# USE OF SALINE WATER IN NORTH WEST CHINA- A CASE STUDY-

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## OUTLINE

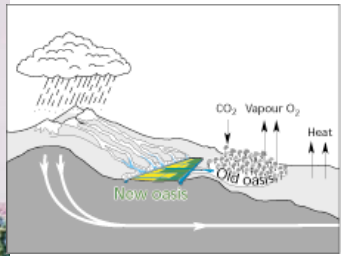
- Introduction to the study area
- Impacts of saline irrigation water on soil physical properties
- Results of a two-years irrigation trial with saline water
- Suggested improvements of the Mass Hoffman relationship.

## Why is surface and groundwater saline?

**Lower reach: mean annual precipitation < 150 mm - mean annual evaporation 2000 to 2650 mm.**


**Middle reach: good quality melt-water**

**Lower reach: poor quality drainage water**



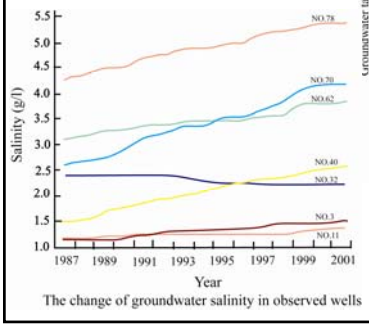

## Population growth and water resources development

| Year | 1949 | 1959 | 1972 | 1979 | 1985 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|
| Population ($10^6$ people) | 0.90 | 1.08 | 1.31 | 1.43 | 1.55 | 2.20 | 2.30 |
| Irrigated area ($10^3$ ha) | 134 | 154.7 | 206.7 | 245.3 | 272 | 302.7 | 304.5 |
| Reservoirs | 0 | 4 | 22 | 22 | 22 | 23 | 24 |
| Reservoirs Storage ( $10^6$ $m^3$) | 0 | 54 | 234 | 271 | 309 | 450 | 478 |
| Groundwater extraction ($10^9$ $m^3$) | 0 | 0 | 0.476 | 0.895 | 1.03 | 1.16 | 1.43 |

| | 1949s | 1960s | 1970s | 1980s | 1990s |
|---|---|---|---|---|---|
| Groundwater recharge in Wuwei Basin | 1.10 | 0.87 | 0.70 | 0.75 | 0.63 |
| Groundwater recharge in Minqin Basin | 0.48 | 0.33 | 0.28 | 0.17 | 0.12 |
| Groundwater recharge in the whole river basin | 1.58 | 1.20 | 0.98 | 0.92 | 0.75 |

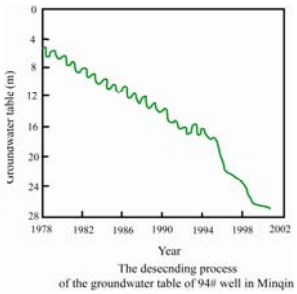
Existing problem :
Reduction of water resource and increase its salinity

## Changes in water quality



The change of groundwater salinity in observed wells

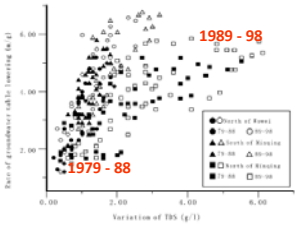
## Changes in water quantity



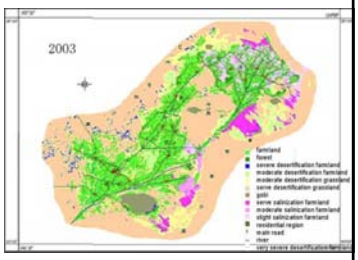
The descending process of the groundwater table of 94# well in Minqin

Future target:
Application of irrigation system with low water demand (drip) and improve irrgation management.

## Water quality and soil conditions




Salinity increasing at a rate of 0.1 g $L^{-1}$ $yr^{-1}$ in water-supplying wells and runoff




Drought and salinization causing severe land degradation

**Existing Problems:**
**wasted plastic mulch causes environmental pollution**

**Future target: use of biodegradable plastic film.**

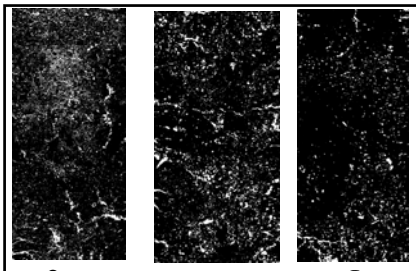
| | | Water | | | | |
|---|---|---|---|---|---|---|
| Elements | Unit | $Cw_{0.35}$ | $Gw_{0.8}$ | $Gw_2$ | $Gw_5$ | $Gw_{12}$ |
| $Ca^{2+}$ | mg $l^{-1}$ | 47 | 87 | 126 | 280 | 533 |
| $Mg^{2+}$ | | 11 | 44 | 192 | 190 | 448 |
| $Na^+$ | | 23 | 52 | 229 | 1000 | 2178 |
| $K^+$ | | 5 | 5 | | | 18 |
| $CO_3^{2-}$ | | 0 | 0 | 14 | 0 | 0 |
| $HCO_3^-$ | | 143 | 296 | 307 | 360 | 301 |
| $Cl^-$ | | 22 | 120 | 323 | 890 | 3455 |
| $SO_4^{2-}$ | | 92 | 225 | 739 | 1640 | 3048 |
| TDS | g $l^{-1}$ | 0.35 | 0.8 | 2.0 | 5.0 | 12.1 |
| ECw | dS $m^{-1}$ | 0.46 | 1.00 | 2.6 | 7.03 | 18.8 |

## Impact of saline irrigation water on soil physical properties

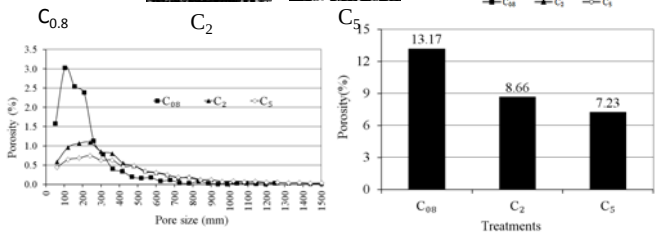
Undisturbed soil samples taken at different depth to estimate:
Water Retention Curve WRC
Soil porosity by image analysis

Disturbed soil samples to evaluate the:
Index aggregate stability (IC) in water

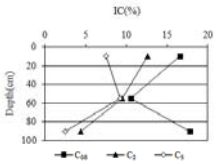
Measurements carried out on
$C_{0.8}$ = soil irrigated with water at 0.8 g $L^{-1}$ =C
$C_2$ = soil irrigated with water at 2 g $L^{-1}$ = $S_1$;
$C_5$ = soil irrigated with water at 5 g $L^{-1}$ = $S_2$;

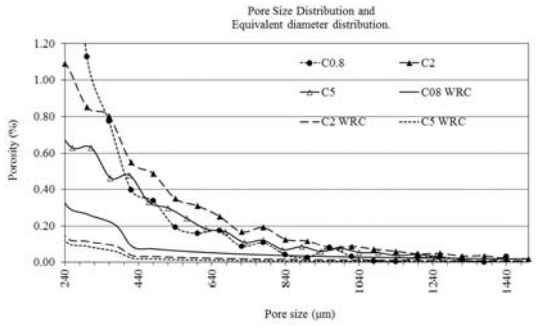


$C_{0.8}$ $C_2$ $C_5$



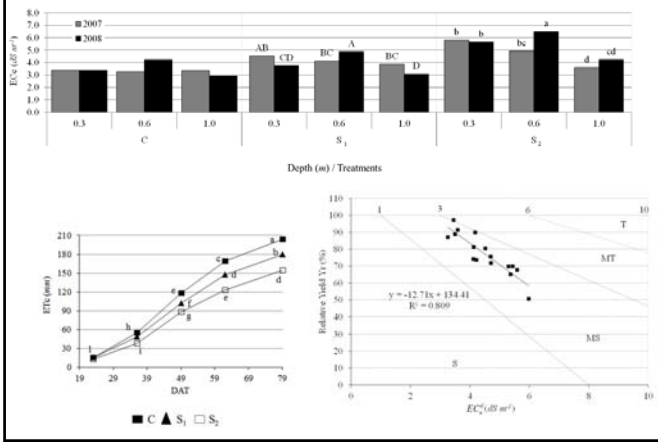

Huang et al, 2011. Environ. Earth Sci; 63, 701-708
Basile et al, 2011. Environ. Earth Sci; DOI: 10.1007/s12665-011-1404-2




| Treatments | Water Hold Capacity (WHC) layer 0.0-0.6cm mm |
|---|---|
| $C_{0.8}$ | 87.82 |
| $C_2$ | 143.13 |
| $C_5$ | 116.01 |

## Two-years irrigation trial with saline water



| Parameter | Unit | C | $S_1$ | $S_2$ |
|---|---|---|---|---|
| Marketable fruit | t $ha^{-1}$ | 37.82 a | 32.71 b | 26.55 c |
| Fruit | g | 1980 a | 1728 ab | 1507 b |
| Harvest Index | - | 0.64 c | 0.69 b | 0.75 a |
| Total soluble solid | °Brix | 9. 07 b | 11.03 a | 11.62 a |
| Seed per fruit | N° | 566 b | 675 a | 697 a |
| Fruit shape index | - | 0.83 a | 0.88 b | 0.91 b |
| dry matter pulp/total dry matter | % | 50.4 B | 57.6 A | 58.6 A |
| Dry matter peel/total dry mat. | % | 39.6 a | 32.1 b | 31.3 b |

Huang et al., 2012, Impact of saline water irrigation on yield and quality of melon (*Cucumis melo cv Huanghemi)* in northwest China. Europ. J. of Agron, 43; 68-76

Zong et al., 2011. Effect of different irrigation water salinities on some yield and quality components of field-grown two *Cucurbit* species. Turkish J of agriculture and forestry (Vol, 35, doi:10.3906/tar-0908-5)

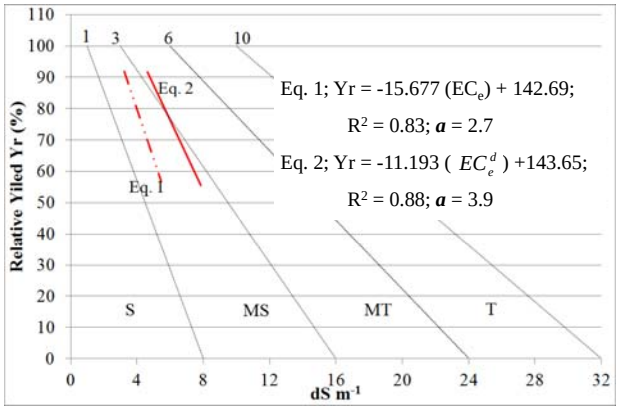
## Suggested improvements of the Mass-Hoffman relationship.

Current limitations:

1) Limited number of ECe measurements
2) Use of the weighted average of ECe obtained by averaging the ECe of different soil layers
3) No account is taken of preferential root water uptake from lower salinity soil layers
4) M&H model may be established using ECw instead of ECe

Question: How does the M&H change if we evaluate it by considering the concentration of the soil solution and the water plant uptake ?

**Letey et al. (2011) showed that plants do not respond to a linear average of soil root zone $EC_e$ because they extract additional soil water from the less stressed portions of the root zone to compensate for reduced root water uptake in the stressed root zone.**




$EC_e^d$ that is the seasonal weighted average of the observed $EC_e$ for each soil layer with weights equal to water uptake in each layer.

## Concluding Remarks

- Soil salinity and groundwater overdraft is threatening food security in the NW of China
- Irrigated agriculture is the largest consumer and polluter of river and groundwater
- Saline irrigation water has severe impacts on soil physical properties: the fraction of smaller pores increase in response to use of saline water
- The irrigation with saline water, $S_1$ if accompanied by leaching at sowing is still sustainable
- Irrigation with saline water, $S_2$ does not seem sustainable: in case of necessity, such $S_2$ water should be accompanied by leaching and applied to crop tolerant to salinity.
- The relationship between relative yield and salinity should be evaluated using a weighted average salinity of soil water to account for root water uptake in soil layers at different salinity


THANK YOU VERY MUCH FOR THE ATTENTION