Impact of salinity on soil organic carbon in a sami-arid environment from 2000 to 2020 (North-western Algeria)

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INTRODUCTION

The largest area of saline soils in the world is in arid and semi-arid regions.
Today, in all Mediterranean countries, the severity and risks of soil salinization are not assessed.
In 2015, the FAO indicated that Algeria loses 300,000 ha of its useful agricultural area (in its northern part) each year due to human or natural factors, including desertification, drought or irregular rainfall.
The plain of Sidi Bel Abbes is an agricultural area mainly dedicated to cereals and is quite representative of all the interior plains of Algeria in terms of soil classes. The plain belongs to the semi-arid stage, its climate is defined by a hot and dry season, quite long, averaging more than five months, and a cool season where the characteristics of the Mediterranean climate prevail, notably by its highly contrasted rainfall pattern. Irrigation waters in the study area are mostly classified as poor, saline, with a high sodium absorption ratio (SAR), and a high risk of alkalinity. This study aims to compare and analyze in a geospatial context the relationship between the salinity of irrigation water and the soil organic carbon content for two periods which are 2000 and 2020.

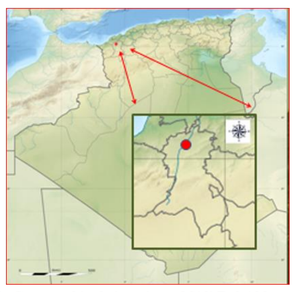

Fig.1. Geographical situation of Sidi Bel Abbes plain.

METHODOLOGY

Our approach is based on the chronic study of soil and land cover using Landsat sensor data, after collecting real field data. A supervised classification was applied to the selected images, namely the normalized vegetation index (NDVI) and the soil redness index (RI) to identify soil and vegetation types.
From the sampled irrigation water points, we were able to interpolate to characterize in a geospatial context the distribution of different salinity levels in the study area.
Several overlays of soil, vegetation, and water salinity maps were made and analyzed.

RESULTS

By exploiting the data collected between 2000 and 2001 on the cereal-growing agricultural soils of the Sidi Bel Abbes plain and comparing them with the data collected between 2019 and 2020, we were able to observe a remarkable decrease in soil organic carbon rates over two decades (Figures 2, 3 and 5).
The current situation shows a decrease in organic carbon capital and in soil fertility and productivity. One of the main causes may be related to the salinity of irrigation water. some recent research demonstrated that in a semi-arid context, a high salinity rate of irrigation water would cause rapid mineralization, thus favoring the destocking of soil organic carbon and consequently the decrease of soil capital carbon.

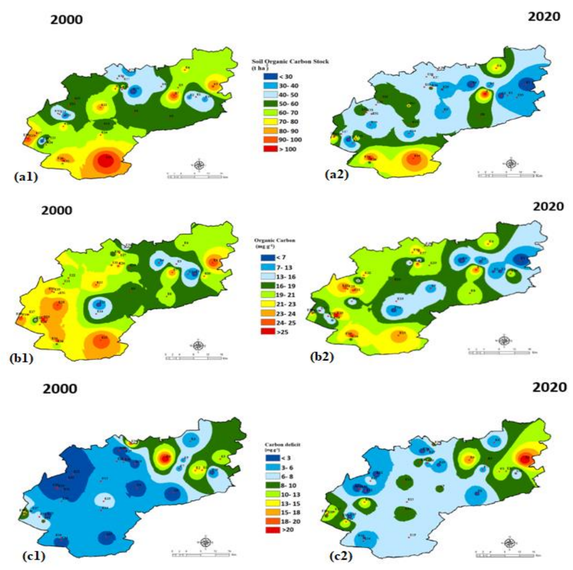

Fig.2. (a1), (a2) Geospatial variation of soil organic carbon stock(2000 & 2020).
(b1), (b2) Geospatial variation of soil organic carbon (2000 & 2020).
(c1), (c2) Geospatial variation of soil carbon deficit (2000 & 2020).

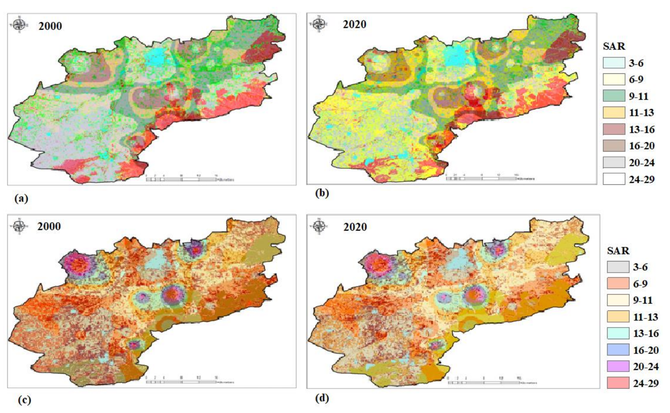

Fig.4. (a), (b) Geospatial distribution of SAR (irrigation water) according to soil types (2000 & 2020).
(c), (d) Geospatial distribution of SAR (irrigation water) according to land use (2000 and 2020).

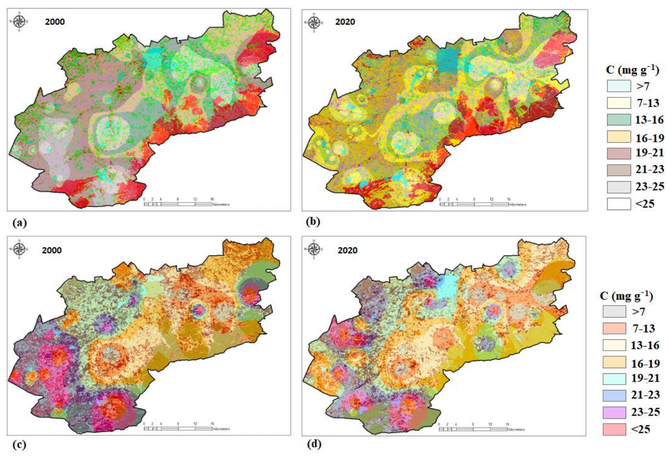

Fig.3. (a), (b) Geospatial distribution of organic carbon according to soil types (2000 & 2020).
(c), (d) Geospatial distribution of organic carbon according to land use (2000 & 2020).

Land use
Bare soil
Cereal crops
Irrigated crops
Natural grassland and pasture
Forest
Scrubland and reforestation

Main soil types
Forest soil
Bare soil
Cambisol
Halpic cambisol chromic
Fluvisol/ Colluvic regosol

Figs 2, 3, and 4 show a decrease in soil organic carbon and its stock coinciding with the areas with the highest SAR values. It is also noted that Cambisols are the most affected by this degradation. The soil redness index indicates an increase in the area of low C soils (light soils) at the expense of high C soils (dark soils).

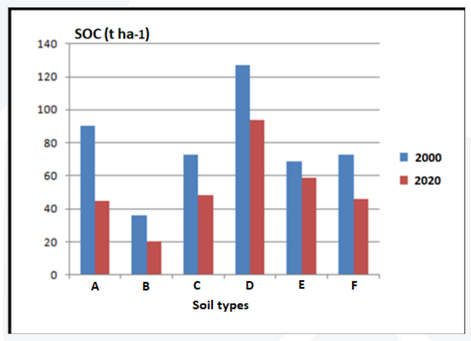

Fig.5. Average variation of soil organic carbon stock (2000-2020).
A: Cambisols Calcaric, B: Halpic Cambisols Calcaric, C: Fluvisols, D: Halpic Cambisols Eutric or Dystric Chromic, E:Colluvic Regosols, F:Halpic Cambisols Eutric or Dystric.

Fig 5 shows the reduction of the organic carbon content stored in all the soils of the plain. This decrease is more important for limestone soils, which go from 90t ha-1 to 45t ha-1, in 20 years. This is alarming, given that it is the dominant soil of the plain.

Land use (ha)	1987	1997	2003	2010	1015	2020
Bare soil	1074	6362	7948	8697	5403	9863
Cereal crops	24706	54511	70594	76403	40761	39000
Irrigated crops	15366	22870	19331	27307	33844	5472
Natural grassland and pasture	52159	18723	9058	338	28992	52040
Forest	13176	13758	14113	10878	8694	10562
Scrubland and reforestation	13222	13142	8322	5741	11628	12428
Total	129365	129365	129365	129365	129365	129365

Table 1. land use change between 1987 and 2020.

Table 1 shows that between 2000 and 2020 the area of irrigated crops had decreased significantly, from about 21,000ha to 5472ha.

CONCLUSIONS

The overlay maps revealed that the soils most affected by a decrease in organic carbon content coincide with the highest SAR values. It was also found that calcareous soils were the most affected with a decrease of about 50% of their organic carbon capital.
The variation in land use over 20 years has probably impacted the degradation of agricultural land.
It would be interesting to identify the salts responsible for this degradation in order to better understand the impact of the salinity of irrigation water on the storage and release of organic carbon in the soil.

ACKNOWLEDGEMENTS

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