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Monitoring of air pollution in the city of Mohammedia (Morocco): Level of hepatic accumulation of Pb, Cd and Zn in pigeons (*Columba Livia*)

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Abstract: *The use of living organisms to control the air quality is a tool to focus. In this context, this study aims to assess the level of air contamination by lead (Pb), cadmium (Cd) and zinc (Zn) on living organisms in industrial, urban and rural area in Mohammedia, using pigeons as bioindicators of air pollution. To this purpose, a liver collection was performed on 40 pigeons (Columba livia) that were caught in four different sites in Mohammedia, classified according to the density of traffic and industrial activities and then analyzed by the method of spectrophotometry atomic absorption. The results indicate the presence of metals in all samples, the highest concentrations were found respectively in the industrial area, town center, Mimouza, the rural area (control site) for zinc the highest rates were recorded in the rural area. These results suggest that we can have two possible sources of contamination by heavy metals: road traffic and industrial activities.*
Keywords: *Air pollution, bioindicators, heavy metals, Mohammedia, pigeon.*

I. Introduction

Large quantities of pollutants have continuously been introduced into different cities as a consequence of anthropogenic activities such as urbanization, traffic, and industrial processes [1]. Toxic metals such as lead (Pb) and cadmium (Cd) can have adverse effects on various physiological systems, including endocrine systems at the environmentally relevant concentrations [2-6]. Some of the metals, at very specific doses, are essential for the life of organisms. There are called trace elements (which are necessary for biological processes such as iron, zinc, copper...), But any overdose has a toxic effect.While others are not essential, but extremely toxic to the living organisms as (Pb, Cd...ect).

Several surveys have been undertaken in urban areas in an attempt to distinguish plant and animal species that in some way reflect ambient metal concentrations to serve as sensitive biological indicators of metal contamination [7-10].

In Morocco, the problems of air pollution continue to grow at various territorial levels, diagnosis and analysis developed around the evaluation of the state of the air underline the seriousness of this state. Recent studies achieved by Elabidi and Bounagua [11, 12] on the accumulation of Pb, Cd and Zn in pigeons and sparrows show an increased interest in the use of birds as monitors geographical, historical and global models of the assessment of pollution by heavy metals in the environment.

In this context and in order to evaluate the level of metal contamination of the air by heavy metals in different cities including the city of Mohammedia, the present work is to complete the work already done on the use of birds as bioindicators of air pollution in order to make a bio monitoring on the state of air quality in this city.

II. Materials And Methods

Forty adults pigeons (Columba Livea) were captured between November 2013 and March 2014 at four sites in Mohammedia, which were classified according to their road traffic density and industrial activities:

- Rural zone (S1) : is situated about 15 km from center town ;
- Mimouza (S2) : urban area with an average traffic density ;
- Center town : classified as a high density area ;

- Industrial zone (S4): hosts the main refinery of Morocco (SAMIR), the only domestic producer of plastic materials (SNEP) and the largest thermal power plant.

Figure 1: Location of the study sites in Mohammedia (Morocco)

After dissection, liver samples of pigeons captured were stocked in polythene bags at -20°C until analysis. About 0,5 g fresh liver were digested in a Teflon vessel which was very well closed and put in the sand bath at 120°C for 4 hours with 4 ml of nitric acid suprapur (65% Merck) and the volume of final solution was adjusted to 25 ml with deionized water [13].

The dosage of Pb and Cd in liver samples was accomplished by (VARIAN GTA 120 AA 240 Z) atomic absorption spectroscopy with graphite furnace, the background correction was made by a Zeeman effect, while the dosage of Zn was performed by atomic absorption spectroscopy (VARIAN AA40 FS) with flame, in the accredited laboratory of toxicology in the National Health Institute (Rabat, Morocco).

The validity of the analytical methods was checked by internal control, using standard samples (Regional Council of Research of Canada DORM-2) and by external control using inter calibration exercises (IAEA-0140, 1997, IAEA-433, 2004).

Statistical analysis of data was performed using Xlstat 2010. To make a correlation between the locations and trace metals studied we used the Principal Component Analysis with Pearson's correlation.

III. Results And Discussion:

The average values of the hepatic accumulation of Pb, Cd and Zn pigeons varied between study sites (fig.2). The highest average concentrations of Pb and Cd (0.82 and 0.18 mg / g, respectively) were recorded at the industrial area while the highest value of Zn (62.12 mg / g) was recorded at the rural areas.

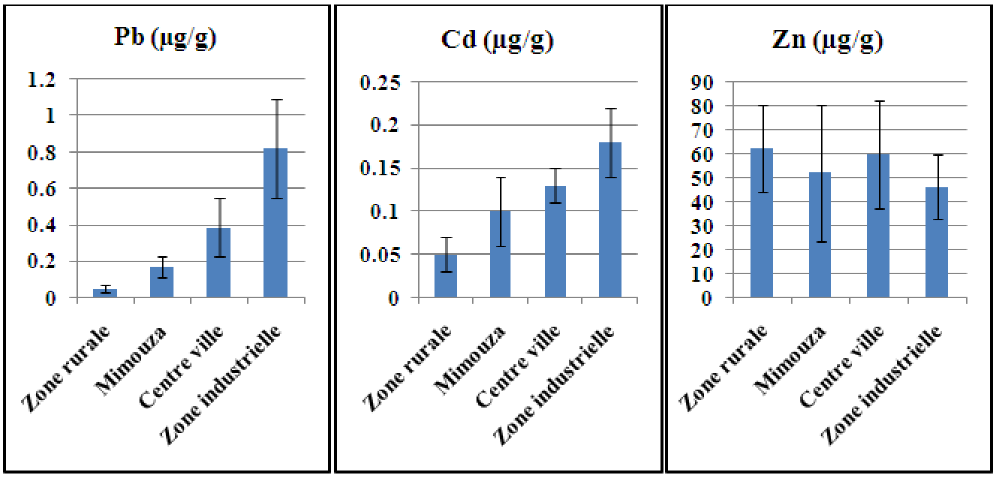

Figure 2: Average contents of Pb, Cd and Zn in the liver of pigeons in the city of Mohammedia

Statistical analysis of the data of the 3 variables (Pb, Cd and Zn) and 40 individuals (pigeons) was made by the principal component analysis (PCA). The correlation matrix (Table 1) of the different elements studied showed a close relationship between the various parameters. This relationship is demonstrated by the correlation coefficients (Table 2).

Table :1 Matrix of Pearson's correlation.

Variables	Pb (µg/g)	Cd (µg/g)	Zn (µg/g)
Pb (µg/g)	1	0,580	-0,102
Cd (µg/g)	0,580	1	-0,017
Zn (µg/g)	-0,102	-0,017	1

Table 2: Correlation between the variables and factors

	F1	F2	F3
Pb (µg/g)	0,890	0,026	0,456
Cd (µg/g)	0,877	0,172	-0,449
Zn (µg/g)	-0,178	0,982	0,067

Table 3: Inertia data and eigenvalues of the first three axes

	F1	F2	F3
Eigenvalue	1,592	0,994	0,414
Variability (%)	53,05	33,146	13,804
(%) Cumulative	53,05	86,196	100,000

The results show that the first axis F1extract 53.05% of inertia, the second (F2) extract 33.14% (Table 3 and Fig.3). The projection plane F1xF2 shows that the three variables are well represented on the correlation circle (Fig.4).

The F1 factor axis is strongly correlated with two variables Pb and Cd (located at the positive side of the component), while the factor axis F2 is correlated with Zn (located on the positive side of the component).

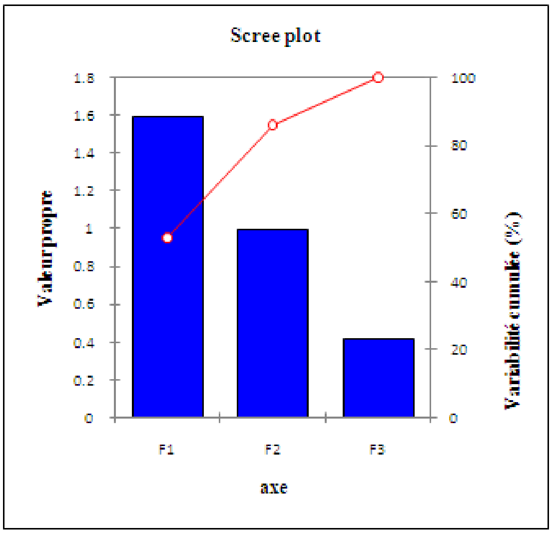

Figure 3: Eigenvalue and cumulative variability

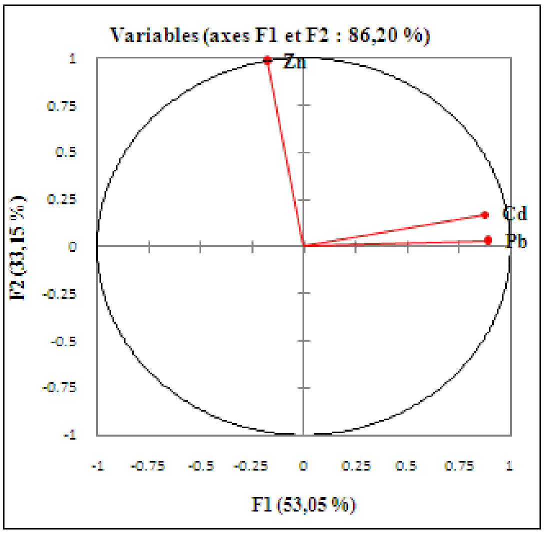

Figure 4: Correlation's circle

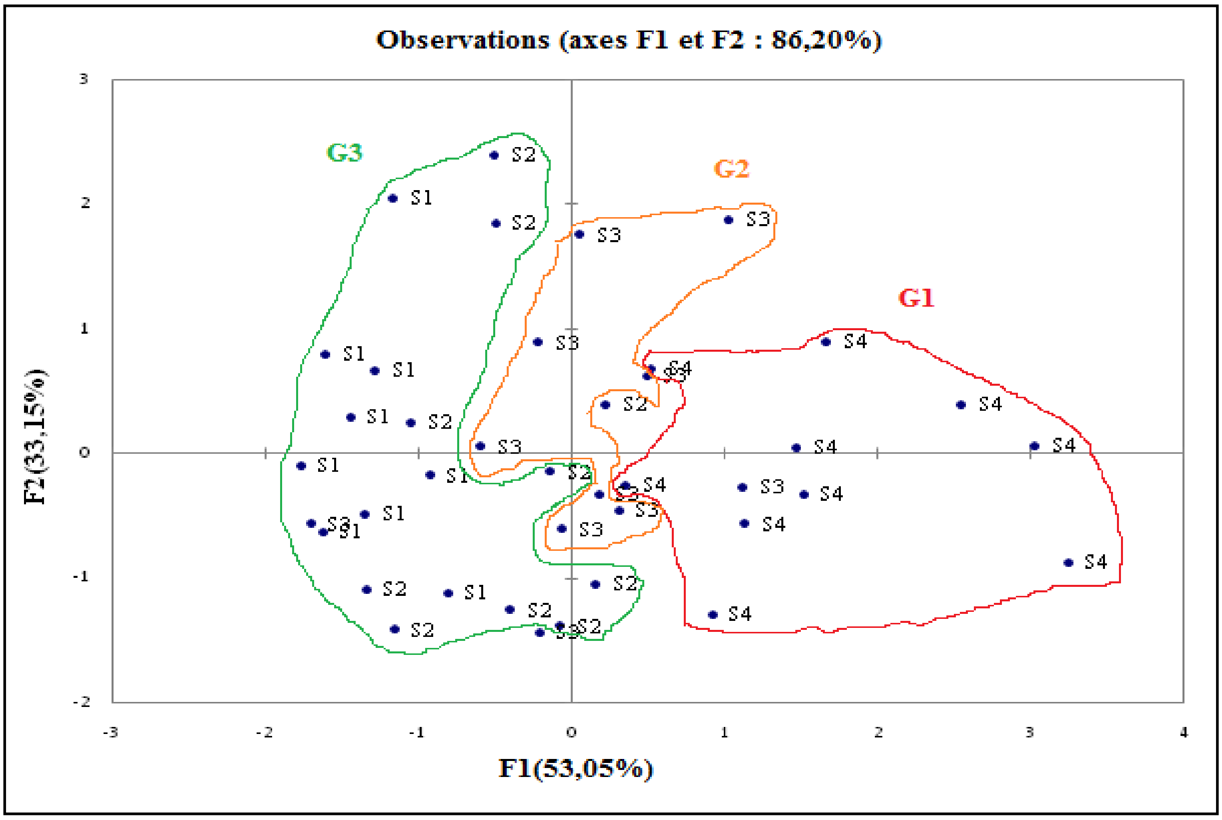

Figure 5: Distribution of sites on the F1xF2 plane.

The analysis of the projection of individuals in the factorial plane F1 and F2 shows a prominent dispersion of the points in the same group; it may be due to the catch taken on different sites in the same area, which explains the remote distribution of these points. Measurements of the points can be divided into three groups:

Group 1: these are the most polluted points Pb and Cd, the sites with high levels of contamination by these two elements are placed on the positive part of the F1 axis. This group contains the sampling points of the industrial area.

Group 2: it includes the least polluted individuals, with concentrations of Pb and Cd lower than those of group 1. These points represent different sampling of downtown sites.

Group 3: it differs from previous groups by its low values Pb and Cd. It includes sampling sites of the two zones (Mimouza and rural area). Zn contents are important to the positive side of the axis F2.

The projection of the sites on axes F1 and F2 shows that the contamination by Pb and the Cd mainly affects the industrial area. These high liver concentrations of Pb and Cd in the industrial area is the origin of the pollution caused by industrial activities, three industrial entities namely SAMIR, SNEP and thermal power plant are installed in this site forming a large industrial complex that threatens whole environment of the city.

Indeed, the extraction of petroleum products is accompanied by countless pollution (especially the dispersion of pollutants in the air), their combustion releases in the atmosphere the gaseous pollutant diverse (lead compounds used as additives in gasoline). As well as the generation of electricity by burning coal used by power plants is a highly polluting activity due to the amount of undesirable products that contain carbon. During pyrolysis (decomposition of an organic compound by heat to obtain other products: gases and material), coal emits many toxic elements such as cadmium.

In urban areas, we can say that the Pb accumulated in the liver of pigeons depending on the density of traffic. Thus the highest lead levels were recorded in the station where car traffic is very dense (City center) followed station where car traffic is moderately dense (Mimouza), while the lowest lead levels have found at the rural area where car traffic is very low.

In urban areas, traffic exhaust is one of the major sources of air pollution that may have adverse effects on ecosystems. Atmospheric pollution by automobile exhaust also results in contamination of soil, water, and food [14].

Our results Cd 0.13, 0.1 and 0.05µg/g respectively were found in areas where car traffic is high, medium and low density. The same observation was made by several authors[9,14-19].

The main routes of uptake of Pb into the body are generally expected to include ingestion of dietary items and inhalation of contaminated air. Nevertheless, in polluted areas, dietary ingestion of small stones may be highly important in Pb uptake because small stones as a gastrolith may be highly contaminated with roadside particles attached to the surface [9].

Indeed, a close association between the Cd levels in pigeons and food intake was also noted at Heathrow, where there was a correlation between the concentration of cadmium in different tissues (liver, kidney ...) and intestinal contents [9].

The low levels of lead and cadmium in the rural area are due to the absence of a significant influence of the two sources of pollution mentioned in other sites, in so far as this area is free of industrial activity and known by a low traffic as it is distant about 15 Kms of industrial emission sources.

In all samples analyzed (Table 1), zinc concentrations were higher than Pb and Cd. This result is quite normal, since zinc is an essential trace element that has a biological function (enzymatic processes, for example), but if it becomes toxic overdoses. While lead and cadmium have no biological role and are toxic to living organisms [20].

Table 5: Comparison of concentration's metals at Mohammedia pigeons with literature data

Region	Pb	Cd	Zn	Reference
Mohammedia-Marocco Rural area Medium road way Town center Industrial area	 0,05±0,02 0,17±0,06 0,39±0,16 0,82 ±0,27	 0,05±0,02 0,1±0,04 0,13±0,02 0,18±0 ,04	 62,12±18,00 52,06±28,29 59,5±22,41 46,16±13,56	 **Present study**
Rabat- Marocco Kamra Centre of town Oulja Allal Behraoui	 0,12±0,01 0,37±0,06 0,56 ±0,05 0,07±0,01	 0,19±0,02 0,20±0,04 0,13±0,02 0,07±0,03	 13,4±3,1 29,0±2,8 120,3±3,3 50,1±4,2	 [11]
Bangladesh Keranigonj Norsingdhi Sirajgonj Mymensingh Comilla	 1,47 5,75 3,02 2,18 1,83	 1,37 0,57 2,41 0,22 0,94	 159,80 280,76 210,50 275,70 272,00	 [1]
Korea Rural Duckjuk Island Urban Seoul Industrial Ansan Busan Ulsan Yochon	 1,57±0,27 2,33±0,78 1,80±0,46 2,72±1,49 1,84±1,20 1,36±0,27	 0,11±0,05 0,24±0,08 0,14±0,05 0,25±0,12 0,31±0,10 0,21±0,05		 [19]
London/Great Britain Chelsea Mortlake Heathrow Controls	 21,6 ±1,95 10,1 ±2,36 6,11± 1,09 2,01± 0,29	 2,45± 0,28 0,40 ±0,07 9,48 ±3,15 0,54 ±0,05	 146,5±8,38 78,8± 6,36 238,6± 36,2 203,9± 31,9	 [9]
Liverpool/ Great Britain Rural Urban Suburban	 2,3±0,6 13,7± 1,6 6,5± 1,7			 [18]
Espagne	 0,29 (0,01-1,66)	 0,10 (0,008-0,37)	 40,91 (20,46-96,63)	 [21]

In the present study, hepatic concentrations of Pb and Cd in the industrial area were found to be higher (0.8 µg/g) compared to the results found by Elabidi (0.56 µg/g) while they were lower compared to the results of studies in Liverpool and London (6.5 et 1.36µg/g respectively) [18-19].

Recent research has shown that the liver appears to be the main heavy metal storage site after the kidneys, and it is a lipid-rich organ which makes it easy to accumulate these metals. These significant differences in concentrations of analyzed heavy metals were observed between the different tissues [1,9, 14, 17, 19].

In the study Korean, lead accumulation in tissues of pigeons may thus be closely related to the feeding habits of pigeons such as ingesting particles on the roadside and/or dust, paint chips and building flakes probably containing Pb. According to this study, the Pb concentrations in tissues of pigeons did not correspond well with the atmospheric Pb levels. Presumably, Pb in air represents a minor contribution to the total exposure to Pb [19].

Cadmium, like lead, is released into the environment by motor vehicles. It is related to the use of tires [22], which explains the one hand the strong levels of cadmium in the liver pigeons from the city center where car traffic is most dense and the other hand the low cadmium levels recorded in the rural area.

Comparison of cadmium contamination levels of Mohammedia pigeons with those found in other international cities (Table 5) shows that cadmium levels in the liver of Mohammedia pigeons are more or less in the range of concentrations measured in the literature.

In our study, it was strongly observed that the highest concentration of Zn (62.12 µg/g) was not recorded in the industrial area but in the rural area, unlike Pb and Cd. In general, rural areas are places where are located agricultural lands. This accumulation of zinc in the liver of pigeons could be explained by the use of fertilizers which usually contain zinc at an impure state and which represents a source of significant benefits to soil [23]. Pigeons may ingest zinc together with stones and soil containing large amounts of this element [24].

IV. Conclusion

This study demonstrated the importance of using pigeons as a bioindicator to examine the biological impact of Pb, Cd and Zn in the environment. The high levels of Pb and Cd found in the liver of pigeons are the result of pollution caused firstly by industrial activities and also by the traffic.

Comparing the metal levels found in the liver of pigeons in the city of Mohammedia with other major world cities, we note that our values are slightly low compared to the results found in the literature, while the two possible sources of contamination by heavy metals are road traffic and industrial activities.

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