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Antimony contamination of mineral water put into PET plastic bottles sold in Kinshasa

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Abstract : In Kinshasa, many companies offer consumers mineral water packaged in plastic bottles. The packaging of the latter gives them prestigious consideration. Unfortunately, these waters exposed to the sun by sellers create health concerns for consumers through the release of toxic chemical compounds. This study focused on the antimony contamination of mineral water put into PET plastic bottles sold in Kinshasa. The samples consist of bottles of mineral water (American Water, Alpina, Eden, and Swissta), purchased in the markets of the city province of Kinshasa, sent and analyzed to the water and environmental chemistry laboratory of the Faculty of Science and Technology of the University of Kinshasa. The general objective of this work is to verify whether water put in plastic bottles (PET) exposed to the sun (to heat) contains or can release antimony. To achieve the results, we used the experimental method, which consisted of collecting mineral water samples and analyzing them before and after their exposure to the sun. Laboratory results revealed the presence of antimony in mineral waters before and after exposure to the sun, exceeding the WHO reference value (6 µg/l). There was also a release of this element into the water, exponentially increasing the initial values. A good monitoring and control policy for marketed food products and environmental education of sellers as well as that of the population are effective measures to recommend to preserve the health of consumers.

***IndexTerms* - Mineral water, antimony, PET plastic bottle, endocrine disruptor.**

I. INTRODUCTION

The physicochemical and bacteriological quality of the drinking water served to the population has been the subject of numerous studies, which have shown the health risks and the impact of consuming water of questionable quality on human health. One of the serious problems in the world is the provision of drinking water to populations (Fatombi, J.K. et al., 2007). Water packaged in PET plastic bottles is heavily contaminated with antimony (Sb) coming from the container after a long period of storage at room temperature. (Shotyk, W. et al., 2006; Shotyk, W. et al., 2007).

Antimony is a trace metal element that is present in drinking water and has major consequences for the health of consumers. It is a potentially toxic trace element with no known physiological function, but its natural and anthropogenic geochemical cycles are poorly understood. Present on the earth's surface mainly in the form of relatively insoluble metal sulfides, its abundance in crustal rocks (approx. 0.3 mg kg1) is lower than that of Pb (15 mg kg1) or As (1. 5 mg kg1), two elements with which Sb is often compared. (Shotyk, W. et al. 2006).

Fite, J. et al. (2004) estimate that drinking water contributes 10 to 38% of oral exposure to antimony.

This element is a powerful toxicant in high doses, as evidenced by its ancient uses as a poison and occupational diseases in the workplace. But chronic toxicity at low doses is insufficiently evaluated. In particular, carcinogenicity is suspected but poorly established. Risk assessments related to antimony exposures were carried out in 1992 in the United States. In addition, dose-response relationships have been established for oral exposures. (Fite, J. et al., 2004).

Walking through the provincial city of Kinshasa, we observe pallets of plastic mineral water bottles that remain for hours or even days in the sun before being stored in supermarkets, shops, or loaded for transport. Their marketing is a response to the demand for water in urban areas, thus stopping its begging, something that most often happens in rural areas. Unfortunately, conservation poses a problem due to the compounds resulting from the manufacturing of said bottle.

Water and drinks packaged in PET bottles represent a real danger to public health. Being exposed to the sun or under the sun, the heat inside the bottle allows the carcinogen antimony to be released. Hence the recommendation to the population not to consume mineral water packaged in these bottles exposed to high temperatures (Admin, 2017). Unfortunately, when you buy a bottle of water, you have no way of knowing if it was exposed to the sun and for how long.

This work aims to verify whether exposure of water in plastic bottles (PET) to the sun contains or can release antimony.

III. MATERIAL AND METHOD

All chemical reagents used for analysis are quality products.

The mineral waters (American Water, Alpina, Eden, and Swissta) were purchased in the markets of the city province of Kinshasa, six bottles per brand. They were placed in a cooler and then brought to the water and environmental chemistry laboratory of the Faculty of Science and Technology at the University of Kinshasa in a cooler at a temperature of 4°C for analyses. The first analysis or dosage was done before exposure to the sun in order to determine the presence or absence and the proportion of antimony, and the second was done after exposure to the sun for two months in order to check if the containers released the contaminating element. Each evening, the samples were kept in a cold cooler.

The antimony measurements were made using the colorimetric/iodometric method, a chemical method where the redox couple I2/I is used to carry out an indirect dosage. Thiosulfate is therefore used to measure the diode formed.
The principle is to put the excess iodine in the presence of a determined volume of the sample of mineral water put in a plastic bottle and a little sodium bicarbonate (NaHCO3);; if there is antimony, the latter will be oxidized by iodine.

$$Sb^{+3} \longrightarrow Sb^{+4} + 1e \qquad (3.1)$$

The excess iodine is measured using a solution of sodium thiosulfate $Na_2S_2O_3$0,1N in the presence of starch as an indicator.
Process: We filled the burette with $Na_2S_2O_3$0,1N (25 ml), prepared a blank solution with 25 ml $I_{2,}$ starch and bicarbonate, which we titrated with $Na_2S_2O_3$0,1N, finally to determine the P Eq_1.

Then, we put 25 ml of mineral water sample in another clean beaker and rinsed well with distilled water and titrated with $Na_2S_2O_3$0,1N in order to determine the P Eq_2 of this last.
Finally, determine the proportion of antimony according to the formula:

$$msb^{+3} = (NI_2.\ VI_2^{(l)} - NI_2.\ VNa_2S_2O_3)\ 121,76 \qquad (3.2)$$

With;
mSb+3, molecular mass of Antimony
NI_2, Normality of Iodine.
VI_2, Volume of Iodine.
$VNa_2S_2O_3$, Volume of sodium thiosulfate consumed.
121.76**,** Equivalent mass of antimony.

To compare the averages of the obtained values of antimony to the standard and check if there is a significant difference between the release percentage of different brands containing PET as well as the effect, we used the R x64 4.1.3 software, which allowed us to do the t test and calculate the p value.

IV. RESULTS AND DISCUSSION

Table 4.1: Antimony values (in µg /l) in mineral waters in PET plastic bottles (Be. Exp: before exposure, Af. Exp: after exposure)

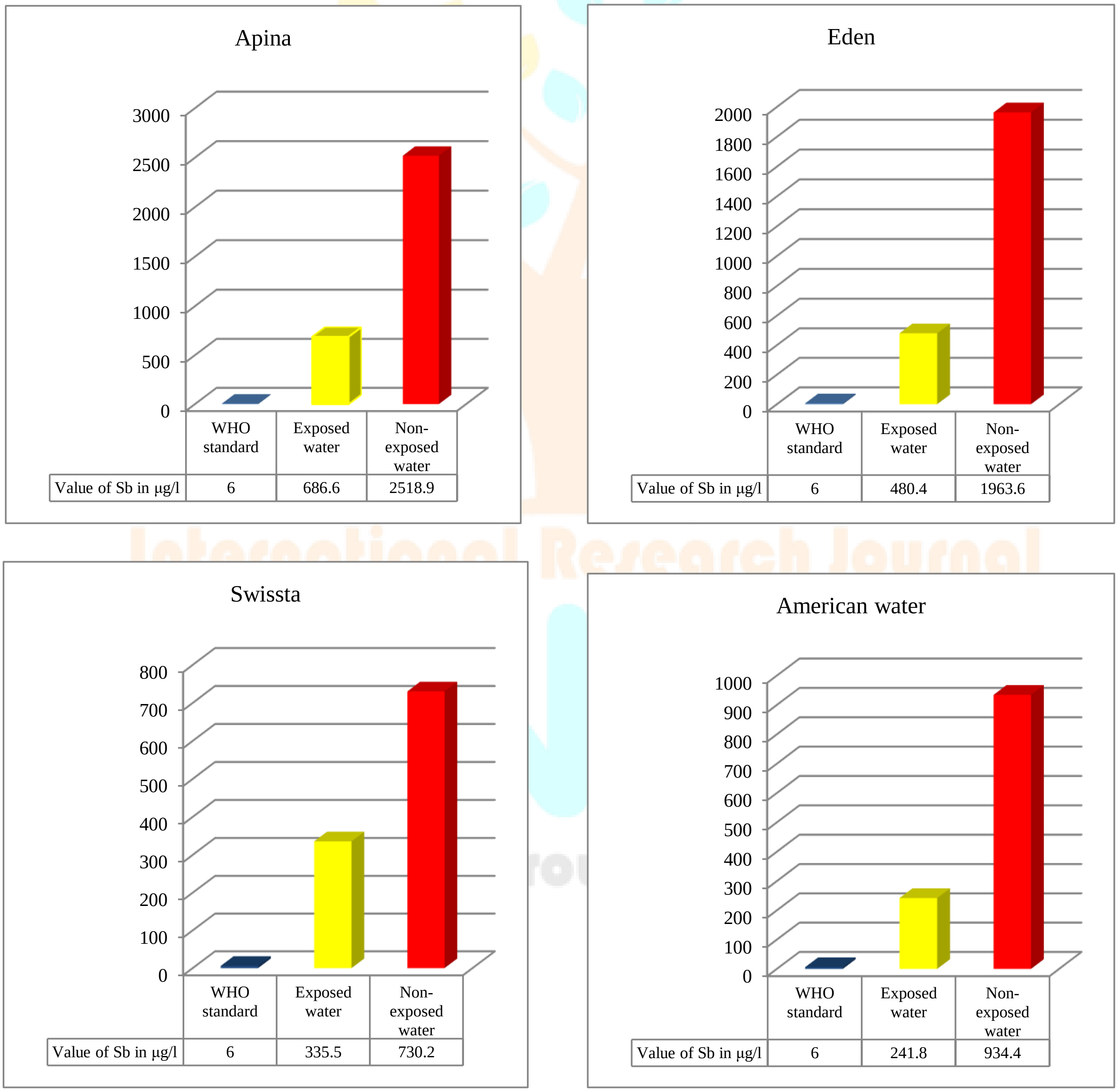
Sample	Be. EXP		Af . EXP		ddl	Standard	t		p-value		Power of liberation (in %)
	Average	Standard deviation	Average	Standard deviation			Be. Exp	Af. Exp	Be. Exp	Af. Exp	
American Water	241.8	28.6	934.4	119.8	5	6	20.16	18.98	0.000	0.000	386.4
Alpina	686.6	89.3	2518.9	395.8			1 8.67	15.55	0.000	0.000	366.9
Eden	335.5	35.8	730.2	39.4			22.57	44.98	0.000	0.000	217.6
Swissta	480.4	74.2	1963.6	89.57			15.66	53.5	0.000	0.000	408.7

The results shown in this table show that before exposing our samples to the sun, the quantity of antimony was 686.6 ± 89.3 µg/l, 480.4 ±74.2 µg/l, 335. 5 ±35.8 µg/l, and 241.8 ± 28.8 µg/l, respectively, for Alpina, Swissta, Eden, and American Water. These values are far higher than the WHO standard (2003); the student test performed showed a highly significant difference between the means of the antimony values with the standard (i.e., p-value = 0.000).

Alpina samples revealed 2518.9 ±395.8 µg/l, followed by Swissta 1963.6 ±89.57 µg/l, American Water 934.4 ± 119.8 µg/l, and Eden 730.2 ± 39.4 µg/l of antimony. This proves that all the bottles released the antimony they contained following the increase in temperature inside the PET container after two months of exposure. This confirms the result of W. Shotyk et al. (2006). Compared to the WHO standard, the difference was found to be highly significant with the average values of released antimony (i.e., p-value = 0.000).

The average release of antimony in the PET bottle after 2 months of exposure is approximately 344.9%. This confirms the thesis of Shotyk W et al. (2007), which states that mineral waters put in plastic bottles release antimony after exposure to ambient temperature. This spectacular release of the element would be due to the climate of the study area (equatorial, characterized by high and constant temperatures throughout the year). All these results before and after exposure to the sun reveal large quantities of antimony higher than the WHO normative value (2003) set at 6 µg/l. This situation constitutes a major problem for the health of consumers and remains responsible for worsening health problems.

The high percentage of release of this element can be attributed to the climate in which the study is carried out (equatorial). Therefore, the higher the temperature (32°C), the more PET releases a lot of contaminants into the water it contains.



Figures 1, 2, 3 and 4 Antimony value in the Alpina, Eden, Swissta and American Water sample

Figures 1, 2, 3, and 4 indicate that the values of antimony in unexposed samples are far higher than those set by the WHO in 2003. This could be justified by the fact that antimony is not taken into account during the process of producing this water by producers, although it is a formidable element.

After exposure, we notice that the values have doubled, tripled, and quadrupled, respectively, for Eden, Alpina, Swissta, and American Water. This is due to the increase in heat inside the bottle caused by the sun's IR rays, which catalyzed molecular exchanges due to the long stay (2 months) of liquid in PET plastic bottles.

CONCLUSION

The results obtained in this work allow us to confirm the hypothesis according to which mineral water put in PET plastic bottles exposed to the sun or to high heat releases into these water chemical compounds known as endocrine disruptors such as antimony. Mineral water producers in Kinshasa take no account of this toxic compound (considered an endocrine disruptor), yet the WHO requires a value not exceeding 6 µg/l for drinking water.
Antimony was measured by iodometry, and its values were at least doubled in each sample exposed to the sun because heat catalyzes molecular exchanges.
Exposure of mineral water in PET plastic bottles to the sun causes the release of antimony, considered an endocrine disruptor capable of causing many health problems, including miscarriages, irregular menstruation, and heartburn, stomach, headaches, to name just a few. Unfortunately, it remains difficult to link these directly to antimony (F. Johanna et al., op cit).

These results guide other studies to explore them further; they are;
Studying the effects of antimony at various concentrations on human health.
Determination of the kinetics of antimony release following the increase in temperature.
The determination of antimony in other sources of drinking water, such as tap water served by REGIDESO in Kinshasa, underground.
Repeat the same study using other antimony determination methods, such as mass spectrometry.

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