Assessment of trace metal contamination in peri-urban soils in the region of Kenitra - Morocco

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Abstract: The spatial distribution of trace metals in peri-urban soils from Kenitra city (Morocco) was investigated. A total of 10 soil samples (0-20 cm depth) were collected from the studied area. The physico-chemical properties including pH, electrical conductivity and texture were determined. Contents of 6 trace metals (Cd, Cr, Cu, Ni, Zn and Pb) were measured using Atomic Absorption Spectrometry method (AAS).

The results showed that soils of Kenitra city have a sandy texture with a predominance of alkaline pH. The analyzed soil samples can be considered as no salt due to low electrical conductivity values. The trace metals contents revealed that soils are uncontaminated.

Keywords: Trace metals, Peri-urban soils, Contamination, Kenitra city.

Introduction

Soil is the support of many industrial, agricultural and urban activities. Trace metals are released into the soil by natural processes 1-4 like weathering/erosion of parent rocks and ore deposits or by anthropogenic activities like industries, urban (heating, sewage, waste water sludge), transport (road, water) and agriculture (fertilizers, herbicides).

Pollution can be divided in two categories: i) the first one is point source pollution, generally reduced to the plot and most often caused by agricultural, industrial and urban activities, and ii) the second called nonpoint-source pollution, that occur on a regional scale, whose vector is the often atmospheric (smoke thermal, metallurgical plant ...).

The accumulation of trace metals in soil can have adverse impacts on the environment, mainly the risk of contamination of crops, surface and ground-water 5-8. This work is conducted to assess heavy metal contamination in peri-urban soils from Kenitra city.

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DOI: http://dx.doi.org/10.13171/mjc8219042505mea

Material and methods

Study area

Our studied region is located in the northwest of the country, given the proximity of the Atlantic Ocean; Kenitra city is influenced by a maritime sub-humid climate.

Geologically Kenitra city is situated in the Gharb plain, so is composed by a substratum of Paleozoic age which incorporates sedimentary and metamorphic rocks: schist, quartzite and limestone overcame by red clay deposits of Trias and by dolomites and dolomitic limestones of Jurassic and Cretaceous periods. The Miocene which constitutes the impermeable flooring of Gharb’s Deep groundwater is formed by blue marls. In the Pliocene, the sedimentation has double origins: the first transgressions on the current coastal zone gave birth to a coastal sedimentation represented by sandstone and limestone. This formation of the coastal zone can reach 200 m thick and constitutes the most important aquifer; simultaneously and further upstream towards the east, continental sediments accumulate
alternatively between coarse and fine according to the rainfall and violence of erosion on the continent during the period of its creation.

The transgressions of Quaternary were represented by calcarenite of the coast and by a carbonate detrital sedimentation with clay intercalations. The surface area coverage of Gharb plain is characterized by an extension of clay and sandy soils favorable to a wide range of cereal crops.

We chose our site selection according to the proximity of highways, the location relative to main sources of pollution and population density. Ten samples were extracted, the geographic location is shown in Figure 1.

**Physico-chemical analyses**

Surface soil samples were collected from a depth of 0-20 cm, and after air-drying; samples were passed through a 2 mm sieve. The analyses were performed on the fine fraction of soil whose diameter is less than 2 mm.

The soil texture is a measure of the size of the elementary particles which constitute the soil, it was investigated by using granulometry analysis.

Soil pH was measured by in a slurry of soil. Weigh 20 g of soil. Add 50 ml of distilled water, leave to rest for 30 min without agitation, and pass the PH-meter in the sample.

The electrical conductivity was determined with glass electrode conductivity with a ratio of 1/5 (10 g fine fraction to 50 ml of distilled water). Sieve 10 g of soil, add 50 ml of distilled water, leave to rest for 30 min. Shake and pass the sample under the measuring device, then read the result displayed on the screen.

A mineralization of the dry soil was performed by taking 0.5 g of the sample, put in the reactors, 1 ml of HCl and 3 ml of HNO₃ are added. The solutions are allowed to stand until the end of the reaction. After that, we put them in the microwave for one hour.

So the determination of trace metals was made in an Atomic Absorption Spectrophotometer.

**Trace metals concentrations**

The Atomic Absorption Spectrometry was used to determine trace metals levels in sampled soils. This method, based on the theory of quantification of the energy of atoms, is used to determine chemical elements in trace state or in very small quantities (a few ppm) contained in a solution.

For the determination, we used the hollow cathode lamp that emits the specific spectrum of the element to be analyzed. The light beam passes through the receiving device.
Analysis of Atomic Absorption Spectrometry uses the Beer-Lambert law equation:

\[
\log \frac{I}{I_0} = K \cdot L \cdot C
\]

With:

* \( I \) and \( I_0 \): intensity of the incident beam and transmitted
* \( L \): optical path length
* \( C \): concentration of the element to be dosed
* \( K \): coefficient that defines the ability of atoms to produce electrical transitions

Contamination Index

Some authors express metallic contamination with the contamination factor \( F_m \) (measured content / reference content with \( F_m > 1 \)) and \( I_m \) contamination index \(^9,11\).

\[
I_m = \frac{1}{n} \sum F_m
\]

With:

\( n \), the number of elements analyzed. These authors suggest that there is a beginning contamination for \( I_m > 2 \).

Results and Discussion

Granulometry analysis

The granulometric analysis of our samples reflects an homogeneous distribution with a sandy texture. This texture distribution of all samples studied is shown in the following textural triangle.

Soil pH

The pH is a significant parameter, which controls chemical behavior of metals and other important processes in soil. As showed in Figure 3, the soil pH in Kenitra area is significantly different and it ranged between 6.68 and 8. Most soils indicate values above 7. The soil alkalinity can be attributed to the presence of carbonates in soil.

Figure 2. Distribution of samples in the textural triangle

Figure 3. Soils pH in Kenitra area
Electrical conductivity

According to results presented in Figure 4, soils of the studied area have low electrical conductivity, with a minimum value of 0.3 ms/cm and a maximum value of 1.7 ms/cm. As a result, the investigated soils are classified as no salty.

![Electrical conductivity (mS/cm)](image)

**Figure 4.** Electrical conductivity in soils of Kenitra area

Concentrations of trace metals

The minimum, average and maximum concentrations of trace elements analyzed (Cd, Cr, Cu, Ni, Zn and Pb) in soils are summarized in Table 1.

Table 1. Medium, minimum and maximum contents of heavy metals in soils in the region of Kenitra.

|        | Cd (mg/kg) | Cr (mg/kg) | Cu (mg/kg) | Ni (mg/kg) | Zn (mg/kg) | Pb (mg/kg) |
|--------|------------|------------|------------|------------|------------|------------|
| Minimum| 0.02       | 0.02       | 1.07       | 5.05       | 0.02       | 0.02       |
| Medium | 0.08       | 0.14       | 1.64       | 10.73      | 0.05       | 0.19       |
| Maximum| 0.18       | 0.29       | 2.44       | 19.14      | 0.07       | 0.53       |
| [1]    | -          | -          | 5-80       | -          | 20-300     | 2-200      |
| [2]    | 0.35       | -          | 30         | -          | 90         | 35         |
| [3]    | 0.2 - 1    | 70 - 100   | 20 - 30    | 50         | 50         | 10-30      |
| [4]    | 0.05-0.45  | 10-90      | 2-20       | 2-60       | 10-100     | 9-50       |

[1] Fleming & Parle (1977); [2] Normes (Bowen, 1979); [3] Alloway (1990); [4] Baize (1997)

The variation of heavy metal concentrations (Cd, Cr, Cu, Ni, Zn and Pb) between samples is shown in the Figure 5.
Figure 5. Contents of trace metals (Cd, Cr, Cu, Ni, Zn and Pb) in the soils of Kenitra region.
Calculation of Contamination Index

The contamination index was calculated for studied trace metals using reference contents for uncontaminated soils. According to results presented in Table 2, it seems that the contamination index has values less than 2 for all studied elements. So, soils of Kenitra region can be classified as uncontaminated.

Table 2. Trace metals soil contamination indexes of Kenitra region.

| Reference            | Im (Cd) | Im (Cr) | Im (Cu) | Im (Ni) | Im (Zn) | Im (Pb) |
|----------------------|---------|---------|---------|---------|---------|---------|
| Fleming& Parle (1977)| __      | __      | 0,27    | __      | 0,04    | 0,41    |
| Bowen (1979)         | 0,39    | __      | 0,09    | __      | 0,08    | 0,02    |
| Alloway (1990)       | 0,69    | 0,00    | 0,14    | 0,36    | 0,08    | 0,08    |
| Baize (1997)         | 1,38    | 0,02    | 1,37    | 0,58    | 0,08    | 0,09    |

Conclusion

The present study was conducted in Kenitra region in order to assess trace metals contamination in peri-urban soils. The studied area is characterized by a large population, an increasing industrial trend, large agricultural activities, and a considerable traffic rate.

The results of this study shows that the concentrations of trace elements (Cd, Cr, Cu, Ni, Zn and Pb) in the studied area vary between the different elements, and from one site to another. However, we note the absence of contamination by the trace metals in the region.

Indeed, the levels of Ni and Cu in the sampled soils are important in the region. This enrichment can be attributed to urban activities and road traffic, in addition to industrial and agricultural activities.

The low enrichments of Zn can be explained either by the nature of the pedogeochemical ground of soil in the region and the adverse physico-chemical conditions to retention of this trace element.

Thus, the variation in concentrations of trace metals show that they are not governed only by anthropogenic inputs, but also by other parameters such as pedogeochemical ground, the physico-chemical characteristics of soil and the phenomena of mobility.

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