Chapter 4
Soil Properties

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4 Soil Properties

4.1 Introduction

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The components which make up a mineral based soil include inorganic particles or minerals, organic matter, living organisms and water and air (pore spaces) as shown in Figure 4.1.

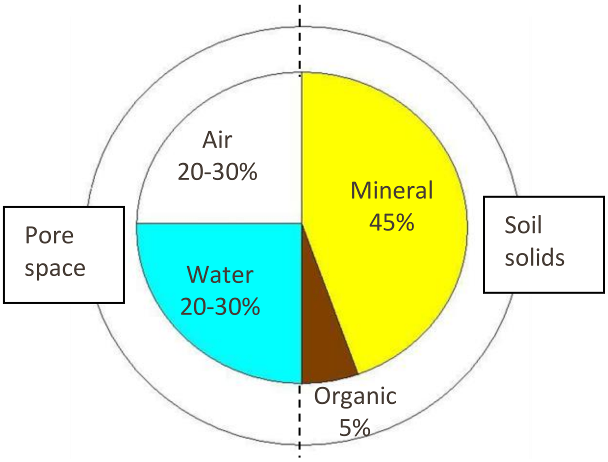


Figure 4.1 Composition of a loam surface soil when conditions are good for plant growth (adapted from Brady and Weil 1999, pg. 15)

Each soil has different types and arrangements of these components which creates unique soil properties or 'soil types'. Soil properties affect;

- plant growth responses
- fertiliser requirements
- the soils' response to management
- land use capability (i.e. suitability for different land uses such as grazing versus cultivation)
- drainage and water runoff
- nutrient loss and leaching
- soil erosion

Understanding soil properties is essential for nutrient planning and can be applied to land-use decisions.

Soil properties such as soil structure, depth, texture, salinity, acidity, waterlogging or compaction can limit plant growth even when the soil has adequate nutrients. Before applying fertiliser, consider what is actually limiting plant growth. Is it really a nutrient deficiency or is it a soil property? Soil properties can be observed in the paddock or measured through soil testing.

A soil's properties are largely determined by its parent material and weathering during its formation (Refer to section 4.6). Topography, age and agricultural practices can also affect a soil's properties.

Three groups of soil properties influence plant growth:
- Physical, or the texture and structure of the soil.
- Chemical, which affects both the fertility of the soil and its physical properties.
- Biological or the organisms in the soil, such as bacteria, fungi, insects and earthworms – See Chapter 5 for more information on soil biology.

It is the combination of these properties that determine soil health and the ability of the soil to provide ecosystem services.

Soil properties influence plant growth and guide fertiliser decision making. Information relating to soil properties can be used to help guide investment decisions on-farm to maximise the benefit, for minimal investment.

4.2 Physical properties

Physical properties of a soil that affect a plant's ability to grow include:
- Soil texture, which affects the soil's ability to hold onto nutrients (cation exchange capacity) and water. Texture refers to the relative distribution of the different sized particles in the soil. It is a stable property of soils and, hence, is used in soil classification and description.
- Soil structure, which affects aeration, water-holding capacity, drainage, and penetration by roots and seedlings. Soil structure refers to the arrangement of soil particles into aggregates (or peds) and the distribution of pores in between. It is not a stable property and is greatly influenced by soil management practices.

4.2.1 Soil texture

Soil texture, or the 'feel' of a soil, is determined by the proportions of sand, silt, and clay in the soil. When they are wet, sandy soils feel gritty, silty soils feel smooth and silky, and clayey soils feel sticky and plastic, or capable of being moulded. Soils with a high proportion of sand are referred to as 'light', and those with a high proportion of clay are referred to as 'heavy'.

Soil texture classes

The names of soil texture classes are intended to give you an idea of their textural make-up and physical properties. The three basic groups of texture classes are sands, clays and loams.

A soil in the **sand group** contains at least 70% by weight of sand. A soil in the **clay group** must contain at least 35% clay and, in most cases, not less than 40%. A loam soil is, ideally, a mixture of sand, silt and clay particles that exhibit light and heavy properties in about equal proportions, so a soil in the **loam group** will start from this point and then include greater or lesser amounts of sand, silt or clay.

Additional texture class names are based on these three basic groups. The basic group name always comes last in the class name. Thus, loamy sand is in the sand group, and sandy loam is in the loam group (see Figure 4.2).

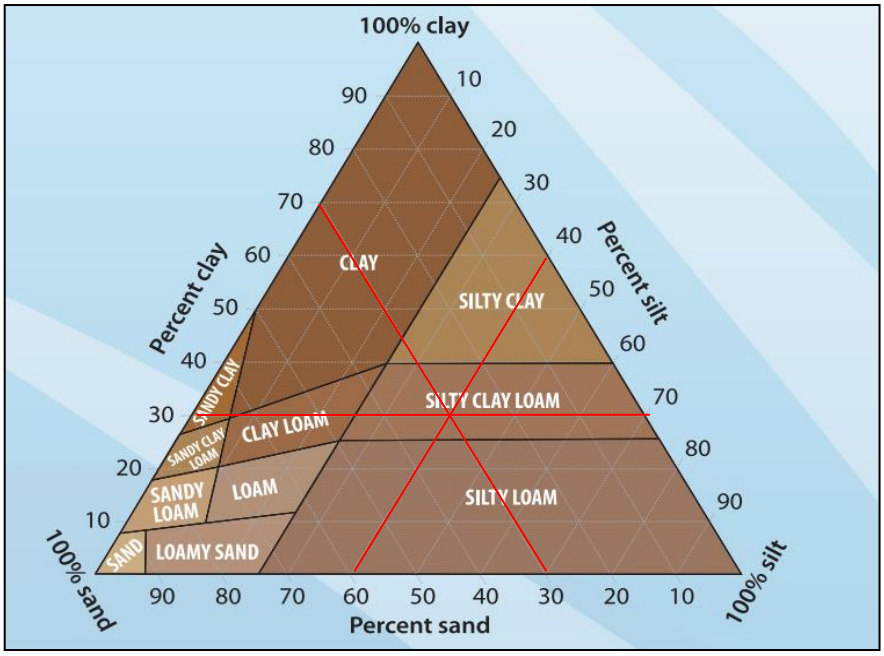


Figure 4.2 Soil Texture Triangle. *Source: Image adapted from Hunt and Gilkes (1992)* https://s3.amazonaws.com/soilquality-production/fact_sheets/28/original/Phys_-_Measuring_Soil_Texture_in_the_Lab_web.pdf

Particle size distribution can be determined by laboratory analysis, with the results shown in percentages. The texture is determined by drawing lines from the percentage point on the relevant axis parallel to the side of the triangle at the zero end of the same axis. Where the 3 lines intersect indicates the soil texture. A soil with 40% silt, 30% clay and 30% sand is a silty clay loam - See the red lines on Figure 4.2.

Soil texture influences many soil physical properties, such as water-holding capacity and drainage. Coarse-textured sandy soils generally have high infiltration rates but poor water holding capacity. Silt particles are much smaller than sand, have a greater surface area, and are generally quite fertile. Silts do not hold as much moisture as clay soils, however more of the moisture is plant available. Fine-textured clay soil generally has a lower infiltration rate but a good water holding capacity.

Soil texture also influences the soil's inherent fertility. More nutrients can be adsorbed by a gram of clay particles than by a gram of sand or silt particles, because the clay particles provide a much greater surface area for adsorption. Clay is the active part of the soil. It is where soil nutrients are held and largely from where they are exchanged. The clay fraction also has a large effect on soil structural stability, and therefore erosion risk. See Section 4.3.1 Nutrient availability and cation exchange capacity for more information.

The texture of a soil can be easily estimated in the field by using the soil texture key – See Table 4.1. First, knead a small handful of soil into a ball about 4 cm in diameter, after removing any stones and plant material. Then slowly wet the soil and mould or press it into a ribbon between your thumb and forefinger. The length of the ribbon and the properties of the ball let you estimate the soil's texture class.

Table 4.1 Soil characteristics indicative of soil texture. *Source:* Euroconsult 1989, McDonald et al 1990 cited in Moody & Cong 2008.

SOIL TEXTURE	DESCRIPTION	LENGTH OF SOIL RIBBON (mm)
Sand	The soil stays loose and separated, and can only be accumulated in the form of a pyramid.	< 15
Sandy loam	The soil contains enough silt and clay to become sticky and can be made into the shape of a fragile ball.	15 – 25
Silty loam	Similar to the sandy loam, but the soil can be shaped by rolling into a small, short cylinder. Soil has a 'silky' feel.	25
Loam	Contains almost the same amount of sand, silt and clay. Can be rolled into a 15cm long (approximately) cylinder that breaks when bent.	25
Clay loam	Similar to loam, although the cylinder can be bent into a U shape (without forcing it) and does not break.	40 – 50
Fine clay	The soil cylinder can be made into the shape of a circle but shows some cracks.	50 – 75
Heavy clay	The soil cylinder can be shaped into a circle without showing any cracks.	> 75

4.2.2 Soil structure

Soil structure refers to the arrangement of soil particles (sand, silt and clay) and pores in the soil and to the ability of the particles to form aggregates.

Aggregates are groups of soil particles held together by organic matter or chemical forces. **Pores** are the spaces in the soil.

The pores between the aggregates are usually large (**macropores**). Their large size allows good aeration, rapid infiltration of water, easy plant root penetration, good water drainage, as well as providing good conditions for soil micro-organisms to thrive. The smaller pores within the aggregates or between soil particles (**micropores**) hold water against gravity (capillary action) but not necessarily so tightly that plants cannot extract the water.

A well-structured soil forms stable aggregates (aggregates that don't fall apart easily) and has many pores of varying sizes – See Figure 4.3a. A well-structured soil is friable, easily worked and allows germinating seedlings to emerge and quickly establish a strong root system.

A poorly structured soil has either few or unstable (readily broken apart) aggregates and few pore spaces – See Figure 4.3b. A poorly structured soil can result in unproductive, compacted or waterlogged soils that have poor drainage and aeration. Poorly structured soil is also more likely to slake and to become eroded.

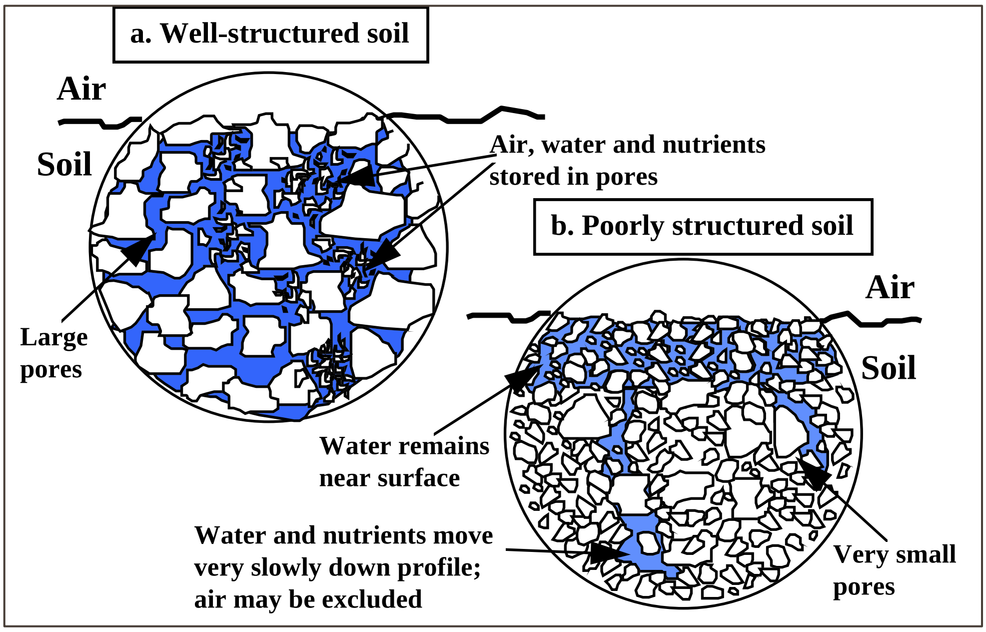


Figure 4.3 Soil structure

4.2.3 Pore spaces

The spaces between soil particles (clay, silt, and sand) and between and within aggregates (clusters of soil particles) are called **pore spaces**. They are the portion of the soil occupied by air and water. Water displaces air in the soil, and consequently the air content of a soil is inversely related to the water content. High water content in soils means there is less air within the soil. This results in higher levels of carbon dioxide and lower levels of oxygen within the soil which is not favourable for plant growth. These conditions also favour denitrification, the biological process that converts nitrate-nitrogen to the greenhouse gas, nitrous oxide.

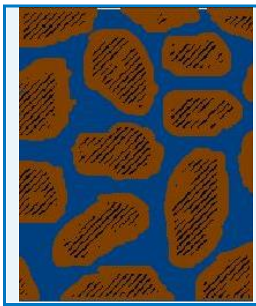
Soil air differs to atmospheric air as the composition is more variable within the soil, can be more humid and has a higher carbon dioxide and lower oxygen content than the atmosphere.

The number and size of pore spaces are determined by the size of the soil particles (soil texture) and the arrangement of the soil particles into aggregates (soil structure). The larger pores (**macropores**) allow air and percolating water to move easily through the soil. The smaller pores (**micropores**) don't allow air to move easily and also largely limit water movement.

Soil biology also plays a role in helping to bind soil. An example of this is the secretions of glomalin from arbuscular mycorrhizal fungi - See Chapter 5 for further information. A sandy soil may have insufficient organic matter to bind the sand grains into larger aggregates. In this case, the soil will have many large pore spaces and very few small pores. The plant roots will have plenty of air, but water will drain freely through the soil with very little storage. On the other hand, a compacted, heavy clay soil will have many small pores and few large pores. Plants suffer as water is so tightly bound in the small pores that plant roots are unable to extract it from the soil. The soil is poorly aerated, and drainage is poor. Consequently, the oxygen is exhausted.

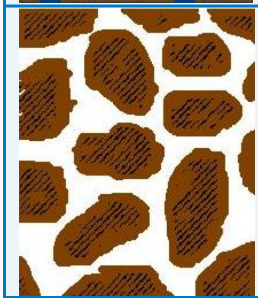
4.2.4 Soil water

Water within the soil strongly influences plant growth and the biological functioning of the soil. It provides a medium for substances to dissolve into, including nutrient elements, allowing them to be accessible to plant roots. Water also enables nutrients to be transported off the farm, and contributes to erosion and weathering processes. The soil texture influences how water is held within the soil and also the rate that water will infiltrate the soil - See Section 4.2.1.



Too much water

When all the soil pores fill with water during rainfall or irrigation the soil can become **saturated** or **waterlogged**. Plants require both air and water within the soil. When a soil is waterlogged, especially for periods longer than a couple of days, plants can suffer. Plants require oxygen to respire and produce energy, without this they can't grow. When soils are waterlogged fertiliser application should be avoided.



Too little water

As the soil dries out, the soil particles (particularly clay) tend to hold onto water more tightly than the plant is able to extract water. Therefore water is held in the soil with increasing strength as soil dries out. At this point, when the plant is unable to extract enough water it wilts and doesn't recover. This is called the **wilting point or the lower extractable limit.**

Illustrations above adapted from Food and Agriculture Organisation of the United Nations 1985

The right balance of air and water

Just after the soil has been saturated and starts to drain, the large pore spaces have air again and there is ample water available for plants. This is when the soil is at **field capacity.** Field capacity varies depending upon soil texture. Once plants have used up the water that's readily available, the soil reaches **refill point.** The soil moisture level between the refill point and field capacity is called the **readily available water (RAW).** RAW is the water that plants can easily extract from the soil, and is also the level that irrigators aim to maintain, unless they are intentionally stressing plants. Figure 4.4 shows that sandy soils require less water before the water is available to plants compared to clay soils which require wetting up before water is available to plants.

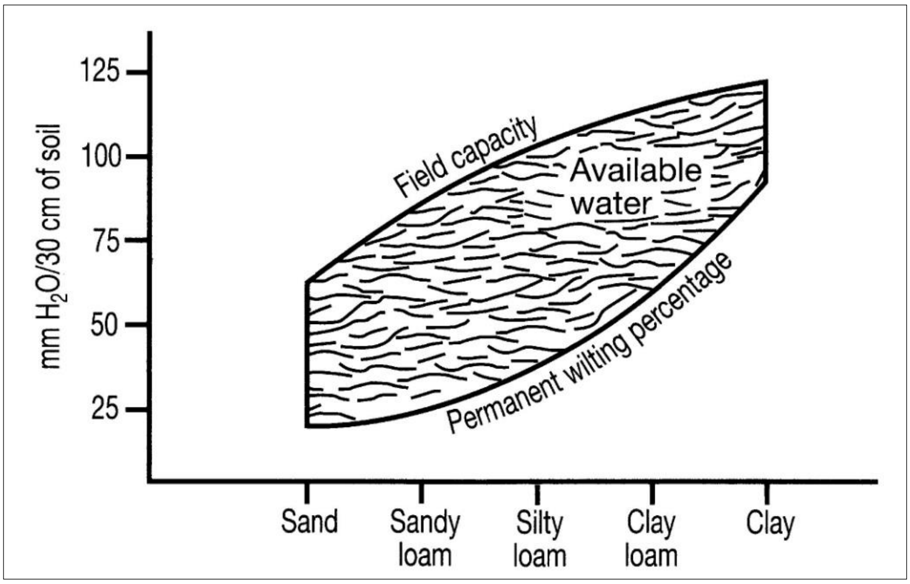


Figure 4.4 Relationship between soil texture and water availability.
Source: Fertiliser Industry Federation of Australia 2006 pg.4

4.3 Chemical properties

The chemical properties of soils that are important to plant growth are:

- Nutrient availability and cation exchange capacity, which affect the soil's inherent fertility and its ability to hold nutrient cations such as calcium, potassium and magnesium.
- The chemical characteristics of the soil solution, which affect pH and salinity.
- The sodicity of the soil, which affects soil stability and nutrient cation supply.

4.3.1 Nutrient availability and cation exchange capacity

In the soil, a large portion of plant nutrients are bound up in complex compounds that are unavailable to plants. The smaller portion is in simpler, more soluble forms, which are useable by plants. The complex compounds are gradually changed into the simpler compounds by chemical weathering and biological processes. Thus, the chemical fertility of a soil depends in part on how easily the plants can access the nutrients in a form they require. This is referred to as the **availability of a nutrient**.

The availability of nutrients within the soil is also dependent on a range of factors such as soil pH, soil solution, soil type and the plant age, type and root system of the plant.

Plant nutrients are composed of single elements (for example, potassium (K)) or compounds of elements (for example, ammonium nitrate (NH_4NO_3)). In all cases, the nutrients are all composed of atoms.

Mineral nutrients are absorbed by plants from the soil solution as ions. An **ion** is an electrically charged particle formed by the removal or addition of electrons from an atom or molecule. An ion with a positive electrical charge is called a **cation**. An ion with a negative electrical charge is called an **anion**. Cations include sodium (Na^+), potassium (K^+), calcium (Ca^{++}), magnesium (Mg^{++}) and aluminium (Al^{+++}). Anions include chloride (Cl^-), nitrate (NO_3^-), sulphate (SO_4^{--}), carbonate (CO_3^{--}), phosphate ($H_2PO_4^-$) and boric acid (BO_3^{---}).

One plus sign or one minus sign means an ion has one positive or negative electrical charge. Two or more plus or minus signs means an ion has two or more positive or negative charges.

Phosphorus availability is greatly influenced by adsorption reactions with calcium, aluminium, iron, manganese and reactive surfaces of certain clay minerals. These reactions can 'fix' the phosphorus and make it less available to plants. The degree of fixation depends on pH. In alkaline soils the phosphorus will combine with calcium, and in acid soils the phosphorus will combine with iron and aluminium, and in both cases less phosphorus is available to the plant.

Cations and anions are not equally held by the soil particle. More positive charges mean an increasing ability to bond with a negatively charged surface. More negative charges mean an increasing ability to bond with a positively charged surface. The order of strength of adsorption is; Al^{3+}> H^+> Ca^{2+}> Mg^{2+}> K^+> NH_4> Na^+. For example, plant root cells can secrete H^+ ions that can displace weaker ions like K^+ which then are available for plants to take up.

The cations and anions can be:

- Absorbed (taken up) by plant roots.
- Leached from the soil via the soil water.
- Adsorbed (attached) to the surfaces of negatively and positively charged soil particles.

The soil's capacity to **adsorb** nutrients in the form of cations is called its **cation exchange capacity** – See Figure 4.5). Cation exchange capacity is measured by a soil test which is discussed further in Chapter 9.2.9.

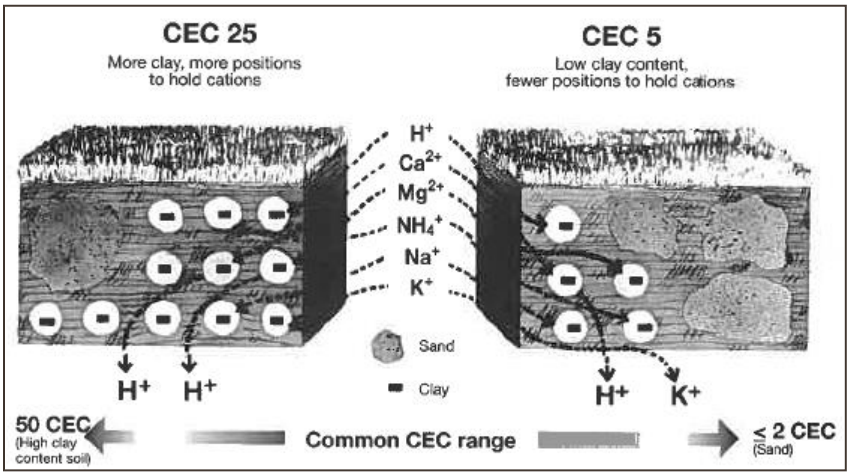


Figure 4.5 Illustration of cation exchange processes. *Source:* Fertiliser Industry Federation of Australia 2006, pg. 6.

The cations are held on the surface of soil minerals and organic matter and within the crystalline framework of some clay minerals. The greater the surface area available to adsorb cations, the higher the soil's inherent fertility. Thus, soil texture has an effect on soil fertility because of the sizes of the particles that make up the various soil texture classes and so does the amount of organic matter – See Table 4.2. Please note, on the edge of some clay minerals there is also a positive charge, which attracts and holds anions.

Table 4.2 Surface area of soil particles and organic matter. *Source:* CSIRO (1979).

PARTICLE	SQUARE CM PER GRAM
Coarse sand	23
Fine sand	90
Very fine sand	230
Silt	450
Clay	around 8,000,000
Organic matter (humus)	around 8,000,000

As you can see, soils with a high clay or organic matter content provide a much greater surface area for cations to adsorb onto.

As long as the nutrient cations and anions are adsorbed onto the soil particles, they cannot be absorbed by plants or leached from the soil, unless the whole clay particle is carried away via erosion. However, they are not held too tightly and can be exchanged with other ions of a like charge that are in the soil solution. Within these exchanges some cations (such as Ca^{2+}) are held more tightly than other cations such as Na^{+} and Mg^{2+}. Once the nutrients are in the soil solution, they can be absorbed by the plant's roots, used by soil biology or lost to leaching.

4.3.2 The soil solution

Soil water is the water held within the soil pores. **Soil solution** is the soil water together with its dissolved salts (cations and anions). The soil solution is the medium by which most soil nutrients are supplied to growing plants. It also has a role in soil salinity and pH - See Section 4.2.4.

4.3.2.1 Soil Salinity

Soil salinity is an increased concentration of salts in the soil solution. In general, as soil moisture is reduced, especially by evaporation, the concentration of soluble salts of sodium, calcium, magnesium, and potassium in the soil solution increases. These salts may already be present in the soil solution or they can be carried upward from the ground water by capillary action if the watertable rises.

The concentration of soluble salts can become so high as to interfere with the growth of plants. Soils that have a salt concentration in the plant root zone that is sufficient to interfere seriously with plant growth are called **saline soils**.

Salinity can occur on dryland farms and on irrigated farms. The salinity that occurs is the same in either case, only the initiating causes and management methods may be different. See Chapter 7.5 for information on managing salinity and Chapter 9.2.10 for information on salinity as measured by a soil test.

4.3.2.2 Soil pH

The soil solution can be neutral, acid, or alkaline. This is called the soil pH. The pH measures the concentration of positively charged hydrogen ions (H+) in the soil solution on a logarithmic scale ranging from 0 to 14. When a soil solution contains more H+ ions, it is **acidic**. When there are fewer H+ ions [i.e., more hydroxyl (OH^-) ions], the soil solution is **alkaline**.

The level of acidity or alkalinity in a soil affects the availability of soil nutrients and the activity of soil micro-organisms and can affect the level of exchangeable aluminium. See Chapter 7.6 for information on managing acidity and alkalinity, Chapter 9.2.4 for information on pH as measured on a soil test and Chapter 5 for information on soil micro-organisms.

4.3.3 Sodicity

The sodicity of the soil refers to the amount of exchangeable sodium cations compared to other cations adsorbed onto the soil. A soil with 6% or more of its exchangeable cations as sodium is called a **sodic soil**.

Excessive exchangeable sodium can cause clay particles to disperse when in contact with water - See Chapter 7.2. A typical sign of dispersion is the blue-grey puddles found in winter in the older basalt areas around lake margins and where drainage is poor.

Sodic soils have poor structure and disperse readily when wet. Seedlings have difficulty penetrating a drying dispersed surface, with consequent poor germination and survival.

Dispersion is caused by weak positive charges, such as sodium, and responds to gypsum application, which replaces the sodium ions with calcium ions.

Traffic on and grazing these soils while wet can make the situation worse. - See Chapter 7.2 for information on managing slaking and dispersion.

4.4 Biological Properties

In this section;

4.4.1 Living Organisms

Many living organisms are found in healthy soil, from large creatures, such as earthworms, to the smallest bacteria. Soil organisms help to decompose organic matter. The burrowing habit of the larger organisms incorporates the organic matter into the soil and also creates large pore spaces that aerate the soil and allow faster water infiltration. The smaller organisms, such as bacteria, actinomycetes, fungi, yeasts, algae and protozoa, further decompose the organic matter, which releases nutrients in a form that plants can use.

Living organisms are an important fraction of the soil. Their presence is encouraged by high organic matter levels, adequate soil moisture, and good drainage and aeration.

In a healthy soil, the domestic animal weight above the ground surface is substantially exceeded by the weight of the organisms living in the soil. For example, the earthworms alone can weigh from 100 kg/ha to more than 1500 kg/ha, depending on the suitability of the soil for earthworm survival (Brady & Weil 1999). A normal population of fungi weighs between 1000 and 15,000 kg/ha (Brady & Weil 1999). Please refer to Chapter 5 for further information.

4.4.2 Organic matter

Organic matter is anything that is living or the remains of a living thing. However, in the context of soil composition, **organic matter** is a build-up in the soil of decayed plant and animal residues.

Organic soils, such as peats, contain from 20% to as much as 95% organic matter. **Mineral soils** contain anywhere from a trace to 15% or 20% organic matter. Organic matter is composed of about 57% organic carbon.

Australian mineral soils contain up to 10% of organic matter, but most range from 1% to 7%. However, the influence of organic matter on soil properties, and consequently on plant growth, is much greater than this small portion might indicate.

The benefits of organic matter in the soil include improving soil structure and increasing the nutrient and water holding capacity of the soil. Organic matter also provides a food supply for soil biology. Soils with low organic matter can have ‘poor’ structure, hold little water, and erode or leach nutrients easily. The exception is cracking clay soils where clay minerals have the main effect on structure. Soils with high organic matter levels have ‘good’ structure, good water-holding capacity, and reduced erosion and nutrient leaching.

Organic matter plays a key role in nutrient cycling in the soil - Refer to Chapter 5 for more information.

When the organic matter is fully broken down, one of the things that is left is **humus**. Humus ranges in colour from brown to black, and the intensity of its colour is influenced by climate (rainfall and temperature) rather than by the amount of organic matter in the soil.

Humus has some useful qualities in that it adsorbs nutrients, adsorbs much higher quantities of water than clay can, and improves soil structure due to its low plasticity and good cohesion. Thus, organic matter also plays an essential role in maintaining a loose, friable soil structure.

4.5 The soil profile

A soil profile describes the various layers within the soil and can be seen as a vertical section through the soil - See Figure 4.6. Each of the layers in the profile can affect plant growth due to differences in soil physical, chemical and biological properties. A soil profile can be created by digging a hole with a shovel, excavator or with an auger. Where there are distinctive layers within the soil, the profile can be divided into horizons.

4.5.1 Soil depth

The depth of soil or 'soil depth' is the material that favours plant growth. Physical and chemical barriers and high water tables can restrict rooting depth which can affect plant growth. For example hard pans, or gravel layers. Pastures and crops therefore prefer deep well drained soils with good texture and structure.

Each **horizon** is a layer within the soil profile that has distinct characteristics, such as colour, texture or structure that are different from the layer above or below it – See Figure 4.6. Where there are no distinct horizons, this soil is referred to as a gradational soil. Please refer to Chapter 6 for further information.

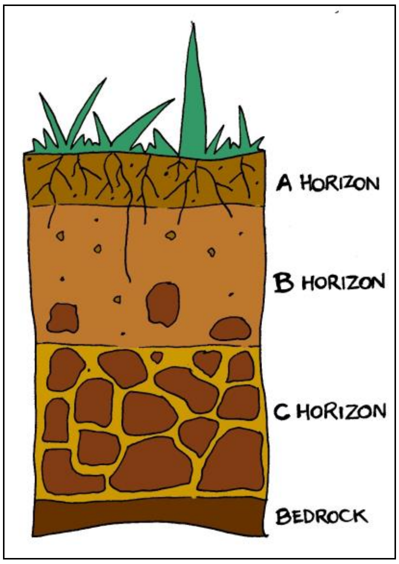
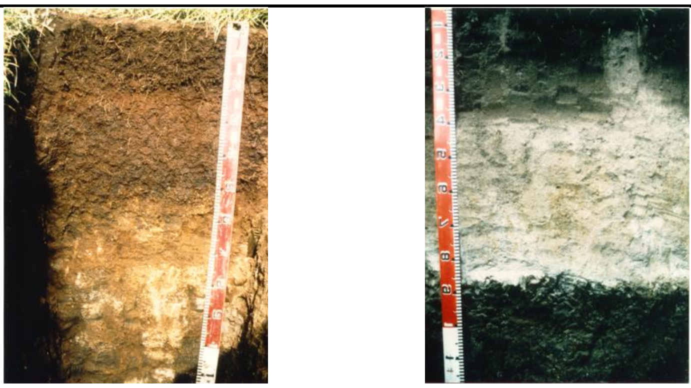


Figure 4.6 An example duplex soil profile

4.5.2 Soil profile descriptions

Soils are called gradational, duplex or uniform based on how the soil texture changes from the A to the B horizon. In a **gradational** soil, the clay content gradually increases, so that the change from the A horizon to the B horizon is indistinct – See Figure 4.7a. In a **duplex** soil, a sharp contrast in texture occurs between the A and B horizons, and the two horizons are easily distinguished – See Figure 4.7b. In a **uniform** soil, the texture change throughout the profile is very small or nonexistent; in general, no textural boundaries can be found in the profile. Figure 4.7 shows two very different soil profiles which have formed through differing geological processes and weathering.

Soil profiles can also be used to classify soil types. In Australia the Australian Soil classification is the method used for determining soil type - Refer to Chapter 6 for more information.



a). Gradational (volcanic) soil b). Duplex (granitic) soil

Figure 4.7 Examples of different soil profiles

4.6 Soil formation

Understanding the soil formation and composition of your soil is important, as the parent material will dictate how the soil will behave. Understanding soil formation also helps in understanding which parts of the landscape certain soil types are likely be found. Having this understanding can help to guide land-use decisions and management.

4.6.1 How soils are formed

Soil formation is a function of regional climate, parent material, topography, relief, biological factors and time. Parent material and landform are the initial reference states for a soil and climate and biological factors determine the rate of soil development. Time determines the stage of the soil forming processes as per Figure 4.8 below.

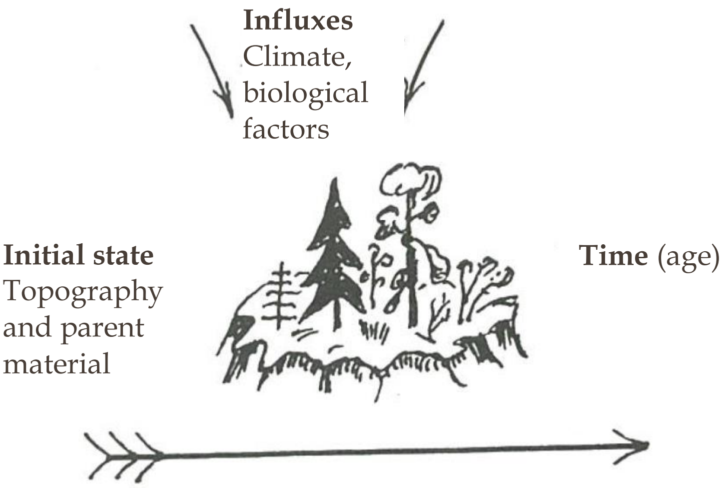


Figure 4.8 Factors that determine soil formation. *Source:* Hans 1980, pg. 10.

Soils are formed when inorganic matter (minerals) and organic matter breaks down into small particles during a weathering process. Weathering can be a mechanical, chemical or biological process.

Inorganic particles are classified by size as gravel or stone, sand, silt, or clay. The size of the inorganic particles determines soil texture.

The inorganic portion of the soil is formed over many years from solid rock (bedrock) found in the earth's crust. These rocks are classified as:

- **Igneous rock** such as granite and basalt, formed from volcanic lava.
- **Sedimentary rock**, such as limestone, sandstone, mudstone, shale, dolomite and conglomerates, formed from the deposit and cementation of the weathering products of other rocks.
- **Metamorphic rock**, such as gneiss, schist, quartzite, slate and marble, formed from igneous or sedimentary rocks subjected to high temperatures or pressures.

Weathering of the original bedrock produces **parent material** for mineral soils. Weathering of the bedrock causes fragments to break off and when subject to further weathering become mineral particles. As the mineral particles continue to weather, they are further decreased in size and also release soluble materials, some of which become plant nutrients – See Figure 4.9.

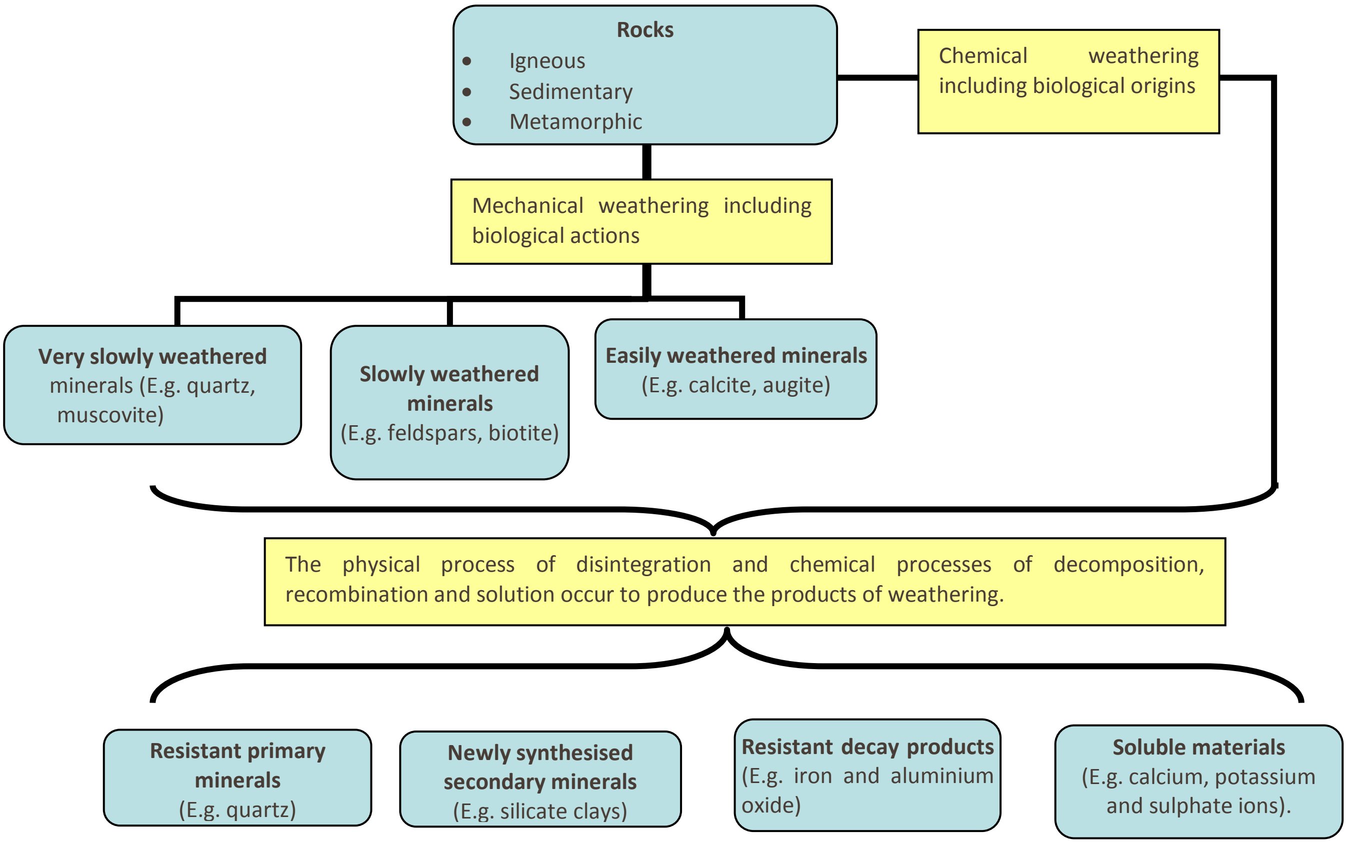


Figure 4.9 Trends in weathering conditions that take place under acid conditions common in humid-temperate regions. *Source:* Adapted from Buckman and Brady (1960).

4.6.1.1 Mechanical weathering

Mechanical weathering is caused by:

- Temperature changes, such as freezing of the water in a rock or the different rates of expansion of the minerals composing the rock.
- Erosion and deposition from water, ice and wind.

Mechanical weathering essentially breaks the bedrock into smaller and smaller pieces and may move it from its place of origin, but it doesn't change its chemical composition.

4.6.1.2 Chemical weathering

Chemical weathering is caused by:

- Hydrolysis – the reaction between water and a compound
- Hydration – the chemical union of water and an ion
- Carbonation – where carbon dioxide is dissolved into a liquid
- Oxidation – the loss of an electron by a substance, therefore gaining a positive charge.
- The solvent action of the soil solution (water and its soluble salts).

Chemical weathering continues to reduce the size of rock fragments and mineral particles and also changes their chemical composition.

4.6.1.3 Biological weathering

Biological weathering involves chemical or physical weathering processes caused by an organism. For example;

- Mechanical weathering of rocks by plant roots or burrowing animals
- Chemical weathering caused by lichen releasing chelating agents

Mechanical weathering also determines whether the parent material is considered to be sedentary or transported – See Figure 4.10. **Sedentary** parent material is either still at its original site above the bedrock from which it was formed (residual soils) or has been moved by gravity down a slope (colluvial soils). **Transported** parent material has been moved by water (alluvial, marine, or lacustrine soils), ice (glacial soils) or wind (aeolian soils) from its place of origin.

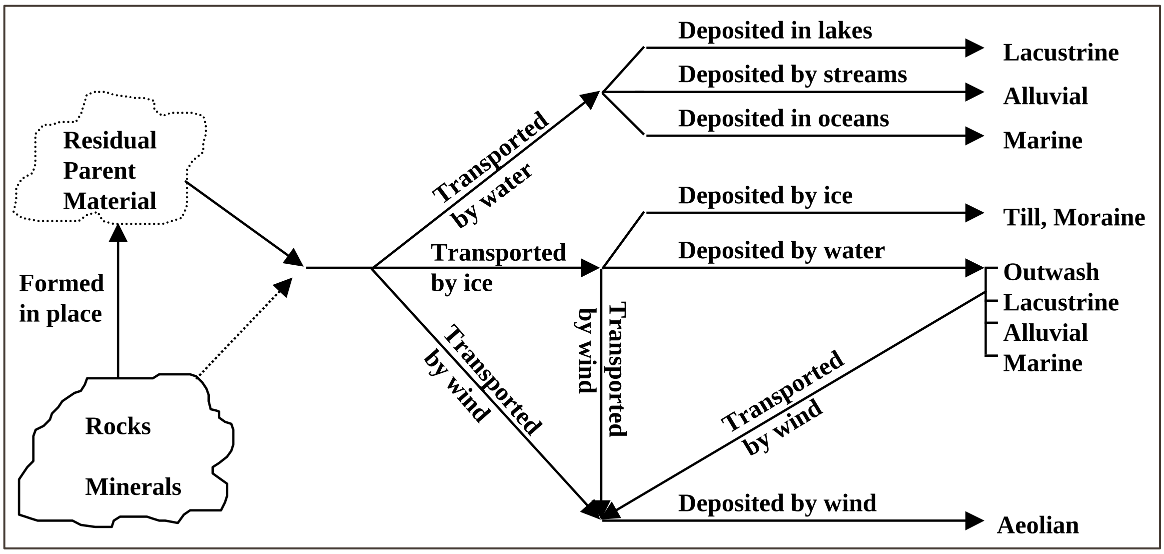


Figure 4.10 Diagrammatic representation of sedentary and transported soils.
Source: Adapted from Buckman and Brady (1960).

4.6.2 How soil formation affects soil properties

The parent material that forms a soil will affect is properties. For example, a quartz-based granite will weather into a sandy soil, which will have a lower water-holding and nutrient-holding capacity than a loam or clay soil. Soil formed from limestone may be alkaline (have a high pH) because limestone consists largely of the mineral calcite ($CaCO_3$).

The weathering process that forms a soil also affects its properties. For example, less chemical weathering occurs in arid (low rainfall) regions than in humid (higher rainfall) regions. This results in the formation of less clay particles and nutrients in arid zones. Rainfall also acts to leach nutrients in higher rainfall areas. This is part of the reason why arid regions often have alkaline soils, and humid regions often have acid soils. It also helps to explain why high rainfall areas often have soils with poor fertility: many of the nutrients have been chemically weathered and then leached from the soil.

The weathering process also influences the soils ability to hold onto nutrients. As soil particles develop during formation, silt and sand sized particles remain relatively inert; however clay sized particles can develop a negative charge. This charge can attract and hold positively charged particles called **cations** and can be measured as the **cation exchange capacity** of the soil.

4.7 Summary

- Soils are composed of weathered minerals, organic matter, living organisms and pore spaces.
- A soil's texture describes the amount of sand, silt and clay particles in the soil.
- A soil's structure is determined by the size and arrangement of aggregates and pores.
- A healthy soil is stable and friable and contains a reasonable level of organic matter and a large and varied population of soil organisms

4.8 References

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