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Levels of Cadmium, Lead and Zinc in Urine of Randomly Selected Smokers and Non-Smokers Residents of Abeokuta City, Nigeria

[1]O. Bamgbose, [1]B.O. Opeolu and [2]J.T. Bamgbose
[1]Department of Environmental Management and Toxicology,
[2]Department of Chemistry,
University of Agriculture, Abeokuta, Nigeria

Abstract: Urine samples of 200 male volunteers comprising 100 smokers and 100 non-smokers were analysed for levels of heavy metals using Perkin-Elmer atomic Absorption spectrophotometer model 4600. The levels of Cadmium (Cd), lead (Pb) and Zinc (Zn) in urine samples of non-smokers ranged from 0.34-0.65, 0.037-0.25 and 0.235-0.664 μg mLG^{1}, respectively while the corresponding range for smokers were 0.075-0.341, 0.076-0.297 and 0.488-1.976 μg mLG^{1}. Most smokers respondents had metal concentrations that exceeded the normal urinary levels for each metal. For the non-smokers in age groups 10-19, 20-29, 30-39 and 40-49, the average urinary excretion values of 0.046, 0.050, 0.054 and 0.051 μg Cd mLG^{1}; 0.152, 0.101, 0.094 and 0.138 μg Pb mLG^{1}; 0.433, 0.515, 0.551 and 0.561 μg Zn mLG^{1} were respectively obtained, while for the smokers in age group 10-19, 20-29, 30-39 and 40-49, the average urinary excretion values of 0.110, 0.207, 0.216 and 0.330 μg Cd mLG^{1}; 0.145, 0.183, 0.203 and 0.182 μg Pb mLG^{1}; 0.563, 1.145, 1.089 and 1.718 μg Zn mLG^{1} were obtained. Regression analysis show that a significant correlation ($r>0.9$) exist between metal concentration (Cd and Zn) and duration of smoking period.

Key words: Cigarette smoking, toxic metals, cadmium, lead, zinc, environmental pollution

INTRODUCTION

Metals get into biological fluids from various sources apart from the direct consumption of food items that contains such metals. These sources include those of partially disintegrated particles of the containers in which food are stored, exposure to fine particles of metal waste in the metals extraction industries through ingestion (drinking) and from inhalation (tobacco smoke).

It has been shown that Environmental Tobacco Smoke (ETS) is a complex mixture of chemicals found in air as a specific result of smoking (side stream smoke that is released from the lit end of the cigarette and exhaled main stream smoke that is exhaled by the smoker after drawing on the cigarette) (Richard and Proctor, 1990). It has also been established that smoking is an important factor in the production of carcinoma of the lungs (Shaham *et al*., 1996; WHO, 1990) and as such tobacco smoke can therefore lead to cancer (Daube *et al*., 1997.)

The control of exposure to toxic metals has become an important part of most studies concerned with environmental pollution and environmental health hazards, although there does not appear to be a simple relationship between exposure to toxic metals and their unitary excretion (Nortrer *et al*., 1997) it has been reported that levels of these metals in urine are indicators of human exposure (Buchancova *et al*., 1994).

The danger of smoking has long been realized in the developed countries with the promulgation of appropriate laws in 1962 (Farrlly and Pybus, 1969) and more recently in Nigeria with the promulgation of Decree 28 of 1990 (Ajayi and Adekunle, 1991).

The presence of these metals in urine is regarded as a reliable index to the extent of recent metal intake and therefore determination of these metals in the diagnosis of incipient poisoning and in monitoring the working. This study discusses therefore the extent to which a relationship exist between smoking habit and the concentrations of Cd, Pb and Zn in urine.

MATERIALS AND METHODS

Twenty four hours urine samples were collected in plastic bottles from (200) male volunteers comprising (100) smokers and (100) non-smokers. The sample collection cut across different age groups and profession.

The plastic bottles had earlier been washed with detergent solution, rinsed with distilled water and 0.1 M HCI.

Corresponding Author: O. Bamgbose, Department of Environmental Management and Toxicology, University of Agriculture, Abeokuta, Nigeria

Few drops of 0.1M sodium azide was then added to the bottles before distribution to the sample donors. After collection of samples they were stored in the refrigerator at -18^{O}C prior to analysis.

Fifty milliliter of the urine sample was digested by the method of (Hernardez *et al*., 1989) and concentration of the metal determined with a Perkin-Elmer Spectrophotometer Model No. 4600.

RESULTS AND DISCUSSION

The results are presented in Table 1-5. Table 1 gives a summary of the biodata of some of the selected smokers (age-group, occupational status, type of cigarette smoked, estimated average number of cigarettes smoked per day and approximate years of smoking) along with the concentration of monitored metals. Table 2 gives a summary of the biodata of some of the selected non-smokers and the concentration of Cd, Pb and Zn in the samples.

Table 3 and 4 show the mean concentration of Cd, Pb and Zn in the urine samples of non-smokers and smokers according to age-group respectively.

Table 5 shows the correlation coefficient between the various biodata parameters and the concentration of Cd, Pb and Zn in the urine samples of smokers.

Trend in biodata of smokers and non-smokers: From Table 1 and 2 it was observed that the occupational status of the residents sampled varied widely from students to different categories of workers (trader, mechanic, carpenter, driver, clerk, painter etc.). However while students constituted about 16% of the smoking population sampled they also constituted a larger percentage of the non-smoking respondents, thus indicating that a smaller proportion of students at the University of agriculture, Abeokuta are involved in smoking. This was further confirmed from the questionnaire administered to the Year II students from which only 15% (120 out of 800) indicated having smoked at one time or the other and to date.

Students also constituted a greater percentage of the non-smokers within the age group 10-19 (60%), 40% for the age group 20-29, 33.3% for the age group 30-39 and 0% for the age group 40-49. This trend appears normal in that as expected the higher the age group, the lesser is the numerical strength of students expected in such age bracket. Similarly, the largest percentage of student smokers was found in the age group 20-29 (20%).

With respect to the type of cigarette smoked, the respondent engaged in smoking various types of cigarettes (Rothmans, Benson and Hedges, St. Morits). It was also observed that the lowest estimated average

Table 1: Biodata of selected smokers and levels of trace metals (Cd, Pb and Zn) in urine samples

Sample code	No. of sample	Age group	Occupational status	Years of smoking	Type of cigarette smoked	Estimated average No. of cig./day	Metal ion concentration (ppm)		
							Cd	Pb	Zn
1.	4	10-19	Carpenter	6	Rothmans	3-4	0.171	0.139	0.620
2.	4	10-19	Student	4	All types	2-4	0.089	0.076	0.488
3.	4	10-19	Bus conductor	7	All types	5-8	0.101	0.245	0.631
4.	4	10-19	Unemployed	5	Benson, St. Moritz	3-4	0.078	0.118	0.511
5.	4	20-29	Unemployed	12	Rothmans	5-7	0.180	0.233	1.181
6.	4	20-29	Air Force Officer	16	Rothmans	>10	0.300	0.230	1.611
7.	4	20-29	Mechanic	12	SM	>10	0.255	0.297	1.282
8.	4	20-29	Carpenter	13	Ten-ten	8-10	0.227	0.223	1.342
9.	4	20-29	Bricklayer	14	Rothmans	7-9	0.241	0.189	1.233
12.	4	20-29	Labourer	12	Eric moore	8-10	0.236	0.245	0.131
13.	4	20-29	Bricklayer	13	SM	7-9	0.241	0.189	1.233
14.	4	20-29	Clerk	14	Benson	8-10	0.262	0.213	1.355
15.	4	20-29	Student	7	Rothmans	3-4	0.095	0.105	0.513
16.	4	20-29	Painter	4	Rothmans, 555	6-8	0.075	0.113	0.656
17.	4	20-29	Civil servant	6	Rothmans	5-7	0.097	0.133	0.660
18.	4	20-29	Student	11	Rothmans, St. Moritz	7-8	0.196	0.124	1.245
19.	4	20-29	Student	11	Rothmans, St. Moritz	4-5	0.186	0.101	1.070
20.	4	30-39	Driver	12	Target	5-8	0.265	0.265	1.170
21.	4	30-39	Baker	14	Benson	8-10	0.301	0.211	1.586
22.	4	30-39	Painter	8	Target	5-7	0.091	0.133	1.511
23.	4	40-49	Trader	18	Benson	8-10	0.320	0.205	1.604
24.	4	40-49	Welder	20	Gold leaf	8-10	0.340	0.158	1.831
25.	4	50-59	Driver	22	Benson	8-10	0.302	0.124	1.976

Table 2: Biodata of selected Non-smokers and levels of metals (Cd, Pb and Zn) in urine samples

Sample code	No. of samples	Age group	Occupational status	Meta Ion concentration (ppm) Cd	Pb	Zn
26	4	10-19	Mechanic	0.034	0.179	0.438
27.	4	10-19	Student	0.037	0.104	0.317
28.	4	10-19	Student	0.054	0.112	0.586
29.	4	10-19	Student	0.054	0.037	0.571
30.	4	10-19	Student	0.048	0.177	0.319
31.	4	10-19	Student	0.043	0.173	0.599
32.	4	10-19	Mechanic	0.043	0.187	0.511
33.	4	10-19	Painter	0.045	0.194	0.243
34.	4	10-19	Painter	0.065	0.188	0.409
35.	4	10-19	Student	0.038	0.168	0.341
36.	4	10-19	Student	0.041	0.057	0.563
37.	4	20-29	Petrol attendant	0.065	0.251	0.576
38.	4	20-29	Trader	0.050	0.038	0.660
39.	4	20-29	Student	0.043	0.144	0.615
40.	4	20-29	Mechanic	0.054	0.194	0.342
41.	4	20-29	Trader	0.043	0.077	0.664
42.	4	20-29	Tailor	0.048	0.038	0.488
43.	4	20-29	Student	0.043	0.046	0.489
44.	4	20-29	Student	0.054	0.123	0.235
45.	4	20-29	Student	0.054	0.038	0.515
46.	4	30-39	Student	0.048	0.048	0.502
47.	4	30-39	Teacher	0.049	0.057	0.516
48.	4	30-39	Driver	0.065	0.178	0.634
49.	4	40-49	Baker	0.048	0.110	0.500
50.	4	40-49	Driver	0.054	0.165	0.622

Table 3: Mean concentration of Cd, Pb, Zn in urine samples of non-smokers according to age-groups

Age group (years)	No. of samples	Cd	Pb	Zn
10-19	40	0.046±0.0094	0.152±0.05	0.433±0.128
20-29	40	0.050±0.0075	0.101±0.075	0.515±0.137
30-39	12	0.054±0.0078	0.094±0.059	0.551±0.059
40-49	8	0.051±0.003	0.138±0.028	0.561±0.061

The figures represent the means in µg mLG^{1}±SD

Table 4: Mean concentrations of Cd, Pb and Zn in Urine samples of Smokers according to age-groups

Age group (years)	No. of samples	Cd	Pb	Zn
10-19	16	0.110±0.36	0.145±0.062	0.563±0.064
20-29	60	0.207±0.072	0.183±0.063	1.145±0.313
30-39	12	0.216±0.090	0.203±0.054	1.089±0.443
40-49	08	0.330±0.01	0.182±0.024	1.718±114
50-51	4	0.302	0.124	1.976

The figures represent the means in µg mLG^{1}±SD

Table 5: Correlation coefficients between duration of smoking, estimated average number of cigarettes smoked per day and concentration of metals in urine of smokers

	Duration of Smoking	Estimated average No.	Cd	Pb	Zn
Duration of Smoking	-	0.76	0.93	0.41	0.95
Estimated average No.	0.76	-	0.77	0.59	0.81

number of cigarettes smoked per day was 2-4 with a highest estimated average value of 8-10 per day.

A trend of increasing age of respondent corresponding to increasing years of smoking was expected and this was as observed with the exceptions of respondent in the age group 20-29 who had been on the smoke for 13, 14 and 17 years. Likewise, a deviation to this trend was also observed for the age group 30-39 with 8 years of smoking experience.

Trends in levels of cadmium, lead and zinc in urine samples

Cadmium (Cd): The concentration of cadmium present in the urine samples of non-smokers ranged from 0.034 to 0.065 µg mLG^{1} and this is an indication that the Cd content of most non-smoker respondent conformed with the normal urinary concentration of 0.055 µg mLG^{1} (Shaham *et al*. 1996). However it was observed that three samples had values, which exceeded the normal urinary concentration. These three respondents belonged to different age group of 10-19, 20-29 and 30-39 and had occupational status of Painter, Petrol attendant and Driver respectively. It is indeed likely that the higher levels associated with these groups of respondents may be related to their occupational status (Staessen *et al*., 1996).

For the smokers the cadmium level in the samples ranged from 0.075-0.340 µg mLG^{1} and in all cases the concentrations were higher than the urinary concentration of 0.055s µg mLG^{1}. The lowest concentration of 0.075 µg mLG^{1} was obtained for a painter in the age group 20-29 with 4 years of active smoking. It was similarly observed that generally for smokers, 4 years of smoking experience represented the shortest duration of smoking (range of 4-22 years). The next to the lowest Cd concentration is that of an unemployed youth with 5 years of smoking with 0.078 µg mLG^{1} (This is followed

by a Cd concentration of 0.089 μg mLG^{1} obtained from a student with 4 years of smoking experience). The highest concentrations of 0.340, 0.320 and 0.320 μg mLG^{1} were obtained from the age groups of 40-49 and 50-59, respectively with 20, 18 and 22 years of smoking experience. In this case it was not necessarily the donor with the longest duration of smoking years that had the highest Cd concentration. (However in all cases an estimated average no. of cigarette of 8-10 per day was recorded for the three respondents). Other high concentrations of Cd observed might suggest a correlation between the years of smoking and concentration of cadmium as shown by the samples 6, 11 and 21 with cd concentration of 0.300, 0.300 and 0.301 μg mLG^{1}, respectively 16, 17 and 14 years of smoking experience.

Lead: The lead content in the urine samples of non-smokers ranged from 0.037-0.251 μg mLG^{1}. Of a total of 100 respondents that were non-smokers, only respondent No. 37 had values higher than the normal urinary concentration of 0.2 μg mLG^{1} (Ostapezuck and Valenta 1989). This sample (No. 37) belonged to the age group 20-29 with an occupational status of a petrol attendant and a Pb level of 0.251 μg mLG^{1}. Since only this non-smoker had a Pb level exceeding the normal urinary concentration, then it may be inferred that his Pb concentration must have been contributed mainly form occupational exposure, particularly in a country in which premium motor spirit additive is still lead. Biodata information on sample 37 further revealed that as at the time of sampling he had spent about a year at the pumps. In a similar manner occupational exposure may have contributed to the levels of Pb observed for samples 32, 33, 34 and 40 with jobn descriptions of mechanic, painter, painter and mechanic respectively and a Pb concentration of 0.187, 0.194, 0.188 and 0.194 μg mLG^{1}, respectively (Hernardez *et al*., 1989).

A range of 0.076-0.297 μg mLG^{1} was obtained for the smoking respondents. Of the total samples (25) about half had levels that exceeded the urinary Pb concentration of 0.2 μg mLG^{1} (sample Nos. 3, 5, 6, 7, 8, 11, 12, 14, 20, 21 and 23). The lowest concentration of urinary lead was obtained from a student respondent with 4 years smoking experience. This result may not reflect a positive correlation in itself for concentration of lead and duration of smoking; though this may seem as an isolated case, other lead concentration particularly of those which exceed the normal urinary Pb concentration whom a relationship between job status, years of smoking and concentration of Pb. Respondents 3, 7, 12 and 20 with Pb levels of 0.245, 0.297, 0.245 and 0.265 μg mLG^{1} and a corresponding occupational status of Bus Conductor, Mechanic, Labourer and Driver had 7, 12, 12 and 12 years of smoking. This may also indicate occupational exposure as a probable contributor to source of Pb in the respondents apart form contribution form tobacco smoke (Hermardez *et al*., 1989).

Also the highest Pb concentration of 0.297 μg mLG^{1} obtained for a mechanic with an average of 10 cigarettes per day is also indicative of the4 possibility of a relationship between number of cigarette consumed daily and the eventual urinary Pb concentration.

Zinc: The levels of zinc found in the urine samples of non-smokers ranged from 0.235-0.664 μg mLG^{1} and in all cases below the normal urinary level of 0.67 μg mLG^{1} (Schuhmacher *et al*., 1994b). No particular trend could be identified with respect ot the zinc concentration, though respondent No. 37 conformed with the trend observed for other metals (cd and Pb) in terms of having a high concentration for Zn (0.576 μg mLG^{1}) which had earlier been attributed to occupational status.

Furthermore, respondents 33 and 34 both painters, had varying zinc levels of 0.243 and 0.409 μg mLG^{1} showing variations in Zinc levels and occupational status. However there seems to be a more positive relationship between occupational status and zinc level for trades (respondents 38 and 41) engaged in selling of galvanished iron sheets with a highest zinc concentration of 0.660 and o.664 μg mLG^{1}, respectively. Similarly respondent No. 48 a driver engaged in supplying with galvanized sheet and a high level of zinc (0.634 μg mLG^{1}).

For the urine samples collected from smokers, the zinc levels ranged from 0.488 to 1.97 μg mLG^{1} and out of a total of 25 samples analysed, 17 had urinary zinc conc. Higher than the urinary conc. of 0.670 μg mLG^{1}.

The lowest zinc concentration was obtained for a respondent that had not only the least years of smoking experience (4 years) but also belonged to the age group of 10-19. The highest level of zinc was found in the respondent belonging to the age group 30-39 years with 22 years of smoking experience indicating a relationship between concentration zinc and duration of smoking. An important observation is that the type of cigarette smoked does not seem to have any relationship whatever with the level of metal concentrated.

Comparison of mean concentration of Cd, Pb and Zn in urine samples.

For the non-smokers, the mean concentration of cadmium 0.046, 0.050, 0.054 and 0.051 µg mL^{-1} which were found for the age group 10-19, 20-29, 30-39 and 40-49, respectively were in agreement with the average urinary excretion value of 0.05 µg mL^{-1} reported by Statesmen *et al*. (1996).

Similarly the mean concentrations of lead and zinc for all the age groups also below the normal urinary excretion value of 0.2 and 0.67 µg mL^{-1}, respectively.

For the smokers, the mean concentrations of 0.110, 0.207, 0.206 and 0.330 µg mL^{-1} which were found for age groups 10-19, 20-29, 30-39 and 40-49, respectively were greater than the average normal excretion value of 0.05 µg Cd mL^{-1}. Also the average concentration values of 0.145, 0.183, 0.200 and 0.182 µg Pb mL^{-1} found for age groups 10-19, 20-29, 30-39 and 40-49 similarly exceeded the average normal urinary excretion. This trend was also observed for the zinc concentrations for the different age groups. In general for he smoking respondents, there is elevation of metal concentration caused by smoking activity and confirming the report of previous workers that smoking increase the concentration of trace metals in urine (Buchancoval *et al*. 1994; Lin *et al*., 1995; Schumacher *et al*., 1994b).

Correlation coefficient analysis: The results obtained from analysis of urine samples donated by smokers were subjected to a simple regression analysis to show if there was any correlation between the concentration of trace metals, duration of smoking and estimated average number of cigarettes consumed per day.

It was observed that in general a positive correlation coefficient was obtained for all the parameters. For duration of smoking and the concentration of Cd and Zn, a regression coefficient of 0.93 and 0.95 were obtained indicating the dependence of these metals on the duration of smoking.

However for the concentration of lead, either for the duration of smoking or the average number of cigarettes per day the regression coefficient ($r = 0.41$, $r = 0.59$) were not significant.

Similarly a significant correlation exist between the estimated average number of cigarettes per day and the concentrations of Cd and Zn, though not as significant as that of the duration of smoking and concentration of Cd, Zn. That correlation exist between the concentration of metals in urine as a function of source (smoking) has been reported (Schuhmacher *et al*. 1994b).

CONCLUSIONS

Analysis of urine sample of (200) smokers and non-smokers show that in general the levels of concentration of cadmium, zinc and lead in the urine samples of smokers are relatively higher than those values obtained for non-smokers. Within the smoking and non-smoking donors, concentration of metals was also dependent on the occupational status of the respondent.

Regression analysis show a positive correlation between the level of metal concentrated and the length of time that the donor had been involved in smoking.

In conclusion this report shows that smokers are more pruned to exposure of heavy metals and that occupational status can elevate the concentration of heavy metals.

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