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# Soils, surficial geology, and geomicrobiology of saline-sodic wetlands, North Platte River Valley, Nebraska, USA

R.M. Joeckel[a,*], B.J. Ang Clement[b]

[a]Conservation and Survey Division, School of Natural Resources, Institute of Agriculture and Natural Resources, 102 Nebraska Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0517, USA
[b]Department of Biology, Lied Center for Science and Mathematics, Doane College, Crete, NE 68333-2496, USA

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**Abstract**

Saline-sodic wetlands along a 200-km stretch of the North Platte River Valley in western Nebraska, USA lie within an important agricultural region, but their processes, salt mineralogy, and geomicrobiology have not previously been investigated. Putative anthropogenic salinization has long been a concern, yet early historical accounts of widespread surface salts in the area have never been applied as comparative standards. Surface salts in the area originate from soil capillarity and surface evaporation. Thenardite ($Na_2SO_4$) and/or mirabilite ($NaSO_4 \cdot 10\ H_2O$) dominate, depending on ambient conditions. Bloedite ($Na_2Mg[SO_4]_2 \cdot 4[H_2O]$), halite (NaCl), burkeite ($Na_6CO_3[SO_4]_2$), and calcite ($CaCO_3$) are minor constituents. Historical accounts indicate that salts accumulated naturally long before Euramerican settlement, apparently as a result of rock–water interaction in nearby volcaniclastic sediments of the Brule Formation.

Ephemeral to permanent water-holding basins in the wetlands contain $Na^+$-rich waters that vary widely in electrical conductivity (as high as 159 mS/cm) and in ionic composition, but local spring waters are extremely dilute. Basin floors exhibit a unique type of microrelief, which appears to form by the filling of microlows with water and the dispersal of soil material therein by $Na^+$, followed by dewatering and collapse of the soil with drying. Illite dominates basin surface soils, but smectite dominates at depth; high soil pH, available $K^+$, and frequent wetting–drying cycles in the wetlands suggest that in-situ illitization may have occurred. Soil crusts and vesicular surface horizons are common as are upward increases in electrical conductivity. The activity of sulfate-reducing microbes

* Corresponding author. Tel.: +1 402 427 7520; fax: +1 402 472 4608.
*E-mail address:* rjoeckel3@unl.edu (R.M. Joeckel).

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forms prominent near-surface horizons of sulfate reduction in saturated soils, which retract or disappear entirely during dry episodes.

Saline-sodic wetland soils in the study area change on daily to seasonal scales. Cycles of surface salt development, microbial activity, and microrelief genesis are all controlled by regular wetting–drying cycles and the interaction of ponded surface waters and shallow groundwaters. Relatively unique aspects of microbial ecology and surface processes make the soils important as "geomicrobial reactors" wherein important parts of hydrological and geochemical cycles occur.


*Keywords:* Wetlands; Soils; Soluble salts; Sulfates; Thenardite; Sulfate-reducing microbes

## 1. Introduction

The North Platte River Valley (NPV) of western Nebraska (Fig. 1) is a very important agricultural region within a region of moderate (~355–405 mm) average annual rainfall, high evapotranspiration, hot summers, and cold winters (Yost et al., 1968; Helzer et al., 1985; Manley, 1993; Vanek et al., 1994; Tangborn, 1996). It is also one of the easternmost sites of saline basins in the western interior of the USA (cf. Joeckel and Ang Clement, 1999). Although soil salts have been studied systematically elsewhere on America's Great Plains (e.g., Keller et al., 1986a,b; Timpson et al., 1986a), similar phenomena in Nebraska have not received the same attention. Our research seeks to identify the mineralogy of NPV salts, determine their processes of formation, characterize the smaller-scale soil landscapes on which they occur, and identify comparatively unique microbial populations in near-surface environments. Observations made in the course of the study reveal that NPV saline-sodic soils, although being of little agricultural value, are pedologically significant because they are dynamic and have a set of comparatively unique features that distinguish them from surrounding soils.

Simultaneously, the issue of natural vs. anthropogenic origins of soil salinity in the NPV warrants investigation. Post-intensive-agriculture (i.e., 1880 to present) anthropogenic effects have sometimes been emphasized over pre-existing natural conditions as causative factors of salt accumulation in the NPV, particularly because irrigation appeared and intensified dramatically after permanent Euramerican settlement. This emphasis is predictable considering the mounting problem of anthropogenic salinization in agricultural lands worldwide. Nonetheless, numerous firsthand accounts of the NPV dated prior to 1866 provide defensible means for testing this hypothesis and making a basic distinction between "natural" and anthropogenic aspects, especially in conjunction with our geological and pedological information.

## 2. Materials and methods

### 2.1. Study sites

The main study site is Facus Springs Wildlife Management Area and environs (FS: Figs. 1–3). "Facus Springs" refers to a famous 19th century watering stop (Mattes, 1969)