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Prepared by

Bouchra Kahlaoui

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Contribution to the evaluation of organic matter content of natural and cultivated soils in Ouargla region

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Before the jury:

Dr. DJILI Brahim	MCB	Chairman	U.K.M.Ouargla
Dr. KHEMGANI Med Abdelmalek	MCB	Examiner	U.K.M.Ouargla
Dr. HAMDI-AÏSSA Baelhadj	Professor	Supervisor	U.K.M.Ouargla
Ms. BAZA Insaf	Doctorante	Co Supervisor	U.K.M.Ouargla

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Dedication

This thesis is dedicated to:

The sake of Allah, my Creator and my Master,

My great teacher and messenger, Mohammed (May Allah bless

and grant him), who taught us the purpose of life,

My great parents; **Djamel eddine** and **Fatima zohra**, who never stop giving of themselves in countless ways,

My beloved brothers and sisters; **Ghazali**, **Adnane**, **Marwa**

My best friend **Roumaissa Meraghnia** who encourage and support me,

All my friends

All the people in my life who touch my heart,

I dedicate this research.

Acknowledgments

In the Name of Allah, the Most Merciful, the Most Compassionate all praise be to Allah, the Lord of the worlds; and prayers and peace be upon Mohamed His servant and messenger.

First and foremost, I must acknowledge my limitless thanks to Allah, the Ever-Magnificent; the Ever-Thankful, for His help and bless.

I am totally sure that this work would have never become truth, without His guidance.

I am grateful to some people, who worked hard with me from the beginning till the completion of the present research particularly my supervisor **Dr. HAMDI-AÏSSA Baelhadj**, who has been always generous during all phases of the research, and I highly appreciate the efforts expended by **Ms. BAZA Insaf**, **Dr. DJILI Brahim**, **Mr. KHEMGANI Med Abdelmalek**, **Mr. Belaroussi Mohamed**, **Ms. OUSTANI Mabrouka**, **Mr. HAMDAOUI Med Lamine**. I would like to take this opportunity to say warm thanks to all my beloved friends, who have been so supportive along the way of doing my thesis.

I also would like to express my wholehearted thanks to my family for their generous support they provided me throughout my entire life.

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List of Abbreviations

Bl: Bour el Haicha

Bm: Bamendil

C: Carbone

Ch: Chott

Cltv: Cultivated

Hdb: Hadeb

Kh: El Nasr district

LOI: loss-on-ignition

Mkh: EL Mikhadma

Nat: Natural

O.R: Om Raneb

OM: Organic Matter

R.Gh: Road of Ghardaia

S.Kh: Sidi Khouiled

S.O: Said Otba

Sd: Sedrata

SOC: Soil Organic Carbon

SOM: Soil Organic Matter

WB: Walkley and Black

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Chapter III. Results and Discussion

Introduction

Introduction

Soil is the fundamental to the well-being, productivity of agricultural and natural ecosystems. Soil quality indicates its functionality, it means what soil can do for plant, human and animal health. Soil quality influences basic soil functions including medium for plant growth, regulator of water supplies, recycler of raw materials, and habitat for soil organisms (Karlen et al. 1997; Vasu et al. 2016; Uttam et al 2020).

The Algerian Sahara is characterized by heterogeneity of edaphic conditions and climatic dissimilarities; although, information on biological indicators of arid soils is poorly documented in this area. Researchers who have studied the biological activities of arid soils have highlighted their low organic matter content (Karabi et al., 2016).

Soil organic matter (SOM) is an essential component of any terrestrial ecosystem, and changes in its quantity and composition have a significant impact on many of the system's activities (IPCC, 1990). As it plays a major role in soil properties and soil functions, it is important that organic matter is constantly renewed (Brady and Weil, 2008). Moreover, SOM is an important indicator of soil fertility and quality, for that, this parameter is often the first measured during the study of a soil and its ecosystem (Paré, 2011). Despite this, little is known about the distribution of carbon in the world's soils, especially in arid environment including agrosystems.

This study aims to evaluate the organic matter content of soils in Ouargla region. It consists in measuring the organic matter in the soil.

The main objective of this work is on the one hand the study of organic matter distribution in the natural and cultivated soil in Ouargla region, in order to establish the soil fertility map according to organic matter, and on the other hand A comparison of two methods of measuring the percentage of SOM (Walkley-Black and Loss on ignition), and check which method is more effective for measuring SOM% in sandy soils.

In this manuscript, we have chosen to structure our study according to logical sequences, made up of the following four (04) chapters:

* A first chapter, is a generality of the soil and the organic matter.

* A second chapter contains a presentation of the study region.

* A third chapter presenting the materials and methods of the study.

* A last chapter presenting the results obtained and discussion.

Chapter I

Bibliographic Overview

I.1. Introduction

In this chapter we recall the main basic concepts involved in the study of the constituents and properties of soils. Emphasize SOM and present some approaches to determine it.

I.2. Soil definition and properties

The Natural Resource Conservation Service (NRCS) defines soil as: "a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment (Soil Survey Staff, 2014)

Soil characteristic depends primarily on the parent materials, and secondarily on the vegetation, the topography, climate and time. These are the five variables known as the factors of soil formation (Jenny, 1941)

Soil is a substance made up of different components. It contains different solid materials, air, free and bound water. (Salam, 2020).

It is a mixture of inorganic (mineral) and organic particles organized into layers (horizons) by physical, chemical and biological processes (Hutson,2016).

The soils have chemical, biological, and physical properties (Table1) that interact in a complex way to give a soil its quality or capacity to function (genesis and classification) (Seybold et al., 1997).

Table 1. Proposed minimum data set of physical, chemical, and biological indicators for screening the quality or health of soils (After Doran et al., 1996 and Larson and Pierce, 1994)

Indicators	Relationship to soil condition and function: rationale as a priority measurement
	Physical
Texture	Retention and transport of water and chemicals; modeling use, soil erosion and variability estimate
Depth of soil and rooting	Estimate of productivity potential and erosion; normalizes landscape & geographic variability

Infiltration and bulk density	Potential for leaching, productivity, and erosivity
Water holding capacity	Related to water retention, transport
	Chemical
Soil organic matter (OM)	Defines soil fertility, stability, and erosion extent
Ph	Defines biological and chemical activity thresholds
Electrical conductivity	Defines plant and microbial activity thresholds
Extractable N, P, and K	productivity and environ mental quality indicators
	Biological
Microbial biomass C and N	Microbial catalytic potential and repository for C and N
Soil respiration	Microbial activity measure (in some cases plants); estimate of biomass activity

I.3. Soil organic matter (SOM)

SOM is consisting of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms and substances synthesized by soil organisms. (Mahendran and Yuvaraj,.2020).

SOM exerts numerous positive effects on soil physical, chemical and biological properties. Particularly, the presence of Soil organic matter is regarded as being critical for soil functions and soil quality. The benefits of SOM result from a number of complexes, interactive, edaphic factors; a non-exhaustive list of these benefits to soil function includes improvement of soil structure, aggregation, water retention, soil biodiversity, absorption and retention of pollutants, buffering capacity, and the cycling and storage of plant nutrients. (Mahendran and Yuvaraj,.2020).

SOM increases soil fertility by providing cation exchange sites and being a reserve of plant nutrients, especially nitrogen (N), phosphorus (P), and sulphur (S), along with micronutrients, which the mineralization of soil organic matter slowly releases. As such, the amount of soil organic matter and soil fertility are significantly correlated (Mahendran and Yuvaraj,.2020).

I.3.1. Composition of SOM

SOM is a highly variable entity because different organic compounds are found in different plant and animal residues and different organic compounds predominate at different stages of decomposition. SOM includes materials that are added in plant and animal residues, those that are formed during decomposition, substances synthesized by microorganisms, and compounds in root exudates and microbial secretions (Osman, 2012)**.**

I.3.2. Decomposition of SOM

The decomposition of SOM is biological breakdown and biochemical transformation of complex organic molecules of dead litter into simpler organic and inorganic molecules (Juma 1998 in Reddy. P. P, 2016.). It is important for the release of nutrients held up in dead organic matter and returning it back to the soil. Decomposition of SOM leads to the release of bio-available nutrients and CO2 and counteracts soil C sequestration (Lehmann and Kleber, 2015 in Reddy, 2016).

The rate of organic matter decomposition depends on physical interactions, chemical, environmental controls, microbial communities, and soil aeration. (Reddy, 2016).

I.4. Soil organic carbon

C stock in soil consists of two components: SOC and C inorganic soil (SIC). SOC is the carbon component of soil organic matter (SOM), which is a heterogeneous pool of carbon consisting of diverse materials including a single fragment of litter, roots, soil fauna, microbial biomass C, microbial degradation products, and other biological processes (such as particulate organic matter), and compounds. As simple as sugar (Jansson et al., 2010).

Soil organic carbon (SOC) is one of the most important indicators of soil quality (Ghosh et al., 2012). Soils contain approximately three times the carbon found in the atmosphere or terrestrial vegetation (Schmidt et al., 2011), which accounts for 80% of the terrestrial carbon pool (Leifeld et al., 2005). Therefore, maintaining and enhancing soil carbon stocks is of great importance when considering both the promotion of soil health and the regulation of the global carbon cycle, (Minasny et al., 2017).

I.5. The different methods of determining organic matter

The table below illustrates the main methods of determining soil organic matter.

Table 2. Features of ex situ soil C determination methods **(**Chatterjee, 2009)

Method	Principle	CO2 determination	Advantages/Disadvantages
I.Wet combustion			
Combustion train	Sample is heated with $K_2Cr_2O_7$-H_2SO_4-H_3PO_4 mixture in a CO_2-free air stream to convert OC in CO_2.	Gravimetric/ Titirimetric	Gravimetric determination requires careful analytical techniques and titrimetric determination is less precise.
Van-Slyke-Neil apparatus	Sample is heated with $K_2Cr_2O_7$-H_2SO_4-H_3PO_4 mixture in a combustion tube attached to the apparatus to convert OC in CO_2.	Manometric	Expensive and easily damaged apparatus.
Walkley-Black	Sample is heated with $K_2Cr_2O_7$-H_2SO_4-H_3PO_4 mixture. Excess dichromate is back titrated with ferrous ammonium sulfate.	Titrimetric	Oxidation factor is needed. Variable SOC recovery. Generate hazardous byproducts such as Cr.
II.Dry combustion			
Weight-loss-on ignition	Sample is heated to 430◦C in a muffle	Gravimetric	Weight losses are due to moisture and volatile organic compounds.

	furnace during 24 hours.		Overestimate the organic matter content.
Automated	Sample is mixed with catalysts or accelerator and heated in resistance or induction furnace in O_2 stream to convert all C in CO_2	Thermal conductivity, gravimetric, IR absorption spectrometry	Rapid, simple, and precise but expensive. Slow release of contaminant $CO_2$from alkaline earth carbonates with resistance furnace.

I.6. Conclusion

Soils are essentially heterogeneous and it is always essential to determine the SOM. Because it is the most dynamic of the soil components, effects of changing soil environment are often recorded first in the quality and distribution of organic matter.

Chapter II

Materials and Methods

II.1. PRESENTATION OF STUDY REGION

II.1.1. Geographical loc

ation of the study region

Ouargla is geographically located in the north of Algerian Sahara, in the arid domain of the great African desert (Salhi, 2017); This wilaya covers an area of 163,323 km² and is bounded in the north by the wilaya of Biskra, in the south by the wilaya of Tamanrasset, to the northwest by the wilaya of Djalfa, in the west by the wilaya of Ghaurdaia, in the East by the wilaya of El Oued, and in the south-east by the wilaya of Illizi (Karabi, 2016).

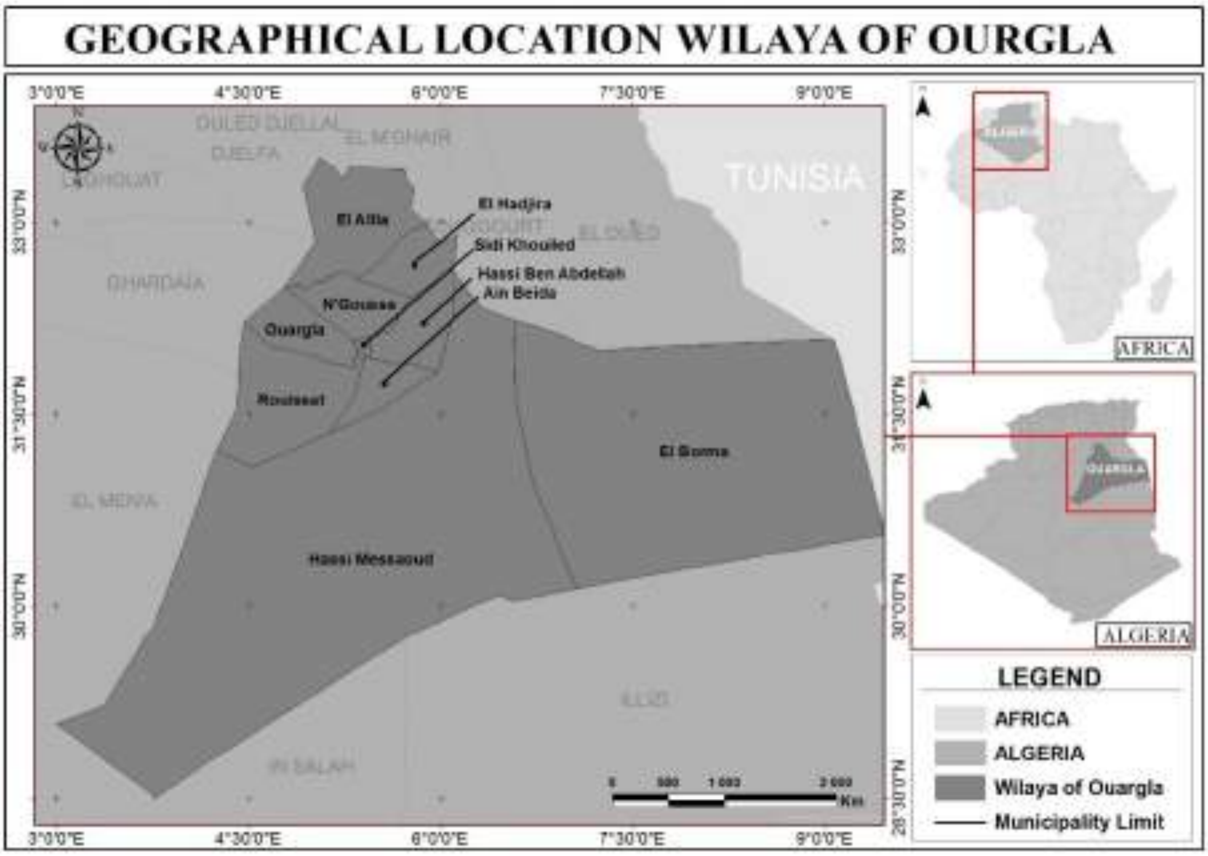

Fig 1. Geographical location of Ouargla Regent

II.1.2. Climate of Ouargla region

Like all the lower Sahara, Ouargla region is characterized by a desert climate, where the thermal amplitudes between the minima and the maxima are important, and by a very low rainfall (Khadraoui and Taleb, 2008).

Table 3. Climatic data for Ouargla region (**2009-2018**)

	Temperature			Precipitation (mm)	Humidity (%)	insolation (Heures)	Evaporation (mm)	Wind (m/s)
	Min	**Max**	**Ave.**					
January	5,23	19,52	12,37	7,94	55,33	248,38	97,85	8,17
February	6,97	21,19	14,08	3,68	47,96	237,43	120,69	9,20
March	10,68	25,67	18,17	4,87	42,26	266,82	180,62	9,74
April	15,35	30,76	23,06	1,38	36,21	285,33	231,34	10,26
May	19,99	35,34	27,67	2,06	30,69	316,25	302,61	10,56
June	24,81	40,42	32,61	0,77	26,97	229,30	366,88	9,96
July	28,14	44,04	36,09	0,35	22,94	317,54	447,18	8,92
August	27,26	42,42	34,84	0,36	26,79	341,44	388,00	8,95
September	23,54	38,14	30,84	4,38	35,68	268,06	266,76	9,14
October	17,15	31,83	24,49	3,36	41,47	270,72	207,61	7,87
November	10,45	24,59	17,52	2,68	51,21	248,21	124,50	7,26
December	5,87	19,83	12,85	3,29	58,09	238,98	86,17	6,93
Average	16,29	31,15	23,72	/	39,63	272,37	/	8,91
Accumulation	/	/	/	38.05	/	/	3102,23	/

II.1.2.1. Climatic parameters study

a. Temperature

The annual average temperature is 23.70 ° C, the maximum value is recorded in July with 36.1° C and the minimum value in January with 12.4 ° C. The highest maximum temperatures are recorded in June, July and August with temperatures above 40 ° C (**Table 3**).

b. Precipitation

In Ouargla region, rains are rare and irregular. The rainiest month is January with 7.94mm. On the other hand, very low quantities are recorded during the month of July with 0.35 mm (**Table 3**).

c. Relative air humidity

The annual average of air humidity is 39.63%; we note that the minimum value is recorded in July (22.94%), when temperatures are high and the highest value is in December (58,09%) with low temperatures (**Table 3**).

d. Evaporation

The annual evaporation is very important in Ouargla region, the annual cumulative is 2820.2mm. The maximum value is recorded in July with 447.2mm; this is consistent with the high temperatures in this month. The minimum value is recorded in December (86.2mm). (**Table 3**).

e. Wind

Winds are frequent throughout the year in Ouargla region, with significant speeds. A maximum of 10.56 m / s in the Month of May is recorded. These winds increase evaporation (**Table 3**).

f. Sunstroke

Insolation is strong in August (341.4 hrs / month), and weak in June (229.3 hrs / month).

II.1.2.2. Gaussen Ombrothermal Diagram

The Ombrothermal diagram highlights drought periods. The x-axis represents the months of the year, the y-axis on the right represents precipitation (P) in mm and on the left the average temperatures (T) in ° C. The scale is P = 2T. The intersection of the precipitation curve with the temperature curve determines the length of the dry period. BAGNOULS and GAUSSEN, defined dry months as those in which the average monthly rainfall in millimeters is less than or equal to twice the average monthly temperature expressed in degrees Celsius (P <2T). The ombrothermal diagram of Ouargla region shows that the drought lasts throughout the year.

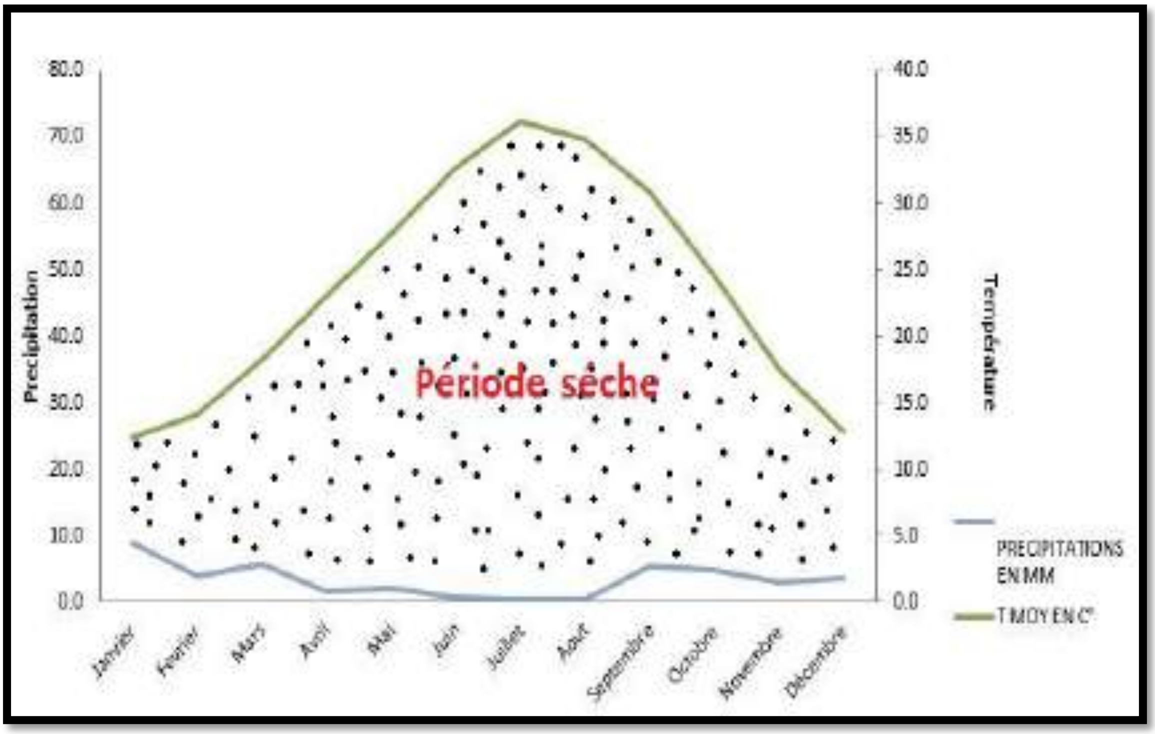

Fig 2. Ombrothermal diagram of Ouargla region (**2009 - 2018**).

II.1.2.3. Emberger climagram

EMBERGER's climagram allows knowing the bioclimatic stage of the study region. It is represented on the abscissa by the average of the minimum temperatures of the coldest month and on the ordinate by the pluviothermal quotient (Q2). It is calculated by the following formula:

$$Q2 = 3.43 P / (M-m)$$

P: Annual rainfall in (mm).

M: Average of the maximum temperatures of the hottest month.

m: Average minimum temperatures for the coldest month.

From these data, we can calculate the pluviothermal quotient which is equal to 5.03. Therefore, the region is classified in the Saharan bioclimatic stage with mild winter (fig3).

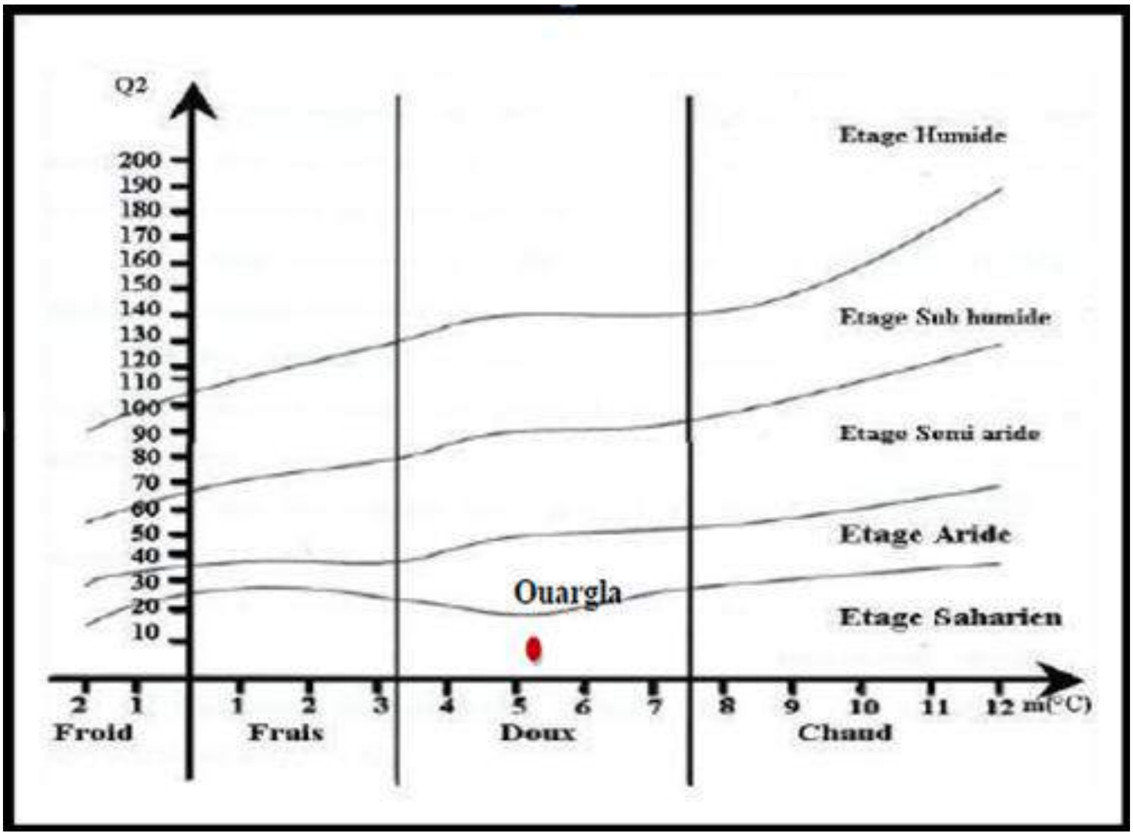

Fig 3. Emberger climagram of Ouargla region

II.1.3. Geology of Ouargla region

Ouargla region is part of the Lower Sahara; which presents itself as a synclinal basin; it is characterized by a more or less circular sedimentary filling having a diameter of 600 km. All the land more or less outcrops on the edges from the Cambrian to the Tertiary, sinking under the sedimentary cover largely hidden by the great eastern (A.N.R.H, 2011).

The Saharan platform has experienced the formation of evaporites on several occasions, in particular in the Triassic, but also in the Senonian. During the various tectonic episodes in the region, these formations impregnated with salt and gypsum the land with which they came into contact and caused a significant diffusion of salts (Gaucher et al., 1974).

Ouargla basin corresponds to the low fossil (Quaternary) valley of Wadi Mya, which descends from the Tademaït plateau and ends to 20 km north of Ouargla. The valley is almost 30 kilometers wide (Hamdi - Aissa et al., 2000; Hamdi-Aissa et al., 2004).

II.1.4. Hydrogeology

What is called Ouargla basin is in fact the lower valley of the Oued M'ya which flows with the Oued M'zab and the Oued N'sa into the SebkhatSafioune. It starts at South with the ruins of Sédrata, the ancient capital of the Ibadites and it ends at the entrance to the SebkhatSafioune, 40 km to the north (Faci, 2017).

Groundwater is the main water resource in the Ouargla region, from four major aquifers. The depth of these different layers varies between 100 and 1800 m.

Three different levels are used:

- A salty water table.

- Part of the Terminal Complex comprising the Miopliocene water table and the Senonian water table.

- The Continental Intercalaire that the underground water reserves have practically inexhaustible. The aquifer system of the northern Sahara (SASS) which extends over more than 700,000 km² shared with other provinces is the main source (Rebah, 2016).

The overall slope is close to 1 %, since the coasts pass from 158 m, on the sandy veneers of Sédrata, to 103 m at the bottom of the SebkhatSafioune (Dubost, 2002).

II.1.5. Pedology of Ouargla region

Soils of Ouargla region derive from the clay-quartz sandstone of the non-gypsum Miopliocene. They are made up of quartz sand. In all soils, the sandy skeleton is very abundant, consisting almost entirely of quartz. The color becomes less red and the film thickness decreases in downstream soils and especially in dunes. On the soils of the depression, the clayey basal mass presents a dusty appearance. It consists of a mixture of detrital micrite and a few mica flakes (Hamdiaissa, 2001). According to Halilat (1993), they are characterized by a low level of organic matter, an alkaline pH, and low biological activity.

The soil landscape of the basin is dominated mainly by the saline character (Idder, 2007**).**

II.1.6 The flora

According to Ozenda (1983), plants are distributed according to the nature and structure of the soil, where we find:

- In the beds of the rivers, the valleys and the surroundings of the gueltas, vegetation with Acacia.
- In the great Eastern Erg mainly the "Drinn" or "Aristidapungens" sometimes accompanied by shrub vegetation "Retamaretam", "Ephedra", "Genistasaharae" and "Caliganumazel". - In Hamadas “Fagonia glutinosa” and “Fredolia arestoides”. In the oases and cultivated areas, abundant natural vegetation.

II.1.7. Palm groves

The palm grove or phœnicicole orchard is a very particular ecosystem with three layers. The most important tree layer is represented by the date palm (Idder et al., 2011).

The palm grove: (phoenicultural orchard): It is a succession of gardens that are also different from each other in terms of architecture, faunistic composition, flora, age, management, maintenance, microclimatic conditions, etc. ... and which form a fairly vast which reminds us of the aspect of a forest (Idder et al., 2006 in Bouammar, 2007).

The oasis of Ouargla basin is classified among the main potential phoenicultural areas of Algeria, it is made up of several palm groves with a total area of 23,300 ha planted with approximately 2,507,000 palm trees having produced in 2015, 1,131,300 quintals of dates (Sidab, 2015). However, the traditional gardens of this oasis generally take the form of anarchic and dense plantations and are characterized by excessive fragmentation (Omeiri, 2016).

II.2. Methodological approach

II.2.1. The experimental study

Given the primordially of SOM in the study of contribution to the evaluation of the organic matter content of natural and cultivated soils in Ouargla region, the basin of Ouargla was selected to determine this parameter.

This chapter brings together all the analytical approaches in the objective of evaluating the SOM of soils in the Ouargla region.

II.2.1.1. Choose sites

The choice of points is done according to criteria which respect the objective of evaluating.

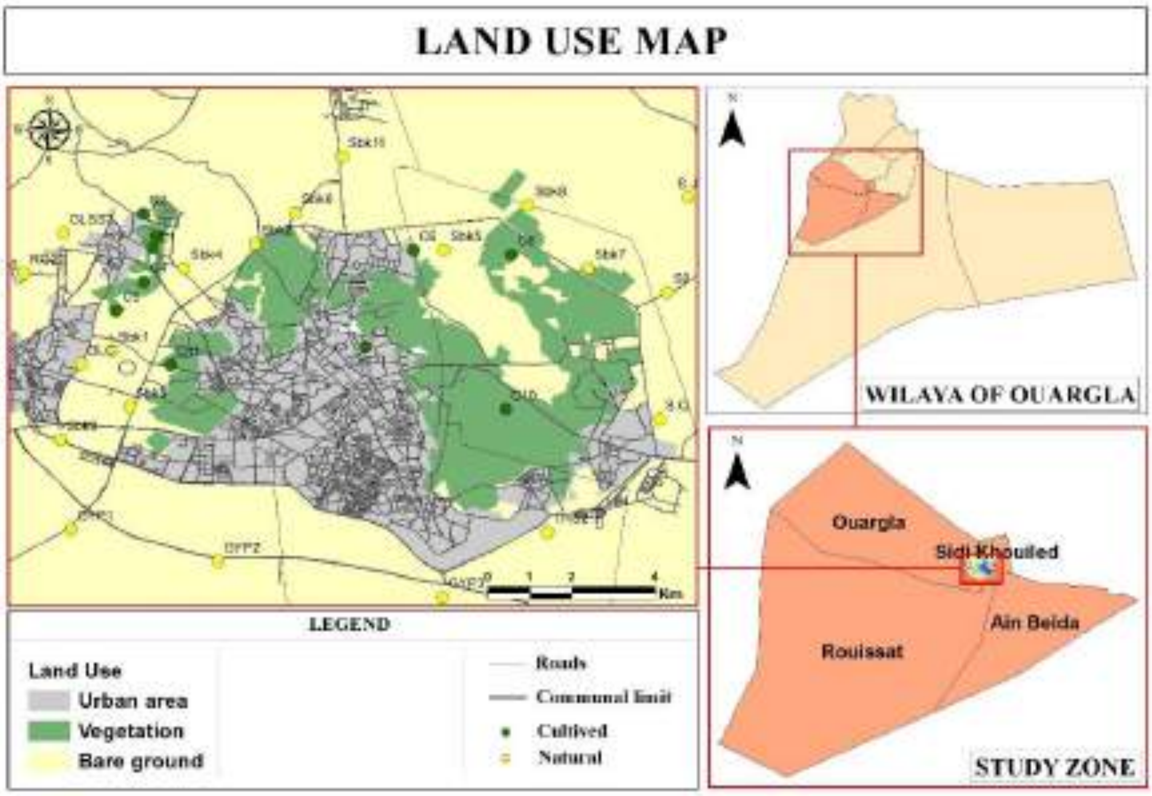

Fig 4. Location of the studied sites

II.2.1.2. Soil sampling

In this study, soil samples were collected in January 2021 from 12 sites in Ouargla region, (Bamendil,Said Otba ,Chott, Balaa, El Mekhadma, El Nasr district, sidi khouiled , road of Ghardaia, Sedrata, El Hadeb, Om Raneb and Bour el Haicha), noting that they were collected differently from both natural and cultivated soil.

As a list of 37 samples, 11 of them were collected in cultivated soil (palm groves) and the other 26 in natural soil.

A detailed description of sampling sites is listed in Table S1

Topsoils were sampled (see **fig5**) in five replicates in one hectare of a depth of 10 cm with a spade (a small size one) (AFNOR., 1999; Boubehziz et al., 2020). After mixing the cores and bringing them back to the lab.

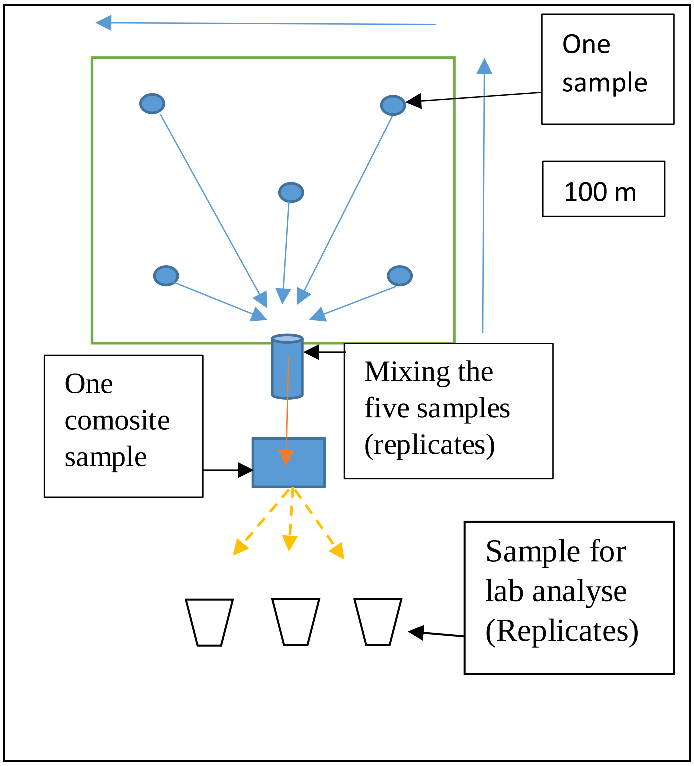

Fig5. How to take the sampling of soils

Photo1. Natural soil (marsh of Bamendil)

Photo2. Cultivated soil (palm groves in Bamendil)

II.2.2. Analysis of soil organic matter content in the soil

II.2.2.1. Walkley–Black (WB) method

Soil samples were grinded and passed through 2 mm sieve. Weigh 1g of soil and transfer to the 250 ml volumetric flask of borosilicate glass. 10 ml of 1 N potassium dichromate ($K_2Cr_2O_7$) and 20 ml of concentrated sulphuric acid (H_2SO_4) were added to soil and stir well to ensure the proper mixing. After 30 min, 200 ml of distilled water and 10 ml of concentrated orthophosphoric acid were added to the sample. Thereafter, 1 ml of Diphenylamine indicator was added in flask and unconsumed potassium dichromate was determined by titration with 0.5 M Fe^{2+} solution to determine SOC in the soil (Walkley and Black 1934 in Kumar, S., 2019).

2.2.1.1. C and OM% (Pansu et Gautheyrou, 2006)

a. **Percent of Easily Oxidizable Organic C**

$$\%C = \frac{(B-S) \times M \text{ of } Fe^{2+} \times 12 \times 100}{\text{g of soil} \times 4000}$$

To convert total organic C to organic matter, use the following equation:

b. **Percent of Organic Matter**

$$\%\,OM = \%\text{ total C} \times 1.72$$

Photo3. The titration

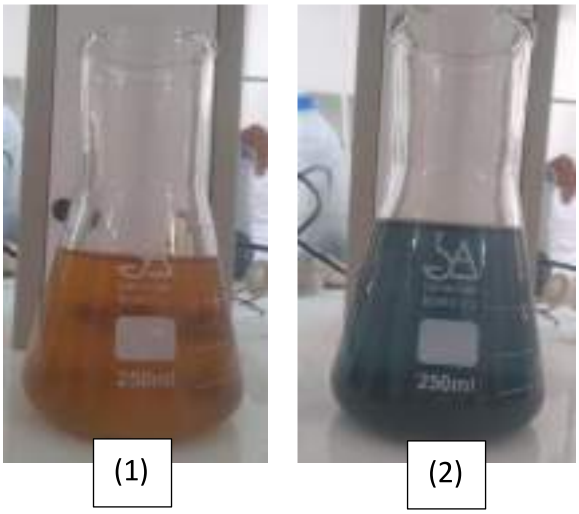

Photo4. The color obtained before (1) and after (2) titration

II.2.2.2. Loss on ignition (LOI) method

Per cent soil organic matter (SOM) was determined using LOI method (Storer, 1984 in Schulte and Bruce. 2009). 5 gm of soil sample (0.2 mm mesh sieve passed) was weighed in known weight of empty silica crucible. It was then heated in oven at 105◦C for 2hrs to remove all of the moisture content then cooled the crucible in desiccators and weighed. This soil weight was taken as dry weight of soil and then transferred the silica crucibles into the muffle furnace at 360◦C for 2 hrs. Thereafter, it was cooled in desiccators and weighed. The weight of soil loss expressed as a percentage of dry soil weight. LOI or per cent SOM.

2.2.2.1. Calculation

Loss of weight on ignition (LOI) is calculated by the following equation:

$$\textbf{LOI (\%)} = \frac{\text{Weight at } 105^{\circ}\text{ C - Weight at } 360^{\circ}\text{ C x 100}}{\text{Weight at } 105^{\circ}\text{ C}}$$

Photo5. The silica crucibles into the muffle furnace at 360◦C

Chapter III

Results and Discussion

III.1. RESULTS

III.1.1. Soil organic matter of Ouargla region

Soil samples in (cultivated and natural soil) were analyzed for SOM by Walkley–Black (wet oxidation), and LOI methods. The SOM content in all soil samples were summarized in Table4 for each station.

Table4. The percentage of organic matter in WB and LOI methods for each station (natural and cultivated soil)

Station	Soil	Sample	OM%	LOI
Bamendil	**Cltv**	C 1	0,83	2,95
		C2	1,13	1,32
		C3	0,78	1,47
		C4	0,63	1,74
		C5	0,81	4,09
	Nat	SBK 1	1,82	2,93
		SBK 2	1,13	7,13
		SBK 3	0,95	8,72
		SBK 4	1,07	2,16
Said Otba	**Cltv**	C6	1,16	3,73
		C7	1,56	2,34
	Nat	SBK5	1,46	4,29
		SBK6	0,88	4,90
Chott	**Cltv**	C8	0,82	1,14
	Nat	SBK7	0,52	2,06
		SBK8	0,95	3,24
El Nasr district	**Nat**	GLC	0,67	1,71
		RG1	0,58	1,15
		RG2	0,59	0,79
		GLSS1	0,52	0,55
		SBK9	0,65	3,31
sidi khouiled	**Cltv**	C9	1,04	4,10
	Nat	S1	0,68	1,18

		S2	0,52	0,47
		S.Q	0,5	0,66
		S.J	0,58	2,53
Road of Ghardaia	**Nat**	RG3	0,52	0,98
		GLSS2	0,41	1,71
Sedrata	**Nat**	GPS1	0,63	6,48
		GPS2	0,68	4,00
		GPS3	0,51	8,01
El Hadeb	**Nat**	TRAS1	0,7	2,79
		TRAS2	0,62	2,60
Om Raneb	**Nat**	SBK1O	1	2,71
Bour el Haicha	**Nat**	SBK11	1,2	2,43
Bala	**Cltv**	C10	1,87	6,83
El Mikhadma	**Cltv**	C11	1,02	2,21

III.1.1.1. Results of Walkley-Black Methods

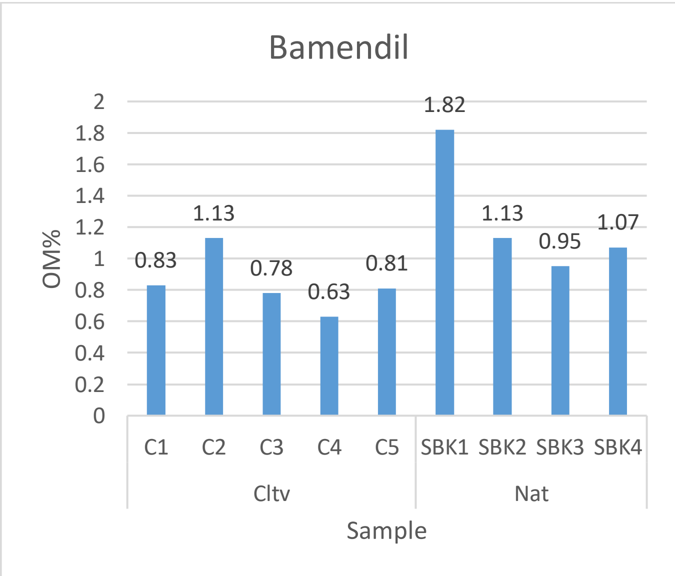

Fig6. The rate of OM in **Bamendil** station

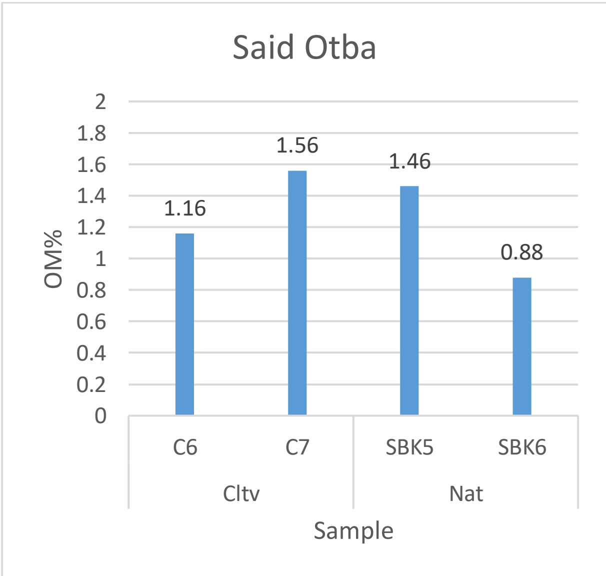

Fig7. The rate of OM in **Said Otba** station

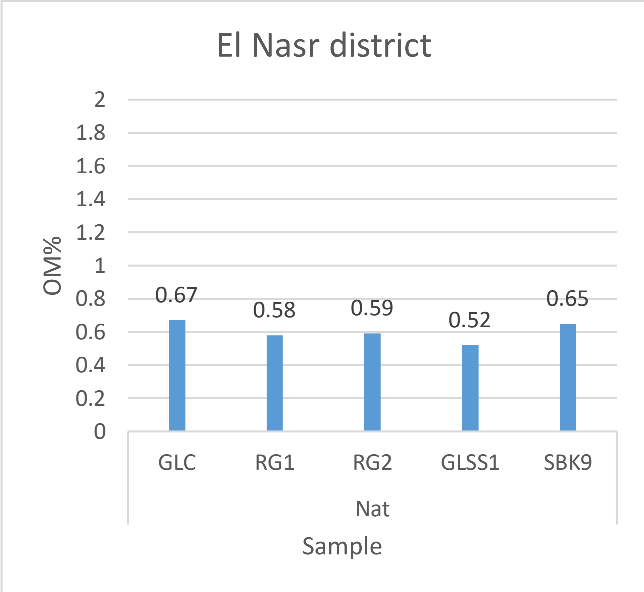

Fig8. The rate of OM in **El Nasr district** station

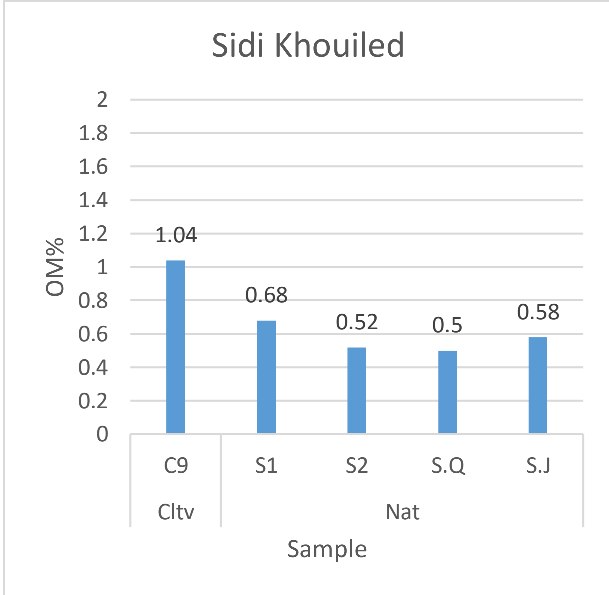

Fig9. The rate of OM in **Sidi khouiled** station

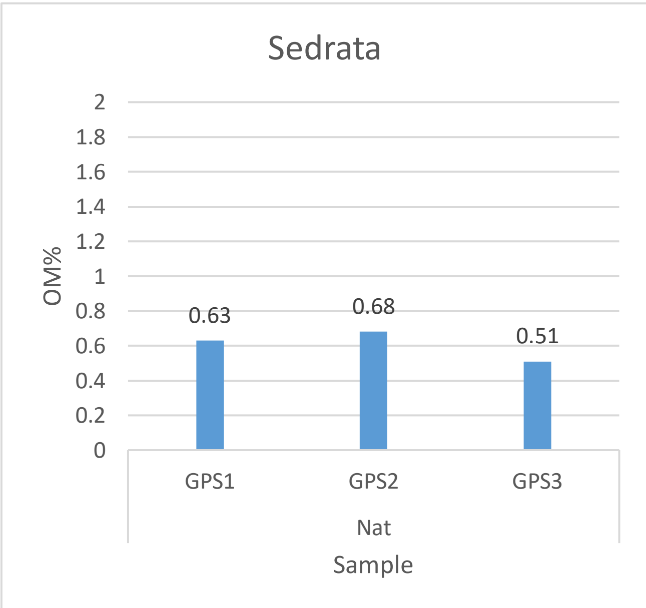

Fig10. The rate of OM in **Sedrata** station

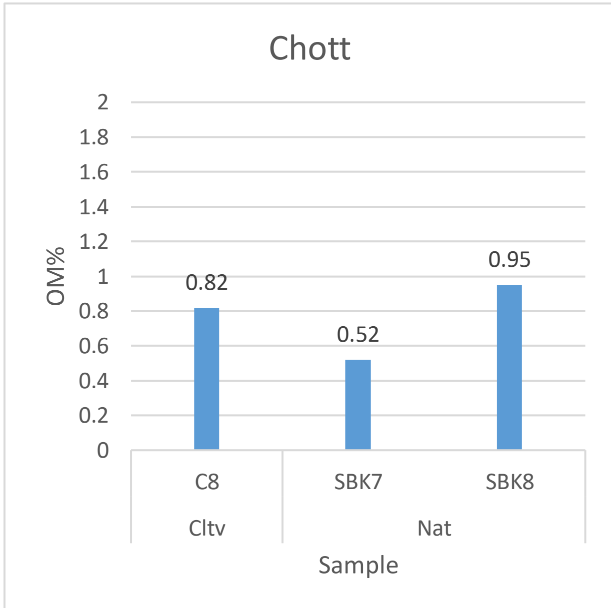

Fig11. The rate of OM in **Chott** station

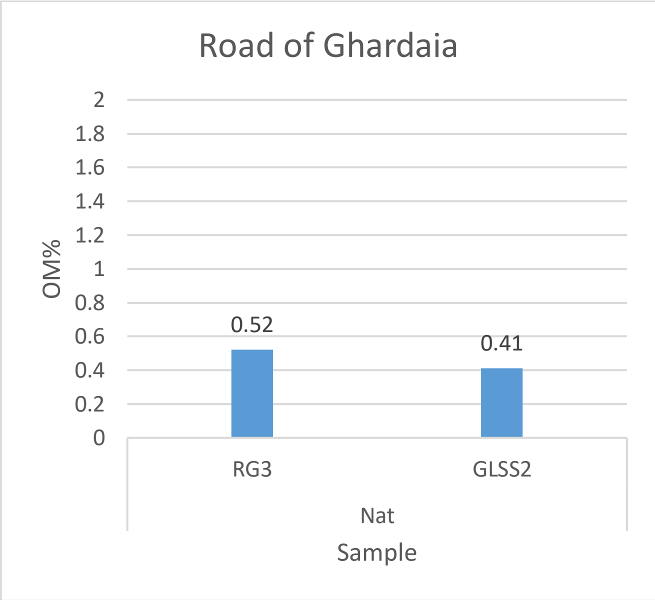

Fig12. The rate of OM in **Road of Ghardaia** station

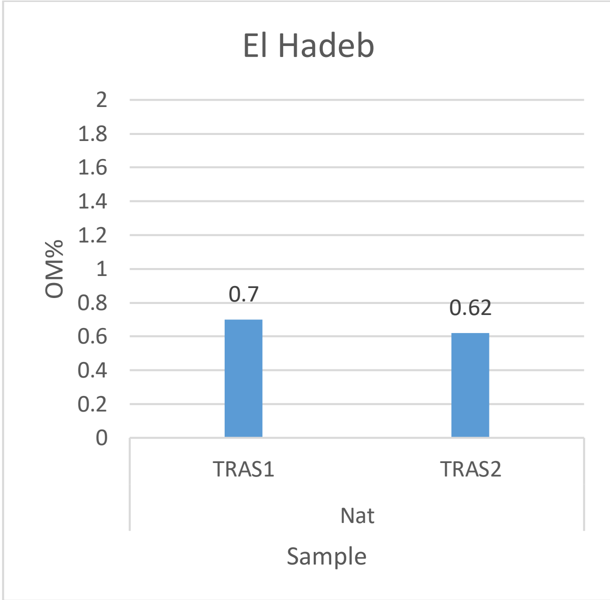

Fig13. The rate of OM in **El Hadeb** station

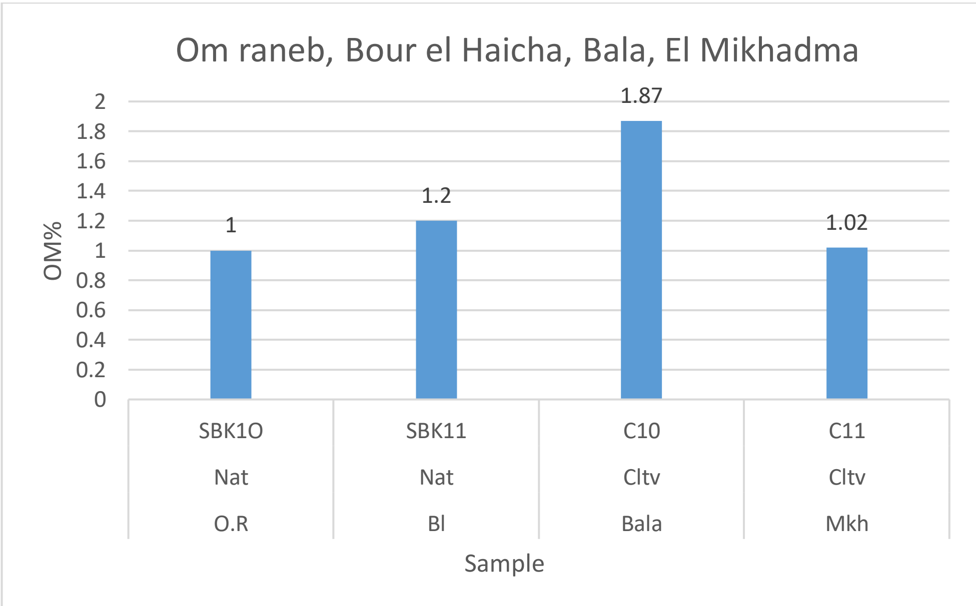

Fig14. The rate of OM in **Om Raneb, Bour el Haicha, Balaa, El Mikhadma** stations

-The highest content of OM (around 1,82%) is obtained in SBK1 of naturel soil (**fig. 6 table3**). It seems that is linked to the effect of the clay content in this land.

The histogram above shows that the highest levels of SOM are observed in the naturel soil (0,95 to 1,82%) compared to the cultivated soil (palm grove). (**fig6 Table3**)

-In Said Otba we can notice that the OM% (**Fig7 Table3**) is (1,16-1,56) in the palm grove and in the natural soil the OM% is 0,88-1,46% has been noted.

And the highest content of OM (around 1,56%) is obtained in the sample C7 of cultivated soil (palm grove).

-The OM% noted (**Table3 and Fig8**) in El Nasr district station shows that the OM% between 0.52 and 0.67%in the natural soil.

-In Sidi Khouiled we can notice the highest content of OM% is obtained in the sample C9 of cultivated soil (palm grove).

And we can notice that the OM% is (1,04%) in the palm grove and in the natural soil the OM rate between 0,5-0,68 % has been noted. (**fig9 Table3**)

-We notice in Sedrata station that the OM%, between (0,51-0,68%) in the natural soil has been noted. (**fig10 Table3**)

-The results of OM% analyze from Chott station (**Table 3 fig 11**), rate between 0.52% -0.95% in the natural soil and in the cultivated soil we can note 0.82%of OM%.

-The results of OM% analyze from the Road of Ghardaia station (**Table3 and fig 12**), show that the OM rate is 0.52% in RG3 and 0.41% GLSS2 in the natural soil.

-The OM% results from Hadeb station (**Table 3 and fig 13**), between 0.7% TRAS1 and 0.62%TRAS2 in the natural soil.

-We notice in natural soil that the OM rate is 1% SBK10 and 1,2% SBK11in cultivated soil we notice 1,87% in C101,02% in C11. (**fig14, Table3**)

NOTE: In general, we can notice that the OM rate is very low in all the samples 2%or less.

III.1.1.2. The difference between Walkley-Black and loss-on-ignition methods

The histogram (fig15) above shows the difference between the OM% results in Walkley-Black (WB) methods and loss-on-ignition (LOI) methods for each 37 station.

Where we notice a high difference between 20 samples results out of 37, compared to the rest results, where the analyzes results of the loss-on-ignition methods are always high, compared to the results of Walkley-Black methods.

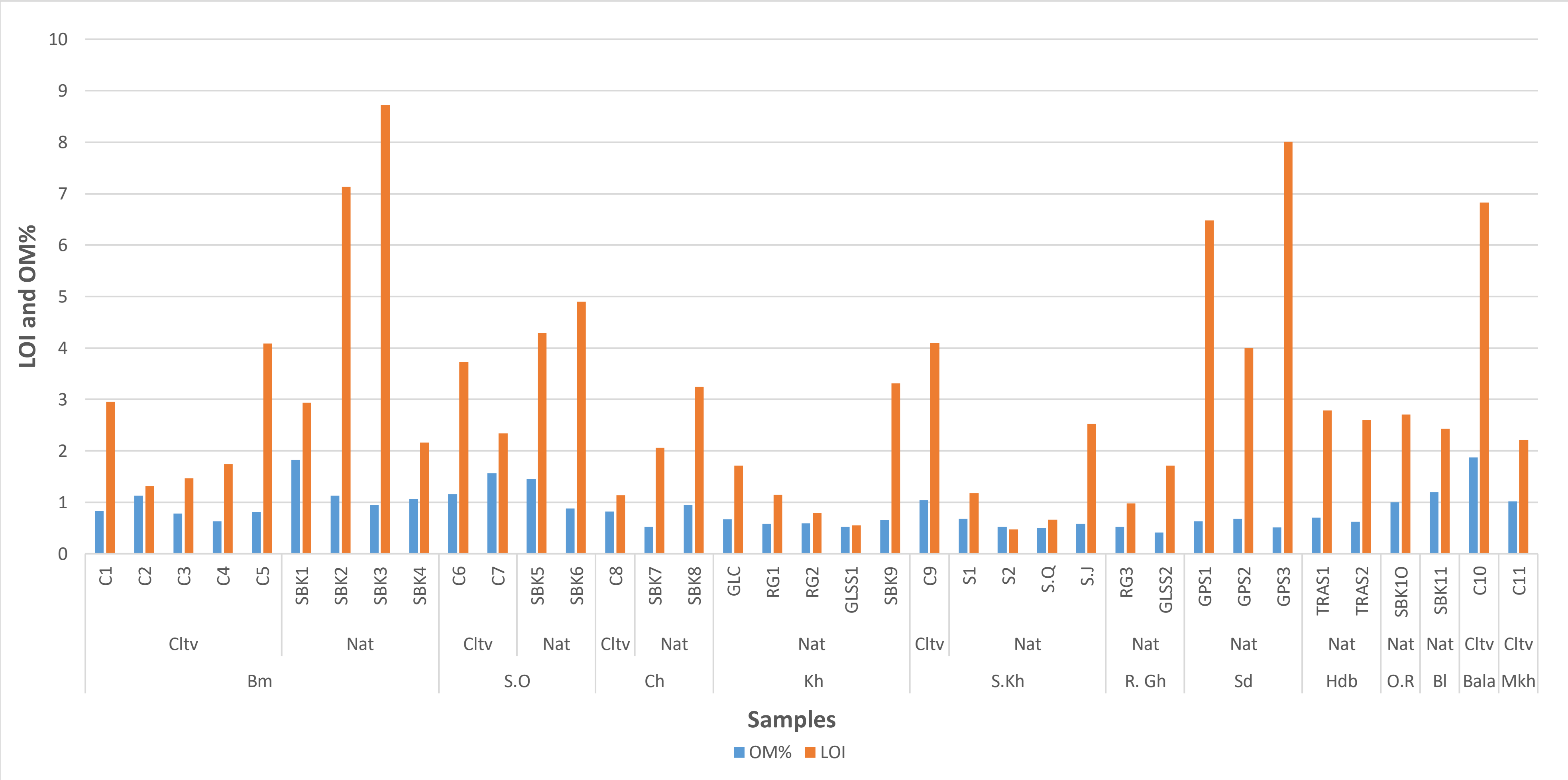

Fig15. Results of organic matter (%) using Walkley-Black (OM) and loss-on-ignition (LOI) methods

III.2. DISCUSSION

III.2.1. The rate of soil organic matter in Ouargla region

Soils of Ouargla region are characterized by low organic matter content (0.1-0.9%) (Halilat, 1993).

In the studied area we noticed that the organic matter rate is low to very low according to Djili (2000 in Berkal, 2006) (table 5).

Table5. The soil organic matter rates

The parsonage of organic matter	Class	The sample
2% > MO >1%	Low content classes.	C2, C6, C7, C9, C10, C11, SBK1, SBK2, SBK4, SBK5, SBK10, SBK11.
MO < 1%	Very low content classes.	SBK3, SBK6, C8, SBK7, SBK8, GLC, RG1, RG2, GLSS1, SBK9, S1, S2, S.Q, S.J, RG3, GLSS2, GPS1, GPS2, GPS3, TRAS1, TRAS2.

We note that the analytical results, recorded in the tables 5, is the OM rate is high (1% <MO <2%) in the palm groves (C2 C6 C7 C9 C10 C11) and SBK samples (SBK1 SBK2 SBK4 SBK5 SBK10 SBK11), compared with the rest of the other samples (fig16,17).

However, according to Schjonning et al., (2004), the capacity of soil to maintain organic matter depend of many factors such as climate, landscape, texture, ... The Sandy soils of arid regions are characterized by a low fertility because of very weak nutritional stock which is explained by the low of organic matter Babaarbi (2013). In addition, the sandy soils are too aerated and the organic matter is more quickly decomposed (Karabi, 2016). The Saharan soils have coarse texture, bad structure and poor in organic matter (Daddi Bouhoun, 2010).

The situation of the deficit organic balance of soils in arid regions is combined with the sand ominance, which characterized the mineralogical fraction of soil. The sand causes the physica l deprotection of organic matter allowing high oxidation and his accessibility to physical ages of degradation the detriment to biological agents (Duchaufour, 1985; Halitim, 1988; Naman et al., 2001; Badiane et al., 2001; Blanchart et al., 2005; Gregorich et al., 2006).

Climatic conditions in these areas did not allow the stock of organic matter, and the few stocked is speedily degraded in the physico-chemical parameters, which inhibit any action of microorganisms in the evolution of soil organic matter (Sasson, 1967; Zombre, 2006; Nicolas et al., 2012).

According to Al-Busaidi et al., 2014 and Bekkariet al. (2016) the organic matter contents are very low and almost nil in some places of bare soils; this is due to the absence of organic matter sources; the vegetation cover in spontaneous plants is very sparse. In cultivated area The SOM comes mainly from manure applied in the palm grove and Crop residues essentially of palm date; this explains the variability of organic matter content in cultivated soils (fig.18).

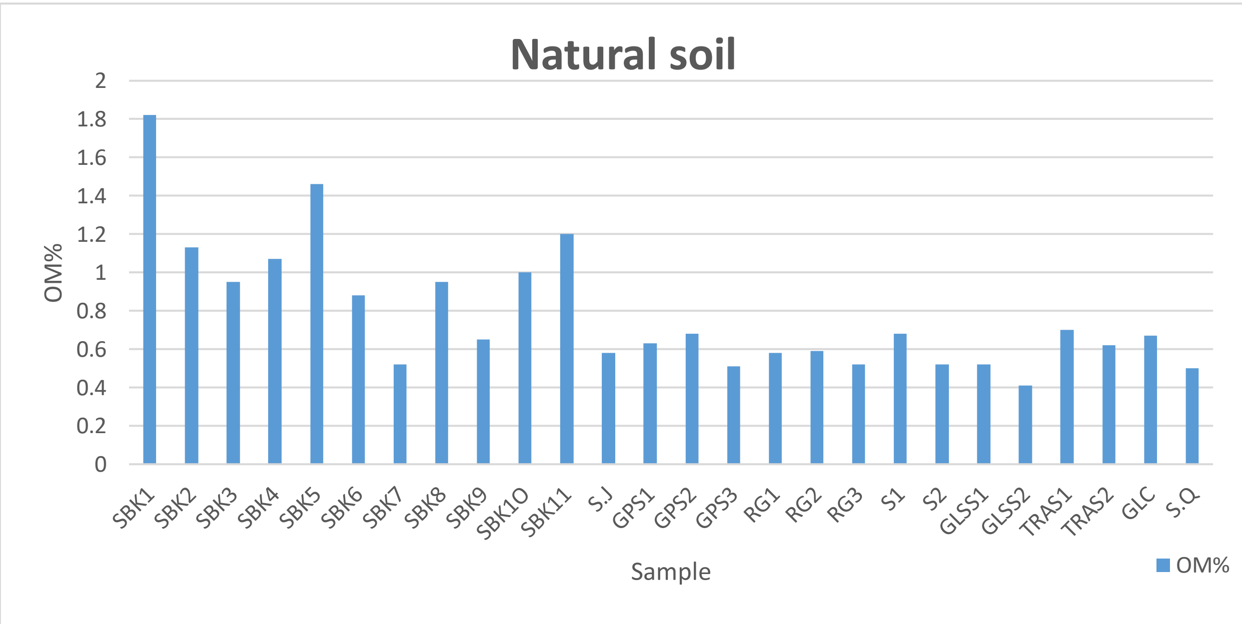

Fig16. The rate of OM in natural soil

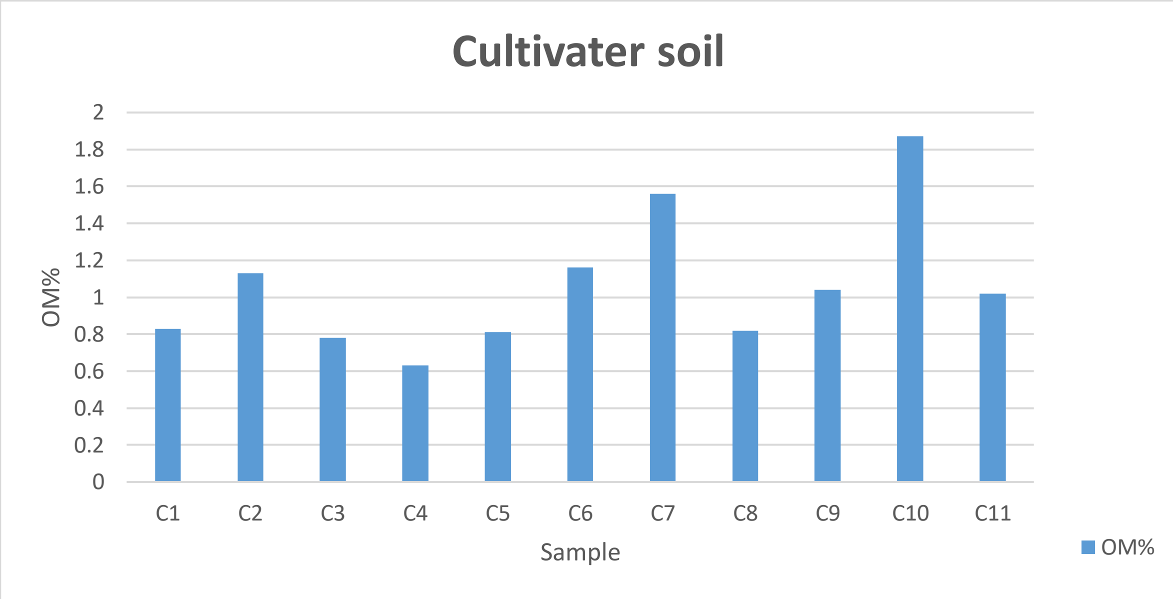

Fig17. The rate of OM in cultivated soil

The texture is sandy, so the carbon sequestration potential is limited (Kösters et al., 2013), and its water retention capacity is also low. This coarse texture makes soil organic carbon quantities subject to erosion and rapid mineralization of organic matter (Lobe et al., 2001; Bruand et al., 2005 in Mlih et al., 2015). Up to 4.7% of organic carbon could be lost annually in the Sahara region in the case of able soils (Karabi, 2016).

Coarse soil texture limits the formation of well-humified soil organic matter and stable organo-mineral complexes. It is known that rapid organic matter turnover exists in coarse-textured soils of arid and semi-arid lands. and only a small amount of fresh organic residues will contribute to the formation of SOM (Karabi et al., 2016).

The Ouargla soils are characterized by alkaline pH and high salinity (Ouastani, 2016). According to (Dellal et Halitim, 1992) the high salinity of the soil can interfere with the growth and activity of bacteria. The concentration of salts in the solution leads to an increase in osmotic pressure. This inhibits the development of microorganisms. A decrease in microbial activity in saline soils leads to an accumulation of undegraded organic matter, which negatively affects the availability of nutrients for plant growth (Zahran, 1997). Therefore, since the biological activity of the soil is low, the percentage of organic matter in the soil is also low.

III.2.2. Spatial variability of SOM

The SOM map (fig. 18) obtained by result of Walkley and Black method of all the samples taken in Ouargla region, to comparing between the natural and cultivated soils and which lands in the region have the highest percentage of organic matter.

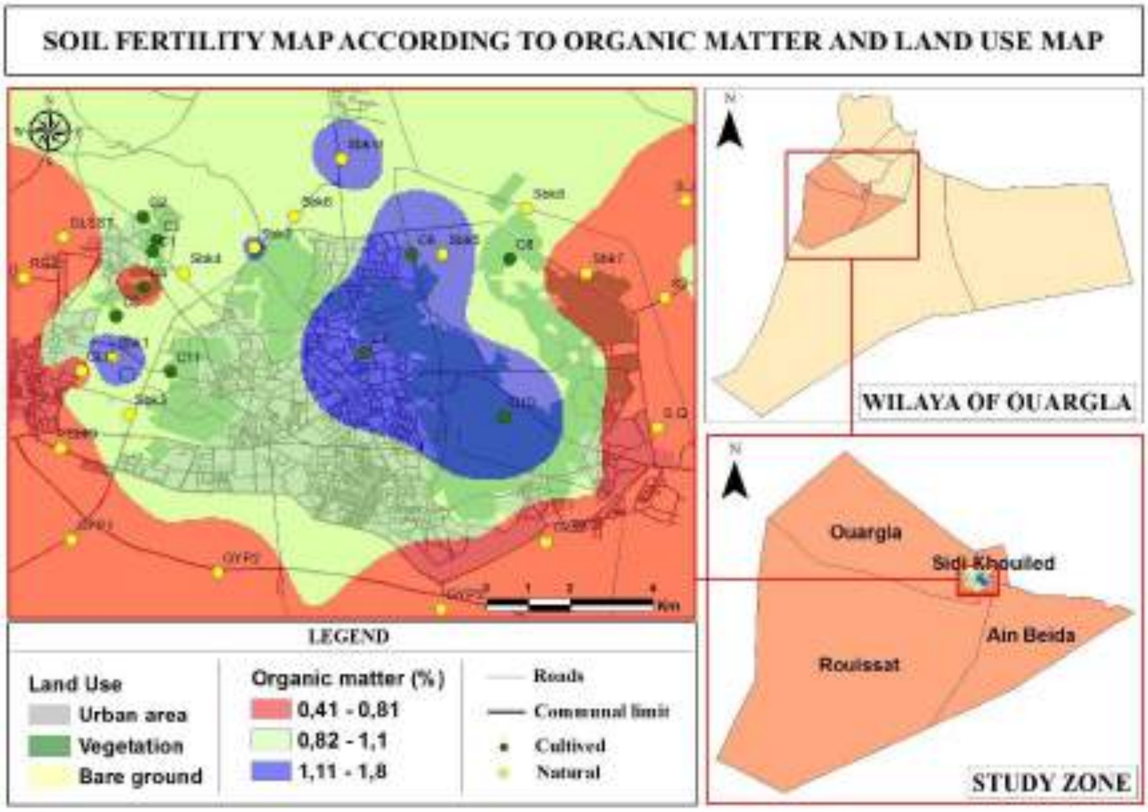

Fig18. The percentage of organic matter at 10 cm depth in natural and cultivated soils in Ouargla region (**See Land Use in fig4**)

Figure18 shows that the soil is irregularly supplied with organic matter at 12 stations (sample 37) in natural and cultivated soils.

We notice that the OM rate is low to very low (<2%) in all the samples. Where the first and the second class of OM% (Table. 5) were distributed almost all over the study area, this can be explained by the nature of the sandy soil and the lack of vegetation cover, (between 0.41-1,1% generally in natural soils).

The last class have > 1% of OM in cultivated soils (palm groves) and natural areas in the marshes.

III.2.3. Comparison between LOI and WB methods

The two methods (WB and LOI) showed us a large difference in OM% results; where the results were high in the LOI method compared to WB results. This is due to the principle of the LOI method which stipulates that the samples are blown in the 360° muffle furnace in order to burn off the organic matter from the soil samples. However, weight loss of soil simples is also related to removing of soil water, especially in soils containing gypsum (CaSO4. 2H2O, CaSO4. H2O, CaSO4.1/2H2O) and/or hydrated salts (Na2SO4. 2H2O, MgSO4. 6H2O, Na2Mg(SO4)2.4H4O…etc). According to Hamdi-Aissa et al, (2004) studied area soils are Gypsic and/or Solonchak (IUSS Working Group WRB, 2015) with high components of gypsum and hydrated minerals especially in the chotts and sebkhas landscape.

And to explain more the results (the table6), we performed statistical operations (Kruskal-Wallis test):

The results of WB method and its three replicates appear in the Groups A (the table5 (1)), while the results of LOI show the difference of the groups in its three replicates (R1 group A, R2 group AB, R3 group B) (see the table5 (2)), Which shows the lack of credibility of the experiment. This makes the WB experiment more realistic and credible in the results of an OM% in sandy gypsum soil.

Table 6. The result of Kruskal-Wallis test

Kruskal-Wallis test	K (observed value)	3,081	K (observed value)	7,164	K (observed value)	33,331
	K (critical value)	5,991	K (critical value)	5,991	K (critical value)	3,841
	DDL	2	DDL	2	DDL	1
	p-value (bilateral)	0,214	p-value (bilateral)	0,028	p-value (bilateral)	< 0,0001
	Alpha	0,05	alpha	0,05	alpha	0,05
Interpretation	Since the calculated p-value is above the significance level		Since the calculated p-value is below the significance level		Since the calculated p-value is below the significance level	

<table>
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<td>alpha=0.05, the null hypothesis H0 can be validated.
The risk of rejecting the null hypothesis H0 when it is true is 21.43%.</td>
<td>alpha=0.05, the null hypothesis H0 must be rejected, and the alternative hypothesis Ha must be retained.
The risk of rejecting the null hypothesis H0 when it is true is less than 2.78%.</td>
<td>alpha=0.05, the null hypothesis H0 must be rejected, and the alternative hypothesis Ha must be retained.
The risk of rejecting the null hypothesis H0 when it is true is less than 0.01%.</td>
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<td>Multiple pairwise comparisons using Dunn's procedure / Two-tailed test:</td>
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<tr><th>Samples</th><th>Groups</th></tr>
<tr><td>R1 WB</td><td>A</td></tr>
<tr><td>R2 WB</td><td>A</td></tr>
<tr><td>R3 WB</td><td>A</td></tr>
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<td>Walkley–Black (WB) method (1)</td>
<td>Loss on ignition method (LOI) (2)</td>
<td>Walkley–Black and Loss on ignition method (3)</td>
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Conclusion

Conclusion

To date, soil studies in the Ouargla region have focused on their physical, chemical and microbiological properties. However, very little data are available on the percentage of soil organic matter in the region. Where organic matter is one of the most important factors of soil fertility and function.

This study made it possible to evaluate the organic matter content of the soil of the Ouargla region.

Twelve stations (Bamendil,Said Otba ,Chott, Balaa, El Mekhadma, El Nasr district, sidi khouiled , road of Ghardaia, Sedrata, El Hadeb, Om Raneb and Bour el Haicha) representing the natural and cultivated soils of the region, A test was performed to measure the percentage of soil organic matter in 3 replicates for each sample. Adopt the WB method and compare it with the results of LOI method.

The results obtained describe that the organic matter content in the soil samples studied which are low and very low. with a medium of 0.86%. The highest percentage of organic matter found in Balaa station (1.87%) in cultivated soils, whereas the lowest percentage was found in Road of Ghardaia station (0.41%) in natural soils.

Generally, the organic matter content is high in cultivated soils (palm groves) (1 to 2%) compared with the natural soils.

The comparison between the results of WB and LOI methods for testing soil organic matter applied to soil samples showed that the results of WB method are more realistic.

Finally, this work is to be continued by:

1) studying the SOM content related to land use and agricultural soil managements especially in the oasis agrosystem;
2) better understand the spatial distribution of organic matter in the Ouargla region and to do more precise SOM distribution maps;

To estimate the SOC stock across the Ouargla region and calculate its storage under different land uses.

References

References

A.N.R.H (2005) Inventaire des forages et enquête sur les débits extraits de la wilaya de Ouargla, Ouargla (Algérie), 23p.

A.N.R.H.2011. Note de Synthèse pièzométrique et hydrochimique relative à la remontée des eaux de la nappe phréatique de la cuvette de Ouargla. Rapport technique.

AFNOR., 1999. Qualité des sols. Vol. 1, Ed AFNOR, Paris, 565 p.

Albrecht, E., A., Bernoux, M., Brauman, A., Chotte, J. L., Feller, C., & Sall, S. (2007). Organic matter and biofunctioning in tropical sandy soils and implications for its management.

Al-Busaidi, K. T., Buerkert, A., & Joergensen, R. G. (2014). Carbon and nitrogen mineralization at different salinity levels in Omani low organic matter soils. Journal of Arid Environments, 100, 106- 110.

Aumassip, G., Dagorne, A., Estorges, P., Lefevre-Witier, Ph., Mahrour, M., Marmier, F., Nesson, C., Rouvillois-Brigol, M., &Trecolle, G. 1972. Aperçu sur l'évolution du paysage Quaternaire et le peuplement de la région de Ouargla. Lybica XX : 206-256.

Babaarbi S., 2013., L'effet des boues résiduaires sur quelques paramètres phénologiques d'orge (Hordeumvulgare L.), Diplôme d'ingénieur d'Etat en Sciences Agronomiques, Université KasdiMerbah, Ouargla, 37 p.

Badiane, N. N. Y., Chotte, J. L., Pate, E., Masse, D., &Rouland, C. 2001. Use of soil enzyme activities to monitor soil quality in natural and improved fallows in semi-arid tropical regions. Appliedsoilecology, 18(3), 229-238.

Bekkari. NE,. alis.Y ,. Benhaddya. ML,. Saker. ML, 2016.Étude de l'impact des activités agricoles sur l'environnement Oasien de la région de l'Oued Righ, Journal Algérien des Régions Arides (JARA) , No 14 (2017).

Berkal, I.2006. Contribution à la connaissance des sols du Sahara d'Algérie. Thèse de magistère. I.N.A EL HARRACHE - ALGER.p63.

Bouammar, B.2007. Le développement agricole dans les régions sahariennes. Université de Ouargla, Algérie, 61p.eille, 20-21 janvier 2011. 12.

Boubehziz, A, Khanchoul, K., Benslama, M., Benslama, A, Marchetti, A, Francaviglia, R. and Piccinid, C. 2020. Predictive mapping of soil organic carbon in Northeast Algeria. *Catena 190* (2020) 104539. https://doi.org/10.1016/j.catena.2020.104539

Brady, N.C., Weil, R.R., 2008. The nature and properties of soils. 14th Edition, PrenticeHall, London, United Kingdom.

Bruand A, Hartmann C, Lesturgez G. 2005. Physical properties of tropical sandy soils: A large range of behaviours. In: Management of Tropical Sandy Soils for Sustainable Agriculture. A Holistic Approach for Sustainable Development of Problem Soils in the Tropics. Khon Kaen, Thailand. http://www.documentation.ird.fr/hor/PAR00007514.

Chatterjee, A., Lal, R., Wielopolski, L., Martin, M. Z. and Ebinger, M. H. 2009.Evaluation of Different Soil Carbon Determination Methods',Critical Reviews in Plant Sciences,28:3,164 — 178 **DOI:** 10.1080/07352680902776556

Daddi-Bouhoun, M. 2010. Contribution A L'étude De L'impact De La nappe Phréatique Et Des Accumulations Gypso-Salines Sur L'enracinement Et La Nutrition Du Palmier Dattier Dans La Cuvette De Ouargla (Sud Es Algérien).

Djili, K. 2000.Contribution à la connaissance des sols du nord de l'algérie Création d'une banque de donnée informations et utilisation d'un système d'information géographique pour la spatialisation et la valonsation des données pédologiques. Thèse de doc,I.N.A .Alger , 243p.

Doran, J.W., M. Sarrantonio, and M.A. Liebig. 1996. Soil health and sustainability. p. 1-54. In: D.L. Sparks (ed.) Advances in Agronomy, Vol. 56. Academic Press, San Diego, CA.

Dubief, J. 1953. Essai sur l'hydrologie superficielle au Sahara. Ed. Service des études scientifique, Alger, 457 p.

Dubost, D.2002. Écologie, aménagement et développement des oasis algériennes. Biskra : Centre de recherche scientifique et technique sur les régions arides.

Duchaufour, PH. (1985). La fertilite du sol : le point de vue du forestier. Le point de vue de l'agronome. Comptes Rendus des Seances de l'Academie d'Agriculture de France.

Dutil P., 1971. Contribution à l'étude des sols et des paléosols du Sahara, Thèse doctorat. d'état, faculté des sciences de l'université de Strasbourg, 346p.

Faci,M. **2017** .Evaluation des changements socioéconomiques dans les anciennes palmeraies (cas de la région d'Ouargla). International Journal of Innovative Research in Human

Sciences,VOL.1,p ?017–034.Journalhomepage: https://oasesvox.com/journals/index.php/ijirhs.

Gaucher, G., Burdin, S.1974. Géologie, géomorphologie et hydrologie des terrains salés. Paris, Presses universitaires de France.

Ghosh S, Wilson B, Ghoshal S, Senapati N, and Mandal B,**2012**. "Organic amendments influence soil quality and carbon sequestration in the Indo-Gangetic plains of India," *Agriculture, Ecosystems & Environment*, vol. 156, pp. 134–141.

Gregorich, E. G., Beare, M. H., McKim, U. F., &Skjemstad, J. O. (2006). Chemical and biological characteristics of physically uncomplexed organic matter. Soil Science Society of America Journal, 70(3), 975-985.

Haddou, M., Babahani , S.,Idder., A .2016.Conduite Du Palmier Dattier DegletNourDans La Région D'ouargla.Vol. N° 6, *.2*.p, *46-55*https://www.researchgate.net/publication/327833382.

Halilat, M. T. 1993. Etude de la fertilisation azotée et potassique sur le blé dur (variété al dura) en zones sahariennes (région de Ouargla), thèse de Magister, université de Batna, Algérie, 130p.

Halitim A., 1988 - Sols de régions arides d'Algérie, Alger, 384 p.

Halitim, A. et Dellal A., 1992.Activités microbiologiques en conditions salines : cas de quelques sols salés de la région de Relizane (Algérie). Cahiers Agricultures, 1, 335-340.

Hamdi-Aissa B., 2001, Le fonctionnement actuel et passé de sols du Nord Sahara (cuvette de Ouargla). Approches micromorphologique, géochimique, minéralogique et variabilité spatiale. Th. Doc. Inst. National Agronomique, Paris-Grignon. 308p.

Hamdi-Aissa B., Valles V., Aventurier A., Ribolzi O., 2004.-Soils and brines geochemistry and mineralogy of hyper arid desert playa, Ouargla basin, Algerian Sahara. Arid Land Research and Management, 18: 103-126

Hamdi-Aissa, B., Girard. M. C., 2000. Utilisation de la télédétection en régions sahariennes, pour l'analyse et l'extrapolation spatiale des pédopaysages. Sècheresse 11(3): 179–188.

Hutson, J. 2016. Teaching Geography, Vol. 40, No. 3, Focus on new horizons (Autumn 2015), Soil sense p. 115-117.

Idder, M.T., Idder, A., Mensous, M. 2011. Les conséquences écologiques d'une gestion non raisonnée des eaux agricoles dans les oasis du Sahara Algérien. Colloque international : usages écologiques, économiques et sociaux de l'eau agricole en méditerranée : quels enjeux pour quels services. Université de Provence, Mars.

Idder, T. 2007. Le problème des excédents hydriques à Ouargla : situation actuelle et perspectives d'amélioration. Sécheresse, Vol .18, n°. 3, p. 161-7. doi: 10.1684/sec. 2007.0085.

IPCC, 1990. Climate Change (eds J.T. Houghton, G.J. Jenkins & J.J. Ephraums), Cambridge University Press, Cambridge.

IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015

Jansson, C., Wullschleger, S., Kalluri, U. & Tuskan, G. 2010. Phytosequestration: Carbon biosequestration by plants and the prospects of genetic engineering. Bioscience, 60: 685-696.

Jenny, H.F., 1941. Factors of Soil Formation. McGraw-Hill, New York.

Juma NG (1998) The pedosphere and its dynamics: a systems approach to soil science, vol 1. Quality Color Press Inc, Edmonton, p 315

Karabi, M., Hamdi-Aïssa, B., Zenkhri, S. 2016.Microbial diversity and organic matter fractions under two arid soils in Algerian Sahara. In: Published by the American Institute of Physics,http://dx.doi.org/10.1063/1.4959402.

Karabi, M.2016, fonctionnement microbiologique des sols oasiens. Cas de quelques sols de la region de ouargla, Mémoire- doctorat, Univ. Kasdi Merbah –Ouargla, 251 P

Karlen, D., M. Mausbach, J. Doran, R. Cline, R. Harris, and G. Schuman. 1997. Soil quality: A concept, definition, and framework for evaluation (a guest editorial). Soil Science Society of America Journal 61:4–10. doi:10.2136/ sssaj1997.03615995006100010001x.

Kayler, Z.; Janowiak, M.; Swanston, C. 2017. Global Carbon. (June, 2017). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. https://www.fs.usda.gov/ccrc/topics/global-carbon

Kemassi, S. 2015. Etude de l’impact des vers de terre sur l’évolution de la matière organique en régions sahariennes : Cas de la cuvette d’Ouargla, MémoireMag, Univ. Kasdi Merbah –Ouargla, 130 P.

Khadraoui, A. 2004. Eau et impact environnemental dans le Sahara Algérien. Définition, évaluation et perspective de développement. Ed. ISBN .310p.

Khadraoui, A. et Taleb , S. 2008. Qualité des eaux dans le sud algérien potabilitépollution et impact sur le milieu (36-37), Ed Khyam Constantine ,367 p.

Kösters R., Preger A.C., Du Preez C. C., 2013. Re-aggregation dynamics of degraded cropland soils with prolonged secondary pasture management in the South African Highveld. Geoderma, 192: 173–181. https://sci-hub.se/https://doi.org/10.1016/j.geoderma.2012.07.011

Kumar, S., Ghotekar, Y. S., & Dadhwal, V. K. 2019. C-equivalent correction factor for soil organic carbon inventory by wet oxidation, dry combustion and loss on ignition methods in Himalayan region. Journal of Earth System Science, 128(3). doi:10.1007/s12040-019-1086-9

Larson, W.E. and F.J. Pierce 1994. The dynamics of soil quality as a measure of sustainable management. p. 37-51. In: J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (eds.) Defining Soil Quality for a Sustainable Environment. SSSA Spec. Pub. No. 35. ASA, CSSA, and SSSA, Madison, WI.

Leger, C. 2003. Etudes d'assainissement des eaux résiduaires pluviales et d'irrigation. Mesures de lutte contre la remontée de la nappe phréatique. Volet étude d'impact sur l'environnement mission IIB : caractérisation environnementale de la situation actuelle.ONA, BG .42p.

Lehmann, J., Kleber, M., 2015. The contentious nature of soil organic matter. Nature 528, 60-68.

Leifeld J and Kögel-Knabner I. 2005, “Soil organic matter fractions as early indicators for carbon stock changes under different land-use?” *Geoderma*, vol. 124, no. 1-2, pp. 143–155.

Mahendran. P. P. and Yuvaraj .M,.2020, Soil Organic Matter. Article: RT0196. Research Today 2(7): 547-549

Minasny B, Malone B P,McBratney A B et al. 2017. “Soil carbon 4 per mille,” *Geoderma*, vol. 292, pp. 59–86.

Mlih R., Bol R., Amelung W., Brahim N., 2015. Soil organic matter amendments in date palm groves of the Middle Eastern and North African region: A mini-review. Journal of Arid Land, doi: 10.1007/s40333-015-0054-8

Mohanty, M., D. K. Painuli, A. K. Misra, and P. K. Ghosh. 2007. Soil quality effects of tillage and residue under rice-wheat cropping on a Vertisol in India. Soil and Tillage Research 92 (1–2):243–50. doi:10.1016/j.still.2006.03.005.

Naman F., Saoudi B., Chiang C., 2001. Impact de l'intensification agricole sur le statut de la matièreorganique des sols en zones irriguées semi –arides au Maroc: Etude de gestion du sol.8(4), 269-277.

Nezli, I.E., 2009. Approche hydrogéochimique à l’étude des aquifères de la basse vallée de l’Oued M’ya (Ouargla). Hydraulique. Université Mohamed Kheider – Biskra, Algérie, p. 117.

Nicolas, C., Hernendez T., GarciaC.2012. Organic amendments as strategy to increase organic matter in particle-size fractions of a semi-arid soil. Applied Soil Ecology (57) 50– 58

Omeiri, N. 2016. Contribution A La Définition D’une Approche De Lutte Contre La Dégradation Des Sols Des Oasis Algériennes : Cas De L’oasis De Ouargla. Thèse de Doctorat, Sciences Agronomiques. Université de Ouargla

Osman, K. T. (2012). Soil Organic Matter. Soils, 89–96. Doi:10.1007/978-94-007-5663-2_7

Oustani, M.2016. Influence des fertilisants organiques sur la réactivité physico-chimique et le fonctionnement microbiologique d'un sol sableux non salé et sableux salé en conditions d'irrigation par des eaux chargées en sels. Thèse de doctorat. Sciences en agronomie saharienne. Universite kasdi merbah–ouargla

Ozenda P., 1983. Flore du sahara. Ed. Centre. Nati. Rech. Sci. Paris.622p.

Pansu, M., Gautheyrou, J. 2006. Handbook of Soil Analysis. Mineralogical, Organic and Inorganic Methods. ISBN-10 3-540-31210-2 Springer Berlin Heidelberg New York, p. 993 **.**

Paré, M.C., 2011. Organic matter quality in cryosols: Effect on soil nitrogen dynamics and greenhouse gas ernissions. Ph D thesis, Saskatchewan University, Saskatoon, Canada.

Pierce, F.J. and W.E. Larson. 1993. Developing criteria to evaluate sustainable land management. p. 7-14. In: J.M. Kimble (ed.) Proceedings of the Eighth International Soil Management Workshop: Utilization of Soil Survey Information for Sustainable Land Use. May 3, 1993. USDA Soil Conservation Service, National Soil Survey Center, Lincoln, NE.

Rebah M, 2016, collection annuaires régionaux annuaire économique et sociale, chambre de commerce et d'industrie Oasis-Ouargla, annuaire 2016-2017 de la région de Ouargla, 210 p.

Reddy. P. P, 2016. Sustainable Intensification of Crop Production, BOOKS, Chapter 11 Soil Organic Matter. P165 **DOI** 10.1007/978-981-10-2702-4_11

Salam A (2020) Internet of Things for sustainability: perspectives in privacy, cybersecurity, and future trends. Springer, Cham, pp 299–327.https://doi.org/10.1007/978-3-030-35291 2_10

Salhi, A.2017. Transformations spatiales et dynamiques socio-environnementales de l'oasis de Ouargla (Sahara algérien). Une analyse des perspectives de développement. Thèse de Doctorat en Géographie. Aix-Marseille Université, 2017 Français. tel-02279906.

Sasson, A. 1967. Recherches écophysiologiques sur la flore bactérienne de sols de régions arides du Maroc., ISC et de la Faculté des Sciences, Série botanique et biologique végétale n° 30 – Rabat Maroc, 230 p

Schjonning P., Elmholt S., Christensen B.T., 2004. Managing Soil Quality: Challenges in Modern Agriculture. CABI, 356 p.

Schmidt M. W. I, Torn M. S, Abiven S et al. 2011., "Persistence of soil organic matter as an ecosystem property," *Nature*, vol. 478, no. 7367, pp. 49–56

Schulte, E. E., and Bruce Hoskins. 2009. Chapter 8 Recommended Soil Organic Matter Tests Procedure for the Northeastern United States: Cooperative Bulletin No. 493.

Seybold, C. A., Mausbach, M. J., Karlen, D. L., and Rogers, H. H 1997. Quantification of soil quality. pp. 387-404. In: Lal, R., Kimble, J., and Stewart, B. A. (eds.). Soil Processes and the Carbon Cycle, CRC Press, Boca Raton, FL.

Sidab (Salon International de la Datte de Biskra).**2015** La datte algérienne .1er salon international de la datte de Biskra, 21 au 24 mars 2015.

Soil Survey Staff. 2014a. Keys to Soil Taxonomy, 12th edition. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC.

Storer, D. A. 1984. A simple high sample volume ashing procedure for determining soil organic matter. Commun. Soil Sci. Plant Anal. 15:759-772.

UNESCO, 1972. Etude des ressources en eau du Sahara Septentrional. In: UNESCO (Ed.), Conclusion et recommandation UNESCO, Algérie, Tunisie, p. 116.

Uttam Kumar , Mishra V.N. , Nirmal Kumar , Srivastava L.K. & Bajpai R.K. (2020) Soil Physical and Chemical Quality under Long-Term Rice-based Cropping System in Hot Humid Eastern Plateau of India, Communications in Soil Science and Plant Analysis, 51:14, 1930-1945, DOI: 10.1080/00103624.2020.1812628

Vasu, D., S. K. Singh, S. K. Ray, V. P. Duraisami, P. Tiwary, P. Chandran, A. M. Nimkar, and S. G. Anantwar. 2016. Soil quality index (SQI) as a tool to evaluate crop productivity in semi-arid Deccan plateau, India. Geoderma 282:70–79. doi:10.1016/j.geoderma.2016.07.010.

Zahran, H.H., 1997. Diversity, adaptation and activity of the bacterial flora in saline environments. Biol. Fertil. Soils. 25, 211-223

Zombre N. 2006. Variation de l'activité biologique dans les zipella (sols nus) en zone subsaharienne du Burkina Faso et impact de la technique du zaï (techniques des poquets) Biotechnol. Agron. Soc. Environ ; 2 : 139-148.

Annex

Annex

Table S1. The location of each station

Station	Soil	Sample	Latitude :N	Longitude :E
Bamendil	Cltv	C 1	N31°59'3.20844"	E5°17'29.90844"
		C2	N31°59'30.04505"	E5°17'22.57143"
		C3	N31°59'11.98615"	E5°17'33.04994"
		C4	N31°58'35.98439"	E5°17'23.12151"
		C5	N31°58'13.07413"	E5°17'1.56641"
	Nat	SBK 1	N31°57'41.05288"	E5°16'58.44693"
		Sbk 2	N31°59'6.50202"	E5°18'49.3546"
		Sbk 3	N31°56'56.66703"	E5°17'11.84487"
		Sbk 4	N31°58'46.77654"	E5°17'54.68136"
Said Otba	Cltv	C6	N31°59'1.08632"	E5°20'52.29604"
		C7	N31°58'2.01259"	E5°20'15.52657"
	Nat	Sbk5	N31°59'1.08682"	E5°21'16.2193"
		Sbk6	N31°59'31.12048"	E5°19'20.67967"
Chott	Cltv	C8	N31°58'57.72245"	E5°22'8.41588"
	Nat	Sbk7	N31°58'46.6244"	E5°23'8.29991"
		Sbk8	N31°59'36.99175"	E5°22'21.87412"
El Nasr district	Nat	GLC	N31°57'30.54554"	E5°16'34.27205"
		RG1	N31°57'48.37442"	E5°15'12.02926"
		RG2	N31°58'43.14212"	E5°15'49.93366"
		GLSS1	N31°59'15.01962"	E5°16'20.8434"
		SBK9	N31°56'30.03097"	E5°16'18.13102"
Sidi khouiled	Cltv	C9	N31°58'42.32824"	E5°24'40.97513"
	Nat	S1	N31°56'59.65235"	E5°24'45.50778"
		S2	N31°58'27.33575"	E5°24'9.66992"
		S.Q	N31°56'46.31903"	E5°24'3.66044"
		S.J	N31°59'43.08227"	E5°24'25.71264"
	Nat	RG3	N31°56'21.00613"	E5°15'5.03888"

Rout de ghardaia		GLSS2	N31°56'34.92791"	E5°15'18.3199"
Sedrata	**Nat**	GYS1	N31°55'18.62972"	E5°16'26.8388"
		GYS2	N31°54'53.53009"	E5°18'20.87147"
		GYS3	N31°54'24.8022"	E5°21'14.96592"
Hadeb	**Nat**	TRAS1	N31°53'52.79125"	E5°22'49.32314"
		TRAS2	N31°55'16.81381"	E5°22'36.66976"
Om raneb	**Nat**	SBK1O	N32°1'24.12509"	E5°23'23.82371"
Bour el Haicha	**Nat**	SBK11	N32°0'15.91038"	E5°19'57.30773"
Balaa	**Cltv**	C10	N31°56'54.50654"	E5°22'3.92862"
El mkhadma	**Cltv**	C11	N31°57'30.0899"	E5°17'44.22007"

2. Location of the studied sites

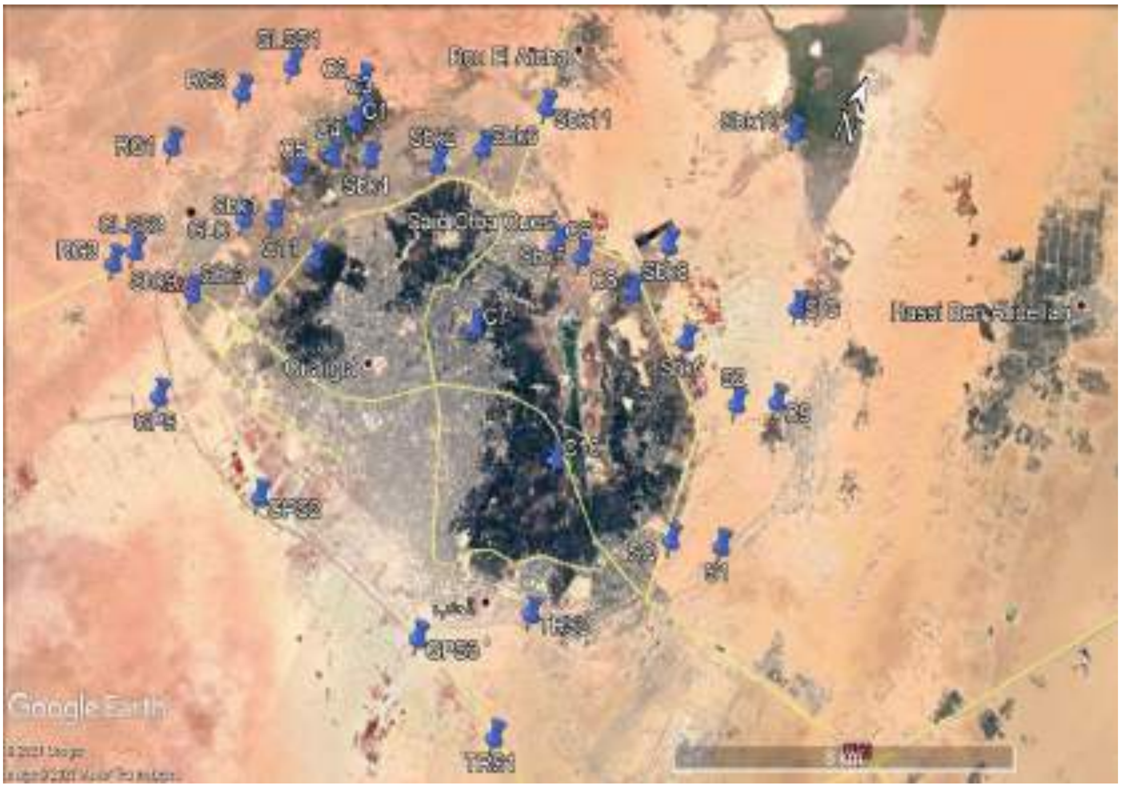

Fig. Location of the studied sites (Google Earth image).

Abstract

The aim of this work was a contribution to the assessment of the content of organic matter in soils of Ouargla region. It is based on the study of the distribution of organic matter in 12 stations (Bamendil,Said Otba ,Chott, Balaa, El Mekhadma, El Nasr district, sidi khouiled , road of Ghardaia, Sedrata, El Hadeb, Om Raneb and Bour el Haicha) representing of natural and cultivated soils in Ouargla region. Organic matter was measured by the Walkley Black method (Wet combustion) and compare it to result of loss-on-ignition method (Dry combustion).

The results obtained indicate that the organic matter was different from one station to another, but show that the majority of the stations have a low and very low content (0,41 - 1,87% of OM). We have observed that the distribution of the organic matter content in the region is different in natural and cultivated soil studied, this is due to several factors, in particular soil characteristics (gypsum and hydrated salts contents).

Keywords: Ouargla; Organic matter; Cultivated soil; Natural soil.

Résume

Le présent travail a été entrepris dans le but de contribuer à l'évaluation de la teneur en matière organique des sols de la région de Ouargla. Il est fondé sur l'étude de la répartition de matière organique dans 12 stations (Bamendil,Said Otba ,Chott, Balaa, El Mekhadma, El Nasr district, sidi khouiled , la raout de Ghardaia, Sedrata, El Hadeb, Om Raneb et Bour el Haicha) représentant les sols naturels et cultivés dans la région de Ouargla. La matière organique a été mesurée par la méthode Walkley Black (combustion humide) et comparée par les résultats de la méthode perte au feu (Combustion sèche).

Les résultats obtenus indiquent que la matière organique était différente d'une station à l'autre, mais montrent que la majorité des stations ont une teneur faible et très faible (0,41 - 1,87% de MO). Nous avons observé que la répartition de la teneur en matière organique dans la région est différente dans les sols naturels et cultivés étudiés, ceci est dû à plusieurs facteurs, notamment les caractéristiques du sol (teneurs en gypse et en sels hydratés).

Mots-clés : Ouargla ; Matière organique ; Sol cultivé ; Sol naturel ; Méthode Walkely Black ; Méthodes de perte au feu.

الملخص

تم تنفيذ هذا العمل بهدف المساهمة في تقييم محتوى المادة العضوية للتربة في منطقة ورقلة. حيث تقوم على دراسة توزيع المادة العضوية في 12 محطة (بامنديل ، سعيد عتبة ، الشط ، باله ، المخادمة ، الخفجي ، سيدي خويلد ، طريق غرداية ، سدراتة ، الحدب ، ام الرانب و بورالهيشة) تمثل التربة الطبيعية والمزروعة في منطقة ورقلة. حيث تم قياس المادة العضوية بطريقة WALKELY BLACK (الاحتراق الرطب) ,ومقارنتها بنتائج طريقة الخصارة بالاشتعال(الاحتراق الجاف).

تشير النتائج التي تم الحصول عليها إلى أن المادة العضوية كانت مختلفة من محطة إلى أخرى، ولكنها أظهرت أن غالبية المحطات ذات محتوى منخفض ومنخفض للغاية من المادة العضوية (0.41 – 1.87%). لاحظنا أن توزيع محتوى المادة العضوية في المنطقة يختلف في التربة الطبيعية والمزروعة المدروسة، ويعود ذلك إلى عدة عوامل، لا سيما خصائص التربة (محتويات الجبس والأملاح المائية).

الكلمات مفتاحية: ورقلة؛ مادة عضوية؛ تربة مزروعة؛ تربة طبيعية , طريقة االخصارة على الشتعال, طريقة WALKELY BLACK .