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Urban salinity – causes and impacts

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What is urban salinity?

Salinity is the accumulation of salts (often dominated by sodium chloride) in soil and water to levels that impact on human and natural assets (e.g. plants, animals, aquatic ecosystems, water supplies, agriculture and infrastructure). Urban salinity occurs in cities and towns as a result of urban development (Figure 1).

Primary and secondary salinity

Primary (or inherent) salinity is the natural occurrence of salts in the landscape for example salt marshes, salt lakes, tidal swamps or natural salt scalds. Secondary salinity is salinisation of soil, surface water or groundwater due to human activity such as urbanisation and agriculture (irrigation and dryland).

Salt sources

Salt may come from several sources including:

- aeolian or wind-borne salt from ocean spray or sedimentary deposits including dune sand and clay particles from the rivers and lakes of the Murray-Darling Basin
- cyclic salt from ocean spray or pollution dissolved in rain water then deposited inland
- connate or fossil salt incorporated in marine sediments at the time of deposition, during periods when Australia was partly covered by sea
- rock weathering that allows salt to be released as minerals break down over time.

The hydrological cycle

The hydrological cycle is the movement of water from the atmosphere to the earth and back again (Figure 2). Salts are highly soluble, so water is the key to the movement of salts in the landscape.

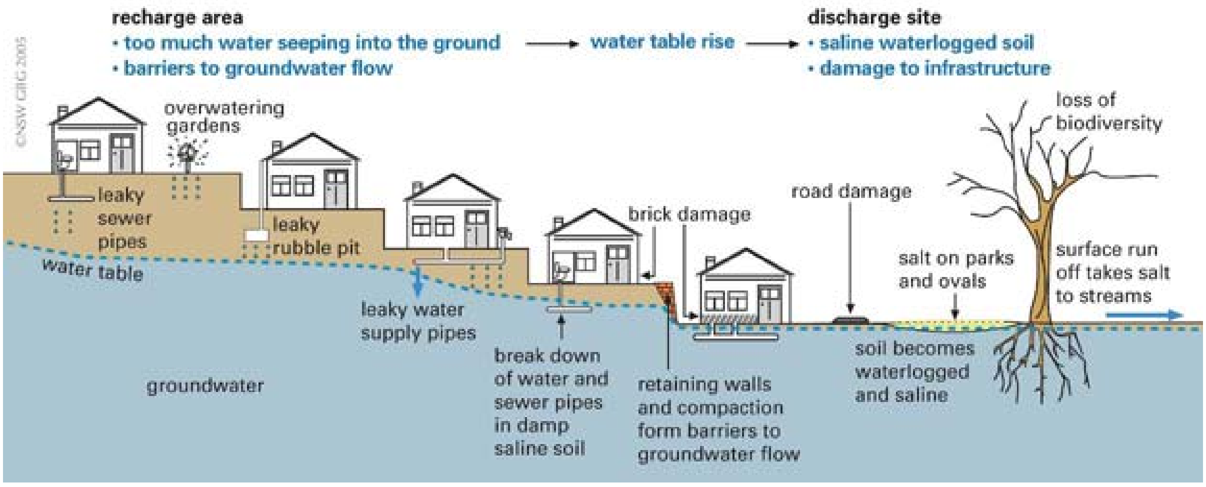

Figure 1. Causes of urban salinity. Source: Slinger & Tenison (2007).

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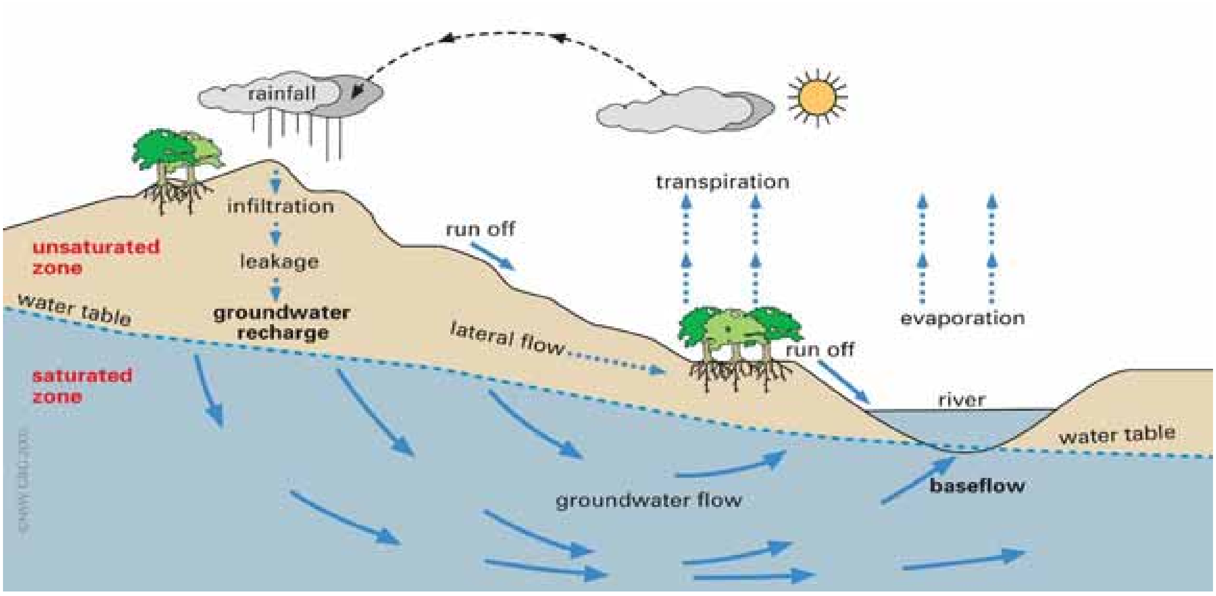

Figure 2. The hydrological cycle. Source: Slinger & Tenison (2007).

The groundwater system

The watertable is the surface below which all the spaces in soil and rock are filled with water. Water in this saturated zone is called groundwater. Above this is the unsaturated zone where the spaces are dry or only partially filled with water.

Water moving downwards past the plant root zone is called leakage. Water may leak from rivers, streams, dams, water, sewer and stormwater pipes, as well as irrigated sporting fields, parks and gardens. Water that enters the saturated zone is called groundwater recharge and groundwater that leaves the saturated zone is called groundwater discharge. When groundwater is at or near the soil surface, discharge occurs as seepage under houses or roads, base flow to streams and stormwater systems.

Causes of urban salinity

Urban salinity, like dryland and irrigation salinity occurs where salt in the landscape is mobilised and redistributed closer to the soil surface and/or into waterways.

Salt mobilisation is largely due to increased leakage which creates an imbalance in the hydrology of the landscape resulting in watertable rise. The rising watertable dissolves salt in the soil and moves it toward the soil surface. These changes in leakage and watertable depth may be related to changes in climate and landuse distant from the urban centre in addition to local leakage related to the urban centre itself.

Factors that contribute to urban salinity include changes to 1) soil properties down the profile or across a landscape 2) vegetation type and composition 3) the hydrological cycle and 4) management of surrounding landscapes.

Soil properties

Changes in soil permeability down the profile or across a landscape can predispose an area to salinity by restricting groundwater movement. Restriction of the vertical or lateral movement of groundwater may cause groundwater to accumulate up-slope and result in a saline discharge area. This may occur in the following examples:

Compaction

Soil compaction during the construction of roads and buildings can:

- increase surface run-off as infiltration is reduced. The run-off water can pond and recharge the groundwater system or undergo wetting and drying cycles concentrating salts.
- impede lateral flow of groundwater causing a saline discharge area up-slope of the development.

Cut and fill

Disturbance of the soil surface (trenching, levelling, and cutting into slopes) required in building and road construction may expose saline subsoil, intercept lateral flows of groundwater or lower the soil surface to within the influence of a watertable.

Importing soil (fill) to a construction site can introduce soil with different characteristics to the on-site soil e.g. a light-textured soil placed over a less-permeable soil. In this example a perched watertable may occur as water can infiltrate quickly until it reaches the less-permeable soil that limits further downward movement. If the water continues to infilltrate over time a perched watertable will develop, which is separate from a deeper intermediate or regional watertable. Salt may also be introduced in the imported fill.

Trenches for underground infrastructure that are backfilled with sand can also act as preferential flow paths for groundwater.

Vegetation type and composition

Less vegetation

Clearing native vegetation can increase groundwater recharge rates as it reduces the number of plants available to use water from a saturated soil or intercept leakage by transpiration.

Annual and perennial plants

The replacement of deep-rooted perennial plants with shallow-rooted annuals reduces the potential for transpiration. Deep-rooted perennials have a much greater capacity to use rainfall and groundwater than shallow-rooted plants.

Changes in growth patterns

Summer-growing plants dry the soil profile during summer which provides a dry-soil buffer for the wetter winter that follows. A dry-soil buffer has a greater capacity to hold water over winter, reducing the amount of water recharging the groundwater system. The amount of water held in the profile depends on soil type and depth.

Composition

The removal of trees and shrubs and the reliance on shallow-rooted plants in high watertable areas can increase evaporation from the soil surface. High evaporation rates increase capillary rise from the watertable resulting in more salt left on the soil surface.

Hydrological cycle

The installation of urban infrastructure affects a landscape's hydrological cycle by increasing recharge rates through:

- the addition of piped water to the input of water through rainfall
- leakage from urban water storages, piped and non-piped stormwater, sewer and water-supply systems
- leakage from over-watering domestic gardens, parks, golf courses and playing fields.

Urbanisation also changes a landscape's surface water flow, distribution and storage. New water disposal systems (gutters, drains, pipes, retention structures) are built to manage the run-off from hard surfaces e.g. roads, roofs, pathways. The change to natural drainage lines may also increase recharge rates though leakage.

Surrounding landscapes

Urban salinity is impacted by the surrounding non-urban landscape. For example, a city may border agricultural properties (dryland and/or irrigation), hobby farms, reserves or national parks. Co-operating to reduce recharge and discharge rates may be more difficult if dealing with large numbers of land owners, who may lack resources to make effective change such as changing from annual to perennial plants in high recharge areas.

Impacts of urban salinity

The salts and waterlogging associated with urban salinity may damage infrastructure, reduce water quality as salts wash into waterways and increase the cost of urban construction and maintenance.

Many urban salinity costs are applicable to rural infrastructure. However, urban salinity costs are more frequently and easily assessed because of the higher density of infrastructure and its visibility to a larger population. Households, commercial and industrial businesses, state-government agencies, public utilities, and local councils may be affected by urban salinity.

Saline water and soil can affect the urban environment in a variety of ways including:

- damage to infrastructure such as roads, bridges, pavements, buildings and other structures; underground services such as gas, water and sewage pipes; railways and other steel structures; telecommunications and industry (Figures 3 and 4)
- damage to houses (rising damp) and domestic structures such as hot water systems, plumbing and household appliances
- increased need for use of soaps and detergents as water becomes saline. Use of alternative products such as rain water tanks, bottled water, domestic filters and water softeners may also result in extra costs
- increased maintenance required on cooling towers, reticulation systems, boilers and water treatment plants increases costs to industry
- increased cost of urban development due to increased focus on design, construction, maintenance and community education to prevent urban salinity by minimising recharge rates
- increased cost of managing urban infrastructure in existing or new saline discharge areas e.g. shortened life of roads

- reduced water quality as salts are washed into waterways
- the degradation of sports fields, open spaces and vegetation in parks and gardens reduce their amenity values (Figure 5).

Figure 3. Salt damage to bricks and mortar. Source: Slinger & Tenison (2007).

Figure 4. Destabilised road base from a shallow watertable resulting in damage to the road surface. Source: Slinger & Tenison (2007).

Figure 5. Saline discharge area on a cricket pitch causing vegetation decline. Source: Slinger & Tenison (2007).

Urban salinity can undermine urban buildings and infrastructure at a significant cost to local communities. There are at least 220 towns in the Murray-Darling Basin at risk from urban salinity including Wagga Wagga, Tamworth, and Dubbo (Wilson 2003). Urban salinity has also been identified as an issue in western Sydney.

Further reading

Department of Environment and Climate Change *Local Government Salinity Initiative* booklets http://www.environment.nsw.gov.au/salinity/solutions/urban.htm

Primefact 936, *Dryland salinity – causes and impacts*

Primefact 937, *Irrigation salinity – causes and impacts*

Primefact 939, *Salinity symptoms*

References

Slinger, D. & Tenison, K. (comps) (2007) *Salinity Glove Box Guide: NSW Murray & Murrumbidgee Catchments*, NSW Department of Primary Industries.

Wilson, S. (2003) *Determining the full costs of dryland salinity across the Murray-Darling Basin: Final Project Report*, Wilson Land Management Services report to the Murray-Darling Basin Commission and National Dryland Salinity Program.

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