Asian Journal of Chemistry Vol. 22, No. 4 (2010), 2753-2760

Evaluation of Air Pollution by Heavy Metals on Bab El Oued Zone of Algiers

M. BELAMRI and K. BENRACHEDI*
Laboratory of Food Technology, Faculty of Engineering Science, University of Boumerdes, Boumerdes, Algeria
E-mail: benrachedik@yahoo.fr

The present study consists in analyzing the quality of the air in the capital. LVS pump (low volume sampler) was used for the collection of the samples in the district of Bab El Oued in Algiers characterized by the presence of a hospital and an incinerator of medical and different other waste as well as a strong density of traffic cars. The aerosols were taken at height of 3 m of the ground in total suspended particulate (TSP) mode. The samples have been analyzed by ED-XRF (energy dispersive X-ray fluorescence). The experimental results show that the daily content of TSP are above limit of the target value 50 μg/m^3. The TSP are responsible for the transport of toxic heavy metals such as Cd, Pb, Cr and Ni.

Key Words: Atmospheric pollution, LVS, ED-XRF, Heavy metals.

INTRODUCTION

The air pollution is a phenomenon which has harmful effects on the environment, the climate and our health. The air is polluted by gas emissions and dust. Thus, the quality control of the air become a necessity to face this problem which becomes more and more universal problem[1,2]. The determination of the polluting agents remains a major concern of the scientists and decision makers. Among these pollutants, one finds heavy metals which play an important role in the toxicity of the air. However, the protection of the quality of the air, imperatively require the knowledge of the nature of the pollutants, their concentrations and the remediation[3,4]. Many conventional and nuclear techniques are used such as the PIXE, the XRF, the INAA and the SAA to control the air quality. These techniques are much requested since the elements going from silicon to uranium are detected and quantified even with the state of traces.

The object of this work consists with the determination of the concentrations of the toxic elements such heavy metal Cd, Pb, Zn, Hg, Cr and Ni in air samples taken in an urban site Bab El Oued in Algiers where the density of population is high and is directly exposed to various transmitting sources of pollution.

EXPERIMENTAL

Air sampling: The site is spread out over 1.8 Km^2 and a density of population estimated at 600000 inhabitants. The site of sampling is the district of Bab El Oued located at the west of Algiers centre 200 m far from the sea. The district is known for its high density of population and intense traffic including weekends (Thursday and Friday). We selected the site on the level of station SAMASAFIA of department of the environment. The station is placed at the entry of the hospital Maillot which knows a great numbers of patients and visitors. The incinerator is approximately 200 m far from the intake point. Most of the cars roll to the diesel and the gasoline with lead exhaust without catalyst. The incinerator functions daily. It incinerates all types of medical waste generated by the hospital. They can be considered the two principal local sources of air pollution around this site.

The collection of the samples was carried out during one month period. The sampling device is composed of a filter holder of the shape of reversed funnels which imbricate one in the other by simple rotation. The head of filter holder is placed on a mast on the top of the cabin approximately 3 m above the ground. The cabin is at the entry of the hospital in front of the principal road axis. The wind prevailing is West-East going towards the direction of the sampler of air.

Generally the sampling of the suspended particles is done on membranes by filtration of the ambient air. Thus, the geometry of the head of filter holder and the sampled air flow condition at the same time the diameter of the particles collected on the filter and the degree of influence of the wind on the effectiveness of sampling[5,6]. The sampling mode used is total suspended particles (TSP). This is justified for two reasons, primarily we don't have a PM10 sampler and secondly this study in TSP aims to implement an increasingly rigorous system of air quality control.

The filter is deposited on a support provided with slits to let pass the air. The pump of aspiration of air used is of low flow of 16.7 L/min and is connected to a volumeter for the measurement of the volume of air passing through the filter. The filters used for the collection of the aerosols are in ester cellulose of porosity 0.8 μm having a diameter of 37 mm. The selected duration of air sampling is 48-72 h to obtain a representative average charge of TSP. This allows us on the one hand an important load of filter and on the other hand to limit saturation for certain elements to avoid saturation effect of the filter leading to worst results.

After the collection and the weighing steps, the sample is deposited in one of tight Petri box and stored in a desiccator. Knowledge of the weight deposited, the sampling duration and the average air flow makes possible to calculate the concentration of the particulate matter expressed in $\mu g/m^3$.

Analytical procedure: The diversity of the substances which can constitute the suspended particles in the atmosphere makes difficult their description. Nevertheless, there are methods which make it possible to determine certain components like their concentration after a preliminary preparation of the sample[7]. For the analytical needs we prepared chemical standards from analytical purity components, by

acid or aqueous dissolution according to the element to be dissolved. The concentration of the mothers' solutions is once diluted to carry out compatible non interfering mixtures, so we can find the required concentrations of 10 µL. These quantities are taken using a micropipette and deposited on filters of the same nature used for the sampling and one lets them dry.

The elementary deposits concentrations on the filters were determined by using energy dispersion X-ray fluorescence technique (ED-XRF). Two sealed radioactive sources were used for the atomic excitation ^{109}Cd for the quantification of elements of weak energies from 0-15 KeV and ^{57}Co for the quantification of elements in the range of energy > 15 KeV. Detector type Si (Li) of 30 mm^2 active surface and a resolution of 165 eV associated to electronic chain has been used. The spectra are treated by software AXIL[8].

RESULTS AND DISCUSSION

Average charges of the filters corresponding to the days of collection obtained over one month period of the 05/04/2007 to the 07/05/2007 in TSP mode are recapitulated in Fig. 1.

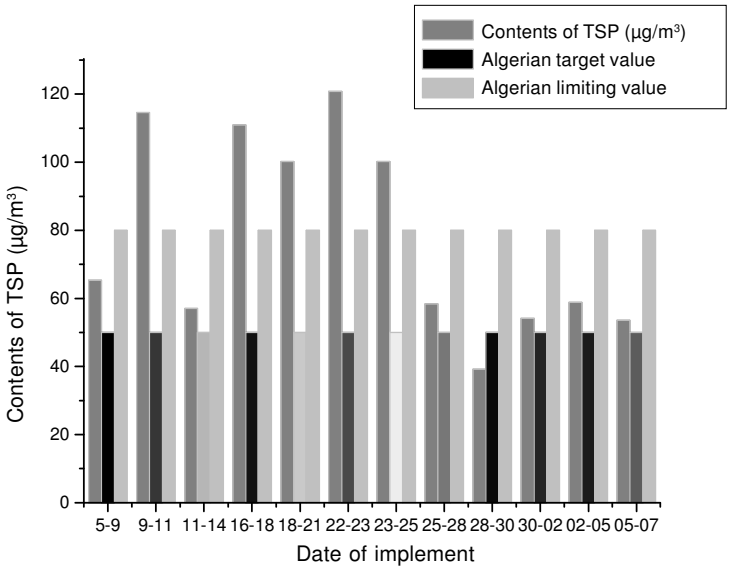

Fig. 1. Contents of TSP according to the date of taking away

The results obtained (Table-1) show that the charges of TSP vary from 39 µg/m^3 to a maximum of 121 µg/m^3. The average content measured is 78 ± 29 µg/m^3 whereas the Algerian standard limit is 80 µg/m^3 and a target value is 50 µg/m^3.

From the point of view of weather parameters, the period of collection was characterized by a strong moisture exceeding the 80 %, a temperature in general stabilize between 13-18 ºC, a direction of wind West-East with velocity varying

TABLE-1
VALUES OF TOTAL SUSPENDED PARTICULATE AND
WEATHER PARAMETERS FOR THE PERIOD OF COLLECTION

Days	Sample	Contents of TSP (μg/m^3)	Rain (mm)	Moisture (%)	Speed (m/s)	Temp. (ºC)
Thursday	1 (05/04/07-07/04/07)	65,35	< 0, 1 mm	81.5	2.4	12.7
Monday	2 (09/04/07-11/04/07)	114,64	< 0, 1 mm	90.0	2.5	15.9
Wednesday	3 (11/04/07-14/04/07)	57,00	18, 3	91.9	2.4	16.6
Monday	4 (16/04/07-18/04/07)	110,92	4, 1	92.9	1.5	15.8
Wednesday	5 (18/04/07-21/04/07)	100,18	< 0, 1 mm	88.8	3.3	17.4
Saturday	5 (21/04/07-23/04/07)	120,77	0	89.4	0.9	17.3
Monday	6 (23/04/07-25/04/07)	100,25	0	90.1	0.4	16.6
Wednesday	7 (25/04/07-28/04/07)	58,40	7, 3	94.0	0.5	17.1
Saturday	8 (28/04/07-30/04/07)	39,19	7, 3	94.0	0.5	17.1
Monday	9 (30/04/07-02/05/07)	54,10	6, 6	89.9	1.1	17.0
Wednesday	10 (02/05/07-05/05/07)	58,83	0	89.6	2.3	18.0
Saturday	11 (05/05/07-07/05/07)	53,59	0	79.3	2.0	17.0

from 0.4-3.3 m/s and a the quantities of rainfall vary from 0-18 mm. The values given in Table-1 indicate that each period of the middle of week a maximum quantity of filter loading except only once when observed a rainfall for this period. It is noticed another high load quantity in TSP in the periods of the beginning and the end of the week where no rainfall has been observed.

According to this data the recorded filter loading is weaker when no rainfall has been observed. It occurred in our opinion a phenomenon of scrubbing which tends to decrease the effect of load of the air filters. The values of the other periods remain beyond the limit fixed by the Algerian regulation. This reveals that the temporal variations of the contents of TSP obtained for this period of air sampling are due probably to the intensity of the road traffic and the incinerator with a notable influence of weather parameters like rainfall rather than the other the speed of the wind, the moisture and the temperature for which post a weak variation have been observed. What does not enable us to appreciate their influence on the contents of TSP.

Study of heavy metals contents associated to the TSP: The analysis by XRF technique allowed simultaneous measurement of several elements, mainly chromium, iron, copper, lead, mercury, nickel, cadmium, selenium, bromine and zinc. Parallel to the determination of heavy metals concentrations, we tested metal contents of blank filters. The experimental results obtained show that they contain notable contents of some metals. There levels are approximately 2-100 % of the total values according to the element concentration. All the concentrations values were corrected from the impurities of the blank filter.

Fig. 2 recapitulates the variation of the concentrations of the various heavy metals proportioned by technique XRF. As example concentration of lead, Fig. 3 vary from 119 ng/m^3 at 1333 ng/m^3, of Cd (Fig. 4) of 29.28 ng/m^3 with 189 ng/m^3 and of Ni (Fig. 5) entre 19-704 ng/m^3, Hg between 148.27-2381.83 ng/m^3 and Cr between 252.16-3507.07 ng/m^3.

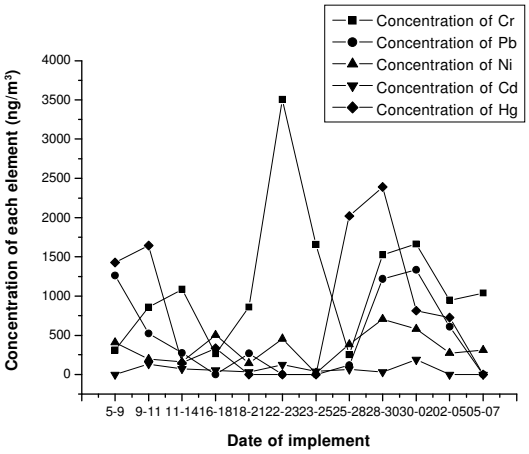

Fig. 2. Variation of concentration of certain metals according to the sampling date

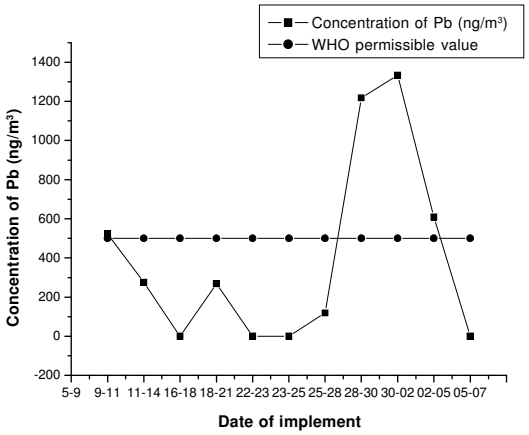

Fig. 3. Variation of the concentration of Pb according to the sampling date

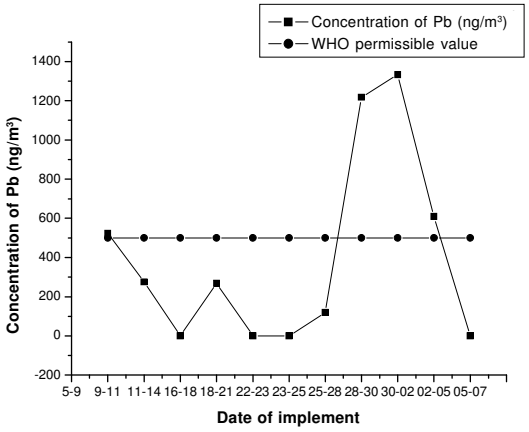

Fig. 4. Variation of the concentration of Ni according to the sampling date

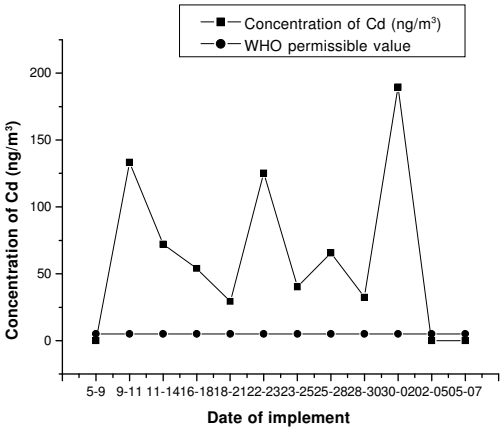

Fig. 5. Variation of the concentration of Cd according to the sampling date

For the elements Pb, Hg and Cr, it is noticed that they tend to increase when the speed of the wind decreases and that a certain rainfall appears involving an increase in moisture. On the other hand for Ni and Cd the variation is almost stable for all the period of collection independently of the variation of the parameters weather.

The strong concentrations of these elements are probably explained by the strong intensity of traffic observed during the period of taking away and the great quantity of hospital waste incinerated *ca.* 1500 Kg/J. The concentrations of the Fe are strongest which could come amongst other things of the abrasion of the tires and the wear of metals.

Due to lack of means one could not characterize the oxidation state of chromium and nickel and that the concentrations presented are total concentrations of all oxidation states of chromium.

With regard to mercury, it is well-known that its presence in the atmosphere is in its near total in gas phase. Thus concentrations of mercury in particulate phase represent a small fraction of the total concentration[9,10]. The results show an abnormal concentration much higher than the general average in ng/m^3. This result remains still unexplained owing to the fact that one did not finalize yet the study of the air pollution in this part to more push sampling towards the direction of the intense sources of contamination and to evaluate in a much more precise way the concentration of Hg with all the precautions of use.

Correlation test: Concerning the couple (Pb, Hg) and (Pb, Ni) Figs. 6 and 7 the presence of the one must implied the existence of the other, as shows it especially the factors of correlation between lead and nickel with a coefficient of correlation $R^2 = 0.58$. On the other hand, one did not find a correlation apparent between lead and cadmium where lead and chromium. Their presence can be had with other factors or sources which could not be same origins as those related to lead, nickel and mercury.

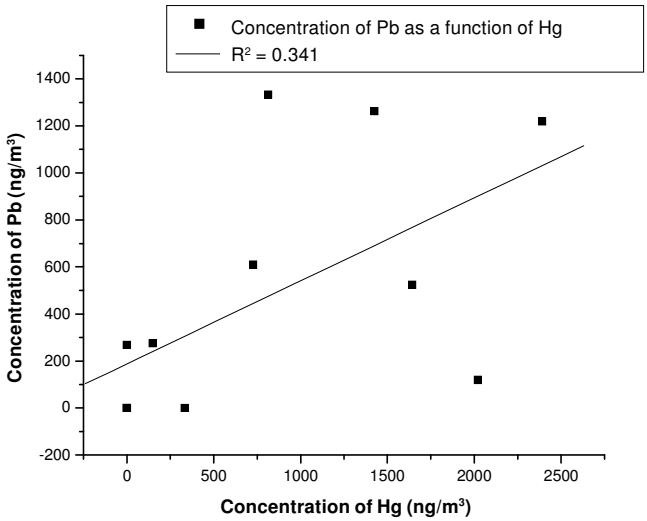

Fig. 6. Concentration of Pb according to Hg in ng/m^3.

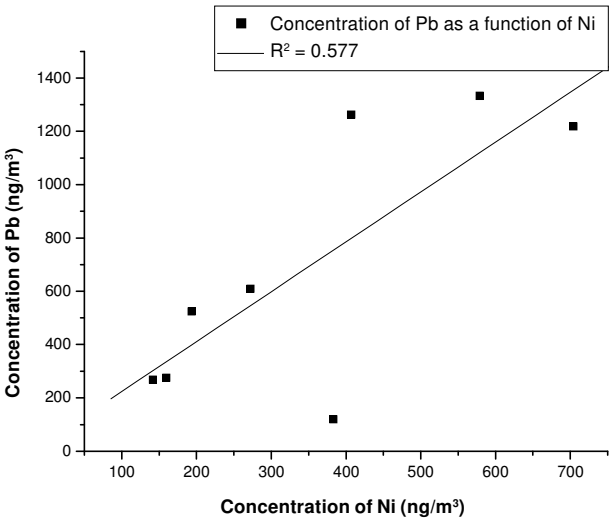

Fig. 7. Concentration of Pb according to Ni in ng/m^3

Concerning the couple (Pb, Hg) the factor of correlation $R^2 = 0.341$ (Fig. 6), one notes a weak correlation. There is no inevitably relation of presence of the one compared to the other. For couple (Pb, Ni) the factor of correlation $R^2 = 0.577$ (Fig. 7). This factor is rather significant which leads to the presence of the one must imply the existence of the other. We did not find a correlation between lead and cadmium or lead and chromium. Their presence can be had with other factors or sources which could not be the same origins as those related to lead, nickel and mercury.

Conclusion

The study performed in the district of Bab El Oued in Algiers shows that the air pollution by the suspended particles reached excessive levels. Indeed, the content average on working day obtained rises to 79 μg/m^3. The maximum level reached is 120 μg/m^3. On approximately 42 % of the studied cases, the content working day of TSP are above Algerian standard of 80 μg/m^3 and in 92 % cases higher than the target value of 50 μg/m^3 recommended for the quality control of the air. It is observed that rain fall has a significance influences on the load of the filters because of scrubbing effect.

Elsewhere, the study shows pollution by heavy metals like Cd, Hg, Pb, Cr and Ni associated to the TSP. Their temporal evolution shows that the parameters weather of the wind and rainfall can influence the quantities measured for certain toxic elements. There are two reasons for contamination by heavy metals. Primarily, the automobile park is made up approximately of half by the vehicles circulating with the gasoline with lead and other half vehicles rolling to the diesel in almost their totality without pot catalyst. Secondly, operating mode of the incinerator which constitutes another source of pollution requires a greater attention. The level of concentration measured for certain toxic elements such mercury can be a consequence of this last source.

Consequently, to avoid this degradation of the quality air, it is necessary to set up a regulation imposing the presence of catalyst on all cars with a better offer of the unleaded gas and to encourage the bicarburation of gasoline LPG or GNL. Moreover, the management of transport with reduction of the points of congestion and multiplication of commune run transport.

REFERENCES

1. J. Popescu and J. Blanchard, Square, Analyzes and Physico-chemical Treatment of the Stack Sisposals, July (1998).
2. H.A. Bravo and R.J. Torres, *Atmos. Environ*., **34**, 499 (2000).
3. J.J. Vandenberg, *J. Aller. Clinical Immunol.*, **115**, 334 (2005).
4. C. Bliefert, R. Parraud, Chemistry of the Environment: Air, Water, Ground, Waste (1997).
5. R. Ayed and Y. Cherifi, Evaluation of the Air Pollution by the Particles Total in Suspension in Algiers Centers, CRNA (2005-2006).
6. Y. Kerchich, Study of the Air Pollution by Particles Fine PM10 and Heavy Metals, MFE.ENP (2003).
7. S. Badj, Evaluation of the Air Pollution by the Fine Particles in Urban Site in Algiers, ENP (2005).
8. Di Benenedetto, S. Anfossi and E. Billiard, Spectrometric Methods of Analyses and Characterization, Heavy Metals, SAM File, Center SPIN, School of the Mines of Etienne Saint (1997).
9. S. Lindberg, R. Bullock, R. Ebinghaus, D. Engstrom, X. Feng, W. Fitzgerald, N. Pirrone, E. Prestbo and C. Seigneur, *Ambio*, **36**, 19 (2007).
10. R.J. Valente, C. Shea, K.L. Humes and R.L. Tanner, *Atmos. Environ.*, **41**, 1861 (2007).

(*Received*: 31 March 2009; *Accepted*: 17 December 2009) AJC-8195