An Innovative Approach for Application of Saline Wastewater From a Coal-Fired Power Plant for Agricultural Purposes

Esmaiel Malek, Self Employed, Port Orange, FL; and L. Dudley

Abstract: Saline wastewater from a coal-fired electrical power plant has been used for irrigation of agricultural crops at the Hunter Research Farm (Farm) with an area of 182.53 hectares = 451 acres, varies slightly from year to year) located at 39° 10' N, 111° 2′ W, 1725 m = 5660 ft above mean sea level since 1987. This research site is in central Utah, USA. The objectives of this research are to determine the water balance in an alfalfa field located at the experimental site, which is irrigated by sprinkler system using saline wastewater coming from the evaporation ponds of the Utah Power Plant (PacifiCorp Energy) at Hunter. This power plant burns coal to heat water. The water boils and changes to steam. The steam is used for spinning a turbine, which turns a generator to produce electricity. After the steam goes through the turbine, cooling water (piped from a nearby river) is used to turn the steam back into water again. After going through the power plant, the heated water which was piped from the river is sent to cooling towers. Some of the water evaporates into the air here and the remaining water goes back to the plant to be used again. After being recycled many times, the water's efficiency for cooling decreases (due to an increase in salinity), subsequently it is channeled to the wastewater evaporation ponds. This saline wastewater has been applied to irrigate various agricultural crops since 1987. The goals of this research are: to dispose of saline wastewater by maximizing actual evapotranspiration (ETa), to prevent contamination of surface and groundwater by eliminating runoff and deep percolation, and to monitor salt and water budgets and the effect of salt accumulation on transpiration and yield during the past 24 years. To evaluate the 20 min, daily, and annual water consumed by crops such as alfalfa, wheat, and barley, irrigated with saline wastewater, we used the Bowen Ratio-Energy Balance (BREB) method, one of the most advanced, accurate, and reliable techniques for long-term, continuous measurement of energy budget components in remote areas with different ecosystems. This method measures the one and two meters air and dew points temperatures along with the solar and net radiation, surface soil heat fluxes, wind speed and direction, and precipitation every 5 seconds averaged into 20-min. Concomitant with use of wastewater for irrigation, experimental plots were established to monitor salt and water budgets and to monitor the effect of salt accumulation on transpiration and yield. Two line-source sprinkler irrigation systems delivered water to the experimental plots where amounts of water and salt that decrease from the source. Forage crops that are currently planted on some portion of the Farm are replicated three times in the research area. Through one line, saline wastewater from the power plant is applied and the other line-source sprinkler applies Huntington River (the control treatment). Catch cans are placed at ten feet intervals in two locations across the plots to measure the amount of water delivered by the line-source sprinklers and the time of irrigation was adjusted so that each side of a line and the two lines delivered the desired amount of water. The research plots are located at the mouth of a canyon so half of the irrigation water is applied in the morning during up-canyon winds, and half of the water is applied in the afternoon during the down-canyon winds, so that both sides of the lines receive

comparable amounts of water. A computer simulation model was used for estimating useful lifetime of the Farm that computes transport of water and salt in one dimension under conditions of variable moisture content and salt transport. The model was used herein to illustrate the pattern of salt accumulation that would lead to the end of the function of the Farm as a method for wastewater disposal. The model predicts crop growth, yield in response to salinity and water availability and salt chemistry. The model contains time-centered, second-order numerical solution to the Richards' equation with a root-sink term and the equation of continuity for solute transport for a physically homogeneous soil profile. The chemistry subroutine computes ion pairing and exchange reactions and dissolution and precipitation of calcite and gypsum, and chemistry that may vary through the soil profile. The model simulates the uptake of water from a potential-flux equation for crop response to water and an empirical transpiration partitioning equation for response to salinity. The model output was found to agree with field-measured soil salinity. The 1987–2010 irrigation season data at this experimental site show that variability in the weather conditions (air temperature, atmospheric moisture, radiation, wind, precipitation, etc.) have resulted in distinctly different actual and potential, ETa and ETp, respectively, from year to year. By careful collection of weather data and evaluation of ETa and proper management of irrigation (amount, time and duration of irrigation), it has been shown that surface runoff and deep percolation have been avoided. These practices should be continued to prevent surface and groundwater pollution. The effect of salt accumulation on the transpiration of alfalfa and other forage crops, modeling of plant-soil-water-atmosphere interactions for use in predicting the Farm longevity, and developing a database for model validation are being studied by another group of researchers. As discussed, the results thus far have shown that alfalfa yield and ET is likely to decrease only slightly for the coming years if saline wastewater continues disposal of saline wastewater from electrical power plants to be used for irrigation. The results of the animal project conducted at the Farm have shown that, despite having soft teeth and bone weaknesses in the cattle, the meat products are safe for human consumption, because the harmful levels of certain elements, characteristics of the water, are removed by filtering mechanisms in the crops and cattle. Keywords: Bowen ratio-energy balance; saline wastewater; power plant; evapotranspiration; chemical assessment model; environment systems.

Abstract ID#: 197806
Password: 905780
Program Selection: Fifth Annual CCM Forum: Certified Consulting Meteorologists: Meeting the Demand for Specialized Weather and Climate Information in the 21st Century Business Environment
Topic Selection: Enbracing New Technology - CCM's Leading Way Into Future Services: Papers on Today's New Markets, Alternative Energy, Climate Change, Forensics, Operational Weather Prediction, Forecasting, Weather Modification and How Technology Is Improving/Changing Client Interaction and Services
Title: An Innovative Approach for Application of Saline Wastewater From a Coal-Fired Power Plant for Agricultural Purposes

Comments to Organizer: The results of 24 years research and consulting are presented in this article.
Presentation Format: Oral
Paper Submitted by a Student: N
Paper Entered in Competition, if Appropriate: Y

First Author

Presenting
Esmaiel Malek
Self Employed
3853 Calliope Ave
Port Orange, FL 32129
Phone Number: 435-770-1253
Email: eemalek@gmail.com
* AMS Member

Second Author

Lynn Dudley
Department of Geological Science
Florida State University
600 W. College Ave
Tallahassee, FL 32306
Phone Number: (850) 644-3864
Fax Number: (850) 644-4214
Email: dudley@gly.fsu.edu