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# Behavior of the Electric Conductivity in two Series of floor of the sector Caño San Miguel, Mara municipality, state Zulia state during a two year-old period

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## Abstract

The study was carried out in soils with salinity problems, located in the influence area of *Caño San Miguel, Mara* Municipality, *Zulia* state, with a continental subequatorial climate, very dry tropical forest. The evolution of the electric conductivity (CE) was studied in two soil series of agricultural importance in the area, during a two-year-period (97-.99). The series, *Caño San Miguel* (L1-3) and *El Derrote*, were selected based on their agricultural development, with three and two salinity levels, respectively. In order to measure electric conductivity (CE), 120 samples where taken at different depths into the soil. A factorial nested design totally at random with six repetitions was applied. Results evidence a significant decrease (P<0,01) in the electric conductivity for both series, mainly caused by salts lixiviation, as a consequence of the high precipitations registered in the period of study. The salinity level increased to more depth into the soil profile.
**Key words:** soil series, salinity, electrical conductivity, leaching

## Introduction

The integration of new lands for agricultural and livestock production, has made soils, in many cases, less productive as a result of a bad management of the resource. This situation brought along many problems such as, soils erosion, loss of soil structure, soil compaction and salinity. This last one is the most important because 30% of soils around the world are affected (9).

The benefits obtained from the frequent irrigation agriculture haven't been sustainable because of salinization of soils, denominating the ones that are not able for most crops as a consequence of salts more soluble than gypsum, with interchangeable sodium or both (15).

In this sense, affected soils are classified and defined as followed: 1)

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salty soils or potentially salty (CE>2 mmhos.cm$^{-1}$; PSI<15), whose concentration, composition and distribution of salts in the profile, associated to climate conditions, drainage, available salts in water, introducing irrigation, cause or may cause problems in crops, 2) Saline-sodic soils or potentially saline-sodic (CE>2 mmhos.cm$^{-1}$, PSI>15), whose concentration, composition and distribution of salts, associated to conditions of drainage, climate and composition and concentration of salts in irrigation potentially waters, physical damage problems caused by accumulation of interchangeable sodium (8).

It also exist the saline-acid soils or potentially saline-acid, which preserving levels, types and location of salts, they also contain small quantities of soluble hydroAluminium, which provokes an acid reaction with pH under 5 (7).

Problems caused by the presence of salts and its quantity in soils are differents and depend on the geochemical processes that take part in salinization, whether primary (natural processes) or secondary (man's intervention) origin. In both cases, the responsible factors are the relative concentration and composition of salts in superficial and underground waters and the changes that may suffer the composition of soils as a consequence of climate, irrigation and drainage over the hydric system of soils. The main climate factors to consider are the rain and the evapotranspiration (11).

In Venezuela, salinity problems are more usual in arid and semiarid lands, specifically in *Maracaibo* lake basin, where a sprout is been observed as a result of an extension of the rural frontier and the introduction of irrigation, with the objective to have a constant production the whole year.

According to previous researches, the study zone is seriously damaged due to the great amount of salts in soils, to the low depression of the zone, to the presence of saline underground stratums and marshes in both sides of *Limon* River, which make more difficult the intern drainage and, in fact, do not have any natural way out. All these factors connected to the climate conditions of the zone and the use and management of soils, specifically excess of irrigation, contribute to the augmentation of the phreatic level making this problematic more pathetic (2, 3, 6, 4).

Observations on the area indicate the effects of the bad management of soils over patterns of use of lands, where initially undamaged soils with horticultural crops, have changed to bovine production (3, 14).

Considering the previous, it has been decided to perform this study in *Caño San Miguel*, to evaluate the behavior of electric conductivity of two types of soils from the agricultural development view and at the same time will show salinity problems, with the objective to bring out solutions and proposals for the area.

## Materials and methods

1. Study area characteristics.

1.1 Location and agroecologic conditions of the study area.

The study took place in Caño San Miguel, located in the Parish *Luis de Vicente*, *Mara* Municipality, *Zulia* State. It is placed at the southwest and southeast of *Carrasquero* town, to the right of *Limon* River. Geographically, it is located between the coordinates N-1215.000 and N-1223.000; E-179.500 and E-181.500, it has a surface of 3500ha approx., with an elevation of 10 msnm according to the alluvial plain and the high plateau (6).

It presents a subequatorial continental climate and dry tropical forest, according to the zones classification of Holdrige methodology (5). The lowest temperature is 23°C and the highest is 29°C; the average annual precipitation is generally between 500 and 1000 mm, which is two or three times lower than potential evapotranspiration (14).

In the zone of study, vegetation has been almost totally treated, so there are some sectors where vegetation is completely in balance with the environment. In secondary vegetation predominates spine species which is evidence of a dry pedoclimate.

2. Description of the study.

2.1 Selection of soil series.

Two types of soil with salinity problems are selected, series *Caño San Miguel* (L1-3) and series *El Derrote* (L1-4), according to the covered surface and its agricultural use. These 2 series of soil have the following characteristics: (14)

**Series: L1-3**

**Taxonomic classification:** Series *Caño San Miguel*, Ustifluventic Haplocambids, fine silty, mixed and isohypertermic.

**Location and Surface:** some sectors of *Caño San Miguel* and abandoned river beds. It covers an extension of 284.17 ha.

**Geomorphology:** it covers a geomorphologic position from the Holocene. It corresponds to a physiographic position of a bank with slope of about 0.5 to 1%, straight microrelief.

**General Characteristics of soil:** predominant textures: loamy-clay, silty and loamy-silty soils. Colors: when humid, dark yellowish brown, spotted grayish brown, weak at the last horizon; subangular, blockade structure, weak and moderated; consistence: firm, hard, adhesive and plastic; permeability: slow; neuter pH and smoothly alkaline at the last two horizons; organic carbon, medium in the first horizon, low to more depth into the soil profile; low phosphorus; moderated cationic interchange; high potassium in the first horizon and low in the rest; high calcium and magnesium; low carbonated calcium; medium sodium in the first horizon and very low in the rest of them.

**Series L1-4:**

**Taxonomic classification:** series El Derrote, Ustifluventic Haplocambids, loamy fine, mixed and isohypertermic.

**Location and surface:** located in the experimental station El Derrote, in Caño San Miguel and surroundings. It has an extension of 535.15 ha.

**Geomorphology:** it covers a geomorphologic position, from the Holocene. It corresponds to a physiographic position of a bank with slope of about 0.5 to 1%, straight microrelief.

**General characteristics of soil:** predominant textures: loamy and loamy-silty soils; colors: when humid, dark yellow, speckled yellowish brown; subangular, blockade structure, weak, medium; consistence: soft, fragile, adhesive and weakly plastic; moderated permeability; neuter pH; organic carbon, medium in the first horizon, low to more depth into the soil profile; low phosphorus; cationic interchange capacity: medium in the three first horizons and low in the rest of them; high potassium in the first horizon and low in the rest; high calcium; high magnesium in most of horizons, medium in the second and last horizon; saturation with high quantities; electric conductivity appears in the last horizon with 2.02 $dS.m^{-1}$ which indicates that highly receptive crops might be affected.

2.2 Samples location

To recollect the data was taken from the Planimara research samples location (15). Out of them, 6 were selected for each one of the salinity levels:

Series Caño San Miguel (L1-3): S0 (0 to 2 $dS.m^{-1}$), S2 (2 to 4 $dS.m^{-1}$) y S3 (4 to 8 $dS.m^{-1}$).

Series El Derrote (L1-4): S0 (0 to 2 $dS.m^{-1}$), S3 (4 to 8 $dS.m^{-1}$).

Samples were indicated in aerial photographs from the year 1997, later on, were moved to a plan at a scale of 1:10.000. Once all the samples were showed on the plan, the zones were explored to locate them in the field.

2.3 Assortment, process and analysis of samples

Samples were selected in 1999, from the previous research (1997) by Planimara; at four depths: 0 to 30 cm; 30 to 60 cm; 60 to 90 cm y 90 to 120 cm, they were taken with a Perrin blasthole and dried for 7 days at room temperature, they were sieved and then it was determined the electrical conductivity (CE), following a methodology recommended by the salinity lab of Riverside (5, 17).

3. Statistical analysis of the experimental information

It was based on a model of a factorial nested design, under an experimental design totally at random with six repetitions, where it was evaluated: factor series with two types (L1-3 and L1-4). In series L1-3 three levels of salinity were studied (S0, S2, S3) and in series L1-4 two levels were studied (S0, S3). For season factor two samples were considered, one in year 1997 and the other one in 1999, besides, factor depth with four levels: 0 a 30cm, 30 a 60cm, 60 a 90cm y 90 a 120cm. The statistical program to evaluate data was Statistical Analysis System (SAS) version 8.1, PROC GLM was applied; LSMEANS was used to compare means.

## Results and discussion

Effect of season factor over soils' salinity

The CE was significantly diminished (P<0.01) during the period of evaluation (figure 1). The decreased on this variable from 1.57 dS.m$^{-1}$ in 1997 to 0.77 dS.m$^{-1}$ in 1999, might be caused by salts cleanings or movements, as a consequence of precipitation of the study zone (figure 2). In fact, in 1997, the annual average precipitation was 525.4 mm, in 1998 was 925.6 mm and in 1999 was tripled, 1595.1 mm, atypical for the zone; even though, it is important to mention that similar quantities of precipitation has been observed in four occasions in 20 years, this situation shows that, maybe, in this zone happen natural cleaning cycles of salts on soils as an effect of precipitation.

About this, several authors have pointed out that precipitation was excellent to clean salts form soils, due to it low content of salts. The efficiency of torrential rains was that they were not completely eliminated; besides, the great drainage on this soil (16, 18, 19).

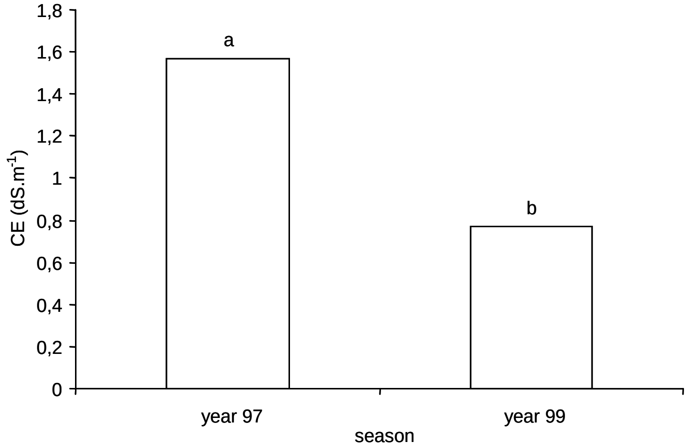
In this sense, differences of 400.2 mm from year 97 to year 98 and 659.5 mm from year 98 to 99, combined to the geomorphologic position, with well drained soils of loamy, silty-loamy-clay and loamy-silty textures, suggest that a cleaning or vertical movement of salts happened due to precipitation. On the other hand, it is very important to consider that, if the zone has been affected by floods during normal precipitation periods, in the years 98 and 99, when precipitations increased, this phenomenon was intensified; getting even in the high zones, which could have been positive for the horizontal and vertical cleaning of salts (1).

Similar situations were reported in *Marismas del Guadalquivir*, Spain, where cleaning salts effect was evaluated due to precipitations since the year 1959 to 1964, where rainfalls reached 4140.5 mm ha$^{-1}$ and the quantity of extracted salts in that period was of about 263.42 kg ha$^{-1}$ (10). In this sense, some researches show that in Israel, precipitations are required to carry out this salts cleaning and even with 200 to 300 mm of rainfall is possible (16). In the same way, in Quibor, Lara state, precipitation would be enough to clean soils but hydraulic conductivity would have to be improved.

Precipitation had its influence in salts cleaning, since practice of leaving lands resting for a period in arid zones caused salts movements, recovering soils in 2 or 3 years (18). This situation coincides with the obtained results in salinity evolution during the study period.

Depth effect over soil salinity

As deeper into this profile, electrical conductivity was higher (figure 3), as a consequence of the cleaning or movements of salts caused by precipitation. A similar behavior was evidenced in a typic haplustert, in *Aragua* state, Venezuela, where CE was around 2 dS.m$^{-1}$ until 40 cm deep, then augmenting to 4.5 to 4.6 dS.m$^{-1}$




Colums with different letters are statsitically differents (P<0.05)

**Figure 1. Season effect on the electrical conductivity (CE) in soils of San Miguel drain.**

in 100 cm deep, because of rainfalls and irrigation (18).

The temporal variability of salinity may come out studying saline profiles in different seasons, since precipitation caused a descending flow of water and join to this, a cleaning of salts (15). Quite the opposite, in a soil in *Lalueza* (*Huesca*), it was observed that in the first 10 cm deep, had a salinity ten times higher in May than at the end of October after the autumnal rains, when the CE was around 6 dS.m$^{-1}$ at 25°C until the 60 cm, where it began to increase; a similar behavior was observed in the profiles of this study.

In salts dynamics of saline-sodic-

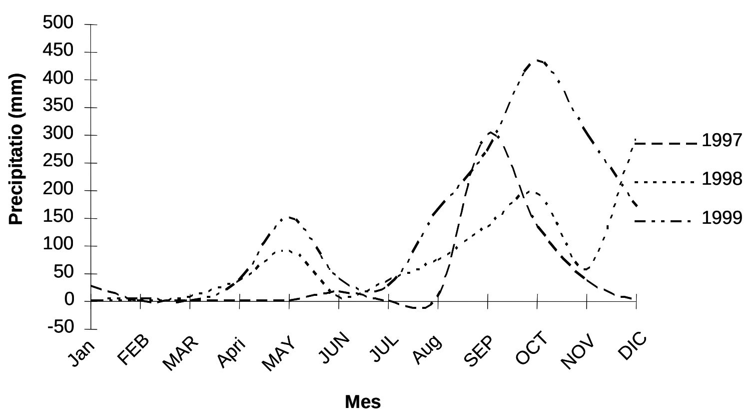



**Figure 2. Annual distribution of the precipitation in San Miguel drain during 1997, 1998 and 1999.**

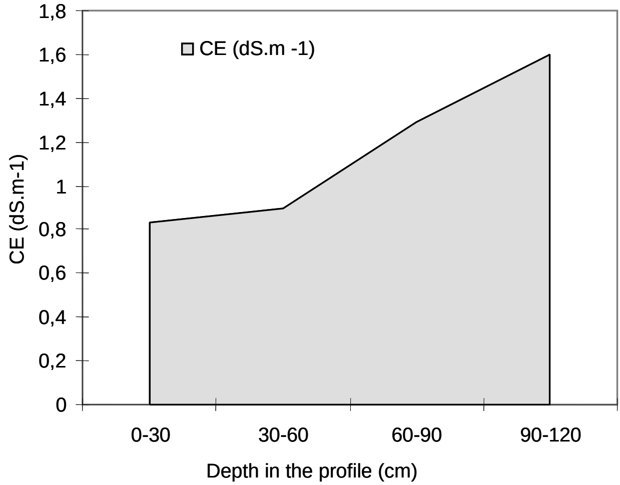



**Figure 3. CE behavior in relation to the depth on soils in San mIguel drain.**

clay soils, it was observed that the lower levels of salinity and sodicity were obtained in the first 40 cm of soil, it means, over the penetration depth of water from rains or irrigation; the lack of permeability under the 40 cm, avoided salts movements deeper into the soil (12).

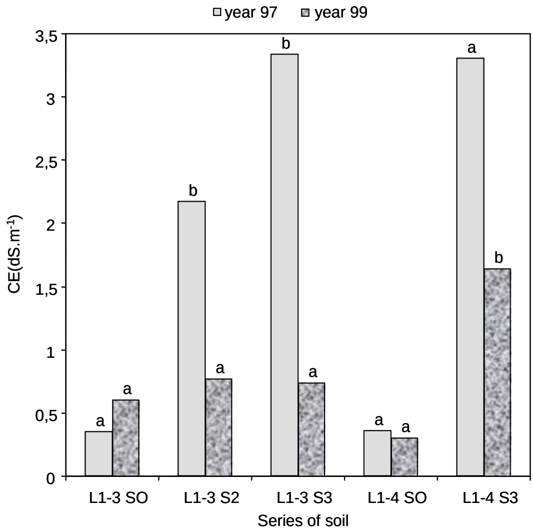
Effect of season interaction and soil series over level of salinity factor

The combined action of the season and the soil series is showed in figure 4. Differences were found in this interaction ($P<0.05$). Salinity levels decreased in both soil series during the period of the study, showing that there was a more important went down in levels S2 and S3 of the L1-3 series than in levels of series L1-4.

Salinity levels, S2 and S3 of the series L1-3, went down to 2.17 $dS.m^{-1}$ and 3.33 $dS.m^{-1}$ in 1997, to 0.77 $dS.m^{-1}$ and 0.74 $dS.m-^{1}$ in 1999, respectively; in series L1-4, levels of salinity S0 and S3 went down from 0.36 $dS.m^{-1}$ and 3,30 $dS.m^{-1}$ in year 97, to 0.30 $dS.m^{-1}$ and 1.64 $dS.m^{-1}$ in 1999, respectively. This behavior could have been caused by the geomorphologic position of the series, which permits to infer that salts move to lower geomorphologic positions, where in other studies Porta *et al.* (15) found high levels (4 to 8 $dS.m^{-1}$) and extremely high levels (8 to 16 $dS.m^{-1}$) of salinity. Under particular conditions, the biggest decrease in salinity levels of series L1-3, was due to the situation of drainage, since this series did not have any problems with the phreatic level and maybe because samples of series L1-4 (*El Derrote*) were far away from the main river bed (Caño San Miguel), which could have operated as natural drainage; L1-3 samples were near ramifications of Caño San Miguel that did not lead the same quantity of water.

Salinity level effect in the soil series

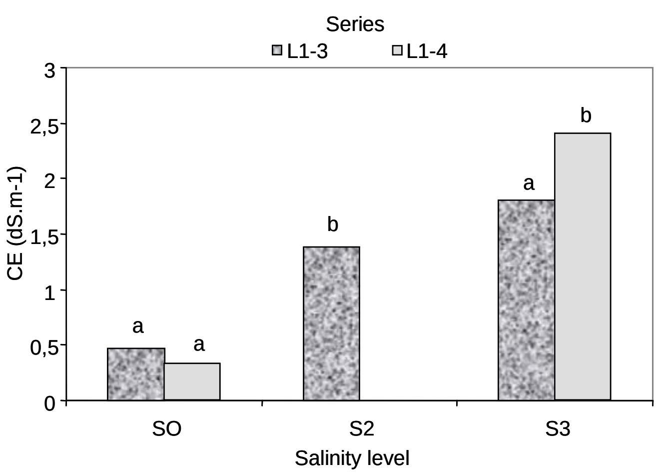
Salinity level S0 was very different from salinity levels S2 and S3 of series L1-3; nevertheless,




Colums with different letters are statistically different (P<0.05)

**Figure 4. Effect of the season interacrion and soil series according to the salinity level in the electrical conductivity (dS.m-1).**

statistical difference were not found between salinity levels S2 and S3, which indicated that during the study the variation between these two levels tended to decrease (figure 5). Equally, in series L1-4 the obtained results in




Colums with different letters are statistically different (P<0.05)

**Figure 5. Series response of soils according to the salinity level at the electrical conductivity (dS.m-1).**

levels S0 and S3 are statistically different ($P<0.01$).

It is important to point out that the CE in levels S0, S2 and S3, of the series L1-3, corresponded to the initial range level of salinity S0 (0 a 2 $dS.m^{-1}$), which confirms the presence of a natural cleaning. In series L1-4, a similar behavior was evidenced.

## Conclusions and recommendations

According to the conditions of the study and in line with the obtained results, it is been concluded that:

Salinity level, in both series, decreased significantly as a consequence of the high quantity of precipitation in the zone during the last two years.

The decreasing levels of salinity in series *Caño San Miguel* (L1-3) was higher than in *El Derrote* (L1-4).

The level of salinity increased to more depth into the soil profile. This was the result of cleanings or movements of salts as a consequence of rainfalls in these types of soils.

It is recommended to continue the research in the zone, to be able to predict accurately the level of salinization of soils, and subsequently, to be able to cooperate with solutions and alternatives for the producers of the zone.

Irrigation is one factor that affects concentration of salts in soils, so that, evaluation of this factor would be recommended; season, frequency and method of irrigation.

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