ASSESSMENT OF ENVIRONNEMENTAL QUALITY IN SOIL UNDER WHEAT AND VINES IN BOUZNIKA-BENSLIMANE REGION OF MOROCCO

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Abstract

This work aims at assessing the environmental quality of agricultural soils under vine and wheat cultivation in the area of Bouznika-Benslimane (Morocco). 50 soil samples were collected and studied. The results obtained been studied and recorded on the agronomic parameters, show that the soil's texture is a little clay with a slightly acid pH neutral.

Moreover, the electrical conductivity values are clearly higher in soils under wheat than in those under vine. The variability of $CaCO_3$ contents within the different studied soils is generally similar in all stations. Moreover, the organic substance rate seems to be more important in the soils under the wheat crops (2%) than in those under the vine crops (1, 7%). The examined soil samples under vine and wheat have shown that these soils contain an important concentration of metal trace elements, essentially the Cu (0, 81 ppm), the Cd (0, 85 ppm), the Ni (81, 86 ppm), the Pb (67, 14 ppm) and the Zn (791, 63 ppm). These metallic elements were also detected in significant concentrations within the soils under vine with a pollution index of high (PI).

Keywords: Bouznika-Benslimane, agricultural soils, vines, wheat, heavy metals

Introduction

When considering different kinds of contaminants, heavy metals are especially dangerous because of their persistence and toxicity (Adriano,

2001). Heavy metal accumulation in soils can result in a loss of soil functions leading to concerns about environmental quality protection, maintenance of human health and productivity. Soil pollution can have implications in phytotoxicity at high concentrations and result in the transfer of heavy metals to the human diet from crop uptake or soil ingestion by grazing livestock (Kabata-Pendias et al., 2001; Nicholson et al., 2003; CCME, 2007 and Kabata-Pendias et al., 2007).

There are two main sources of heavy metals in the soil (Li et al., 2009b): (i) natural background, which represents the heavy metal concentration derived from parent rocks; (ii) including agrochemicals, organic amendments, animal manure, mineral fertilizer, sewage sludge and industrial wastes. In the last several decades, the natural input of several heavy metals to soils due to pedogenesis has been exceeded by the human input, even on global and regional scales (Facchinelli et al., 2007).

The importance of pH in metal solubility is well-known as it influences heavy metal adsorption, retention and movement (Sauvé et al., 1998; Sauvé et al 2000). Related to this, (Matos et al., 2001) have demonstrated that pH and Ca concentration affect Cd, Cu, pb and Zn mobility in soils by competition of adsorbing sites (Oste et al., 2002; Hernandez et al.; 2003; Micó et al., 2006 and Dragovic et al 2008).

Materials and methods

Field of study

The area of this study belongs to the provinces of the Bouznika and Benslimane cities all of which are the Atlantic coast of Morocco. This area is between the cities of Rabat and Casablanca (Figure1). This region is characterized by a semi-arid Mediterranean climate. The annual rainfall average of the last 20 years in the region is about 400 mm. Oceanic influence creates variations at the level of the forest microclimate. These changes result in an increase of the coast rainfall in Benslimane. In other words, the rainfall tends to decrease by the North-South gradient. The minimum and maximum annual temperature average is respectively 10.3 and 23.7 °C (Amami et al., 2010)

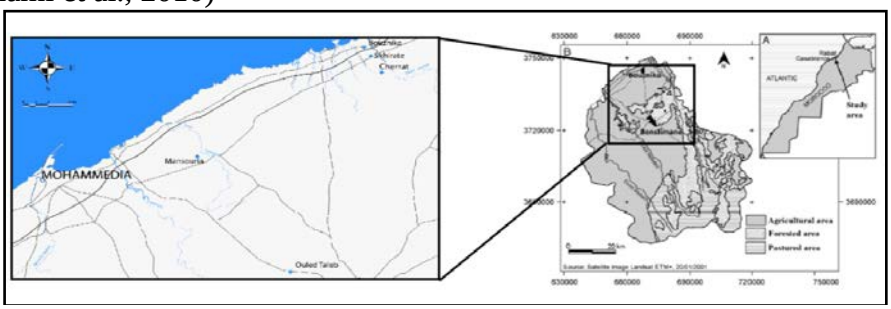

Figure 1: Location of study area

The metal contamination degree of soil is often estimated through the total contents of heavy metals in the surface horizon (El Morhit et al ., 2012). Through out this work, five stations within the region of Bouznika Benslimane are our main field of study. We have looked at 50 samples in all stations (superficie of each station is 0.5 hectar) in the horizon [0-20 cm], this sampling is aleatory.

The stations are selected and classified according to the treatment type of the vine cultivation. Those stations are namely OuledTaleb and Cherrate stations which are characterized by a traditional treatment. Then, there are the stations of Skhairate and Mansfield which are modern stations. The last one is Bouznika which is considered as a check station.

The mode of irrigation has an effect on soil enrichment in some trace element metal (Cd, Pb, Zn ...), it is the case of irrigation with wastewater. In our study, irrigation is drop by drop for plots under vine and the rainwater for plots under wheat.

The Analysis Method

The soils are dried out during seven days, crushed, sifted on 2mm and analyszed. The analysis of the texture in the various stations determined by the Robinson pipette method of (AFNOR. NF X31-107), the analysis of the organic substance has been conducted using Walkley and Black method (1934), the electrical conductivity in the method of Rhoades (ISO 11265:1994), the pH in the method of Mc Lean (1982) while the $CaCO_3$ dosing was made by the method of Bernard (1966).

The determination of heavy metals is carried out by ICP-AES method at the National Centre for Scientific and Technical Research (Rabat). The analytical laboratory follows the standards (1000 ppm accurate JobinYvon) certified by the ISO 9001 quality assurance system.

Statistical analyzes

Statistical analyzes were performed with the help of the XLSTAT 2013 statistical software. The analysis of variance was used to find the significant effect of environmental parameters (Cd, Cu, Fe, Ni, Zn, Pb and Al) and of the other plots.

Results and discussion

Agronomic parameters

The analysis of texture in the various stations revealed that the texture is clay in the Ouled Taleb, silty clay loam in Bouznika and Mansouria, silt loam in Skhairate and clay loam in cherrate station (Figure 2).

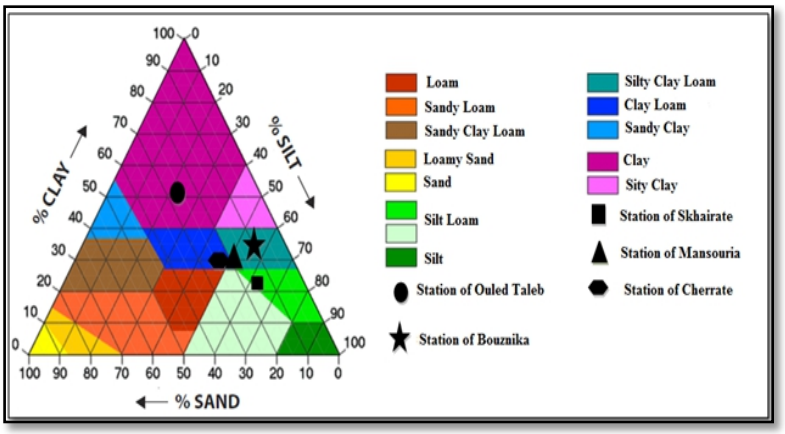

Figure 2: Texture of soils in areas of Bouznika Benslimane

The pH is considered the main chemical parameter controlling the bioavailability of heavy metals in the soil (Brallier et al., 1996). The results of this study show that the highest pH is recorded in the Skhairate station, whereas the Mansouria station show a lower pH under vine and wheat. (Figure3.a). The measurements of the electrical conductivity are lower in the soils stations of Bouznika, Mansouria and Ouled Taleb than in the soils of Skhairate and Cherrate. Measurements are higher in soils under wheat cultivation in comparison with that of the soil vine (Figure3.b).

The $CaCO_3$ values are similar under wheat and under vine in all station, however they can vary in the stations of Cherrate and Mansouria (Figure3.c).

Moreover, the average rate of organic substance in the wheat plots is higher (2%) than under vine (1.7%) with the exception of the plot of land under wheat in Skhairate where there is a supply of organic fertilizer (Figure3.d).

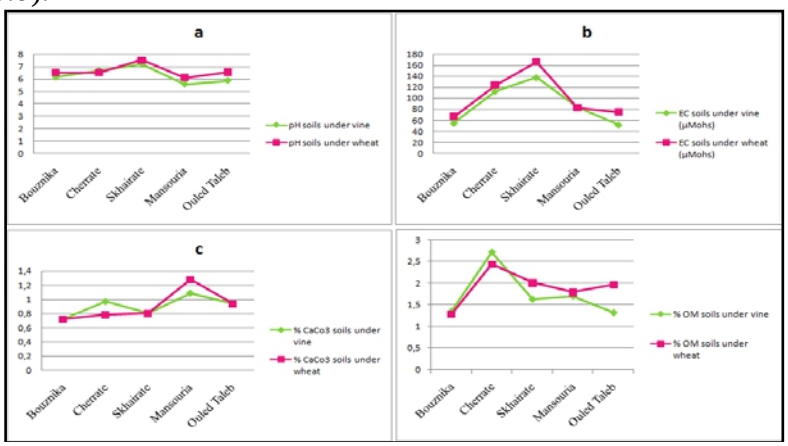

Figure 3: Variations in organic matter, EC, CaCO3 and soil pH under vine and under wheat stations studied

Environmental Parameters

The concentration of metal trace elements (MTE) that is measured in the soil is the outcome of the heritage created by the alteration of the rock concentrations (local geochemical background), more or less altered by soil formation process (soil geochemical background).This background is enhanced by the contributions of human activities (Baize,1997). For aluminum, there is no difference between all stations except in Cherrate station which his concentration is heigher in wheat (Figure4.a). The concentrations of Fe, which are the lowest, are recorded in the stations of Mansouria (6.91 ppm) and of Bouznika (9.49 ppm) while the maximum concentrations are obtained in the soils of the region of Ouled Taleb (65.31 ppm). The difference in the iron concentrations between plots under vine and plots under wheat is highly significant in all stations (Figure.4.b).

The maximum cadmium was obtained in the under vine soil within the area of Cherrate with a grade of 0.81 ppm. The lowest cadmium content was observed in the Shkairate station with an average value of 0.52 ppm. The difference of concentrations is highly significant between plots under vine and plots under wheat at the OuledTaleb, Cherrate and Skhairate stations (Figure.4.c).

Fungicide treatments of the vines have long been based primarily on the salt spray of copper (Cu) on the vine leaves. Their widespread use since the late 19th century has led to the pollution of Cu that resulted in risks such as the Cu phytotoxicity which threatens the plants grown in these soils (Navel, 2011).

In our study, the soil under vine shows high or very high levels of Cu in comparison with the one under wheat. The maximum concentrations of Cu were recorded in soils of Ouled Taleb (66.70 ppm), the difference in copper concentrations between stations is highly significant (Figure4.d).

The highest concentrations of Ni are recorded in the Ouled Taleb under wheat soils. These ones were cultivated with vines before wheat. The difference of Nickel concentrations between plots under vine and wheat is highly significant in all stations (Figure4.e).

The levels of lead found in all stations under study do not generally exceed the normal value of uncontaminated soils (100ppm) set by the OMS. Thus, the maximum lead is recorded in the under vineyards soils which are treated in the traditional way (from 40.84 to 67.14 ppm), while areas of Mansouria and Bouznika show low levels of lead with an average of (38.36 to 40.84 ppm). The difference in lead concentrations between plots of vine and wheat is highly significant in all stations (Figure4.f).

The Zinc substance which is an essential element is to some extent low. However, it causes an acute toxicity with a high dose (Godin, 1982). The average concentrations in soil under vines are greater than those

obtained in the soil under wheat in all the stations with the exception of OuledTaleb station. The difference in zinc concentrations between the plots of vine and wheat is highly significant in the stations of Cherrate and Mansouria (Figure4.g).

Figure 4: Concentration of heavy metals in soils under vine and wheat on the sites studied

The average concentrations of the Cu, Cd, Ni, and Pb found in the soils of the studied regions are below the OMS standard which is namely 2 ppm Cd, 100 ppm Cu, 50 ppm Ni, and 100 ppm for pb (El Morhit et al., 2009).

The average concentrations in soil under vine Zn are above the standard set by the OMS (300 ppm) in the stations of Bouznika, Shkairate and OuledTaleb while they exceed it in the of stations of Cherrate (274 - 378.35 ppm) and Mansouria (261.98 to 791.63 ppm).

In addition, very low levels of iron (6.91 to 65.3 ppm) are recorded in the soils being studied at the level of all stations in comparison with the average maximum levels recommended by the OMS (10 000- 50 000 ppm). These values have allowed us to detect iron deficiency in our soils.

The correlation test between the different parameters being studied allowed us to highlight:

Positive correlations were found between pH, EC and organic matter while moderate correlations were observed between Cadmium and Nickel, Lead and Zinc (Table 1).

Table1: The best correlation coefficients obtained in this study.

	pH	$CaCo_3$	MO	CE	Cd	Cu	Fe	Ni	Pb	Zn	Al
pH	**1,000**										
$CaCo_3$	-0,292	**1,000**									
MO	**0,715**	**-0,526**	**1,000**								
CE	**0,773**	-0,076	**0,637**	**1,000**							
Cd	**-0,423**	0,149	-0,186	-0,246	**1,000**						
Cu	0,103	-0,111	0,300	-0,092	0,263	**1,000**					
Fe	0,172	-0,146	0,380	0,000	0,273	**0,989**	**1,000**				
Ni	-0,135	-0,012	-0,004	-0,253	**0,429**	**0,322**	**0,331**	**1,000**			
Pb	-0,227	0,232	-0,105	-0,128	0,425	0,057	0,028	0,014	**1,000**		
Zn	**-0,538**	**0,507**	**-0,716**	-0,239	**0,480**	**-0,411**	**-0,417**	0,063	**0,246**	**1,000**	
Al	0,325	0,039	0,082	0,304	0,277	-0,278	-0,233	**0,406**	0,195	0,257	**1,000**

Iron concentrations in the different studied soils are perfectly correlated with copper concentrations (Figure 5). Negative and remarkable correlations are recorded between the Zinc, pH, organic matter, copper and iron. In addition, positive correlations were found between the CaCO3 and Zinc, Cadmium and Lead and between Nickel and Cadmium, Copper and Iron (Table 1).

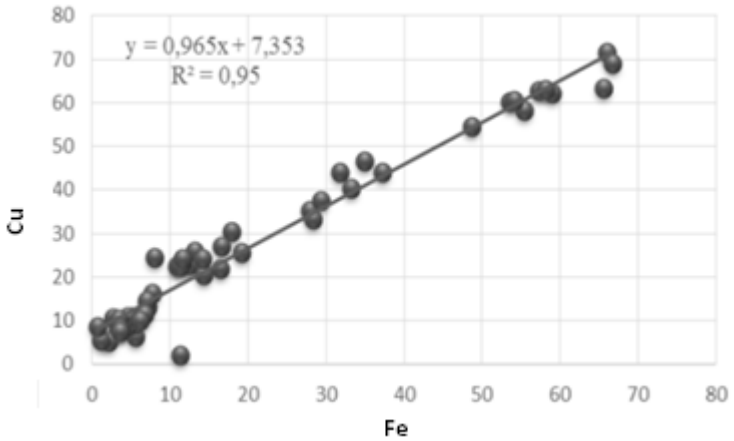

Figure 5: Diagram Correlation iron / copper in soils studied

The heavy metals contamination in the environmental surface is related to all the contaminants rather than to one metal. Several authors have introduced the pollution index of soil to identify the multi-element contamination which leads to an increase in the metal pollution (Lee et al., 2001; Chon et al., 1998 and Nimick et al., 1991).

The pollution index is defined as the rapports means of the metal concentrations in soil samples against the limit values (Jung, 1995).

The calculated values of pollution index shows that soil under vines are more polluted soil under wheat. This pollution seems to reduce in the control station of Bouznika.

The decrease in pollution in the wheat plots of land is comparable to other wheat plots with the exception of the OuledTaleb station.

In fact, in this station, the soil under wheat show high concentrations of Cd (0.724 ppm), Cu (54,696 ppm), Fe (59,868 ppm), Ni (44.762 ppm), Pb and 54.338 ppm (Figure6).

The spatial variation of the pollution index in the region of Bouznika-Benslimane indicates maximum values observed in soil under vine station Mansouria (0.508) while the lowest values are noticed in the under wheat soils within the Skhairate area (0,298).

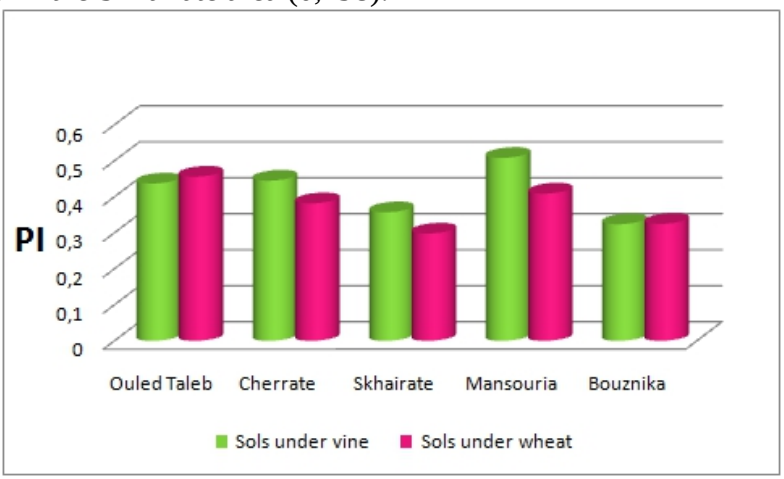

Figure 6: Indices of pollution soils under vine and wheat in each station

Conclusion

The agronomical characterization of the study of soil has allowed us to demonstrate that the electrical conductivity, pH and organic matter are significantly higher in soils under wheat compared with soils under vine.

The contamination evaluation in the soils under vine and wheat within the region of Bouznika-Benslimane and by the metal trace elements (Al, Cd, Cu, Fe, Ni, and Pb) shows that these soils have concentrations below the established standards OMS, with an abnormality detected for Zn

especially for soils under vine. Indeed, some values of this element exceed the critical threshold of 300 ppm set by OMS. The Iron deficiency was recorded at the five study sites.

From a statistical point of view we could highlight:

Positive correlations between organic matter, pH and EC;

- A perfect correlation between Cu and Fe;
- Strong correlations between the Zn, the pH, the CaCO3, the organic matter, the Cd, the Cu, and the Fe.

The pollution index, calculated in the layer [0-20 cm], shows higher values under vine in the OuledTaleb, Cherrate, Skhairate and Mansouria stations and in comparison with the control station of Bouznika.

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