Agricultural Irrigation Management
in Semi Arid Areas
Dr. Larry L. Russell, P.E.

-BS, MS, Ph.D. – UC Berkeley in Civil Engineering
-Dissertation computer model "Chemical Aspects of Ground Water Recharge with Wastewater"
-Registered Civil, Chemical, Corrosion Engineer
-35 years of experience in water conservation/wastewater management for food processing and agriculture
- Ran private sector work for MWH
-Currently run REED International Ltd and SOS
-Elected in 2004 to the Board of Marin Municipal WD

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Agricultural Irrigation

- **Must meet ET of Crop – 1-2 meters per year**
- **Water is primary crop yield determining factor**
- **Salt left behind in soil - can require sulfuric acid**
- **Salt requires flushing for soil to remain capable**
- **Equilibrium chemistry**
- **Salt tolerance of plants**
- **Initial water quality is only moderate concern when using fertilization => mineralization**

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Acid rain

Salt increases

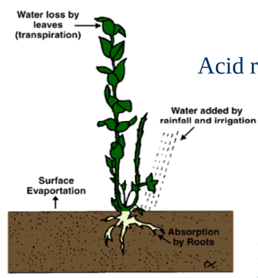

Fig. 1. The plant/soil/water cycle.

Nutrient uptake

Ground water

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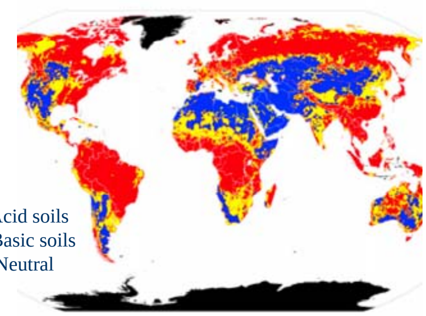

Red = Acid soils
Blue = Basic soils
Yellow = Neutral

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Current Status – getting worse every day

Region	**Salinized Area (10^6 ha)**
Australia	85
Africa	70
Latin America	60
Middle East	50
Europe	20
Far East	20
North America	15

1 ha ~ 2.5 acres – total irrigated land ~250*10^6 ha

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Critical Aspects of Mineralization (Salinization)

- Calcium salts – arid area caliche layers or hardpans
- In general, arid soils are alkaline with high calcium levels
- High Calcium increases mineralization
- High Sodium causes clays to swell/bind water
- Crop salt tolerance/diminished yield (less food)
- El Paso, TX – building desalters to address Ciudad Juarez salt issues – robbing Peter to pay Paul?
- Coastal cities different situation

All crops have salinity threshold

- Threshold varies by crop – need higher salt tolerance – potential worldwide resistance to using genetic modification GMO (or OMG)
- Available water supply will decrease in quantity and be saltier
- Critical to evaluate salt buildup – rarely done today – salt balances essential

In California, reclamation of wastewater on the land is tightly regulated on the basis of EC/TDS

- but real issue is mass of salt not concentration
- Ag contribution is ignored in basin plan/evaluations and unregulated
- for wastewater - must show that cropping is suitable to achieve uptake N & P (TDS?)
- with concentration limits – water efficiency is bad
- for Ag left up to economics & the farmer

- Ammonia vs. nitrate – carbon dioxide produced
  - by ammonia oxidation to nitric acid

    $2NH_3 + 4O_2 \Rightarrow 2HNO_3 + 2H_2O$

    $2HNO_3 + CaCO_3 \Rightarrow H_2CO_3 + Ca(NO_3)_2$

    $H_2CO_3 + CaCO_3 \Rightarrow Ca(HCO_3)_2$
- Carbon dioxide chemistry/equilibrium
- In the long run, ground water is a poor sink for salt
- Permanent damage? MAYBE

What can be done?

- on average 20%-40% of irrigation water is wasted
- but some wastage needed to rinse salt away
- pressure for water conservation is increasing
- Ag irrigation is 80% of water usage in CA
- Current water usage in CA 82 million AF/yr(10^11 cum)
- Salt sink required /or land will fail
- Suitable chemistry models exist – Morel/Trussell/Russell

Key Consequences

- Mass based control of salt is required
- Ag irrigation adds salt – it is a discharge
- Salt flush and salt drains are essential
- Water conservation increases salt buildup
- Need for more salt tolerant crops – GMO?
- Food production will fall – if salt not managed
- Is drip irrigation safe in the long run?