Abstract

The goal of this research is to use geoinformatics, geochemistry, hydrogeology, and soil chemistry to form a multidisciplinary approach aimed at remediating brine-impacted soils. The primary research location is a 14-acre “kill zone” located on a private ranch approximately 14 kilometers south of San Angelo, Tom Green County, Texas. The Natural Resources Conservation Service (NRCS) classifies the site soils as part of the Angelo Series, a clay loam derived from limestone. A Geospatial Information System for 3-D soil chemistry modeling, which includes measuring for total alkalinity, extractable calcium, chloride, total copper, potassium, magnesium, sodium, total phosphorus, nitrate, pH, SAR, and total nitrogen, was compiled from soil sampling over 2015. Average sodium levels exceed 2,500 mg/kg, and average chloride levels exceed 5,500 mg/kg. This excess of sodium classifies the soils not only as saline soils, but also as a sodic soil. Chemistry data was analyzed by creating ternary diagrams allowing for soil classifications. All data collected are stored in an ArcGIS database for data management, project planning, and various models. Lithologic data manipulated in ArcGIS is transferred to ArcSCENE to create 3-D models of the subsurface. Techniques for remediation that are being investigated include bioremediation with halophytes, physical soil ripping and furrowing, and using various soil amendments including magnesium sulfate, gypsum, and compost. This research is ongoing and further exploration regarding soil chemistry and forage quality will be analyzed 2016.
The goal of this research is to use geoinformatics, geochemistry, hydrogeology, and soil chemistry to form a multidisciplinary approach aimed at remediation of brine-impacted soils. The primary research location is a 16-acre “field site” located on a private ranch approximately 14 kilometers south of San Angelo, Tom Green County, Texas. The Natural Resources Conservation Service (NRCS) classifies the soils as part of the Angelo Series, a clay loam derived from limestone. A Geospatial Information System for 3-D soil chemistry modeling which includes measuring for total alkalinity, extractable calcium, chloride, total copper, potassium, magnesium, sodium, total phosphorus, nitrate, pH, SAR, and total nitrogen was compiled from soil sampling over 2015. Average sodium levels exceeded 2500 mg/kg, and average chloride levels exceed 5500 mg/kg. This excess of sodium classifies the soils not only as saline soils, but also as a sodic soil. Chemistry data was analyzed by creating ternary diagrams allowing for soil classifications. All data collected are stored in an ArcGIS database for data management, project planning, and various models. Lithologic data manipulated in an ArcGIS to create 3-D soil chemistry models along with hydrology, physical soil piping and furrowing, and using various soil amendments including magnesium sulfate, gypsum, and compost. This research is ongoing and further exploration regarding soil chemistry and forage quality will be examined 2016.

Site Structure

Due to the excess amount of salts found on-site, the structure of the soil has been adversely affected. A salt crust is formed on the surface of the site. This crust impedes water infiltration. Without proper infiltration, the soils dry out and are allowed to become severely compacted. A penetrometer measure the soil pressure at >500 psi, where plants cannot push their roots past 300 psi. Because the soils ESP is >70, the soils can become dispersed. This dispersion causes the clay particles to create impermeable layers that can further impede water infiltration. Tom Green County, Texas averages 21.25" of rainfall per year, and an average yearly pan evaporation rate of 73.15". This difference between precipitation and evaporation allows for low soil moisture content. The high rate of evaporation creates mud cracks along the surface of the site. These mud cracks should allow for infiltration of water into the soil, but the clay layers formed from soil dispersion act as an impermeable layer within the soil. Soil structure and chemistry were then examined 2016.

Testing and In House Calculations

We conducted an ECs, EC1 field test with a YSI multisensor to determine the electrical conductivity of the soil. By determining the electrical conductivity, we are able to determine the level of salinity.

Table 2 shows the conversion from EC1 to ECs. ECs is equal to the EC of a saturated extract (method used to calculate EC in lab). Any value over 4.5 dS/m is considered saline.

Sodic soils are classified as anything with an ESP >15%. Once planted, ensure plant safety using sturdy cages surrounding bushes and a fence around the site perimeter.

Understand discrepancies between physical soil characteristics and quantitative data from soil testing results.

Continue soil testing as more plants are planted on the site to determine success of bioremediation.

Discussion and Future Work

We observed that the soil present at the private ranch site is unsuitable for even the salt tolerant plants that we grew. This is due to degraded soil structure (low permeability and porosity) as evidenced by our hydrogeology data. Furthermore, organic material is essential to improve soil structure as well as provide essential nutrients depleted within the soil necessary for plant growth.

Future work:
- Determine appropriate soil amendments based on geomorphological data.
- Improve soil structure.
- Magnesium sulfate: increase Mg levels and improve structure.
- Compost: add organic material.
- In a controlled setting (e.g., a greenhouse), determine viability of each amendment technique both in terms of plant growth and soil uptake.

Once planted, ensure plant safety using sturdy cages surrounding bushes and a fence around the site perimeter.

Understand discrepancies between physical soil characteristics and quantitative data from soil testing results.

Application effective techniques from this study to other brine water spill sites across West Texas.

Develop a cost benefit analysis outline that can be modified for each site.

Conclusion

In conclusion, brine impacted soils have degraded structure (due to high SAR and ESP), and chemistries (due to high EC) that are unable to support viable plant life. Degraded soil structure impairs water infiltration, and a plant’s ability for root penetration. The unfavorable chemistries increase pore pressure within roots, inhibiting the plants ability to uptake required nutrients and water.

References

A reference list is available upon request.

Figure 1a: Ternary Plot showing Low Percentages of Ca2+ and Mg2+ Relative to Na+

Figure 1b: Ternary Diagram Showing Low Percentages of Ca2+ and Mg2+ Relative to Na+

Figure 1c: Piper Plot Showing Chemistry Clustering of all 5 Sections.

Figure 2: Map of Site Showing Soil Sample Locations

Figure 3: Water Pooling due to Berms in Section 3

Figure 4: Aerial Phooshowing Site and Lack of Vegetation

Figure 5: Photo Showing Salt Crust, Mudcracks, and Erosion

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Methodology

- Collect and analyze geospatial data using GPS
- Collect soil samples (top 6”)
- Process soil data in Geocentral Workbench
- Collect soil samples (top 6”) with the YSI multiprobe to calculate electrical conductivity (EC) by using EC1 test
- Determine if soils are saline, sodic, or both by calculating the sodium adsorption ratio (SAR), the exchangeable sodium percentage (ESP), and interpreting the electrical conductivity (EC)