Erosion, Salinification and Acidification

Blackwood Basin Group

Ngala kaaditj Noongar moort keyen kaadak nidja boodja.

We acknowledge the Noongar people as the Traditional Owners of this land

Australian Government
National Landcare Programme

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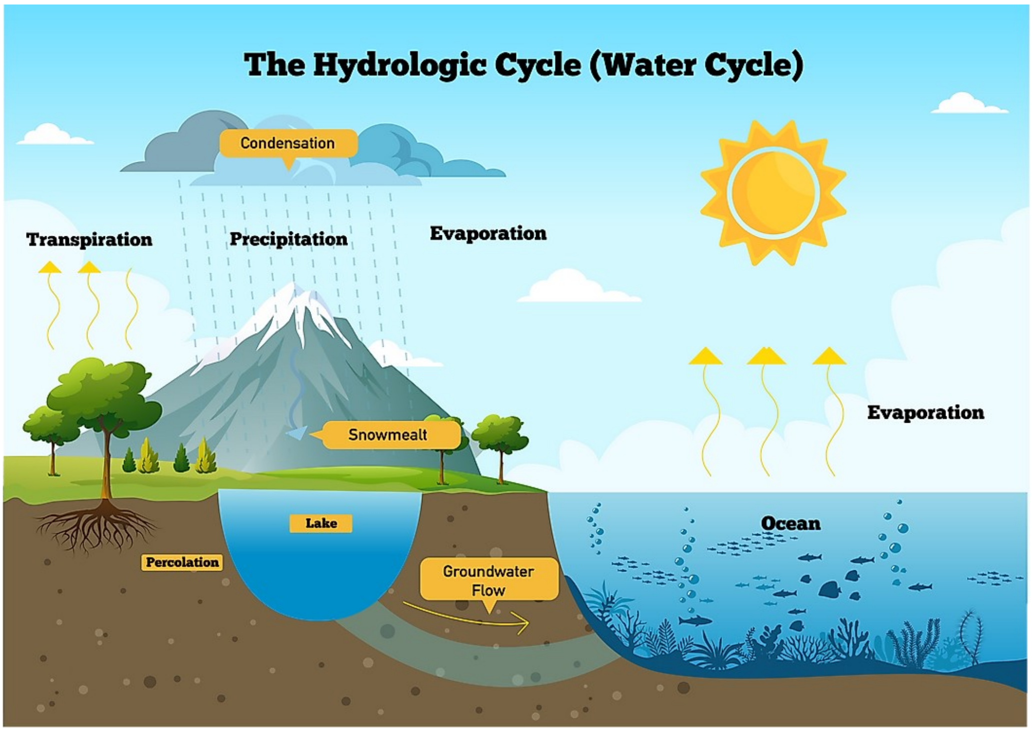
The Hydrological Cycle

The hydrological cycle, or the water cycle as it is commonly known, is the cycle in which all of the earth's water is continually used, recycled as such. The water cycle, powered by the sun, is one of the largest physical processes on earth, using rainfall and evaporation to complete this process.

The water cycle naturally cleans the earth's water, with impurities being left behind when water evaporates from ocean, rivers and lakes. The same process occurs when plants transpire (breathe) and water evaporates from their leaves.



All of the water on earth today, already exists and is stored in the ground, oceans, lakes, ice, snow and the atmosphere

Salt in the landscape

Changes in land use practices, seasonal variations and climate changes are all contributing factors to the quantity and flows of surface and ground water and their salt content. Aquatic plants and animals rely on small amounts of dissolved salts in natural waters for survival, however once salt levels become too high, they become harmful to the aquatic plants and animals.

Salts in natural water resources generally comes from three sources;

- Firstly: small amounts of (primarily sodium chloride) evaporate from the ocean and are carried in rainclouds to be deposited across the landscape within rainfall.
- Secondly: some landscapes already contain salt that has been released over time, through weathering of rocks.
- Thirdly: salts may remain in sediments left behind by the subsiding ocean from periods where the sea levels were higher or the land surface much lower than they are today.

Levels of salt in rainfall are higher near the coast, decreasing as they move inland

Salinity

Salinity can be classified in three ways, primary salinity (natural salinity), secondary salinity (dryland salinity) and tertiary salinity (irrigation salinity).

Primary Salinity: occurs throughout the world in arid climates and is caused by the natural processes such as, the accumulation of salt from rainfall and the weathering of rock over thousands of years.

When rain falls on the landscape, a certain amount evaporates from the soil, vegetation and water bodies, some infiltrates into the soil and ground water and a portion enters streams and rivers, flowing into lakes or oceans. Small amounts of salt left in the soils by rain, can over time build up in the soils (especially in clay based soils), and can also penetrate the groundwater system.

The larger volumes of water infiltrating soils, in areas of higher rainfall, tend to enter and discharge from the groundwater, leaving the catchment via a 'flushing effect', through rivers and streams. This 'flushing effect' enables the soil and groundwater salinities to stay relatively fresh.

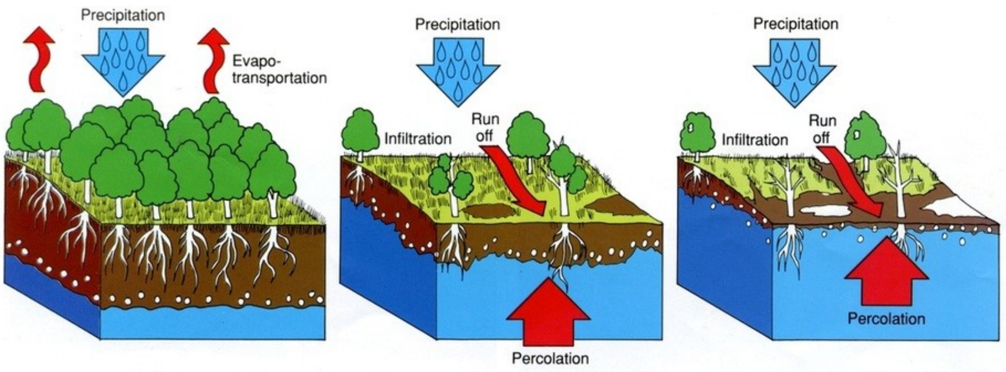
However, drier areas with natural vegetation, there is less flushing and the majority of water that falls on the landscape is lost due to evaporation and transpiration from the vegetation. In these areas, salt tends to build up in the soil and groundwater and can, over a period of time, accumulate reaching high levels. Groundwater salinities can also be high, in these areas, especially if salts have been released in the weathering bedrock.

Secondary Salinity: is caused by rising groundwater, this brings salt accumulated via 'primary salinity' to the surface. This process is caused through the clearing of perennial (long-lived) vegetation in drier areas, such as the Wheatbelt in Western Australia. Once vegetation is cleared, the quantity of water lost from the landscape via vegetation in drastically reduced, resulting in more water entering the groundwater, causing the groundwater level to rise, commonly known as the 'rising watertable'.

As groundwater levels rise, they bring the dissolved salts already present within the water table, dissolving more salt from the previously unsaturated soil profile as they rise. Over time, low lying areas of valley floors may become fully saturated (especially during the winter months) with the quantity and duration of flow in streams and rivers increasing. The discharging saline water mixes with the fresher surface water causing flow to vary between marginal to brackish. Once these saturated areas dry out, salt crystals can be left behind, causing salt scald to areas of the landscape.

Increased salinity and flow to wetlands, stream and rivers, will eventually cause an issue for salt tolerant vegetation, threatening ecosystems and their constituent species. Many plants can tolerate higher levels of salinities for short period of time, but cannot survives long periods of inundation as well. Rising levels of salt within the ground and surface water and salt scold left behind in the landscape may eventually render both water and land unusable for human activities.

Tertiary Salinity: occurs when water is reapplied to crops or horticulture over many cycles, either directly or by allowing it to filter into the groundwater and pumping it for re-application. With each water application, a portion of it will evaporate leaving the remaining salts in the water at a higher concentration, multiple cycles of use can result in very high salt concentrations in the soil.



Before clearing
Most water is used where it falls. The system is in balance.

After clearing
Saline groundwater rises and is concentrated at the surface by evaporation. Vegetation growth is affected.

Later
Accumulation of salt at the surface kills protective plant cover. The land is open to erosion.

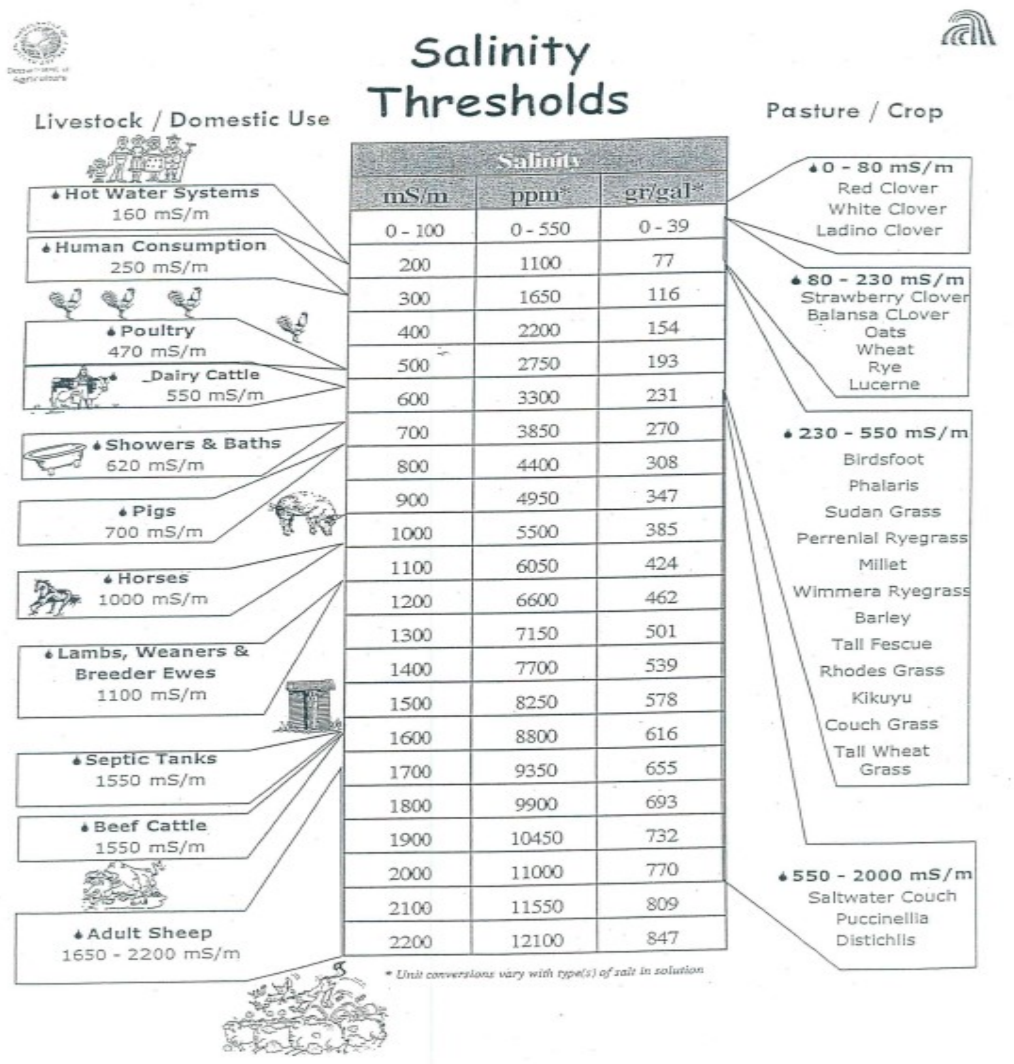
Impacts of Salinity

Salinity affects:

- **Farms:** salinity can decrease plant growth and water quality resulting in lower crop yields and degraded stock water supplies. Excess salt affects overall soil health, reducing productivity, it kills plants, leaving bare soil that is prone to *erosion*.
- **Wetlands:** as salinity increases over time, wetlands become degraded, endangering wetland species and decreasing biodiversity. Where sulphate salts are present, there is an increased risk of *acid sulphate soils.*
- **Rivers:** increased volume (load) and/or concentration (electrical conductivity or EC) of salinity in creeks and streams degrades town water supplies, affects irrigated agriculture and horticulture, and adversely impacts on riverine ecosystems.
- **Drinking water:** when a source of drinking water becomes more saline, extensive and expensive treatment may be needed to keep salinity at levels suitable for human consumption and use.
- **Buildings, roads and pipes:** salinity damages infrastructure, shortening its life and increasing maintenance costs.
- **Sports grounds:** salty ground may lose all grass cover, making playing fields unusable.

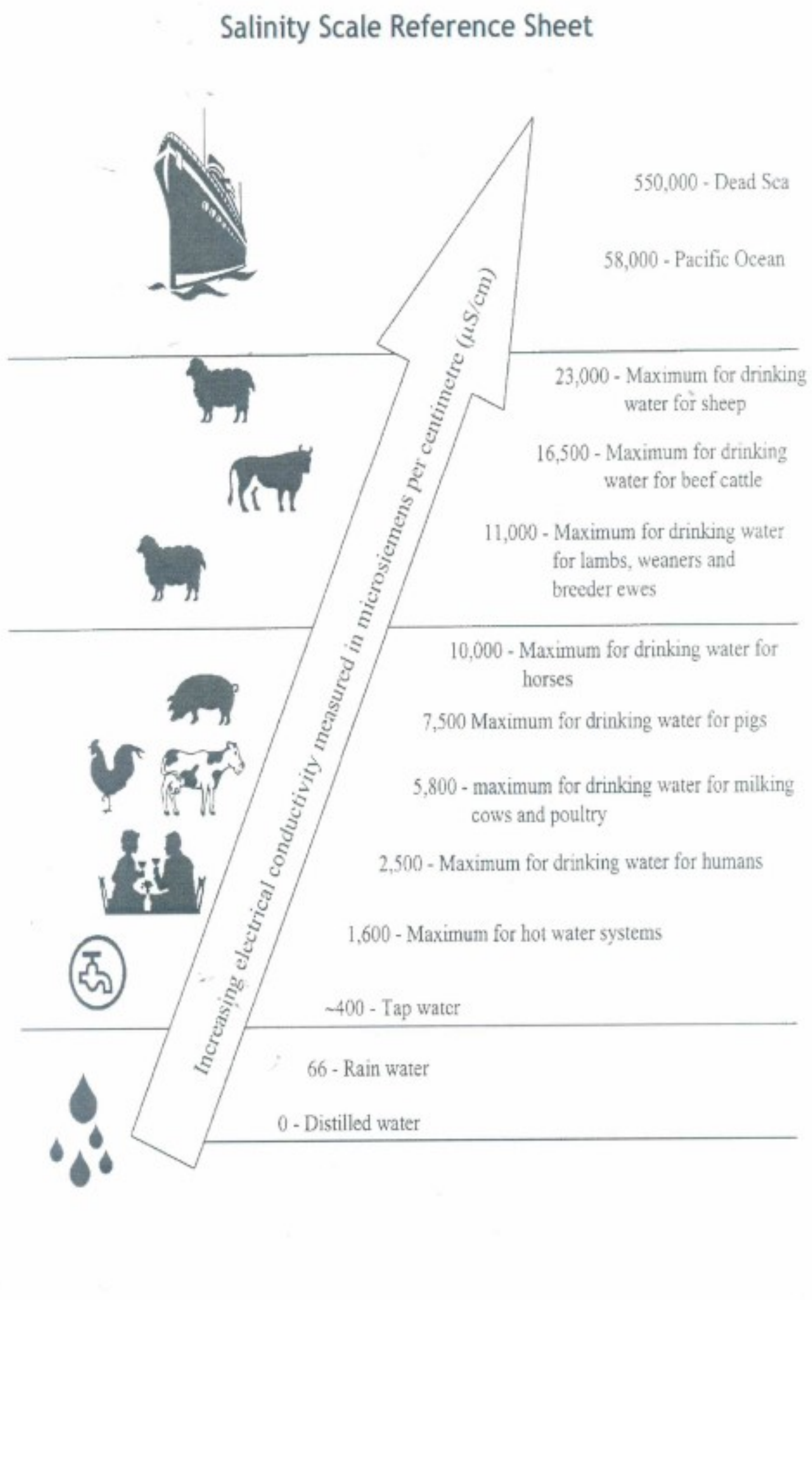
Salinity Thresholds

Salinity thresholds can be defined as the point or level at which a physical change begins to occur



Salinity		
mS/m	ppm*	gr/gal*
0 - 100	0 - 550	0 - 39
200	1100	77
300	1650	116
400	2200	154
500	2750	193
600	3300	231
700	3850	270
800	4400	308
900	4950	347
1000	5500	385
1100	6050	424
1200	6600	462
1300	7150	501
1400	7700	539
1500	8250	578
1600	8800	616
1700	9350	655
1800	9900	693
1900	10450	732
2000	11000	770
2100	11550	809
2200	12100	847

** Unit conversions vary with type(s) of salt in solution*


Salinity Scale Reference Sheet
Increasing electrical conductivity measured in microsiemens per centimetre (µS/cm)
550,000 - Dead Sea
58,000 - Pacific Ocean
23,000 - Maximum for drinking water for sheep
16,500 - Maximum for drinking water for beef cattle
11,000 - Maximum for drinking water for lambs, weaners and breeder ewes
10,000 - Maximum for drinking water for horses
7,500 Maximum for drinking water for pigs
5,800 - maximum for drinking water for milking cows and poultry
2,500 - Maximum for drinking water for humans
1,600 - Maximum for hot water systems
~400 - Tap water
66 - Rain water
0 - Distilled water

Salinity tolerance in Plants/Crops

Salinity tolerance in plants/crops is the maximum salt level a plant/crop can withstand before it begins to lose productivity, however, salts can affect plants/crops in different ways depending on a range of factors:

- Salinity of irrigation water
- Salinity of soil
- Soil moisture
- Wind-borne salt spray
- Salinity of groundwater and depth to the water table (summer and winter)
- Soil type
- Interaction with waterlogging
- Timing and amount of rain
- Temperature and evaporation stress
- Stage of growth of the plant

Salinity affects production in crops, pastures and trees through interfering with nitrogen uptake, thus reducing and inhibiting plants reproduction.

Salinity Management

Reasons for managing salinity:

- Potential to decrease farm profitability and productivity if left unmanaged
- Could decrease water and soil erosion
- Demonstrates good farm management
- Provide longevity for farm enterprise
- Decrease salt export off farm into waterways

Principles for salt management

- Have a goal for salt land management, be committed, this is going to take some years
- Assess the site, most importantly know what is causing the salt build up
- Produce a whole farm plan for water management and land use
- Choose management options that suit the environment, farm plan and long term land use
- Design and implement the option to suit the site conditions
- Monitor changes and adapt management to the changing conditions

Management Strategies

⇒ Leaching

Leaching excess salts and maintaining a sustainable salt balance is the best strategy in preventing damaging salt accumulation in the soil profile. Leaching of excess salts is achieved through supplying the right amount of water, to the affected area, to allow salts to be leached below the root zone but not into the ground water.

⇒ Drainage

A requirement for using leaching as a salt reduction method is to ensure the area has good established internal and external drainage. Poor internal soil drainage caused by surface crusting and hardpans can be managed through tillage and regular deep ripping. Surface drainage is also important, especially with furrow irrigation, the increase of tile drains for horticultural plantings, v or w drainage in broad acre will assist in surface water management. Growers need to be aware of crop watering requirements to ensure over irrigation does not occur.

⇒ Irrigation

The method of irrigation and volume of water applied contribute greatly to salt accumulation and distribution. Flood irrigation and an appropriate leaching fraction, as well as managed sprinkler irrigation are generally successful in moving salts below the plant roots zone. In furrow irrigation, soluble salts in the soil travel with the wetting front, concentrating at its end point or at its meeting point with another wetting front. With drip irrigation, water travels away from source with salts concentrating in the area the water evaporates. In furrow irrigation plots, the water moves from the furrow to the bed via capillary flow. When adjoining furrows are irrigated, salts are concentrated in the centre of the joining beds, altering bed shapes and plant positioning are methods often used to avoid salt damage in these adjoining beds. Plants tend to tolerate higher levels f salinity in drip irrigation systems than in furrow irrigation, due to the fact that drip irrigation maintains a more constant beneficial soil conditions.

⇒ Fertiliser management

Many synthetic fertiliser contain high concentrations of soluble salts, therefore the nutrient source, timing of application and placement are important factors to consider. The salt content of other soil additives such as gypsum an manures, also need to be brought into consideration.

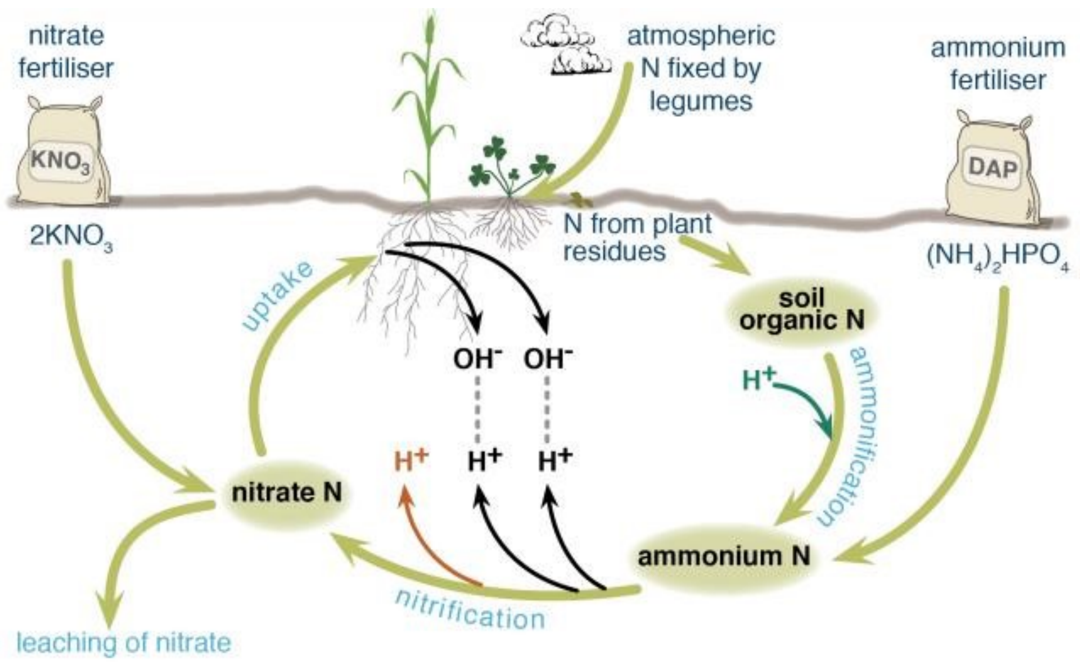
Acidification of soils

Soil acidification occurs naturally as soil is weathered at a very slow rate, it occurs due to the concentration of hydrogen ions increasing in the soil. This process can be accelerated through productive agriculture and can affect both surface soil and sub soil.

Some contributing factors:

- The application of high levels of ammonium-based nitrogen fertilisers to naturally acidic soils
- Leaching of nitrate nitrogen, originally applied as ammonium-based fertilisers
- Harvesting plant materials, plant material is alkaline so once it is removed the soil becomes more acidic than if the plant material had been returned to the soil

Nitrogen in agricultural systems is either fixed from the atmosphere by legumes, decomposed from organic soil matter by soil organisms or added through various types of fertilisers. All nitrogen fertilisers follow a different chemical pathway as they break down, contributing different amounts of hydrogen ions (acid) to the soil.



All nitrogen fertilisers follow different pathways in the nitrogen cycle, releasing different numbers of hydrogen ions

Ammonium-based fertilisers are the major contributors to soil acidification, particularly if the nitrogen is leached rather than taken up by plants. Ammonium nitrogen from fertiliser or soil organic matter is quickly transferred to nitrate and hydrogen ions by soil bacteria, contributing different amounts of hydrogen ions to the soil, depending on the fertiliser.

Effects of acidification on soils

Exceedingly acidic soils can lead to a considerable decline in crop and pasture production due to the pH of the soil changing the availability of soil nutrients.

Some problems associated with acidic soils:

- Beneficial soil micro-organisms can be prevented from recycling nutrients eg– nitrogen supply may be reduced
- Decreased availability of phosphorus to plants may occur
- Calcium, magnesium and molybdenum deficiencies may occur
- Plants ability to utilise subsoil moisture may be limited
- Aluminium, which is toxic to micro-organisms and plants, may be released from the soil
- Manganese may reach toxic levels in the soil
- An increased uptake of heavy metal contaminant, cadmium, by crops and pastures may occur

It is extremely important to treat soil acidity in its early stages, if acidity spreads into the subsoil, serious reductions to crop yield may occur

Subsoil acidity is also very difficult and costly to control

Managing soil acidification

The first factor in managing soil acidification is to diagnose any increase in acidity, this can be done via a soil test of pH, aluminium levels and manganese levels.

Recommended farming practices for minimising soil acidification:

- **Matching nitrogen fertiliser inputs to crop demand**
- **Using forms of nitrogen fertiliser that cause less acidification**
- **Efficient irrigation management to minimise leaching**
- **Early sowing after ploughing to ensure more rapid utilisation of available nitrogen**
- **Growing deep rooted perennial species to take up nitrogen from greater depths**
- **Regular applications of lime to counter the acidification inherent in the agricultural system**
- **Growing acid tolerant crops or crop varieties more tolerant of acidic soils**

Soil Erosion

Soil erosion is essentially a natural process, were the top soil of an area is carried away by physical sources such as wind and water. Natural soil erosion has been accelerated over the years by practices such as land clearing, mining, construction, overgrazing, some cultivations and poorly constructed farm roads and dams. Erosion removes the topsoil, most fertile section of soil, where most plant nutrients and carbon are found.

To fully understand erosion, firstly we need to understand the different types of erosion:

⇒ Water Erosion

Is caused by rain drops hitting the bare soil with enough force to rupture the soil aggregates, these fragments wash into soil pores, preventing water from infiltrating the soil. This water then accumulates on the soil surface, increasing runoff, taking the soil with it. Well structured soils are less prone to breaking up, with the impact of the rain being minimised on soils with adequate groundcover. Soil vulnerability to water erosion depends on:

- Rainfall intensity (erovisity), high intensity rainfall generates a serious risk, with havy raindrops on bare soil causing the soil surface to seal
- Nature of the soil (erodibility), clay soils vary in their ability to withstand the impact of raindrops
- Slope length, if the slope is long, the water running down it becomes deeper ad faster moving, removing more soil with it
- Slope steepness, the speed of runoff will increase on steeper slopes, thus increasing the power of the water to break off and carry soil particles

⇒ Sheet and Rill Erosion

Hill slopes are prone to sheet and rill erosion, the amount of erosion to a hill slope will be determined by how the land is used.

Sheet erosion occurs through a thin layer of topsoil being removed over an entire hillside paddock, this form of erosion is not always readily noticeable.

Rill erosion occurs through water runoff forming channels as it becomes concentrated down a slope. Rills can be up to 0.3m deep, if they become any deeper than this they are classed as gully erosion.

⇒ Scalding

Scalding occurs where wind and water erosion removes the top soil to expose saline or acidic soils, large amounts of soil can be moved by heavy raindrops alone. However water or wind movement over the soils surface, will remove more soil and can contribute to sheet, rill or gully erosion. This type of erosion removes smaller, lighter soil particles first (clay and silt), leaving behind fine and coarse sand. The combination of large amounts of find sand and small amounts of clay on the soil surface, creates the soil to seal and set hard, limiting water infiltration.

⇒ Gully Erosion

Gully erosion occurs when water runoff concentrates and flows with enough force to remove and transport soil particles. For example, a waterfall can form with runoff increasing energy as it plunges over the gully head. Splash back at the bottom of the gully head erodes subsoil and the gully makes its way up the slope.

Gullies can develop in watercourses or elsewhere as runoff concentrates, advanced rill erosion can develop into gully erosion within cultivation, pastures or bare paddocks.

Gully erosion is extremely visible, often limited by the depth of underlying rock, normally reaching 2m in depth but has been know to reach depth of 10-15m. This type of erosion can effect the productivity of the soil, restricting land use and damaging roads, fences are potentially buildings.

⇒ Tunnel Erosion

Tunnel erosion is caused by the removal of subsoil when water perforates through a soil crack or hole, where a tree/ plant root has decayed, the soil disseminates and is taken away with the flow of water, leaving behind a small tunnel.

In the beginning the soil surface will remain intact, but eventually with each flow the tunnel becomes larger with the soil eventually collapsing to form gully erosion. This whole process will speed up if there is an outlet, such as an existing gully or cutting in a roadside, due to the free flow of subsurface drainage.

Soils susceptible to this form of erosion have dispersible subsoils containing naturally high levels of sodium, these soils are known as being sodic or called sodosols. As clots of these soils become exposed to water, they willingly breakdown into individual particles of sand, silt and clay, making them easily removed by water through the subsoil.

⇒ Steam Bank Erosion

Stream bank erosion is mainly caused due to the destruction of vegetation along a riverbank, caused by clearing, over-grazing, cultivation, vehicle traffic and fire, and the removal of sand and gravel from the stream bed. Stream bank erosion can be increased by the following factors:

- Stream bed lowering or infill
- Inundation of bank soils followed by rapid drops in flow after flooding
- Saturation of banks from off-stream sources
- Redirection and acceleration of flow around infrastructure, obstructions, debris or vegetation within
- Soil characteristics such as poor drainage or seams of readily erodible material within the bank profile
- Wave action generated by wind or boat wash
- Intense rainfall events

Wind Erosion

Wind erosion is a massive issue for arid grazing lands of Western Australia, it occurs mainly when strong winds blow across light textured soils that have been heavily grazed throughout drought periods. Wind erosion is a contributing factor to scalding, the process in which smooth, bare areas are formed on impermeable subsoils.

Such areas can be difficult to revegetate due to:

- Lack of topsoil
- Low permeability
- Often saline surface
- Sheer size of area

In general, wind erosion is not a serious issue for cropping, due to the heavy structure of the soil. Sandy soils are most vulnerable to this type of erosion as they cannot store much moisture and have low fertility.

Managing Soil Erosion

Managing soil to minimise erosion is essential for all landholders, erosion not only looks unattractive, it largely compromises farm sustainability and profitability.

Understanding seasonal pasture growth potential and rain fall outlook will assist in the way soil erosion is managed.

Rainfall has much more energy than runoff, when raindrops hit bare soil, a number of things occur:

- Soil structure is compacted, therefore reducing the infiltration capacity and allowing more runoff
- Surface soil particles are shattered and broadcast into the air, if these particles land into running water, they are easily transported away. If the particles contain plant nutrients then these will go too
- If the broadcasted particles land on bare soil, they may block up soil pores, further decreasing water infiltration rates
- On sites that are sloped, particles are broadcasted further downslope than up slope, causing a net movement of soil down slope to the paddocks

Raindrops impacting bare soil are the initiators of moist erosion and run-off

Preventing wind erosion is really no different from preventing water erosion, maintaining soil coverage provides a barrier between the erosion agent and the soil

The 3 main principles to erosion control are to:

- Use land according to it's capability
- Protect the soil surface with some form of cover
- Control runoff before it develops into erosive force

Surface cover is a major factor to managing erosion, it reduces the impact of raindrops falling on bare soils and wind removing soil particles.

Erosion risk is dramatically reduced when there is more than 30% soil cover.

Landholders running livestock should be regularly monitoring their paddocks to manage soil erosion, when bare patches of ground appear, stock should be removed from the paddock, allowing for the bare ground to recover. Such bare patches of ground are more likely to appear during the summer and autumn months, prior to new rains and during times of drought.

Livestock tracks (pads) are common areas that can become susceptible to erosion, livestock walk directly to water sources when they are thirsty and graze away from water after they have drunk. Pads emerge at water points, pads situated upslope of a water point, concentrate runoff towards that water point, whilst pads downslope from the water point, spread runoff.

Designing fences that allow water points to be located in the upslope portion of paddocks will assist in reducing erosion caused by pads. Keeping gates closed, prevents padding between paddocks, however this will require each paddock to have it's own water point.

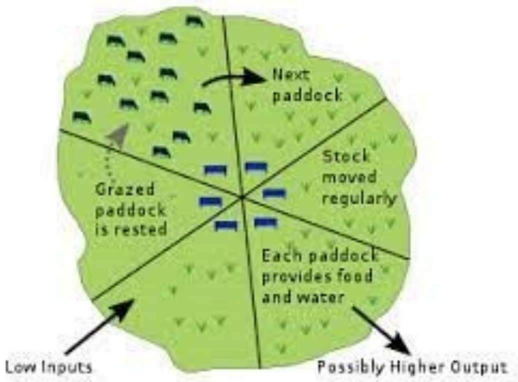
In general setting your property up with smaller paddocks, each containing a water source, along with frequent rotation of stock to paddocks, reduces the risk of bare patches, thus reducing the risk of soil erosion.

Reducing the risk of erosion for crop production has proven to be successful through the use of conservation agriculture, this is better known as minimum or no-tillage farming, crop rotations and the maintenance of soil coverage. This type of farming involves:

- Leaving part of the straw from previous crops on the soil surface
- Chemical weed control as opposed to cultivation
- Disturbing the soil as little as possible when seeding the next crop

Other ways to control erosion are through:

- Planting deep rooted vegetation
- Installing contour banks and strip cropping



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