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A cross sectional study to Estimate the presence of Plasticizers in Plastic water bottles and its effect on Hormonal disruption at a Tertiary care hospital in Puducherry

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Abstract

Background: Humans are regularly exposed to a wide array of chemicals everyday through consumer products. Many of these chemicals are at very low concentrations and do not present any significant health risk. Certain bisphenols, plasticizers, and flame retardants are receiving growing attention as they have recently been classified as proven or potential endocrine disrupting chemicals (EDCs), meaning they mimic hormones in the human body and can be associated with altered reproduction in males and females, abnormal growth patterns and neurodevelopmental delays in children.

Objectives & Methodology: The aim of the study was to quantify the presence of plasticizer [di (2- ethylhexyl) phthalate (DEHP) and bisphenol A (BPA)] in Plastic water bottles/cans, to Characterize potential exposure through drinking water to plasticizers while taking into account temperature variations, to characterize the Effects of temperature and storage time on leaching of plasticizers and to assess the knowledge and attitude of consumers on the usage of disposable plastic water bottles and hormonal disruption property of the same.

Results: The results was found that significant leaching of DEHP and BPA from disposable plastic water bottles at both high (40°C and above) and low temperatures (5°C and less). DEHP and BPA, a common plasticizer, is regulated by various countries. Indian regulatory should also bring about strict regulations for the same. The survey also showed a lack of knowledge about plasticizers (51.2%), with 15.5% storing bottles in high temperatures and 77.7% storing bottles in refrigerators, out of which 15.5% had history of endocrine abnormalities.

Conclusion: The detected levels of plasticizers were within international limits and also well within toxic limits, emphasizing the need to avoid storing the bottles in extremes of temperature and reuse of disposable plastic or PET bottles. Even during transport temperature conditions should be ensured by regulatory authorities. This can be emphasized only if the consumers are made aware about the Plasticizers and the harmful effects of the same. Also, proper storage of water bottles under normal temperature conditions should be recommended by regulatory authorities. FSSAI regulates that certain infant nutritional food supplements should be packed in BPA free material, similarly standard for making water bottles and the allowable limits of BPA in it can be specified by regulatory authorities.

Key words: Bisphenols, plasticizer, flame retardants, high temperatures, refrigerators, di (2- ethylhexyl) phthalate

INTRODUCTION

The widespread use of plastic products has led to increasing human exposure to a variety of synthetic chemicals, including plasticizers such as bisphenol A (BPA) and di(2-ethylhexyl) phthalate (DEHP). These substances, used to improve the flexibility and durability of plastics, are now recognized as endocrine-disrupting chemicals (EDCs) capable of mimicking or interfering with hormone signaling in the human body. Even at low concentrations, EDCs have been associated with a range of health issues, including reproductive

abnormalities, metabolic disorders, neurodevelopmental delays, and hormone-dependent cancers [1,2]. Governments around the world have implemented regulations regarding the production and importation of certain EDCs, such as bisphenol A (BPA), and this has led to the development of replacement chemicals. Unfortunately, these replacement chemicals are not always thoroughly tested for low-dose or long-term toxicity. Contaminated potable water, which can be caused by contaminated water sources, insufficient water treatment technologies, or contaminated piping and packaging, is one route of human exposure to flame retardants, bisphenols, and plasticizers. Some rural areas do not have easy access to potable water so it is collected and stored in plastic containers, which might result in higher risks of contamination. Nowadays, food packaging is an indispensable element in the food manufacturing process [2]. Bottled water consumption has become very popular worldwide due to ease of transportation, expected safer conditions, and ease of storage in case of emergency. Different policies have banned the sale of bottled water due to the pollution generated by the disposal of the bottles, the use of fossil fuels in their production, and the high consumption of water in the manufacture [1].

Plastic containers, particularly those made from polycarbonate and polyethylene terephthalate (PET), are widely used for packaging water due to their convenience and low cost. However, storage conditions such as temperature and duration significantly influence the extent of chemical leaching from these containers into the water they hold [3]. DEHP and BPA are of particular concern because they are prone to migrate into bottled water under certain conditions, and have been detected in various international and Indian studies at levels that raise concerns about chronic exposure [4,5].

DEHP, DBP, and DEP were chosen as legacy plasticizers, as well as MEHP, which is a metabolite of DEHP and has demonstrated similar endocrine disrupting properties [4]. Plasticizers with higher molecular weights, such as di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH) and DINP, have been introduced as replacements as they are less likely to migrate out of plastics, however recent studies find the toxicity similar to that of legacy compounds [5]. Adipates, classified as low temperature phthalates, have lower molecular weights than legacy phthalates making them ideal for low temperature storage. However, adipates have greater potential to leach relative to phthalates due to their lipophilic properties at varied temperatures. Studies have shown that di (2-ethylhexyl) adipate (DEHA) and di isodecyl adipate (DIDA) have much lower toxicity and endocrine disrupting potential [6]. DEHA, DIDA, DINCH, and DINP were chosen as replacement plasticizers. Plasticizers (BPA) have been detected in South Africa's bottled and drinking water at concentrations ranging from <LOD to 3415 ng/L [7], and in Egyptian bottled water from <LOD to 104 ng/L [8]. Few studies investigating potable water from Canada found the concentration in bottled water as high as 1720 ng/L for DBP and concentrations as high as 188 ng/L for DEHP in drinking water. The average Estradiol level revealed that BPA, BBP, DBP and DEHP in bottled waters may induce adverse estrogenic effects and thyroid abnormalities and other endocrine related diseases on human health [9]. This study aims to quantify the levels of BPA and DEHP leaching into bottled water under varying temperature and storage time conditions, and to evaluate consumer awareness regarding the safe use of plastic containers and their potential for hormonal disruption.

OBJECTIVE OF THE STUDY:

To quantify the presence of plasticizer (di (2- ethylhexyl) phthalate and BPA) in Plastic water bottles/cans

- To Characterize potential exposure through drinking water to plasticizers while taking into account temperature variations.
- To characterize the Effects of temperature and storage time on leaching of plasticizers
- To assess the knowledge and attitude of consumers on the usage of disposable plastic water bottles and hormonal disruption property of the same.

MATERIALS AND METHODS:

- Type of study: Cross sectional.
- Period of study: 2 months (60 days)
- Study population: Water samples from Plastic water bottles/cans of Patients, Faculties and students of a Tertiary care medical college and teaching hospital
- Sample size: 27 water samples
- Study site: Tertiary care medical college and teaching hospital.

SELECTION CRITERIA:

Mineral water bottles/cans of at least 3 different companies, were obtained from consuming patients, Doctors and Students (aged more than 18 years) at a tertiary care medical college and teaching hospital, after getting proper consent.

PROCEDURE:

Mineral water bottles/ cans of 3 different companies, were analyzed for Plasticizer BPA and DEHP(di (2-ethylhexyl) phthalate and bisphenol A) at 5 °C, 25 °C and 45 °C at 24 hrs, 48 hrs and 1 week. (Three samples each for different temperature and time setting)

1. Sample Category A: 5 °C for 24 hrs, 48 hrs and 1 week(Three samples each) : 9 samples
2. Sample Category B: 25 °C for 24 hrs, 48 hrs and 1 week(Three samples each) : 9 samples
3. Sample Category C: 45 °C for 24 hrs, 48 hrs and 1 week(Three samples each) : 9 samples

Total Samples: 27

The samples were sent to Asthagiri Research Foundation- laboratory, Chennai, Tamil Nadu for analysis under LC-MS method.

Method of analysis of water samples:

Instrument used: SHIMADZU SPD-20A (UV/VIS Detector)

Column: Agilent C18 column, 4.6 X 250 mm (5micron)

Mobile phase: MeOH : Water(50:50)

Detector wavelength: 224nm

Injection volume: 20µl

Flow rate: 1.0ml/min

Further a questionnaire on the usage of Plasticizers and the knowledge of Plasticizers and its effects was prepared and sent among the study participants (sample size of 45) and the survey was conducted after getting the participants consent. Presence of any Endocrinal abnormality among the participants who were consuming water regularly from the various categories, which tested positive for abnormal level of plasticizers was documented based on history and laboratory findings of the participants.

STATISTICAL ANALYSIS:

Quantitative data was analysed in terms of descriptive statistics like mean, standard deviation. ANOVA was performed for within the group and between the group comparison. Statistical analysis was carried out using SPSS version 23.0 software. P value of < 0.05 was considered as statistically significant.

OBSERVATIONS AND RESULTS:

There was no statistically significant difference in the DEHP levels on using one way and repeated measure ANOVA, between the different water samples on comparing the different temperature conditions with various time points as shown in Table 1.

As shown in Table 2, there was no statistical significant difference in the BPA levels on using one way and repeated measure ANOVA, between the different water samples on comparing the different temperature conditions with various time points.

*There was a statistically significant difference observed on applying one way ANOVA on various water samples for DEHP levels based on various temperature conditions. Particularly, there was a significant increase in the DEHP levels of the water sample kept at higher temperature (T40° C) and also a significant increase was observed in a refrigerated water sample (T5°C) kept for 7 days as shown in Table 3.

*There was a statistically significant difference observed on applying one way ANOVA on various water samples for BPA levels based on various temperature conditions. Particularly, there was a significant increase in the BPA levels of the two-water sample kept at higher temperature (T40° C) for 7 days and also a significant increase was observed in a refrigerated water sample (T5°C) kept for 48 hours.

The levels of BPA detectable in various water samples were less compared to the DEHP levels but now most of the bottles are made of BPA free materials as shown in the above Table 4.

Table 5 shows the result of Study Questionnaire - On usage of Plastic water bottles. There is a lack of knowledge among 51.2 % of participants about the Plasticizers in disposable plastic water bottles. The number of participants who store the disposable plastic water bottles under Sun (particularly in vehicles) are very less 15.5%, but participants who store it in refrigerators (average of 2 days) are more with 77.7 %. Only 22 % of participants never reuse disposable plastic water bottles.

The number of participants with history of known Endocrine abnormalities out of the 45 participants who reuse plastic water bottles were 7 (15.5%). The endocrine abnormalities among them included; a. Thyroid abnormalities: 4 participants, b. PCOS: 1 and Diabetes mellitus: 2 participants.

DISCUSSION:

In the present study, results highlights that there is a significant leaching of plasticizers (DEHP and BPA) from the disposable plastic water bottles when kept at higher temperatures (40° C and above) and also at lower temperatures (5° C and less).

Kumar A et. al., in his study observed that traces of BPA in canned soft drinks and little amount of BPA concentrations were found in all the plastic-bottled water that was analyzed and the BPA concentrations in household water were non-detectable to very low concentrations. Sunlight exposure did not significantly increase the BPA concentrations in plastic water tanks. Only minute increase in BPA concentration was found in sunlight exposure [10].

In another study done in India by Bhardwaj LK, it was found that the migration of DEHP was dependent on high temperature and storage time. DEHP was present only in those samples, which were stored in sunlight for 2 & 6 months and at − 20 °C for 6 months and it was below the detection limits in samples which were analysed immediately after purchase [11]. Our current study findings was concurrent with the above study. The migration of DEHP may depend on the brand because water characteristics and bottling process vary from brand to brand. In spite of the increased usage of Plastic/ PET bottled water in developing and developed countries, the concentration of DEHP and BPA detected is far below the toxic levels.

Di (2-ethylhexyl) phthalate (DEHP) is a plasticizer commonly used in the production of plastics, including some types of water bottles. However, due to health concerns about its potential adverse effects, regulatory agencies have established limits on the allowable levels of DEHP in food contact materials such as water bottles. The European Union (EU) has set specific migration limits for DEHP in food contact materials, for

plastic materials that come into contact with fatty foods (including water bottles), the migration limit for DEHP is 1.5 mg/kg of food or food simulant. The U.S. Food and Drug Administration (FDA) has regulations regarding phthalates in food contact materials, including water bottles. However, there is no specific migration limit set for DEHP in water bottles. Instead, the FDA regulates DEHP as part of its overall evaluation of food contact substances for safety.

It's important to note that DEHP and other phthalates have been associated with potential health risks, especially concerning their endocrine-disrupting properties. To minimize exposure to DEHP, consumers can choose water bottles labelled as DEHP-free or made from alternative materials such as glass, stainless steel, or BPA-free plastics. India does not have specific regulations regarding the allowable levels of Di (2-ethylhexyl) phthalate (DEHP) in water bottles. However, India generally follows international standards (like EU and FDA) and guidelines for food safety and packaging materials.

With regard to BPA, India does not have specific regulations regarding the allowable levels of Bisphenol A (BPA) in water bottles though FSSAI regulates that certain infant nutritional food supplements should be packed in BPA free material. With regard to plastic water bottles the FSSAI has recommended use of certain materials like polyvinyl chloride and polycarbonate which contains BPA in it [12,13]. BPA is regulated in other countries such as the European Union and the United States, where there are specific limits on its use in food contact materials including plastic bottles. The allowed levels of Bisphenol A (BPA) in water bottles can vary depending on the country and regulatory agency. The EU has set a specific migration limit for BPA in food contact materials, including water bottles. The limit is 0.05 mg/kg of food or food simulant. The U.S. Food and Drug Administration (FDA) regulates BPA in food contact materials, including plastic water bottles. The FDA has not established a specific limit for BPA, but it has set a safe daily intake level (Tolerable Daily Intake or TDI) of 50 micrograms per kilogram of body weight per day.

Based on the survey questionnaire undertaken among consumers who regularly use disposable plastic/PET water bottles keeping them at extremes of temperature conditions, it was found that there is a lack of knowledge among 51.2 % of participants about the Plasticizers in disposable plastic water bottles. The number of participants who store the disposable plastic water bottles under Sun (particularly in vehicles) are very less 15.5%, but participants who store it in refrigerators (average of 2 days or more) are more with 77.7 %. Only 22 % of participants never reuse disposable plastic water bottles.

BPA and DEHP absorption into the body can result in the development of metabolic disorders such as low sex-specific neurodevelopment, immune toxicity, neurotoxicity and interference of cellular pathway [14].

Although there was a minimal number of consumers with a history of endocrine abnormalities in our study, the adverse health effects of plastics recommend measuring the effects of endocrine disrupting compounds (EDCs) such as bisphenols (BPA, BPS, BPF), bis (2-ethylhexyl) phthalate and dibutyl phthalate (DBP) for human health. Exposure to these compounds in utero can cause testicular, prostate, kidney and immune system abnormalities and cause tumors, uterine bleeding during pregnancy and polycystic ovaries. These compounds also control the processes of epigenetic transgenerational inheritance of adult-onset diseases by modulating DNA methylation and epimutations in reproductive cells [15, 16]. Studies have shown that the complex action of DEHP/BPA mixture may disturb the thyroid hormone homeostasis, which ultimately would affect the development of thyroid during puberty [17]. In the other study done by Lucas A et. al., also confirms the harmful effects of Plasticizers in causing cardiometabolic diseases [18].

The leaching of BPA from water bottles also depends on the bottle quality and material with which it is made. Bottled water is very much readily available to the public and they are considered safe and hygienic when compared to tap water. But many do not use BPA free water bottles and also these bottled waters are not maintained at proper temperature conditions during transport and storage.

Henceforth, though the levels of BPA and DEHP detected in the disposable plastic water bottles are within the International allowed limits and well within toxic limits, this data which is showing leeching of Plasticizers in water bottles stored in high or low temperature conditions should be considered as an eye opener, as the plasticizers can cause deleterious effects to our human body affecting many vital functions.

CONCLUSIONS:

This study demonstrated that significant leaching of plasticizers—namely DEHP and BPA—occurs in plastic water bottles subjected to both elevated (45°C) and refrigerated (5°C) temperatures, particularly with extended storage durations. While the detected levels remained within internationally accepted safety limits, the presence of these endocrine-disrupting chemicals, even in small amounts, raises concerns about cumulative exposure and long-term health risks. The findings underscore the urgent need for regulatory attention in India to establish clear safety standards for BPA and DEHP in food and beverage packaging materials, particularly for drinking water. Although FSSAI has issued limited guidelines for BPA in infant food packaging, a comprehensive national policy covering all consumer plastic containers is essential.

Equally important is the low level of consumer awareness revealed in the study, with over half of participants unaware of the potential hormonal effects of plasticizers and many engaging in unsafe storage practices, including bottle reuse and exposure to extreme temperatures. This highlights the need for public health campaigns, clearer product labelling (e.g., "BPA-free"), and education on safe storage practices. In conclusion, while bottled water remains a convenient and widely used source of hydration, this study serves as a critical reminder that temperature and time-dependent leaching of harmful plasticizers cannot be ignored. To protect public health, both regulatory reforms and consumer behavioral changes must go hand in hand.

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TABLES:

Table 1: DEHP levels at various time durations (Mean ± SD):

Temperature Condition	Time duration	Water sample A (mg/litre)	Water sample B (mg/litre)	Water sample C (mg/litre)	p-value
T 5° C	24 hrs	0.003 ± 0.001	0.005 ± 0.004	0.008 ± 0.001	0.115
	48 hrs	0.01 ± 0.006	0.006 ± 0.003	0.009 ± 0.007	0.668
	7 days	0.01 ± 0.003	0.01 ± 0.001	0.001 ± 0.006	0.062
	p-value	0.140	0.169	0.902	
T 25° C	24 hrs	0.002 ± 0.001	0	0	-
	48 hrs	0.005 ± 0.002	0.003 ± 0.001	0.002 ± 0.001	0.08
	7 days	0.003 ± 0.001	0	0	-
	p-value	0.08	-	-	
T 40° C	24 hrs	0.03 ± 0.01	0.03 ± 0.012	0.009 ± 0.003	0.052
	48 hrs	0.02 ± 0.009	0.01 ± 0.008	0.011 ± 0.010	0.388
	7 days	0.03 ± 0.018	0.02 ± 0.011	0.019 ± 0.009	0.563
	p-value	0.582	0.143	0.333	

Table 2: BPA levels at various time durations (Mean ± SD):

Temperature Condition	Time duration	Water sample A (mg/litre)	Water sample B (mg/litre)	Water sample C (mg/litre)	p-value
T 5° C	24 hrs	0.004 ± 0.004	0.005 ± 0.004	0	**0.563**
	48 hrs	0.007 ± 0.002	0.008 ± 0.003	0.007 ± 0.007	**0.811**
	7 days	0.001 ± 0.002	0.001 ± 0.001	0.001 ± 0.0009	**0.999**
	p-value	**0.104**	**0.070**	**0.155**	
T 25° C	24 hrs	0	0.004 ± 0.003	0	-
	48 hrs	0.007 ± 0.006	0.002 ± 0.001	0.002 ± 0.001	**0.219**
	7 days	0.001 ± 0.001	0.001 ± 0.001	0.001 ± 0.001	**0.999**
	p-value	**0.099**	**0.228**	**0.064**	
T 40° C	24 hrs	0.004 ± 0.002	0.002 ± 0.001	0.003 ± 0.001	**0.296**
	48 hrs	0.001 ± 0.001	0.007 ± 0.003	0.003 ± 0.002	**0.19**
	7 days	0.002 ± 0.001	0.006 ± 0.002	0.004 ± 0.002	**0.19**
	p-value	**0.098**	**0.064**	**0.573**	

Table 3: Comparison of DEHP levels at various temperature conditions:

Time duration	Temperature Condition	Water sample A (mg/litre)	Water sample B (mg/litre)	Water sample C (mg/litre)
24 hours	T 5° C	0.003 ± 0.001	0.005 ± 0.004	0.008 ± 0.001
	T 25° C	0.009 ± 0.001	0	0
	T 40° C	0.03 ± 0.01*	0.03 ± 0.012*	0.009 ± 0.003
	p-value	**0.009**	**0.02**	**0.613**
48 hrs	T 5° C	0.01 ± 0.006	0.006 ± 0.003	0.009 ± 0.007
	T 25° C	0.005 ± 0.002	0.003 ± 0.001	0.008 ± 0.002
	T 40° C	0.02 ± 0.009	0.01 ± 0.008	0.011 ± 0.010
	p-value	**0.24**	**0.296**	**0.874**
7 days	T 5° C	0.01 ± 0.003*	0.01 ± 0.001	0.001 ± 0.006
	T 25° C	0.003 ± 0.001	0	0
	T 40° C	0.03 ± 0.018*	0.02 ± 0.011	0.019 ± 0.009*
	p-value	**0.01**	**0.19**	**0.04**

Table 4: Comparison of BPA levels at various temperature conditions:

Time duration	Temperature Condition	Water sample A (mg/litre)	Water sample B (mg/litre)	Water sample C (mg/litre)
24 hours	T 5° C	0.004 ± 0.004	0.005 ± 0.004	0
	T 25° C	0	0.004 ± 0.003	0
	T 40° C	0.004 ± 0.002	0.002 ± 0.001	0.003 ± 0.001
	p-value	**1.0**	**0.33**	-
48 hrs	T 5° C	0.007 ± 0.002	0.008 ± 0.003*	0.007 ± 0.007
	T 25° C	0.007 ± 0.006	0.002 ± 0.001	0.002 ± 0.001
	T 40° C	0.001 ± 0.001	0.007 ± 0.003	0.005 ± 0.002
	p-value	**0.16**	**0.03**	**0.28**
7 days	T 5° C	0.001 ± 0.002	0.001 ± 0.001	0.001 ±0.0009
	T 25° C	0.001 ± 0.001	0.001 ± 0.001	0.001 ± 0.001
	T 40° C	0.002 ± 0.001	0.006 ± 0.002*	0.009 ± 0.002*
	p-value	**0.28**	**0.01**	**0.003**

Table 5: Result of Study Questionnaire - On usage of Plastic water bottles:

1. Mean Age of participants: 28.9 + 3.0 years (n=45)
2. Male: 55.5 % Female: 44.5 %
3. How frequently do you consume water from disposable plastic water bottles in a month? (6.7 ± 6.1) times per month on an average

Sl.NO	QUESTIONNAIRE	RESPONSE (%)	
1	Are you aware of plasticizers in disposable plastic water bottles?	YES-48.8 % No- 51.2 %	
2	Do you store Plastic water bottles in your vehicles under sun?	YES-15.5 % No-84.5 %	
3	If Yes for question 2, How long do you store?	8.0 ± 6.5 hours	
4	Do you store Plastic water bottles in your refrigerator?	YES- 77.7 % NO- 32.3 %	
5	If Yes for question 4, How long do you store?	2.0 ± 1.5 days	
6	How frequently do you reuse plastic water bottles?	Rarely – 44.5% Frequently-33.3% Never-22.2%	
7	How long do you reuse plastic water bottles?	Less than a week	66.7 %
		More than a week	20 %
		More than a month	8.9 %
		Up to a Year	4.4 %

REFERENCES

Tandon SA, Kolekar N, Kumar R. Water and energy footprint assessment of bottled water industries in India. Natural Resources. 2014 Feb 14;2014.

Koch HM, Calafat AM. Human body burdens of chemicals used in plastic manufacture. Philosophical Transactions of the Royal Society B: Biological Sciences. 2009 Jul 27;364(1526):2063-78.

Cadogan DF. Plasticizers: a consideration of their impact on health and the environment. Journal of Vinyl Technology. 1991 Jun;13(2):104-8.

Rowdhwal SS, Chen J. Toxic effects of di-2-ethylhexyl phthalate: an overview. BioMed research international. 2018 Feb 22;2018.

Campioli E, Lee S, Lau M, Marques L, Papadopoulos V. Effect of prenatal DINCH plasticizer exposure on rat offspring testicular function and metabolism. Scientific reports. 2017 Sep 11;7(1):11072.

Santana-Mayor Á, Rodríguez-Ramos R, Herrera-Herrera AV, Socas-Rodríguez B, Rodríguez-Delgado MÁ. Monitoring of the presence of plasticizers and effect of temperature and storage time in bottled water using a green liquid–liquid microextraction method. Food Research International. 2023 Feb 1;164:112424.

Mukhopadhyay M, Jalal M, Vignesh G, Ziauddin M, Sampath S, Bharat GK, Nizzetto L, Chakraborty P. Migration of plasticizers from polyethylene terephthalate and low-density polyethylene casing into bottled water: a case study from India. Bulletin of Environmental Contamination and Toxicology. 2022 Dec;109(6):949-55.

Zaki G, Shoeib T. Concentrations of several phthalates contaminants in Egyptian bottled water: Effects of storage conditions and estimate of human exposure. Science of the Total Environment. 2018 Mar 15;618:142-50.

da Silva Costa R, Sainara Maia Fernandes T, de Sousa Almeida E, Tomé Oliveira J, Carvalho Guedes JA, Julião Zocolo G, Wagner de Sousa F, do Nascimento RF. Potential risk of BPA and phthalates in commercial water bottles: a minireview. Journal of Water and Health. 2021 Jun 1;19(3):411-35.

Kumar A, Singh D, Bhandari R, Malik AK, Kaur S, Singh B. Bisphenol A in canned soft drinks, plastic-bottled water, and household water tank from Punjab, India. Journal of Hazardous Materials Advances. 2023 Feb 1;9:100205.

Bhardwaj LK. Evaluation of bis (2-ethylhexyl) phthalate (DEHP) in the PET bottled mineral water of different brands and impact of heat by GC–MS/MS. Chemistry Africa. 2022 Aug;5(4):929-42.

https://www.fssai.gov.in/upload/uploadfiles/files/Comp_IFR_VERSION-II_04_01_2024.pdf (Accessed on April 2024)

https://www.fssai.gov.in/upload/media/FSSAI_news_Bottles_FNB_17_02_2021.pdf (Accessed on April 2024)

Ohore OE, Zhang S. Endocrine disrupting effects of bisphenol A exposure and recent advances on its removal by water treatment systems. A review. Scientific African. 2019 Sep 1;5:e00135.

Basak S, Das MK, Duttaroy AK. Plastics derived endocrine-disrupting compounds and their effects on early development. Birth defects research. 2020 Oct;112(17):1308-25.

Manikkam M, Tracey R, Guerrero-Bosagna C, Skinner MK. Plastics derived endocrine disruptors (BPA, DEHP and DBP) induce epigenetic transgenerational inheritance of obesity, reproductive disease and sperm epimutations. PloS one. 2013 Jan 24;8(1):e55387.

Zhang X, Zhao Y, Cheng C, Li L, Xiao M, Zhang G, Lu X. Combined effects of di (2-ethylhexyl) phthalate and bisphenol A on thyroid hormone homeostasis in adolescent female rats. Environmental Science and Pollution Research. 2020 Nov;27:40882-92.

Lucas A, Herrmann S, Lucas M. The role of endocrine-disrupting phthalates and bisphenols in cardiometabolic disease: the evidence is mounting. Current Opinion in Endocrinology, Diabetes and Obesity. 2022 Apr 1;29(2):87-94.