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BPA and Environmental Estrogen in Potable Water Sources in Enugu Municipality, South-East, Nigeria

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Abstract BPA and environmental estrogen levels were assayed in potable water samples (38 tap water, 36 well water, 18 river water and 24 rain water samples) that were randomly collected from the different parts of Enugu metropolis, south-east Nigeria. The mean ± SD estrogen levels in tap, well, river and rain water samples were 0.10 ± 0.09, 0.05 ± 0.02, 0.05 ± 0.02 and 0.05 ± 0.02 μg/L respectively. Also, the mean BPA levels (μg/L) in the different water sources were 0.20 ± 0.07, 0.21 ± 0.07, 0.18 ± 0.04, and 0.40 ± 0.16, respectively. There was statistically significant difference ($p = 0.0227$) in BPA levels between the harvested rain water and the drinking tap water.

Keywords Environmental estrogen · Bisphenol-A · Potable water sources · Enugu · Nigeria

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The possibility that some chemicals may disrupt the endocrine system in humans and animals has received considerable attention in the scientific and public community (Lintelmann et al. 2003). These compounds may be man-made (so called xenoestrogens), such as industrial chemicals, crop protection chemicals, or they may be natural, like the phytoestrogens (Lintelmann et al. 2003). Schlumpf et al. (2001) were the first to investigate influence and concentrations of natural sex steroids as environmental pollutants. The composition and adverse effects of Bisphenol-A (BPA) are well researched (van Aerle et al. 2001). BPA, a well known endocrine disruptor which can lead to various health hazards, is one of the most important chemicals worldwide (Witorsch 2002). It is synthesized for diverse applications. BPA, for instance, serves as a stabilizer for plasticizers in PVC (Ohlson and Hardell 2000), a thermal stabilizer for PVC resins (Kielhorn et al. 2000), an antioxidant in rubber and plastics and a fungicide. It is also used in the manufacture of hard, clear plastic known as polycarbonate, used in packaging many consumer products (Latini et al. 2004). Upon discharge to the environment, BPA is distributed between air, water, soils, sediments, and biota compartments (Witorsch 2002). Therefore, transportation of bisphenol-A in the aquatic environment is considered to be the predominant pathway for distributing the compound between environmental compartments (Lintelmann et al. 2003). Due to paucity of information on the preponderance of the chemical in developing countries, such as Nigeria, there is the need to carry out this very study to show the distribution of the chemical in potable water sources. The present study is therefore aimed at

analyzing the BPA and environmental estrogen levels in potable water sources in Enugu, Nigeria, to show the aquatic distribution of the chemical and its possible contamination.

Materials and Methods

Potable water samples (tap water, rain water, well water and river water) were randomly collected from different parts of Enugu metropolis, south-east Nigeria and assayed for BPA and estrogen levels. A total of 38 tap water, 36 well water, 18 river water and 24 rain water samples were randomly collected for the studies. All the water samples were collected from the various sources directly into clean, dry and sterile glass bottles. The samples were taken to the laboratory immediately after collection and analyzed within 7 days of collection. The water samples were centrifuged at 3,000 g for 10 min and the supernatant fluid was filtered off. Methanol was added to the remaining fluid to form a final methanol concentration of 10% (v/v). BPA was analyzed using Ecologenia® supersensitive BPA ELISA kit, Batch No. T2KSI of 2007 whereas Estrogen was analyzed using Ecologenia® Estrogen (E1/E2/E3) microplate ELISA kit, Batch No. T2GR4 of 2007, both from Japan Envirochemicals Ltd, Japan. The limits of detection for both assays was 0.01 μg/L. Samples and standards were analyzed in duplicates and the average used for the calculation. Internal quality control serum was used for each batch of the assay.

Results were expressed as mean ± standard deviation (mean ± SD). Significant differences between means were determined using student's *t* test. Student's *t* test was analyzed by the use of graph pad prism computer software programme.

Results and Discussion

A mean ± SD, BPA level of 0.20 ± 0.07, 0.21 ± 0.07, 0.18 ± 0.04 and 0.40 ± 0.16 μg/L respectively were obtained in tap, well, river and rain water sources with median values of 0.20, 0.21, 0.17 and 0.35 μg/L. The estrogen levels were 0.10 ± 0.09, 0.05 ± 0.02, 0.05 ± 0.02 and 0.05 ± 0.02 in that order with median values of 0.06, 0.05, 0.04 and 0.04 μg/L respectively

Table 1 BPA level (μg/L) in the different potable water sources

	Potable water sources			
	Tap (n = 38)	Well (n = 36)	River (n = 18)	Rain (n = 24)
25% Percentile	0.11	0.10	0.05	0.11
75% Percentile	0.29	0.25	0.21	0.60
Minimum	0.01	0.01	0.03	0.03
Maximum	0.52	0.58	0.23	0.92
Mean	0.20	0.21	0.18	0.40
Median	0.20	0.21	0.17	0.35
Standard deviation	0.07	0.07	0.04	0.16
Standard error	0.03	0.03	0.02	0.10
Lower 95% CI	0.14	0.14	0.05	0.20
Upper 95% CI	0.27	0.28	0.16	0.59

Table 2 Environmental estrogen level (μg/L) in the different water sources

	Water sources			
	Tap (n = 38)	Well (n = 36)	River (n = 18)	Rain (n = 24)
25% percentile	0.05	0.03	0.03	0.02
75% percentile	0.07	0.06	0.04	0.09
Minimum	0.02	0.01	0.03	0.00
Maximum	0.82	0.11	0.11	0.13
Mean	0.10	0.05	0.05	0.05
Median	0.62	0.05	0.04	0.04
Standard deviation	0.09	0.02	0.02	0.04
Standard error	0.04	0.01	0.01	0.01
Lower 95% CI	0.02	0.04	0.03	0.03
Upper 95% CI	0.18	0.07	0.07	0.08

Table 3 Test of difference in mean of BPA and estrogen level (μg/L) between tap water and other water sources

Water source	Estrogen		BPA	
	Mean (±SD)	*p* Value	Mean (±SD)	*p* Value
Well (n = 36)	0.05 (±0.02)	0.2230	0.21 (±0.07)	0.8802
River (n = 18)	0.05 (±0.02)	0.3839	0.18 (±0.04)	0.0615
Rain (n = 24)	0.05 (±0.02)	0.3641	0.40 (±0.16)	0.0227[a]

[a] Statistically significant

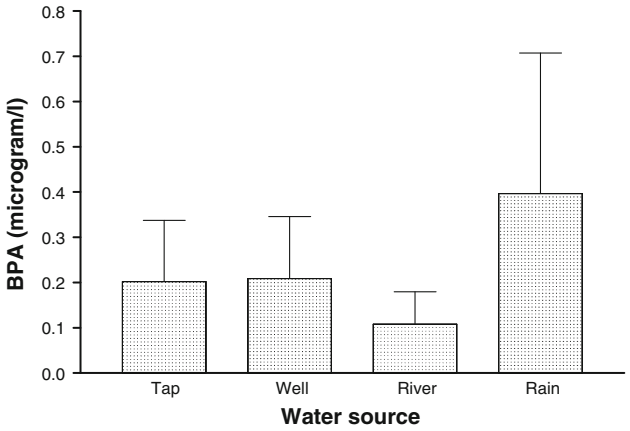

Fig. 1 Bar Chart of Mean (±SD) BPA level (μg/L) in different potable water sources. *Vertical Bars* represent Arithmetic mean whereas T = standard deviation (SD)

(Tables 1 and 2). Table 3 showed a non-significant difference ($p > 0.05$) in means of estrogen and BPA between the treated tap water and other water sources with the exception of harvested rain water, which had statistically significant increase ($p = 0.0227$) in BPA, when compared to the tap water. Figures 1 and 2 show the mean (±SD) BPA and estrogen levels (μg/L) respectively in the various water sources. The highest mean (±SD) BPA level 0.40 (±0.16) was observed in rain water source while the lowest level 0.18 (±0.02) was seen in the river water source (Fig. 1). However, the highest mean (±SD) estrogen level of 0.10 (±0.09) was obtained in tap water while the lowest level of 0.05 (±0.02) was obtained in river water (Fig. 2). On a daily basis, people are exposed to a vast number of chemicals through food, air and water. The level of BPA and environmental estrogen in potable water sources in Enugu, Nigeria were evaluated, and the results indicated presence of significant amount of both chemicals in the water sources studied. 75th percentile of the water sources have BPA concentrations (μg/L) ≥ 0.29, 0.25, 0.21 and 0.60 for tap, well, river and rain water sources, respectively, and estrogen levels (μg/L) ≥ 0.07, 0.06, 0.04 and 0.09 respectively.

A comparison of tap water with other water sources showed a non-significant difference ($p > 0.05$) in the mean

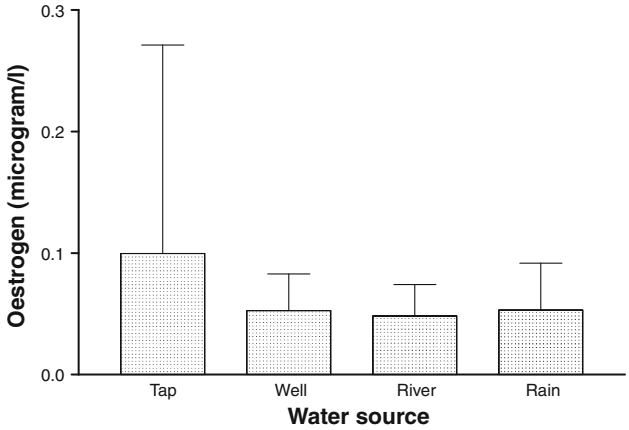

Fig. 2 Bar Chart of Mean (±SD) Estrogen level (μg/L) in different potable water sources. *Vertical Bars* represent Arithmetic mean whereas T = standard deviation (SD)

estrogen levels between tap water and all the other water sources. There was, however, a statistical significant increase ($p = 0.0227$) in the mean BPA level of rain water compared to the drinking tap water. This relatively lower amount obtained in the tap water may be attributed to a reduction in the level during its treatment.

The levels of BPA obtained in the different water sources in this environment are very high compared to that reported by Brock et al. (2001)(<0.1–1.6 ng/ml), Witorsch (2002) (0.0003–0.42 μg/L), and Sumpter (2005) (0.5–16 ng/L). The levels also exceeds that set by the United States Environmental Protection Agency for municipal drinking water (van Aerle et al. 2001), notwithstanding the water treatment processes. Also, the levels of estrogen obtained in this study, far exceeds that recorded by the United States Environmental Protection Agency (2000) for all river samples (1.0–3.2 ng/L). Poor sewage disposal system and uncontrolled use of chemicals may be the contributory factors. This calls for serious concern considering the recorded deleterious effects of these endocrine disruptors (Lintelmann et al. 2003).

In the present study, environmental estrogen and BPA were present in the different potable water sources including the drinking tap water. The significantly increased presence of BPA in harvested rain water may possibly be as a result of environmental contamination from industries. Also, the treatment of water at the public water treatment plant does not completely remove these hormone disruptors leading to exposure of the population to the endocrine disruptor.

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