Bull. Chem. Soc. Ethiop. **2004**, 18(2), 215-220. ISSN 1011-3924
Printed in Ethiopia

SHORT COMMUNICATION

ENVIRONMENTAL TOXICOLOGY: ACUTE EFFECTS OF SUSPENDED PARTICULATE MATTER (DUST) ON HEMATOLOGICAL INDICES OF ALBINO RATS

V.O. Ogugbuaja*, P. Gwaski and I.Z. Khan

Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B. 1069, Maiduguri, Nigeria

(Received September 26, 2003; revised May 4, 2004)

ABSTRACT. The elemental contents of suspended particulate matter (dust) samples from Maiduguri, Nigeria, were determined which showed appreciably high levels for especially Pb, Fe, Cu, Zn, K, Ca, and. Na. Wister albino rats were exposed to graded doses of phosphate buffered saline carried dust particles. The hematological indices of the exposed rats were examined on days 10, 20, 30, and 60 post administrations. White blood cell, red blood cell and hemoglobin counts peaked between days 20 and 30. This observation was markedly so for the higher doses, 1000 and 2000 mg/kg, in contrast to the 500 mg/kg dose. The platelet count however indicated a gradual increase within the study period. Observed changes for these indices from the control values were found significant at 99% confidence level. Possible inhalatory problems are thus anticipated from prolonged accumulation of the dust in the respiratory system.

KEY WORDS: Environmental toxicology, Suspended particulate matter, Dust analysis, Hematological indices, Wister albino rats

INTRODUCTION

Maiduguri, Borno State, Nigeria has a semi arid climate and is close to the Sahara desert. The open and flat topography of this region allow an uninterrupted incursion of the harmattan dust bowl across the Sahara desert into the region. The incursion is persistent almost throughout the year. All season agricultural activities carried out here add to the dusty nature of Borno state in general and Maiduguri in particular with her scanty industrial activities.

Dust particles in form of suspended particulate matter (SPM) form media for transportation of other forms of pollutants and assist in their movement in the environment. Trace elements, which are within the same median particulate diameter as the SPM, are most notable [1-4]. Bio-exposure through inhalation to these dust particles is therefore of environmental health concern as they penetrate even up into the inner respiratory system [5-7]; this exposure has its attendant health implications.

Dust particles from Maiduguri Metropolis were therefore collected. The elemental content was determined. Rats' exposure to the dust was carried out to examine the environmental toxicology of the dust on hematological indices of the animals.

*Corresponding author. E-mail: victotin@yahoo.com

EXPERIMENTAL

Sample and sampling

Dust in form of suspended particulate matter was collected at three different areas of Maiduguri, Metropolis. Collection was by direct gravity deposition on Whatman filter papers. Collections within the period of March and June 1999 and then 2000 were from four different locations in Maiduguri, North-east Nigeria. These months are the dustiest in any year in this region.

Determination of the elemental contents of the dust particles

Collected dust particles from the four locations were thoroughly mixed and then sieved to obtain a size range of 4-5 μm. A portion, 5 g, of the sieved sample was acid digested using 2:1 ratio of 20 mL of 2 M HNO_3 and 10 mL of 30% v/v H_2O_2, and heated at 90 ^oC for 1 h using a heating mantle. This was filtered and the supernatant solution was made up to the mark in a 100 mL volumetric flask. Flame atomic absorption spectrophotometer (Pye UNICAM model SP9) was used to determine the elemental content of the sample solution. Appropriate lamp current and wavelength for each element determined were employed as noted by Ramirez-Munoz [8]. Standard calibration curve method was utilized for the analysis.

Animal exposure studies

Dust sample administration. Doses of the dust particles of 500, 1000, and 2000 mg/kg from a stock solution of 5 g dust particles in 100 mL phosphate buffered saline (PBS) as carrier were differently administered to three randomly grouped six Wister strain adult albino rats. Each dose was divided into four portions. Each portion of each dose was separately given to the six rats in each group daily for four days by oral administration.

Hematological studies

Blood samples were collected from the exposed rats at day 0, and days10, 20, 30 and 60 post-dust administrations. The blood parameters, red blood cell (RBC), white blood cell (WBC) and platelet counts were determined by visual counting using improved Neubauer counting chamber [9]. Hemoglobin (Hb) levels and packed cell volume (PCV) were estimated using the cyanmethaemoglobin and microhaemacrit methods, respectively [9]. Obtained results were statistically analyzed using t-test at 95% confidence level.

RESULTS AND DISCUSSION

The dynamic nature of air pollution may constitute environmental problems far removed from the immediate point source of the SPM. Presence of other possible SPM passengers may act in synergism with the elements to further enhance the potency of dust particles on inhalation and subsequent accumulation in bio-systems. So therefore, the relatively high level of elemental content (Table 1) of the dust particles from Maiduguri may have part of their origin from winds blowing across the Sahara Desert. The results were in agreement with earlier studies on the element content of SPM from this region [10, 11] as compared in Table 1. Sources as burning of tires, prevalent agricultural activities and emissions from vehicles and bush burning are suspects in this case. Bowen [2] has noted that many elements found in the Nigerian environment are soil derived. This is especially so in Northeast zone of Nigeria which is scantly industrialized. The

high concentration of an element as Fe in percentage level is thus of note. High K/Na ratios obtained here as shown in Table 1, 2.5 (1999-2000) and 6.4 (1990-1992) indicate a substantive use of fertilizers for agricultural purposes, as prevalent in this region.

The exposure studies showed a general peak between day 20 and 30 for the hematological indices RBC, WBC and Hb. This is illustrated in Figures 1, 2 and 3, respectively. Effects on the packed cell volume (PCV) were markedly high for the 1000 and 2000 mg/kg doses (Figure 4) while the platelets had elevated levels for all the doses (Figure 5) administered as compared to the control values. Turgeon and Holt [12, 13] have proffered reasons for these changes. A notable mechanism for the observations here is a probable engulfment of the dust particles by macrophages; and possible deposition of the particles on some body organs. These may limit their presence in the blood and hence the indicated decreases observed after the peaking. The dust particles may have caused damage to the bone marrow leading to peripheral cytopenia, decrease in production of blood cells in the peripheral vessels [12]. It may also be stated here that engulfment by macrophages could have been overwhelmed at the high dust dosages. In addition about 75 to 80% of SPM inhaled is retained in the body whereby the cleansing action of the ciliary is paralyzed [6] especially at high dose exposures. Dust is prevalent almost all season round in the study region; inhabitants are thereby persistently exposed to atmospheric dust load.

Table 1. Levels of some elements in suspended particulate matter (dust particles) from Maiduguri, Northeast Nigeria (1989-2000).

Element	Concentration, μg/g		
	1999-2000	1990-1992[a]	1989-1990[b]
Ca	8000 ± 400	8030 ±4340	-*
Fe%	1.4 ± 0.6	1.38 ± 0.59	0.38 ± 0.69
Pb	350 ± 1.7	-*	97.5 ± 56
Zn	450 ± 20	157 ±118	318 ± 38
K%	2.0 ± 1.0	3.5 ± 0.7	-*
Na	7000 ± 90	5440 ± 93	-*
Cu	60 ± 3	-*	25.9 ± 10.1

*Not determined; a: determination by INAA [10]; b: determination by AAS [11].

A simulation of the immune system by the dust particles is suggested here as the reason for the peaking of the WBC at day 20 and elevated PCV and platelets levels. The rat body system might have treated the buffered dust samples as foreign bodies; hence the elevated level of WBC and the other related indices. Despite the elevation in the values of the indices though, the effects of the buffered dust samples were minimal for all the doses with a near complete recovery especially for the RBC and WBC at day 60. Low tissue absorption of the particles arising from effects of particle size (≥1 μm), and depositional sites (nasopharyngeal and trachea-bronchial regions.) of the rat inhalation region [14] are targeted reasons for the observation. Particles of above median diameter range are poorly absorbed by bio-systems [15]. Invariably the effects of metals typically Pb on the bone marrow, which could have altered the effects on these blood parameters, were lessened. In addition, the levels of many elements of environmental health concern were relatively low in the dust samples. Maiduguri is scantly industrialized. Elemental point sources are therefore limited and elemental levels low hence the observed low effects of the dust particles because of their elemental contents on the hematological indices of the rats examined.

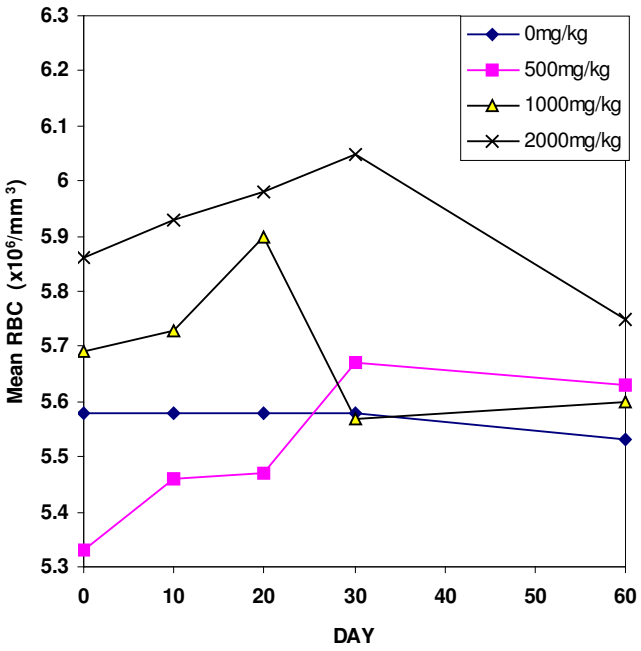

Figure 1. Mean red blood cell (RBC) (x 10^6/mm^3) of albino rats administered graded dose of buffered dust particles (n = 6).

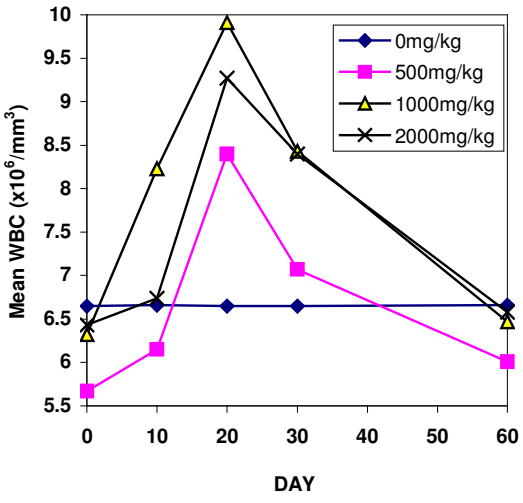

Figure 2. Mean white blood cell (WBC) (x 10^6/mm^3) of albino rats administered graded dose of buffered dust particles (n = 6).

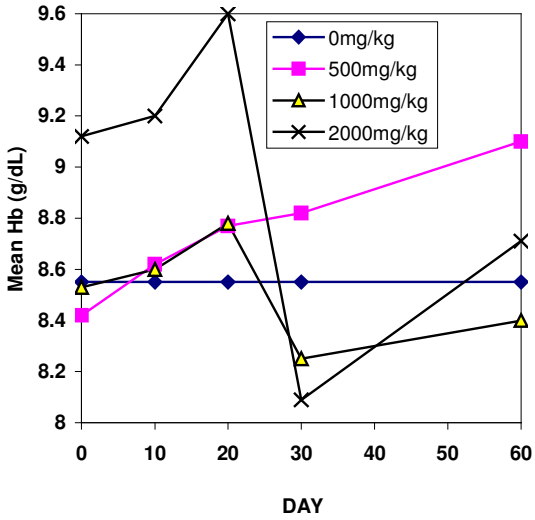

Figure 3. Mean haemoglobin (Hb) (g/dL) of albino rats administered graded dose of buffered dust particles (n = 6).

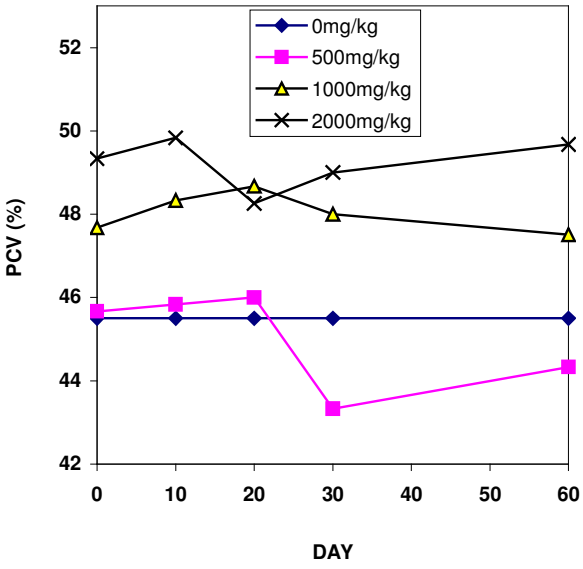

Figure 4. Mean packed cell volume (PCV) (%) of albino rats administered graded dose of buffered dust particles (n = 6).

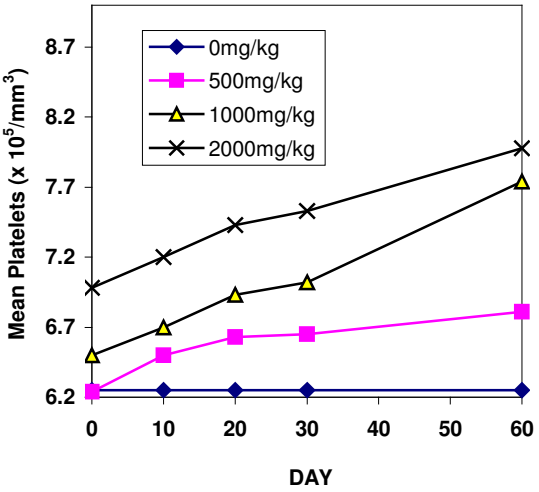

Figure 5. Mean platelet (x 10^5/mm^3) of Albino rats administered graded dose of buffered dust particles (n = 6).

REFERENCES

1. Arthur, N.S. *Interaction between Natural System and Man*, Hamilton Publishing Co.: California; **1973**; pp 151-152, 161-162.
2. Bowen, H.J.M. *Environmental Chemistry of the Elements*, Academic Press: London; **1979**; pp 6-10, 147.
3. Heishohn, R.J.; Kabel, R.L. *Sources and control of Air Pollution*, Prentice Hall: New Jersey; **1999**; p 969.
4. Meethan, A. R.; Bottom, D. W.; Cayton, S. *Atmospheric Pollution*, 3rd ed., Macmillan: New York, **1984**.
5. Patterson, J.T. *The Climate of Cities: A survey of Recent Literature*, U.S Department of Health, Education and Welfare AP-59: Washington; **1969**.
6. Schroeder, H.A. *Metals in the Environments* **1971**, 13, 18.
7. Hatch, T.F.; Gross, P. *Pulmonary Deposition and Retention of Inhaled Aerosols*, Academic Press: New York; **1964**.
8. Ramirez-Munoz, J. *Atomic Absorption Spectroscopy and Analysis by Atomic Absorption Flame Photometry*, Elsevier: Amsterdam; **1969**; p 382.
9. Dacie, J.V.; Lewis, M. *Practical Hematology*, 5th ed., Churchill Livingston: New York; **1977**; pp 21-40.
10. Ogugbuaja, V.O.; Goni, D.A.; James, W.D *Annals of Borno* **1998-99**, 150-156.
11. Ogugbuaja, V.O.; Barsisa, L.Z. *Bull. Chem. Soc. Ethiop*. **2001**, 15, 109.
12. Turgeon, M.L. *Erythrocytes in Clinical Hematology: Theory and Procedure*, 2nd ed., Little Brown and Co.: London; **1993**; pp 55-81.
13. Holt, P.E. *J. Pathol*. **1981**, 133, 123.
14. Gross, P. *Pulmonary Deposition and Retention of Inhaled Aerosols*, Academic Press: New York; **1964**; pp 34-41.
15. Gladney, E.S.; Zoller, W.H.; Jones, A.J.; Gorden, E. *J. Environ. Sci. Technol.* **1974**, 8, 551.