Salinity control in northern China

G A. Robertson

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China has vast areas of saline land, perhaps as much as six million hectares. Some of this saline land is a result of marine influence in coastal areas and some is the result of soil formation in areas with saline geological deposits and inadequate rainfall to leach out the salts at that time.

However, most saline soils in China are a result of secondary salinisation processes induced by a hydrological imbalance resulting from over-clearing of the land or irrigation. This imbalance has produced rising watertables bringing the salt closer to the soil surface.

In this article, G. A. Robertson, Commissioner of Soil Conservation, looks at aspects of salinity control in northern China which are aimed at a co-ordinated approach to reducing the level of the watertable.

Dr Robertson was one of six scientists from Western Australia who visited China in 1983 as part of a scientific exchange agreement between the University of Western Australia and the Chinese Association of Science and Technology.

The purpose of the visit was to examine salt-land reclamation and arid farming techniques relevant to Western Australian agriculture.

About the land

The valleys and flood plains of the Huang Ho (Yellow River), the Huai River and the Hai River in northern China are particularly affected by salt. The alluvial plains of the three rivers cover 300 000 square kilometres. About 22 per cent of the land is saline and 39 per cent is affected by severe waterlogging. The salt-affected soils occur mainly in areas of poor drainage.

There is about 600 millimetres of rainfall each year, mostly in the summer months of June, July and August. Spring is dry and windy, with evaporation in that period nine to ten times the rainfall.

Winter wheat is the main crop grown. It is irrigated in spring and often in autumn. A large part of the area can be irrigated.

Salt has accumulated in these areas for many centuries, but large parts have probably become saline in the past 100 years or so. The saline areas contain between 0.5 and 1 per cent salt and cannot be cropped without treatment.

The traditional treatment has been to use sticks to scrape the salt-encrusted surface soil from the fields. The saline soil was stockpiled and often leached in specially constructed pits to produce a concentrated brine. The brine was evaporated in an iron dish over a fire to produce crystal salt which could be sold.

The continued removal of the surface soil was not considered important in terms of soil lost as the soils are very deep uniform deposits of secondary loess. However, the process was very labour consuming and provided only a temporary solution. Even after crust removal, crop yields were still depressed.
Causes of salinity

China's scientists have researched and defined the causes of their salinity problems. In the Huang Ho, Huai and Hai River region the cause has been identified as a saline watertable rising too close to the soil surface.

Research information presented at a workshop on reclaiming salt-affected land held at Handan in 1983 showed that surface salt accumulation in China had a similar cause to the problem in Western Australia.

Table 1 shows the influence of capillary action in transporting salts to the surface. Salt accumulation increased as the watertable rose closer to the soil surface. Research has indicated that on the secondary loess alluvial soils of China the watertable must be kept below 1.8 metres if surface salinisation is to be avoided.

China's scientists have clearly shown that salt concentration in the surface layers is highest when the salt concentration in the groundwater is highest (Table 2).

Salt concentrations in the soil vary throughout the season, with climate affecting the movement of salt up and down the soil profile. The Chinese have identified five major periods when this occurs:

- Strong upward movement and surface accumulation of salt caused by evaporation and capillary action during the warm, dry and windy spring.
- Relatively stable soil salt levels in early summer as rainfall increases to equal evaporation.
- Infiltration of water and downward leaching of salts during the rainy summer.
- A short period of upward movement of salts during autumn.
- Stable salt levels during the cold winter when evaporation is very low.

The driving force for salt accumulation is capillary action which leads to upward movement of salts as soil moisture evaporates during the dry, windy spring and to a lesser extent autumn. The conditions prevailing in Western Australia during summer and autumn are probably more severe than those in China in the spring, and the rate of salt accumulation is probably higher.

Source of excess water

The rising groundwater levels are a result of several processes. These include recharge from rivers, irrigation channel leakage, excessive downward percolation of irrigation water, and the effects of heavy rainfall inducing waterlogging and flooding and hence recharge to the groundwater.

Much of the salt problem appears to be a result of local recharge but China's scientists have evidence of regional recharge systems. One interesting system involves the former bed of the Huang Ho acting as a preferred recharge area.

The Huang Ho has changed its course drastically 26 times in recorded history. In 1855 during a flood the river broke its levees and developed a new course over 575 km of its length. The old, elevated river bed remains and is now a vast recharge zone, collecting and transferring 320,000 cubic metres of water per kilometre of its length to the watertable.

As the old bed and levee is elevated, a result of massive deposits from the high silt load of the sluggish river (up to 50 per cent solids by weight in river water), a positive hydraulic head exists which maintains the watertable of the plain at a high level all year.

Reclamation projects

The Chinese have developed some impressive saline land reclamation schemes over the past few years. Up to now these have been pilot schemes, but following their success there are plans to greatly accelerate the programme.

Table 1. Effect of depth to watertable on percentage concentration of salt in the soil (after data of Wong Chou Chung).

<table>
<thead>
<tr>
<th>Sampling depth cm</th>
<th>Depth to watertable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0 m</td>
</tr>
<tr>
<td></td>
<td>May</td>
</tr>
<tr>
<td>0-20</td>
<td>0.25</td>
</tr>
<tr>
<td>20-100</td>
<td>0.21</td>
</tr>
<tr>
<td>100-150</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 2. Effect of concentration of salt in groundwater on accumulation of salt in the soil when level of watertable held constant (data after Wong Chou Chung)

<table>
<thead>
<tr>
<th>Concentration of salt in groundwater (g/L)</th>
<th>Salt concentration in 0-20 cm of soil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.57</td>
<td>0.125</td>
</tr>
<tr>
<td>2.81</td>
<td>0.292</td>
</tr>
<tr>
<td>7.80</td>
<td>0.549</td>
</tr>
<tr>
<td>13.60</td>
<td>0.646</td>
</tr>
</tbody>
</table>
The emphasis in the programme is on lowering the watertable by a co-ordinated approach. The main elements of the programme are:

- Land is levelled to provide even distribution of irrigation and rainfall and good runoff of flood waters.
- The soil's uniform nature permits a regular drainage layout. Main drains 3.5 m deep and leading water back to the rivers are spaced every one to two kilometres; farm drains two metres deep every 0.5 km; and farm ditches one metre deep every 100 m. The deep drains help to significantly lower the groundwater; the shallow farm drains control flooding and waterlogging.
- Shallow wells are installed to help lower the watertable. The water pumped from these wells is too saline for irrigation but it can be mixed with fresh water from deep wells, or from the rivers, to provide satisfactory irrigation water. If irrigation is not required during a period when pumping is necessary, the shallow well water is discharged into the rivers. These large, fast flowing rivers are not adversely affected by the added salt at this stage, although a problem could develop in the future.

Shallow wells up to seven metres deep are spaced about every six hectares. Pumping from the shallow wells starts when the watertable rises to closer than two metres from the soil surface.

- Tree planting is an integral part of the salinity control programme. Rows of trees are planted alongside all drains and irrigation supply channels, along roadsides and surrounding all paddocks.

In one project area at Yucheng in Shandong Province, four million trees and 2.5 million shrubs have been planted on 13,000 ha. Plantations of fruit and other trees have been developed to assist in lowering the watertable. Cropping is usually practised between fruit trees in an agro-forestry system.

The rows of trees are said to have some effect on the groundwater levels, and their layout in shelter belts apparently reduces wind speed and hence soil water evaporation. This both increases the water available to the plant and reduces the capillary rise of salts.

- The improvement in crop productivity by developing more appropriate rotations, particularly those including legumes, and by improving soil fertility was seen as an integral part of the saltland reclamation process. Healthy crops used more water, were more profitable, and helped to justify the cost of reclaiming saltland.

**Project organisation**

The research and planning for a saline reclamation project is carried out by agricultural scientists and engineers from various state organisations, in close co-operation with the leadership of the communes and brigades.

The Government lends a particular brigade money for capital works, such as wells and pumps, and the brigade mobilises its own resources and labour for the land levelling and drainage works. The brigade also plants the trees and raises the seedlings.

A major strength of the Chinese system is its ability to use human resources to achieve the desired community objectives. Projects, which varied in size from about 200 to 13,000 ha, were usually developed on a brigade or commune basis.

The total capital cost of reclaiming saltland in one project visited in Kuchu County, Hebei Province was $825/ha. This did not include the labour contributed by the brigade, which comprised 600 people farming 190 ha. The reclamation project had greatly increased production and it was confidently predicted that the Government loan would be repaid within five years.

**Conclusion**

China's approach to salinity control is to completely re-develop the farming area and the farming system to control and fully use the major cause of salinity, the excess water that was escaping to the watertable.

The co-ordinated approach taken is relevant to Western Australia's salinity control programme. As in China, water in Western Australia must be controlled, used more efficiently and any excess discharged safely. Any salinity project in Western Australia must consider and combine surface water control, drainage, high water-using crops and farming systems and trees.
Leaching pits used to produce concentrated brine from saline topsoil removed from the field.

Recently reclaimed saltland. The mounds of topsoil in the background were previously scraped from fields during traditional salt control methods.