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Assessment of Bisphenol A in Some Aquatic Food Samples from Eti-Osa Area of Lagos

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Abstract

Aquatic organisms, being one of the most abundant groups in the aquatic ecosystem are sometimes exposed to all sorts of environmental assaults. These assaults can have serious effects on the nutritive quality of aquatic organisms inhabiting the contaminated aquatic environment. Thus, this study investigated the level of Bisphenol A (BPA) and estimated risk assessment in crayfish, shrimp, periwinkle and crabs obtained from Eti Osa in Lagos Nigeria. The samples were analyzed using solvent extraction, separation and quantitation by gas Chromatography- mass spectrometric method. The recovery value for BPA in the method was 89% with relative standard deviation of 3%. The concentration of Bisphenol A ranged from 0.012 mg/kg to 0.245 mg/kg. Crayfish has the highest concentration of Bisphenol A while periwinkle has the lowest concentration of Bisphenol A. The concentration of Bisphenol A followed this order crayfish > shrimp > crabs > Periwinkle. The concentrations of crayfish is higher than the European Food Safety Authority Specific Migration Limit (SML) of 0.006 mg/kg in food sample while the concentration of crayfish is within the limit set by European Food Safety Authority Specific Migration Limit (SML) {10}. Also, The US environmental protection agency (USEPA) has established the tolerable daily intakes (TDI) for BPA at 0.8 mg/kg-bw/day. Contamination from aquatic environment is a major source of BPA exposure to aquatic organisms and the samples analyzed in this work maybe therefore, of a potential health concern to the consumers particularly for vulnerable population groups after a long term consumption hence there is need for regular monitoring of our aquatic environment.

Keywords: Bisphenol A, Sea food, Solvent extraction, GC-MS

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1 Introduction

Seafood are aquatic organisms of high economic value that responds to environmental changes. Thus, it is extremely suitable to be utilized as an indicator for pollution studies [1]. The foods we eat influence our health. Different food items contain different nutrients in various proportions and they all contribute to human health in one way or another. Living in a low-lying coastal setting with delicate coastal ecosystems and a strong reliance on tourism, agriculture, and industry for economic activity makes residents of the coastal settlements of Lagos State particularly vulnerable to the effects of a changing climate [2]. Eti Osa is a coastal settlement which houses many industrial, residential and tourism activities most especially fish farming, hence vulnerable to pollution.

Bisphenol A (BPA), 2, 2,-bis (4-hydroxyphenyl) propane, CAS No. 80-05-7, is an industrial chemical that is made by combining acetone and phenol. It is extensively used as a monomer in the production of polycarbonate plastics and as a precursor of epoxy resins. Polycarbonate (PC) is widely used in the manufacture of food containers (e.g., milk, water and infant bottles) and epoxy resins are used as the interior protective lining for food and beverage cans [3]. As a result of these food contact uses, minute quantities of BPA can potentially leach out into water or food and consumers may be exposed to BPA through the diet [4]. Bisphenol A has also been widely utilized in recent years for assessing aquatic toxicity due to its negative effects on organisms, particularly seafood. As a result of its extensive use and massive production, it can enter aquatic systems [5]. The US environmental protection agency (USEPA) has proposed a reference dose of 50 µg/kg body weight/day through oral exposure [6]. The specific level of migration of BPA in food was also reported as 600 µg/kg [7]. Since the migration of chemicals, especially plastic compounds, to food is done through chemical reactions in very low concentrations, chronic toxicity is caused by the accumulation of low concentrations of contaminants over time. In addition, the use of general health risk assessment techniques to estimate EDCs risks is common throughout the world [8]. Thus, in order to look into potential exposure and hazard risk for human consumption, this study measures the amount of Bisphenol A in various aquatic seafood samples from Eti-Osa Area of Lagos.

2 Experimental section

2.1 Study Area

The Lagos lagoon is a wide expanse of estuarine water and the largest lagoon system off the Gulf of Guinea and is ecologically and economically important aquatic ecosystems that provide water and food, primarily in the form of Seafood, to many people worldwide. The study area (ETI OSA) is located from N6^{o}27’49.6512”, and E3^{o}32’ 19.5072”. Eti-Osa local government area is located on a land mass measuring roughly 129.5 square kilometers along the foreshores of sandy beaches, wetlands, mangroves, and creeks in the south-eastern region of Lagos State. It is bordered on the north by the Lagos lagoon, on the south by the Atlantic Ocean, and on the west and east by the local governments of Ojo and Ibeju-Lekki. With a wide range of economic activities like banking, tourism, retail and wholesale trading, commercial transportation, and massive real estate development for both residential and commercial purposes, the Eti-Osa local government area—which includes Victoria Island and the Lekki peninsula—is rapidly urbanizing and hence vulnerable to pollution.

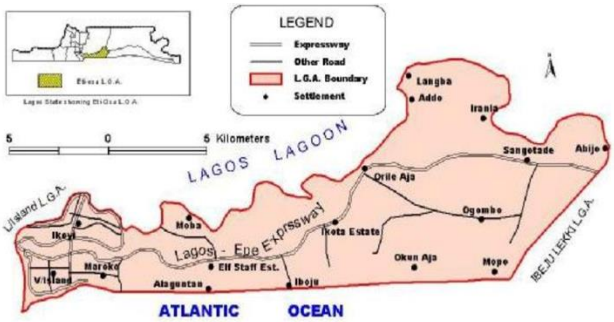

Figure 1. The study area (ETI OSA)

2.2 Materials and Methods

All equipment and apparatus used are in good condition which include steel blender, weighing balance, micro pipette, measuring cylinder, suction pump, Buchner flask, glass funnel, pH meter, separating funnel, fume compound, beaker, standard flask, burette, hot plate, glass fiber, 10 mL reaction vial.

2.3 Sampling

A total of four fresh commercial aquatic species (Cray Seafood, shrimp, Crab and Periwinkle) were collected from fishermen for a period of one month (February 2022) using seine net.

Seafood samples were transported to the laboratory in ice packed glass container. The samples were sorted and homogenized with Warning two-speed laboratory blender (120 Gax Model GFA-EX7i, Germany). 10g portion of each sample was used for the extraction process, where 50% of the samples were portioned in duplicates. The samples were refrigerated in glass containers at 4 ± 1°C until the time of analysis. Some procedures during sampling and analysis were applied to avoid external BPA contamination during the analysis. The use of plastic materials was avoided, collection flask and glass materials were rinsed with dichloromethane [9].

2.4 Procedure

The method employed for the extraction procedure avoids the requirement for solvents like acetonitrile, which may have required somewhat lengthy evaporation durations.

All the glassware were washed, dried and rinsed with acetone before it was heated to 220°C to remove any possible contaminate with BPA since the melting point of BPA is 158°C and the boiling point is 220°C. A stock solution of 4, 4'-isopropylidenediphenol commonly named Bisphenol A (CAS number 80-05-7, Aldrich) containing 50 μg/L was prepared in a 100 mL volumetric flask, by dissolving 5.0 mg of the compound in ethanol 96% (v/v) (Panreac). A standard solution of 100 mg/L of $2H_{10}$-anthracene in n-hexane supplied by Cromlab (Barcelona, Spain) was used as an internal standard after adequate dilution with n-hexane to a final concentration of 3 μg/L. This solution was used to spike the samples. Potassium dichromate was heated at 300°C in a muffle furnace. Sodium sulfate, Potassium dichromate and dichloromethane were used for the extraction procedures.

150 g of K_2CO_3 and 3 drops of 0.1 M NaOH was added to a 2 g of each seafood sample containing 10.0-250.0 μg/L of bisphenol A in glass bottle. The mixture was mechanically shaken for 2 mins and then filtered using a suction filtration, the solid residue was washed with 15 mL of 0.1 M NaOH. The pH of the filtrate was adjusted to 4 using 1.2 M hydrochloric acid and transferred to another separating funnel where it was extracted with 20 mL of dichloromethane. The mixture was mechanically shaken using a laboratory shaker (Carbolite model ARG 20/2A/UK) for 1 min at 1500 rpm and left to stand for 5 min which led to the formation of two layers (organic and inorganic layers), and the underlying organic phase was allowed to drip into a glass beaker filled with sodium sulfate in order to dehydrate it. The walls of the dry beaker was rinsed with 5.0 mL diethyl ether. The organic phase was then directly transferred to a 10 mL reaction vial (Reacti-vap-evaporator model, Thermo Fisher Scientific, USA) where diethyl ether was evaporated to dryness under nitrogen at 40°C. The reaction vial was allowed to cool after which 0.2 L of a mixture of 1:1 hexane–dichloromethane was added. The

mixture was shaken for 30 minutes and 50 µg of $2H_{10}$-anthracene internal standard solution was added before transferred into gas chromatography vials for GC-MS analysis.

2.5 GC-MS analysis

A GCMS (Agilent 6890 series I gas chromatograph with auto-sampler ejector series 7683) was used. A 10 µL aliquot of the extract was injected by the auto-sampler using the split less injection mode with the split valve closed for 0.5 min. The GC-MS parameters used were as follows: injector temperature, 325°C; detector temperature, 285 °C; and oven temperature, programmed from 100 °C for 3 min then 30 °C/min to 280 °C for 5 min, Run Time 14 min. The concentrations of the environmental estrogenic pollutant BPA were calculated by the internal standard method. In order to check the accuracy of the method used, a recovery study was carried out by analyzing one of the samples (shrimps) at two concentration levels corresponding to 0.05 mg/kg. The recovery of the BPA from spiked samples with an average recovery ± standard deviation (SD) (n=1) of 89±3. A calibration graph was constructed in the same way using solutions of bisphenol A of known concentrations.

3 Results and Discussion

Table 1. The concentration of Bisphenol A

Sample code	Average BPA ± (SD) (mg/kg)	pH
E(Crayfish)	0.246±0.0021	4.0
F(Shrimp)	0.173±0.0014	4.1
G(Periwinkle)	0.024±0.0035	4.1
H(Prawn)	0.012±0.0014	4.0

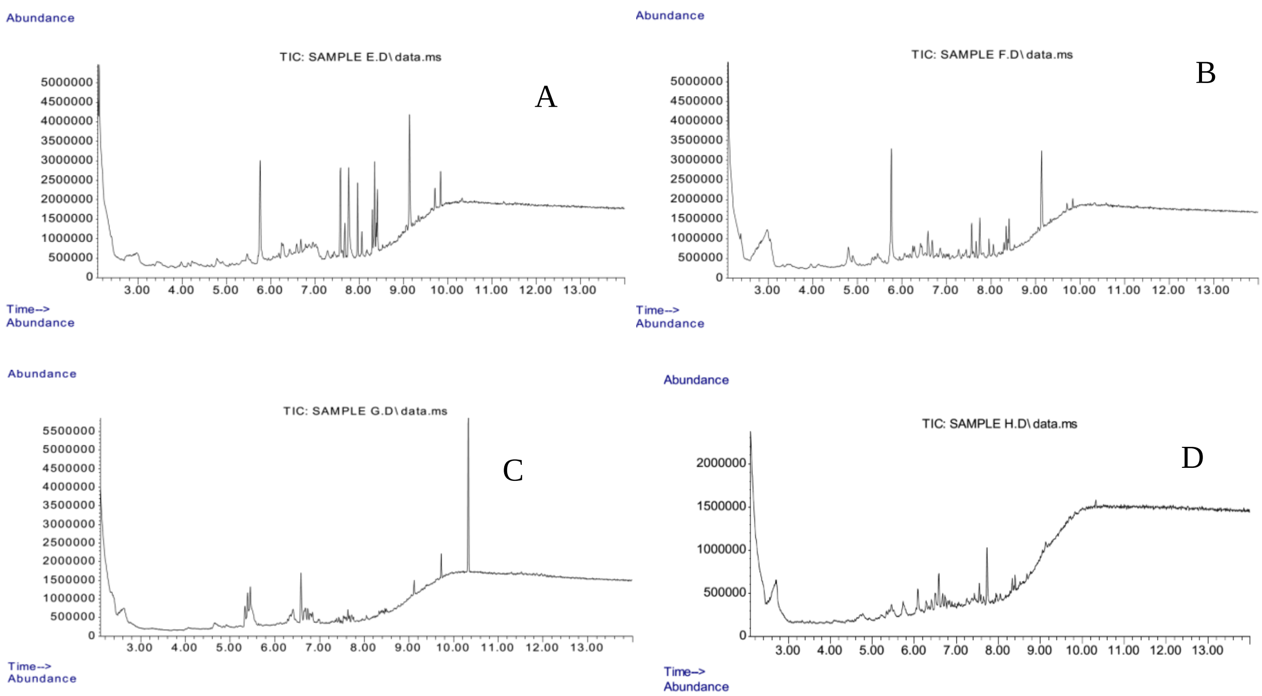

Figure 2. GC-MS absorbance Graph for (A) Crayfish, (B) Shrimp, (C) Periwinkle and (D) Prawn

3.1 Health Risk Assessment

The survey on the possibility of adverse health effects associated with the exposure to contaminant over a specified period of life and on a specific population, is called human health risk assessment, which includes hazard identification, toxicity evaluation, exposure assessment, and risk characterization.

3.2 Estimated Daily Intake

$$EDI = \frac{C_{BPA} \times IR}{BW}$$
(Equation 1)

Where EDI is the estimated daily intake through ingestion (μg/kg/day), C_{BPA} is the concentration of BPA (μg/L). IR is seafood ingestion rate (mL/day), and BW is body weight (kg) [5].

3.3 Potential Risk Index

$$HI = \frac{EDI}{RFD}$$
(Equation 2)

Where HI indicates potential risk. The HI value was calculated using equation (2). BPA reference dose (RFD) based on the oral exposure route was considered as 50μg/kg/day using the USEPA Integrated Risk Information System (IRIS) database. The HI values of BPA in seafood of body weight was less than 1. The HI values of <1 indicates safe level while HI values >1 indicate levels of concerns. From the estimated HI values, low health concern of BPA is associated with the consumption of these seafood samples. This result supports the HI value as reported by [1].

Table 2. Data of potential risk

Sample code	Average BPA ± (SD) (mg/kg)	pH	HI	EDI
E(Crayfish)	0.246±0.0021	4.0	0.0035	0.1740
F(Shrimp)	0.173±0.0014	4.1	0.0025	0.1223
G(Periwinkle)	0.024±0.0035	4.1	0.0003	0.0170
H(Prawn)	0.012±0.0014	4.0	0.0002	0.0085

The extracts were analyzed to qualify and quantitate the amount of BPA present in them. The GC-MS analysis results are provided for each extract. The obtained BPA quantitative GCMS results are summarized in the tables above indicated with the sample names and the final units in mg/kg. Samples were injected in duplicate in addition to method blanks. By the analyzed categories, the average concentrations of BPA in the foods ranged from 0.012 to 0.246 mg/kg. 0.173 mg/kg (Shrimp), 0.024 mg/kg (Crab) and 0.012mg/kg (Periwinkle). Crayfish and Shrimp showed the highest BPA concentrations of 0.246 and 0.173 mg/kg respectively. The results were in agreement with [10], which is higher than the 0.06 mg/kg permissible limit set by the European Commission (2018) [11] and USEPA [6]. Crab and Periwinkle showed a lower concentrations. This maybe as a result of crabs and periwinkle external hard shell on their body making the rate of adaptation of the organisms to the leaching processes slower. The results were in agreement with [1], which is within than the 0.06 mg/kg permissible limit set by the European Commission [11] and USEPA [6]. Therefore, there are low health risks of BPA as a result of consuming periwinkle and crabs around Eti Osa in Lagos.

The highest estimated daily intake of BPA was higher in crayfish followed by shrimps, followed by crabs and periwinkle. These values were lower than 35.1, 200–2000, 180 and 80 ng/kg bw/day reported in the USA [12], Japan [13], Canada [14] and New Zealand [15]. The values of HI of BPA in the selected seafood samples in Eti Osa Lagos ranged from 0.0035–0.0020 mg/kg (Table 1). In all the seafood categories analyzed, HI was lower than 1, which suggested no human risk of exposure to BPA by ingestion of the selected seafoods commonly consumed in Eti-Osa but long term consumption indicates potential risk.

4 Conclusions

Bisphenol A is a contaminant of great concern, particularly for vulnerable population groups. Thus, it is necessary to construct efficient BPA control/ removal systems within the aquatic environments. As a chemical hazard, BPA may enter the food chain during processing and discharging of effluents into various water bodies. Considering the ubiquitous presence of BPA in the environment and its widespread use, to reduce human dietary exposure, further measures for different food items should be carefully considered.

5 Declarations

5.1 Author Contributions

The names of the authors listed in this journal contributed to this research.

5.2 Conflicts of Interest

The authors declare no conflict of interest.

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