Research Article *Open Access*

Journal of Geoscience and Eco Agricultural Studies

ISSN: 3067-7297

Studies on some Endocrine Disrupting Chemicals from Water Samples within Kaduna Metropolis Nigeria

Ekpa Emmanuel[1*], Astajumba Juwairiya[2] and Micheal Nancy Erika[1]

[1]Faculty of Science, Biology Unit- Airforce Institute of Technology Kaduna, Nigeria
[2]Faculty of Science, Chemistry Department, Airforce Institute of Technology Kaduna, Nigeria

Citation: Ekpa Emmanuel, Astajumba Juwairiya and Micheal Nancy Erika (2025). Studies on Some Endocrine Disrupting Chemicals from Water Samples within Kaduna Metropolis Nigeria. J.of Geo Eco Agr Studies 2(1), 01-09. WMJ/JGEAS-103

Abstract

Endocrine disruptors in water impose risks to reproductive health and they come majorly from chemical contamination in water from a variety of sources. This may include byproducts formed during water disinfection processes, domestic cross contamination between shallow wells and soak a-ways, industrial discharges, livestock activity, and therapeutic drugs released into sewages. Most of these compounds are known to possess endocrine disrupting potentials (the so called Endocrine Disrupting Chemicals-EDCs). EDCs have been found to affect the endocrine system and subsequently impair the fertility in non-human animals as well as humans too. In this current study, four water samples were aseptically obtained from different sources in order to investigate the level of these chemicals in them. The sources include: tap water from public supply, borehole, local hand dug well water, and effluent from some industrial discharges. They were collected between the months of August and September 2023 from all the four local government council covering Kaduna Metropolis of Nigeria. This is with a view to determining the amount of some EDC's particularly Bisphenols and phthalate in the water. Liquid-liquid extraction, column chromatographic clean-up and capillary Gas chromatography-Mass Spectrometry (GC-MS) were used to quantify amounts of some of these EDCs. Levels of phthalates in water samples from the Tap, Well and Borehole water ranged from 1.46 µg/ℓ-2.02 µg/ℓ, while a concentration of 4.02 µg/ℓ in industrial water for both Bisphenol and phthalates were also recorded. Generally, levels found in the water samples except for the industrial water were all within the criterion of 3 µg/ℓ recommended by the United States Environmental Protection Agency (USEPA) for drinking water. The implication of these findings is hereby elaborated.

***Corresponding Author:** Ekpa Emmanuel, Faculty of Science, Biology Unit- Airforce Institute of Technology Kaduna, Nigeria.

Submitted: 07.02.2025 Accepted: 18.02.2025 Published: 20.02.2025

Keywords: EDCs, Water, GC-MS, Fertility, Kaduna metropolis, Nigeria

Introduction

Endocrine disrupting chemicals (EDCs) are synthetic or naturally occurring substances that can interfere with the endocrine system which regulates hormones in the body. These chemicals can mimic, block or interfere with hormonal signaling, leading to a range of adverse health effects in humans and wildlife [1]. EDCs can be found in various sources, including food, personal care products, and the environment. In particular, water sources are a major route of exposure to EDCs, as these chemicals can leach into water from industrial and agricultural activities, wastewater treatment plants, and landfills [2]. Some of these EDCs include Bisphenol A (BPA) found in plastic bottles, food packaging, and canned foods, Phthalates found in personal care products, plastics, and building materials, Pesticides found in agricultural products and drinking water, and Flame retardants found in furniture, electronics, and textiles. Their effect ranges from Reproductive and developmental disorders, Hormonal imbalances, Thyroid dysfunction, Immune system dysfunction, and Cancer. The concentrations and types of different man-made xenobiotic pollutants continue to be on the increase in aquatic environments in recent times Lecomte et al. Some of these pollutants are reported to be present in the tissues of aquatic organisms including fish, wildlife and humans [3].

Recently, wide varieties of chemicals, some of which are emerging contaminants, were reported of capable of disrupting the endocrine system of higher life forms by mimicking the hormones [4]. These substances not completely regulated even in the most developed countries of the world and can be a hazard to an entire ecosystem. Endocrine disrupting chemicals (EDCs) are a large and varied group of chemicals that are able to cause endocrine mediated abnormalities in invertebrates, fish, avian, reptilian and mammalian species including humans [5,6]. These categories of chemicals can be synthetic or naturally occurring and may be directly or indirectly released into the aquatic environment Vilela et al. They are also classified as heavy metals and organic chemicals such and include polychlorinated biphenyls (PCBs), organochlorine pesticides, plasticizers, surfactants, pharmaceuticals, natural and synthetic estrogens as well as phyto- and myco-estrogens [5].

Kaduna City is one of the major urban centers in Nigeria with a growing population and increasing demand for water. However, there is limited information on the levels of EDCs in different water sources within Kaduna metropolis. This raises concerns about the potential health risks associated with exposure to these chemicals. The presence of endocrine disrupting chemicals (EDCs) in water sources has become a major concern globally, with increasing evidence linking exposure of EDCs to adverse health effects, including reproductive and developmental problems, cancer and immune system dysfunction. Kaduna metropolis, like many urban areas in Nigeria, is facing challenges related to water quality and availability, with many residents relying on different sources of water for their daily activities. These challenges come with diverse health and reproductive related issues. It is expected that the results from studies like this will be useful to policy makers, environmental and health authorities, water treatment plant operators, and the general public. The presence of endocrine disrupting chemicals (EDCs) in any community is a major concern as these substances have adverse effects on humans and wildlife. Exposure to EDCs has been linked to reproductive and developmental problems, cancer, and immune system dysfunction, among other health issues. Despite the potential risks associated with exposure to EDCs, there is limited information on the levels of these chemicals in water sources within Northern Nigeria and Kaduna city in particular. This lack of information raises fear about the potential health risks associated with exposure in water sources and highlights the need for an assessment in different water sources in Kaduna metropolis. Therefore, assessment of EDCs in water sources within Kaduna City is important to understand the extent of their contamination or otherwise and develop strategies for managing and controlling exposure. The aim of this present work is to assess the levels of some endocrine disrupting chemicals (EDCs) especially Bisphenol and Pthalates from different water sources within Kaduna metropolis, so as to understand the degree of prevalence or otherwise.

Materials and Method

All reagents used were of analytical grade and they include the following:

- Hydrochloric Acid

- Methanol
- HPLC Grade Acetone
- Ethanol
- Sodium Hydroxide
- Dichloromethane
- GC-MS Machine

Methods

The Study Area

Kaduna metropolis has a total land area of about 3,080km2. It is located between Latitudes 100 52' and 100 30'N and Longitudes 70 15' and 70 45' east. The area is situated on a relatively low plain liable to flood. The topography of the area consists of a rolling park-like terrain with little relief situated about one hundred feet (500m) above sea level. The soils of the study area fall within the tropical ferruginous soils. The topsoil is coarse sandy loamy to clay loamy. The area was initially characterized by over 80% agricultural land-use. However, owing to the petroleum industry, the land-use pattern is fast changing now. The climate of the study area is part of the tropical wet and dry climate of Nigeria. The climate is characterized by the wet and dry seasons. The wet season begins in April and ends in October. Though, there are fluctuations in the beginning and the ending of the seasons from year to year in some years it begins early may. The area has a mean annual rainfall of about 1204 to 1567mm, mean daily temperatures of between 270c to 330c, and relative humidity of about 99% during the wet season and less than 55% in the dry season. The 2006 census estimated the population of Kaduna metropolis to be above a million people.

Sample collection [4]:

For this work, four sample points were chosen to cover the four Local Government Areas that makes up the entire Kaduna Metropolis namely Kaduna North, Kaduna South, Chikun and Igabi. The surface water samples were collected at the mid-stream using Grab method and were collected from 4 selected sources (Well water, Tap Water, Borehole Water, and Industrial effluents). Prewashed amber bottles bathed with water were used to collect samples. Thereafter, samples were kept cool in ice packed coolers before extraction of compounds. The samples were marked A, B, C, and D respectively. The samples were collected on different days in the month of August and September 2023.

Sample Extraction [3,4]:

Water samples were extracted via liquid–liquid extraction. About 200 mL of the water samples were filtered through glass fibre filters (Whatman GF/F, 1 µm effective pore size) to remove suspended particles. One hundred (100) µL each of 1 mg/L BPA-d16 was then added to the filtrate as internal standards. Extraction was carried out with 50 mL dichloromethane and then with 25 mL hexane. Were added to the extracts and dried over anhydrous sodium sulphate. For all extraction procedures, methanol was added to enhance the isolation of analytes [5].

Characterization [4]:

A glass column was packed with about 5 g silica gel (Kieslgel Merck 60, 230 to 400 mesh) in 20 mℓ of hexane with a 0.5 to 1.0 mℓ top layer of anhydrous Na2SO4. The reconstituted phthalate residues from both water and sediment extracts, were run separately through the column and then eluted successively with hexane and about 20 mℓ benzene ethyl acetate mixture (95:5). The benzene/ethyl acetate eluants were allowed to dry separately and then redissolved in hexane with internal standard and then run on the GC using the optimum conditions described above. The eluants were left to dry at room temperature respectively in a glass container to form a residue.

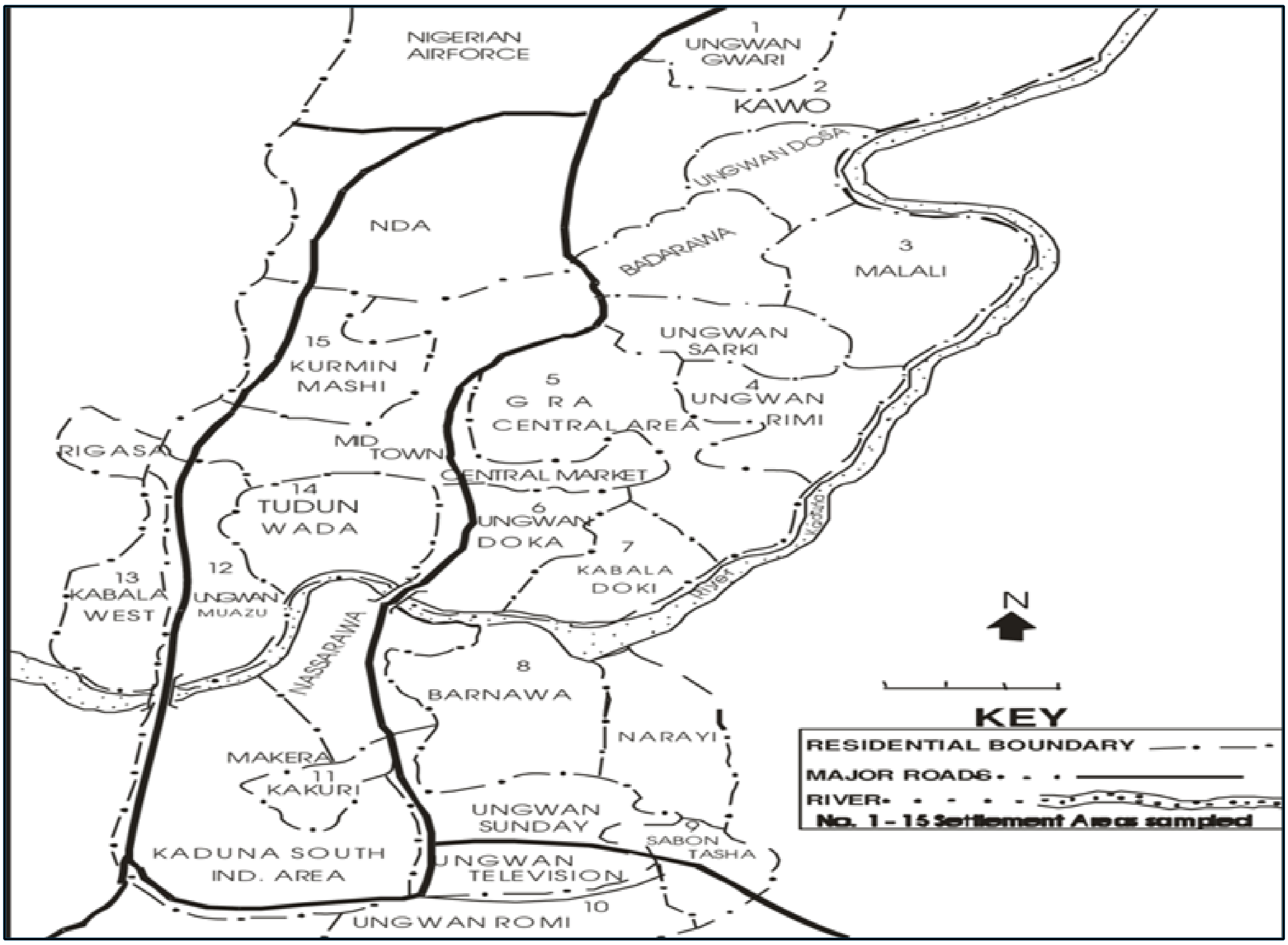

Figure 1: Map of Kaduna Metropolis (Google Map, 2023).

Water Analysis Using GC-MS [3,7]

Analysis was undertaken using the Perkin Elmer Clarus 500 Gas Chromatograph, with FID detector and capillary column (Col-Elite 5 to 30 m, 0.25 µm to 0.25 mm) supplied by Perkin Elmer SA (Pty.), Ltd., Cresta, Johannesburg, South Africa. The gas chromatograph had an auto-injection, dual column system for both FID and ECD. The chromatograms were handled by a total Chrom Work Station supplied by Perkin Elmer, South Africa.

Results and Discussion

Figure 2: GC-MS Chromatogram of Sample A

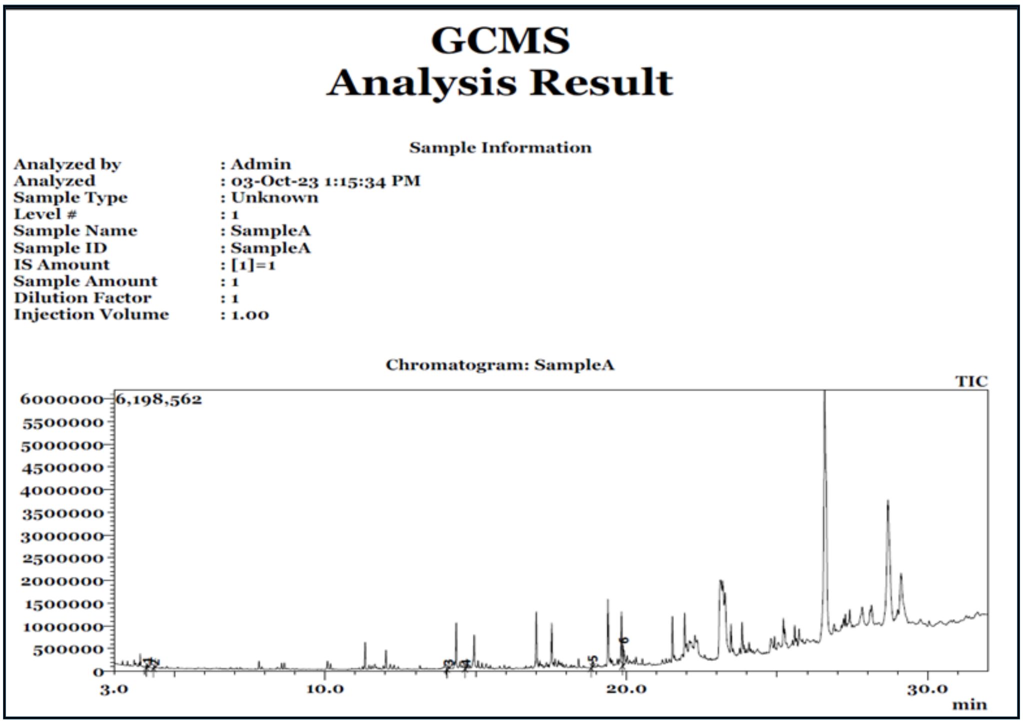

Figure 3: GC-MS Chromatogram of Sample B

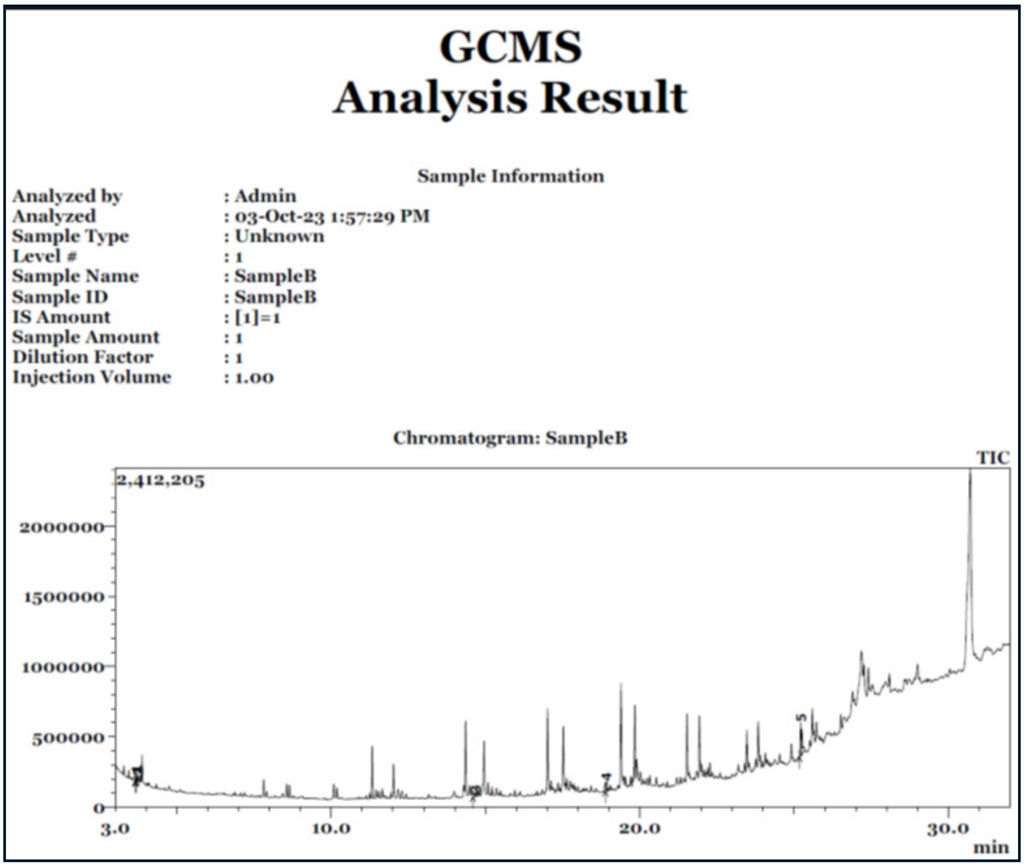

Figure 4: GC-MS Chromatogram of Sample C

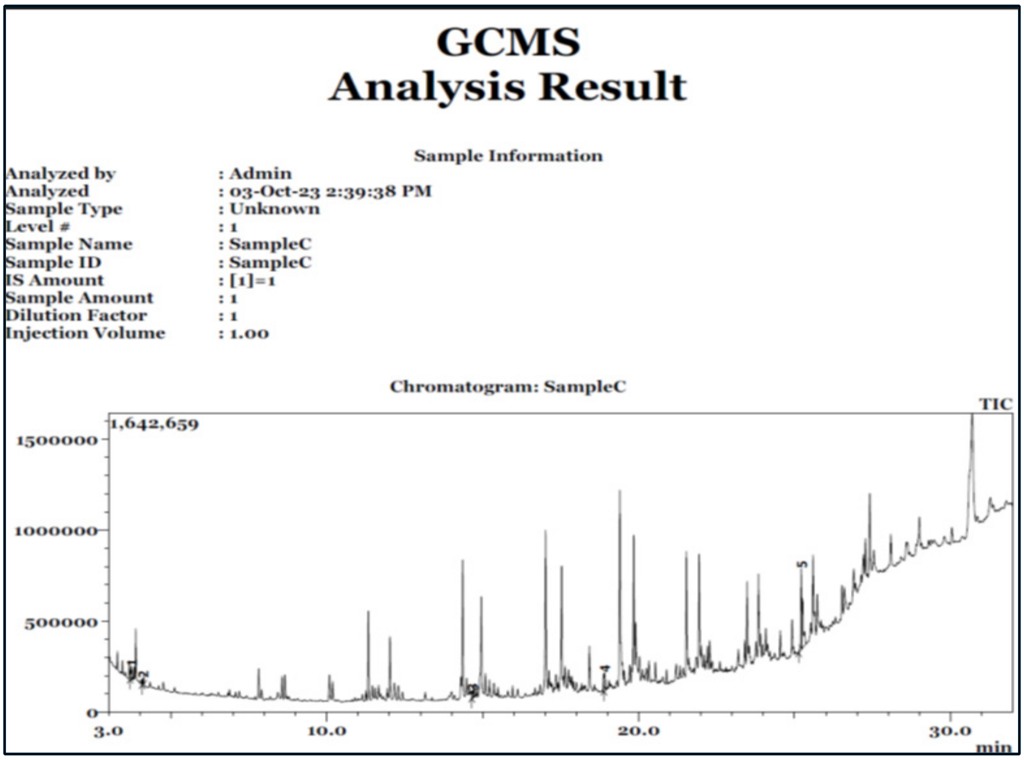

Figure 5: GC-MS Chromatogram of Sample D

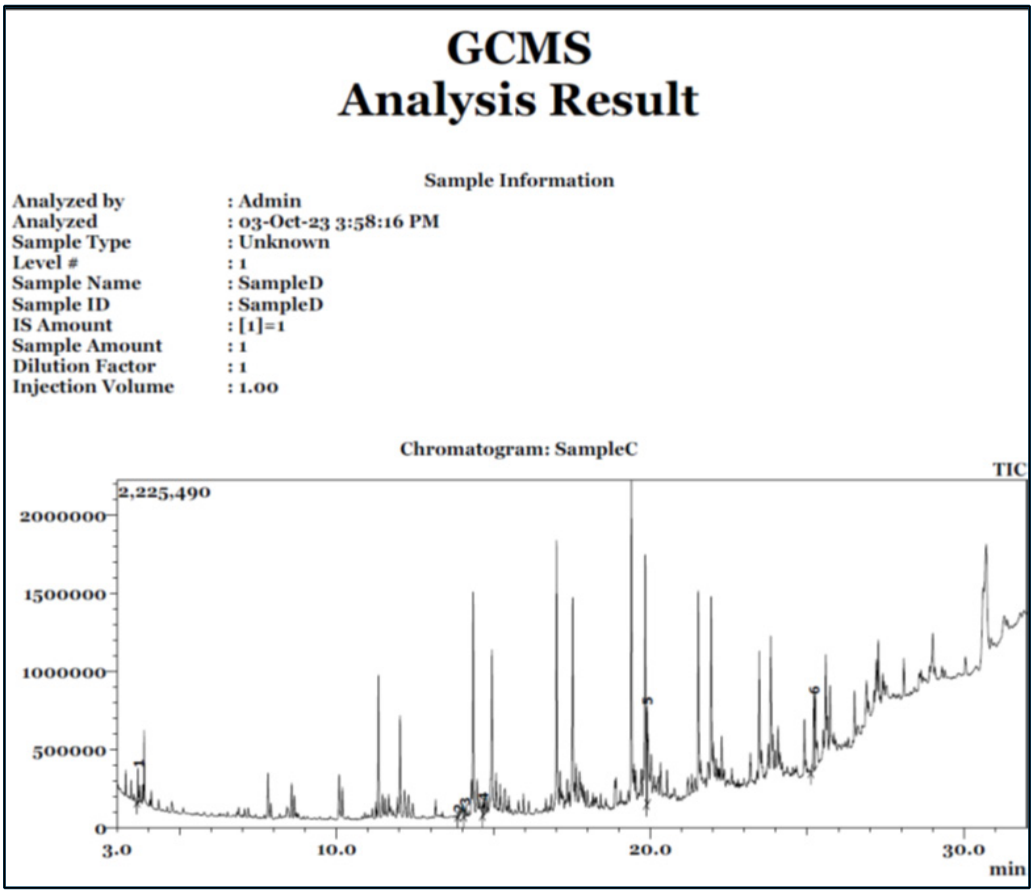

Table 1: Summary of Concentration of Phthalate and BPA in Water Samples Analyzed

S/N	Sample	BPA (µ/l)	WHO Limit (µ/l)	Pthalate ((µ/l)	WHO Limit (µ/l)
1	A	1.67	2	2.03	8
2	B	4.04	2	2.14	8
3	C	1.94	2	2.22	8
4	D	3.85	2	12.78	8

Discussion

Results of GC-MS determination of some endocrine disruptors from four water samples in Kaduna metropolis (Figures 2-5 and table 1) shows that a number of organic compounds were found in each of the water samples studied, however Bisphenol and phthalates were the predominant ones. Lowest levels of Bisphenol compounds were seen in sample A (1.67µ/l) which increased to 4.04µ/l in sample B probably due to the fact that the sample been tap water might have been undergoing treatment which involves the use of organo-chloride compounds, Though the values are still within acceptable limits as seen in Figures 1 and 2. However the amount of phthalates was expectedly higher in sample D which is effluent water. This might be due to discharges of various kinds of contaminants from the industries. The Industrial water used for this particular work came from a combination of Brewery spent water and plastic making companies. Recently, researchers around the world have studied the occurrence of phthalates and Bisphenol A (BPA) (19). They are considered ubiquitous pollutants because they can often be found in different point and nonpoint contamination sources such as industrial and domestic wastewater, raw and treated wastewater used for irrigation, bio-solids or sewage, sludge and landfill leachates [8-10]. Therefore, phthalates and BPA could migrate and infiltrate aquifers contaminating shallow groundwater at any point in time. Consequently, the problem becomes paramount if we consider that groundwater is one of the major freshwater resources which approximately accounts for one-third of global population consumption [11]. Additionally, most of these EDCs are quite stable and resistant to actual potable water treatment methods, and there is concern because they may persist in drinking water at relatively high concentrations [12]. This accounts for the result obtained from tap water also in this work (Figure 3). Most of the work done within the country on similar compounds gave results of between 2.0-6.4 µ/l corresponding to values gotten in this work. It must be stated at this juncture that majority of literature on this kind of work were done in the southern part of the country. The occurrence or arrival of phthalates and BPA in municipal and industrial wastewater treatment plants (WWTPs) has been widely studied. The influent mean concentrations have been shown to vary from 0.06 to 146.37 µg L−1 and from 0.02 to 416 µg L−1 for phthalates and BPA respectively which agrees with most of the findings in this work (Table 1). For instance, reported that the mean concentration of the six priority phthalates in wastewater from Alice in Eastern Cape, South Africa, varied from 2.54 µg L−1 (influent) to 2.196 µg L−1 (final effluent), which represents 98.2% of their elimination from wastewater by activated sludge treatment. Despite this high removal percentage, a significant amount of phthalates is still transferred to sewage sludge [13].

BPA is ubiquitous in aquatic environments and can be detected in rivers, effluent from sewage treatment plants, and water from water treatment plants. Specifically, the mean concentrations of BPA in the Huangpu River in China were 2.293 µ/l in surface waters, 8.411 µ/l in suspended solids, and 7.13 µ/l in dry weight surface sediments. Furthermore, a study in Taiwan determined that BPA concentrations in drinking water were increased with contact time in polyvinyl chloride (PVC) pipes. In some provinces of South Africa, BPA was found to be present in 62% of the analyzed drinking water and wastewater samples. All these findings are in consonance with results gotten from researches done in various parts of Nigeria's southern coast. For instance, finding of this study corresponded to the study of which reported concentrations of BPAs in water samples between 0.06 and 6 µg/L. reported a total BPAs concentration range of 0.00004 – 0.011 µg/L. A slight increase in the levels of PBAs and pthalates in this study was observed compared to the study of which could be as a result of factors of the environment. Other studies from raw and tap water samples in France, BPA levels were up to 14.30 µ/l and between 9.0 and 50.0 µ/l respectively [4,5,14]. The United States Environmental Protection Agency (USEPA) reported that BPA concentrations in US drinking water are typically below 10 µ/l. Although exposure to BPA through tap water is a minor source of human BPA exposure, bottled mineral water may also lead to exposure and long-term harm [2,15,16].

Conclusion

Growing evidence indicates that anthropogenic contaminants are present in water across the world and that they can impose negative health effects in non-human animals and humans. This particular studies shows that water within Kaduna metropolis do not harbor higher concentrations of EDCs except for those seen from industrial effluents. Results obtained for now may give cause for alarm but we need to realize that these environmental toxicants can act directly or indirectly on the reproductive system, impairing development and fertility as they keep accumulating overtime. Considering that the routes of exposure to these chemicals are not restricted to the ingestion of water, the levels of exposure for some of these compounds can be much higher than those from water alone. Further studies in a wide variety of populations and species are required to explore the long-term consequences of exposure to contaminants present in water and their health effects. Although the effects of chemicals among species may differ, non-human animal models serve as a basis for scientific experimentation as they provide mechanistic, effective, and toxicological information about EDCs. Additionally, it is necessary to consider the effects of mixtures of contaminants from different categories to mimic the normal environmental exposure in domestic animals, wild life, and humans. More studies are needed in a variety of populations to determine if the impacts of environmental chemicals on reproduction differ by populations in different locations worldwide.

References

1. Ayodele Ifeoluwa Faleti (2020) Microplastics in the Nigerian Environment- A review.
2. United Nations Environment Programme (2021) Global Chemicals Outlook II - From Legacies to Innovative Solutions: Implementing the 2030 Agenda for Sustainable Development. Retrieved from https://www.unep.org/resources/report/global-chemicals-outlook-ii-legacies-innovative-solutions-implementing-2030-agenda.
3. Adeniran AA, Abiodun OA, Adeyemi OB (2019A) Levels of Bisphenol A and Phthalates in Surface Water Samples Collected from Lagos, Nigeria. Nigerian Journal of Technological Research 14: 250-256.
4. Adeniran HA, Ibor OR, Adebayo OO (2019B) Occurrence and risk assessment of phthalates and bisphenol A in surface water from Lagos Lagoon, Nigeria. Heliyon 5: e02564.
5. Taiwo NA, Suraju AL, Elizabeth OO, Mumuni A (2023) Occurrence of bisphenol A, nonylphenol, octylphenol and heavy metals in groundwater from selected communities in Ibadan, Nigeria 26.
6. Onwurah INE, Diagboya PN, Zebaze Kana MG (2018) Levels and risk assessment of heavy metals and endocrine-disrupting chemicals in selected drinking water sources in Nigeria. Environmental Monitoring and Assessment 190: 103.
7. Adeyi AA (2020) Distribution and bioaccumulation of endocrine disrupting chemicals (edcs) in lagos lagoon water, sediment and fish. Ife Journal of Science 12.
8. Vandenberg LN, Colborn T, Hayes TB, Heindel JJ, Jacobs Jr, et al. (2012) Hormones and endocrine-disrupting chemicals: low-dose effects and nonmonotonic dose responses. Endocrine Reviews 33: 378-455.
9. Zoeller RT (2015) Executive summary to EDC-2: The Endocrine Society's Second Scientific Statement on endocrine-disrupting chemicals. Endocrine Reviews 36: 593-602.
10. Lauby-Secretan B, Loomis D, Grosse Y, El Ghissassi F, Bouvard V, et al. (2013) Carcinogenicity of some industrial chemicals. The Lancet Oncology 14: 1132-1133.
11. Kwaku AA, Agyei-Mensah S (2017) Endocrine

Disrupting Chemicals (EDCs) in Water Sources: Effects, Sources, Challenges and Removal Technologies - A Review. Science Journal of Chemistry 5: 59-70

12. Gore AC, Chappell VA, Fenton SE, Flaws JA, Nadal A, et al. (2015) Executive summary to EDC-2: the endocrine Society's second scientific statement on endocrine-disrupting chemicals. Endocr Rev 36: 593-602.
13. Rochester JR (2013) Bisphenol A and Human Health: A Review of the Literature. Reproductive Toxicology 42: 132-155.
14. Leffers H, Bendixen M, Hagmar L, Toft G (2012) Risk of Endocrine Disrupting Chemicals in Drinking Water - A Review. Ugeskrift for Laeger 174: 2613-2617.
15. Kumar A, Lamberton J, Alves A, Blazer V, Bullard S, et al. (2019) State of the Science of Endocrine Disrupting Chemicals 2012. UNEP/WHO. Retrieved from https://www.who.int/ceh/publications/endocrine/en/.
16. World Health Organization (2019) Endocrine Disrupting Chemicals (EDCs). Retrieved from https://www.who.int/news-room/fact-sheets/detail/endocrine-disrupting-chemicals-(edcs)