Mechanisms Contributing to Degradation of Soils by Produced Water and an Improved Process for *In-situ* Remediation.

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SOS Environmental

- Providing products and services for over 20 years
- Specializing in *in-situ* remediation
- “Service on Site”
- Products and application technology developed through continued research

Salt Impacted Soils – Overview

Produced water the biggest culprit

- Essentially all wells make some oil, gas and water
- Predominantly NaCl brine
- Produced water usually high in total dissolved solids (TDS)
- “Water cut” can be very high

A large portion of oilfield infrastructure is designed to handle produced water

Accidents happen

Factors Affecting Degree of Contamination

The spill itself

- Volume of the spill
- Composition of the produced water
- Duration of impact

Existing environmental conditions

- Climatic conditions – Precipitation
- Soil conditions

Soil Conditions Important

Drainage characteristics important

- Sandy soils and soils rich in organic material drain well
- Soils high in clay content do not

Cation exchange capacity (CEC)

- Electronegative charge from clay and organic material in soil
- Measure of the quantity of cations adsorbed per unit weight of soil
- The predominant cations in soils are Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}
- Fertile soil has saturation greater than 80%, predominantly Ca and Mg

Impact of Salt Contamination

Production water can be very high in NaCl concentrations

Two main issues cause negative impacts

- Total dissolved solids (TDS)
- Sodium ion (Na^+) concentration

Total Dissolved Solids

Soluble constituents (ions) present in the brine

Produced water predominantly Na^+ and Cl^- ions

Ion gradient controls osmotic pressure

- Can make it difficult or impossible for plants to uptake water
- Energy must be dedicated to overcoming osmotic pressure
- Can be lethal to plants or simply inhibit growth

Sodium Contamination

Na ions bind to electronegative sites on clay and organic particles

Can cause major problems to soil quality

- Displaces other nutrients
- Disperses soil causing increased erosion
- Decreases water infiltration

Sodium Contamination (cont.)

Measuring Sodium Concentration

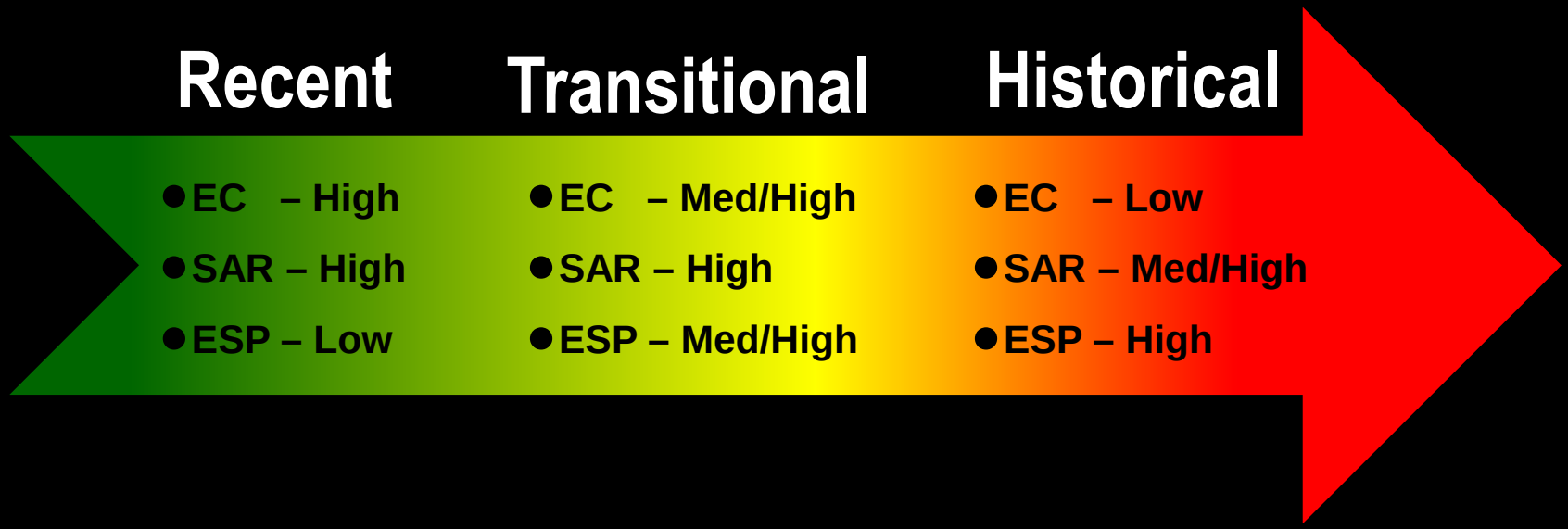
Sodium Adsorption Ratio (SAR)

- Measurement of total sodium vs other cations (e.g., Ca and Mg)
- May not reflect permanent damage

Exchangeable Sodium Percentage (ESP)

- Measurement of the sodium bound to soil structure as a percentage of total available sites (CEC)
- Indicates permanent damage

Site Designation



Remediation Strategies

Natural Recovery

- Minor spills
- Sandy soils
- Wet areas
- Proceeds slowly
- Na effected soils may never recover

Excavation

- Expensive
- Wasteful
- Essentially not addressing the problem

***In-situ* Remediation**

- Treating spill onsite
- Application important
- Chemically displace Na
- Met with some reluctance

In-situ Remediation

Treating the spill onsite eliminates…

- Trucking and over-the-road liabilities
- Potential contingent liabilities

Supports soil conservation

Actually addresses the problem

Is both timely and cost effective

Improved Process for the *In-situ* Remediation of Salt Impacted Soils

Case Studies



Harris County, TX

Historical site – Brine discharge pond and ditch

High CECs – Dense Houston gumbo type clays

ESP readings as high as 97%

- EC: 77
- SAR: 125
- ESP: 93
- CEC: 40

Harris County – Treatment Plan

- Entire site plowed and bulked with hay
- French drains constructed with hay corridors leading to ditch
- ½ of site treated with DeSalt Plus and ample fresh water
- Planted grass and turnips 30 days later
- 18 months to restore
- Still looks good 12+ years later

Haynesville, LA

Historical Site – Saltwater disposal

- 7 acres
- Sandy soils and red clay
- Contamination up to 7 feet

Previously Treated

- Treated with gypsum for 3 years
- Drain system with 2 sumps
- Water well for irrigation

Haynesville, LA (cont.)

Still severely impacted

- EC: 17-49
- SAR: 12-64
- ESP: 17-52
- CEC: 6-15

Pilot test with DeSalt Plus

Haynesville, LA – Treatment Plan

- Site tilled / disked with tractor
- Shredded hay tilled into soil
- DeSalt Plus applied
- Sprinkler system installed
- 24 month recovery

Montgomery County, TX

Recent spill – Saltwater leak

Sandy loam soil

Characteristic recent spill

- EC: 84
- SAR: 38
- ESP: 35
- CEC: 17

Montgomery County – Treatment Plan

- Tilling and bulking not possible
- Applied DeSalt Plus based on *First Response Chart*
- Limited access to water
- Fairly wet climate
- 9 months to recovery
- “Miracle in Montgomery”

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Questions?

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