Can Land Utilization of Swine Effluent Pose a Soil Sodicity Hazard?

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Introduction

Swine effluent has generally been considered for application on agricultural land as a fertilizer. However, the effluent should also be evaluated from a salinity, sodicity, and specific ion hazard perspective. Current application guidelines for effluent are based on its fertilizer value. It must also be recognized that effluent may contain other constituents that pose potential concern when applied. For example, an excess of sodium dissolved in soil solutions relative to the total electrolyte concentration can cause surface-crusting of seedbeds, deteriorate root-zone permeability of water and air, impact germination and seedling root development, and impair internal drainage in many Saskatchewan soils. Current guidelines suggest that irrigation waters with sodium adsorption ratio (SAR) values greater than 5 $(mmol_c/L)^{0.5}$ and solution electrical conductivities (EC_s) less than 1 dS/m may create a soil sodicity problem. As the EC_s increases to 2.5 dS/m, the "safe" SAR increases to 10 $(mmol_c/L)^{0.5}$. This latter SAR value also sets the upper limit above which such waters are unsuitable or require soil monitoring for irrigation.

The use of saline ground or surface waters in hog operations can definitely increase the sodicity potential. One mid-size hog-farm in southwestern Saskatchewan, drawing sodic ground water, creates swine effluent with SAR values ranging from 19 to 28 $(mmol_c/L)^{0.5}$ and ECs from 11 to 16 dS/m (Tables 1). There is a need to determine 'safe' concentrations and total loadings (Table 2) for land injections of swine effluent on different Saskatchewan soils; to suggest suitable methods of land application; to direct the frequency and the best time of year for application; to identify specific hazards for specific soils and specific landscapes; to quantify capacities for soils under different land uses (e.g. fallow, annual cereals, perennial hay, pasture); and to implement monitoring techniques to safeguard Saskatchewan's soil resources. In short, when and under what conditions can land utilization of swine effluent pose a soil sodicity hazard?

Table 1. Analyses of Locations A, B & C hog effluent, and Locations D, E, F, G & H deep well water samples used in hog operations in southwestern Saskatchewan and derived from the Judith River Formation over ten years.

Location	T.D.S. (ppm)	pH	EC (dS/m)	Na^{+} (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	K^{+} (mg/l)	SAR. $(mmol_c/L)^{0.5}$
A	10048	8.5	15.7	1248	84	150	1083	18.9
B	7488	8.3	11.7	1006	77	14	1096	27.6
C	9088	6.1	14.2	646	206	44	772	10.7
D	1805	8.3	2.8	648	8	4	2	46.6
E	2522	7.5	3.9	918	28	10	6	37.9
F	2605	7.5	4.1	907	30	10	6	36.6
G	1709	7.6	2.7	654	5	2	4	62.3
H	1696	7.8	2.6	595	7	2	4	51.2

Table 2. Impact loading of ionic constituents added per hectare using SAR 18.9 hog effluent from Location A and applied in increasing volumes.

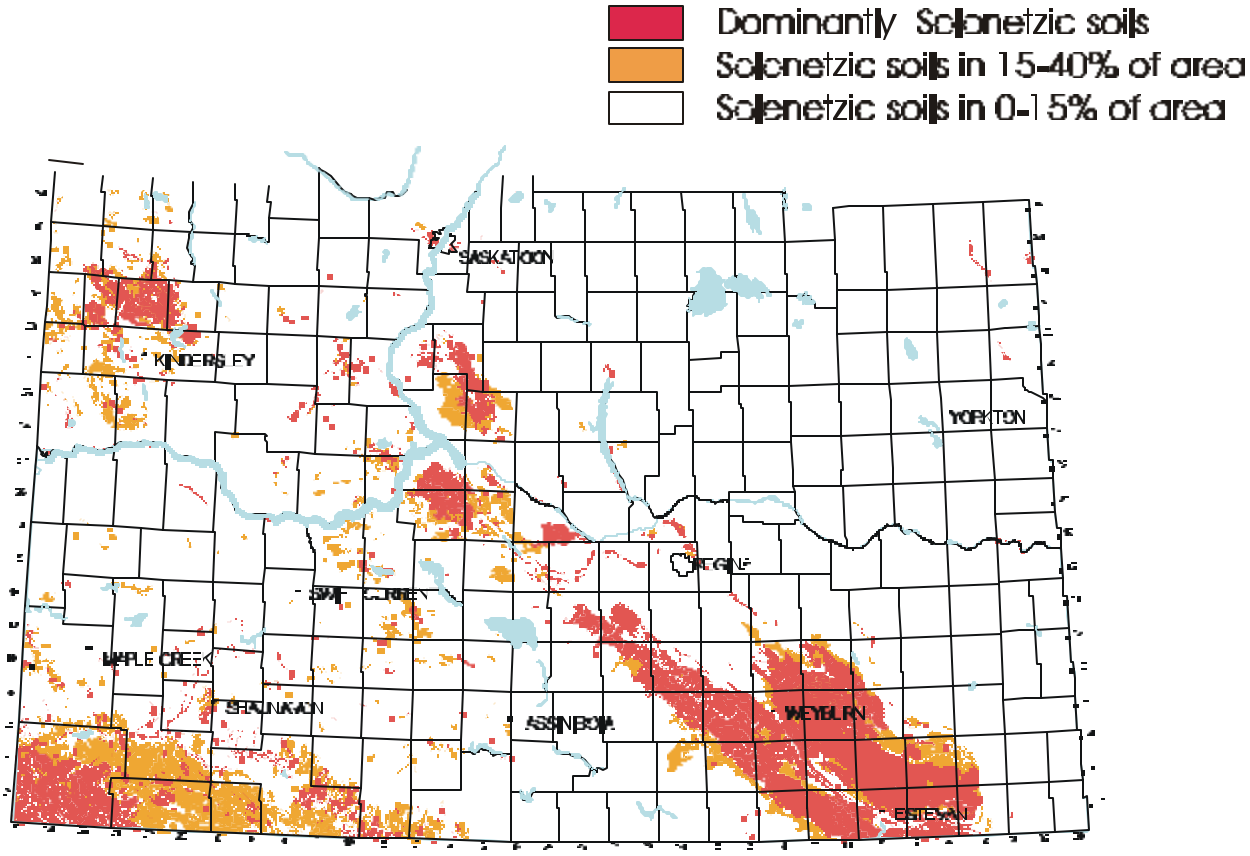
Volume (1000 gal/acre)	Na^{+} (g/ha)	Ca^{++} (g/ha)	Mg^{++} (g/ha)
3	42,019	2,828	5,050
6	84,038	5,656	10,101
9	126,057	8,485	15,151
12	168,076	11,312	20,201
15	210,095	14,141	25,252
18	252,113	16,969	30,302
21	294,132	19,797	35,352

First Concern: The Primary Receiver, "Landscape and Soils"

A major concern relates to the mixed soil associations found throughout southern Saskatchewan landscapes (Map). Soil surveys have documented the existence of solonetzic soils 1 to

30 ha in size interspersed within chernozemic-dominated fields (Table 3). When effluents with SARs of 10 $(mmol_c/L)^{0.5}$ or greater are injected into solonetzic soils, what consequences can be expected?

Distribution of Solonetzic Soils in Southern Saskatchewan



This map depicts areas where solonetzic soils comprise a significant (>15%) portion of the landscape. Solonetzic soils may occur sporadically in small amounts even in those areas mapped as having less than 15% of the area occupied by solonetzic soils. These soils have formed under the influence of Sodium salts and may represent an added susceptibility to further damage by sodium applied via high sodium effluent.

Second Concern: Concentrations at the Soil Delivery Point

Land disposal of swine effluent typically utilizes a range of equipment from irrigation sprinklers and guns, to surface broadcast, to fluid soil injectors connected to an adjacent effluent-supply vessel or pressurized pipeline. Injection implements often leave deep bands of concentrated hog effluent just beneath the soil surface spaced according to the spacing of the openers. Such band spacings usually range between 30 to 75 cm. Consequently, the land is left with parallel bands where the soil solution has assumed the character of the hog effluent. If the effluent is rich in sodium and shows excessive

SAR-values, so will the soil solutions within the bands. Will the soil impacted by the bands leach and disperse? Will soil test core sampling miss these hot bands giving incorrectly low sodicity levels? Can semiarid precipitation dependably dilute the effluent-bands sufficiently to avoid local soil sodicity problems?

Table 3. Typical Exchangeable Cation Composition and Sodium Adsorption Ratio for Solonetzic and Chernozemic Soils of South Western Saskatchewan.

Echo Brown Solodized Solonetz

		mmol (+) kg^{-1}						
Horizon	Depth (cm)	CEC	ExCa	ExMg	ExNa	ExK	ESP	SAR
Ahe	0 - 5	134.4	52.0	32.5	3.9	6.2	2.90	4.30
Ae	5 - 11	110.9	48.0	26.8	9.1	3.2	8.21	8.10
Bnt	11 - 26	183.5	78.0	65.8	26.6	3.4	14.50	10.10
Csk	26 - 100	225.5	150.3	118.5	32.6	9.4	14.45	10.00

Frontier Orthic Brown Chernozem

		mmol (+) kg^{-1}						
Horizon	Depth (cm)	CEC	ExCa	ExMg	ExNa	ExK	ESP	SAR
Ah	0 - 10	202.9	125.0	53.6	0.6	13.5	0.29	0.40
Bm	10 - 18	225.8	149.0	57.7	0.4	11.3	0.18	0.40
Cca	18 - 58	167.6	143.0	86.7	5.3	7.7	3.16	2.70
Cksa	58 - 100	227.5	139.0	149.3	21.9	11.6	9.63	7.40

The table above indicates typical exchangeable cation characteristics of solonetzic (Echo) and chernozemic (Frontier) soils of south western Saskatchewan. Solonetzic soils have an elevated level of exchangeable Na+ as compared to the Chernozemic soils which results in clay dispersion in the upper soil zones leading to poor water infiltration and crusting problems. Additionally a hard, clayey Bnt horizon further restricts moisture infiltration and root development. An increased level of Na+ in both the solonetzic and chernozemic soils can lead to management problems.

Third Concern: Soil Crusting

Effluent-treated land may also develop soil surface crusting problems. If the effluent-dominated soil solutions rich in sodium permeate seedbeds, either from unsaturated flows or mechanical

movement, they impart vulnerability for soil surfaces to deflocculate and form hard crusts. Precipitation, especially that falling as drop-impacting rain, enhances the process by diluting electrolyte concentrations which encourage sodification and surface crusting. Crop diversification and rotational limitation impact future economic choices. Small-seed crops, such as alfalfa, canola, flax, mustard, etc. often do not emerge because of surface crusting.

Fourth Concern: Benchmark Soil Sampling

Detailed salinity analysis to depth on the recipient lands is the responsibility of each landowner. Operations practising due diligence should be advised to document existing soil conditions prior to commencement of manure application. This information, not only forms a baseline with which to compare, but also serves to delineate areas that may be at greater risk in receiving effluent and therefore may be unsuitable as an area for manure utilization.

Fifth Concern: Benchmark Groundwater Sampling

Groundwater monitoring of the areas receiving manure is also the responsibility of every landowner. The potential for contamination is relatively low if effluent application volumes are based on nutrient uptake. Anytime an excess is applied the potential exists for a portion to affect the groundwater system. Naturally, application on coarse textured soils overlying shallow water tables will have the greatest potential for impact.

Understanding a Resource Hazard, "Where do we go from here?"

As land stewards and owners, it is in our best interest to take the necessary steps to see that the utilization of manure will be a positive experience. In agriculture today, environmental responsibility realized through stewardship sustains profitability.

As swine development proponents, it should be a goal, particularly if we plan to at some point in time "sell" hog effluent for some portion of its value, to see that those who utilize our product are satisfied with all it's properties.

As professionals, we must foster research and make both the operator and recipient aware of all the known implications in regard to this practice. The utilization of effluent can not be solely based on nutrient content. An allowance for the potential impacts, both positive and negative, must also be weighed. Detailed background information on receiving sites is only the beginning. The ongoing monitoring and the diligent following of an application plan is paramount for successful utilization of saline effluent. **It costs a little extra to manage sodicity, or it costs a lot (for a long time) to cure sodicity.** Experienced Professional Agrologists, Hydrogeologists, and Soil Chemists can design, monitor and recommend sound practises to utilize saline effluent.

Research opportunities exist today on current sodicity hazards areas from a decade or more of loading with Saskatchewan hog effluent.