

title	Salt Leaching, Nutrient Movement and Crop Absorption
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additional	None
department	Earth and Soil Sciences Department
proj_desc	<p>This Honors Research Proposal is being submitted at the request of Angie Quintana-Jones. We have discussed this and she is interested in participating in this work.</p> <p>Background Soil particles of clay and humus (organic matter) have the property of Cation Exchange Capacity (CEC) whereby Cations (+ charged electrical ions) are held against leaching downward with rain or irrigation water. Typically, the major cations on the soil Cation Exchange Capacity are Calcium (Ca²⁺), Magnesium (Mg²⁺), Sodium (Na⁺) and Potassium (K⁺), with small amounts of Strontium (Sr²⁺) and Barium (Ba²⁺). Dehydration of sea water or other salty water preferentially causes the calcium, strontium and barium to become relatively less soluble as carbonates and sulfates. This allows more magnesium and especially sodium and potassium to accumulate as has occurred in the Tulare Lake basin and in the Buena Vista Lake basins.</p> <p>Sodium (Na⁺) cations cause the soil to disperse (moving the clay and humus particles away from one another). This is detrimental to soils because these particles move downward and seal over the smallest existing soil pore thereby preventing further downward water movement and preventing effective salt leaching. Ideally, the cations are leached downward with applied irrigation water through open soil pores as either the Anions (negatively charged ions) of Sulfate (SO₄²⁻) or Chloride (Cl⁻). Although other salt anions could be used, they have undesirable consequences. For example, Nitrate (NO₃⁻) is a fertilizer, but if it is leached into ground water it can cause environmental contamination as would the use of Perchlorate (ClO₄⁻).</p> <p>Application of sulfuric acid (H₂SO₄) to soil high in lime causes the lime (Calcium Carbonate CaCO₃) to dissolve and to become Gypsum (CaSO₄ · 2H₂O) in the soil. This insures effective soluble Calcium (Ca²⁺) ions to Exchange on the CEC sites pushing the Sodium (Na⁺) ions off and allowing them to be leached downward. Normally, in a high lime soil the calcium is essentially insoluble and not effective in Exchanging with the sodium and thereby prevents effective sodium leaching.</p> <p>Plants can tolerate a modest level of sulfate, but they do not grow as well with high chloride. The problem for growers is sulfates have lower solubility and lower salt leaching ability than do chlorides.</p> <p>Irrigation water is commonly applied in furrows. As this water passes down the furrows, it preferentially dissolves and carries with it various ions. The same thing occurs when rain water moves across the soil surface dissolving ions and carrying them as surface runoff into rivers and streams. This runoff can be considered an environmental pollution problem if the water contains Phosphate (H₂PO₄⁻). The Nitrate (NO₃⁻) ion would be a major contaminant if it exited from the soil in the runoff water.</p> <p>Farmers of cotton and tomato crops in the San Joaquin Valley of California are experiencing decreasing yields because of high salt accumulation in soil. The irrigation water used for their crops often has a pH of approximately 9. At this pH, clay particles are dispersed in the water. The pH associated with high a high bicarbonate (HCO₃⁻) concentration in the irrigation water seals the surface soil by forming relatively insoluble calcium carbonate (CaCO₃) lime inside existing soil pores thereby preventing irrigation water from leaching the salts downward through the soil. Although these seem to be straight forward experiments, they have never been reported in the literature.</p> <p>Nature of the research: Salt Leaching, Nutrient Movement and Crop Absorption This research project will span the entire quarter, and has three parts. Each part of this experiment will use the same soils. Eight soils representing typical salty soil conditions in growers' fields will be collected from eight growers' fields in the San Joaquin Valley. Sufficient soil will be returned to Cal Poly to allow all of these experiments to be performed. The soil collected will be sieved through a 5 mm diameter sieve to insure uniformity.</p>

Part I

Cotton, tomatoes and corn plants will be grown in the Soil Science greenhouse in gallon plastic containers of each of these eight soils. The soil will be amended with gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ a conventional agricultural amendment), sulfuric acid (H_2SO_4 commonly injected into irrigation water or applied to soil high in lime), or calcium chloride (CaCl_2 use in limited amounts) to remove sodium from the soil. These amendments are chosen to examine the relative effectiveness of the calcium cation (from gypsum and from calcium chloride) in removing sodium and in enhancing leaching of salts. In addition, the effectiveness of the sulfate anion (from gypsum and sulfuric acid) will be assessed for enhancing leaching of salts. Each crop will be irrigated with water acidified with either sulfuric acid (H_2SO_4 for gypsum and sulfuric acid treatments) or hydrochloric acid (HCl for the calcium chloride treatment) to eliminate the problems associated with the high bicarbonate (HCO_3^-) precipitating the calcium and magnesium as carbonates inside soil pores. At the end of the quarter, plants will be harvested, dried, and weighed to determine yield values at mid-growth. The research aims to determine whether acidifying irrigation water in addition to adding gypsum can improve soil conditions for growing these crops. During the second quarter, the dried plant tissue will be analyzed to assess the total removal of the various ions of calcium, magnesium, potassium, sodium, strontium, barium, sulfate and chloride. The relative effectiveness of the calcium exchange with sodium and the relative effectiveness of the sulfate and chloride will be investigated for crop growth.

Part II

The rate of Exchange of cations on the soil CEC sites will be evaluated with depth in the soil for each of these eight soils. Several 4-inch PVC (polyvinyl chloride) plastic pipes will be cut into 5 centimeter long rings. These rings will be re-attached into 50 cm long columns by wrapping them with duct tape. This pre-cutting and taping will facilitate separating each 5 cm segment at the end of the experiment. Varying rates of Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), sulfuric acid (H_2SO_4), and calcium chloride (CaCl_2) will be added to each column of soil periodically throughout the quarter. The rates of application will correspond to 20 %, 40 %, 60 %, 80 % and 100 % of the concentration need to Exchange with the entire CEC sites. Each column will be leached with the equivalent of 50, 100, 150 or 200 cm of water (representing 1x, 2x, 3x and 4x fold leaching). At the end of the leaching experiment, the 5 cm thick rings will be carefully separated. The concentration of calcium, magnesium, potassium, sodium, strontium, barium, sulfate and chloride will be measured in each soil segment with depth. The leachate passing through the 25 cm column during the quarter will be analyzed for these same ions. This will enable the relative movement of each ion to be followed with depth for each treatment. This has never been reported in the literature, in spite of the fact this leaching is a common process used in agriculture.

Part III

Each soil will be pulverized. Ten grams of each soil will be placed into containers with 10 milliliters (mL), 100 mL, 500 mL, 1000 mL, 5,000 mL, and 10,000 mL of water. Soil in each container will be allowed to equilibrate for one week prior to analysis. Each of the eight soils will be used to examine the relative solubility and mobility of the calcium, magnesium, potassium, sodium, strontium, barium, sulfate, chloride, phosphate (H_2PO_4^-) and nitrate (NO_3^-) in the irrigation water. This will allow the relative solubility and mobility of each ion to be followed with dilution. This can answer several questions about the potential environmental damage from irrigation and rain water runoff from these soils.

inter_desc

Interdisciplinary nature:

Students from the Earth and Soil Sciences Department will gain a better understanding of many soil processes. Chemistry Department students will learn about many chemical reactions occurring in both the soil and the water entering and leaching through the soil. Crop Science Department students will learn about problem concerning crop production in the San Joaquin Valley and other salty soil areas and possible ways to solve them. Biological Science students interested in Botany will learn about the ways the plants absorb nutrients and other ions and how salt interferes with this absorption and utilization of these nutrients inside the plant. In addition to other agricultural and plant processes, Environmental Engineering majors interested in the water treatment and leaching through the soil into rivers, lakes, and groundwater can gain a greater

	<p>understanding of the environmental rates of change and consequences of these ions moving through the system as issues of environmental concern.</p> <p>Expectations Three students will be recruited to work on this project. Each student will be encouraged to work with the other students to learn about each part of the experiment. However, ideally, each student will have the major responsibility for one part. Each student will be expected to complete the research. They will be expected to attend a regional or national meeting to report the results of their research .</p>
links	No, not at this time. We would be willing to make one.
students	3
majors	ERSC, BOT, CRSC, FRSC, ENVE, CHEM, SS, VGSC
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