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DRYLAND SALINITY AND IRRIGATION WATER QUALITY

BY

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Abstract. Soil salinity represents a factor that must be taken into account to characterize the conditions of plants development. In this context, the research presented in this work reveal a number of issues regarding: the conceptual of dryland salinity (causes, impact, remedial actions and crop salt tolerance), irrigation water quality and its influence on the regime of saline soils, such as the irrigation systems supplied from the Siret and Buzău rivers.

Key words: soil; dryland salinity; electrical conductivity; irrigation; root zone salinity.

1. Causes of Dryland Salinity

Dryland salinity occurs where removal or loss of native vegetation, and its replacement with crops and pastures that have shallower roots. This results in more water reaching the groundwater system. The groundwater rises to near the surface in low-lying areas. It carries dissolved salts from the soil and bedrock material through which it travels. As saline groundwater comes close to the soil surface (within 2 m), salt enters the plant root zone. Even where the groundwater does not bring much salt with it, the water logging of the plant root zone alone can damage or kill vegetation.

2. The Impact of Dryland Salinity

Dryland salinity has many environmental, economic and social impacts [1],…,[3], [9], [10]. The costs associated with salinity are potentially enormous and are borne not only by the rural community, but also ultimately by the whole country and its environment. The effects of dryland salinity may impact on: 1° agriculture, 2° water quality, 3° public infrastructure and urban households, 4° biodiversity and the environment.

1° *Agricultural impacts*. The impacts of dryland salinity on soil have adversely affected agriculture. The consequences include

a) Significant losses of productivity in agriculture, with some land entirely out of production. With increasing soil salinity, plants always find it more difficult to extract water from the altered soils. Most normal crop and pasture plants are not highly salt-tolerant and will eventually die out under saline conditions.

b) Damaged soil structure and increasing content of toxic substances that may be limiting to plant growth.

c) More serious soil erosion, both by wind and by water, due to worsening soil structure and reducing vegetation cover.

2° *Impacts on water usage.* Dryland salinity may increase salt concentrations in streams and rivers, and has a significant impact on a wide range of uses, including:

a) Declining suitability for drinking by humans and livestock, and for irrigation.

b) Increasing costs for water treatment.

c) Corroding water pipes, concrete channels, similar infrastructure, and of various machines and household appliances.

d) Affecting industrial and domestic uses such as washing and food processing.

3° *Impacts on public infrastructure, buildings and houses.* Dryland salinity also affects rural towns. Apart from land clearing, salinity there is partly caused by human activities such as over watering of gardens and sports grounds. It has potential effects on infrastructure, buildings and domestic houses. The impacts include

a) Damage to houses, buildings and other structures caused by the deterioration of brick, mortar and concrete due to saline water crystallizing in brickwork.

b) Corrosion of metal buried in the ground or set in structural concrete may also occur.

c) Shifting or sinking of foundations may result in structural cracking, damage or collapse. Damage to heritage buildings may be of particular concern and land values may be degraded by salinity.

d) Salt damage to roads and highways includes the breakdown of concrete, bitumen and asphalt with associated pot holing, cracking and crumbling of the road base.

e) Damage to underground pipes, cables and other infrastructure due to the breakdown of unprotected metal, cement and other materials.

f) Loss of amenity in recreational areas such as gardens and sports fields due to the appearance of bare, exposed patches where grass and other plants cannot grow.

g) Failure of septic tanks caused by high water tables. This often leads to other environmental and health problems.

4° *Impacts on biodiversity and the environment.* Rising water tables and increasing salinity have serious impacts on native vegetation, in the same way as they do for crops and pastures. Remnant vegetation may be threatened and with this, a variety of animal species and their habitats.

3. Remedial Actions

Remedial actions can be preventive and aimed at eventually stopping further loss of resource (land and/or water) to salinity, or ameliorative and attempt to reclaim the resource. Preventive measures aim to stabilize the depth to the water table, while for amelioration there must be a lowering of the water table.

The remediation strategies can be split into two broad themes: (i) an agronomic approach and (ii) an engineering approach. The agronomic approach relies on reducing the amount of recharge to a level commensurable with, or less than the discharge (a causal approach). Engineering solutions rely on the ability to cost effectively remove salt from the zone of interest and dispose of, or store, in a minimal impact way (a symptomatic approach).

(i) *Agronomic solutions* include

a) *Revegetation with woody perennials*. Trees and shrubs on recharge areas can reduce recharge, maintain or lower water tables and thus prevent or ameliorate salinity. However, unless there is: (α) an economic value (or an economic value can be assigned by society, for instance, in terms of carbon sequestration) in the trees or shrubs themselves and (β) a recognition of the spatial extent of the recharge zone and the magnitude of the reduction in the absolute amount of recharge, implementation on a broad scale is unlikely.

With plantings closer to, or on discharge areas, the range of species is limited to those that are salt tolerant and, with the exception of halophytes, their longevity is questionable.

b) *Perennial pastures*. Perennial pastures, such as lucerne, can control water table rise. The advantage of perennial pastures is that potentially they can be grown on large areas. The current economics of the animal industries predicate against widespread adoption. In high rainfall areas the effectiveness of this treatment is dubious.

c) *Phase cropping*. With the prospect of a significant proportion of cropping land being lost to salt (as high as 30% in some regions) the use of deep rooted perennials as part of a longer cropping rotation offers some opportunity for water table control.

d) *Productive use of saline land*. Salt tolerant shrubs (*e.g. Atriplex*) and grasses (*e.g. Puccinellia, Agropyron*) can grow well on saline land. They have been shown to lower water tables *in situ* and the limited leaching this allows permits the invasion or establishment of less salt tolerant species. The resulting species mix can be a productive fodder source. However, this type of treatment is only localized in terms of the extent of its applicability.

(ii) *Engineering options* include: drainage, aquifer pumping. Drainage (with drains to 1.5…2 m) and aquifer pumping can be effective at controlling water tables. The area of effect away from the drains or pump depends on the transmissive properties of the aquifer. Disposal of the effluent can present legal and environmental problems.

Integrated approach include catchments water management.

Rarely will a single treatment be sufficient or applicable, even within small catchments. In most cases the water balance of a catchment can only be manipulated by invoking a treatment or treatments appropriate to the land unit, its underlying hydrology and the major land use, and with due recognition of potential off-site impacts.

Technically salinity is reversible, with massive revegetation, drainage and pumping. However, in practice, and recognizing the need for farmers to continue to make a dollar, we contend that it is only reversible on a local scale. In large catchments the time constants for reversal are very long (hundreds of years) and there needs to accept that what is now saline will remain saline. Thus the aim must be to reduce the rate of spread and learn to live with salinity by getting production from the saline land and the saline water – salt land agronomy.

4. Crop Salt Tolerance

Crop salt tolerance also needs to be taken into account when assessing the suitability of water and soil for irrigation [4],..,[6]. The salt content of the soil water in the crop's root zone, referred to as the average root zone salinity (EC_{se}), is important in assessing which crops are suitable for growing in particular soils.

The average EC_{se} can be calculated using the measured EC_i of irrigation water [8]. This requires estimation of the average root zone leaching fraction (LF) of the soil under irrigation, *i.e.* the proportion of applied water moving below the root zone. This is shown in Fig. 1.

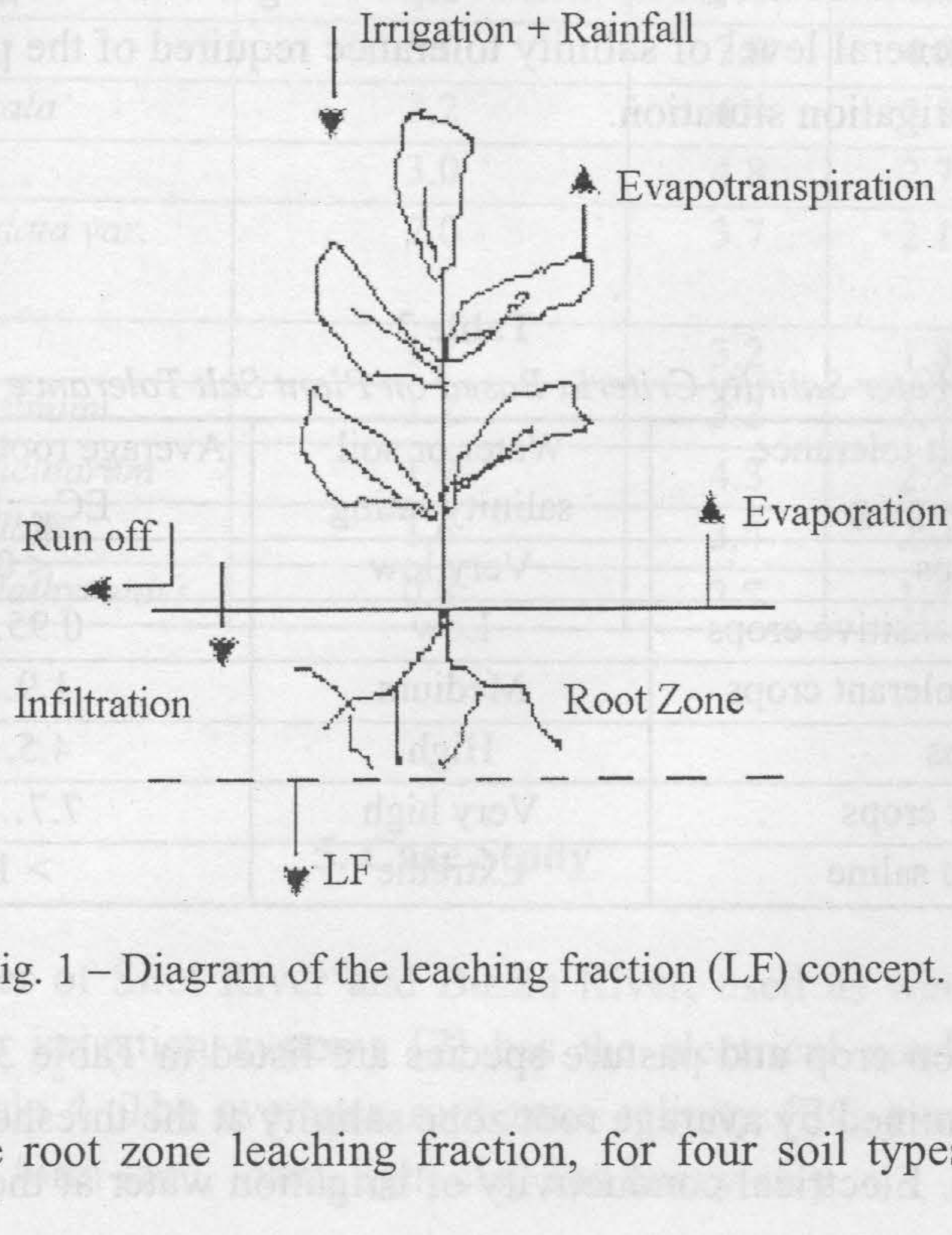

Fig. 1 – Diagram of the leaching fraction (LF) concept.

Average root zone leaching fraction, for four soil types, are listed in Table 1.

Table 1
Soil Type and Average Root Zone Leaching Fraction

Soil type	Average root zone leaching fraction (LF)
Sand	0.6
Loam	0.33
Light clay	0.33
Heavy clay	0.2

Average root zone salinity can then be calculated using the following relation

$$EC_{se} = \frac{EC_i}{2.2LF}, \quad (1)$$

where: EC_{se} is average root zone salinity, [dS/m]; EC_i – electrical conductivity of irrigation water, [dS/m]; LF – average root zone leaching fraction.

The calculated EC_{se} can then compared against the EC_{se} values in Table 2 to asses the general level of salinity tolerance required of the preferred crop in the particular irrigation situation.

Table 2
Soil and Water Salinity Criteria Based on Plant Salt Tolerance Groupings

Plants salt tolerance grouping	Water or soil salinity rating	Average root zone salinity EC_{se}, [dS/m]
Sensitive crops	Very low	< 0.95
Moderately sensitive crops	Low	0.95…1.9
Moderately tolerant crops	Medium	1.9…4.5
Tolerant crops	High	4.5…7.7
Very tolerant crops	Very high	7.7…12.2
Generally too saline	Extreme	> 12.2

Common crop and pasture species are listed in Table 3 in order of salt tolerance determined by average root zone salinity at the threshold level causing yield reduction. Electrical conductivity of irrigation water at the threshold level for a range of soil types is also shown and can be used as a general guide for selecting suitable crops for the particular irrigation situation.

Table 3

Tolerance of Plants to Salinity in Irrigation (Field Crops)

Scientific name	EC_{se} average root zone salinity threshold for yield reduction, [dS/m]	EC_i threshold for yield reduction for crops growing, [dS/m]		
		Sand	Loam	Clay
Sorghum almun	8.3	11.6	6.6	3.9
Hordeum vulgare	8.0	12.6	7.2	4.2
Gossypium hirsutum	7.7	12.1	6.9	4.0
Beta vulgaris	7.0	11.0	6.3	3.7
Sorghum bicolor	6.8	9.4	5.3	3.1
Carthamus tinctorius	6.5	8.2	4.7	2.7
Triticum aestivum	6.0	9.4	5.3	3.1
Triticum turgidum	5.7	9.6	5.5	3.2
Helianthus annual app.	5.5	7.5	4.3	2.5
Avena sativa	5.0	7.0	4.0	2.3
Glycine max	5.0	7.0	4.0	2.3
Arachis hypogala	3.2	4.4	2.5	1.5
Oryza sativa	3.0	4.8	2.7	1.6
Vigna unguiculata var. Caloona	2.0	3.7	2.1	1.2
Zea mays	1.7	3.2	1.8	1.1
Vinum usitatissimum	1.7	3.2	1.8	1.1
Saccharum officinarum	1.7	4.3	2.5	1.4
Vigna uncuiculata	1.6	3.4	2.0	1.1
Macroptilium lathyroides	0.8	2.7	1.5	0.9

5. Case Study

The water of Siret River and Buzău River, used as water sources for eastern Romania irrigation systems [7] has the electrical conductivity (EC_i) presented in Table 4. The averages root zone salinity (EC_{se}) were calculated with relation (1), form sand, loam, light clay and heavy clay.

Table 4
The Averages of EC_i and EC_{se}

River	EC_i, [dS/m]	EC_{se}, [dS/m]			
		Sand	Loam	Light clay	Heavy clay
Siret	1.30	0.98	1.79	1.79	2,95
Buzău	2.03	1.53	2.79	2.79	4,61
Plants salt tolerance grouping		Moderately sensitive crops	Moderately tolerant crops	Moderately tolerant crops	Moderately tolerant crops

6. Conclusions

A detailed knowing of the soil salinity, of the quality of irrigation water and the of the salinity tolerance in plants represents a very important component of management of irrigated lands.

Dryland salinity has many environmental, economic and social impacts. The remediation strategies can be split into two broad themes: an agronomic approach and an engineering approach.

Supplementing the volume of water in the soil by irrigation can lead to changes in the soil salinity, making it saline or alkaline if management is inadequate. Therefore, control of irrigation water quality, especially in arid areas, is a mandatory requirement.

Where there is uncertainty regarding the effect of irrigation water quality on soil structure stability or crop salt tolerance, it is recommended that soil samples from the surface and subsoil of representative profiles of the soil under irrigation be submitted for laboratory analysis.

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DESALINIZAREA TERENULUI ŞI CALITATEA APEI DE IRIGAŢIE

(Rezumat)

Salinizarea solului constituie un factor de care trebuie să se ţină seama la caracterizarea condiţiilor de dezvoltare a plantelor. În acest context, cercetările prezentate în lucrare se referă la o serie de aspecte ca: desalinizarea terenului (cauze ale salinizării, impact, acţiuni de remediere, toleranţa culturilor la săruri) calitatea apei de irigaţie şi influenţa sa asupra regimului salin al solului, cu exemplificare pentru sistemele de irigaţie alimentate din râurile Siret şi Buzău.