Soils, Western Australian Perspective

The Perth metropolitan area is unique among Australian cities, and possibly the world, in that it is located on an extensive infertile sand plain covered in sedimentary material. Even on a world scale, the Perth metropolitan area is extensive.

The Swan Coastal Plain stretches more than 100 km from north to south along the coast, and more than 20 km inland. The dune systems run parallel to the coast, with alluvial plains lying inland. Along the coast are beach ridges, dunes and calcareous deep sands (Quindalup Dunes). Behind these are dunes of siliceous sands overlying limestone (the Spearwood dunes - yellow deep sands, through to yellow to brown shallow sands).

The third system is a complex of low dunes, sand plains, and poorly drained swampy flats (the Bassendean dunes – pale grey deep sands with brown deep sands). On the eastern side of the coastal plain are flat and often poorly drained alluvial plains (Pinjarra plain- deep sandy duplex soils, sandy duplex soils, brown sandy earths, brown shallow loamy duplex soils and brown loamy earths), which meet the gentle foothills of adjoining scarps (the Ridge Hill Shelf) along the eastern edge.

The sand plain soils (undisturbed and/or unamended, that is) are characterised by extremely low fertility, poor nutrient retention and low water holding capacity.

To create an attractive garden means to have healthy plants and soils, to achieve this we must follow one of two basic rules:

- Choose the plant for the soil, or
- Amend the soil to suit the plant

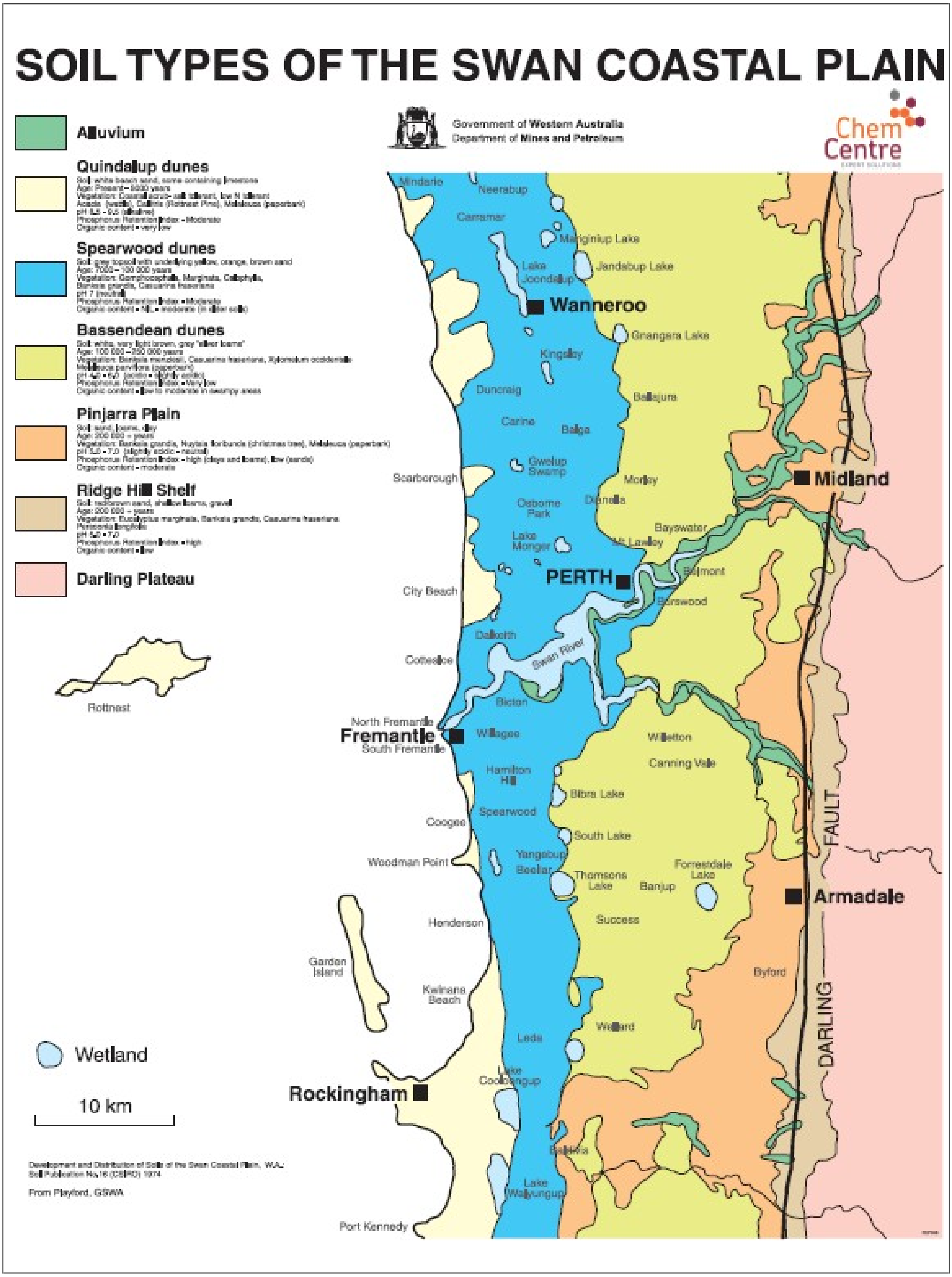
The Role of Science, and the Scientist

Soils are tested for a variety of reasons and purposes. Unfortunately, many try to determine what's going on in the soils from the top down. Our testing methods provide a quick and simple snapshot to try and explain the health of what's above, what's in and what runs out the bottom (see picture below). Most common requests are based on diagnostic or prognostic requirements.

Soil chemical analysis and its interpretation evolved from a need to assess the quality of soils supporting plant growth and to identify nutritional problems in plants. It can be a valuable tool to gauge the potential for nutrient leaching (soil chemists refer to this as "leaky soils").

More recently soil testing has gained environmental and regulatory importance, where concentrations of potentially toxic elements in soil are assessed to signal and regulate risk to humans and the environment. Soil testing and its interpretation are becoming essential components in the development of sustainable soil management systems.

ChemCentre has been testing WA soils and plants for over 120 years, and as a local, independent analytical laboratory, has extensive experience providing advice and testing for the Western Australian environment.



Please note: the information contained in this fact sheet has been prepared by ChemCentre as a guide only.
Your individual conditions and situation may vary from the generalised information presented here

Understanding your results

The first step is to learn more about what the numbers mean. This can be achieved by comparing the data from your report(s) to the information provided below.

Interpreting a soil analysis report is similar to a doctor explaining your blood test results. However, it can be much more complicated. A lot of research is required to determine the optimum levels of nutrients and soil properties for different plant species. Most of the research required to optimise nutrient levels and soil properties for the wide range of plants we grow in our gardens in Western Australia has not been done. Much of the information provided has either come from the eastern states or overseas where their soils are very different to ours. Optimum levels vary depending on the plant species, planting density, soil properties, amount of irrigation water (sprinklers and rainfall) and nutrient removal (such as pruning, removing grass clippings and harvesting fruit and vegetables). As a rough guide, the nutrient requirement of plants increases in the following order; native plants < turf < ornamental plants < fruit and vegetables.

Please note: ChemCentre is the provider of choice for credible, meaningful and independent data. Our intention or role is NOT to promote or recommend particular products, but rather provide information and guidance.

You can take the information you learn from ChemCentre Open Day Soil Testing to your local expert or garden center where they should be able to recommend the types of products to rectify your specific issue.

IMPORTANT NOTE: This information is to be only used as a guide

ChemCentre Open Day complimentary soil testing will provide you will some insight to the chemistry of your soil. ChemCentre offers additional tests (for a fee) if you require more detailed results.

Benefits of Soil Amendment

Soil amendments have the potential to improve WA's typically sandy soils by increasing nutrient retention and water holding capacity. More and more quality commercial blends are available from nurseries, gardening centers and hardware stores. They are a combination of *inorganic* i.e. clean sands and clays mixed with *organics*, i.e. composted green waste, treated sewage ("biosolids"), animal manures and sawdust. These blends are valuable in that many supply "slow release" forms of nutrients such as nitrogen and phosphorus and also increase the water holding capacity and retention of nutrients such as calcium, potassium, sodium and magnesium and essential trace elements (boron, copper, iron, molybdenum, manganese and zinc).

Always choose a certified product (Australian Standard certified or equivalent).

Understanding the Electrical Conductivity Results

Electrical Conductivity (EC) is a simple procedure to measure salt content (salinity) of soils.

Salinity problems are very rare in WA's sandy soils on the coastal plain, especially when sampled in winter and spring. Salt levels may increase during summer, especially if bore water containing salt levels higher than scheme water is used for watering gardens. If your soil has a very high salinity rating, it is recommended to get an independent water test done.

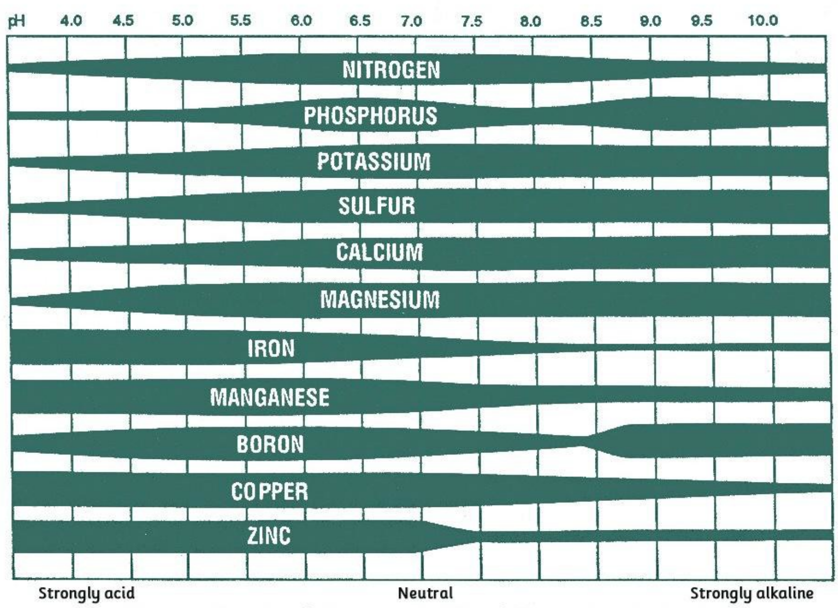
(EC) (as measured 1:5 soil water extract)

Conductivity EC (1:5) (mS/m)	Salinity Rating	Approximate Salt Content TSS* = EC x 0.0032 %
<15	Very low	<0.05
15-45	Low	0.05 – 0.15
46-90	Moderate	0.15 – 0.3
91-200	High	0.3 – 0.6
>200	Very high	>0.6

* TSS = total soluble salts

Understanding your pH Results

Soil pH is one of the most useful soil chemical parameters, as the availability of many nutrients and toxic elements is controlled by soil pH (see table below). pH of soil also influences various biological and chemical processes. pH values of most Western Australian soil types in water (1:5) are between 4.5 and 9.5.



The general relation of pH to the availability of plant nutrients in the soil: the thicker the bar, the more available the nutrient.

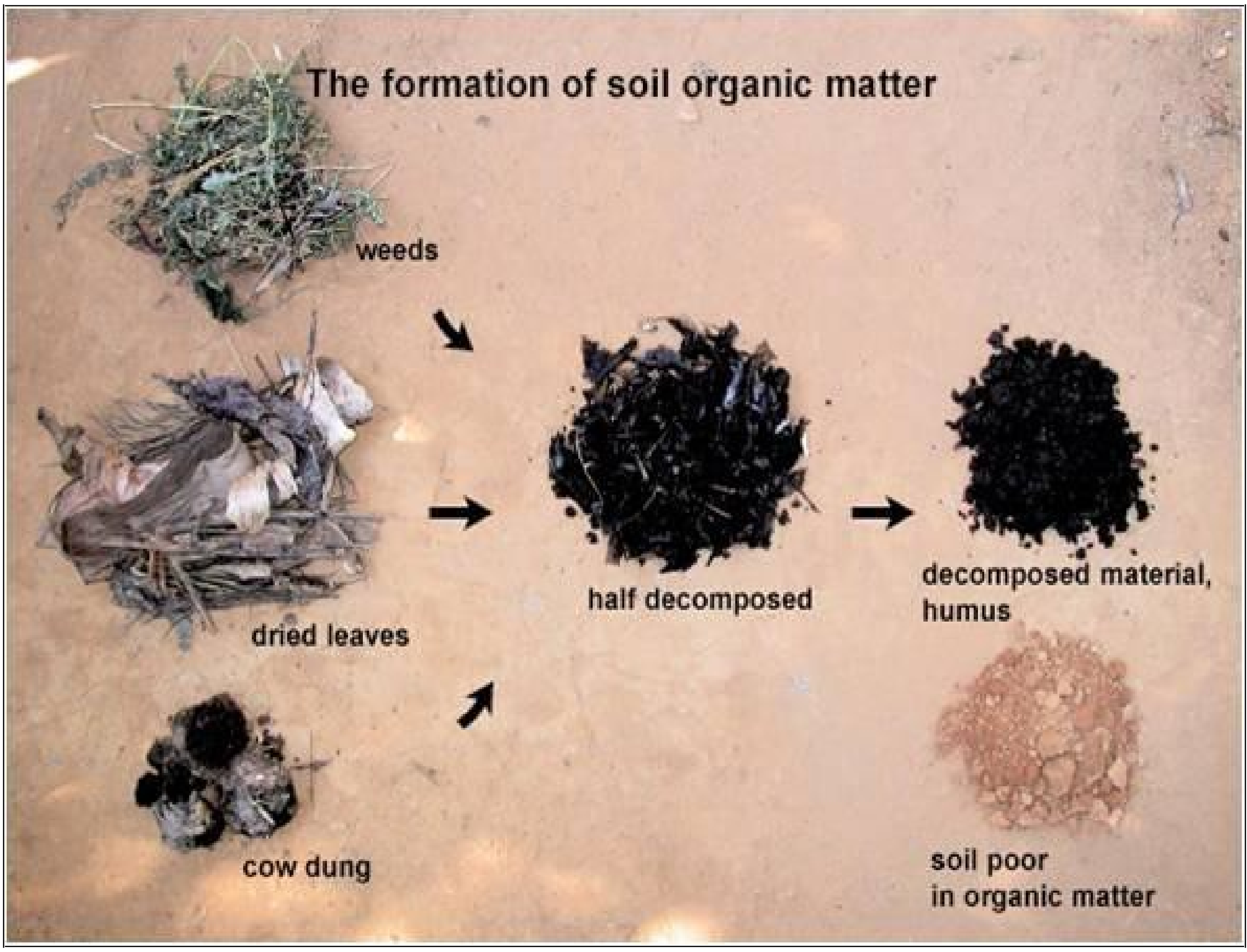
pH values on natural Swan Coastal plain soils range from moderately alkaline (pH 8 to 9) on coastal soils to strongly acidic (pH 4.5 to 5) on the Bassendean sands. However, use of soil amendment materials and alkaline irrigation water has increased pH values of Bassendean sands to near neutral values (pH 6 to 7), which are ideal for most plant species.

If specific pH conditions are required (e.g. for acid loving plants), there are numerous products available from garden centres or hardware stores that can rectify the situation. It can be difficult to decrease the pH of alkaline soils containing free limestone (such as soils in coastal areas). In these cases, it may be a better idea to select plants that are suited to alkaline soils.

pH (H_2O)	**Rating**
<4.5	extremely acid
4.5-5.2	strongly acid
5.3-5.9	moderately acid
6.0-6.5	slightly acid
6.6-7.0	near neutral
7.1-7.5	slightly alkaline
7.6-8.3	moderately alkaline
8.4-9.0	strongly alkaline
>9.0	very strongly alkaline

Please note: the information contained in this fact sheet has been prepared by ChemCentre as a guide only.
Your individual conditions and situation may vary from the generalised information presented here

Organic Carbon



The non-mineral fraction of soil is referred to as organic matter. While this is made up of a number of constituents, it is conveniently expressed and measured as organic carbon, since this is the primary element. Virgin (uncleared) soils usually contain higher levels of organic carbon compared to farmed soils, while topsoil organic carbon is generally much higher than that of the subsoil. Organic matter serves both as a source of plant nutrients which are made available through breakdown by microbial activity, and as a means of storing applied nutrients. In addition it plays a significant role in the water holding capacity of the soil and in the quality of the soil structure.

In their natural state, Swan Coastal Plain topsoils contain between 1 and 2% organic carbon, which is considered low by world standards. Soil organic carbon levels can be easily increased by adding organic materials such as compost. A typical application rate of 10 litres of compost per square metre (100 cubic metres per hectare, or 10mm layer) will increase the soil organic carbon level by approximately 1.2%.

Phosphorus Retention Index (PRI)

Soils vary widely in their ability to adsorb soluble phosphate from solutions. Soils containing large amounts of iron and aluminium oxides (heavier red/brown soils or clays) are able to adsorb large amounts of phosphate. The high phosphate adsorption capacities of such soils have implications in soil testing for plant available phosphorus. Soils with high phosphate adsorption capacities require a higher soil test value for P to support the same level of relative productivity as soils with lower phosphate adsorption capacities. Conversely, sandy soils with low iron and aluminium contents have very little adsorption capacity for phosphate and may lose phosphate by leaching in high rainfall areas. What this means is on soils with a low to negative PRI (<2 mL/g), any addition of soluble P applied to the garden will leach. Most of it will be wasted.

PRI values for Western Australian soils range from negative values (desorbing soils) to >1000 mL/g. Soils with PRI values >10 mL/g are considered to be able to retain a large proportion of added phosphate at typical application rates of fertiliser.

Negative	Soil is saturated with P. Significant leaching losses will occur if soluble P-fertilisers are used. There is no need to apply additional phosphorus to these soils.
0.1 – 2.0	Very low. Soil has very little capacity to adsorb soluble P from fertilisers. Low application rates, preferably of slow-release fertilisers, are recommended.
2.1 – 5.0	Low. Soil has some capacity to retain soluble P fertilisers. Well balanced fertilisers are appropriate.

Plant Available Nutrients (Mehlich No.3 Soil Test)

The Mehlich No.3 Test is an alternate soil test using universal extractants for multi-elemental analysis. Results obtained using the Mehlich 3 extractant are highly correlated with the standard "single element" soil tests currently used for a wide range of Western Australian soil types. What does the test mean? The test provides information on the amount of plant-available nutrients including phosphorus, potassium, sulphur, calcium, magnesium, sodium, boron, copper, iron, manganese and zinc, in the soil. It can be used as a screening tool to measure concentrations of cobalt, aluminium, molybdenum and toxic metals such as cadmium, lead, arsenic, selenium and nickel in soil. It is ideally suited to acid and neutral soils, the amounts of nutrients extracted being similar to those of other soil tests used in WA.

Aluminium (Al)

Soils containing moderate levels of extractable aluminium (greater than 100 mg/kg) and low pH (less than 4.5 to 5.2) may be toxic to plants. In such cases, the soil pH can be increased by adding either lime, dolomite or an alkaline compost.

Soils containing very high levels of extractable aluminium (greater than 500 mg/kg) are capable of “fixing” phosphorus fertilisers. These soils usually require regular applications of balanced fertilisers to meet the needs of vegetable crops, fruit trees and other plants (for example, roses) that have a high requirement for phosphorus.

Soils containing very low levels of extractable aluminium (less than 50 mg/kg) are either highly weathered grey sands or coastal soils containing free lime.

Boron (B)

Boron is an essential nutrient required for plant cell development. Boron deficiency can impede the uptake of calcium, hence impact of the plants ability to use it.

It is only required in small amounts, while high concentrations (greater than 10 mg/kg) may be toxic to some plants.

Levels below 1 mg/kg are likely to be deficient. Although borax can be used to correct boron deficiency, a safer option is to use a balanced fertiliser that lists boron as one of its constituents.

Calcium (Ca)

Plants need calcium for healthy cells, which means healthy plants. Much of the older soils of the Swan Coastal plain contain very little of the more common forms of calcium, either from clays or calcite (limestone). However calcium present in groundwater and scheme water is a significant contributor to topping up calcium levels.

Low values (<200 mg/kg) are associated with very acidic soils. Addition of agricultural lime will increase both the pH and soil calcium.

Very high levels (>5000 mg/kg) indicate alkaline limestone soils.

Copper (Cu)

Copper is an essential constituent of enzymes, an essential component of healthy plant life. However, excessive applications of copper based fungicides can results in copper toxicity.

Levels below 0.1 to 0.2 mg/kg are likely to be deficient. Deficiency, if suspected by visual symptoms, is better confirmed by tissue testing.

Most garden soils on the Swan Coastal plain that have a history of regular applications of balanced fertilisers and/or organic materials contain adequate levels of copper.

Iron (Fe)

Iron plays two important roles in Swan Coastal plain soils: Iron in the form of oxide minerals (which are often responsible for the yellow, orange, brown and red colours of soil) plays an important role in reducing leaching of soluble nutrients such as phosphorus, sulphur and molybdenum. Iron is also an essential plant nutrient that plays an important role in nitrogen nutrition of plants.

Iron deficiency commonly occurs on alkaline soils, resulting in yellow leaves similar to nitrogen deficiency.

Potassium (K)

Levels below 30 mg/kg are likely to be deficient for turf. Vegetables and fruit trees may require much higher levels to produce good crops.

Deficiencies of potassium in WA agricultural soils are well documented, especially in deep sandy soils in which potassium is easily leached as a result of very long periods of weathering. Potassium is an essential macronutrient for all plants, essential in the processes such as photosynthesis and cell formation. Quite often, low levels in already deficient soils are due to plants being removed (harvested) such as mowing or pruning. Common visual evidence of potassium deficiency is yellowing of outer edge of leaves of plants (the centre being green).

Potassium sulphate is a very effective means of correcting potassium (and sulphur) deficiency on impoverished soils.

Levels below 25 to 50 mg/kg are likely to be deficient for turf. Vegetables and fruit trees usually require much higher levels to produce good crops.

Magnesium (Mg)

Magnesium is a key component of the chlorophylls, the green colouring materials of plants. It is therefore vital for photosynthesis. Additionally, plants need magnesium before they can make use of phosphorus. Magnesium makes up a large part of clay minerals, but as many sandy soils have no clay, magnesium levels can be quite low. Some of the magnesium present in gardens soil comes from scheme or bore (hard) water.

Manganese (Mn)

Levels below 5 to 10 mg/kg are likely to be deficient for turf. Other plants, especially citrus trees, require higher levels.

If the soils are alkaline, high soil test levels may not necessarily indicate sufficiency. Tissue testing is more reliable for diagnosis of manganese (and iron) deficiencies.

The function of manganese is plants is poorly understood; however, it is believed it plays a major role in photosynthesis. Sufficient levels of manganese (together with iron), applied in moderation will result in nice green plants and lawns.

Molybdenum (Mo)

Molybdenum is an essential element required in minute concentrations for healthy plant growth. The reporting limit for the soil test used by ChemCentre (0.1 mg/kg) is too high to diagnose molybdenum deficiency. If you suspect molybdenum deficiency, which is highly unlikely on Swan Coastal plain garden soils, used a balanced fertiliser that contains molybdenum (Mo) as one of its listed ingredients.

Sodium (Na)

High concentrations of sodium in soil are usually associated with soil salinity, in which salts such as sodium chloride accumulate in soil through either poor drainage or high concentrations in irrigation water or sea spray in coastal areas.

Phosphorus (P)

Phosphorus is a key element in virtually every process in plants. It helps transfer the energy from sunlight to the plant, to enable the chemical processes to take place in involved in growth and reproduction.

Levels below 15 to 20 mg/kg are likely to be deficient to most plants other than WA natives, which have adapted to very low phosphorus levels in our natural soils. If phosphorus levels exceed, 200 mg/kg there is sufficient P present and “P-free” fertilisers should be applied.

Sulphur (S)

Levels below 5 to 10 mg/kg are likely to be deficient. Note that sulphur is present and rainfall and groundwater and these sources may supply sufficient sulphur for turf and native plants.

Zinc (Zn)

The major role of zinc in plants is in the production of auxin, a plant hormone which is responsible for promoting strong stem and leaves. Leached soils and soils on the coast could be linked to zinc deficiency. A small dose of a zinc product such as zinc sulphate, can rectify the problem for up to 7 to 10 years.

Levels below 0.5 mg/kg are likely to be deficient.

Zinc is a common element in composted organic materials and animal manures. Quite high levels (up to 100 mg/kg) can accumulate in our soils after many years of using these materials. Zinc is an essential nutrient for humans and so the health risk to human consuming vegetables and fruit grown on soils high in zinc is quite low. However, very high levels may cause nutrient imbalances in plants.

Lead, Cadmium, Nickel, Arsenic (Pb, Cd, Ni and As)

Heavy metals are ubiquitous in our environment. However, prolonged usage of organic waste products and historical emissions of lead from vehicles can increase soil levels, especially in older suburbs. Ironically, even though Western Australian soils are amongst the cleanest soils in the world, in 'old' suburbs (gardened for up to 100 years), heavy metal concentrations have accumulated to levels that can be measured by soil tests. Provided the levels are not excessive, these elements provide minimal risk for soils used for turf, ornamental plants and herb gardens. If you are concerned by elevated concentrations (greater than 10 to 20 mg/kg) of these elements and vegetables or fruit grown on these soils provide a significant contribution to your diet, you may wish to have the soils tested by a different method. In this case, results obtained will be compared with nationally recognised human health and environmental limits to determine levels of risk.

Cobalt and Selenium (Co and Se)

Cobalt and selenium are two elements that are essential for human health but can be toxic if present in elevated concentrations. There is no evidence for toxicity from these elements in Swan Coastal plain garden soils. Very low levels (less than 0.1 mg/kg) may be deficient for grazing livestock.

Molar Ethanol Droplet (MED) Test

Water repellent (hydrophobic) soils are a result of sandy soil particles being coated by waxy material from organic matter in soil. This is common in unamended older soil (Bassendean grey sands or "silver loams"), or samples that have had frequent application of compost or mulch, and been allowed to go bone dry.

Wetting agents are only a temporary fix. The wetting agent only coats the waxy outer layer, but with time will breakdown, leaving the original problem behind.

Longer lasting treatments that actually change the soil structure include adding clays to a level of 2 to 3%. Yellow sands for instance have typically around 2-4% clay and incorporating that to a non-wetting soil can instantly improve water penetration and water holding capacity in soil.

If adding organic mulches or compost, ensure they are **NOT** allowed to dry out completely. A little water applied often is the key. Increasing the frequency of watering, without increasing the total volume of water is a better option. Another useful method for managing water repellency is applying a good quality mulch. There is on-going research to identify the best mulch materials and the optimum thickness - too much mulch can absorb all the water, leaving very little water to penetrate the soil to the root zone

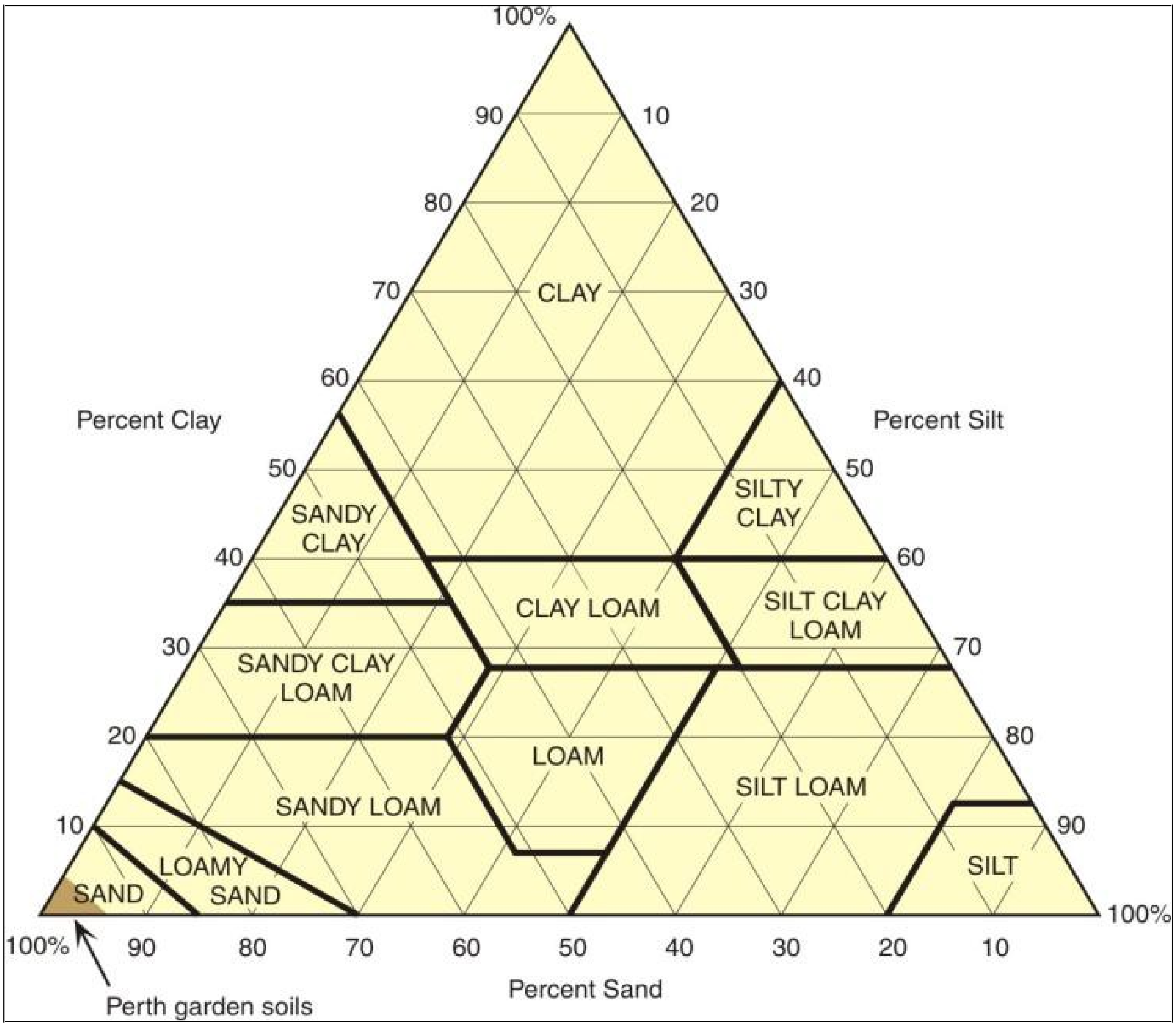
MED (M)	Rating of soil hydrophobicity
0	Soil has sufficient wettability (ie is NOT hydrophobic)
0.1 – 1.0	Slightly water repellent
1.2 – 2.2	Moderately water repellent
2.3 – 3.0	Severe (soil is likely to become hydrophobic if allowed to completely dry out.
> 3.0	Very Severe (soil is water repellent / non-wetting = hydrophobic)

Soil Texture – the Soil Triangle

Soil texture is defined by the particle size distribution of the inorganic component. For convenience, soil particles are divided into three groups based on particle diameters; sand (0.02 to 2 mm), silt (0.002 to 0.02 mm) and clay (less than 0.002 mm).

Describing the texture of a soil based on particle size measurements is achieved by using a "soil triangle" diagram, such as that presented below.

Most garden soils from the Swan Coastal Plain fall within the "Sand" texture classification. Typical clay contents of Swan Coastal Plain sands range from 0.5 to 1.5%.



What about Nitrogen (N)?

Most researchers agree there is no suitable soil test for nitrogen. The problems in measuring total nitrogen and/or its mineral forms (i.e ammonia and nitrate), is that soil is a living and dynamic system. Unlike the other properties described in this document, a large rain shower, soil disturbance, a heat wave, or a biological event in the soil can alter nitrogen levels quite significantly. A soil test for nitrogen hence is basically snap shot in time, and that time is the exact time the sample is taken.

Plants can obtain their nitrogen from various sources including breakdown of soil organic matter, fertilisers and rainfall (especially from thunderstorms). Fortunately nitrogen deficiently in plants is easy to identify visually. Symptoms include yellowing of old leaves and a lack of vigour.

On sandy soils, slow release forms of nitrogen are much more effective than soluble chemical fertilisers. Suitable sources include coated granular fertilisers, composted manures and quality (i.e Australian Standard certified or equivalent) composts with a low carbon to nitrogen ratio.