for soils high in organic matter to compensate for greater adsorption in these soils (Stevenson 1986:20–21). Table 8.3 summarizes important properties of soil humus.