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Mathematical Modeling Of Salinity Of Drainage Water

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Abstract: Salinity of the drainage water percolating below the root zone is discussed, for this first we have discussed leaching fraction and salinity of irrigation of water, using these terms, we have calculated Salinity of the drainage water percolating below the root zone.

1. Introduction: In the Planning and implementation of wastewater reclamation and reuse, the reuse application will usually govern the wastewater treatment needed and the degree of reliability required for the treatment process and operations. Because wastewater reclamation entails the provision of continuous supply of water with consistent water quality, the reliability of the existing or proposed treatment processes and operations must be evaluated in the planning stage.

In this paper we present and discuss waste water reuse applications and to emphasize water quality requirements that protects the environment and mitigates health risk. The main reuse categories are (1) agricultural and landscape irrigation, (2) industrial applications, (3) ground water recharge and (4) potable reuse. Here we present only agricultural and landscape irrigation and using this term we estimate salinity of drainage water percolating below the root zone.

The irrigation of crop developed along with the settlement of the arid because irrigation was needed to raise crop. In humid part, irrigation is used to supplement natural rainfall, to increase the number of plantings per year and the yield of crops, and reduce the risk of crop failure during drought periods. Irrigation is now also used to maintain recreational land such as parks and golf courses. The irrigation of landscape areas golf courses in the urban environment has become an important use of reclaimed wastewater in the recent years.

2. Drainage Water Quality Modeling: The quality of irrigation water is of the particular importance in arid zones where extremes of temperature and low humidity result in high rate of evapotranspiration. Evapotranspiration refers to water lost through evaporation from the soil and water bodies and transpiration from plants. Water used for irrigation can vary greatly in quality depending upon the type and quality of dissolved salts. The consequence of evapotranspiration is salt deposition from applied water, which tends to accumulate in the soil profile. The physical and mechanical properties of the soil, such as degree of dispersion of the soil particles, stability of aggregates, soil structure and permeability, are sensitive to the types of exchangeable ion present in irrigation water. Thus, when irrigation with reclaimed wastewater is being planned, crop yield and soil properties must both be taken into consideration. The problems however are no different from those caused by salinity or trace elements in any water supply and are of concern only restrict use of water or require special management to maintain acceptable crop yields.

A number of different irrigation water quality guidelines have been proposed. The guidelines were developed by the University Of California Committee Of Consultants and were subsequently explained by Ayers and Westcot. The long term influence of water quality on crop production, soil conditions, and farm management is emphasized, and guidelines are applicable to both freshwater and reclaimed wastewater. We are presenting salinity out of four categories of potential management problems associated with water quality are (1) salinity, (2) specific ion toxicity, (3) water infiltration rate and (4) miscellaneous problems.

2.1. Salinity: Salinity of irrigation water is determined by measuring its electrical conductivity and is the most important parameter in determining the suitability of water for irrigation. The electrical conductivity (EC) of water is used as surrogate measure of total dissolved solids (TDS) concentration. The electrical conductivity is expressed as mmho/cm or decisiemens per meter (dS/m). Where one mmho/cm is equivalent to one dS/m. Value of salinity is also reported as TDS in mg/L. For most agriculture irrigation purpose, the value of EC and TDS are directly related and convertible with an accuracy of about 10 percent. The following equation can be used to convert EC values to TDS values.

$$TDS\ (mg/L) \approx EC\ (\text{mmho/cm or (dS/m)}) \times 640 \qquad (2.1.1)$$

The presence of salt affects plant growth in three ways (1) osmotic effects, caused by the total dissolved salt concentration in the soil water; (2) specific ion toxicity, caused by the concentration of individual ion; and (3) soil particle dispersion caused by high sodium and low salinity. With increasing soil salinity in the root zone, plants expend more of their available energy on adjusting the salt concentration within the tissue (osmotic adjustment) to obtain needed water from the soil. Consequently, less energy is available for plant growth.

In irrigated areas, salts originate from the local groundwater or from salts in the applied irrigation water. Salts tend to concentrate in the root zone owing to evapotranspiration and plant damage is tied closely to an increase in soil salinity. Establishing a net downward flux of water and salt through the root zone is the only practical way to manage a salinity problem. Under such conditions, good drainage is essential to allow a continuous movement of water and salt below the root zone. Long term use of reclaimed wastewater for irrigation is not possible without adequate drainage.

2.2. Leaching Fraction: If more water is applied than the plant use, the excess water will percolate below the root zone, carrying with it a portion of the accumulated salts. Consequently, the soil salinity will reach some constant value dependent on the leaching fraction. The fraction of applied water that passes through the entire rooting depth and percolates below is called the leaching fraction (LF).

$$LF = \frac{D_d}{D_i} = \frac{D_i - ET_c}{D_i} \qquad (2.2.1)$$

Where

LF = leaching fraction

D_d = depth of water leached below the root zone, inches

D_i = depth of water applied at the surface, inches

ET_c = crop evapotranspiration, inches

A high leaching fraction results in less salt accumulation in the root zone. If the salinity of irrigation water (EC_w) and the leaching fraction are known, salinity of drainage water that percolates below the rooting depth can be estimated using following equation

$$EC_{dw} = \frac{EC_w}{LF}, \qquad (2.2.2)$$

Where EC_{dw} = salinity of drainage water percolating below the root zone

EC_w = salinity of irrigation water

A crop is irrigated with reclaimed wastewater whose salinity measured by electrical conductivity is 1.0 dS/m. If the crop is irrigated to achieve a leaching fraction 0f of 0.14 (that is 86 percent of the applied water is used by the crop or lost through evapotranspiration and the crop is known to suffer significant loss in yield when TDS of the soil water exceeds 5000 mg/L, we get

$$EC_{dw} = \frac{EC_w}{LF} = \frac{1.0}{0.14} = 7.15 dS/m,$$

$$TDS\ (mg/L) \approx EC\ \text{(mmho/cm or (dS/m)} \times 640 = 7.15 \times 640 = 4576 mg/L$$

And

$$LF = \frac{EC_w}{EC_{dw}} = \frac{1.0 \times 640}{5000} = 0.13$$

Thus, to prevent loss in yield, 13 percent of the applied water will be needed to carry salts below root zone and 87 percent will be consumed by evapotranspiration.

Conclusion: The EC_{dw} value can be used to assess the potential effects on crop yield and on groundwater. For salinity management, it is often assumed that EC_{dw} is equal to the salinity of the saturation extract of the soil sampleEC_e. This assumption is conservative, however, in that EC_{dw} occurs at the soil water potentials of field capacity and EC_e occurs at a potential of zero, by definition, at laboratory condition. For a quick check, the value of EC_{dw}can be estimated as twice the value of EC_e for most soils.

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