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The Assessment of Soil Quality in the Irrigated Area in the Perimeter Low-Service of Doukkala for the Two Lockers Sidi Bennour and Sidi S'mail in Morocco

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Abstract: The Doukkala-Abda region covers an area of about 13,285 km^2 representing 1.87% of Morocco. The agricultural area is 428,000 ha of which 96,000 ha of large irrigation schemes, 8,250 ha of private irrigation in coastal areas and 327,800 ha of rainfed agriculture. The two large irrigation perimeters of Doukkala are the low-service with an area of 61,000 ha and the high service with an area of 35,000 ha. Since the implementation of irrigation perimeter down service Doukkala, he experienced an imbalance both in the ground and water. At first, the state of the quality of soil Doukkala is not alarming. However, observation and comparison of test results between soils in different years seem significant on the evolution of soil quality parameters (organic matter, Phosphorus olsen, pH and salinity) under intensive farming practices. Practical measures for rehabilitation and prevention are to be taken immediately in order to identify these problems and prevent them from degeneration. The methodology for the realization of this work consists of sampling, measurements in situ and analysis of soil quality parameters. The analyses reveal that the soils of Doukkala are poor in organic matter and very rich in phosphorus, with an alarming rate of salinity evolution comparing the results of different years which must be taken into account to prevent the problem from occurring spread and preserve the soil.

Key words: Low service, imbalance, irrigation, degeneration, quality.

1. Introduction

The Doukkala irrigation perimeter is one of the largest irrigated perimeters in Morocco, notable for its size and strategic importance for domestic production, notably sugar beet (38%) and marketed milk (20%).

It consists of two sub-units:

- Low-service perimeter with an irrigated area of 61,000 ha, developed for the most part for more than 25 years.
- Haut-service perimeter, of which the first and the second tranche of 35,000 ha are currently developed and impounded for a total planned area of 64,000 ha.

The irrigated perimeter low-service was laid out at the end of the fifties with the impoundment of the Faregh trap (8,900 ha), development was carried out progressively: the lockers SB-SS (Sidi Bennour-Sidi S'mail) (18,600 ha) from 1963, Zemamra (16,000 ha) from 1978, Gharbia (13,100 ha) between 1982 and 1984, and the extensions Faregh in 1992 and Sidi S'mail in 1996.

In the Haut-service perimeter, the development work was started in the early nineties. Currently all equipment in the first and second installments are completed. The various sectors of the first phase (16,000 ha) were impounded from the 1999-2000 crop year, the second phase (19,000 ha) was impoundment during 2003-2004.

1.1 Water Resources in the Region

- Surface water: average annual volume of inputs estimated at 2,695 Mm^3, contributions regularized by 2 dams with a total capacity of 3,540 Mm^3 (The fill rate of these dams is 90%).
- Groundwater: constituted by groundwater reserves estimated at 125 million m^3/year.

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The irrigation methods adopted in the Doukkala perimeter are:

- In the lower-service area, sprinkler irrigation on 33,500 ha and by gravity on 27,500 ha;
- In the Haut-service perimeter, on the first and the second tranche of 35,000 ha, irrigation is designed in a gravity mode with a conventional gate distribution network of 22,300 ha and a network of low pressure pipelines in 12,700 ha.

1.2 The Climate of the Region

The climate of the area is characterized by:

- Annual rainfall ranging between 300 mm and 400 mm (average: 322 mm);
- An average annual temperature of 18.6 °C, (maximum: 40 °C in June, July and August);
- An average annual sunshine duration of 3,030 hours (summer: 1,000 h, winter: 590 h);
- High annual values of evaporation (1,700 mm), higher than the rainfall;
- A significant hygrometry close to 100% due to oceanic winds and fogs;
- Permanent winds with average speeds varying between 1.7 and 2.8 m/s.

In the region there are dune reliefs (the coastal strip and the Sahel), the current or ancient valleys, draining the Faregh and Bouchane wadis, the plateaus and the karsts.

The Doukkala basement contains a multilayer aquifer with free upper water table and continuous lower captive aquifer.

1.3 Soil Types in the Region

The main soils encountered in the Doukkala are of six types according to the French classification (CPCS, 1967):

- Poorly developed soils: 10,800 ha, or 16.5% of the total area;
- Vertisols (shots), with an area of 18,250 ha (30% of the low-service perimeter);
- Calcimagnetic soils, with 5,760 ha; 9.4% of the total area of the perimeter;
- Isohumic soils: 21,970 ha representing 36% of the low-service perimeter;
- Soils with iron sesquioxides, ferralitic soils, with 4,100 ha, representing 6.7%;
- Hydromorphic soils: 840 ha, or only 1.4% of the low-service perimeter.

1.4 Low Service Locker

The irrigated perimeter low service of Doukkala corresponds to a vast plain of 61,000 ha of irrigated lands in large hydraulic, located in the south of the city of El Jadida on the Atlantic coast Moroccan.

It is subdivided into 5 agricultural compartments whose distinction is based on the date of impoundment and irrigation: gravity or sprinkling. Each bin is managed by several CDAs (Agricultural Development Centers).

The climate of the region is semi-arid Mediterranean type with temperate winter. Annual rainfall varies from 400 mm along the Atlantic coast to 250-300 mm within the plain with an average of 322 mm recorded during 50 to 60 days of rains between October and May. The average annual temperature is 18.6 °C and annual evapotranspiration reaches 1,700 mm/year with daily values varying between 2 mm and 8 mm depending on the season.

The main soil types of the plain belong, according to the French classification (CPCS, 1967) to the following six classes: isohumid soils, vertisols, calcimagnetic soils, little evolved soils, sesquioxide soils iron and hydromorphic soils. These soils generally have a balanced surface texture that becomes clayey in depth with dominance of the sandy fraction (fine sands in particular).

My study is limited to two lockers belonging to the low-service perimeter which are Sidi Bennour and Sidi S'mail (Fig. 1, Table. 1):

For the purpose of better agronomic and economic management of these agricultural soils, analyses of soil quality are however essential. It is a means to

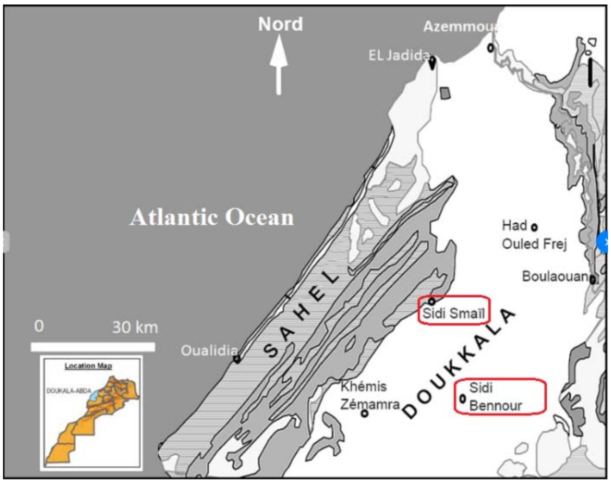

Fig. 1 Geographic location of the two traps in the study area.

Table 1 Sidi S'mail and Sidi Bennour.

Locker	Net irrigated area	Irrigation mode	Date of impoundment
Sidi S'mail	8,000 ha	Gravity	1963-1969
Sidi Bennour	9,300 ha	Gravity	1975

adapt to each particular case agronomic references of plot, crop, or operating.

Practical measures in the field of rehabilitation and prevention should be undertaken immediately in order to identify the problems that these soils may encounter and prevent their degeneration. The methodology adopted for the realization of this work consists of:

- Sampling, in situ measurements and analysis of soil quality parameters;
- Treatment of analysis results.

2. Materials and Methods

The representativeness of the soil sample contributes critically to the interpretation of soil analyses. Soil characteristics vary in surface and depth and are influenced by time and soil management practices and crop management.

The samples are distributed in the two sectors SB (Sidi Bennour) and SS (Sidi S'mail) in Fig. 2.

2.1 General Conditions for Taking Samples

- In annual culture, operate after harvest, preferably after a cereal;
- Avoid the April-May period due to pH variation;
- Do not take samples:

- Less than one month after adding fertilizer (fertilizer, amendment);
- On soggy ground;
- Avoid the April-May period due to pH variation;

2.2 Subsoil Sampling

Collect at a depth to be determined based on the profile examination.

Take care to avoid soil fallout before and during sampling.

2.3 Apparatus and Depth of Sampling

First and before taking the samples, it must be ensured that the equipment used does not induce any interference (pollution or loss) with the elements to be determined.

Samples were taken with an auger, the choice of this material must be such as to obtain the smallest possible elemental sampling, which is compatible with the nature and state of the soil and the representatively of the sampling.

The profounder of the sample is taken between 0 to 30 cm. An information sheet has been prepared

Fig. 2 Study zone and distribution of sampling points in both Sidi Bennour and Sidi S'mail.

specifically for this work. Thus each sample includes: farmer's name, geographic coordinates taken by GPS, sampler name and date of collection, type and area of land, current occupation, type and frequency of irrigation, fertilizer and pesticide used.

2.4 Sample Conditions

Each laboratory sample should be placed in a soil-resistant, moisture-proof, water- and dust-proof package.

In addition, a label placed on the outside or glued or written on the packaging should make it possible to identify each laboratory sample in relation to the information sheet. Labels should never be placed inside packages containing the soil.

2.5 Transport and Storage of the Samples

The collected samples were sent to the laboratory as soon as possible (same day or the next day) where they were numbered, dried, crushed and analyzed.

Once the sample is dry, grinded and sieved to 2 mm, we begin the analysis in our laboratory.

To take stock of soil quality, an MDS (minimum data set) of physical and physicochemical quality parameters was selected. The chosen parameters are directly related to the real degradation processes encountered in the study area, are dynamic and evolving and are simple to analyze and economical. It is organic matter, phosphorus olsen (P_2O_5), pH and salinity.

3. Results and Discussion

The analyses were carried out on two different years (2011 and 2016) in order to clearly distinguish the changes of the parameters and to be able to identify the problem that these two lockers Sidi Bennour and Sidi S'mail meet and to be able to possibly find suitable solutions for a better management of the plots and to avoid situations of soil exhaustion, which may occur in the absence of monitoring the fertility of the latter.

3.1 Organic Matter

Values are ranked according to Table 2.

More than 60% of the soils in the two lockers Sidi Bennour and Sidi S'mail are poor in organic matter as demonstrated in Fig. 3, with average values of 1.3 in 2011 and 1.26 in 2016, which reveals that we are on a path of decreasing the rate of organic matter in these soils.

The low soil organic matter in the region (like any other region of Morocco) is related to the management of crop residues that are exported in the whole plot after harvest. This practice is a kind of mining agriculture that affects soil quality and leaves it bare and exposed to wind and water erosion. It can also have a negative effect on the mineralization potential, the retention of water and mineral elements, especially in light soils, and the availability of mineral elements, especially trace elements.

3.2 P_2O_5

Values are ranked according to Table 3.

Table 2 Standards for organic matter defined by the national institute of agronomic research.

Appreciation	Organic matter rate
Very poor	< 0.7%
Poor	0.7-1.5%
Moderately provided	1.5-3%

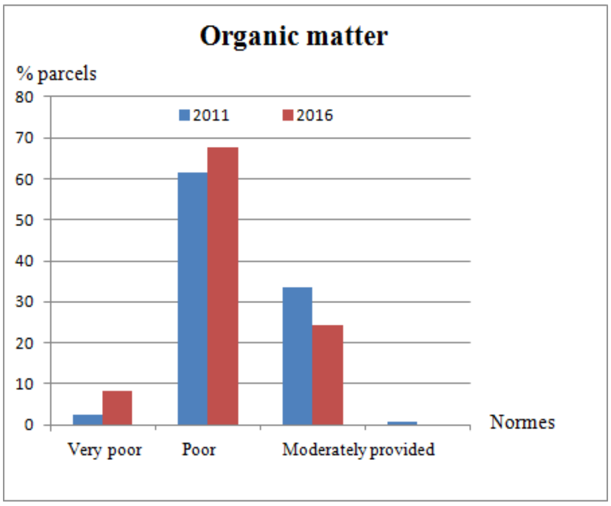

Fig. 3 Organic matter according to the percentage of the parcels.

Table 3 Standards for P_2O_5 defined by the national institute of agronomic research.

Appreciation	Content of P_2O_5 (mg/kg)
Low content	< 20 mg/kg
Moderately provided	20-30 mg/kg
Rich	> 30 mg/kg

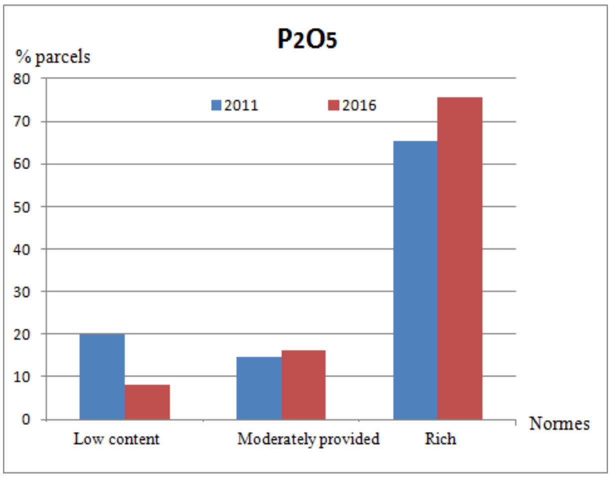

Fig. 4 P_2O_5 according to the percentage of the parcels.

More than 70% of soils in the region are rich in phosphorus as specified in Fig. 4, with an average value of 65.78 in 2011 and 55.61 in 2016.

Phosphorus is an indispensable element for the growth of plants and for the fertility of agricultural soils. It is concentrated in the superficial part of the soil, in mineral or organic form. Mineral phosphorus comes from rock alteration, while organic phosphorus results from the degradation of plants by soil fauna and flora. These forms of phosphorus are not immediately available to plants. Only phosphorus in solution in the soil water can be taken from the roots of plants.

Phosphorus has a positive effect on root growth and the absorption of nitrogen and potassium.

Phosphorus promotes root development and therefore the interception of water and nutrients in the soil, there by contributing to plant resistance to drought.

In cultivated environments, the phosphorus content of the soil is depleted since the phosphorus contained in the harvested plants does not return to the soil. The supply of inorganic or organic phosphate fertilizers is then necessary. The amount of phosphorus to be added varies, like nitrogen, with crop management and pedoclimatic conditions.

3.3 Potential Hydrogen (pH)

Values are ranked according to Table 4.

The soils of our study area are mostly moderately basic as shown in Fig. 5. The average value of potential hydrogen in both lockers is 7.59 in 2011 and 8.05 in 2016.

The pH gives information on the nutrients and the risks of toxicity.

Knowing the pH values, it is possible to outline the fertility of a soil and its behavior.

The pH in the soil affects directly the plant growth.

Some plants prefer an acidic soil (pH < 7), others a neutral soil (pH = 7), others a basic soil or an alkaline soil (pH > 7).

The variability of pH is due to the nature of the rocks (sandy and loam soils are more acidic than calcareous soils), the season (in winter it is higher) and its biological activity in the soil.

Table 4 Standards for potential hydrogen (pH) defined by the national institute of agronomic research.

Appreciation	pH content
pH neutre	6.6-7.3
pH slightly basic	7.3-7.8
Basic pH average	7.8-8.5

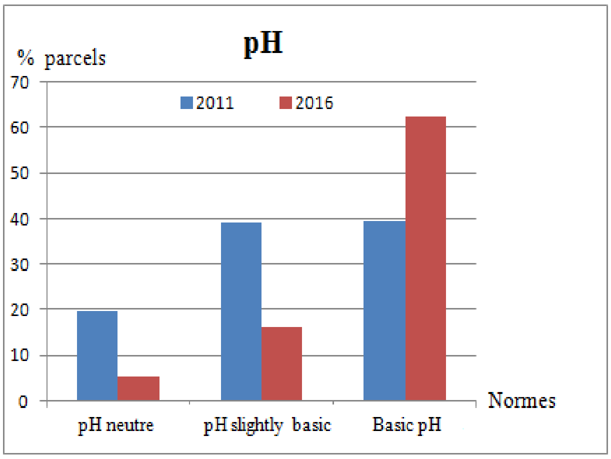

Fig. 5 Potential hydrogen (pH) according to the percentage of the parcels.

3.4 Salinity

Values are ranked according to Table 5.

The average value of salinity in the soil has increased from 0.17 in 2011 to 0.40 in 2016.

As indicated in Fig. 6, salinity levels in our soils are moderately low to medium, they have increased from 2011 to 2016 and varied from low to medium, but in general the problem of salinity is still not laid in this area except in some distinguished plots where high percentages may be found, which could be the consequence of several factors such as:

- The nature of the source rock, which is a natural source of salinity;
- Irrigation, by water, which is one of the major human causes of salinization;
- The intensification of agricultural activity;
- The use of fertilizers and pesticides;
- Poor drainage of excess water from the large doses of irrigation applied.

Table 5 Standards for salinity defined by the national institute of agronomic research.

Appreciation	Salinity mmhos/cm
Low	< 0.2
Weak	0.2-0.3
Average	0.3-0.5
High	0.5-0.7
Very high	0.7-0.8
Extremely high	> 0.8

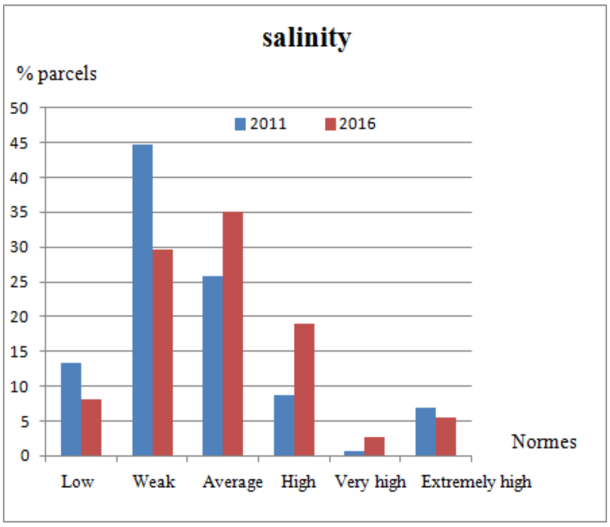

Fig. 6 Salinity according to the percentage of the parcels.

In that case farmers need to give the plants the amount of water they really need without exaggerating by adding the right dose to ensure that the soil is leached, thus reducing salinity in the root zone.

4. Conclusions

Currently the environment is a complex patchwork resulting from successive changes in land use and development by humans. The intensity of these changes differs according to climate, applied production systems, effective ecosystem management and enforcement.

Morocco has made considerable investments in agricultural development and water development with a view to modernizing its agriculture and thus ensuring food self-sufficiency.

The irrigated perimeter of the Doukkala is one of the oldest and most important in the country, and is experiencing an intensification of cultural practices. While this intensification has a positive effect on agricultural yields, it has, however, a negative impact on the degradation of quality of both soil and receiving environments, including groundwater.

At first glance, the state of soil quality of the Doukkala does not seem to be alarming. However, the observation and comparison of the results of analyses, show a considerable impact on the evolution of soil quality parameters under intensive cropping practices.

Therefore, the present study constitutes a diagnosis of the current situation of the soil quality of the irrigated perimeter of the Doukkala especially the two lockers Sidi Bennour and Sidi S'mail of the low-service based on the analysis of the quality parameters. It is first of all a methodological approach for the diagnosis of soil quality in order to establish an inventory. This approach will promote monitoring over time and space of soil quality.

In general, the soils of Doukkala present:

- Poor to very poor percentage in organic matter;
- Present occasional and punctual problems of salinity;

- Very rich percentage in phosphorus.

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