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Soils of the Salt Marsh

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Salt marshes are a vegetation type containing a rather narrow range of different plant species that in all cases involve halophytic (salt loving) vegetation forms. They show their greatest extent in tropical Australia and diminish in size but increase in species diversity in the southern states occurring even in Tasmania (Adams 1990). They are considered the smallest and rarest of vegetation types in NSW and Victoria and are at an elevation and location in coastal areas that has been very prone to over-development and destruction. While the actual species and certainly genera of plants can overlap into inland salinas (salt lakes) (Adams 1990) it is development in the coastal environment that brings these communities to most people's attention.

Estuarine salt marsh communities occur in the supratidal zone in marine/estuarine environments which is that above the zone of frequent tidal inundation (intertidal) but below the zone of occasional inundation (extratidal). Classically the vegetation in eastern Australia will be mangroves of various species in the intertidal zone, salt tolerant grasses and rushes with Casuarina and Melaleuca in the extratidal zone and the halophyte vegetation typical of saltmarsh only in the intermediate supratidal zone. The dynamic relationship between saltmarsh and Mangrove swamp vegetation is not well understood but is probably related to the tolerance of saltmarsh species to hypersalinity (Adams 1990).

The soils of the supratidal zone (the saltmarsh zone) are quite as peculiar as the vegetation which has some extraordinary adaptations to cope with high and fluctuating salt levels. Fundamentally the supratidal zone is almost flat and is inundated completely only in high tidal periods. At other times the area is exposed to intense evaporation leading to salt accumulation. This leads to the development of "hypersalinity". Salt levels rise in the surface few centimetres to the point where even the Casuarina cannot grow and the area is characterised by a strange collection of succulent type genera such as *Sarcocornia, Lampranthus, Cotula, Wilsonia, Suaeda, Sporobolus*, and *Halosarcia*. Even within the saltmarsh a range of salinity levels can occur leading to an edaphic distribution of halophytes within the saltmarsh itself (microhabitat). In a study on transplantability of saltmarsh species at Homebush bay, for example, the Olympic Coordination Authority (OCA 1996) found that *Sarcocornia quinqueflora* transplanted only on the lower half of the slight gradient of the saltmarsh and *S. virginicus* only on the uppermost level whereas *Halosarcia pergranulata* grew at all levels. They also found significant drought related alterations in distribution with areas of healthy saltmarsh dying back in extreme drought but regrowing rapidly upon the advent of rain.

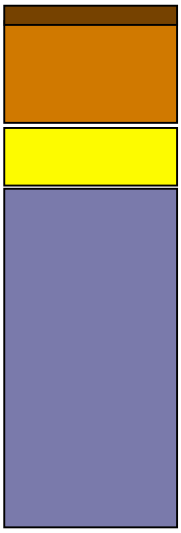
Significantly, the OCA (1996) found that the distribution of saltmarsh was not related to soil properties and appeared to be related only to the distribution of salinity which is essentially a topographic phenomenon. Thus even in recently deposited fill saltmarsh community had established and flourished at Homebush Bay in many cases as well as any saltmarsh associated with intact soil types. It is, however, worth examining the expected natural soil type associated with the classic estuarine salt marsh.

The typical salt marsh soil has previously been known as a "Solonchak" (Stace et al 1972) which is a shallow saline soil showing little or no profile development except in the surface 30 centimetres essentially showing the nature of the sediments below this. The Solonchak can be divided into inland and coastal forms which show unique features. The coastal form is always associated with shallow saline water tables and frequent but not constant tidal inundation. The general features of the coastal plain solonchak is shown in figure 1.

Figure 1. Profile form of a Saltmarsh Solonchak (sulphuric/sulphidic Supratidal Hydrosol).

Depth
0-2cm

2-5 cm
water table-----
5-20 cm



O horizon, some peaty accumulation of undecomposed organic matter or salt crust
A horizon, zone of drying, structured clay with iron staining in cracks and pores, brownish/mottled
B horizon. Sulphuric or oxidised zone. sulphuric acid development, yellow jarosite mottles.

C horizon, sulphidic anoxic zone showing steel grey/blue colour of sulphidic sediments, no structure, smell of sulphides.

The Australian Soil classification (Isbell 1996) classifies all wet or inundated soils in the Order “Hydrosols” and the estuarine hydrosols associated with saltmarsh as “Supratidal Hydrosols”. They can be further divided up into those containing sulphidic material (black or grey iron sulphide associated with the rotten egg gas smell of hydrogen sulphide), those containing sulphuric materials (ie sulphides that have already oxidised to sulphuric acid). Sulphuric materials are often associated with the appearance of a butter yellow layer or mottles of “Jarosite” and extremely acidic pHs. In the profile form shown, which is based on an actual profile at Mason Park NSW the term Sulphidic/sulphuric is used to denote that both features can be found in the same profile

In the profile form described in Figure 1. the geology is based on marine lacustrine (sulphidic or potential acid sulphate) sediment which forms a layer of sulphuric material at the depth of the fluctuating water table (actual acid sulphate layer). This sulphuric layer typically shows the butter yellow or jarosite and has pH or around 2.0 providing additional challenges for the vegetation growing on it. Salt marsh communities then are often and in fact nearly always associated with the risk of acid sulphate soil conditions.

The likely distribution of soils supporting saltmarsh is probably best described in such soil maps as the “Acid Sulphate Soil Risk Maps” published by the NSW Dept of Land and Water Conservation (DLWC 1995).

The profile is typical of solonchaks forming on clayey mangrove mud type sediments such as occur at Homebush Bay and many estuaries but salt marsh communities can occur on sandy sediments, the key factor, it appears, being the accumulation of salts to form hypersaline (saltier than seawater) conditions, not the soil texture.

In their study on the distribution of soil and plant communities in Homebush Bay saltmarshes the OCA (1996) measured salinities using a 1:3 water extract and obtained values of from 21 to 95 dS/m. A soil is defined as saline for agriculture if the EC by this method is over 1.5dS/m giving a fair idea of just how saline these soils are. This is a 1:3 extract so to give an estimate of the actual salinity of pore water the results can be multiplied by around 3 giving a range of around 60 to 270dS/m. Seawater has an electrical conductivity of around 50-55 dS/m so the OCA's results give numbers roughly correlating with that of seawater and ranging up to five times higher than seawater. Interestingly the *Wilsonia* species only occurred at EC 1:3 levels of 40 dS/m or less whereas the other species showed a more general distribution in areas showing EC 1:3 of 21 up to 95 dS/m. There is obviously a variation in tolerance to hypersalinity.

In a study conducted by ourselves at Mason Park Auburn NSW we found a profile very much like that described in Figure 1. Salinities of the surface mud varied from approximately that of seawater near the tidal entrance up to ECs of 200 dS/m in stagnant areas. pH's in this stagnant water shows numbers as low as 1.5 pH units (sulphuric acid!) and such microclimates showed little or no saltmarsh growth. Things were obviously too tough even for these remarkable plants.

Such extreme conditions usually only occur where the topography of the saltmarsh has been disturbed, most commonly by reducing the tidal ventilation or lowering water tables. Seawater is an effective pH buffer and salt dilutor and acts to regulate the balance between saltmarsh and mangrove. While little is known here it appears that by encouraging tidal ventilation mangroves will start to dominate and by reducing such ventilation to an optimum level salt marsh communities can be favoured. Were we skilled enough we could even reconstruct the microhabitat required for each species of saltmarsh plant. This is an interesting area for research.

In recommending soils for rehabilitation of salt marshes it would appear that texture is of little importance. Possibly a very well drained sand is the only texture that may not prove suitable and a heavy clay may be a problem to work with from a practical viewpoint. We have usually recommended clayey sands that do not lose too much strength when wet (ie you sink to your knees while transplanting), are friable enough to level out well without lumps, and stand up to water flow without severe erosion. pH should be adjusted to around that of seawater (pH7.2) for the most rapid establishment.

Most importantly, organically enriched and fertilised soils should not be used. Organic matter will produce toxic anoxic reaction products upon inundation that the new plants may not be adapted to and seawater will, in the long term, provide all the nutrients required. In one successful transplant job the contractors used just a clayey sand adjusted to pH 7 with lime and a little controlled release fertiliser right under new plantings. The marsh has established well with some natural sorting out of the vegetation into zones of halophytes that would most likely be completely understandable in terms of the microhabitat salinity levels.

While not to be encouraged, and in most places now prohibited, the reclamation of these soils for agriculture, particularly for sugar cane in Northern NSW and Qld provides some interesting physical and chemical problems. Firstly the areas were drained so that the process of leaching salts out can start. This results in severe acidification that does not necessarily hurt the sugar cane (which is highly acid tolerant) but often would result in severe fish kills from the acid leachate. To leach salts out a high salinity water must be used. If fresh water is used the soil immediately disperses, clogs and prevents further leaching. Thus a 50/50 shandy of fresh and salt water might be used for the first year slowing going less and less saline over a period of around 5 years. We are still living with the legacy of the sulphuric acidity caused by this reclamation with the Tweed River in NSW considered the most polluted river in Australia.

In summary soils suitable for coastal saltmarsh communities -
• have a narrow band of distribution between the mangroves and the true terrestrial community
• occur only in locations where hypersaline salt conditions can develop
• show mostly clayey properties in their natural condition
• can be reconstructed using a variety of soil textures, clayey sand being possibly of the most practical use
• should be totally protected in all states as a vulnerable and rare soil/topographic occurrence
• must not be over-ventilated with seawater or mangroves will dominate
• must never be developed without consideration of acid sulphate potential.

References and further reading:

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