Learner Guide and Workbook

Module Four

HLUMELELISA
A NEW SPIRIT

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SCHEDULE THE APPLICATION OF WATER TO PLANTS AND LANDSCAPES

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FACTORS INFLUENCING DEPLETION OF WATER IN SOILS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

A plant reacts very simply to too little or too much water; it just stops growing and over a period of time dies. So how much water does your plant need to growth healthy and strong?

How much water is taken up by your plant depends on two processes:

- Water absorption, which is the process by which plants take up water.
- Transpiration, which is the process by which plants lose water in the form of vapour.

To develop and maintain sustainable landscapes, we need to understand the stressors that affect plant growth. Some areas of our country are subject to extremes of weather, from hurricanes to droughts. Although it is difficult to predict the frequency of these weather events, experts indicate we can expect greater severity, particularly of drought.

How do we come to understand the impact of extreme drought on our landscapes, and how can we cope? The first step is to educate ourselves. Experts consider a plant to be drought tolerant if it can withstand a moderate period of limited moisture.

This does not imply that a drought-tolerant plant prefers hot, dry conditions or that the drought will not adversely affect the plant. Woody plants are typically more tolerant of water stress than herbaceous plant varieties because they can store more energy in their roots and woody tissues.

How do plants respond to water stress? When a plant's roots experience a period of limited soil moisture, the plant hormone abscissic acid (ABA) signals the closure of stomata (small openings found mainly on the underside of leaves). Closure of stomata reduces transpiration (water lost from a plant through its leaves).

Transpiration serves to cool the plant by pulling water and nutrients from the soil throughout the plant. A prolonged drought will therefore negatively affect plant growth by reducing the plant's capacity to regulate its temperature, and with less water, the plant can experience a nutrient deficiency, thereby reducing photosynthesis.

When photosynthesis is reduced, the plant may become energy starved and be unable to support all its activities. Woody plants exhibit both short- and long-term responses to drought. Short-term symptoms are similar to those experienced by herbaceous plants and include wilting, marginal leaf scorch (browning along edges), and loss of some foliage in an effort to preserve energy. In the long term, after severe drought, twigs and branches may die back.

You may notice a reduction in flower and fruit production and a decrease in leaf size. Eventually, the damage can kill a plant, sometimes years after a drought. Young and recently planted trees or shrubs are more susceptible to death from water stress.

They have not had time to establish their root systems fully. Some plants, particularly turf grasses, will go dormant, which is normal. Based on the extent of damage to your landscape plants, you can decide to either prune the dead material or replace the plant.

How do plants adapt to dry conditions or regular drought periods? Many drought-tolerant species have thick, waxy, or hairy leaves that minimize water loss. These leaves are generally small. Some plants, such as cacti and succulents, open their stomata only at night to capture the carbon dioxide necessary for photosynthesis, when cooler temperatures mean a reduction in water loss.

Plants wilt when faced with a limited water supply. Wilting redirects the leaves, reducing the amount of solar heating they intercept. Many herbaceous plants avoid drought by completing their life cycles before the annual dry period. Once established, a variety of ornamental and turf grasses grow well in hot, dry areas

In contrast, cool season turf species protect themselves by going dormant. Your lawn will recover when sufficient moisture returns. Some plants have developed extensive root systems that let them access greater soil area and potentially more water.

Highly adapted plants combine many of these traits not only to survive, but also to thrive in low-moisture landscapes. Matching drought-tolerant species to the appropriate sites in the landscape is a crucial step in developing sustainable landscapes.

During the growing season, plants must use their energy for a variety of functions such as growth, reproduction, and protection. Because plants cannot escape from droughts, floods, or construction, they must be able to defend themselves. Therefore, they have evolved a complex system of chemical defences that close over wounds and "wall out" decay, disease, and insect organisms.

When resources are limited, such as water during a drought, a plant must conserve its energy. It will favour growth and reproduction over protection because producing the protective, secondary chemicals requires so much energy.

When drought is severe, a plant will reduce the production of these compounds, thereby increasing its susceptibility to a variety of other stressors, as well as to attack by diseases and insect pests. Typically, disease will not become evident until a year or two after the drought. Therefore, it is often difficult to identify water stress as the primary causal agent; numerous diseases, considered secondary factors in plant decline or death. In the case of most disease organisms, drought stresses plants in the year or two prior to infection.

When normal rainfall resumes or properly applied irrigation follows these drought periods, disease organisms moving through the soil's water system have an opportunity to infect the weakened plants.

During transpiration water passes through the plant's root hairs, travels up the root system, through the stem structure of the plant, into the leaves and then out of the stomata of the leaves into the air. This process helps to move sugars, plant nutrients and food through your plant and helps to cool your plants leaves and stem tissue through a process called evaporation. The objective of regular watering is to replace the moisture that is lost through transpiration so that the moisture level remains more or less the same. To understand how much water your plant is using and how much water is being evaporated, you need to know:

- How different soil types affect your plants watering needs.
- How the seasons affect your plants watering needs.
- How climatic factors affect your plants watering needs.

Soil Water Content

Water loss begins at the top of the soil and works its way down. Because your plants root system is generally deep in the soil you need to test your soil to see how wet or dry your soil is. This will tell you whether your plants are getting enough water.

Before you apply water, test how dry or wet your soil is by:

1. Digging about 15 cm below the soil surface:
   - If your soil is dry at this level, your plants are not getting enough water and so you need to water.
   - If your soil is moist at this level, your plants are getting enough water and you are watering correctly.
   - If your soil is soggy at this level, your plants are getting too much water and you are over watering your plants. You need to cut down on the amount of watering you are doing.

Using a moisture meter. This is an instrument which you stick into the soil. The gauge on this instrument will then give you a reading of how wet or dry your soil is.

Soil Types

There are three main types of soil:

- Sandy soils.
- Loam soils.
- Clay soils.

A simple and cheap way to test which soil type you will be watering, is to pick up a handful of soil, wet the soil slightly and then try to roll your handful of soil into a sausage shape, this is called the sausage test.

Sandy Soil	**Loam Soil**	**Clay Soil**
Sandy soil will feel gritty and rough in your hand. With sandy soils you will not be able to form a sausage shape at all.	Loam soils don't feel very rough or very smooth. With loam sands you will be able to form a sausage shape but it will keep breaking apart.	Wet clay soils are smooth and will feel sticky in your hand. Dry clay soils will feel powdery in your hand. With clay soils you will be able to form a sausage that holds its shape.

Infiltration rates of soils

Water is taken up and held by these different types of soils at different rates. How quickly or slowly water moves through the soil is known as the soils infiltration rate. If you apply water faster than the soil can absorb it, the water simply flows over the surface of the soil and runs-off the soil and so the water is wasted and the soil below the surface does not receive the amount of water needed to supply your plants with their water needs. Let's take a look at the infiltration rates of the different types of soils.

Infiltration rate and infiltration test

The **infiltration rate** is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate.

In dry soil, water infiltrates rapidly. This is called the **initial infiltration** rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic **infiltration rate** (table below).

Soil type	Basic infiltration rate (mm/hour)
sand	less than 30
sandy loam	20 - 30
loam	10 - 20
clay loam	5 - 10
clay	1 - 5

The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles) and is a useful way of categorizing soils from an irrigation point of view. The most common method to measure the infiltration rate is by a field test using a cylinder or ring infiltrometer.

Conducting your own field infiltration test

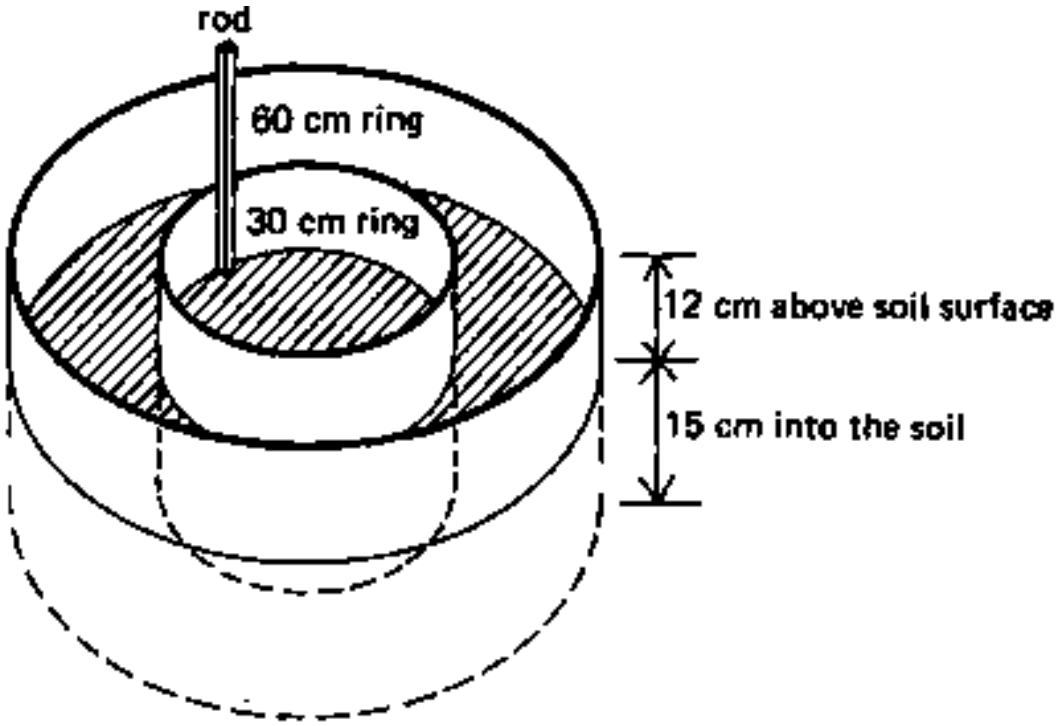
Equipment required

- Shovel/hoe
- Hammer (2 kg)
- Watch or clock
- 5 litre bucket
- Timber (75 x 75 x 400)
- Hessian (300 x 300) or jute cloth
- At least 100 litres of water
- Ring infiltrometer of 30 cm diameter and 60 cm diameter. Instead of the outer cylinder a bund could be made to prevent lateral water flow.
- Measuring rod graduated in mm (e.g. 300 mm ruler)

Method

- Step 1: Hammer the 30 cm diameter ring at least 15 cm into the soil. Use the timber to protect the ring from damage during hammering. Keep the side of the ring vertical and drive the measuring rod into the soil so that approximately 12 cm is left above the ground.
- Step 2: Hammer the 60 cm ring into the soil or construct an earth bund around the 30 cm ring to the same height as the ring and place the hessian inside the infiltrometer to protect the soil surface when pouring in the water.
- Step 3: Start the test by pouring water into the ring until the depth is approximately 70-100 mm. At the same time, add water to the space between the two rings or the ring and the bund to the same depth. Do this quickly. The water in the bund or within the two rings is to prevent a lateral spread of water from the infiltrometer.
- Step 4: Record the clock time when the test begins and note the water level on the measuring rod.
- Step 5: After 1-2 minutes, record the drop in water level in the inner ring on the measuring rod and add water to bring the level back to approximately the original level at the start of the test. Record the water level. Maintain the water level outside the ring similar to that inside.
- Step 6: Continue the test until the drop in water level is the same over the same time interval. Take readings frequently (e.g. every 1-2 minutes) at the beginning of the test, but extend the interval between readings as the time goes on (e.g. every 20-30 minutes).

Note that at least two infiltration tests should be carried out at a site to make sure that the correct results are obtained.



Soil Infiltration Rates and Watering Needs

When you water you need to make sure that the water is infiltrating the soil at the correct rate because if you apply water faster than the soil can take it up, the water will simply flow over the surface of the soil and run-off the soil. This will mean a lot of the water is wasted and the water will not have had a chance to reach the roots of your plants, which means that your plants can dehydrate and die.

Let's take a look at how to water different types of soils.

Soil Type	Infiltration Rate	Watering Needs
Sandy soils	Have large air pockets between their grains. These large air pockets allow water to run very quickly through the soil, this is knows as a **high infiltration rate.**	Because sandy soils have a fast infiltration rate, you need to allow a large amount of water to flow quickly into the soil. Sandy soils need much more water than other soil types. Because sandy soils dry out quickly, plants growing in sandy soils will need to be watered more frequently than plants growing in other soils.
Clay soils	Have very small air pockets between their grains. These small pockets allow water to move slowly through the soil, this is known as a **slow infiltration rate.**	Because clay soils have the lowest infiltration rate, water moves slowly through clay soils and is often held below the surface of the soil although the surface may look dry. So if you are watering plants in clay soil you need to water slowly. Because clay soils hold water, plants growing in clay soils will need to be watered less frequently than plants growing in other soils.
Loam soils	Have a combination of sand particles and humus (organic matter) and so has medium size air pockets between their grains. These moderate air pockets allow the loam soil to hold water. Water moves through these soils at a moderate rate and this is known as a **moderate infiltration rate.**	Because loam soils don't dry out as quickly as sandy soils and don't hold as much water as clay soils, plants growing in loam soil will require a moderate rate and frequency of watering.

Can you see that if you are watering:

- A sandy soil the water moves almost directly down into the soil and so reaches deep into the soil.
- Clay soil the water moves slowly down and sideways.

So if the same amount of water is applied to sandy soil and clay soil, the water will reach deeper in the sandy soil. This is important to understand because the water you are applying needs to reach the roots of your plants which are often growing deep in the soil.

Watering Compacted Soil

Soil becomes compacted when the soil is frequently walked or traveled over. When a soil becomes compacted it has less air pockets or spaces between the soil participles for water to move through and so compacted soils absorb water more slowly than other soils.

If you are watering compacted soil, you should firstly loosen the soil with a gardening pick or fork to allow for better water infiltration. Be careful when working with very clayey soils because as you spike the soil with your fork, the soil around the hole made by the fork can become more compacted.

If you don't have the time to do this you will need to water slowly so that the water gets a chance to penetrate the soil. You can also water for a few minutes and then stop watering for a short while, allowing the water to penetrate into the soil and then water again.

Watering Sloping areas

The steeper a slope, the faster the water will run off it. As the water runs off slopes it can take with it the top layer of the soil and so cause soil erosion. If you are watering on a slope, you will need to water slowly so that water can penetrate the soil.

SEASONAL EFFECTS ON EVAPOTRANSPIRATION RATES

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

There are four seasons in a year – spring, summer, autumn and winter. Each season brings changes in temperature and different amounts of rain and these factors will influence the amount of water you need to give to your plants. Let's first take a look at seasonal temperatures.

Seasonal Temperatures

Spring is a time of awakening and plants are beginning to actively grow after the dormant (sleeping) winter season. During this cool season your plants need enough water to sustain their needs but not as much water as they will need during the hot summer because the evapotranspiration rate is generally low.

As a general rule, in spring you need to water each section of your landscaped area for about 20 minutes twice a week depending on the type of watering system you are using.

Summer is the time that plants are actively growing. This is the hottest season, and high air temperatures mean that the evapotranspiration rate (the rate at which your plants are losing moisture) is high. High evapotranspiration rates can cause your plants to loose large amounts of moisture and this can cause your plants to wilt.

Wilting that occurs during the heat of a summer day is common and temporary, but if your plants show signs of wilting in the early morning or late afternoon your plants are not getting enough water. In the summer months during very hot periods with little rain or breeze you need to give your plants a lot of water, regularly. So as a general rule, water each section of your landscaped area for 10 to 15 minutes, daily, depending on the type of watering system you are using.

Autumn is the time of the year when the growth of your plants starts to slow down and many plants are in their seeding and fruiting phase. In the autumn you need to cut back on the amount and frequency that you are watering your landscaped area.

So as a general rule water each section of your landscaped area 20 minutes, three times a week because during this cooler season, transpiration slows down as the days get shorter depending on the type of watering system you are using.

Winter is the time when many plants especially deciduous plants are in their dormant period (this means that they are resting). Because plants in their dormant period are not actively growing, they do not need much water and nutrients and so need to take up less water.

If you keep on watering these plants, in the same way as you did during the summer months when they are actively growing, these plants will drown. This is the coolest time of the year which means that the evapotranspiration rate is low, especially for deciduous trees that have lost their leaves.

During this time plants require little watering and so the frequency and duration of watering should be bought down to a minimum. So as a general rule, water each section of your landscaped area 15 minutes, once a week, depending on the type of watering system you are using.

If you are watering in cold winter climates it is recommended that you water during the warmer part of the day, for example between 10h00 and 14h00 so that your plants are not wet at night because this water can freeze and damage your plants.

Early in the morning usually at sunrise when the air is cool and the soil gives off heat, small water droplets, called dew drops form on the leaves of the plants. This time of day is known as dew point. In winter in cold climates that receive below zero degree Celsius night temperatures, this time of the day can be very dangerous for plants because these dew drops can freeze if the temperature is low.

This is called frost. Frost is frozen dew drops and is as sharp as razors. If wind blows lightly over these pieces of sharp ice they rub over the leaves of the plant and make tiny 'cuts' all over the surface of the leaves. The leaves then shrivel and turn black. This is called frost damage.

So can you see that the hotter it is the higher the rate at which your plants will be losing water through the process of evapotranspiration and so you will need to give your plants lots of water? The hotter it is the more frequently and more deeply you will need to water. And the cooler it is the lower the rate at which your plants will be losing water through the process of evapotranspiration and so you will need to give your plants less water.

Rainfall Patterns

In South Africa we have three rainfall pattern areas – summer rainfall areas, winter rainfall areas and in a small area around George the summer and winter rainfall areas overlap and they have rainfall all year round. To make sure that you are not over watering or under watering your plants, you need to adjust how much and how often you water your landscaped area to suit the rainfall of each region. Keeping track of how much it has rained helps you to do this.

The best way to check on how much rain your landscaped area is getting is to place a rain gauge, which is sold at most garden centres, in or around your landscaped area. Rain gauges need to be placed out in the open, on a stand, several meters from trees, or any other features because these can stop the rain from getting into your rain gauge and give you a false reading

Rain gauges help you to work out watering patterns that compliment rainfall patterns. By keeping a daily record of the rainfall over a year, you will be able to work out when the landscaped area will need more watering and when it will need less because in the dry season your plants will need more watering and in the rainy season they will need less watering. A rain gauge needs to be read every day at the same time in order to get an accurate reading, during the rainy season and emptied after each reading. Rain gauges have markings on their sides which are in millimeters, beginning at zero. By holding the rain gauge still, making sure that the water inside is not moving around, you will be

able to see where the water level is. You will see a downward curving line, read the millimeter markings in line with the bottom of this line.

How to use your rain gauge readings

If 2 ½ cm of rain has fallen, then this means that the rain has penetrated:

- About 30 cm into sandy soil.
- About 21 cm in a loam soil.
- About 15 cm in a clay soil.

So if you want to water to a depth of 30 cm, you will need:

- 2 ½ cm of water or rainfall in a sandy soil.
- 3 ½ cm of water or rainfall in a loam soil.
- 5 cm of water or rainfall in a clay soil.

If after a few days you see that less than 15 mm of rain has fallen, you should water your area.

What is evaporation?

Evaporation

Evaporation is the process whereby liquid water is converted to water vapour (vaporization) and removed from the evaporating surface (vapour removal). Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soils and wet vegetation.

Energy is required to change the state of the molecules of water from liquid to vapour. Direct solar radiation and, to a lesser extent, the ambient temperature of the air provide this energy. The driving force to remove water vapour from the evaporating surface is the difference between the water vapour pressure at the evaporating surface and that of the surrounding atmosphere.

As evaporation proceeds, the surrounding air becomes gradually saturated and the process will slow down and might stop if the wet air is not transferred to the atmosphere. The replacement of the saturated air with drier air depends greatly on wind speed. Hence, solar radiation, air temperature, air humidity and wind speed are climatological parameters to consider when assessing the evaporation process.

Where the evaporating surface is the soil surface, the degree of shading of the crop canopy and the amount of water available at the evaporating surface are other factors that affect the evaporation process. Frequent rains, irrigation and water transported upwards in a soil from a shallow water table wet the soil surface.

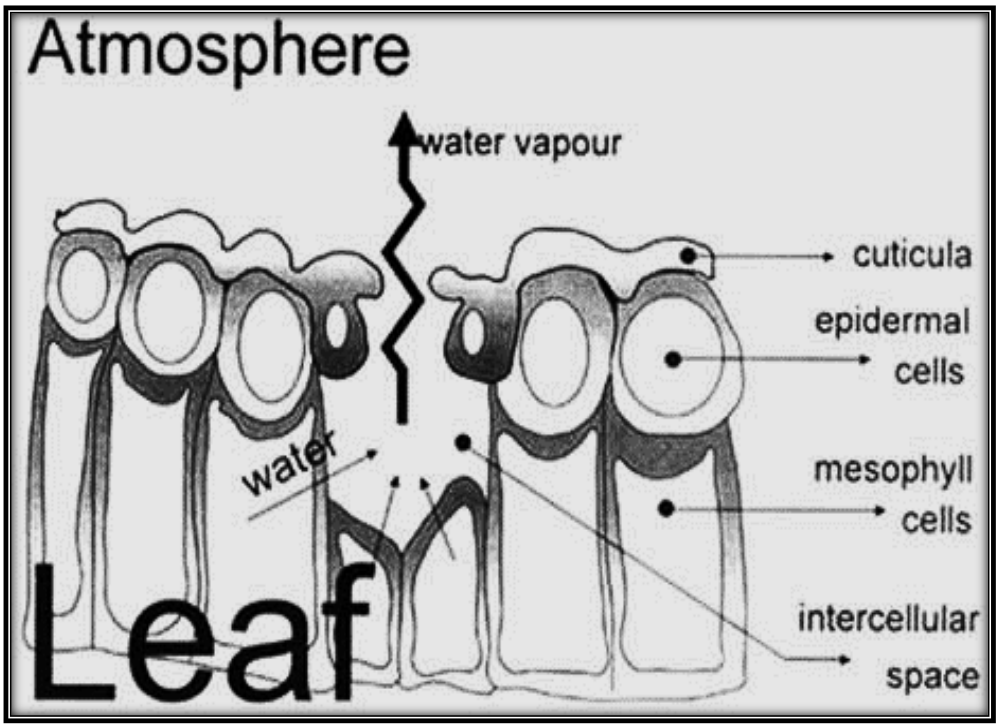
Where the soil is able to supply water fast enough to satisfy the evaporation demand, the evaporation from the soil is determined only by the meteorological conditions. However, where the interval between rains and irrigation becomes large and the ability of the soil to conduct moisture to pear the surface is small, the water content in the topsoil drops and the soil surface dries out.

Under these circumstances the limited availability of water exerts a controlling influence on soil evaporation. In the absence of any supply of water to the soil surface, evaporation decreases rapidly and may cease almost completely within a few days.

What is transpiration?

Transpiration

Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapour removal to the atmosphere. Crops predominately lose their water through stomata. These are small openings on the plant leaf through which gases and water vapour pass (Figure below).



The water, together with some nutrients, is taken up by the roots and transported through the plant. The vaporization occurs within the leaf, namely in the intercellular spaces, and the vapour exchange with the atmosphere is controlled by the stomatal aperture.

Nearly all water taken up is lost by transpiration and only a tiny fraction is used within the plant. Transpiration, like direct evaporation, depends on the energy supply, vapour pressure gradient and wind. Hence, radiation, air temperature, air humidity and wind terms should be considered when assessing transpiration. The soil water content and the ability of the soil to conduct water to the roots also determine the transpiration rate, as do waterlogging and soil water salinity.

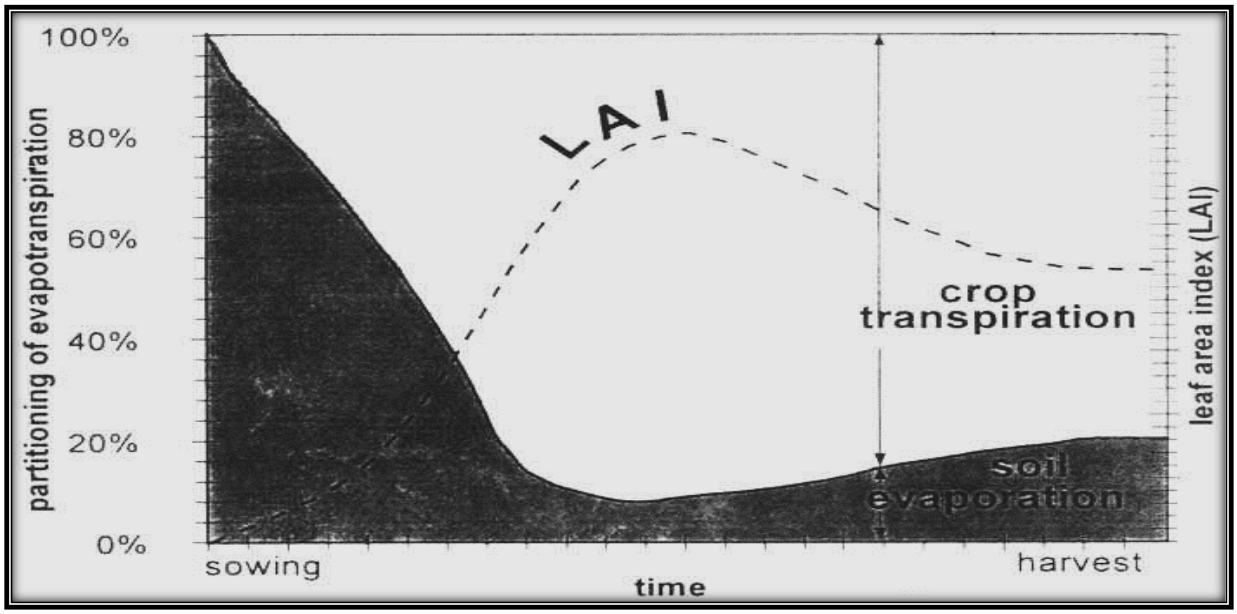
The transpiration rate is also influenced by crop characteristics, environmental aspects and cultivation practices. Different kinds of plants may have different transpiration rates. Not only the type of crop, but also the crop development, environment and management should be considered when assessing transpiration.

What is Evapotranspiration (ET)?

Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. Apart from the water availability in the topsoil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface.

This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

In the figure below the partitioning of evapotranspiration into evaporation and transpiration is plotted in correspondence to leaf area per unit surface of soil below it. At sowing nearly 100% of ET comes from evaporation, while at full crop cover more than 90% of ET comes from transpiration.



THE MOST APPROPRIATE CLIMATIC CONDITIONS AND TIME OF THE DAY FOR WATERING

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

What are climatic factors?

Climatic factors means the weather conditions of the landscaped area in which your plants are growing. Because plants lose water when moisture is sucked out of the leaves of the plant by:

- The heat of the day.
- The amount of wind and air movement in the area.

You need to look at the landscaped area that your plants are growing in and ask yourself these questions:

Climatic Factors

- **How hot is the day?**

On hot days the soil dries out quicker than on cold days and plants lose a lot of water through their leaves, this is called evapotranspiration. The hotter the day is the higher the rate of evapotranspiration. If you water your plants at midday when the sun is at its hottest, a lot of the water you are giving your plants will evaporate before your plants get the chance to take up the water.

This is a waste of water, so it is better to water your plants early in the morning. This gives your plants a chance to absorb and store enough water for the day. If you can't water early in the morning then you can water late in the afternoon or at sunset when the temperature is cooler as this also allows your plants to absorb and store water overnight for use the next day.

A drawback with sunset watering is that when moisture is kept overnight on the leaves of your plants (especially in humid climates) fungi often have time to develop on the leaves of your plants and infest the plant. By watering in the early morning this can be avoided as the sun dries any moisture off the leaves before fungi can set in.

- **How hot is the area?**

Plants growing in a hot, exposed north or west facing position will need more water than plants growing in cooler, shady east or south facing positions because the soil in shade stays wetter for a longer period of time.

- **How much air movement or wind is there?**

When the wind blows it dries out the soil quicker and increases the rate at which your plants loose water through their leaves and so your plants will use more water on windy days. Areas sheltered from the wind will tend to dry out more slowly than an area that is windy, so plants growing in windy positions need more frequent watering.

When you water plants in the wind, a lot of the water is blown away by the wind and so is not available for your plants. This is a waste of water, so it is better to water when there is no wind and the air is still. Early morning is usually when the air is at its stillest.

Watering the garden/landscape

Watering of a garden may have some recreational or therapeutic value to the homeowner but too much watering ends up just being a waste, especially in our dry South African conditions. There is no reason why existing landscapes can't be altered as time goes by to incorporate water saving ideas.

Landscaping to use less water must become a culture within South Africa in order for the effects to be of lasting value. Whether you are starting a new garden/landscape from scratch or have an existing garden you should constantly look at your options for saving water and where possible improve on old non water saving techniques.

All gardens need to be watered at some time or another, whether it is to initially plant or establish plants or to maintain plant growth on an on-going basis. It is therefore important that the individual applying the water be aware of these water saving ideas. Irrigation systems have a reputation of wasting water but through correct design and application different combinations of irrigation systems within a garden will actually assist in saving water.

Don't start watering programs too early in the spring. Plants will normally only flourish after the first good rains. Rather spend time improving soil and top dressings. Switch off irrigation before puddling starts. Water dry spots individually, avoid wasting water by watering a large area with the sprinkler if the intention is just to water a single rose or a small section of grass.

Where to water - (a) if the soil in the root zone feels dry and crumbly, if it looks as though the plant is starting to wilt. (b) Late evening, early morning is best. (c) Avoid mid-day irrigation which usually results in loss of water through evaporation. (d) Lawns are best watered in the mornings to help prevent disease.

Sprinklers with course, low spray are best. Fine high pressure systems loose water when the droplets atomize into the atmosphere. This is often caused by too high water pressure in the line. Make sure your selection of irrigation nozzle suits your pressure; water trees individually giving them a deep drink but less often.

Water slowly to prevent runoff but long enough to penetrate the root zone. By over watering, water penetrates beyond the reach of the roots, and excess water will run off and be wasted. Experiment to see how far water penetrates within a given period. Then take a slither of soil from the watered area and check the soil moisture or use a moisture meter (tensio meter). Drip irrigation is very effective when used on vegetables, fruit trees and specimen trees.

Automatic watering systems should be altered according to season, time of day and amount of rain received unless it is connected to an automated tensio meter and or rain check. Never waste water by allowing the automatic system to water when not necessary. This is especially important for office blocks. Check all water connections for leaks.

When planting a tree place a water pipe from the base of the tree roots to just above the soil surface. Watering into this pipe will take the water directly to the tree roots and prevent water wastage. Flowers and vegetables need short, frequent watering, while shrubs and trees need deeper but less frequent watering. In cool seasons plants need less water; in hot weather and when windy, all plants use more water. Where possible water trees separately and consider digging a shallow trench around the tree to catch and hold water.

Light and the impact it has on water utilisation by the plant

Light, water and food are the most basic needs a plant requires to live. Plants will photosynthesise food by using light energy in direct proportion to the amount of light they receive, provided the light does not cause damage to the leaves through heat. Light is also required to produce essential hormones for growth and flowering.

If moderate amounts of light are available, plants may not grow but will maintain a healthy, good looking, condition. Other plants merely survive as the light levels deplete. At even lower levels of light intensity the plant will begin to die. Watering should be reduced as the light intensity drops and the plant starts to grow slower. It is easy to over water plants in low light causing more stress to the plants. Common symptoms of over watering are root and stem rot.

Low light particularly in doors will cause the plant to become etiolated (leggy). These plants are not strong and are very susceptible to disease and pests. To combat this, interior plantscapers keep plants very dry. This regulates the plant growth. Keep in mind that water should be gradually reduced.

Humidity and pot plants

Air conditioners often dry out the air making it difficult for plants to grow well. The amount of moisture in the air is referred to as Humidity. This is the percentage of maximum amount of water vapour the air can hold at a given temperature. As air warms it is able to hold more water. When cold air is heated it dries out. Plants are grown at about 80% humidity compared to the average building which ranges from 35 to 65%, these plant leaves become brittle and develop brown edges.

This will be aggravated if:

- The soil is allowed to dry out
- There is air movement over the surface of the leaf
- Direct sunlight through a window shines on the leaves. (This will cook the plant.)
- Use a wet bulb and a dry bulb thermometer to calculate your humidity. Refer to the table for the calculation

Effects of watering on plant growth and development

For optimal growth, optimal watering is required; too much or too little will reduce growth.

Over watering; Plants roots require oxygen as they are living and respire. Long periods of saturated soil will suffocate the roots. Secondary infections caused by bacteria are quick to move in and further damage the roots.

Symptoms of over watering include:

- Wilting foliage
- Leaves turn pale and new growth is weak
- Stem base is soft and spongy
- Strong pungent odour
- Excessive leaf loss
- Brown tips with yellow stripe on leaves
- Young shoots appear shrivelled and blackened
- Roots appear dark and mushy
- Few or no flowers
- Flowers buds develop brown spots
- Plants are easily uprooted
- The presence of fungal growth and fungus gnats or sciarid flies

Symptoms of under-watering include

- Leaf edges turn brown
- Flowers fall off
- Stems show signs of wrinkles
- Leaves lose their shine and take on a blueish luster
- The growing medium shrinks away from the side of the container
- Leaves become yellow or crispy and suddenly

Innovative alternatives to watering trees and large shrubs

Most common watering practices include:

- Irrigation systems
- Hand watering
- Use of basins and mulches

The problems most commonly experienced are:

- Soil compaction does not allow water penetration and results in restricted root growth and smaller trees.
- Erratic watering of trees also restricts root and tree growth.

Innovative methods to try - for special trees needing extra attention:

- Use a deep root irrigating lance that is pushed into the soil and waters deep down.
- Inserting pipes into the base of the tree hole before soil is put back. This allows for water to be applied directly to the roots.
- Drill holes into the compacted soil all around the tree drip line. Wetting granules and water retention granules can also be included into these holes.
- Use soaker hose or leaky pipe for slow even watering. It should be well hidden under the mulch. They can be coiled around the tree.
- Harvest water using swales to direct water to the tree. Trees planted in these hollows should have good drainage (Could drown the tree if very frequent rain is expected.)
- Drip grey water onto the tree - as in a forest garden.

Other good ideas for water efficiency:

- Where possible water trees separately and consider digging a shallow trench filled with mulch around the tree as wide as the drip line to catch and hold water.
- Cut down on high nitrogen based fertilizers, rather use fertilizers with high ratios of potassium (K) and phosphorus (P). This will encourage plant cell walls to thicken enabling them to cope better in drought conditions.
- Light pruning helps plants cope during water restrictions because of reduced transpiration from aerial parts.
- Erect tanks around the house to collect rainwater from roofs.
- Apply mulches to soils and garden beds in order to reduce water loss.

- Aim to contain rainwater, rather than allowing it to run off site. This can be done by, altering the slope of the land, using retaining walls, making berms and gabions or by draining water into depressions where it can slowly seep back into the landscape.
- Avoid transplanting plants as this will induce unnecessary stress.
- Established shrubs and hedges will rarely need to be given additional water. In the majority of years their roots will be extensive enough to enable them to obtain all the moisture they require from the soil. When they are first planted, however, a shortage of moisture can easily lead to stunted growth, or even death.
- The amount of water these plants require will depend upon the soil type, weed competition and the weather conditions. Applying water for 15 to 20 minutes as fast as the soil can absorb it will be adequate for most situations. Ideally you should aim at moistening the soil to a depth of about 150 mm.

When and how long to water

- Fully established trees should be able to survive without any extra water in normal rain cycles. In extended dry periods good long watering will need to be considered.
- Watering will depend on the soil type. Sandy soils don't hold water well and dry out quickly, whereas clay soils hold water well and need watering less frequently - they can in fact hold too much water and become water logged. Loam soils are ideal as they have the right balance of water retention and drainage.
- The type of sprinkler used will affect the time that it takes to water a tree. Slow delivering drippers could take hours to water a section while a high pressure hose could fill a trees water basin in seconds.
- Fruit trees require watering to help fruit set and form. Once they are well formed over watering will cause the fruit to be lacking in flavour and cause them to split.
- Deciduous fruit trees should not be watered in the winter to prevent early development and frost damage, but as soon as the blossoms start they need good watering to lengthen the pollination period because this keeps the blossoms on the tree as long as possible. The longer the blossoming period the more chance there will be for pollination to occur. The tree will require large amounts of initial water to moisten the soil profile all the way down so don't be hasty in watering.
- Remember to water well after fertilising so as to soak the fertiliser into the soil and to lessen the effect of fertiliser burns that may accrue.

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During early spring watch new growth as the fresh leaves are very sensitive to wind and heat wave damage. During these periods extra water will be needed. Remember to water at night as day time watering contributes to the loss of large amounts of water due to evaporation

Watering plants immediately after planting

- When plants are placed in their growing positions it will be beneficial to water them in. You should aim to thoroughly wet the soil around the roots, and moisten the leaves with a fine spray. Applying water in this way will ensure that the plants have the correct conditions for rapid establishment, and will reduce the time they remain wilted. Water should not be spared when planting as this first watering is the most important one.
- If you plant shrubs or hedges during late autumn or winter the soil will need extra water on the Highveld because of the lack of rain. If you find that the soil begins to dry out immediately after planting you should irrigate the site. But don't overwater.
- When transplanting large trees use a product like Kalpak which contains cytokinin, a hormone to stimulate root growth. The product is mixed with water and sprayed on to the leaves and watered in the roots.
- Remember to seal any wounds or tears occurred during planting.

Plants in clay containers

- Plants in clay containers can be checked for water by lightly tapping the side of the container with a solid object, such as a cotton bobbin on a stick. A light ringing noise will tell you that the growing medium is dry, whereas a dull noise will tell you that there is moisture present. This method works best for loam based growing mediums.
- Lifting the containers up will also give you an indication of their moisture content. Light containers will contain less moisture than heavy ones.
- The third way of telling if these plants need watering is to push your finger lightly into the soil. If your finger feels moist and the compost sticks to your finger, the soil probably contains sufficient moisture. But be aware, frequent light watering may wet the top portion of the pot, but leave the bottom portion dry. When you water, therefore apply enough to ensure that surplus water runs out of the drainage holes. This ensures that the entire root ball has received water.

Plants in plastic containers

- It is very difficult to judge the moisture content of growing mediums in plastic containers. You cannot use the 'tapping' method as no distinct ringing noise is made, and it is also difficult to judge the moisture by lifting the containers. With this type of container the best method of checking the moisture content is to press your finger into the compost.
- When you first start to water plants in pots or other containers you may tend to either under, or over water them. With a little experience you will soon learn whether your plants need watering or not. In practice it is better to slightly under water than to allow the soil to become waterlogged.
- Never leave a plant standing in deep saucers for a prolonged time as this will cause the roots of the plants to die because of the lack of oxygen in the growing media.
- Should you be going away and cannot do your regular watering, use this as a very short term solution and don't make the basin deeper than on tenth of the height of the container.
- You may use watering sticks to gently water the soil during periods of leave. They are made of porous clay and water seeps through to the plant.
- Many pots have a built in sump under the pot. A sump is a collection area for water under the container this allows for extended periods between watering. Always inspect the pipe into the sump with a dip stick to check that you do not over water the plant. Over watering will cause the water in the sump to rot and will cause bad smells, this is because the roots start to die due to the lack of oxygen. Water will move back into the soil medium when the soil dries. It is not uncommon for some plants to adapt their roots and dangle them into the water, provided there is still air available for the respiration of the roots.

Patering hanging baskets

- Hanging baskets can produce excellent displays during the season, but their management is difficult because the limited amount of growing medium available in the smaller area means that they dry out quickly in hot weather. The correct watering of these containers is critical if healthy growth is to be obtained.
- The use of soil moisture granules help to increase the water holding capacity of the soil and are very valuable in these instances.
- During the early stages of establishment, hanging baskets can be dipped into containers of clean water, and allowed to soak until all the soil is wet. However, as growth proceeds and they are hung in their final positions, this often becomes impracticable, and watering using cans or other special equipment becomes necessary.

Training Provider Accreditation Number: AGRI/c prov/0282/1

- You will need to water hanging baskets at least once per week during the season, and in hot periods this may be increased. You should never allow the soil to dry out, as the plants can rapidly deteriorate, and may die.

Window boxes

- Window boxes are similar to hanging baskets in the sense that they have a relatively small amount of growing medium for the plants to grow in. They tend to dry out quickly during hot weather, and need to be watered as often as twice a week. In extreme conditions daily watering is required.
- Always ensure that the soil is completely watered. It is best to use a watering can with a rose fitted, when the plants are first established, but the rose can be removed, once establishment is complete.
- Watering well in the evening, enables the plants to absorb a good store of water overnight, light watering during the day could also be necessary for cooling, but the sun may evaporate much water before the plants can utilise it.

Tips

- You should use a lance at the end of the hose pipe with an on and off trigger for controlling the water. A rose will be necessary with young delicate plants.
- Remove the rose from your watering can once the plants are well grown so that the stem of the can allows easier aiming of the water into the container.
- Always water each plant individually. You must water the whole area.

Watering bedding plants

- Bedding plants are often grown in individual containers, or massed in seed trays or directly from seed.
- Plants grown in individual containers should not normally have their roots damaged during planting, but those grown in trays can sometimes suffer from accidental root loss. Root loss will require extra watering to prevent damage to the plant.
- Immediately following planting you should make sure that all the plants are watered thoroughly, so as to reduce the risk of wilting - this is especially important for any plants with damaged roots. Watering should be continued every day until the plants are established.
- Bedding plants grown from seed need more sensitive watering techniques. A watering can fitted with an upward facing rose, is used with a continuous swinging movement. At no time may puddles occur as this will cause the seed to float away and be displaced. Dribbles as the water starts and finishes will also disrupt the seed bed so start and finish the swinging movement off the side of the seed bed.

Should the seed at any time dry out the plants will die so three hourly checks will need to be made in hot weather.

- Bedding plants are shallow rooted, which means that they can dry out rapidly in hot weather. If the maximum floral display is required you should water them during any dry or hot periods.

Always be on the lookout for drooping plants which will be the sign that you should water. Mulching around the annuals is a great water saver as the evaporation from the surface is cut down. Be careful not to swamp the annuals with mulch as this will result in them rotting or make them vulnerable to fungal attach. On small beds watering can be carried out using watering cans, or hose pipes fitted with a rose.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Caring for plants in a heat wave

Summer is here and the heat is on. Add that to the dry spell we've been having lately, and your landscape may start to suffer.

Potted plants will be the most vulnerable to dry, hot weather. Potted plants in full sun may need to be watered twice a day. There are a few things you can do to keep potted plants from suffering during a heat wave.

Put trays of water under the pots and allow the plants to soak it up from the bottom. Be careful not to leave the tray under the pot when it rains. Move potted plants to the shade during a heat wave, plants in the shade won't dry out as quickly.

Full sun plants will be fine sitting in the shade for a few days. Drip irrigation systems are a great option to ensure potted plants are watered consistently. If you have an irrigation system in your yard, you can place potted plants in areas where they will get some water from the sprinklers.

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Although it's difficult to over-water a potted plant during a heat wave, it's a good idea to check the soil before you water to ensure the plant needs it. Established perennials, trees and shrubs won't need as much attention during a heat wave; they certainly don't need to be watered every day. If your perennials are standing tall and looking healthy, they don't need water.

Look for signs that your plants need a drink; signs to look out for are drooping plants, and browning or crispy leaves. Plants that show any of these signs will benefit from a deep drink. Water the plant slowly with trickling water directly on top of the root ball, allowing the water to soak in. Don't drown the plant; consistently saturated soil can do more damage to plants than under watering.

It's important to pay extra attention to newly planted grass, trees or plants during a heat wave. These will need to be watered more often, and you should never allow their soil to dry out completely. Mulching the garden helps keep the soil moist and cool, and perennials hydrated longer. Ground cover plants are also great to help retain soil moisture.

As for the vegetable garden, most vegetables should be established enough to withstand a short dry spell. But it's important to water the vegetable garden consistently. Inconsistent watering can cause long-term damage to vegetable crops. Plants like tomatoes and peppers need consistent watering to avoid blossom end rot.

Inconsistent watering also causes vegetables like carrots and tomatoes to crack, and causes leafy crops to bolt. When vegetable plants are dehydrated, the stress could cause the plant to stop flowering, or drop its flowers and fruit. The easiest way to keep the vegetable garden happy during a heat wave is to get on a watering schedule. Put sprinklers or soaker hoses in the vegetable garden and run them at the same time every other day.

Here are some other hot weather garden care tips:

- Don't fertilize during a heat wave, especially when a plant is dried out. Plants that are dehydrated will soak up fertilizer faster, which could cause fertilizer burn.
- Weeds compete with garden plants for water, so it's especially important to keep the weeds from taking over during dry periods.
- Don't use sprinklers during the hottest part of the day because most of the water will evaporate before it reaches the ground. If you must water during the day, water at the base of the plant.

Training Provider Accreditation Number: AGRI/c prov/0282/1

- Early morning is the best time to water, that way the plant will have time to absorb it and be well hydrated during the hottest hours of the day.
- Don't transplant anything during a heat wave. Plants that are stressed by hot weather may not recover if they're moved.
- Keeping plants hydrated during the dog days of summer can be a major chore, especially during a heat wave. I hope these tips will help ease the stress, both for you and your plants.

How to Water Plants in Cold Weather

While the drooping plants that suffer in the summer heat get all our attention, sometimes we forget to care for plants enduring the cold. Watering is still an essential part of plant care during the winter, both before and after the first freeze.

Properly caring for plants in the garden and in containers will ensure that they will survive winter's cold and be ready to bloom again in the spring. Lately, we have been receiving really cold weather. Now is a good time to be prepared and take precautions from low temperatures in the landscape. Winter damage is caused not only by low temperatures, but also by drying winds that lead to desiccation of plant tissue.

What to do before a Freeze

Move all tender plants (plants killed or severely damaged by temperatures below 32 degrees) in containers and hanging baskets into buildings where the temperature will stay above freezing. If this is not possible, group all container plants in a protected area (like the inside corner of a covered patio), and cover them with plastic. If plants are kept inside for extended periods, make sure they receive as much light as possible.

Water

If it has been dry, thoroughly watering landscape plants before a freeze may reduce the chance of freeze damage. Many times cold weather is accompanied by strong, dry winds. These winds may cause damage by drying plants out, and watering helps to prevent this. Wetting the foliage of plants before a freeze does not, however, provide any cold protection. There is a freeze protection system used in citrus, but this is a controlled water flow onto the tree.

Mulch

For plants growing in the ground, mulches can help protect them. Use a loose, dry material such as pine straw or leaves. Mulches will protect only what they cover. Mulch at the base of a bird-of-paradise will help the

roots, but will provide no added protection to the leaves. Mulches, then, are best used to protect below-ground parts crowns, or they may be used to completely cover low-growing plants to a depth of about 12-15 cm. If you use mulch as a complete cover, leave it on no more than 3 days.

Covers

If plants are not too large, covering them with cardboard or Styrofoam boxes can offer protection. Larger plants can be protected by creating a simple structure and covering it with sheets, quilts or plastic. Be sure the structure holds the covering off the foliage. The cover should extend to the ground; seal with soil or other heavy objects. Plastic covers should be vented or removed on sunny warm days. These covers will work best for light, quick freezes. For extreme prolonged cold, this is another story.

For treasured plants, you can try providing a heat source under the cover. Extreme care should be used. Most commonly a 100-watt bulb or Christmas tree lights can be placed under the cover with the plant. Be careful the bulb does not come in contact with foliage or the cover material; use outdoor approved extension cords and sockets.

Some plants can be pruned to make them more practical to cover. Hibiscus is a good example. For trees such as citrus that are too large to cover, you may at least wrap the trunk with an insulating material such as foam rubber, pipe wrap or blankets. The top may die, but you may save the rootstock.

What to do after a Freeze

After a freeze is over, check the water needs of plants in containers and in the ground. Remove or vent plastic covers to prevent excessive heat build-up if the day is sunny. Pull mulch back that completely covered low plants. Delay hard pruning on woody plants until new growth begins in the spring, then you can accurately determine which parts are alive and which are dead. Don’t be too quick to dig up and remove plants that appear to be dead. On occasion, they may eventually re-sprout from the roots.

Winter Weed Control

One good winter weed control practice is to apply liquid atrazine. The rate is 3 tablespoons per 5 litres of water and 5 litres will treat 300 sq. m.

Atrazine has activity on both emerged and non-emerged weeds. It does a really good job on clover, lawn burweed or stickweed and works well on newly germinated annual bluegrass. You can reapply atrazine in early February for a clean-up control. Read label and apply product correctly. Atrazine can injure landscape plants

Training Provider Accreditation Number: AGRI/c prov/0282/1

and trees if applied near their root zones. Stay away from the drip line of trees and shrubs with this herbicide. Many Drake elms have been killed by this.

The effects of cloud cover on evaporation

Water usage impacts the management of our water resources. It is believed that accurate information on the hydrological cycle disseminated to the public, will considerably alter consumer usage behaviour.

Evapotranspiration is one of the most variable and sensitive of the hydrological components and it is imperative that we fully understand what environmental factors directly or indirectly affect evapotranspiration.

A recent study concluded:

"The objective of this study was to confirm the indirect effect of clouds on evaporation by examining how clouds affect variables used by the Penman-Monteith equation. As expected, during the day or night it was found that clouds had a negative correlation with solar radiation and temperature, and a positive correlation with humidity all at the earth's surface. There was no significant relationship between wind speed and clouds except during the night. Correlation coefficients, with respect to cloud, for temperature and humidity varied only slightly from day to night, but interestingly wind speed showed a significant change from 0.077 to 0.264. These findings may suggest that there are some occasions when 'water-wise' activities, for example watering the garden at night to decrease potential evaporation, may not be as beneficial as previously thought."

Watering plants during a heat wave is a matter of knowing the unique needs of different plants. Protect each plant from the ravages of extreme heat, avoid water waste with basic plant-watering guidelines, and, above all, pay attention to your plants

1. Check the soil in every plant. Make daily morning rounds of potted plants and those planted in the garden each day during a heat wave. Lift potted plants to judge water content. If you use clay pots, the outside of the pot will look wet if the soil is still moist. Dry soil causes pots to be lighter than moist or wet soil. The more you perform this daily duty, the more you will gain a sense of the heft of your plants. For gardens, the Innovative Gardener suggests using a soil core sampler, or just dig into soil near plants with a spade between 6-and-12 inches deep. If the soil is dry, it's time to water.

2. Use water wisely; water plant roots. Watering leaves is a waste of water. Some plant leaves are prone to fungal diseases and should not get wet. Mix mulch into the soil. Mulch reduces evaporation and promotes even water absorption. Cover the top of soil with pine needles or another ground cover to prevent evaporation.

3. Water sufficiently, but not too often. Too little water creates a hostile soil environment. Too much water can damage plants as well. Avoid water-logging roots, which can cause fungus to develop. The rule of thumb is that it is better to allow plants to dry out than to over water them.

4. Water in the morning before the sun's scorching heat increases, evaporating surface moisture and searing soil and roots as moisture heats. Water deeply enough to reach roots. Lawn roots are closer to the surface than those of trees and shrubbery. Provide ample time for water to penetrate to roots.

Water with hoses or sprinkling systems, which supply water efficiently. Water soil directly. Do not use sprinklers that spray into the air. The water evaporates and what reaches the ground does not penetrate deeply enough. The Innovative Gardener recommends using half-water pressure through an open-ended or a soaker hose.

FREQUENT WATERING OF SEEDLINGS AND NEWLY PLANTED PLANTS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Water is one of the vital elements when starting plants from seed. Too much water and your seeds will drown or rot. Too little and they will either fail to germinate or die once they do.

If you are starting your vegetable garden from seed, you have two choices. One, you can start your seeds indoors and then plant them outside as seedlings several weeks later, or you can direct seed into your garden. There are a number of good reasons to start seeds early indoors.

Most importantly, you get ahead of the growing season. This is especially important if you live in a place with a short growing season. Another advantage is that you can tightly control the ideal growing conditions: temperature, moisture, sunlight, etc. A third advantage is cooling that early spring itch to get outside and get something in the ground!

The best candidates for early starts are things like broccoli, cabbage, cauliflower, celery, eggplant, leeks, onions, parsley, peppers, and tomatoes. Root crops, like beets and carrots do not like to be transplanted and are best sown directly into the garden. Corn and peas are other things that do not take well to a transplanting.

To germinate your seeds you can do one of two things:

1. You can moisten a paper towel, place the seeds in the middle of the paper towel and place it on the window sill in the sunlight.
2. Alternately, you can fill small sections of a seed starting tray with a soil mixture and plant the seeds into the mixture about 1 inch deep. Then water lightly.

Either way, you don't want the seeds sitting in water. You want to have the soil or paper towel moist but not soaked. Let the soil mix dry out just a bit, but not completely, before wetting again. I use a spray bottle to keep my starting mixture moist.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The key is good drainage. Make sure that excess water has a way to drain away from the seeds. There are seed starting systems available that work via a capillary system. This keeps your soil at the right moisture level with no work from you but I find the spray bottle method pretty simple.

If you cover your seeds with some loose plastic you will create a mini-greenhouse environment that will hold in both heat and moisture. You will need to get air to the seeds so remove the plastic every once in a while so that you don't get mold formation that can ruin your seeds.

After a few days, two small leaves will appear once your seedlings begin poking through the soil and unfurling. Again, keep the soil moist as the seedling begins to take off.

As the days warm and lengthen you will begin taking your seedlings outdoors to "harden off". That is, to get them used to being outside by putting them out for portions of the day (you will still be bringing them inside at night). Be careful here. The sun and spring winds can dry out that delicate soil in a heartbeat.

When the day comes that you are ready to plant your seedlings into the garden, water them well before the transplant. Once they are in the garden, water them again very well. Finally, to avoid drying out your seedlings try not to transplant during the hottest, sunniest part of the day.

Always remember:
Water is important for plants because of the following reasons:

- Water helps in the germination of seeds.
- Water helps in the process of photosynthesis by which plants prepare their food.
- Water helps in the transport of nutrients and minerals from the soil to the plants.
- Water helps in the maintenance of the plant structure by providing the appropriate pressure to the plant tissues

Water is the primary need of a recently established plant. Hot summer days and drying winds take a great deal of moisture from the leaves and stems. This water must be replaced through root absorption of soil water. When transplanting a balled-and-burlapped tree (roots of container grown trees and shrubs are not removed), most of its wide-spreading, deep-growing roots are cut. In its new location, the only water that a newly established tree can utilize is the water in the soil close that is to the tree. If this soil area becomes dry, the leaves wilt, turn brown and drop.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The death of many branches or even the entire tree or shrub can follow. For trees planted within the past year, it is wise to water at regular intervals. IF the soil is sandy, water once a week. If it is clay or loam, thorough watering every 10 days or 2 weeks should suffice. Using an open-end hose, regulate the water flow so there is no run-off, and let it flow until the soil around the tree is saturated.

It is also extremely important to control insects. Since even a few insects can cause severe damage to a newly planted tree, control measures should be applied promptly when insects are found. Applications of appropriate insecticides, following label instructions, are useful in controlling pests.

Once the tree is established, promote steady vigorous growth of the tree through proper use of fertilizer. If the tree or shrub was worth planting, it is certainly worth the little extra effort required to keep it in good growing condition.

Planting Instructions for the Newly Planted Tree

The fact that thousands of trees die unnecessarily each year is very disturbing. After shelling out hard-earned cash and going to all the effort of digging and planting, many new tree owners then throw the ball game by failing to give proper post-planting care (pruning, mulching, fertilizing and watering).

We'll assume you've just planted, in good soil, an outstanding, well-adapted species such as Texas mountain laurel, Chinese pistache or cedar elm, and have avoided the common trap of the so-called fast-growing but very troublesome trees (those that are either poorly-adapted or subject to many insect and disease problems - examples such as Arizona ash, sycamore and chinaberry are but a few).

Now what are you supposed to do? What steps should you take to ensure your tree survives, re-establishes its root system and grows to be a beautiful specimen- Here's a hint—the first life-saving step involves pruning. Your main objective with a brand new tree or shrub is to get it stabilized, keep it from going into severe transplant shock, until it can send new feeder roots into the surrounding soil and thus re-establish a viable, functioning root system.

Your biggest threat to survival at this point is that many times the top of your plant will transpire or lose water vapour faster than the new, often severely injured root system can absorb it ? regardless of how much moisture is in the soil. You simply don't have enough functioning roots to absorb the required amount of

Training Provider Accreditation Number: AGRI/c prov/0282/1

water. If this happens, the leaves wilt and drop and the plant eventually dies if corrective steps are not taken. The hotter, drier and windier is the weather, the worse the problem.

To prevent this excessive water loss from the top, prune it back to bring it more into balance with the damaged root system. Ideally, this pruning would have been done the same day you planted. It may also need to be done right now for trees planted this spring that are just now starting to wilt and/or scorch on the edges of the leaves.

Remove l/3 to l/2 of the top from bare-root trees, as their roots are severely damaged during digging prior to shipment. Balled-and-burlapped (B&B) and container-grown trees are not subjected to such extensive root damage and thus transplant much easier. But even with B&B and container stock, I find that removal of about l/4 of the top aids in re-establishment, particularly during hot, dry weather.

In unusual cases, like planting during the middle of the summer, pruning and providing some form of temporary shade and wind protection, as well as misting their canopies several times daily, helps newly planted trees and shrubs a great deal.

You also need to mulch immediately after planting. Use grass clippings, leaves, straw, hay, compost, etc., to mulch a circle 4 feet in diameter, 4 inches thick. Replenish as required for the next 3 years.

This mulch will promote root growth, during both summer and winter, by moderating soil temperature (root growth slows in extremely cold or hot soils), conserving moisture, and reducing soil crusting after watering. One very important advantage of mulching is that it reduces grass and weed competition - letting grass grow right around new plants severely stunts their growth!

Be aware of this important fact: Many container-grown trees and shrubs are now grown in artificial or soil-less mixes (peat moss, pine bark and sand are the major components) that do a super job in wholesale nursery operations. But, they do need to be handled differently than plants grown in mixes containing actual soil.

First, they must be watered differently. The soil-less root ball may dry out rapidly even though the backfill or surrounding soil may be wet. This is a greater problem in windy weather, either winter or summer. When watering a recently planted tree or shrub, water slowly at the plant trunk to wet the root ball. You may have to water weekly, or even more often, if significant rainfall is not received.

You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ I understand the factors that affect the loss of water in soils.
- ☐ I am able to adjust the quantity and frequency of watering to suit prevailing conditions.
- ☐ I am able to utilize knowledge of scheduling to operate a manual irrigation system.

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

_____
_____
_____
_____
_____
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_____
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Training Provider Accreditation Number: AGRI/c prov/0282/1

PROPAGATE PLANTS FROM STEM CUTTINGS

264118

A person credited with this unit standard will be able to:

- Select and prepare the cutting material
- Utilise the tools and equipment to perform stem cuttings
- Perform cuttings with various stem types
- Provide primary care for stem cuttings

PROPOGATION AND THE REQUIREMENTS FOR PERFORMING THIS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

The process of removing a plant part then having that part grow into a genetically exact replica of the original plant is called cutting propagation. It is a plant cloning technique. The plant part that is removed is called a cutting. This cutting may be referred to by the location from which it is taken. Plants can be propagated from root cuttings, leaf cuttings, stem cuttings, etc. We will be addressing stem cuttings here.

When propagating plants by cuttings, it is important to remember that the cutting is a living plant part that has been separated from its life support system. As a plant propagator you are trying to both provide conditions that will keep this plant part alive and also to encourage it to grow the organs necessary for it to become a whole, self-supporting plant that is a clone of the parent plant.

Cutting propagation is often the preferred method for plant propagation because it is the easiest and most cost effective way to produce a clone of a particular parent plant. Other methods that are more difficult or

Training Provider Accreditation Number: AGRI/c prov/0282/1

more expensive may exist but are often not chosen. *Everything depends upon everything else* when propagating plants by stem cuttings. Major factors to be considered are the parent plant or stock plant and the propagating conditions along with the techniques and tools of cutting propagation.

Stock Plant Management:

The parent plant from which your cuttings are gathered should be true to type and as pest free as possible. You have enough of a challenge when rooting cuttings without choosing pest problems or something unsalable because it does not resemble the parent. The conditions frequently chosen to root stem cuttings are warm, moist and shaded or at least away from drying air movement.

These same conditions can be excellent for the growth of disease and insect pests. Therefore, it is important to choose cuttings that are as pest free as possible. If appropriate, use appropriate pest management tools prior to taking cutting so that you have limited or eliminated pests such as leaf spots, mildew, rusts, aphids, whiteflies and scale insects.

'Start clean and stay clean' is a statement heard in most propagation workshops. It is a good rule. Good sanitation in plant propagation is essential to preventing problems with disease and insects. Stock plants should be at a stage of growth most likely to have stem cuttings root. Old, mature plants are often more difficult to root than young, vigorously growing plants.

Therefore, established blocks of trees and shrubs used for parent plants, called stock blocks, will need to be replanted every 5 to 10 years. The less mature a plant, generally the easier it is to root a cutting from it. Plant maturity is not the same as stem maturity because every new flush of growth contains young, maturing tissue. However, if new growth is occurring on an old, mature plant this new growth may produce shoots that are difficult or nearly impossible to root.

Stock plants should receive balanced nutrition, usually at a moderate level for average or more difficult to root plants. When fertilizing stock plants, avoid too much available nitrogen or too great an imbalance of essential nutrients. Also be sure that plants are not nutrient deficient.

Field grown blocks of stock plants are often fertilized only once per year in the Carolinas. However, you may be taking cuttings from relatively easy to root container grown plants that require high levels of nutrition to be grown economically.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Rooting percentages are usually not negatively affected when container grown plants serve as parent plants as long as complete fertilizers such as controlled release fertilizers containing nitrogen, phosphorus and potassium are utilized along with minor elements. Secondary nutrients like calcium and magnesium should be provided to stock plants from some source either within the growing medium or irrigation.

Timing:

Timing can refer to many aspects of cutting propagation. Perhaps one of the most important but most often overlooked is the time of day and conditions at the time when the cutting is taken. Most stem cuttings root best at a particular stage of growth for each plant even though it may be possible to root cuttings at multiple growth stages. The less mature the growth stage, i.e., a softwood cutting, the more easily it can lose water, dry out and die.

However, a cutting may wilt then be re-hydrated by soaking it in water. It may look perfectly normal once it recovers from wilting but it may still root in lower percentages than it would if it had not been allowed to wilt in the first place. Therefore, try to take cuttings from shoots that are fully turgid and not even slightly wilted, particularly when working with softwood and semi-hardwood cuttings.

This is best accomplished by collecting cuttings early in the day, particularly for plants that are growing in full sun. If parent plants are starting to wilt, irrigate then return to take cuttings when shoots are again fully turgid. Hardwood deciduous and evergreen cuttings may not appear to wilt but care should be taken to collect them when temperatures are above freezing and roots have adequate moisture or they may be lacking sufficient moisture within them to root at their highest potential.

Research has demonstrated that cuttings collected when temperatures were above freezing and stored in plastic bags or moist burlap in a refrigerator rooted in higher percentages than fresh, un-stored cuttings taken when shoots were frozen.

For all types of stem cuttings, the cuttings should be removed with a clean, sharp (don’t crush stems) knife or pruners and placed into a container that will keep the cutting from losing more moisture. Plastic bags work well for this purpose. Clear plastic bags should be avoided if they cannot be quickly moved out of the sun after cuttings are put in the bag.

Clear plastic bags quickly heat and become solar ovens that can damage or kill cuttings. For most non-tropical origin plants, storing cuttings in plastic bags under refrigeration or in portable coolers can greatly enhance the chances for success. Tropical plants and cuttings of tropical plants should not be refrigerated below 10°C.

Types of Cuttings:

Cutting types can be described by their origin such as leaf, root or stem cuttings. They can also be described by their location on the stem such as the cuttings from the ends of stems being called terminal or tip cuttings. Cuttings from further down the stem are called secondary cuttings. Terminal cuttings often root in higher percentages than those located further down the stem due to changes in natural hormone concentrations as well as type of cutting, i.e., softwood vs. semi-hardwood.

To further confuse the issue, on some plants it is very important to take cuttings that are on vertical or horizontal growth because if taken from the wrong place the nature of the plant may be changed. For example, cuttings taken from side branches on some shrubs and trees will always grow laterally or require long-term staking to ever grow vertically.

This is particularly common in some conifers that may never grow vertically or have needles completely surrounding stems if taken from side shoots. For our purposes, we will refer to three types of cuttings: softwood, semi-hardwood (sometimes called greenwood) and hardwood cuttings.

Most stem cuttings taken on herbaceous perennials will be softwood or semi-hardwood because few herbaceous plants, by definition, produce woody tissue. However, some older tissue on plants referred to as herbaceous perennials becomes sufficiently firm, particularly during dormant season, that growers will refer to cuttings as hardwood even though they are not technically hardwood cuttings.

A softwood or herbaceous cutting is taken when stem tissue is firm but easily wilts. These cuttings can often be snapped off because stems are still brittle or succulent. A semi-hardwood cutting comes from tissue that has started to firm whether it is producing “wood” or not. A hardwood cutting is fully hardened and contains no newly expanding growth. A hardwood cutting does not have to be taken from dormant growth although most hardwood cuttings, particularly on deciduous plants, are taken from dormant stems and may look like lifeless sticks.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The rooting environment

The race to keep cuttings alive until they can root and support themselves has prompted plant propagators to develop many creative ways to provide an environment that\ favours rooting. Light, temperature and moisture are usually the environmental factors most often manipulated.

Light:

Light can keep a stem cutting from rooting by either being too bright or too dark. Rarely is not enough light available, however multiple layers of white copolymer plastic or layers of white plastic and shade cloth may limit light levels to less than 70 meter candles, cause defoliation of cuttings and reduce rooting percentages.

More frequently, cuttings are exposed to excessive light intensities that can cause heat damage to shade grown leaves and desiccates cuttings during propagation. Remember that you are both trying to keep a cutting alive and also provide conditions most favourable for plant growth. Plants that normally grow in the shade often can be rooted at lower light levels than those that grow in the full sun.

Plants that normally grow in the full sun usually need some shade or other method of cooling to prevent excessive heating and drying out while a plant is rooting. For this reason it is common to root plants under 25 to 70% shade with 50% being the most common shading provided for rooting stem cuttings. Winter cuttings may require little or no shading while summer cuttings may require maximum shade.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The type of shade provided is usually not critical. However, some wood or lath shade may contain chemicals that will leach from the wood and harm plant growth. Usually the chemical in question is a wood preservative but galvanized metals have also been shown to leach zinc and, if propagating media is not replaced between crops, zinc can accumulate in propagating beds which may result in nutrient problems.

Many plants do not root well when they are flowering. Others must break bud and develop a flush of vegetative growth in order to survive winter. To encourage vegetative growth over flowering or to stimulate a new flush of vegetative growth on a recently rooted cutting, supplemental lighting is often used. Full spectrum lights such as “warm” fluorescent bulbs or incandescent light bulbs may be used.

These lights are generally turned on for a few hours during the night to cause plant light receptors to respond as if the plant was being exposed to short nights (long days). The brightness (intensity) of these lights is usually not an issue because cuttings are getting some normal daylight even when under rooting under artificial shade.

Temperature:

The most effective environment for rooting different plants may vary somewhat. However, the best temperature for stems and leaves, i.e., the part of the cutting that will be in the air above the propagating medium, is a temperature that allows normal photosynthesis and other plant life processes to occur.

However, it should not be so warm that the plant will lose excessive moisture or respire away any food stored in the cutting at the time the cutting was taken from the parent plant or food made through photosynthesis during the rooting process.

Most often, normal cool to warm greenhouse temperatures are maintained, depending upon the needs of the individual plant, with cooler air temperatures at night than during the day. Shading is used to reduce heat build-up during bright, sunny days.

Roots for most plants seem to develop best on cuttings where the rooting medium is kept between 20°C and 26°C. This will vary with species and also with the type of cutting and time of year. Often the rooting medium temperature will be warmer than the daytime air for late season and winter stem cuttings.

Supplemental bottom heat has been provided for rooting stem cuttings from a variety of sources during the past few centuries.

Composting manures were used beneath rooting beds at one time, steam from boilers or smoke and heat from fires has been directed under beds plus electrical resistance cables have been used.

The most common source of bottom heat currently used is warm water circulated through tubing placed at uniform intervals within or beneath the propagating medium with a temperature maintained at 23°C to 25°C for most cuttings.

The general rule of "cool tops and warm bottoms" is applied to rooting cuttings but bottom heat is not required for rooting most cuttings. It does, however, usually result in more rapid rooting and a more extensive root system when cuttings are being rooted during cooler seasons.

Moisture:

High humidity around the leaves and stems of softwood and semi-hardwood cuttings keeps the cutting from drying out and allows normal plant functions like photosynthesis and respiration to take place without the plant wilting while new roots are forming.

Under most propagation systems, roots are formed in a medium that has the proper balance of moisture and air space to allow for the development of healthy roots.

Propagation Facilities

Propagation facilities range from simple shaded outdoor polyethylene tents to elaborate temperature, humidity, CO_2, light and nutrient controlled state of the art chambers that for all appearances look like a tanning bed. Simple outdoor tents and mist frames can be very successful for propagation.

Direct sunlight must be avoided for shaded poly-tents to avoid extreme temperatures and desiccation of cuttings. Propagation trays can be placed inside frames or frames can be filled with propagation media. Adding an intermittent mist system to poly-tents or outdoor frames can improve rooting and provide greater flexibility in rooting cuttings.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Open sun propagation frames equipped with intermittent mist provide low cost facilities for summer propagation of a wide variety of broadleaved evergreens, deciduous shrubbery and conifers. Some screening may be needed to keep wind from blowing mist off cuttings for outdoor frames.

Recently, with the availability of new irrigation equipment technology and experienced sales representatives, nurseries have upgraded and retrofitted propagation structures with electronic controllers with infinite choices of time of misting and time between misting and environmental overrides. These controllers have capability to operate multiple solenoids in numerous sections of propagation houses.

Propagation houses have been converted to plastic mist nozzles suspended over cuttings, with stabilized weighted, spaghetti tubes to provide 100% overlapping mist coverage. Most nurseries have installed hot water tube bottom heat systems in part of their propagation houses.

Floors of these houses are graded into a center crown and covered with black plastic and ground cloth on which propagation trays are placed on the fabric. Some nurseries have gravel floors to set tray on and other nurseries have constructed raised benches or ground benches filled with propagation media covering hot water tube systems and misted by suspended plastic mist nozzles.

The propagation houses are covered with 1 or two layers of clear polyethylene film. Air circulation and ventilation in these structures is controlled thermostatically. Multiple zone equipped propagation houses provide great versatility for rooting many different nursery crops taken at different times yet all in one house under optimum rooting conditions simultaneously.

Other technically advanced propagation greenhouses are equipped with traveling booms that travel the entire length of a house, misting cuttings. As cutting root, nozzles can be changed to provide irrigation after mist is no longer needed. Traveling booms work well when entire houses are filled with cuttings stuck approximately the same time with one species or cultivars of one species such as entire houses of azalea cultivar cuttings.

Another innovation in propagation facilities are greenhouses equipped with high pressure fog systems that maintain nearly 100% humidity in greenhouses. Oscillating mist blowers have also been used to maintain fog in propagation houses. Fog systems are controlled by a humidistat rather than a timer.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Water quality requirements for intermittent mist propagation

Most commercial nurseries rely on mist delivery systems to maintain high humidity in propagation facilities. The orifices of mist nozzles are very small and therefore, require water supplies free of sediment and minerals. Ground water from wells or public water supplies are usually considered the cleanest water supplies and usually require only minimal filtration for removal of sediment.

However iron, iron bacteria and calcium bicarbonate are frequently contaminants even in these water supplies. Intermittent mist operating every 5 minutes during daylight hours through the first few weeks of cutting propagation adds up to thousands of mist applications and amplifies water quality impurities. Iron, iron bacteria or calcium bicarbonate residues coat cuttings and propagation facilities reducing aesthetics of cuttings and propagation facilities.

These residues also reduce light penetration into leaf chloroplasts, slow rooting and reduce rooting percentages. Chelating agents or oxidizing agents can be injected to reduce iron staining. Iron bacteria require injection of a disinfectant and possibly a chelating agent.

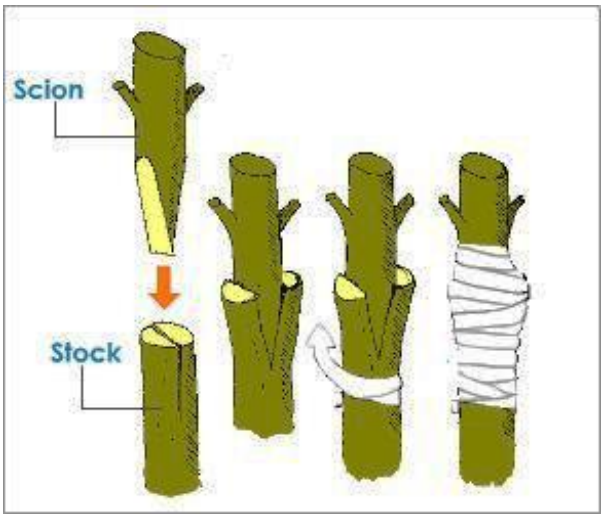
Chlorine or bromine can be used as disinfectants to kill iron bacteria and as oxidizing agents to reduce iron solubility and staining. They also will help control algae growth in propagation structures. Bicarbonate precipitation can be reduced by acidifying irrigation supplies. Sulphuric acid injection is generally recommended for this purpose.

Training Provider Accreditation Number: AGRI/c prov/0282/1

THE PROPOGATION PROCESS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Plants can be propagated, or multiplied, in several different ways. Most people are familiar with growing new plants from seeds, but new plants can also be created by cutting off a portion of an established plant. This "cutting" is placed in an environment that encourages it to produce new roots and/or stems, thus forming a new, independent plant.



There are several advantages to propagating plants using cuttings:

1. The new plant will be identical to the parent plant. For example, if the parent plant has variegated (multi-coloured) foliage, the new plant grown from the cutting will have the same foliage. If the parent plant is female (as a holly or ginkgo might be), the new plant will also be female. Propagating a plant by cuttings will allow you to keep the special characteristics of that plant. Plants grown from seed will often be different from the parent plant and from each other.
2. Propagating a new plant via cuttings avoids the difficulties of propagating by seed. For example, by using cuttings you could propagate a young tree that has not yet flowered (and thus has not yet produced seed), a male tree, or a sterile plant such as a navel orange. Additionally, some seeds are difficult to germinate, taking two to three years for the seedling to appear.
3. A new plant grown from a cutting will frequently mature faster and flower sooner than a plant grown from a seed.

Types of Cuttings

Cuttings can be made from any part of the plant. Most frequently, however, either a stem or leaf is used. A stem cutting includes a piece of stem plus any attached leaves or buds. Thus, the stem cutting only needs to

Training Provider Accreditation Number: AGRI/c prov/0282/1

form new roots to be a complete, independent plant. A leaf cutting uses just the leaf, so both new roots and new stems must be formed to create a new plant.

Stem Cuttings

Stem cuttings can be taken from both herbaceous plants (e.g., garden flowers and houseplants) and woody trees and shrubs. Because the new growth of trees and shrubs hardens as the summer progresses, cuttings taken at different times of the year vary in their ability to form roots. Softwood and herbaceous cuttings are the most likely to develop roots and become independent plants, hardwood cuttings the least likely.

1. Herbaceous

Stem cuttings from herbaceous plants can be taken any time the plant is actively growing.

2. Softwood

Softwood cuttings are prepared from soft, succulent new growth of woody plants just as it begins to harden (typically May through July). Shoots at the softwood stage will snap easily when bent. The youngest leaves have not yet reached their mature size.

3. Semi-hardwood

Semi-hardwood cuttings are taken from the current season's growth after the wood has matured. The wood is firm and all leaves are full size. This occurs in mid-July to early fall for most plants. Many broadleaf evergreens (e.g., boxwood, holly, rhododendron) can be propagated by semi-hardwood cuttings.

4. Hardwood

Hardwood cuttings are prepared from shoots that grew the previous summer. They are cut in winter or early spring while the plant is still dormant. The wood is firm and does not bend easily. Some deciduous shrubs and needled evergreens will root from hardwood cuttings.

Leaf Cuttings

Leaf cuttings are prepared by taking a single leaf from the plant. This leaf must generate not only new roots, but new shoots as well. The leaf used for propagation usually does not become part of the new plant, but disintegrates after the new plant is formed. Only a limited number of plants have the ability to produce new roots and shoots from just a leaf.

Root Cuttings

Cuttings taken from roots may also be used but only a few species can be propagated this way. Cuttings are taken when the plant is dormant and the roots contain the most stored energy. Each root produces two to three new stems and each stem then produces its own roots. The original root cutting disintegrates.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Propagation Basics

To successfully propagate plants from cuttings, a number of challenges must be overcome. Once a cutting is severed from the parent plant, it can no longer take up water, and excessive water loss will result in death. The wound from the cut makes it susceptible to diseases. New roots must be formed as rapidly as possible if the new plant is to survive.

Decreasing Water Loss

Start with cuttings that contain as much water as possible. Water the plant well the day before and take the cutting before the heat of the day reduces water content. Once the cutting is harvested, excessive water loss must be prevented.

To minimize water loss:

1. Process the cutting immediately. If this is not possible, stand the cut end in water or place the cutting in a plastic bag with a damp paper towel and store out of direct sun. If the plant is frost-tolerant, store the bagged cutting in the refrigerator.
2. For a stem cutting, remove some of the leaves. Most of the water will be lost through the leaves, so by decreasing the leaf surface you also decrease the amount of water loss. A general rule of thumb is to remove 1/2 to 2/3 of the leaves. Cut remaining leaves in half if they are large.
3. Once the cutting has been prepared and placed in the rooting mix, enclose the pot in a plastic bag. Insert straws or wooden sticks around the edge of the pot to hold the bag away from the cutting. Place the pot in a bright area, but out of direct sunlight, so the leaves will receive the light they need but the plant will not get overly hot. The plastic bag insures that humidity around the leaves remains high, which slows the rate of water loss.

Preventing Disease

Take cuttings only from healthy plants. To prevent the spread of disease, use clean tools and pots (clean with 10% bleach, rinse, and let dry thoroughly). Use fresh soilless potting mix since garden soil can harbor plant diseases.

Encouraging Root Formation

Just like leaves, the roots of plants need air to live. Rooting mix that is continuously waterlogged is devoid of air and cuttings will rot rather than form roots. A mixture of 50% vermiculite/50% perlite holds sufficient air and water to support good root growth, but any well-drained soilless potting mix is acceptable. If your cuttings

frequently rot before they root, you know the mix is staying too wet. Add vermiculite or perlite to increase its air- holding capacity.

Cuttings use energy to form new roots. If the cutting has leaves, most of the energy comes from photosynthesis. Expose these cuttings to bright light, but not direct sunlight, during the rooting period. If you use hardwood cuttings that have no leaves, the energy will come from reserves stored in the woody stem.

For best results, select shoots that are robust for the species. Since you want all the energy to go into the new roots, make sure you cut off any flowers or fruits that would compete for energy.

Auxin, a naturally occurring plant hormone, stimulates root formation. Several synthetic forms of auxin are sold as "rooting hormone." Though some plants will root readily without treatment, application of rooting hormone to the base of the cutting will often improve your chance for success. Two synthetic auxins, IBA (indolebutyric acid) and NAA (naphthaleneacetic acid) are most frequently used.

They are available in several concentrations and in both liquid and powder form. 1,000 ppm (0.1%) is used most often for herbaceous and softwood cuttings; 3,000 ppm (0.3%) and 8,000 ppm (0.8%) are used for semi-hardwood and hardwood cuttings. Liquid formulations can be used at low or high concentration for softwood or hardwood cuttings, respectively.

To determine the appropriate concentration for your cutting, follow the instructions on the product label and the general guidelines just given, or consult the references listed at the end of this publication. To use rooting hormone, place the amount needed in a separate container. Any material that remains after treating the cuttings should be discarded, not returned to the original container.

These precautions will prevent contamination of the entire bottle of rooting hormone. Cuttings will root more quickly and reliably in warm rooting mix. Keep your cuttings between 18°*C* and 23°*C*, avoiding excessive heat. If your area is too cold, consider a heating mat or cable especially designed for this purpose.

How to make herbaceous and softwood stem cuttings

Many houseplants, annuals, perennials, and woody plants can be propagated by stem cuttings when they are in active growth and the stems are soft.

Training Provider Accreditation Number: AGRI/c prov/0282/1

1. Cut off a piece of stem, 5-15 centimeters long. There should be at least three sets of leaves on the cutting.

2. Trim the cutting in the following way:

a. Make the bottom cut just below a node (a node is where the leaf and/or the bud joins the stem) (top figure).

b. Remove 1/2 to 2/3 of the leaves, starting from the bottom of the cutting. Cut large leaves in half (middle figure).

c. Remove all flowers, flower buds, and fruit.

3. (Optional) Dip the lower inch of the cutting in rooting hormone.

4. In a pot of damp, but drained, rooting mix, make a hole for the cutting using a pencil. Put the cutting in the hole and firm the rooting mix around it. If any leaves are touching the surface of the mix, trim them back. Several cuttings can be placed in the same pot as long as their leaves do not touch.

5. Enclose the pot in a plastic bag, making sure the bag does not touch the leaves.

6. Place the pot in a warm, bright spot but out of direct sunlight. Every few days, check the rooting mix to make sure it is damp, and water as necessary. Discard any water that collects in the bottom of the bag.

Training Provider Accreditation Number: AGRI/c prov/0282/1

7. After two or three weeks, check to see if roots have formed by working your hand under the cutting and gently lifting (bottom figure). If no roots have formed, or if they are very small, firm the cutting back into the mix, re-bag, and check for roots again in one to two weeks.

8. Once roots have formed, slowly decrease the humidity around the plant by untying the plastic bag and then opening it a little more each day. When it is growing well without a plastic bag, pot in a good quality potting mix and move to its permanent location.

How to make semi-hardwood cuttings

Follow the same steps as described for herbaceous cuttings. Semi-hardwood cuttings may need a higher level of rooting hormone and may take longer to form roots. Wounding the base of the cutting sometimes stimulates root initiation (see Step 5 in "How to Make a Hardwood Cutting" below).

How to make hardwood cuttings

Take hardwood cuttings in winter or early spring. Deciduous plants (those that lose their leaves every winter) have no leaves at this time. Thus, water loss is not a serious problems with these cuttings, unless the buds open.

Hardwood cuttings are more difficult to root than softwood cuttings, and it may take two to four months for roots to form. The technique does work well with some shrubs such as forsythia, privet, and willow. Needled evergreens can also be propagated using hardwood cuttings, but care must be taken to reduce water loss.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Preparing Deciduous Hardwood Cuttings

1. Select a robust stem.

2. Cut off a length of stem that was formed over the past summer (depending on species, it may be 30-60 centimeters long).

3. Trim the cutting in the following way:

a. Working from the base of the stem, cut just below a node (top figure).

b. With a pencil, gently make a line 5 centimeters above this cut. The portion of the stem between the cut and the line will be in the rooting mix (middle figure).

c. Make a second cut 5-15 centimeters above the line, making sure that this segment contains at least two buds.

4. Remove buds from the bottom 2 inches of the stem so they will not grow during the rooting period.

5. Wound the cutting by removing two 1-inch slices of bark from opposite sides of the base of the stem. Cut deeply enough to expose the green layer under the bark, but not so deeply that the stem is cut in half (bottom figure).

6. Apply rooting hormone to the lowest 2 centimeters of stem and place it into damp rooting mix up to the pencil line. Firm the rooting mix around it.

Training Provider Accreditation Number: AGRI/c prov/0282/1

7. It may be possible to get two to five cuttings from each stem. Repeat steps three through six if the remaining stem is long enough. Make sure you keep track of which end of the cutting is the base and which is the top. The base of the cutting, not the top, should always be the end placed in the rooting mix.

8. There are now two options, depending on the facilities and equipment available.

a. If you have a cold garage and a heating system to warm the rooting mix, place the pot on the heating system in the cold garage. The cold air will keep the buds from opening and forming leaves, and the heater will keep the mix warm enough for roots to form (18-24°*C*). It is acceptable for the air temperature to go below freezing as long as the heater can keep the rooting mix between 18°*C* and 24°*C*.

b. If you do not have a cold garage with a heating system, place the pot in a plastic bag as you would for herbaceous cuttings, and place in a warm room. In two or three weeks the buds will open, but the plastic bag should keep humidity around the leaves high and prevent excess water loss. Make sure the pot is in a bright spot, that it does not overheat, and that the rooting mix is moist but not waterlogged.

9. Check for roots every two to three weeks.

10. Acclimate rooted cuttings to warmer, less humid conditions as described for softwood cuttings (Step #8).

Training Provider Accreditation Number: AGRI/c prov/0282/1

Preparing needled evergreen cuttings

Needled evergreens are often propagated as hardwood cuttings. Because they still have leaves (needles), these cuttings are handled in a different manner than hardwood cuttings of deciduous plants.

1. Use shoot tips only, making the cutting 18-24 centimeters long.

2. Remove the needles from the bottom 7-10 centimeters of the cutting. To reduce water loss, trim the remaining needles so that they just cover the palm of your hand (top figure).

3. Wound the base of the cutting by drawing a knife point down the lower inch of stem on two sides (bottom figure). Cut into the stem but do not split it. Apply rooting hormone to the lower inch of the stem and place about 5 centimeters of the stem into the rooting mix, making sure that no needles touch the surface of the mix. Firm the mix around it.

The potted cuttings may be placed in an unheated area with a heating element to warm the rooting mix if the area is well lit. If not, cover the pot and cuttings with a plastic bag and place in a warm, brightly lit room, as with deciduous hardwood cuttings.

Providing light is essential for successful rooting of these cuttings. Check for roots once a month. It may take three or four months for roots to develop. Acclimate rooted cuttings as described above.

Training Provider Accreditation Number: AGRI/c prov/0282/1

How to make specialized stem cuttings

Some houseplants can be propagated most easily using these variations of stem cuttings.

Cane

Cane cuttings are used for *Dieffenbachia*, *Dracaena* (including corn plant), and other plants with thick stems. The stem, or cane, is cut into segments and placed into rooting mix. New shoots emerge from the buds that are on the cane; roots grow from the portion of the cane in the rooting mix (top figure). The initial absence of leaves reduces water loss.

1. Cut the cane into segments that contain several buds (usually 5-8 centimeters in length).

2. Select a healthy bud and place the cane horizontally into the rooting mix so that this bud points up and only the bottom half of the cane is in the rooting mix. The portion of the cane placed in the rooting mix may be treated with rooting hormone.

3. Alternately, the end of the cane closest to the base of the plant can be treated with rooting hormone. The cutting is then placed into the rooting mix vertically, about 1.5 centimeters deep (bottom figure).

Training Provider Accreditation Number: AGRI/c prov/0282/1

Leaf-bud

Leaf-bud cuttings use just a small portion of the stem (up to 4 centimeters) that contains a single bud and single leaf. The stem portion produces roots, and a new shoot develops from the bud (figure on the right). Treat the stem with rooting hormone, then place in rooting mix so that the bud is below the surface and the leaf is exposed to light.

This method is used with grape ivy, geranium, philodendron, English ivy, and the fleshy-leaved peperomias. Since both types of specialized stem cuttings will lose water easily, place the pot in a plastic bag until roots form.

Training Provider Accreditation Number: AGRI/c prov/0282/1

How to Make Leaf Cuttings

Some plants can be propagated from just a single leaf. Many of these plants have compressed stems, making it impossible to take stem cuttings. These include African violets, bush-type peperomias, and Sansevieria. Some succulents, such as jade plant and jelly bean plant, can also be propagated from a single leaf.

Leaf Petiole

African violets and bush-type peperomias are propagated from the whole leaf, that is, the blade (the flat part of the leaf) plus the petiole (the leaf stalk). Break off a robust leaf, trim the petiole so it is no more than an inch long, apply rooting hormone, and sink the petiole into the rooting mix.

The base of the leaf blade should just touch the mix (top figure). Place the pot in a plastic bag in a bright spot. In a few weeks roots will form and new plantlets will develop from these roots.

When they are large enough to handle, gently divide them, making sure each plantlet has roots, and plant in individual containers. A single leaf will give rise to several small plantlets (bottom figure).

Training Provider Accreditation Number: AGRI/c prov/0282/1

Leaf Blade

Some succulent plants (for example, jade plant and j

Training Provider Accreditation Number: AGRI/c prov/0282/1

These leaves can simply be broken off the stem, the broken end dipped in rooting hormone, and the leaf inserted about 1/3 of its length into rooting mix.

Since these plants are very sensitive to excess water, make sure the rooting mix stays damp but DO NOT enclose the pot in a plastic bag. Roots and then new shoots will develop at the base of the leaf and can be separated into individual plantlets (second from top figure).

If the leaves rot instead of root, start over with fresh cuttings and media, add vermiculite or perlite to your rooting mix, and water only when the upper 1 centimetre of mix has dried.

Although not a succulent, Rex begonias can also be propagated from just the leaf blade. Two techniques can be used.

Method 1: With a knife cut the major veins on the underside of the leaf (second from bottom figure). Dust with rooting hormone. Place the leaf flat onto a bed of rooting mix, underside down. Use small wire hairpins or bent paperclips to hold the leaf firmly against the rooting mix (bottom figure).

Training Provider Accreditation Number: AGRI/c prov/0282/1

Method 2: Roll up the leaf blade, dip the base in rooting hormone, and insert about 1/3 of the roll into the rooting mix. Place extra mix into the center of the leaf roll to hold it in place (top figure). Rolling should break some of the veins, so cutting is not required. For both methods, enclose the pot in a plastic bag as with softwood cuttings. Check the pot frequently to make sure the veins are in contact with the rooting mix. If the leaf pulls away from the mix, no roots or plantlets will form. Each wound in a major vein will give rise to roots and small plantlets (second from top figure). Transplant each plantlet into a separate pot when large enough to handle (second from bottom figure).

Leaf Section

Sansevieria, or mother-in-law's tongue, has long, sword-like leaves attached to a compressed stem. Cut off one of the leaves at its base, then cut it into 5-10 centimetre inch segments. Dip the basal end (the end of the segment that was closest to the base of the plant) of each segment in rooting hormone and then insert 3-7 centimetres into the rooting mix. If the segments are put into the mix upside down, no roots will form. Put the pot in a plastic bag and place in a bright spot. After several weeks, first roots, then shoots, will develop at the base of the cutting (bottom figure). Each new shoot with roots can become a separate plant.

How to Make Root Cuttings

Though very few plants can be propagated from root cuttings (for example, oriental poppy, phlox, and horseradish), the technique is simple and should be tried if you wish to propagate these species. When the plant is dormant, dig it up and cut off robust segments of the root, 5-10 centimetres long (replant the parent plant). If the roots are thin, lay them horizontally on the rooting mix and cover with 1cm of the damp mix. If the roots are thick, lay them horizontally or place them vertically into the rooting mix, covering them completely. If placing the root vertically, make sure the end of the cutting that was nearest the crown of the plant points up. Put the

Training Provider Accreditation Number: AGRI/c prov/0282/1

pot in a plastic bag and place in a bright spot. In several weeks, shoots should emerge from the rooting mix. Keep the pot in the plastic bag until new roots have formed on the shoots.

Activity – in your groups

In your groups, discuss and answer the following questions:

Part 1 – Safety practices

What personal protective clothing and equipment must be used worn to while propagating plants?

What are the safe use cutting methods of "cutting" knives and secateurs?

How should hazardous chemicals be handled to ensure safety?

Why is it important to report a safety incident?

What are the benefits of utilising good housekeeping practices in terms of the role that these procedures play in minimizing the occurrence of safety incidents?

Training Provider Accreditation Number: AGRI/c prov/0282/1

Part 2 – Hygiene practices

What is the importance of maintaining good personal hygiene when cutting conducting stems cuttings in terms of the potential health risks to workers if these are ignored?

Why is it important to adhere to plant hygiene practices in respect of the various ways in which plant diseases and viruses can be transmitted in the cutting environment?

What are the potential dangers that plant diseases and viruses pose, in terms of the detrimental effects that these have on the crop/batch of plants that are being propagated?

How should cutting equipment be cleaned and sanitised after their use?

Part 3 – Stem cuttings from soft-wood

Identify and explain the objectives of taking a softwood cutting in respect of the processes that promote growth in the cutting.

Research and give examples of commonly used softwood plant material in terms of their ease of "take" and propagation.

Explain how softwood plant material must be prepared for cuttings

Explain the importance of using the correct tools to take cuttings in respect of the cleanness of cut and stem protection given by these tools

Part 4 – Stem cuttings from semi hard-wood

Identify and explain the objectives of taking a semi-hardwood cutting in respect of the processes that promote growth in the cutting.

Research and give examples of commonly used semi-hardwood plant material in terms of their ease of "take" and propagation.

Explain how semi-hardwood is prepared for cutting.

Explain the importance of using the correct tools to take cuttings in respect of the cleanness of cut and stem protection given by these tools

Part 5 – Taking care of stem cuttings

Identify and explain the importance of keeping the cuttings moist in terms of maintaining a suitable environment to encourage rooting.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Identify and explain the procedure for the inspection and the reasons for regular removal of dead and rotted cuttings

Identify and explain the importance of regularly checking for the presence of pests and disease amongst the cuttings by referring to the danger to the batch/crop that can occur if the corrective actions are not timeously implemented.

Identify and explain the necessity of conducting periodic checks of the cutting's status, in terms of the need to confirm when rooting has taken place.

You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ **Select and prepare the cutting material**
- ☐ **Utilise the tools and equipment to perform stem cuttings**
- ☐ **Perform cuttings with various stem types**
- ☐ **Provide primary care for stem cuttings**

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

_____
_____
_____
_____
_____
_____
_____
_____

Training Provider Accreditation Number: AGRI/c prov/0282/1

CREATE AN AWARENESS OF ENVIRONMENTAL PROTECTION

119701

A person credited with this unit standard will be able to:

- Show sensitivity to the protection of the environment
- Recognise the dangers of pollution
- Apply the preventative practices to minimize pollution
- Utilize the environmental protective principles in landscape maintenance

THE EXTENT OF ENVIRONMENTAL AND AIR POLLUTION

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

What is pollution?

Pollution means any contamination of air, soil, water and environment. Why, even loud noise and sound is also a part of pollution. Nowadays humans live facing lots of problems in their life. One of the major problems is pollution. Pollution is nothing but the contamination of our air by harmful substances and wastages or the unwanted things which is added to the natural contents like air, water and etc..

Air pollution - Harmful gases and tiny particles (like carbon monoxide, nitrogen dioxide and sulphur dioxide) when released into the air pollute the air. The smoke released from burning fuel, from factories and not to forget the motor cars are the major sources of air pollution. Air pollution is one of the major causes of that funny cough, asthma and burning eyes that you develop.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Water pollution- All that dirty water from our house drains through the pipes into river, oceans dirtying the water. Can you imagine all those chemicals from factories draining into the river? And that is the water that you drink. Think about all the diseases that you can get from drinking such water

Land pollution -All that plastic and dirt that you throw on the ground dirties the land and when you don't maintain the hygiene, then disease prevails.

Noise pollution - You want to listen to head banging rock music and your parents orbit into the space. But have you thought about your dear little sensitive ears? How much can they take?

Not much and the effect is seen within a few years when you can't hear what people say. You land up becoming deaf. Not to mention other problems like high blood pressure and other diseases that you develop. In this section we will take a closer look at air pollution and the various ways that it affects us in our workplaces, homes and in the general environment around us.

Air pollution

Air is the ocean we breathe. Air supplies us with *oxygen* which is essential for our bodies to live. Air is 99.9% nitrogen, oxygen, water vapour and inert gases. Human activities can release substances into the air, some of which can cause problems for humans, plants, and animals.

There are several main *types* of pollution and well-known *effects* of pollution which are commonly discussed. These include smog, acid rain, the greenhouse effect, and "holes" in the ozone layer. Each of these problems has serious implications for our health and well-being as well as for the whole environment.

One type of air pollution is the release of **particles** into the air from burning fuel for energy. Diesel smoke is a good example of this *particulate matter*. The particles are very small pieces of matter measuring about 2.5 microns or about .0001 centimeters.

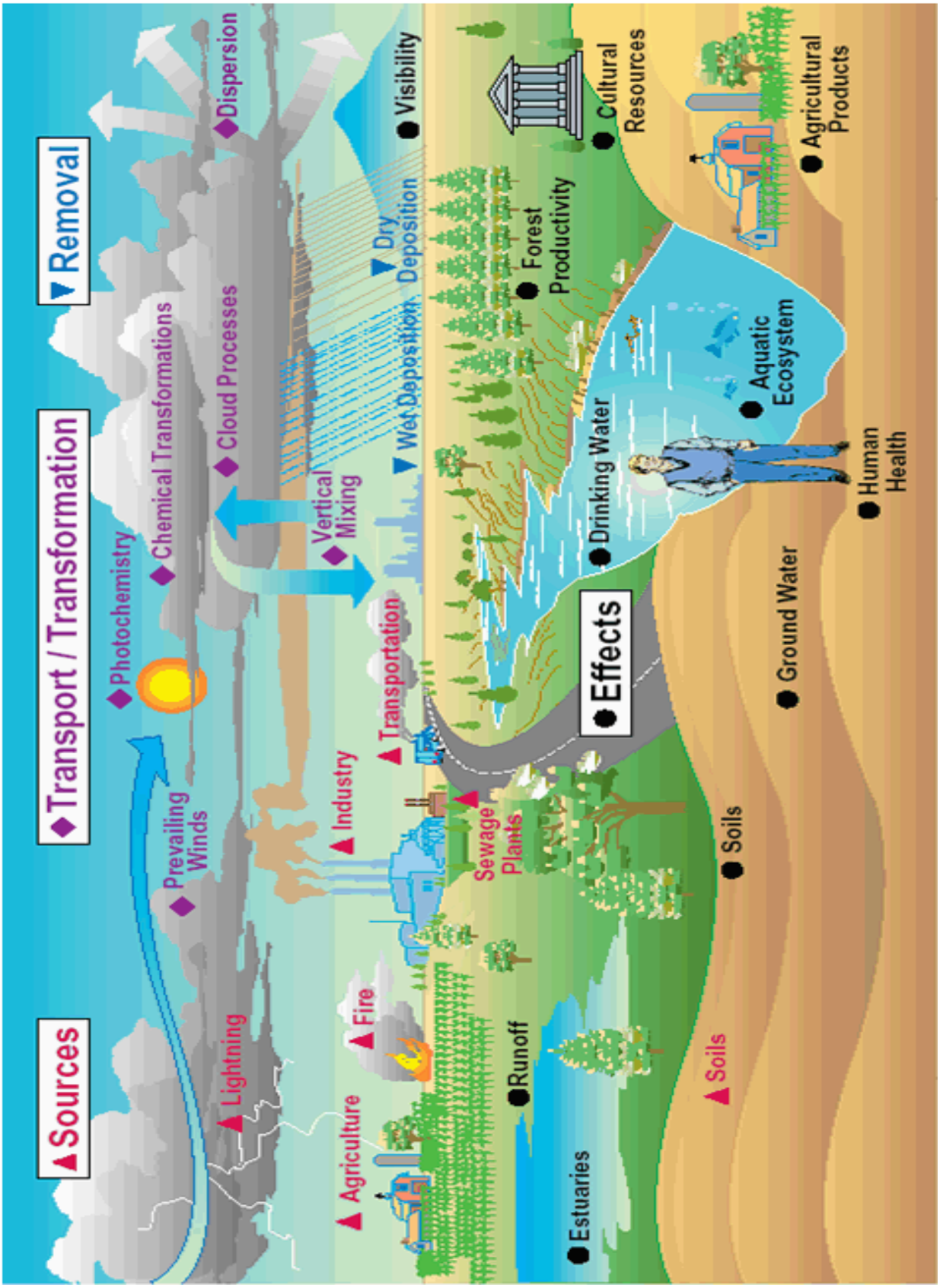
This type of pollution is sometimes referred to as "black carbon" pollution. The exhaust from burning fuels in cars, homes, and industries is a major source of pollution in the air. Some authorities believe that even the burning of wood and charcoal in fireplaces and braais can release significant quantities of soot into the air.

Another type of pollution is the release of **noxious gases**, such as sulphur dioxide, carbon monoxide, nitrogen oxides, and chemical vapours. These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain. The picture above indicates the results of smog in the air.

Pollution also needs to be considered *inside* our homes, offices, and schools. Some of these pollutants can be created by indoor activities such as smoking and cooking. In the United States, we spend about 80-90% of our time inside buildings, and so our exposure to harmful indoor pollutants can be serious. It is therefore important to consider both indoor and outdoor air pollution. Air pollution affects everyone. Every day, the average adult breathes over 12,000 liters of air

Training Provider Accreditation Number: AGRI/c prov/0282/1

Below you can see the various effects that air pollution has on our daily lives.



The major types of air pollution are:

Gaseous pollutants: A different mix of vapours and gaseous air pollutants is found in outdoor and indoor environments. The most common gaseous pollutants are carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, sulphur oxides and ozone. A number of sources produce these chemical compounds but the major man-made source is the burning of fossil fuel. Indoor air pollution is caused by cigarette smoking, the use of certain construction materials, cleaning products, and home furnishings. Outdoor gaseous pollutants come from volcanoes, fires, and industry, and in some areas may be substantial. The most commonly recognized type of air pollution is smog. Smog generally refers to a condition caused by the action of sunlight on exhaust gases from motor vehicles and factories.

The **Greenhouse effect** prevents the sun's heat from rising out of the atmosphere and flowing back into space. This warms the earth's surface causing the greenhouse effect. While a certain amount of greenhouse gases in the atmosphere are necessary to make the earth warm, activities such as the burning of fossil fuels are creating a gaseous layer that is too dense to allow the heat to escape. Many scientists believe this is causing global warming. Other gases contributing to the problem include chlorofluorocarbons (CFC), methane, nitrous oxides, and ozone.

Acid rain forms when moisture in the air interacts with nitrogen oxide and sulphur dioxide released by factories, power plants, and motor vehicles that burn coal or oil. This interaction of gases with water vapour forms sulphuric acid and nitric acids. Eventually these chemicals fall to earth as precipitation, or acid rain. Acid rain pollutants may travel long distances, with winds carrying them thousands of miles before they fall as dew, drizzle, fog, snow or rain.

Damage to the ozone layer is primarily caused by the use of chlorofluorocarbons (CFCs). Ozone is a form of oxygen found in the earth's upper atmosphere. The thin layer of ozone molecules in the atmosphere absorbs some of the sun's ultraviolet (UV) rays before it reaches the earth's surface, making life on earth possible. The depletion of ozone is causing higher levels of UV radiation on earth, endangering both plants and animals.

Particulate matter is the general term used for a mixture of solid particles and liquid droplets found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. When particulate matter is breathed in, it can irritate and damage the lungs causing breathing problems. Fine particles are easily inhaled deeply into the lungs where they can be absorbed into the blood stream or remain embedded for long periods of time.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Climatic effects: Normally pollutants rise or flow away from their sources without building up to unsafe levels. Wind patterns, clouds, rain, and temperature can affect how quickly pollutants move away from an area. Weather patterns that can trap air pollution in valleys or move it across the globe may be able to damage pristine environments far from the original sources.

Millions of people live in areas where urban smog, very small particles, and toxic pollutants pose serious health concerns. These health concerns can stem from either short-term or long-term exposure to air pollution. When people have a short-term exposure to air pollutants above certain levels, they may experience temporary health concerns, such as eye irritation and burning, throat irritation, and difficulty breathing.

Long-term exposure to air pollution can cause chronic health concerns, such as cancer and damage to the body's immune, neurological, reproductive, and respiratory systems. The problem of air pollution is also found outside of major urban centres.

Air pollution can be wide-ranging as well as persistent. Many air pollutants, such as those that form urban smog and toxic compounds, remain in the environment for long periods of time. These air pollutants can also be carried hundreds of miles by winds and can thus affect areas far-removed from the source of the pollution.

Children are very sensitive to the effects of air pollution. Children's lungs are still developing and polluted air may contribute to permanent lung damage. Children breathe more rapidly than do adults, and inhale more pollution per pound of body weight than adults. Therefore, their lungs have a greater chance for being exposed to harmful air pollutants.

How do we measure this?

The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health affects you may experience within a few hours or days after breathing polluted air.

In America the EPA (Environmental Protection Act) calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulphur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health .Ground-level ozone and airborne particles are the two pollutants that pose the greatest threat to human health

Training Provider Accreditation Number: AGRI/c prov/0282/1

Each category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- "Good" AQI is 0 - 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- "Moderate" AQI is 51 - 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- "Unhealthy for Sensitive Groups" AQI is 101 - 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. .
- "Unhealthy" AQI is 151 - 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects. .
- "Very Unhealthy" AQI is 201 - 300. This would trigger a health alert signifying that everyone may experience more serious health effects.
- "Hazardous" AQI greater than 300. This would trigger health warnings of emergency conditions. The entire population is more likely to be affected.

Air Quality Index (AQI) Values) *When the AQI is in this range:*	Levels of Health Concern *...air quality conditions are:*	Colors *..as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Training Provider Accreditation Number: AGRI/c prov/0282/1

AQI colours

EPA has assigned a specific colour to each AQI category to make it easier for people to understand quickly whether air pollution is reaching unhealthy levels in their communities. For example, the colour orange means that conditions are "unhealthy for sensitive groups," while red means that conditions may be "unhealthy for everyone," and so on.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

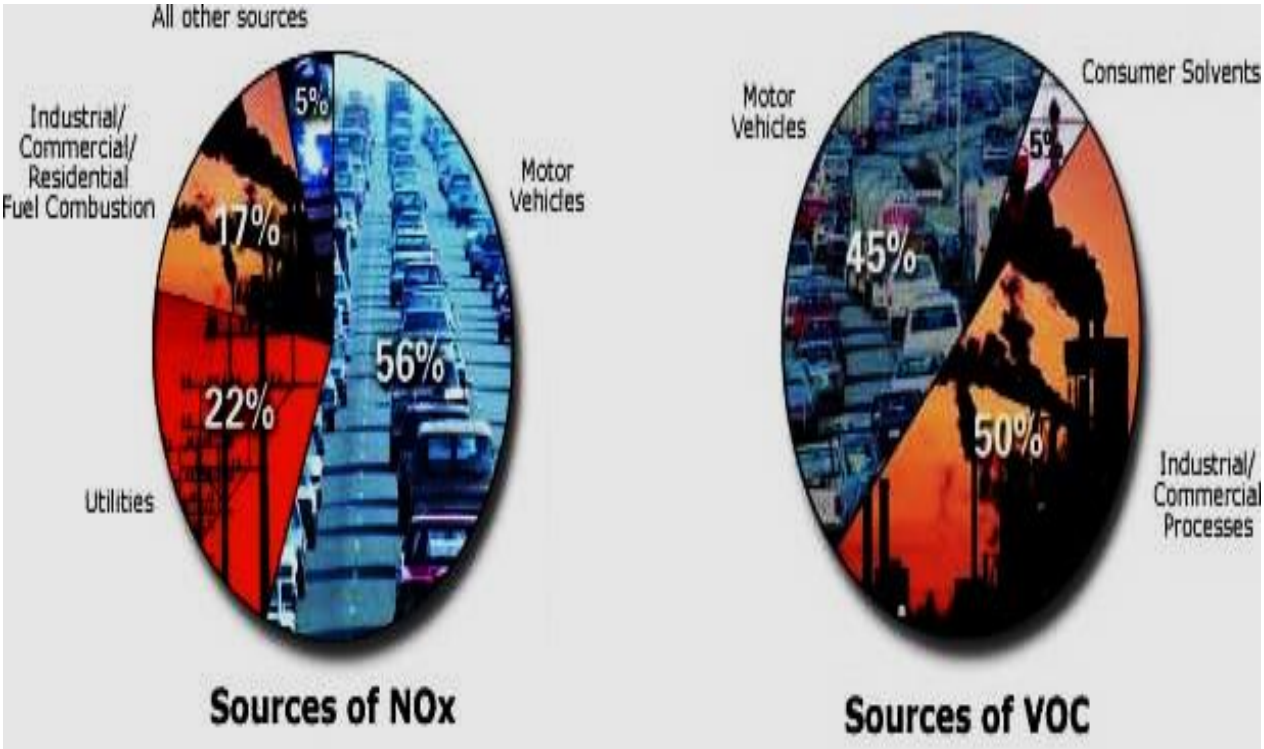
Smog

Smog is a kind of air pollution; the word "smog" is a portmanteau (a word or morpheme that fuses two or more words or word parts to give a combined or loaded meaning) of smoke and fog. "Smog" refers to a noxious mixture of air pollutants that can often be seen as a haze in the air. It often stays for an extended period of time over densely populated cities or urban areas, such as Johannesburg, London, New York, Los Angeles, Mexico City, Houston, Toronto, Athens, Beijing and Hong Kong.

A temperature inversion occurs when air close to the earth is cooler than the air above it. Under these conditions the pollution cannot rise and be dispersed. Cities surrounded by mountains also experience

trapping of pollution. Inversion can happen in any season. Winter inversions are likely to cause particulate and carbon monoxide pollution. Summer inversions are more likely to create smog.

Smog can make breathing more difficult, even for healthy people, and it can make us more susceptible to cardio-respiratory diseases. Even healthy young adults breathe less efficiently on days when the air is heavily polluted, especially if exercising outdoors. Particularly vulnerable to smog are people with heart or lung disease, the elderly and small children. The two main ingredients in smog that affect our health are ground-level ozone and fine airborne particles.



Airborne Particles

Airborne particles are microscopic and remain suspended in the air for some time. Particles can be both primary pollutants and secondary pollutants, sent directly into the atmosphere in the form of windblown dust and soil, sea salt spray, pollen and spores. Secondary particles are formed through chemical reactions involving nitrogen oxides, sulphur dioxide, VOCs and ammonia.

Particles give smog its colour and affect visibility. Depending on the type of particles, the air can appear yellowish-brown, or even white. Like ozone, particles are believed to have adverse effects on vegetation, and on various synthetic and natural surfaces. .

Training Provider Accreditation Number: AGRI/c prov/0282/1

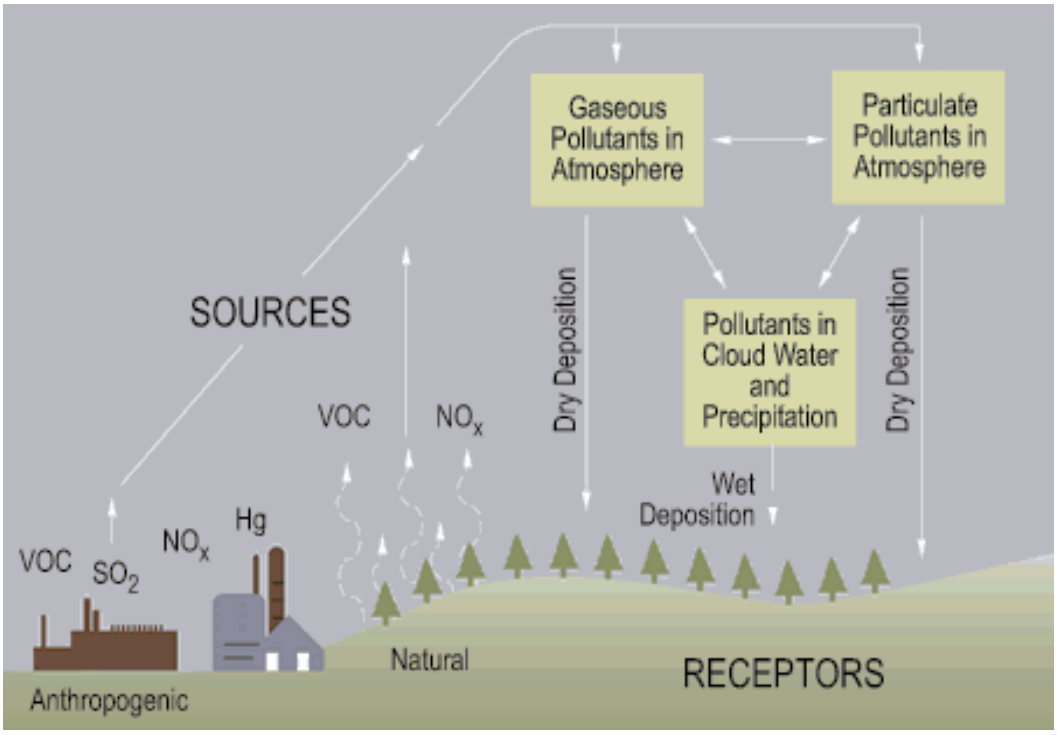
Other Pollutants in Smog

Nitrogen Dioxide (NO_2) is a principal member of the family of nitrogen oxides (NOx). It is a toxic, irritating gas that results from all combustion processes. Sulphur dioxide (SO_2) is a colourless gas that smells like burnt matches. It can be chemically transformed into acidic pollutants such as sulphuric acid and sulphates (sulphates are a major component of fine particles).

The main sources of airborne SO_2 are coal-fired power generating stations and non-ferrous ore smelters. Sulphur dioxide is also the main cause of acid rain, which can damage crops, forests and whole ecosystems. Carbon Monoxide (CO) is a colourless, odourless and tasteless gas that comes primarily from automobile emissions.

Acid rain

"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulphuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulphur dioxide (SO2) and nitrogen oxides (NOx) resulting from fossil fuel combustion. In the South Africa, roughly 2/3 of all SO2 and 1/4 of all NOx that come from electric power generation relies on burning fossil fuels, like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and



other chemicals to form various acidic compounds. The result is a mild solution of sulphuric acid and nitric acid. When sulphur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of kilometers.

Wet Deposition

Wet deposition refers to acidic rain, fog, and snow. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic water flows over and through the ground, it affects a variety of plants and animals.

The strength of the effects depends on several factors, including how acidic the water is; the chemistry and buffering capacity of the soils involved; and the types of fish, trees, and other living things that rely on the water.

Dry Deposition

In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff. This runoff water makes the resulting mixture more acidic. About half of the acidity in the atmosphere falls back to earth through dry deposition.

Acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations (for example, trees above 700 meters) and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.

Prior to falling to the earth, sulphur dioxide (SO2) and nitrogen oxide (NOx) gases and their particulate matter derivatives, sulphates and nitrates, contribute to visibility degradation and harm public health.

Some of the problems attributed to acid rain include:

- Trees lose some of the protection in their leaves, leaving them more at risk from frost and diseases.
- Tree roots may also become stunted, so they can't take up as many nutrients.
- Soils lose some of their nutrients.
- Increasing acid levels may cause problems for aquatic animals and plants. Some fish may have trouble breathing for example.

- Acid rain may dissolve the stonework and mortar of buildings causing structural problems of buildings.

How Acid Rain Harms Trees

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil. Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats.

Scientists know that acidic water dissolves the nutrients and helpful minerals in the soil and then washes them away before trees and other plants can use them to grow. At the same time, acid rain causes the release of substances that are toxic to trees and plants, such as aluminium, into the soil. The picture above shows the extent of damage which acid rain has on trees.

Scientists believe that this combination of loss of soil nutrients and increase of toxic aluminium may be one way that acid rain harms trees. Such substances also wash away in the runoff and are carried into streams, rivers, and lakes. More of these substances are released from the soil when the rainfall is more acidic.

However, trees can be damaged by acid rain even if the soil is well buffered. Forests in high mountain regions often are exposed to greater amounts of acid than other forests because they tend to be surrounded by acidic clouds and fog that are more acidic than rainfall.

Scientists believe that when leaves are frequently bathed in this acid fog, essential nutrients in their leaves and needles are stripped away. This loss of nutrients in their foliage makes trees more susceptible to damage by other environmental factors, particularly cold winter weather.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Human Health

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain, sulphur dioxide (SO2) and nitrogen oxides (NOx), do damage human health.

These gases interact in the atmosphere to form fine sulphate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

Decreases in NOx emissions are also expected to have a beneficial impact on human health by reducing the nitrogen oxides available to react with volatile organic compounds and form ozone. Ozone impacts on human health include a number of morbidity and mortality risks associated with lung inflammation, including asthma and emphysema.

Wet Deposition

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This runoff water makes the resulting mixture more acidic. About half of the acidity in the atmosphere falls back to earth through dry deposition.

The Greenhouse Effect

The Greenhouse Effect, also referred to as global warming, is generally believed to come from the build-up of carbon dioxide gas in the atmosphere. Carbon dioxide is produced when fuels are burned. Plants convert carbon dioxide back to oxygen, but the release of carbon dioxide from human activities is higher than the world's plants can process.

The situation is made worse since many of the earth's forests are being removed, and plant life is being damaged by acid rain. Thus, the amount of carbon dioxide in the air is continuing to increase. This build-up acts like a blanket and traps heat close to the surface of our earth.

Changes of even a few degrees will affect us all through changes in the climate and even the possibility that the polar ice caps may melt. (One of the consequences of polar ice cap melting would be a rise in global sea level, resulting in widespread coastal flooding.)

Ozone depletion

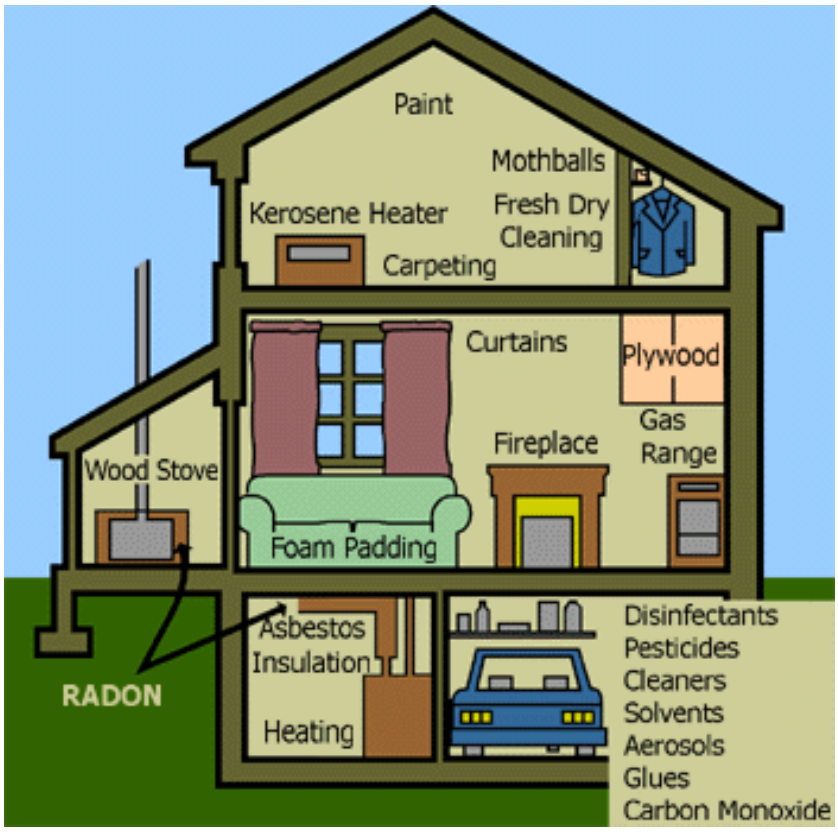
Ozone depletion is another result of pollution. Chemicals released by our activities affect the stratosphere , one of the atmospheric layers surrounding earth. The ozone layer in the stratosphere protects the earth from harmful ultraviolet radiation from the sun.

Release of chlorofluorocarbons (CFC's) from aerosol cans, cooling systems and refrigerator equipment removes some of the ozone, causing "holes"; to open up in this layer and allowing the radiation to reach the earth. Ultraviolet radiation is known to cause skin cancer and has damaging effects on plants and wildlife.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Indoor air pollution

We usually think of air pollution as being outdoors, but the air in your house or office could also be polluted.



Sources of indoor pollution include Biological contaminants like mould and pollen Tobacco smoke Household products and pesticides Gases such as radon and carbon monoxide Materials used in the building such as asbestos, formaldehyde and lead

The levels of pollutants in the air inside homes, schools, and other buildings can be higher than the level of pollutants in the outdoor air. Indoor air pollution comprises a mixture of contaminants penetrating from outdoors and those generated indoors.

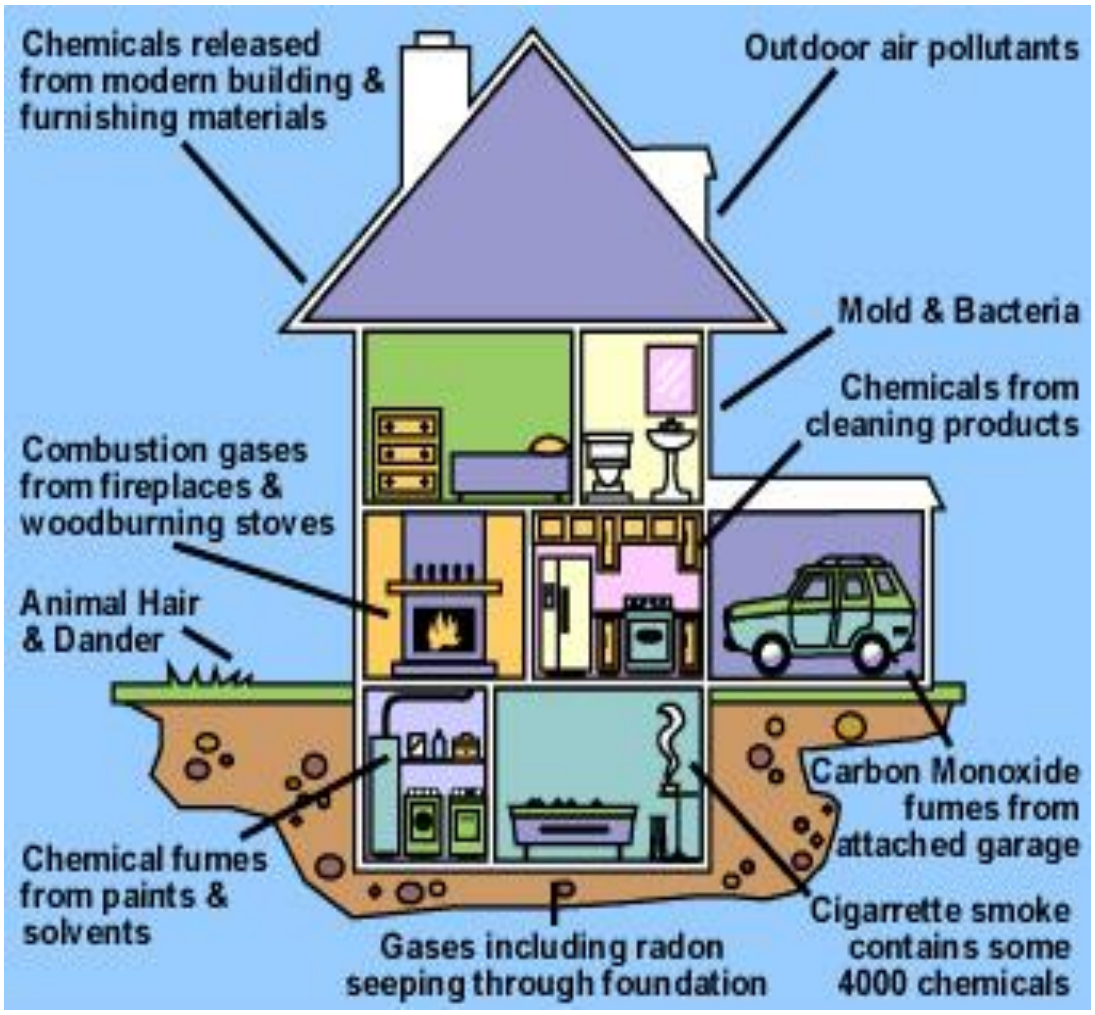
In the last several years, the amount of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities.

Other research indicates that people spend approximately 90 percent of their time indoors. In addition, people who may be exposed to indoor air pollutants for the longest periods of time are often those most susceptible to the effects of indoor pollution. Such groups include the young, the elderly, and the chronically ill, especially those suffering from respiratory or cardiovascular disease.

There are many sources of indoor air pollution in homes. These sources of indoor air pollution include combustion sources (oil, gas, kerosene, coal, wood, tobacco products), building materials, wet or damp carpet, cabinetry or furniture made of certain pressed wood products; household cleaning products, central heating and cooling systems, humidification devices, and outdoor sources such as radon, pesticides, and outdoor air pollution.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted.



Radon and environmental tobacco smoke (ETS) are the two indoor air pollutants of greatest concern from a health perspective. **Radon** is a naturally occurring gas that is odourless, colourless, and radioactive.

Environmental tobacco smoke (ETS) is the smoke emitted from the burning of a cigarette, pipe, or cigar, and smoke inhaled by a smoker. It is a complex mix of more than 4,000 chemical compounds, containing many known or suspected carcinogens and toxic agents, including particles, carbon monoxide, and formaldehyde. More than three billion people worldwide continue to depend on solid fuels, including biomass fuels (wood, dung, agricultural residues) and coal, for their energy needs.

Cooking and heating with solid fuels on open fires or traditional stoves results in high levels of indoor air pollution. Indoor smoke contains a range of health-damaging pollutants, such as small particles and carbon monoxide, and particulate pollution levels may be 20 times higher than accepted guideline values.

Training Provider Accreditation Number: AGRI/c prov/0282/1

- Poor indoor air quality can cause or contribute to the development of chronic respiratory diseases such as asthma and hypersensitivity pneumonitis. In addition, it can cause headaches, dry eyes, nasal congestion, nausea and fatigue. People who already have respiratory diseases are at greater risk.
- Biological pollutants, including moulds, bacteria, viruses, pollen, dust mites, and animal dander promote poor indoor air quality and may be a major cause of days lost from work and school. In office buildings, heating, cooling, and ventilation systems are frequent sources of biological substances that are inhaled, leading to breathing problems.
- To help prevent growth of mould when humidity is high, make sure bathrooms, kitchens and basements have good air circulation and are cleaned often. The basement in particular may need a dehumidifier. And remember, the water in the dehumidifier must be emptied and the container cleaned often to prevent forming mildew.
- An estimated one out of every 5 homes in the South Africa has radon levels above 4pci/L, the recommended action level. Radon, a naturally occurring gas, can enter the home through cracks in the foundation floor and walls, drains, and other openings. Indoor radon exposure is estimated to be the second leading cause of lung cancer.
- Environmental tobacco smoke (ETS) also called "second-hand smoke," a major indoor air pollutant, contains about 4,000 chemicals, including 200 known poisons, such as formaldehyde and carbon monoxide, as well as 43 carcinogens.
- ETS causes an estimated 3,000 lung cancer deaths and 35,000 to 50,000 heart disease deaths in non-smokers, as well as 150,000 to 300,000 cases of lower respiratory tract infections in children under 18 months of age each year.
- Formaldehyde is a common chemical, found primarily in adhesive or bonding agents for many materials found in households and offices, including carpets, upholstery, particle board, and plywood panelling. The release of formaldehyde into the air may cause health problems, such as coughing; eye, nose, and throat irritation; skin rashes, headaches, and dizziness.
- Asbestos is the name given to a group of microscopic mineral fibres that are flexible and durable and will not burn. Asbestos fibres are light and small enough to remain airborne; they can be inhaled into the lungs and can cause asbestosis (scarring of the lung tissue), lung cancer and mesothelioma, a relatively uncommon cancer of the lining of the lung or abdominal cavity.
- Many asbestos products are found in the home, including roofing and flooring materials, wall and pipe insulation, speckling compounds, cement, coating materials, heating equipment, and acoustic insulation. These products are a potential problem indoors only if the asbestos-containing material is disturbed and becomes airborne, or when it disintegrates with age.

- Heating systems and other home appliances using gas or wood, can produce several combustion products, of which the most dangerous are carbon monoxide (CO) and nitrogen dioxide (NO2). Fuel burning stoves, furnaces, fireplaces, heaters, water heaters, and dryers are all combustion appliances.
- Carbon monoxide is an odourless, colourless gas that interferes with the distribution of oxygen to the body. Depending on the amount inhaled, this gas can impede coordination, worsen cardiovascular conditions, and produce fatigue, headache, confusion, nausea, and dizziness. Very high levels can cause death.
- Nitrogen dioxide is a colourless, odourless gas that irritates the mucous membranes in the eye, nose and throat and causes shortness of breath after exposure to high concentrations. Prolonged exposure to high levels of this gas can damage respiratory tissue and may lead to chronic bronchitis.
- Household cleaning agents, personal care products, pesticides, paints, hobby products, and solvents may be sources of hundreds of potentially harmful chemicals. Such components in many household and personal care products can cause dizziness, nausea, allergic reactions, eye/skin/respiratory tract irritation, and cancer.

Training Provider Accreditation Number: AGRI/c prov/0282/1

THE EXTENT OF WATER POLLUTION

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Water

Before we continue to water pollution, let's take a closer look at what water is. Something that we take for granted in everyday life, but it is such an interesting matter.

The water molecule is one of the most versatile structures known. Comprising two atoms of hydrogen and one of oxygen (H_2O), water has remarkable dissolving powers and is therefore a supreme solvent. Changing from solid to liquid to gas, water absorbs large amounts of energy in the form of heat, and releases equivalent amounts when going from gas to liquid to solid.

Water sculpts landscapes as rivers, waves and floods; it dissolves soft soluble rocks (such as limestone) and erodes hard insoluble rocks (such as granite); it obscures the sun as clouds; it carries chemicals dissolved in it; it transports suspended materials that will be deposited on flood plains, along coastal margins, and on deep ocean floors. Its capacity for heat exchange drives our weather systems!

In our bodies it is the most abundant molecule present. As a solvent it allows the transport of vital materials such as foodstuffs and oxygen into and within cells, and the export of waste products such as ammonia and carbon dioxide from cells.

Water is absolutely essential for all forms of life. We experience this every day when we become thirsty. Why do we need so much water? Simply because our bodies consist of approximately 75% water. If we do not drink enough water we may dehydrate. When you dehydrate it means that you have lost more water from the cells that build your muscles, than has been replaced. That is a very dangerous situation, because irreversible damage may be done to your body, and if you lose too much water you will die.

The Water (Hydrological) Cycle

The water that we have on Earth is very old. The same water that is used presently was used by the dinosaurs millions of years ago. This is because the Earth recycles its water, i.e. it re-uses the water. This recycling of water is called the **water cycle**.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Water exists on Earth as water droplets and is found in oceans, rivers, lakes, dams, the soil, and other places. Heat from the sun causes some of these water droplets to change from a liquid to a gas, called water vapour. This process is called **evaporation**.

At the same time some water vapour is released from plant leaves through very tiny openings in the leaves, by way of a process called **transpiration**. As soon as the water vapour is released from the leaves, it forms part of the other water vapour in the air. Another process by which water vapour is formed is when evaporation occurs from the ice sheets at the poles, and from glaciers. This process is called **sublimation**.

The reverse process whereby water vapour freezes without condensing into water is also call **sublimation**. The water vapour that has been released into the air eventually cools down and changes from a gas to a liquid, and thus back into water droplets. This process is called **condensation**. While these water droplets float in the atmosphere they join together to form clouds.

As soon as the combined droplets become too heavy to stay in the air, they fall to the Earth as either **rain or hail**. On the other hand, if the air temperature is low enough, some of the water vapour may freeze before it condenses into water (by the process of sublimation). When this happens **snow** is formed which falls to the ground as very light flakes instead of water droplets.

By a similar process of sublimation, water vapour that occurs close to the ground surface may freeze if the temperature falls below freezing point. In such a situation, frost will form on surfaces such as leaves, grass and even rocks. If the temperature is very low during the night, but not at freezing point, very small water droplets may form, by condensation, from water vapour in the air, which we observe as dew. The rain, hail, snow, frost and dew all form part of a process called **precipitation**.

Some of these water droplets fall into the oceans, some into rivers and streams, some into lakes and dams, and some onto the land. On land it either seeps into the ground to form groundwater, or forms surface drainage when it runs on the surface through rivers, lakes and dams and ultimately back into the ocean.

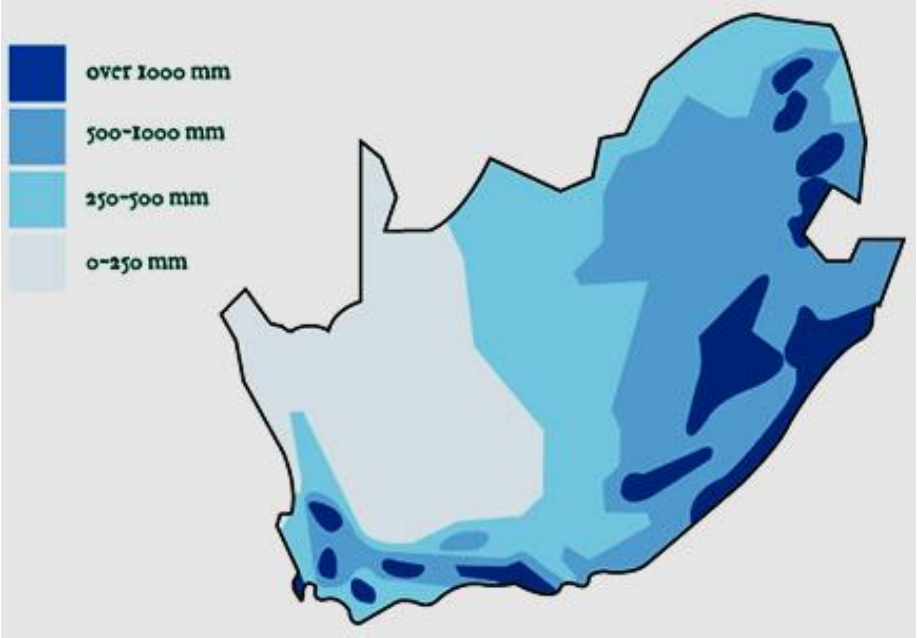
Water knows no boundaries, and as it flows over the Earth's surface, it is used by communities of plants, animals and humans in order to survive. At any stage in the cycle the water can be reheated by the sun and evaporate, then the whole cycle repeats itself, and so it will continue without interruption throughout time.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The water situation in South Africa

Water is life. For millions for years life on earth has been dependant on water for survival. When Neil Armstrong landed on the moon in 1969 he described Planet Earth as “a shining blue pearl spinning in space”.

The blue colour is, in fact, the amount of water that is present on the surface. 70% of the earth’s surface is covered with water but of this, approximately 97% is salt water, with the remaining 3% being fresh water. Of this 3%, less than 1% is available for life on earth, whilst the rest is in the form of ice at the poles. But where does water come from?



The water that we have on earth is very old. The water that we are using now was used by the dinosaurs millions of years ago. This is because the earth recycles its water, i.e. it reuses its water. This recycling of water is called the water cycle. Water exists on earth as water droplets and is found in oceans, rivers, lakes, dams, swimming pools, the soil, etc.

Heat from the sun causes some of these water droplets to change from a liquid to a gas, called water vapour. This is called evaporation. The water vapour then rises into the atmosphere. As the water vapour rises it cools down and changes from a gas to a liquid, and thus back into water droplets. This is called condensation. When these water droplets are in the atmosphere they join together and form clouds.

When these droplets get too heavy to stay in the atmosphere they fall to the earth as rain, hail, snow, etc. This is called precipitation. Some of these water droplets fall into oceans, some into rivers and streams, some into lakes and dams, and some onto the land where it either seeps into the ground or runs off the surface into rivers, lakes, dams or the ocean. Water knows no boundaries and as it flows over the earth’s surface it is used by communities of plants, animals and humans in order to survive. These water droplets can then be reheated by the sun and the whole cycle repeats itself.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The amount of water on earth is constant and cannot be increased or decreased, but it is unevenly distributed across the earth. South Africa receives an annual rainfall of 492 millimetres whereas the rest of the earth receives 985 millimetres. This is nearly half the earth's average. Thus South Africa is classified as a water-stressed country.

There is also uneven distribution of rainfall across South Africa. The eastern half of the country is much wetter than the western half due to the nature of the weather conditions. South Africa also experiences alternating periods of droughts and floods which affects the amount of water across South Africa. In addition, hot dry conditions result in a high evaporation rate. Scientists predict that with global warming, South Africa will experience much wetter wet seasons and much drier dry seasons, resulting in an increase in floods and droughts.

Presently there are a large number of dams all over South Africa that store this precious water. There are also a number of water transfer schemes that move water from one catchment via pumps, pipes and canals into another catchment. Gauteng is supplied with water from the Vaal Dam catchment, which includes the Vaal River, Wilge River and all their tributaries.

There are two water transfer schemes that feed into the Vaal Dam catchment, namely the Lesotho Highlands Water Project, which obtains water from the mountains of Lesotho, and the Thukela-Vaal Water Transfer Scheme, which obtains water from Kwa-Zulu Natal and is released into the Vaal Dam catchment when needed.

According to the Department of Water and Environmental Affairs, the demand for water will outstrip supply in Gauteng by 2013, and in the whole of South Africa by 2025. South Africa cannot afford to build more dams and water transfer schemes as they cost large amounts of money. Thus water in South Africa is in great demand, and as the human population increases with its increasing needs for survival, the greater is the demand for water.

A further problem adding to this demand is water quality. Water quality is defined as water which is safe, drinkable and appealing to all life on earth. In South Africa the scarce fresh water is decreasing in quality because of an increase in pollution and the destruction of river catchments, caused by urbanisation, deforestation, damming of rivers, destruction of wetlands, industry, mining, agriculture, energy use and accidental water pollution. As the human population increases, there is an increase in pollution and catchment destruction.

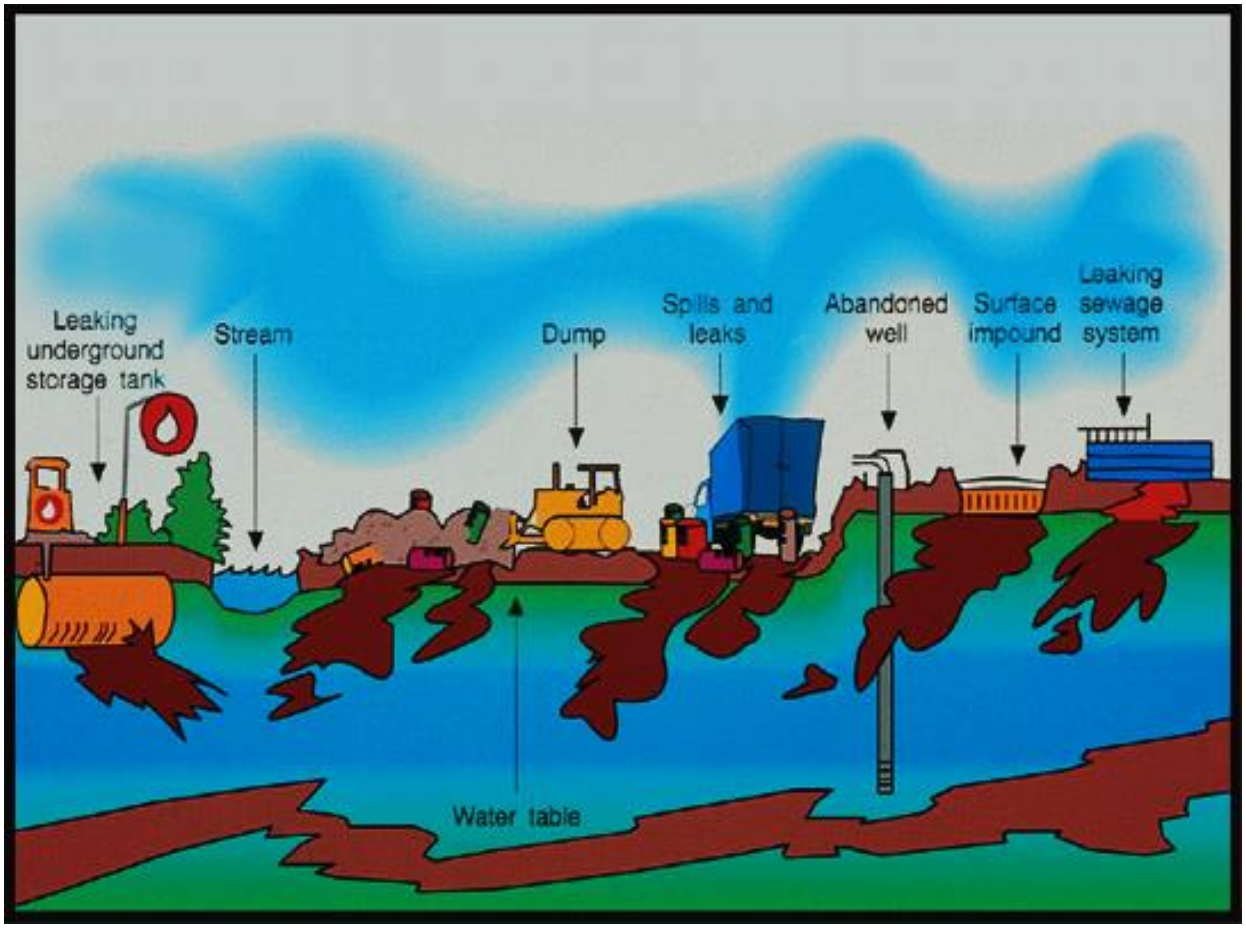
Water pollution

Water covers over 70% of the Earth's surface and is a very important resource for people and the environment. Water pollution affects drinking water, rivers, lakes and oceans all over the world. This consequently harms human health and the natural environment. Here you can find out more about water pollution and what you can do to prevent it. As more and more people move into cities and towns, a number of factors cause pollution:

- the physical disturbance of land due to construction of houses, industries, roads, etc.;
- chemical pollution from industries, mines, etc.;
- inadequate sewage collection and treatment;
- Increase in fertilisers to grow more food. These results in an increase in nutrients (nitrates and phosphates) in the water which causes enhanced plant growth (algal blooms). When this plant material dies and decays the bacteria uses the oxygen in the water. This lowering of oxygen levels results in the death of other water life that needs oxygen to survive, e.g. fish. This process is called eutrophication;

Training Provider Accreditation Number: AGRI/c prov/0282/1

- Litter, which causes disease and has a negative visual impact.



Deforestation

Clearing land for agriculture and urban growth often leads to water pollution. When soil is stripped of its protective vegetation it becomes prone to soil erosion. This leads to an increase in the murkiness of the water which can cause the following:

- it can block the gills of fish;
- bottom dwelling plants cannot photosynthesize as the sun's rays cannot reach them; and
- there is an increase in disease as bacteria and viruses use the soil particles as a method of transportation.

Damming of Rivers

Damming of rivers can have an impact on water in the following ways:

- Water flowing out of dams:
    - has reduced suspended material as a large amount settles to the bottom of dams;
    - is depleted of nutrients; and
    - is often more saline

with detrimental effects on downstream agriculture and fisheries.

- Enhanced eutrophication may result due to the water spending a longer time in the dam.
- There is also increased evaporation in dams, especially those with a large surface area, such as the Vaal Dam.

Destruction of wetlands

Wetlands are nature's way of cleaning water as well as damming water (they hold back water in summer and release it in winter). Destruction of wetlands:

- Destroys the habitat of many birds and fish;
- Removes the natural filters capable of storing and degrading many pollutants, such as phosphorus and heavy metals;
- Destroys natural dams and causes flooding further downstream.

Industries

Industries produce waste that can affect the:

- pH of water (whether it is acid, neutral or alkaline);
- colour of water; amount of nutrients (increase in nutrients can cause eutrophication);
- temperature (increase or decrease in temperature can have an impact on temperature sensitive organisms living in the water);
- amount minerals and salts (too much can cause health problems);
- murkiness of water (can block fish gills; bottom dwelling plants cannot photosynthesize as the sun's rays cannot reach them; increase in disease as bacteria and viruses use the soil particles as a method of transportation).

Mining

Mines produce waste that:

- can increase the amount of minerals and salts in the water (too much can cause health problems);
- can affect the pH of the water (whether it is acid, neutral or alkaline);
- can increase the murkiness of the water.

Agriculture

- Increases soil erosion due to the physical disturbance of soil and vegetation due to ploughing, overgrazing, logging and road building. This effects the murkiness and the amount of salts and minerals in water;
- Increases nutrients due to fertilisers and excreta, which contribute worrying amounts of nitrates and phosphates to water supplies (this can cause eutrophication);
- Increased pesticide use

Energy use

As human populations increase, more energy is required for human activities such as cooking, lighting, etc. The majority of our energy in South Africa comes from the burning of coal at power stations and results in greatly increased emissions of sulphur and nitrogen oxides into the atmosphere. These gases are the main cause of acid rain. Also the release of carbon dioxide, from the burning of coal, increases global warming.

Accidental Water Pollution

Accidental water pollution can arise from many sources (such as burst pipes and tanks, major leaks, fires and oil spills) and can cause varying degrees of damage, depending on the quantity, toxicity and persistence of the pollutant, and the size and adaptability of the water body.

Substances Causing Pollution in Rivers

The substances that cause water pollution can be divided into two main groups - germs and chemicals. Germs are small organisms that cause diseases such as malaria, cholera and bilharzia, and chemicals are poisons, which are mainly produced by industries.

1. Possible Poisonous Chemicals in River Water

Natural chemicals are found everywhere in the environment. Unfortunately, many of the chemicals that are produced by industries are not found naturally in the environment or are only found in very small amounts. Different industrial processes produce different types of products and waste products. Unfortunately many industries release their waste products directly into rivers or let them leak into the groundwater. These chemicals are poisonous or toxic to plants, animals and people. Some examples are:

Insecticides

Insecticides are chemicals that are sprayed onto crops to kill the insects that eat crops. One of the more controversial insecticides is DDT. The use of DDT on crops was used to control the malaria mosquito in South Africa. At certain levels (10 mg per kg) DDT can cause human poisoning with the following symptoms: dizziness, vomiting and convulsions. At lower levels, DDT can affect the development of babies and has been associated with cancer

. DDT has been banned in South Africa. Another group of controversial insecticides are the organo-phosphates. These insecticides have been used in the place of DDT since it was banned. Some specialists believe that these insecticides have caused even greater environmental damage than DDT and that they are even more toxic to humans and other mammals.

Insecticides are easily washed by the rain into streams and groundwater where they poison fish and domestic animals. Many insecticides are stored for a long time in the bodies of animals and can end up in the meat, fish, egg and milk that you eat. Fruits and vegetables that have been sprayed with insecticides also remain poisonous for many days afterwards and must be washed very well before eating.

Ask questions about the use of insecticides in your area. Keep a look out for fish or birds that have been poisoned. Dead fish and birds provide a good indicator of chemical pollution. If you suspect pollution by insecticides then contact your local council as soon as possible.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Heavy Metals

Heavy metals such as nickel, molybdenum, zinc, cadmium and lead are mined and processed by the mining and ore-smelting industries, many of which occur in Gauteng. These metals are easily washed into streams and groundwater. Copper and mercury are another two heavy metals, which are found in fungicides.

Fungicides are also sprayed on crops and easily washed into rivers. These heavy metals are toxic to biological life including the people who may have to drink from the polluted rivers. Crops that have been irrigated with polluted water can also be dangerous. In a similar way to DDT, heavy metals can also build up in the body causing symptoms of poisoning.

In the past, toxic waste products were dumped into the rivers or into landfill sites close to where people lived causing health problems and even death. Today all South Africans have a constitutional right to a clean and safe environment. Make sure that you remain informed and observant so that you can prevent toxic chemicals from being used in your environment. If you suspect water pollution in your area then contact your local council.

Problem Products

We all know about the destruction that oil pollution causes along the marine coastline. However, a lot of oil pollution also occurs inland. Petrol and diesel is stored in underground tanks at petrol depots. When these tanks are not properly maintained, they can develop cracks allowing the petrol to leak out.

Many people are also very negligent when changing the oil in their car engines. Many people just throw the oil onto the ground! This oil and petrol is washed by the rain into the groundwater. This ground water eventually surfaces at boreholes and wetlands.

In the past, groundwater was considered clean since chemicals and germs were not present, but this is changing very quickly. Groundwater is becoming more and more polluted with a number of toxic substances including insecticides, petroleum products and heavy metals. South Africa is a dry country and as the human population grows, our groundwater is becoming very valuable. We must all work towards keeping this resource as clean as possible for the future when we really need it.

Chlorine and Detergents

Training Provider Accreditation Number: AGRI/c prov/0282/1

Paper and pulp mills and textile factories are amongst the worst water polluters. Paper and pulp mills use up large amounts of water and produce a lot of polluted wastewater. The wastewater contains strong chemicals such as chlorine, which is used to make paper white and soft.

Textile factories also release strong chemicals like caustic soda, acids, dyes and detergents into water. These strong poisons also cause bird and fish kills similar to insecticide poisoning. These chemicals are also directly poisonous to humans. Ask questions about what industries occur in your area and how they release their wastewater.

Do not drink water that is downstream from a factory that releases wastewater into the river.
Remember that the detergents that you use at home are just as poisonous so use only biodegradable products. Read the label on the product that you are buying; this will tell you what the product is made of and if it is environmentally friendly.

2. Fertilisers and Sewage

Some chemicals like fertilisers are made of substances that do occur naturally in the environment, but only in small amounts. When too much fertiliser is washed from farmlands into a river then that water will also become polluted. Human sewage or cattle excrement that is untreated also causes water pollution in the same way as fertilisers do.

Human sewage also contains germs that cause diseases such as hepatitis and cholera. Soaps and washing detergents contain both natural and man-made (artificial) chemicals. Artificial chemicals like bleach and chlorine were discussed earlier. The natural chemicals can cause a pollution problem similar to that caused by fertilisers.

Phosphates and nitrates are found in fertilisers, sewage and soaps. Phosphorus is an essential element for life, both as a nutrient for plant life and as a key element in the metabolic processes of all living things. The normal low phosphate (PO_4) level in water inhibits the growth of plants but a small increase of phosphates can result in a rapid increase in plant growth such as blue-green algae and water hyacinth, especially in dams.

The water plants become overcrowded and die. When they die the decomposing bacteria uses up more oxygen and affects other forms of life badly, e.g. fish suffocate. This process is called eutrophication, and can be increased by human activities, e.g. domestic effluent (especially soapy water), farm and lawn fertilisers, industrial effluent and the destruction of wetlands.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Nitrogen in the form of ammonia (NH_3) and nitrates (NO_3) form part of the plant nutrients that can lead to eutrophication. Nitrate enrichment through sewage contamination and fertiliser runoff is not as critical as it is with phosphates because aquatic ecosystems are not as sensitive to increases in nitrate levels.

Nitrogen normally occurs in a form that plants cannot use (i.e. nitrogen gas), however, it may be used in the decomposition of dead water plants and by blue-green algae which can convert nitrogen in the air into ammonia and nitrates that plants can use. This subtle interdependence illustrates the complexity of the relationships within an aquatic ecosystem. The best way to stop this kind of pollution is to prevent human sewage, cattle excrement and fertilisers from washing into rivers.

3. Water Pollution and Disease

Most diseases in the world are related to water and sanitation. To break the cycle of disease, there must be improvements in the quality of water that people use. Most rural communities in South Africa do not have access to running water, toilets or latrines and they use watercourses for defecation and urination.

In many cases, where they are present, latrines are situated upstream from where the community collects their water supply. Faecal pollution of water increases the risk of infection of various diseases to those using these courses as their life supporting water source.

Groundwater, which is another water source, can become contaminated through unclean irrigation water. Water related diseases could be spread in other ways, which also affect urban communities, such as insect bites and poor hygiene. Although there are many more, these are some of the most common water – related diseases in South Africa:

Bilharzia

This occurs, like most diseases, in a cycle with a parasite and different hosts. Bilharzia only occurs in areas where conditions are right for the parasite to be able to complete its life cycle. The adult parasite is a worm that lives in the bladder or intestine of humans (the main host). They mate inside the body and eggs are released in the urine or faeces of the host.

If an infected person defecates and urinates into the water, the eggs hatch into the swimming form of the parasite. It then burrows into the body of a snail (the intermediate host). The snails favour slow moving water

Training Provider Accreditation Number: AGRI/c prov/0282/1

with plenty of vegetation. Here the parasite changes form and exits out into the water again. This is the stage that infects humans.

If a person has contact with contaminated water the parasite will penetrate their skin and move through the body causing illness. Some symptoms of Bilharzia: an itchy rash, headaches, abdominal pain, diarrhea, bladder infections, fever, enlarged liver and swollen veins. Within South Africa, Bilharzia is most common in the Northern Province, the Lowveld and KwaZulu-Natal.

Malaria

In South Africa Malaria is given very high priority. This disease, which also occurs as a cycle, is caused by a parasite that is transmitted by some species of female mosquitoes. The female mosquito requires a blood meal in order to obtain sufficient energy and nutrients to produce her eggs.

When a mosquito bites a human, it injects saliva into the bloodstream to prevent the blood from clotting. If the mosquito is infected with the malarial parasite, the parasite will be released from the mosquito's saliva into the blood of the human. The parasite travels through the body and enters the red blood cells. The red blood cells eventually burst releasing the parasite into the blood stream where it is ready to be sucked up by the next mosquito.

Mosquitoes breed in water, especially dams, ponds, water tanks, old car tyres, and other hollow objects that can hold water, like tins. The best way to protect yourself from Malaria is not to leave litter lying around, and to prevent getting bitten by wearing long sleeve clothing and by applying insect repellent to your skin, especially at night.

Some symptoms of Malaria: fever, headache, diarrhoea, nausea, joint and muscular pains, shivering, sweating and fatigue. Malaria is distributed in the Northern Province, Mpumalanga, Northern KwaZulu–Natal and parts of the northern Cape.

Cholera

Cholera is a disease that is caused by bacteria (Vibrio cholerae) that is spread through water contaminated by faeces from an infected person. The bacteria produce a toxin that causes the small intestine to secrete large amounts of fluid, which leads to fluid loss, i.e. diarrhoea and vomiting.

People who do not wash their hands after using the toilet can spread the disease. It can also be spread when human faeces are used as a fertiliser for vegetable crops. It is important to remember that even if a person does not show symptoms of the disease, they could still be infected and spread the disease.

Cholera can be found in most places where there is poor sanitation. Some symptoms of Cholera: diarrhoea and vomiting. People who have the disease should drink plenty of clean water to prevent dehydration.

THE EXTENT OF WORKPLACE POLLUTION

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Pollution in the workplace

These days we hear about pollution often as if it could be anywhere! The word almost lost its meaning while it seems to be intrinsically connected to the modern society and has become as much part of our way of living as it is hard to imagine that we can really have any escape from it. And yet, this is far from the truth as there are many things we can do both as individuals and society in order to prevent and change our pollution exposure at workplace or elsewhere.

The first step is to become aware that some people are more exposed or more at risks than others. If we identify we are at a higher risk, then, there are many things we can do to change this.

In this section, we provide information related to workplace pollution and simple things you can do to test and change the exposure and risks with the final goal of pollution prevention (for a similar evaluation of pollution risks based on your home location please click here). Below is a checklist with professions/jobs at higher risk of workplace pollution:

- Mining and smelting jobs
- Foundry workers
- Construction workers
- Chemical industry jobs (including chemical manufacture, as well as chemical re-package and storage)
- Manufacturing jobs (including Auto manufacturing)
- Aerospace jobs

Training Provider Accreditation Number: AGRI/c prov/0282/1

- Dry cleaning jobs
- Gas station jobs
- Convenient store jobs
- Textile industry jobs
- Some office jobs – depending on the location and/or building materials used for the office building
- Research jobs (researchers) – may be exposed to various hazardous materials if accidents occur in the research lab

Additionally, any jobs involving the storage and disposal of waste may also create a pollution exposure risk.

What is Workplace Pollution?

Workplace pollution is the presence of polluting materials and/or noises within a workplace to which people performing their job (workers) may be exposed and which could be hazardous to human health. The exposure to hazardous materials can occur in several ways including through:

- the breathing air – if the air indoor the workplace gets polluted
- direct contact with toxic and/or corrosive materials
- accidental ingestion of toxic chemicals or of polluted water/liquids

Additionally, workplace noise is another example of workplace pollution that could affect worker's hearing and is unpleasant.

Workplace Pollution – A Definition

The definition of workplace pollution is the presence of hazardous materials or noises within a workplace that may get in contact with people while performing their job. Such workplace pollutants may affect worker's health especially if exposure continues over longer periods of time even at low levels. The most common exposure is that to workplace air pollution.

This involves workplace hazards from airborne pollution or in other words the presence in the workplace indoor air of hazardous substances either as gases (fumes) or as particulate matter (tiny particles - dust) dispersed in the air. Other type of exposure may occur involving skin contact, ingestion, and/or injection.

Environmentalists that Work with Pollution

In addition to the jobs listed above, the environmentalists or environmental professionals may also be exposed to hazardous materials while performing their job. However, the environmental professionals, unlike other workers, are aware of the risks and thus take precautionary measures.

However, this category of professionals usually performs field work in polluted environments and could still be exposed to hazardous materials in the following situations:

- when accidents occur;
- when new pollutants or mixture of pollutants become of health risk in certain environmental conditions; in such situation the precautionary measures may not be effective or enough to prevent dangerous exposure situations

These events are however disparate and, although they can cause acute exposure episodes, overall they may pose a lower threat than the exposure to lower levels of hazardous materials through workplace pollution in the situation of the jobs listed above.

Thus, one may ask: what kind of regulation corrects air pollution or job discrimination? Well, there are many regulations in place, starting with safety procedures and preventive regulations under OSHA (Occupational Safety & Health Administration) regulations. In general, employees are required to comply to such regulations, while employers insure safe workplace environments.

Pollution prevention at workplace involves the same measures as anywhere else. These include: wearing protective equipment if contact with hazardous materials may not be avoided otherwise, good air ventilation indoors and deployment of safety procedures (e.g., such as identify and avoid direct contact with toxic materials, do not drink or eat in the presence of hazardous materials, wear protective equipment whenever required). In fact, any environmental investigation contains appropriate Health and Safety Plans.

Workplace pollution exposure

The most common and dangerous workplace pollution exposure is that which occurs through the breathing air. Such exposure may be many times hard to identify since it is not necessary perceived by smell or other senses.

In fact, many gases or fumes could pose a health threat at concentrations much below the smell threshold, especially when exposure occurs over long periods of time (e.g., a person works in the same place for 20 years or more with an average of 8 hours 5 days a week).

It is easy to imagine that anything that is in the breathing air goes straight into human body via inhalation and that cannot be avoided without changing the air (through ventilation). However, even under good ventilation,

if the source of airborne pollutants is within the workplace and the emission of the airborne pollutants is at a higher rate than their dissipation through ventilation, it is deduced that ventilation by itself may not help.

Thus, even if the work is performed in a space with good air circulation or even outside, if the worker is close to a device that emits air pollutants the exposure may still happen unless protective equipment is used (e.g., masks or respirators).

Therefore, it is important that pollution prevention measures are in place, such as for example wearing of appropriate protective equipment while working with materials that can emit hazardous airborne pollutants (such as waste materials, volatile and semi-volatile chemicals, etc.).

Yet, problems arise when the need to wear protective equipment does not exist and yet exposure may still occur due to workplace indoor air pollution. An example is an office building that may be subjected to air pollution due to various reasons including: it overlays a polluted groundwater plume or polluted soil with volatile chemicals, or it contains building materials that may emit toxic air pollutants (such as Chinese drywalls, or office furniture made of medium density synthetic boards reported to emit fumes).

Apart from exposure through the air, workplace pollution exposure may occur via:

- Contact with waste or hazardous materials (liquid or solid)
- Accidental injection of hazardous material – that enters the human body in other ways that through breathing or via skin adsorption
- Accidental ingestion through swallowing of waste or hazardous materials (solids or liquids) – an example would be drinking contaminated water or eating contaminated food that was exposed to pollutants in the workplace

Let's take a look at an example of pollution which results from the workplace:

Oil spill include any spill of crude oil or oil distilled products (e.g., gasoline, diesel fuels, jet fuels, kerosene, Stoddard solvent, hydraulic oils, lubricating oils) that may occur on land, in the subsurface, in air and/or in water environments.

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Although oil spills occur in various media, the term is mainly associated with marine oil spills (related to oil released in the ocean and coastal waters). Oil spills may comprise a variety of amounts starting with one or more gallons of oil and up to millions or even hundreds of millions of gallons spilled.

Oil spill pollution represents the **negative polluting effects that oil spills have on the environments and living organisms including humans**. These negative effects are due to the environmental discharge of various organic compounds that make up crude oil and oil distillate products, the majority of which include various individual hydrocarbons.

Hydrocarbons are made exclusively from carbon and hydrogen atoms which bind together in various ways, resulting in paraffins (or normal akanes), isoparaffins (isoalkanes), aromatics (such as benzene or various PAHs), cycloalkanes and unsaturated alkanes (alkenes and alkines). Other individual compounds that are present in crude oil and oil discharges include (apart from carbon and hydrogen) sulfur, nitrogen and/or oxygen atoms too.

How Does Oil Spill Pollution Affect Us?

These organic compounds may affect the wildlife (including fish and birds) and humans in various ways:

- DIRECTLY:
    - **by direct contact with the skin** – some of oil components could be irritants to the skin and may also penetrate into our bodies via skin absorption;
    - **through inhalation** – many oil individual components are volatile and thus may easily evaporate and while in the breathing air enter our bodies. Some less volatile compounds (such as PAHs) may adsorb on dust and other small particulate matter suspended in the breathing air and may get into our bodies through inhalation of small particulate matter from the air.
    - **through ingestion of contaminated water and/or particles** – accidental ingestion in the presence of absence of pollution awareness provides a fast conduit of pollutants into our bodies;

Training Provider Accreditation Number: AGRI/c prov/0282/1

- **through emitted odours** – How many of us have smelled gasoline or diesel/fuel oil and noticed the strong unpleasant smell? Usually crude oil and its various distillates have strong unpleasant odour

- INDIRECTLY:
  - **by consuming contaminated food** (some of the oil hydrocarbons such as PAHs bio accumulate in fish and other organisms and may concentrate many times more than in water or other media)
  - **by disrupting professional and/or recreational activities** due to the oil pollution in certain areas
  - **by decreased property values from the affected areas** – it is logical to imagine the drops in house values in a polluted area;
  - **aesthetically** – by visual alteration of marine, beach and many other environments (where the oil spill occurred)
  - **Overall economic impact** – in the community affected by the oil spill may occur.

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How Does an Oil Spill Behave in the Environment?

Depending on where and how an oil spill occurs, it will have distinct environmental fate & transport. For example:

- a marine oil spill is usually degraded fast since water is an excellent media for dispersion, emulsifying and microbial degradation processes. If released in the water, oil and oil products tend to accumulate at the surface of the water and float on the water. Small oil droplets may also form which may increase the surface contact with water and also the natural biodegradation of the spilled oil;
- an oil spill on the land may penetrate underground and move downward reaching eventually the groundwater. However, such vertical movement may be slowed done if not prevented by the presence of paved surfaces, natural clay layers or other natural or anthropogenic barriers. Oil may also move laterally along less permeable layers (including surface pavements) or with groundwater and surface waters.
- an oil spill in the underground (such as from pipelines or underground storage tank leaking) will likely affect the groundwater since the vertical traveling distance is reduced. Such spill may also result in oil residuals that could be entrapped underground constituting a secondary source for groundwater pollution.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Oil spills may be both of **natural and anthropogenic sources**:

- **Natural** - such as oil seeps from the bottom of oceans which enters the marine environment. Crude oil is formed during long periods of time through natural processes involving organic matter from dead organisms. Thus, oil exists in many environments and may be naturally spilled due to various factors (including climatic conditions, disturbance, etc.). Such natural oil spills may occur in oceans, due to eroding of sedimentary rocks from the bottom of the ocean (the effect may be similar with that of an accidental oil spill from human drilling in oceans such as the recent BP oil spill from the Gulf of Mexico)
- **Anthropogenic** – including accidental oil spills (such as the recent BP oil spill in the Gulf of Mexico) as well as leaks and spills due to a large variety of human activities related to oil refining, handling and transport, storage and use of crude oil and any of its distilled products.

Thus, it is evident that a variety of sources for oil spill and a variety of ways the oil could be spilled exist. While various anthropogenic and natural sources for oil spill pollution determine the type and amount of oil spilled, as well as the location of the oil spill, the type of the oil spill pollution is important for the fate of the spilled oil and its impact on humans and the environment.

For example: a sudden oil spill involving large amounts spilled (thousands or even millions of liters - such as that from an oil tanker failure or due to accidents in offshore drilling) could have disastrous effects due to the high concentrations of released contaminants and the difficulty to remediate such big spills.

At the same time, an oil spill involving small but continuous releases such as those from leaking pipelines or road runoffs may have little visible effect (they are naturally attenuated usually due to microbial degradation as well as due to many chemical-physical processes.

The type, amount of oil discharged and its location will dictate the oil spill clean-up efforts, which could involve deployment of adsorbent booms, controlled burning, bioremediation, emulsification using detergents for increased degradation.

Training Provider Accreditation Number: AGRI/c prov/0282/1

RECYCLING AND ITS BENEFITS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

What is Recycling?

Recycling is the process of making or manufacturing new products from a product that has originally served its purpose. If these used products are disposed of in an appropriate, environmentally friendly way, the process of recycling has been set in motion.

Before you know about the importance and benefits of recycling and its relation to a better environmental condition, it is essential to understand what it is. Recycling refers to the process of collecting used materials which is usually considered as 'waste' and reprocessing them.

In this process, these used materials are sorted and processed to be used as 'raw materials' for the production of new products. Recycling varies from 're-use' in the sense that while re-use just means using old products repeatedly, recycling means using the core elements of an old product as raw material to manufacture new goods. Some of the most common items that are recycled are plastic, glass, paper, batteries, aluminium etc.

Recycling is the conversion of waste products into new materials, such as waste paper which can be converted into new paper goods. Recycling is a lengthy circular process which has to include transportation of collected materials to a processing facility where they are cleaned and sorted.

The new materials that have been converted must comply with the same safety legislation and health and hygiene regulations as products made from virgin materials. We can only say a product has been recycled when it has been purchased and used again.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Process of Recycling

The recycling process involves three stages. In the first stage the old products are collected and processed, where they are sorted, cleaned and made ready for recycling or manufacturing new products.

The second stage involves the manufacturing of new products from the raw material obtained by the processing of the old products.

Finally, the process ends with the purchasing of recycled goods by the consumers. The more people step forward to buy recycled products the better the success of the recycling process can be ensured. Buying recycled products will only increase when every individual will develop an awareness of the difference that can be made by utilizing their old household objects as raw materials to produce new goods and help the environment by recycling.

If you buy only what you need and avoid products with excessive packaging, that's a good start. But our goal must be zero waste going into landfills, especially in Cape Town where land is precious and our biodiversity is unique.

Not to mention that landfills put off loads of methane, a potent greenhouse gas. Separate your waste. Drop off recyclables yourself or pay a service to collect it for you. Start a worm farm. Compost if you have a garden. You can also donate used items and repair broken ones.

Items that are made from materials such as aluminum, plastic water bottles, and certain kinds of paper (plus many more) can be separated from your regular trash and put in an appropriate recycling bin. Let's take a look at two of these items' recycling processes:

Training Provider Accreditation Number: AGRI/c prov/0282/1

Aluminum Recycling

One of the most common statistics stated about aluminium recycling is that South Africans throw away enough aluminium every six months to rebuild the entire national commercial air fleet.

Aluminium recycling is a process by which discarded aluminium is collected, reprocessed, and reused in products after its initial production. The process is quite simple it merely involves re-melting the scraps of aluminium. This process is far less expensive and consumes far less energy than extracting new aluminium from bauxite ore through the Bayer process which uses electrolysis. Recycling aluminium from scraps and discards uses only about 5 percent of the energy required to manufacture new aluminium.

Aluminium recycling has been a common practice since the early 1900's and was quite widespread and intensive during World War II. Since aluminium does not lose any of its important properties or damage the metal's structure it can then be recycled indefinitely.

Aluminium recycling is economically beneficial to both the aluminium and recycling industry. The capital cost for the production of recycled aluminium is already recognized to be far lower than making new aluminium.

The financial benefit has also spurred the development of the recycling program. The price of scrap aluminium has fluctuated in the market but its traditionally high value has generated enough income for the recycling program to subsidize other less lucrative recycling programs like PET and glass.

Aluminium cans are the poster child of the recycling movement. This is by far the most valuable component in the solid waste stream. The aluminium can is also the most recognized recyclable item among household waste. Aluminium cans are also the financial drive behind most municipal and private recycling programs. Prices can and do fluctuate in conjunction with the price of new aluminium but the price of aluminium scrap has always been high when compared to other recyclable items.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Glass recycling

So what happens to the glass you have consumed? You could “dump it” in landfill. But that is wasteful, irresponsible and even anti-social. Glass is too valuable a commodity, and it should be recycled, for all the reasons given in the section “Benefits of Glass Recycling”. So what happens on the recycling journey?

You can take it to a bottle bank (a system known as bring), or it might be collected on your doorstep (known as kerbside collection). It speeds up the process if glass is already roughly sorted into brown, clear and green, as it is at bottle banks, but with many methods of collection, including domestic recycling boxes, that isn’t always possible.

Once it is collected, the glass is transported to a MRF (Materials Recycling Facility) or a glass recycling and treatment plant, such as the ones operated by Berryman Glass, the country’s leading glass recycler.

The most popular and environmentally favourable approach is to glass recycling is to re-melt it to produce more bottles and jars. Every 1,000 tonnes of recycled glass that is used in this ways saves 345,000 kWh of energy, 314 tonnes of CO_2, 1,200 tonnes of raw material and 1,000 tonnes of landfill.

Put simply, the energy saved from recycling one bottle will power a 100 watt light bulb for almost an hour or a computer for 20 minutes. In 2008, the UK recycled 1,650,000 tonnes of used bottles and jars. That means though that 1,000,000 tonnes still went through the residual waste stream and was lost in landfill.

Once in the treatment plant, the bottles and jars are placed on a conveyor belt and sorted to remove the metal and plastic caps and collars that dress bottles from the neck up. This is done both manually and by using powerful vacuums to suck up the waste from the belts.

Training Provider Accreditation Number: AGRI/c prov/0282/1

The glass, or cullet as it is known, then goes through machines that use laser, X-ray and digital technology to remove critical contaminants such as ceramic and stone. It can also distinguish between colours and types of glass. As it falls, each fragment is scanned and identified and the information fed into a computer which activates air jets lower down.

These jets are fired at the specified piece of contamination or glass with pinpoint accuracy, blasting them onto separate conveyor belts. In this way the green, brown and clear glass can be separated out.

Once sorted, the furnace-ready cullet , if it is of sufficient quality, is supplied to the bottle and jar manufacturer, who make new bottles and jars from the finished, high quality cullet. This is known as a closed loop system, where waste material is turned back into its original form and sent back to be consumed. In the case of bottles and jars, the loop can repeat itself over and over again, forever!

For manufacturing green bottles up to 90% cullet can be used, with the rest made up of raw materials including sand, soda ash and limestone. The ingredients are melted in a furnace that can reach 1600 degrees C from which toffee-like strands of glass will be cut into 'gobs' and placed into moulds.

From there, they are reheated to 550C to allow for a controlled period of cooling that will ensure a strong, non-brittle final product. Following stringent safety and inspection tests, the finished bottles and jars are put into pallets and distributed to customers and retailers to end up back on your table.

Other uses for low grades of recycled glass which do not meet the specification for new bottle and jar manufacture include a coarse aggregate substitute for use in road construction, concrete product manufacture or as trench backfill. When crushed to a finer size, it may be used as a replacement aggregate. Other applications include sports turf sub base, golf course bunkers, grit blasting, glass bead manufacture or as a fluxing agent in brick manufacture.

Another popular use for recycled glass is in fibreglass insulation manufacture where either mixed colour bottles and jars or flat glass cullet is used offering numerous benefits over virgin materials.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Why is Recycling Important

The importance of recycling can be observed in multiple ways. If you are wondering in your mind as to "why I should recycle" then here are some causes which should convince you to do so.

Recycling Saves Energy

When new products are manufactured from the raw material obtained from recycled products, it saves a lot of energy which is consumed for the production. When new products are manufactured from 'virgin materials', the amount of energy consumed is much higher. Besides, the energy required to acquire and transport the 'virgin' raw materials from their origins or natural sources is also saved. Add to that the energy which is required to clean and protect the environment from the pollutant waste products, especially those which are non-biodegradable (plastic) and fill up the landfill areas.

Recycling Saves Environmental Conditions and Reduces Pollution

Recycling helps in preventing global climate change to a great extent. By minimizing the energy spent on industrial production, recycling also helps in reducing greenhouse gas emission. Some of the major fossil fuels used in most industries include coal, diesel, gasoline etc. All these emit harmful gases such as methane, sulfur dioxide, carbon-dioxide to the environment. The processing of fresh raw material also creates toxic materials which pollute the environment. By reducing the energy used, recycling also minimizes the amount of fuel usage which in turn reduces the amount of harmful pollutants in the environment.

Recycling Saves Natural Resources

We know that recycling involves the processing and usage of the core elements of an old product for the production of new products. This helps in saving our natural resources to a great extent. For example, once an old newspaper is recycled we do not need to use the resource of another tree to produce new paper products. This way, proper recycling can help us preserve our natural resources for our future generations and maintain the balance of the nature.

Economic Benefits

Similar to energy and natural resource, recycling also helps in saving a lot of expense, demanded for the production of new products from 'virgin' materials. These expenses include the entire production cycle starting from acquiring the raw materials, transferring them from their origin to production places, processing and manufacturing costs. Recycling process creates employment opportunities for a lot of people, involved in the various stages of the process. This in turn contributes to the economic development of the state or country.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Recycling Saves Space for Waste Disposal

Most of the landfill sites are filled up with a lot of waste products that could have been recycled effectively. Some of these waste materials belong to non-biodegradable category which takes a long time to decompose. Recycling enables proper usage of these waste products and saves space for landfills. The pace with which landfills are getting filled up, soon we might run short of landfills unless we start following recycling at our own home and spread the word to others.

What can, and cannot be recycled?

Recycling for your average suburban household in South Africa is a bit of a schlep: the infrastructure for collecting recyclable material isn't really in place – yet. Households generally have to separate their rubbish and take the recyclables to a municipal drop-off centre or a buy-back centre because there's not much in the way of kerbside collection. Many people just can't be bothered. But, there are also many people out there who would recycle if they knew how to. This guide aims to help you get started.

How good is South Africa at recycling? The recovery rates for various materials are as follows:

- Cans: 69 percent
- Paper: 59 percent
- Glass: About 25 percent
- Plastic: About 17 percent

Informal recyclers recover much of this material from dustbins and landfill sites. This is not ideal, firstly from the point of view of the health and safety of the recyclers. But also because the recyclable material is contaminated with other waste. First prize would be if households sorted their waste, so that "uncontaminated" recyclable material could be collected.

Why you should recycle

Firstly, the Earth's resources are not infinite so we shouldn't waste them. And, you know that sign that reads "Leave this place in the same condition as you'd like to find it"? Well, the same applies to the planet. You'd rather see your grandchildren running through piles of fallen autumn leaves than piles of discarded rubbish (wouldn't you?). More specifically, the government wants to reduce the amount of plastic, cans, paper and glass going to landfills by 70 percent in the next decade or so. To meet that target, households need to stop

Training Provider Accreditation Number: AGRI/c prov/0282/1

simply throwing away rubbish and start implementing the three Rs: Reduce, Reuse and Recycle. Reasons to recycle

What can all be recycled, and why?

1. Metal

- Cold drink and beer cans
- Food tins
- Metal lids of glass jars
- Aluminium cans (e.g., Red Bull), foil and foil packaging
- Paint, oil and aerosol cans (leave labels on them so recyclers can see whether they contain hazardous material).
- Rusty cans can be recycled

2. Glass

Beverage bottles

Food jars such as tomato sauce, jam and mayonnaise bottles

The following CANNOT be recycled

Drinking glasses

Light bulbs – ordinary and energy-saving compact fluorescent lights (CFLs) – and fluorescent tubes. NB CFLs and fluorescent tubes should not be thrown away with ordinary rubbish. They contain mercury, a toxin that can leach into the soil and groundwater if not disposed of properly. Take your old CFLs to the drop-off points at Pick n Pay and Woolworths stores where they will be disposed of safely. If you don't have this option, place your old CFLs in a sealed plastic bag before you throw them in the bin. To dispose of standard fluorescent tubes you can either contact Don't Waste Services if you have a lot of them.

3. Paper

- White office paper
- Magazines and books (as long as nothing is laminated)
- Newspaper
- Cardboard (boxes and cereal boxes)

The following CANNOT be recycled:

- Laminated or waxy paper
- Punch confetti
- Carbon paper
- Stickers

4. Plastics

Plastics are made from oil, a non-renewable resource, and much of the plastic packaging we use every day is recyclable. Ice cream and milk containers, fabric softener bottles, plastic bags and even cling-wrap can all be recycled.

The easiest way to determine whether a plastic product is recyclable is by looking for its recycling logo. There are seven plastic recycling logos and most plastic packaging is imprinted with one of them. The logos tell you what type of plastic a container is made of. Each type has to be recycled separately. (Plastic recycling logos)

5. Tetrapak

Fruit juice and milk containers look like they're made out of paper, but they are lined with aluminium foil and plastic so they must be recycled separately. Tetra Pak has opened its first small-scale recycling facility in Germiston, Gauteng, where its packaging is recycled into roof tiles, furniture and stationery. The company has plans to open more recycling plants around South Africa.

6. Batteries

Disposable batteries are not recycled – this is apparently because the material recovery rate is too small to make recycling economically viable. But they should not be thrown away with ordinary household waste either, because they contain toxic chemicals that can leach into the soil and groundwater.

Rechargeable batteries, on the other hand, are recyclable. Add to this the fact that they last a lot longer than ordinary batteries and you have a compelling argument to buy rechargeables from now on.

7. Other

You CANNOT recycle

- Pyrex
- Ceramics (plates)

A

You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ **I am able to show sensitivity to the protection of the environment.**
- ☐ **I am able to recognise the dangers of pollution.**
- ☐ **I am able to apply the preventative practices to minimize pollution.**
- ☐ **I am able to utilize the environmental protective principles in landscape maintenance.**

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

_____
_____
_____
_____
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Training Provider Accreditation Number: AGRI/c prov/0282/1

PLANT AND ESTABLISH HERBACEOUS PLANTS IN LANDSCAPED AREAS

264190

A person credited with this unit standard will be able to:

- Describe the role of herbaceous plants in the landscape.
- Work with many species and varieties of herbaceous plants.
- Lift, divide and store herbaceous plants.
- Prepare the soil and replant the herbaceous plants.

HERBACEOUS PLANTS AND THEIR MAINTENANCE

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Herbaceous plants are plants with growth which dies back to the ground each year, in contrast with woody plants, which keep adding growth and remain active during the season when herbaceous plants are dormant.

As a general rule, annual plants are all classified as herbaceous, but herbaceous plants can also be biennials or perennials as well. Many gardeners rely heavily on herbaceous plant species to add colour and texture to their gardens, and these plants often form the core of a garden.

A typical herbaceous plant starts to die down in the fall, often dropping leaves in the process. In the spring, new growth appears as the plant's roots and low-lying stems start to put out fresh shoots. Eventually, the plant

Training Provider Accreditation Number: AGRI/c prov/0282/1

will flourish again, often producing bright, colourful flowers and rich greenery which will thrive through the summer before the plant starts to die back again.

In the case of annuals, the plant often reseeds itself, and new plants will grow again in the following spring. Biennials and perennials may be able to reseed, but they can also spread through rhizomes, corms, and bulbs.

Some plants die back completely, while others retain some growth near the ground, especially in temperate zones, where the weather will not be severe enough to force the plant to die off entirely. This trait can be valuable, as gardeners usually do not want to look at dead stems and vacant patches in the garden every winter.

The stems of herbaceous plants are typically soft and fleshy, unlike those of woody plants. Many herbaceous plants are characterized by very bold, bright flowers, which makes them a very popular addition to the garden.

Their foliage may also be bold and colourful, with some species being bred specifically for variegated foliage which will add colour to the garden. Some examples of herbaceous plants include: irises, nasturtiums, peonies, carrots, and cosmos.

These plants can be used in a variety of ways in the garden. Herbaceous plants often make excellent borders and groundcovers, because they tend to grow rapidly and they take well to shaping with careful pruning and clipping.

Their bright flowers also make them popular for container gardening. Some can be forced to bloom indoors in the winter, adding some colour to the home in months when winter weather can make life seem grim, and these plants can also be used for things like erosion control, with seeds being spread over erosion-prone areas so that plants will develop and put out roots which will hold the soil in place.

Most nurseries keep an array of herbaceous plants in stock, along with seeds for growing them. Gardeners can also collect seeds from the gardens of friends and neighbours, and some plants will grow from clippings, as well. One of the advantages to using annuals and biennials in gardening is that the look and feel of a garden can constantly be changed as old plants die and new plants are established in their place.

Training Provider Accreditation Number: AGRI/c prov/0282/1

How to care for herbaceous perennials

While shrubs and trees provide a permanent woody structure, and bulbs have their moment of glory, herbaceous perennials are with us from spring, when their young shoots re-emerge from winter dormancy, right through to the frosts of autumn and beyond.

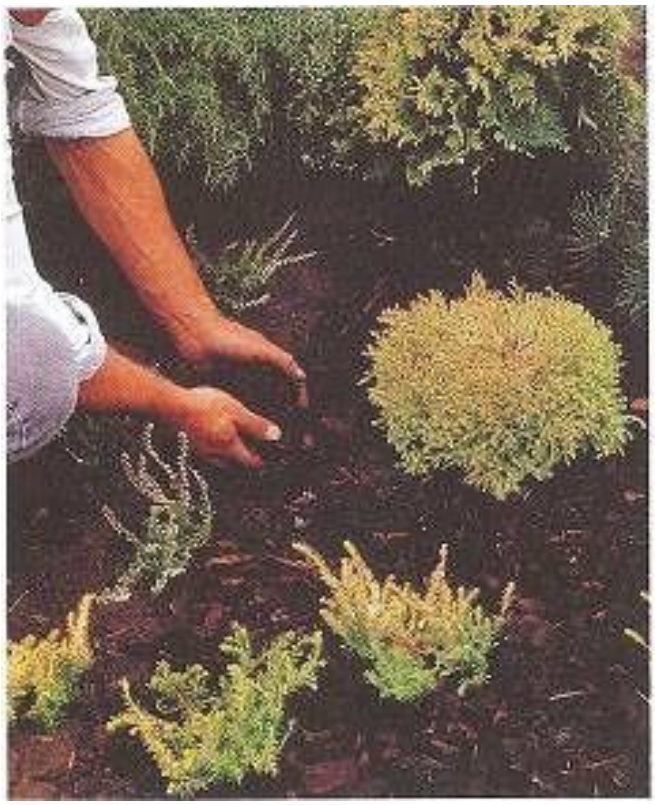
How to plant

Choosing plants that relish the conditions in your garden is the first step, but investing some care and attention at planting time, and while your plants are establishing themselves, will be handsomely rewarded by better performance all round for many years to come.

Make sure the soil has been well prepared and all perennial weeds in the border have been removed. Choose healthy, vigorous-looking plants, bought in spring or autumn. Ensure that the soil in the planting hole is loose enough to allow the roots to grow out. Soak roots in water before planting, so they will grow out, gently tease roots away from the rootball. Herbaceous perennials are tremendously important in virtually every garden Plant with a trowel and firm by hand and water thoroughly; you should also plant herbaceous perennials in groups of three or five for best effect.

Routine maintenance

Maintenance is minimal if plants have been selected to suit the conditions, but, even so, care taken in carrying out some simple tasks will be repaid by better performance and a more attractive display. Spring is the best time to apply mulch, which will help to prevent weed seeds germinating and will also lessen the need for watering in the summer. Mulches include bark chippings, cocoa shells, plastic membranes, grass clippings or even pebbles.



Some perennials (asters and delphiniums, for example) need staking, and supports should be put in place in spring – they will soon be masked by foliage if you want them to be hidden. Staking can be rustic to blend in, or elaborate and part of the design. Painted stakes can give early colour to the border, or you

Training Provider Accreditation Number: AGRI/c prov/0282/1

could try interesting cane toppers in the form of butterflies or fancy finials to give another decorative dimension.

Single staking: delphiniums and similar plants look best with one stake per stem, tied individually as it grows. Group staking: asters and other similar plants will need a group of stakes or a wire ring to grow up through, supporting the many flower spikes on display.

Young spring growth is vulnerable to slugs and snails, some more than others, but it is best to take action as soon as you can. There are many options for slug and snail control. Keep weeds in check, as they are not only unsightly, but also compete for space, light, food and water. As the border fills out with plants, weeds should become less of a problem.

Keep young plants well watered

Established plants may need watering in dry periods. Deadheading keeps plants tidy, can lead to a second flowering, and encourages leafy growth that will flower well next year. In autumn, cut back dead and dying top growth – unless you require them for winter effect, such as the flower heads of sedum or the golden flower heads and foliage of grasses. In cold areas cutting back can be left until spring, as it provides some protection against the cold.

Dividing and propagating

After a few years you will find that your perennials have grown into large clumps. You may also find that some of them do not flower as prolifically as in their younger days and may start to die out in the centre. The solution is to divide these congested clumps.

The benefits are substantial:

- Better flowers will be produced on a rejuvenated plant.
- Resistance to pest and disease attack increases as the plant becomes more vigorous.
- More invasive perennials will be curbed, preventing them from suffocating their neighbours.
- You will have a greater number of plants which can either be planted elsewhere in the garden or given away to friends or family.

The principles of division are basically the same for all perennials. Divide perennials during their dormant season, between late autumn and early spring, but only when the weather is suitable, neither too cold nor too wet. Dig up the clump to be divided and put it on a bench, or other hard surface. Divide the rootstock up by

Training Provider Accreditation Number: AGRI/c prov/0282/1

teasing the clump into separate pieces by hand or, failing that, use two garden forks back to back or a sharp knife if the roots are tough and woody.

Discard the old central root section – it is the youngest, outermost roots that are the most vigorous. Each section should have at least three buds; smaller sections should be grown on elsewhere before going into the border. Make sure, too, that each piece has more roots than top growth. This helps re-establishment. Perennials can also be propagated from cuttings in spring or by collecting seed, though seedlings may not be the same as their parents.

Planting

Planting depth should be the same as container depth or to soil line on bare root plants; don't bury the crowns. If planted too deeply, crowns and roots may rot; if too shallow, they may dry out. Plants in containers may become root bound. If so, disturb the root system by gently pulling it apart before planting (figures on the right). Most annual plant tags will give spacing tips.

Use the following table for spacing perennials:

Mature plant height	Spacing between plants
1m or above	60-90cm
60-90cm	30-45cm
Less than 60cm	30cm

After planting, water well with a "starter" solution of fertilizer that is high in phosphorous and aids root establishment. Established perennials can be transplanted in early spring just after growth starts, or in late summer (early September). Dig as large a root ball as possible and keep plants watered to aid establishment. If plants must be relocated during the growing season, cut off all flowers, cut back foliage, and attempt to transplant on a cloudy day. Dig a large root ball and follow good watering practices.

Fertilizing

Fertilizers contribute to good growth, colour, and bloom. Perennials are fertilized in spring as new growth emerges, and again eight weeks later. Broadcast 500g of a 5-10-5 or 6-12-6 fertilizer over 30sq meters of bed, each time. Keep fertilizer away from stems and off of foliage (it can be washed off with a light sprinkling of

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water). For annuals, broadcast 1kg of a 5-10-5 fertilizer per 30sq meters at planting; apply other 500g six weeks later, and another one pound six weeks after that.

Irrigation

Additional water may be required during the growing season. In general, plants need one inch of water per week as rainfall and/or applied water. Watering should be done in the morning, and at soil level, rather than sprinkled over the top of plants, which may spread disease. Soaker hoses, bubblers, and water breakers all aid in watering. Plants that are recently planted or transplanted may need additional water during the establishment period.

Mulching

Mulches are used to help prevent mud-splashed blooms, conserve moisture, moderate soil temperatures, and suppress weeds. Spring mulch can be applied, once soil has warmed. A depth of 5cm is sufficient and should be kept away from plant stems. Compost, chipped or shredded bark, pine needles, shredded leaves, etc., are all suitable to use.

Perennials that are transplanted or newly divided in autumn should have three to 12cm of mulch applied over the crown **after** the ground freezes to prevent soil from freezing and thawing and potentially heaving plants out of the ground. Plants that are marginally hardy should also have 7-10cm of mulch for winter protection. Pull these mulches back from the crowns once new growth begins to emerge in spring.

Pinching and Deadheading

"Pinching" is done to promote bushiness and, consequently, more flowering. Many annuals are "soft pinched;" the terminal is pinched out to allow for branching. Gardeners may give annuals a pinch at planting, and then pinch again later in the season to rejuvenate and encourage more new growth.

Do not pinch cockscomb, poppies, stock or balsam which tend not to branch. Perennials are pinched or pruned for the same reasons. Research specific plants to know when and how much to pinch.

Both perennials and annuals should be deadheaded (dead flower removed) throughout the season. This encourages rebloom, eliminates seed production and self-seeding, and helps maintain compactness. Don't deadhead, however, if you wish to dry flowers, save seed, or are wanting seed pod development for drying. Leave flowers on most ornamental grasses and on *Sedum* 'Autumn Joy' for some winter effect.

Staking

Some plants require staking since stems and flowers may flop or fall over in the garden. Plants with heavy flower heads and/or long thin stems tend to blow over or be beaten down in heavy rains. Overly fertile soils that cause succulent, soft stems, or inadequate sunlight can also lead to floppiness.

Staking should be done when perennials are about six inches in height; put stakes on annuals at planting time. This allows plants to grow up through and around the supports, usually hiding them by mid-season. Perennials often requiring support include: *Delphinium, Digitalis, Achillea* 'Gold Plate,' some peonies, tall lilies, mums, and asters. Tall annuals, such as Cosmos, may also require staking.

Division

Division is a necessary chore in maintaining most perennials. A few plants never like to be disturbed, and should not be moved or divided; *Aconitum, Baptisia, Dictamnus, Eryngium, Helleborus, Limonium*, and *Papaver* are good examples. Most others will need division every three to four years or so. It's time to divide when a dead center forms in the crown area, with a ring of plants around it; blooms are fewer and smaller; or growth appears crowded.

A general rule is to divide the plant in the non-bloom season. Midsummer bloomers should be divided in spring. In spring, divide when plant growth is 5-7cm in height. Autumn divisions must also be done; plants should be semi-dormant and temperatures cooling.

Use a spade to dig the clump and cut off divisions. If you don't want to divide an entire clump, divisions can be cut from the edge of a clump using a spade and trowel (Figures 3 and 4). Some plants have tough, thick root systems that are a challenge to divide; *Hosta, Hemerocallis*, and *Astilbe* may be hard to divide.

Autumn Clean Up

At season's end, after a hard killing frost, the garden can be cleaned out. Cut off annual plants at the soil surface, leaving their roots in the soil to add organic matter. Perennial tops can be cut off too, above the crown.

Leaving a short piece of stem, especially if it's a bit woody, may aid in locating plants the following spring. These tops can be chipped or shredded for composting, or otherwise worked into a compost pile. Plants that have a tendency to emerge late in spring, such as *Platycodon*, should be marked with a wooden or plastic tag, in order to avoid destroying them when working the garden early the following spring.

Soil and Bed Preparation

Good soil preparation is essential for success. Be aware of soil type on your property and be willing to amend and work it to provide good aeration and drainage. Sandy soils may need additional organic matter incorporated (compost, dried manure, or peat moss) to help retain moisture and nutrients. Clay soils will typically need amendments, such as peat moss or compost, to improve aeration and drainage. Soils that drain poorly, especially in winter, cause the death of many perennials due to crown rot.

Start with a soil test that will give a pH reading and nutrient levels. Most perennials grow well in the 6.2 to 6.7 pH range and most annuals do fine in the 6.0 to 7.0 range. A few perennials for acid soil include: *Iris ensata, Iris cristata, Chelone, Asclepias, Phlox, Baptisia*, and *Astilbe*.

Perennials preferring alkaline soil include *Centranthus, Centaurea, Dianthus, Geranium, Dictamnus*, and *Gypsophila*. The pH can be changed through the addition of lime or sulfur (or sulfur-containing) products. Phosphorous and potassium may need to be added. Follow soil test recommendations for rates. These items can be added and incorporated as the bed is being prepared.

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Bed preparation is ideally done the summer or fall before planting the following year. Soil is typically drier than in spring and can be worked more easily. Perennial weeds can be completely killed, sod can be removed, and the action of winter freezes and thaws can break up clay clods.

Perennial beds should be worked deeply, to an 50-75cm depth if possible. Add one-third by volume of organic material and incorporate throughout the depth; sphagnum peat moss, dried manure, or compost work well. Annual beds should be worked 10-20cm deep and organic matter added (one-third by volume) and incorporated as well.

Also, add and incorporate 1kg of a 5-10-10 fertilizer or the equivalent per 30sq meters of bed area, unless soil test recommendations state otherwise. In wide beds, make some provision for paths or stepping stones to reduce soil compaction during maintenance. Some gardeners work from a board laid in the bed to distribute their weight over the soil.

To summarise:
Many gardeners grow herbaceous plants to add colour and texture to the spring, summer, and fall landscape. "Herbaceous" means non-woody, and includes many common annuals and perennials grown for bloom or foliage effect.

Success is nearly assured if a proper planting site is selected and good cultural practices are followed. Knowing the particulars of a plant's culture is beyond the scope of this fact sheet; do further research on your own for plants that interest you.

The term "annual" refers to a plant that completes its life cycle in one growing season. It begins from seed, flowers, produces seed, then dies. A "biennial" is a plant requiring two growing seasons. The first season, it is simply vegetative. It overwinters, and in the second season produces flowers and seeds and then dies. A "perennial" is a plant that is winter hardy and reappears year after year from its crown and root system.

It can bloom and produce seed every season. Sometimes a perennial will not bloom in its first season. This may be due to establishment problems, improper photoperiod, or lack of a cold period that induces bloom. Plants started from seed in winter seedlings (in greenhouses) often fail to bloom the first season.

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You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ **I am able to describe the role of herbaceous plants in the landscape.**
- ☐ **I am able to work with many species and varieties of herbaceous plants.**
- ☐ **I am able to lift, divide and store herbaceous plants.**
- ☐ **I am able to prepare the soil and replant the herbaceous plants.**

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

_____

_____

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PLANT AND ESTABLISH HERBACEOUS PLANTS IN LANDSCAPED AREAS

264178

A person credited with this unit standard will be able to:

- Utilise safety practices when cleaning interior plants.
- Indicate the reasons why interior plants should be cleaned.
- Identify the presence of pests or diseases on the plants.
- Select the correct cleaning materials and equipment for plant cleaning.
- Clean various types of interior plants and their containers.
- Utilise knowledge of plant cleaning to conduct interior plant maintenance.

HERBACEOUS PLANTS IN GARDENS

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Because hardy perennials usually reappear year after year, they have advantages over annuals. These plants can fill space rapidly if grown under proper conditions. Many reach their mature size several years after planting, expanding gradually into large, showy clumps. There are hundreds of different perennials, each with a distinct texture, colour, scent and form, making garden design an intriguing adventure.

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Most perennials bloom for a fairly short time, from 1 to 3 weeks, although some, such as yarrow (*Achillea*) or catmint (*Nepeta*) can bloom persistently for as long as 6 weeks. With careful perennial plant selection, you can have garden interest from early spring until frost.

Successful flower gardening depends on understanding your site's characteristics and matching them to the needs of individual plants. Annual and perennial flowers have been hybridized for centuries, chosen from wild plants originating in bogs, sunny landscapes, meadows, woodland shade and other growing conditions.

Understand your garden environment before selecting herbaceous plants. Analyze the hours of daylight, soil texture, drainage, water availability and winter frost conditions. Choose plants whose cultural needs match your garden situation.

A common question asked by gardeners everywhere is which flowers will grow in the shade. For full-shade, the list of annuals is pretty short — wax begonias and impatiens. Perennials suitable for shady locations include bluebells, some ferns, lily-of-the-valley and hosta.

But most shade-loving perennials don't require shade in Alaska and can be grown in full sun as long as the plants receive enough water. Hosta actually performs better if not planted in full shade as do many of the new coleus cultivars.

Another factor is that at high latitudes the north sides of buildings receive some direct sunlight during the growing season. If low maintenance is your design objective, consider the following plant characteristics when designing a perennial garden:

- Is the plant long-lived (lasting at least four seasons)?
- Does it grow strongly, but not overwhelm other plants?
- Will it have a long bloom time?
- Is it attractive when out of bloom?
- Is it generally pest-resistant?

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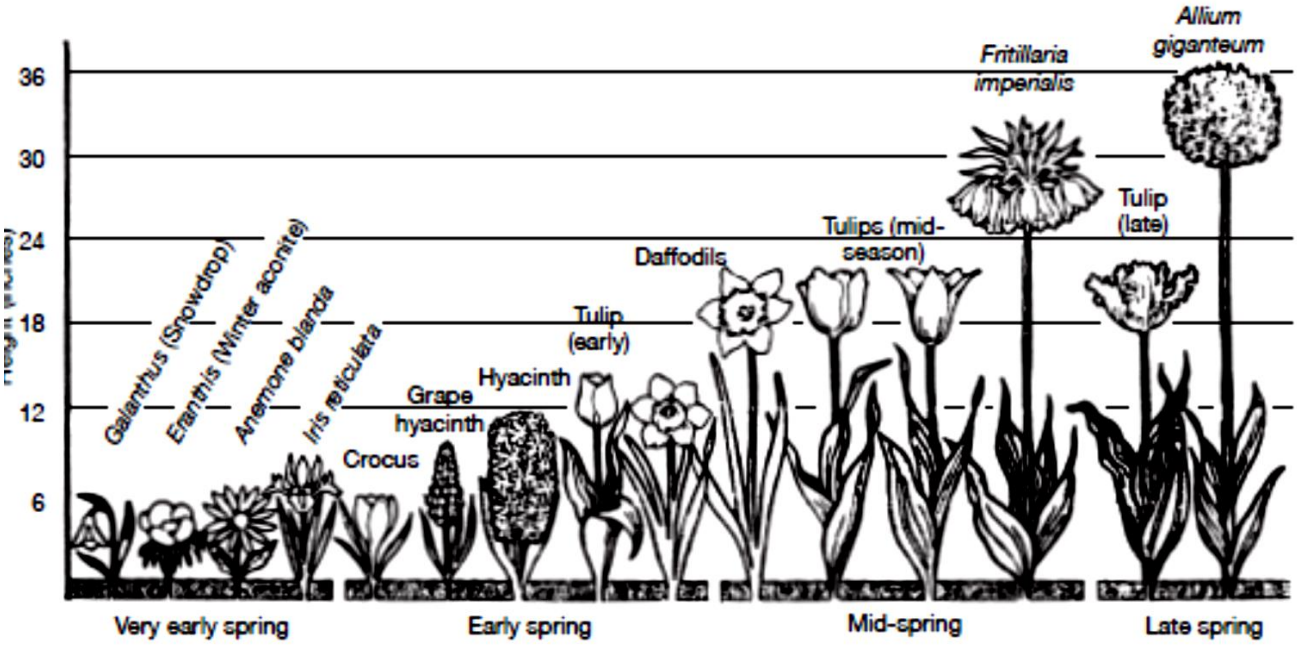
Peonies (*Paeonia*), globe flower (*Trollius*) and dwarf bleeding heart (*Dicentra formosa*), are among the many herbaceous perennials that meet these criteria in gardens. Garden design uses harmonious colour patterns, bloom sequence and intriguing texture to create a place of beauty. Which plants you utilize depends entirely on your taste. Keeping an idea notebook when you visit gardens and nurseries will help you develop confidence in making design choices.

Bulbs, corms, rhizomes, tubers and tuberous roots

Many garden plants are classified botanically as bulbs, corms, rhizomes, tubers or tuberous roots. All of these underground structures store food for the plant. The figure on the right illustrates flowers of several types of bulbs and corms.



Bulbs are composed of a thin, flattened stem surrounded by fleshy leaf bases called *scales*. Roots grow from a basal plate. Onions, narcissus, tulips and lilies are examples of plants that form bulbs. Slicing an onion vertically and observing the interior gives a good look at a bulb's anatomy.

Corms have solid interiors, developed from swollen stems. If you cut one open, you see a homogenous mass inside. Roots form at the base. Some examples of plants that form corms are crocus, gladiolus and anemone.

Tubers are swollen, modified, underground stems. They don't have basal plates where roots originate. Tubers come in various shapes and include *Caladium*. *Tuberous roots* are composed of root tissue. Dahlias and

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tuberous begonias are examples of plants with tuberous roots. *Rhizomes* are specialized stems that grow horizontally at or just below the soil surface. Lily-of-the-valley has rhizomes.

Like other herbaceous ornamentals, bulbs, corms and tubers are classified as hardy or tender. Most hardy bulbs and corms are planted in autumn for early spring and summer bloom. Daffodils and tulips define spring for many people. Lilies, which bloom in early or midsummer, should be planted in the spring.

Tender bulbs, tubers and corms generally bloom mid- to late summer. Examples are dahlias, tuberous begonias and gladiolus. These tender perennials don't survive severe winter cold, so they must be dug in the fall before freezing temperatures. Store them in a frost-free location. Plants need to be started indoors and planted outside after they have been hardened off and all danger of frost is past.

Selection and storage

Choose solid, healthy plants. With lilies, tulips and daffodils, larger bulbs yield larger blossoms. Some bargain bulbs are not worth the price, no matter how inexpensive, because they are too small to bloom well. Purchase hardy bulbs in autumn.

If you can't plant bulbs immediately, keep them cool and dry. Temperatures between 10° and 15°*C* are best for storage. Use paper sacks rather than plastic bags, since mould may develop if moisture accumulates inside the package.

After digging tubers, such as dahlias, store them in peat, vermiculite or perlite in a cool area. Check bulbs regularly and dampen the storage media if bulbs or tubers are starting to shrivel. Moose are very fond of tulips but avoid daffodils and many of the smaller species of bulbs.

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Site preparation and planting

Crocus, narcissus, tulips and lilies must have excellent drainage or they will rot. Remove all weeds before planting, making sure to get perennial weeds by their roots. Add organic amendments such as compost. Remember, bulbs can also be mixed with annuals and other perennial flowers. Planting depth depends on soil conditions.

Opinions vary on planting depth but many gardeners plant about three times the depth of the bulb. Others plant more shallowly because of our cold soils. If dry, water the soil thoroughly after planting. If desired, mulch hardy bulbs after the ground freezes. Winter protective mulches should be moved slowly to allow new shoots to emerge in spring.

Soil preparation

If you follow some basic steps when installing a new garden, you will have good results. For perennial gardens, soil preparation is the key to strong future growth. Later applications of fertilizer can't compensate for poorly prepared soil. This is the most important component of starting a successful garden.

First, get rid of weeds, especially perennials such as dandelions and quack grass. If you are fortunate to garden in an area with good topsoil, dig thoroughly, loosening the soil to at least 30 cm. Spread 7-10cm of organic material across the soil surface and dig it in well. This addition will help increase the soil's water-holding capacity, improve root penetration and aeration. Commercial compost, homemade compost, chopped or composted leaves and composted manure make good amendments. Be wary of introducing weed seeds when using composted manure that has not been sterilized.

Building raised garden beds is one way to warm the soil and make your gardening easier. Plants benefit from the deeper soil provided by beds built up from the existing grade. In addition, drainage is improved and the soil warms faster in the spring. If you do not have good topsoil, consider the benefits of building beds up as much as 18 inches. Use good quality topsoil and amend with organic ingredients such as composted manure, garden compost or whatever weed-free organic material you have available.

Recognize that many perennials form large, heavy root structures, which can rot if the site isn't well drained. If you face this situation, improve drainage or choose plants suitable for damp conditions. Soil testing is helpful when starting a garden on an unfamiliar site or when expanding an existing garden. Many herbaceous perennials grow well in slightly acid soil, but some need supplemental lime if the soil pH is below 6.0

Propagation

Annuals and biennials

These flowers generally are started from seed or purchased as small plants. Some annual seeds can be sown directly in the garden depending upon location. These include annual poppies, baby-blue-eyes and nasturtiums.

Many other annuals and biennials do best if started on a propagation mat or other heat source and then transplanted. Marigolds, sweet alyssum and sunflowers transplant well. Start seedlings indoors 4 to 6 weeks or more before they will be planted in the garden. Ample light is needed to grow stocky, healthy transplants.

Beware of starting seedlings too early; they grow poorly if left too long in low light and crowded indoor conditions. Grow seedlings in cool temperatures if possible, with 14 or more hours of light. Seedlings can be successfully grown with window light, but most benefit from auxiliary fluorescent lights placed a few inches above the plants.

Buying seedlings from nurseries is convenient, especially for annuals with very fine seeds such as petunias, lobelia and impatiens. Unless you have excellent propagation facilities, these plants are more difficult to grow from seed.

Perennials

Perennials grow more slowly than annuals, and many will not bloom the first year. You can start them from seed in a nursery bed and transplant them to a final location when they are sturdy enough to move. Perennials are often ready to transplant late in their first season.

Division

As herbaceous perennials develop established root systems, many spread into large clumps and can be propagated by division. Divide perennials as part of your general garden maintenance. Growth and performance decrease when plants get crowded. Division rejuvenates plants and results in extra plants to share with friends or donate to plant sales. Some plants, such as our native Alaska wild iris, perform better if divided regularly.

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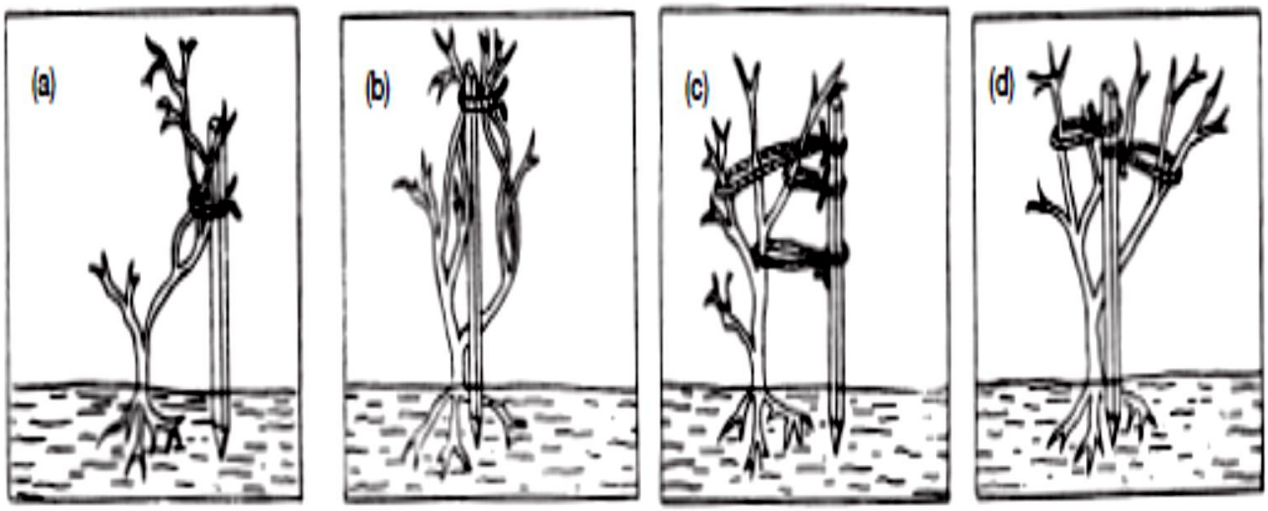
Dividing perennials when they are dormant or just beginning to grow is optimal, allowing a full season for root development. Time the division to allow for root development before the plant normally blooms. Dig the plant with a generous number of its roots intact.

Select vigorous shoots from the outer part of a clump and discard the center. Then, divide the plant into several sections of three to five shoots each. Make large divisions. Small pieces will not bloom much the first year. Before replanting, add compost or other organic materials to the soil.

Cuttings

Many plants can be propagated from either tip or root cuttings. Generally, tip cuttings are easier to grow than root cuttings. Take5-10cm-long tip cuttings from perennials such as candytuft (*Iberis sempervirens*). Remove all foliage from the lower one-third of the cutting. Insert cuttings into a clean planting mix which contains perlite, vermiculite and peat moss.



Professional growers supply bottom heat and provide moisture through automatic misting systems that keep cuttings moist while roots develop, but home gardeners can still be successful. Cover cuttings with clear plastic to retain moisture and support the plastic to keep it from touching the foliage. Place the cuttings in a light area, but out of direct sun.

High temperatures can build up under the plastic on warm days and kill cuttings. When cuttings resist a slight tug, they have begun to root. Poke holes in the plastic to provide more air circulation. Remove the plastic altogether once the roots are formed. When the root systems are large enough, transplant cuttings to a nursery bed or container and begin fertilizing.

CLEANING PLANTS

TIME: 90 MINUTES **ACTIVITY: SELF & GROUP**

Plants growing outdoors are washed regularly by rain and feather dusted by the wind. But it's up to us to clean indoor plants, especially the hard-working ones--houseplants that clean air. Dust, grease, oil, and other airborne particles settle on leaves, making them unattractive and dull-looking. Leaves that are dirty can't absorb as much sunlight as clean ones.

This affects overall plant health because plants sustain themselves through photosynthesis, a process in which the leaves absorb sunlight and carbon dioxide to make their food. When plants are coated with residues, their stomata (stoh-MAH-tuh), the openings through which they exhale oxygen and inhale carbon dioxide, become blocked and they have a difficult time with this critical process.

Periodically cleaning your houseplants improve their appearance (we all like to look our best, right?), stimulates growth, and helps to control insects and other pests. No plant likes to be left in the corner and forgotten. They thrive when you pay more attention to them. Clean your indoor house plants every couple months or so. If you live in a dusty area, do it more often. Clean firm, not African violets and other hairy-leafed plants, with a soft sponge or cloth.

A word about sponges; look for soft, pliable, and gentle ones. Avoid coarse, rough sponges like loofas and some commercial varieties--even if you have to test squeeze them in the store! The best sponges are natural cellulose types and the big, light brown, round-cornered ones (not loofas) that are used at car washes. Baby sponges also work great.

Moisten the sponge or T-shirt with plain, tepid water. Don't use milk, vegetable oil, or those commercial "leaf shine" products. They only clog the leaf pores. For extra-dirty plants, go ahead and add a couple drops of liquid, non-detergent soap.

Support the leaf on an upturned hand and gently wipe with the other. Try to clean the top and bottom of each leaf. For plants with hairy leaves, such as African violets, do not clean them with a damp sponge or cloth. Use a soft cosmetic or children's brush or even a feather duster.

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The majority of houseplants originate from the tropics, so it's no wonder that they love to be misted. Most interior spaces however, have very low humidity, which explains why most houseplants dry out so quickly. Brown leaf tips are one of your first clues. Think of misting as a form of preventive maintenance. It helps discourage dust from settling and sticking to the leaves in the first place and it keeps the leaves from drying out. Remember to use tepid, not cold tap water!

Activity – In your groups

Discuss and answer the following questions:

Why is it important that plants are cleaned?

Why is it important that the correct materials are used when cleaning plants?

Why is it important that the correct liquids are used to clean the plants?

What dangers are there for the plants when they are not cleaned correctly or frequently?

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You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ **I am able to utilise safety practices when cleaning interior plants.**
- ☐ **I am able to indicate the reasons why interior plants should be cleaned.**
- ☐ **I am able to identify the presence of pests or diseases on the plants.**
- ☐ **I am able to select the correct cleaning materials and equipment for plant cleaning.**
- ☐ **I am able to clean various types of interior plants and their containers.**
- ☐ **I am able to utilise knowledge of plant cleaning to conduct interior plant maintenance.**

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

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TREAT FORESTRY PLANT MATERIAL

119693

A person credited with this unit standard will be able to:

- Utilise safety practices when cleaning interior plants.
- Indicate the reasons why interior plants should be cleaned.
- Identify the presence of pests or diseases on the plants.
- Select the correct cleaning materials and equipment for plant cleaning.
- Clean various types of interior plants and their containers.
- Utilise knowledge of plant cleaning to conduct interior plant maintenance

SELECTION, PREPARATION AND CONDITIONING OF FLOWERS, STEMS AND LEAVES

TIME: 180 MINUTES **ACTIVITY: SELF & GROUP**

Conditioning involves the preparation of cut plant material prior to its arrangement, to ensure that its life is not unduly shortened. Correct conditioning will make sure that flowers and foliage last for the maximum time, providing the most value and enjoyment.

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One of the most common causes of wilting in cut flowers and foliage is the presence of an air-lock in the stem. The air-lock usually forms as the flower is cut, when atmospheric pressure forces air into the water ducts of the stem in which there is normally a partial vacuum.

It is virtually impossible to prevent the ends of dry-packed flowers and foliage from drying out during transit from the grower to the wholesaler, and from the wholesaler to the Florist. For this reason, many flowers are now shipped with their stems in a few inches of water.

Flowers cut from the garden and left for any time before being conditioned will also form an air lock, so always carry a bucket of water with you into the garden, so that you can place the plant material into water immediately, on a temporary basis, thus preventing the stem ends from drying out.

All plant material should be unpacked as soon as possible after buying from the florist, and any plastic sleeves and elastic bands should be removed. If cutting flowers and foliage from the garden, the best time for cutting is early morning, or late evening.

This is the time when flowers have the maximum amount of water in their stems, and they will condition more readily. Cutting in the heat of the day allows the material to wilt much quicker. Whether flowers are bought from the florist, or picked from the garden, all lower leaves should be removed from each stem, as any leaves left under water when conditioning will quickly begin to rot and cause a build-up of bacteria which will clog the stem ends, preventing the uptake of water, as well as causing the water to smell foul.

All buckets used for conditioning should be meticulously clean, and should be cleaned out regularly, to prevent the build-up of bacteria. After removing the lower leaves, all stem ends should have the bottom

Training Provider Accreditation Number: AGRI/c prov/0282/1

removed at a sharp angle, thus exposing more of the central area of the stem, known as the xylem tissue, which is responsible for the uptake of water.

As a general rule, buckets should be filled to about ¼ full with warm water, to which cut flower food has been added at the appropriate rate. This will prolong the life of the flowers, and helps to prevent bacterial growth. Using warm water allows the water to enter the stem more rapidly, so conditioning is quicker. However, use cool water for bulb flowers, unless you want them to open quickly. Flowers and foliage should be left in the water for at least two or three hours, and preferably overnight, before arranging them.

Selecting plants for arrangements:

When to cut flowers

Time of day

- For best results, collect cut flowers in the morning when their stems are fully turgid (filled with water).
- Avoid picking during warm and sunny conditions as the plants will be water-stressed.
- Wait at least until the evening when they have had a chance to recover
- Place the stems straight into a bucket of water or as soon as possible after cutting

Stage of development

- Most flowers are best picked when they are just starting to show colour. Those in full bloom will go over more quickly. However, the flowers of some plants ,such as roses and dahlias, may not fully develop if picked in tight bud
- Pick blooms in a spike arrangement, such as foxgloves and gladiolus, when the lowest flowers have just opened. However, wait until most flowers are open before cutting delphinium spires

Frequency

- Many annuals, such as sweet peas, and some perennials will bloom over a longer period if picked regularly
- Pick lightly and infrequently from slower-growing shrubs to avoid stressing the plant. Picking is a form of pruning, and heavy pruning may result in fewer flowers the following season

Precaution: It is best to use gloves when picking and handling cut flowers. All parts of some flowers, such as monkshood (Aconitum), are poisonous; others can cause skin irritation.

One important thing to remember is that stem ends should never be hammered, as this causes damage to the tissues, which leads to a build-up of bacteria, thus shortening the life of the material. Plant material should be conditioned according to its stem type, and conditioning varies with different stem types:

Woody Stems (E.g. Roses, Mimosa, Eucalyptus, Beech, Yew, Pittosporum, etc.)
Stems should be cut at a sharp angle, and the stem ends split for about ½". Remove all the lower foliage which will be below the level of the water, and place the stems in a bucket about ¼ filled with warm water, to which cut flower food has been added at the appropriate rate.

Semi-Woody Stems (E.g. Chrysanthemum, Lily, Carnation, Leatherleaf, Asparagus Fern, etc.)
These should be conditioned by cutting the stem ends at a sharp angle, removing all the lower foliage which will be below the level of the water, and placing the stem ends in a bucket about ¼ filled with warm water, to which cut flower food has been added at the appropriate rate. Special flower food is available for Lilies, and this should be used if possible.

Soft Stems (E.g. Freesia, Hellebore, Anemone, etc.)
Condition as above, but deeper water should be used so that the flowers are immersed up to their necks. After a good overnight drink, the flowers can then be arranged. Hellebores are a special case and benefit from the boiling water treatment - see special notes below for details.

Hollow Stems (E.g. Delphinium, Lupin, etc.)
Hollow stems are notorious for forming air-locks, as air enters the stem as soon as it is cut. Cut the stems at an angle and remove lower leaves as usual. Turn the stems upside down, and fill the hollow stem with tepid water. Plug the stem with cotton wool, or hold your thumb over it until it is placed in the bucket.

Milky Stems (E.g. Poppy, Euphorbia, Poinsettia, Ficus, etc.)

The stems of some flowers exude a milky substance, called latex, when cut. This can be messy, and also can be an irritant if it comes into contact with the skin. Therefore, plant material in this category should have the stem ends cut, and then the end should be burnt in a flame for a few seconds, to seal it. The cut stem ends can also be rinsed under running warm water to remove excess latex, before placing into warm water for conditioning.

Bulbous Stems (E.g. Daffodil, Tulip, Bluebell, Hyacinth, etc.)

Most bulbous stemmed flowers are pulled, not cut, from the plant by the grower. This means that the end of the stem is often white and firm. The stem will often not drink from this white area, therefore, it should be removed completely, by cutting at an angle, as water can only be absorbed through the green part of the stem.

Bulb flowers should be conditioned in cool to tepid water, unless the flowers are wanted open, as warm water speeds up the development of bulbous flowers. Special flower food for bulb flowers is available, and should be used if possible. Daffodil stems exude a poisonous sap when cut. This will shorten the life of other flowers if Daffodils are conditioned in the same water. Therefore, they should always be conditioned separately. If they are being arranged in water, they should be arranged separately, but if being arranged in floral foam, this is not necessary, and they can be arranged together with other flowers.

Special Notes for certain types of material:

- Hellebores and Hydrangeas are notoriously difficult to condition when very fresh. Both will benefit from boiling water treatment as follows: Add about an inch of boiling water to a jug, then place the stem ends in the water for around 1 minute. This will force out the air from the stems and allow better uptake of water. Take them out of the hot water, then re-cut the stem ends and put them into water up to their necks or immerse them completely overnight before arranging.
- A more fool proof method for Hellebores is to wait until they have formed (or are beginning to form) seed pods. At this stage they will condition very well and last a long time. For Hydrangeas, it is better to wait until they are mature and turning slightly papery before picking as very young flowers often don't condition well.
- Shiny or smooth foliage should always be washed, as this removes any dirt and dust. It's also a good idea to use a leaf-shine product, thus enhancing the appearance. Single leaves can be completely immersed in water to condition them.
- Grey foliage such as Santolina or Senecio, or woolly foliage such as Stachys lanata should never be fully immersed to condition it, as the water is absorbed by the grey covering and the colour of the foliage

Training Provider Accreditation Number: AGRI/c prov/0282/1

would be spoiled. Also, absorbed water can be siphoned by these leaves, creating pools of water outside the container.

- Very new growth, such as spring foliage, should not be used, as it is very difficult to condition, and does not last well.
- Flowers which sometimes wilt even after conditioning, (roses, for example), should have their stems re-cut, and the stem ends placed in about 3cm of very hot or near-boiling water. This destroys the air lock, and enables the plants to take up water again. The heads of the flowers should be wrapped in tissue paper or newspaper to protect them from the steam. When the flowers have revived, (usually after ¼ to ½ hour) re-cut the stem ends, as the boiling water will have damaged them, and continue to condition overnight before re-arranging them.
- Carnations and pinks should have their stems cut between the node or joint, as they cannot take up water if cut or broken on the node.
- Tulips should be wrapped in newspaper when conditioning, to keep the stems upright, as Tulips tend to "do their own thing" when being conditioned. Tulips continue to grow after being cut, and can grow up to 1" per day. They will always turn towards the light as well, and the flowers will turn upwards if arranged horizontally or almost horizontally. This should be taken into account when using tulips.
- Some flowers, such as Gladioli, will always turn upwards at the tip if not arranged vertically. (For the botanically minded, this is a phenomenon called "negative geotropism" whereby the stem tips always turn away from gravity. Roots are positively geotropic, therefore, they will always head towards gravity!) One way to avoid this happening is to carefully pinch out the top few buds, as it is only these which are affected.
- Clematis, Violets and Hydrangea benefit from complete immersion of the flowers to condition them.
- Lilac, Azalea, Philadelphus, Forsythia, Rhododendron, and other woody flowering stems, should have all the foliage removed, as it prevents sufficient water from reaching the flower head.
- Lilies should have their stamens removed before the pollen forms, to prevent staining of the petals, or clothes and furnishings.
- Mimosa should have the flower heads covered in a plastic bag whilst being conditioned, to prevent drying out.
- Sweet peas, Pansies and Primroses should not be sprayed with water, as this can disfigure the petals.

Conditioning plants

Conditioning

- Conditioning is preparing the cut flowers to prolong their longevity in displays and ensure they look their best. Condition the cut stems by following these five simple steps:
- Strip all the leaves from the bottom half to two-thirds of each stem. As a general rule, any foliage below the water level should be removed to prevent it rotting in the water
- For best results, re-cut all stems. Use a sharp knife or secateurs to avoid crushing the stems and reducing their ability to take up water and nutrients
- Cut the stems to length with a clean, angled cut without leaving jagged edges that could lead to decay
- Place prepared stems in a bucket of clean water and leave in a cool place for at least two to three hours or, ideally, overnight. This will allow the flowers to drink before being brought into a warmer environment
- Some plants with soft stems and heavy flower head, such as tulips and gerberas, are prone to bending. If left, the stem will remain in this position. To straighten the stems, wrap the bunch flowers in newspaper and stand them deeply in water for at least two hours – ideally over night

Special requirements

- Woody flower stems (roses) should have an additional vertical cut through the base of the stem to a length of about 5cm (2in)
- Hammering the bottom of woody stems is often suggested, but this may increase the rate of bacterial infection and is not usually necessary
- Stems prone to drooping, such as poppy, euphorbia, smyrnium and hellebores can be sealed by dipping the bottom 2.5cm (1in) of the stems into hot water (just off the boil) for 20-30 seconds. Always wear gloves when handling euphorbia to protect skin from its irritant milky sap
- Try to revive drooping roses with the hot water treatment described above. Remember to re-cut the stems first
- Condition the stems of plants with hollow stems such as delphinium, amaryllis and lupins by filling the stem with water. Plug the stem with cotton wool and tie a rubber band around the base to keep the plug in place and prevent the stem from splitting

Training Provider Accreditation Number: AGRI/c prov/0282/1

In the vase

- Always use clean vases. If dirty, wash put thoroughly with detergent and a bottle brush
- Dissolve some cut-flower food in the water before placing the flowers in the vase. As well as feeding the flowers, this will also help keep the water clean as it contains an anti-bacterial treatment
- Check the water level every couple of days and top up as necessary
- Change the water and re-cut the base of the stems every two to four days, re-cutting a little off the bottom of the stem each time
- Remove any dead or dying flowers to keep the arrangement looking fresh for longer
- Position the vase in a cooler spot in the room away from source of heat such as radiators and fires

Problems which may occur

- Drooping stems are likely to be a result of lack of water or poor water uptake. Top up water regularly. Re-cut the stems. Try treating the cut end with hot water. Check in literature or on website if any particular treatments are recommended
- Flowers aging prematurely. Keep arrangements in a cool spot. Change water regularly. Feed the flowers and prevent bacteria build up by adding cut flower food in the water. Keep away from ripe fruit
- Buds not opening due to being picked to early, especially roses. Pick in loose bud in the future
- Water in the vase becoming murky or smelly. Change water more regularly and ensure vases are thoroughly cleaned before use
- Small black pollen beetles coming out of flowers whilst in the room. Before bringing into the house, place the bucket for a day in a dark shed or garage with a door or window open. The pollen beetles will be drawn to the light, leaving the flowers inset free
- Earwigs can be troublesome, especially on dahlias, damaging the flowers. They can be also brought into the house on the cut flower stems.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Preparing for your arrangements

Pre-Arranging Treatment

In order to destroy bacteria from previous plants, scrub plastic buckets and vases with detergent and rinse thoroughly. Rinse again with a mild solution of bleach; one cap full per gallon of water. Bacteria from unclean containers are a primary cause of short-lived arrangements.

They clog the stems preventing the life-giving water from reaching the head of the flower and nourishing the complete plant. Plastic storage containers are preferable to metal ones, because the metal can interact negatively with preservatives and shorten plant life.

Fill a clean, plastic storage bucket half full of bottled or purified water and the proper amount of preservatives. It is important to use purified or bottled water, because the chemicals and hard minerals in tap water block the flow of water in the stems. Allow the water to sit for a half hour so trapped air can be released, and so the water can reach room temperature.

Trim off all broken, dying, diseased, wilted or damaged flowers and leaves. This is preparation for arranging as well as for cleaning off bacteria producing plant material. Remove the lower leaves from the stems.
Make the stem ends even, then hold them several inches underwater.

Cut 3cm from the bottom of the stems. Make sure your cutting tools are sharp. A water droplet will form on the end of the stems and prevent air bubbles from entering and blocking the flow of water when you transfer the flowers to the storage bucket.

Flowers need to hydrate in a preservative solution to replace moisture lost during cutting and handling. Let the flowers stand and balance themselves in the storage bucket. Keep them in a cool, well-ventilated place (never in direct sun) while they drink up the preservative through freshly cut stems.

Allow to sit for six hours or so (or overnight) before placing them in their “designer home”. This nourishing treatment step maximizes solution uptake and greatly enhances the life of the flowers.

A florist stores flowers in a special cooler that has a constant temperature, a humidifier and fans to circulate the air and moisture. Home refrigerators are not suitable for storing flowers. As individual flowers die, remove them to keep the arrangement looking fresh and to direct the energy of the flower to the development of emerging buds. Sometimes, if a flower has wilted, or looks a little “tired”, shorten the stem, remove some of the foliage, and put it in a smaller vase. Avoid getting water on the leaves and flowers.

Special Treatments

Semi-woody stemmed flowers like hydrangeas, clematis, helleborus, poppies etc., exude a sticky sap. The sap pollutes the water and kills the other flowers. The stems need to be cauterized in order to seal in the sap. Immerse the fresh cut stem ends in boiling water for ten seconds, or hold them over a candle flame until the ends are sealed.

Water will be absorbed through the cell walls of the stems. Solid woody stems that do not exude sap do not require cauterization. They need to be mashed to maximize water uptake.

Daffodils, narcissus, crocus and hyacinth also exude sap that is poisonous to other flowers. The stems are too fragile to cauterize. They need to be hydrated in separate containers for 6-8 hours before adding them to a bouquet. Some flowers benefit from total immersion in cool water, if they have been left out of water for a few hours.

They drink the moisture through their cell walls and regain their composure. Roses, peonies, lilies, wilted violets, wild flowers and especially tropical flowers rebound stronger than ever with a tepid bath before being placed in a storage container for hydration in a preservative solution.

Tulips that have curled up can be straightened by carefully placing them upright in a tall, straight vase and adding a couple of pennies to the water. To perk up roses when their heads begin to droop, take them out of the arrangement and place them in a tepid bath for an hour or so. Cut an inch off the stems under water before putting them back in a clean vase.

When using growing plants in an arrangement, submerge the whole plant in tap water to clean the leaves and roots. Then, hydrate them in a preservative solution before adding them to your arrangement. Taking the time

to trim off dying plant material and leaves beneath the water line, cutting the stems under water, and allowing the flowers to hydrate in a preservative solution before arranging them in a vase, will add significantly to the life and beauty of your arrangement.

Helpful Hints for Fresh Flowers

• Scour containers with a plastic pot cleaner, brush or sponge and rinse with a mild solution of chlorine bleach.

• Remove all leaves and foliage below the water line. They decay quickly, have an acrid odour and distract from the design.

• Cut stems under water.

• Cut ends of stems on a slant. Crush the ends of thick stems.

• To change the water in a cut flower arrangement place the vase in a sink or bucket and add purified water until the vase overflows and the water runs clear. The life of the arrangement will be significantly extended by not exposing the stems to air.

Wiring & Taping Techniques

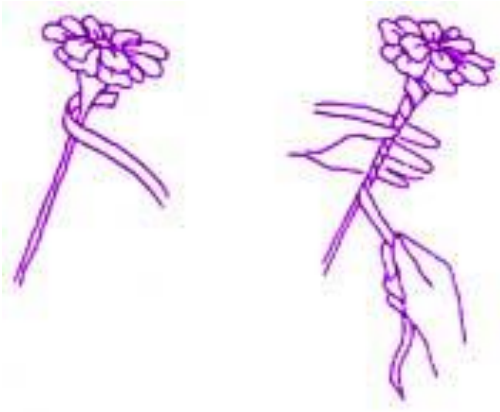
Professional flower designers wire and tape stems for a good reason. Many flowers have heavy heads and need the extra support including roses. If you do not wire and tape them they will eventually start to droop. You can extend the length of a flower easily, with wires and taping, so that it works in your arrangement. Once cut flowers are wired you should tape them with florist tape to hold the moisture that is in the stem. And the tape conceals the wires. Dried flowers and sometimes silks are covered with florist tape to ensure that the material does not slip out of a wired mount

Lengthening a stem (Wiring Techniques)

Having the ability to lengthen a flower stem is a great advantage in flower arranging. Also, if the flower has two or more blossoms, you can cut off the blooms and give each flower a new stem. It is a money saver and provides other possibilities when arranging flowers. This technique can be used on fresh, silk or dried flowers.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Taping and Lengthening a stem

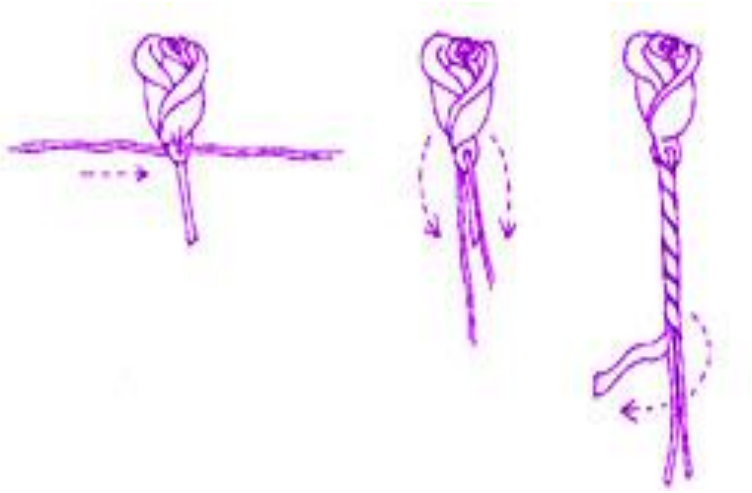


1. Place a stem wire next to the flower stem. Hold the wire near its top. Wrap a piece of floral tape around the top of the wire and flower stem.
2. Twirl the stem while stretching and pulling the tape in a downward angle. The tape should be tightly wrapped around the wire and flower stem without buckles or gaps along the stem.
3. While taping the stem you may wish to add further stems setting the flower heads at different heights.
4. Fasten off just above the end of the wires by squeezing the tape against itself.

Making a Stay Wire

1. Group together four florist wires. Have each overlap the next by 1-1/4".
2. Start taping the wires together from the one end.
3. As the tape reaches the end of the first wire add another wire to the remaining three ends of wires and continue taping. And so on. Adding wires and taping four together until you achieve the required length.

Pierce method



This wiring method is perfect for roses
To give support to a weak flower head with a thick calyx beneath the flower head, insert an 18-gauge stem wire.
1. Push one end of the wire horizontally through the calyx using half the length of the wire.
2. Bend both ends down parallel with the stem. Tape the wire starting just above the insertion.

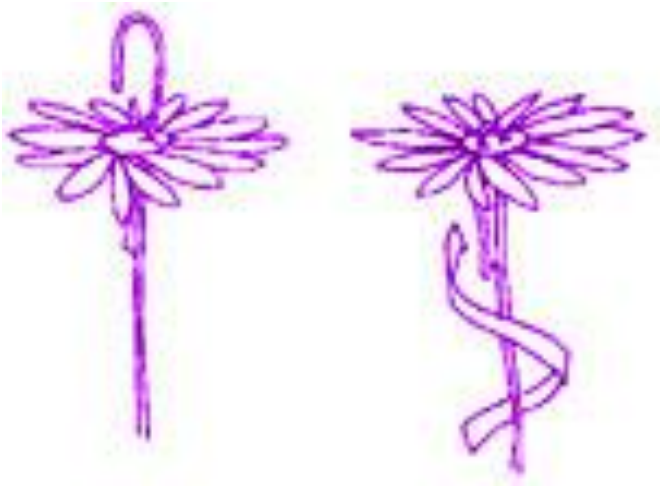
Note: A second wire may be inserted through the flower so that the two wires are crisscrossed for heavier flower heads.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Hook method

This method works well if the flower head is firmly attached to the stem.

1. Cut the flower stem an inch from the bottom of the calyx. Insert the stem wire inside the center of the stem up into the flower head until it is secure.
2. Form a hook, and pull the wire back down through the flower.
3. Tape the stem and wire tightly.



Single & Double Leg Mount

This is for wiring flowers which have a strong stem or where a double weight of wire is not necessary.

1. Hold the flowers between your thumb and index finger letting the weight of the flower lay across the top of your hand. Position a wire behind the stem one third the way up.
2.Now bend the wire ends together -with one leg shorter than the other.
3. Holding the short wire leg parallel with the stem, wrap the long wire leg around both the stem and the other wire leg.
4. Straighten the long wire.

Double Leg Mount

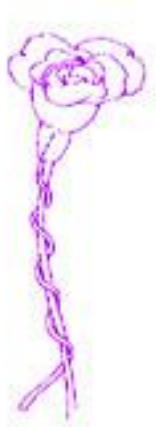
Similar to the single leg mount but the double leg mount will lengthen the stem with two equal length floral wires.

1. Start by holding the flower between your thumb and index finger. Allow the weight of the flower to lay across the top of your hand.
2. Position a wire 1/3 the way up from the bottom of the stem. Note: 1/3 of the wire should be to one side of the stem.
3. Bend the wire parallel to the stem. One leg of the wire will be about twice as long as the other.
4. Hold the shorter leg against the stem and wrap the longer length of wire around both the stem and the other wire to secure.

Training Provider Accreditation Number: AGRI/c prov/0282/1

5. Straighten both the wires legs which should now be equal length. See illustration above for finished look.

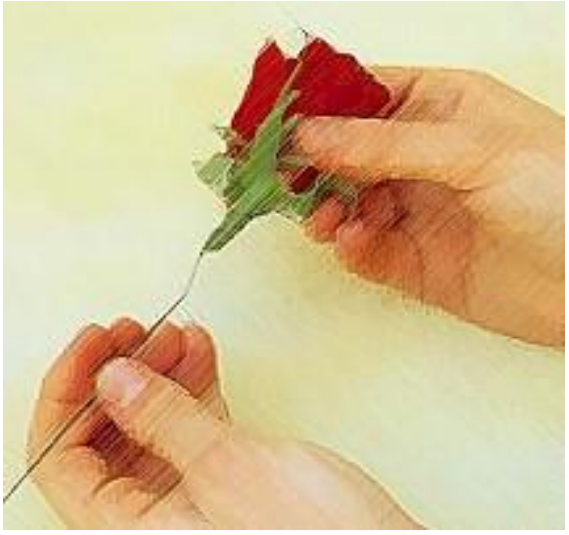
Stem supports for heavy flower heads



A must for roses which have a woody stem that when bent will cause the flower to wilt. This will reinforce them and make them ready for arranging. Flower supports add strength and flexibility to the stem allowing the flower to be gently bent.

1. Insert the end of a stem wire vertically into the base of the calyx.
2. Loosely wrap the wire around the full length of the stem in a spiral. Tape the stem to cover the wire.

Wiring a rose bud



Quite necessary if you are attempting more complex floral designs with roses. You will be replacing the rose stem with a wire so this arrangement would be perfect for drying.

Use this style of wiring for floral head pieces .

1. Cut the stem of the rose to 1-1/4" . Push one end of a floral wire through the seed-box (bottom of rose-thickest part) at the side. Holding the head of the rose in one hand wrap the wire firmly around and then down the stem.
2. Straighten the remaining wire to extend the length of its natural stem. Cover the wire with florist tape.

Training Provider Accreditation Number: AGRI/c prov/0282/1

Wireless taping

Wireless Taping is a perfect technique for free flowing hairpieces or corsages.

1. Cut the stem to 1" long.
2. Wrap a piece of floral tape around the top of the stem and twirl the flower in one hand while twisting the tape lightly around itself until it is as long as you want it. If you need more support, tape it again.

Equipment and techniques

Waterproof tape is an all-purpose method for holding either soaked or dried foam in place. It comes in two colours: white and green. The tape is waterproof and pressure sensitive. Once adhered to a dry surface, it will remain firm and in place even when exposed to moisture. It sticks on pottery, metal, plastic, wood, glass, ceramics... almost anything.

Waterproof clay is the designers' tool for positioning candles and figurines. It will also anchor dry materials like anchor pins to each other or to vases; frogs to bases, dry foam to bases etc. It is waterproof and heat proof; can assist in positioning and holding ribbons and tissue, and will hold fruit in place for cornucopia displays. Make sure the surface is absolutely dry and free of dust or the clay won't stick.

Floral Clay **Waterproof Tape**- Waterproof tape is a fast easy and all-purpose method for holding either soaked or dried foam in place. The tape is waterproof and pressure sensitive. Once adhered to a dry surface, it will remain firm and in place even when exposed to moisture.

Pan melt glue pot is a small electric pan, or glue skillet that you can either melt small pellets or (if it comes with an attachment) broken glue sticks at a low temperature. Use it for placing your foam by waiting until the glue is melted, but not hot, dip the four corners of the floral foam into the glue, and push it onto the bottom of the container. Pan melt glue is also used to secure the ends of silk flowers in foam when making large arrangements. Dip the ends of the flower stems into the pan glue before inserting into the floral foam.

Hot glue gun and glue sticks may be used instead of pan melt glue pellets. They come in high and low temperature styles and in various sizes.

Floral stem tape, a strong stretchable tape adheres to itself without sticking to your fingers. It is the ideal way to lengthen and strengthen stems. Use to create corsages, bouquets, headpieces, cascades, nosegays or boutonnieres. As the tape is stretched, the adhesive material is activated. Stretch the material as you wrap it around fresh, dried or silk flower stems.

Anchor pins or foam prongs secure the floral foam firmly to the bottom of a vase. Affix the pin to the bottom of the vase with hot glue or waterproof clay. Then press the foam into the pins of the prong.

Floral Wires or stem wires comes in different gauge sizes, colors and styles. The higher the gauge number the more flexible and thinner the wire is. Floral wires come covered and uncovered as well as in different painted colors. Choose between spooled or pre-cut wires. Floral wires are used to lengthen and support stems. You can use them for hanging wreaths by shaping them into loops. Perfect for securing floral material to wreaths and forms.

Candle Cups are small, inexpensive containers designed to hold taper candles in floral foam. A necessity when making centerpiece arrangements that will have taper candles in it. Use floral clay to secure positioning of your candles.

Floral Foam

Before floral foam was available, arranged flowers were held in place with chicken wire, sphagnum moss, cut greens, pine needles or newspaper. Transporting arrangements was difficult with water sloshing and flowers moving. Flowers lasted a day or two at most. The advent of floral foam expanded the art of floral design. There are many types of floral foam, and it comes in various shapes, styles, textures and sizes. The blocks can easily be cut with a serrated knife (or florist knife) to fit the size of your container.

Plastic foam or Styrofoam is coarse, non-porous foam. It is very sturdy and a good choice for working with large silk flowers or swags. It can be cut and wedged into a container or cut smaller than the container and secured to the bottom with hot glue or pan melt glue.

Desert foam of Dry Floral Foam is also coarse and non-porous, but it is easier to penetrate than plastic foam. Secure to the bottom of the container with hot glue or pan melt glue. Perfect for silk and dried floral arrangements.

Oasis foam or water holding floral foam is highly absorbent. It is best for fresh plants, because it holds water and is easy to penetrate. Leave a space between the foam and the sides of the container so water can be added to the flowers. This softer, finer foam is also preferable for standard silks and dried arrangements. It is perfect for inserting either thick or fragile stems. When using silks or dried flowers, the foam can be cut up in blocks and stuffed inside the container or shaped to fit, and wedged securely in place.

Preparing the Saturated Foam

Floral foam bricks self-saturate quickly and continue to wick water to the flowers for the life of the arrangement. Water lost by evaporation or consumed by the flowers needs to be replaced. The saturated foam is not a substitute for water. It is best to add bottled water with preservative to your arrangement daily. As little as 10% moisture loss will cause flower wilting.

• Fill a soaking container with fresh water and a proper amount of floral preservative.

• The foam should be large enough to be wedged into place and extend 1 to 2" above the rim of the vase. This allows for top and side placement of stems.

• Cut a wedge in the foam so you can add water daily. Place the cut out section at the back of the container.

• Allow foam to free float in a flat position. There should be enough water to fill the brick and allow it to float free when fully saturated. Don’t force the saturation or air pockets will form in the foam.

• When foam is fully saturated, place in vase and tape down with waterproof tape.

Training Provider Accreditation Number: AGRI/c prov/0282/1

You are now ready to go through a check list. Be honest with yourself.

Tick the box with either a √ or an X to indicate your response.

- ☐ **I am able to utilise safety practices when cleaning interior plants.**
- ☐ **I am able to indicate the reasons why interior plants should be cleaned.**
- ☐ **I am able to identify the presence of pests or diseases on the plants.**
- ☐ **I am able to select the correct cleaning materials and equipment for plant cleaning.**
- ☐ **I am able to clean various types of interior plants and their containers.**
- ☐ **I am able to utilise knowledge of plant cleaning to conduct interior plant maintenance.**

You must think about any point you could not tick. Write this down as a goal.

Decide on a plan of action to achieve these goals. Regularly review these goals.

My Goals and Planning:

_____
_____
_____
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