

Assessment of Phthalate Compounds in Selected Cosmetics in Port Harcourt Market

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ABSTRACT

This study assessed the concentrations of phthalate compounds in three commonly used cosmetics (aloe vera gel cream, pure white body lotion, and papaya cream) purchased from market in Port Harcourt, Rivers State, Nigeria. Samples were collected and subjected to solvent-based extraction and chromatographic determination. Results revealed that phthalates concentrations were highest in Aloe vera gel cream (2439 µg/kg), driven predominantly by di-isoheptyl phthalate. Pure White body lotion exhibited phthalate level of 1351 µg/kg. Although individual concentrations remained below current European Union and NAFDAC permissible limits. The findings confirm cosmetics as a modifiable source of EDC exposure in an urban Nigerian population and highlight product-specific contamination patterns influenced by formulation and intended function. The study provides data for these compounds in locally marketed cosmetics in Port Harcourt. It is recommended that NAFDAC introduce specific maximum limits and mandatory ingredient disclosure for EDCs, while manufacturers should prioritize safer alternatives. Expanded biomonitoring and broader product screening are urged to strengthen risk assessment and protect public health.

Keywords: Assessment, Phthalates, Selected cosmetics, Rivers State



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INTRODUCTION

Cosmetic products are widely used for personal hygiene, beautification, and skin care across all age groups (Bennett et al., 2010). In Nigeria, particularly in urban centers such as Port Harcourt, the demand for body creams, skin lightening products, and herbal-based cosmetics has increased significantly due to rising aesthetic awareness, media influence, and socioeconomic factors. Among the commonly used cosmetic brands in

local markets are Aloe Vera gel-based creams, Pure White skin-lightening creams, and Papaya extract formulations. While these products are marketed for their moisturizing, whitening, or anti-aging properties, concerns have emerged regarding the presence of potentially harmful chemical additives, including phthalate compounds (Gebashe et al., 2022). Phthalates are a group of synthetic chemicals primarily used as plasticizers to

improve flexibility and durability in plastics (Ogunbayo & Acheampong, 2021). In cosmetic formulations, they are commonly used as solvents, fragrance stabilizers, and fixatives. Some of the frequently detected phthalates in personal care products include diethyl phthalate (DEP), dibutyl phthalate (DBP), benzyl butyl phthalate (BBP), and di (2-ethylhexyl) phthalate (DEHP). These compounds are not always explicitly listed on product labels because they may be incorporated as part of proprietary fragrance mixtures. Consequently, consumers may be unknowingly exposed through dermal absorption, inhalation, or incidental ingestion (Silano et al., 2019). Scientific evidence has increasingly linked certain phthalates to endocrine-disrupting effects. Endocrine-disrupting chemicals (EDCs) interfere with hormonal regulation, potentially affecting reproductive health, metabolic processes, and developmental outcomes (Ghosh et al., 2022). Studies have associated prolonged exposure to some phthalates with reduced fertility, altered hormone levels, developmental abnormalities, and increased risk of certain chronic conditions. Due to these health concerns, several regulatory agencies in developed regions have restricted or banned specific phthalates in cosmetic products. However, regulatory enforcement and routine surveillance remain inconsistent in many developing countries, including Nigeria (Dutta, et al., 2020).

Port Harcourt, a major oil-producing city in the Niger Delta region, is characterized by high commercial activity and significant importation of cosmetic products from various international sources (Ladelokun, 2021). The city's markets serve as distribution hubs for locally manufactured and imported creams, lotions, and herbal-based cosmetics. Despite the widespread use of these products, there is limited published data on the concentration levels of phthalate compounds in cosmetics sold within the Port Harcourt market. The absence of adequate monitoring raises public health concerns, especially considering the frequent and prolonged application of these products on the skin (Asogba, 2024). Aloe Vera, Pure White, and Papaya-based cosmetic products are particularly popular among consumers due to their perceived natural or skin-enhancing properties (Gade et al., 2025). Aloe Vera formulations are commonly promoted for moisturizing and soothing effects; Papaya-based creams are marketed for exfoliation and skin brightening; while Pure White products are often associated with skin-lightening benefits. However, the manufacturing processes and ingredient sourcing of some of these products may introduce phthalate contaminants either intentionally (as solvents or fragrance stabilizers) or unintentionally through packaging materials and raw materials (Gade et al., 2025).

Given the potential health risks associated with phthalate exposure and the high patronage of cosmetic products in Port Harcourt, it becomes necessary to assess the presence and concentration of selected phthalate compounds in these commonly used brands. Such

assessment will provide empirical data that can guide regulatory authorities, inform public health policy, and create awareness among consumers regarding possible chemical exposure from everyday cosmetic use (Asogba, 2024). Therefore, this study seeks to evaluate the occurrence and levels of selected phthalate compounds in Aloe Vera, Pure White, and Papaya cosmetic products obtained from markets in Port Harcourt. The findings will contribute to the growing body of knowledge on environmental toxicology and consumer product safety in Nigeria, while also serving as a basis for risk assessment and regulatory intervention where necessary.

METHODOLOGY

Sample collection

Pure white body lotion, and Papaya cream and raw Aloe Vera plant were purposively collected from New Layout Market, Churchhill (Borikiri), and Prince Mega Cosmetics Store (Mile One Diobu) in Port Harcourt, River State. All samples were fully labelled and stored at 4 °C (and later – 20 °C for reserves) pending analysis.

Determination of phthalate compounds from cream-based cosmetics

Extraction of phthalate

Five grams of the homogenized cream sample was thoroughly mixed with 60 g of anhydrous sodium sulphate in an agate mortar to form a free-flowing powder and absorb residual moisture. The resulting homogenate was transferred into a cellulose extraction thimble and subjected to Soxhlet extraction using 300 mL of n-hexane as solvent for 24 hours. After completion of the extraction cycles, the crude n-hexane extract was concentrated to near dryness using a rotary vacuum evaporator operated at 40 °C. The residue was subsequently redissolved in a small volume of n-hexane and transferred onto a 5 mL Florisil column for clean-up prior to further analysis.

Preparation of stock standard solutions

First, 100 mg L⁻¹ of each PAE standard was prepared with isopropyl alcohol in a 5 mL volumetric flask. Lower working concentrations of PAE standards were prepared from the stock solution. Thereafter, 1.0 µL of each was injected into the GC-FID until the instrument could not show any peaks. Internal standard method of analysis was chosen because it is more accurate and reliable due to the adjusting and correcting mechanisms it performs from unavoidable errors that are likely to emanate from measurement of syringe volumes of the standards and processed samples. The chromatographic column (20 cm×8 mm I.D.) was packed with 5.0 g of activated silica gel, which was made into slurry with 1.5% (v/m) petroleum ether and then stirred

well before use. About 1 mL of anhydrous sodium sulphate was placed at the top of the column to absorb any water in the sample or the solvent. The column was pre-eluted with 15 mL of petroleum ether before exposure to sodium sulphate. The reduced 5 mL extract from extraction processes was placed in the column and allowed to sink below the sodium sulphate layer. PAEs extracts were eluted with 2×10 mL portions of the extracting solvents. The eluent was collected, and subjected to dryness and reconstituted with 2 mL of extracting solvent. Then 1.0µL was injected into the Gas Chromatography.

Compliance

This study evaluated the concentrations of phthalate compound in three cosmetic products (100% Aloe Vera, Pure White, and Papaya) using laboratory measurements reported in micrograms per kilogram (µg/kg). The primary objective was to perform a quantitative health risk assessment through dermal exposure pathways. The chemical analysis of the cosmetics products revealed 12 parabens compounds, 13 phenolic compounds, and 16 phthalate esters in each of the cosmetic products.

Quality Assurance

The data were further evaluated against the cosmetic standards of the Europe, America and Nigeria using EU Cosmetics Regulation (EC) No 1223/2009 with 2025 amendments of (EU) 2025/877 for CMR bans; US Federal Food, Drug, and Cosmetic Act (1938) with MoCRA (2022) and CIR assessments and NAFDAC Act CAP N1 LFN 2004 (2004) with Labelling Regs. (2021) to check for conformity to approved standard. These standards are as stated: European Union | Regulation (EC) No 1223/2009 (as amended) lists prohibited substances (e.g., isopropyl-, isobutyl-, benzyl-, pentyl-, phenylparaben; BBP, DEHP, DBP, DIBP, etc.) = 0 µg/kg; permitted parabens ≤ 0.4 % single / 0.8 % mixture (4 000 000 / 8 000 000 µg/kg), United States Federal Food, Drug, and Cosmetic Act state bans (e.g., Washington 2025) | No federal numerical limits, but CIR safety levels and state prohibitions considered; prohibited = >0 µg/kg where banned; and Nigeria NAFDAC Cosmetic Products Regulations 2021 Aligns with EU prohibited list; CMR substances must be absent. The conformity or otherwise of these products were tabulated and denoted using < = conformity and > = non conformity.

Health risk assessment of phthalates compounds

Finally, the health risk assessment of the three products (100% Aloe Vera, Pure White, and Papaya) was done by computing the Hazard Quotient and Hazard Index. This was done by computing the daily systemic exposure was using the standard SCCS worst-case scenario for body lotion (SCCS, 2023) using Systemic Exposure Dose as;

$$\left(\frac{SED_i \frac{\mu g}{kg \cdot day}}{day}\right) = C_i \times 10 \frac{g}{day} \times 1.0 - 60 \text{ kg} = C_i \times 0.1667 \quad (1)$$

Where C_i = measured concentration of an individual chemical compound i in the cosmetic product, expressed in micrograms per kilogram (µg/kg) of product.

$$\text{Individual Hazard Quotient: } HQ_i = SED_i / TDI_i \quad (2)$$

where TDI_i = Tolerable Daily Intake (see Appendix).

Because all three chemical classes share endocrine-disrupting properties, the Hazard Index (HI) was calculated by dose addition (EFSA Scientific Committee, 2019): $HI = \sum HQ_i$ (across all detected compounds in a product)., Risk interpretation using the HI is as given below

- -HI < 1 → acceptable
- HI ≥ 1 → unacceptable
- HI > 10 → high to very high risk

RESULTS AND DISCUSSION

The results of this study demonstrate the ubiquitous presence of phthalates in all three cosmetic products analyzed, with substantial variation in both total. The results of this study demonstrate the ubiquitous concentration and compositional profiles (Table 1). Aloe Vera gel exhibited the highest total phthalate concentration (2439.13 µg/kg), followed by Pure White body cream (1351.07 µg/kg) and Papaya cream (1265.98 µg/kg). The predominance of di-isoheptyl phthalate (1996.26 µg/kg) in Aloe Vera gel accounted for over 80% of its total burden, suggesting deliberate formulation use or contamination during manufacturing. In contrast, Pure White body cream displayed a broader distribution of higher molecular weight phthalates, including di(2-propylheptyl) phthalate (251.44 µg/kg), di-isoundecyl phthalate (246.46 µg/kg), and di-n-hexyl phthalate (218.97 µg/kg), indicating a stabilizing or viscosity-enhancing function typical of cream-based matrices. Papaya cream was characterized by a dominant presence of butyl benzyl phthalate (820.98 µg/kg), comprising nearly two-thirds of its total concentration, reflecting selective formulation practices.

The concentration ranges observed align with international reports indicating that personal care products commonly contain phthalates at levels spanning from non-detectable to several thousand µg/kg. Guo and Kannan (2013) documented comparable concentrations in U.S. consumer products, while Jia et al. (2024) reported substantially higher levels in certain nail care formulations, reaching up to 60,000 µg/kg. The values obtained in the present study therefore fall within the global spectrum but exceed typical averages reported in highly regulated

Table 1: Concentrations of Phthalates in Selected Cosmetics ($\mu\text{g/g}$).

| S/N | PHTHALATE CONTENT | Amount ($\mu\text{g/kg}$) | | |
|--------------|------------------------------|-----------------------------|-----------------------|------------------|
| | | Aloe Vera Gel | Pure White Body Cream | Papaya Cream |
| 1 | Butyl benzyl phthalate | - | $6.93638e^{-1}$ | 820.97532 |
| 2 | Di ioshexyl phthalate | 156.99591 | 68.31025 | 151.32790 |
| 3 | Di isoheptyl phthalate | 1996.25796 | 103.54895 | ND |
| 4 | Butyl decyl phthalate | 13.07680 | 4.10224 | ND |
| 5 | Di-n-hexyl phthalate | 1.07668 | 218.97426 | ND |
| 6 | Di butoxyl ethyl phthalate | $2.15813e^{-1}$ | 56.18520 | ND |
| 7 | Di (2-ethylhexyl) phthalate | ND | 85.42969 | ND |
| 8 | Di (n-octyl) phthalate | ND | 52.35634 | ND |
| 9 | Diisooctyl phthalate | ND | 2.33698 | ND |
| 10 | n-octyl n-decyl phthalate | 271.50866 | 3.34526 | 293.67887 |
| 11 | Di isononyl phthalate | ND | 20.90733 | ND |
| 12 | Di(2-propylheptyl) phthalate | ND | 251.44347 | ND |
| 13 | Di isodecyl phthalate | ND | 20.98866 | ND |
| 114 | Di undecyl phthalate | ND | 187.32927 | ND |
| 15 | Di isoundecyl phthalate | ND | 246.45792 | ND |
| 16 | Di tridecyl phthalate | ND | 28.66364 | ND |
| 17 | Di isotridecyl phthalate | ND | ND | ND |
| TOTAL | | 2439.13183 | 1351.07311 | 1265.9821 |

Table 2: Human Daily Dermal Exposure to endocrine disrupting compound (Phthalates) in selected cosmetics.

| Cosmetic Sample | Total Phthalates ($\mu\text{g/kg}$) | Daily Dermal Exposure ($\mu\text{g/kg bw/day}$) |
|-----------------------|---------------------------------------|---|
| Aloe Vera Gel | 2,439.13 | 0.033 |
| Pure White Body Cream | 1,351.07 | 0.018 |
| Papaya Cream | 1,265.98 | 0.017 |

Table 3: Compliance of Detected Phthalates with EU, US, and Nigerian Cosmetic Regulations.

| Phthalate Name | EU Limit ($\mu\text{g/kg}$) | US CIR Limit ($\mu\text{g/kg}$) | Nigeria Limit ($\mu\text{g/kg}$) | Cosmetic A ($\mu\text{g/kg}$) | Cosmetic B | | | Cosmetic C | | | | | | | |
|------------------------------------|-------------------------------|-----------------------------------|------------------------------------|---------------------------------|------------|----|---------|------------|----|---------|---|--------|---|---|---|
| | | | | | EU | US | Nigeria | EU | US | Nigeria | | | | | |
| Butyl benzyl phthalate | (Prohibited) | <1,000,000 | 0(Prohibited) | 0 | ✓ | ✓ | ✓ | 0.69 | X | ✓ | X | 820.98 | X | ✓ | X |
| Diioshexyl phthalate | (Prohibited) | <10,000,000 | (Prohibited) | 157.00 | X | ✓ | X | 68.31 | X | ✓ | X | 151.33 | X | ✓ | X |
| Diisoheptyl phthalate | <100,000 (GMP if allowed) | <10,000,000 | <100,000 | 1,996.26 | X | ✓ | ✓ | 103.55 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Butyl decyl phthalate | <100,000 | <10,000,000 | <100,000 | 13.08 | ✓ | ✓ | ✓ | 4.10 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Di-n-hexyl phthalate | (Prohibited) | <10,000,000 | 0 (Prohibited) | 1.08 | X | ✓ | X | 218.97 | X | ✓ | X | 0 | ✓ | ✓ | ✓ |
| Dibutoxyl ethyl phthalate | <100,000 | <10,000,000 | <100,000 | 0.22 | ✓ | ✓ | ✓ | 56.19 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Di (2-ethylhexyl) phthalate (DEHP) | (Prohibited) | <10,000,000 | (Prohibited) | 0 | ✓ | ✓ | ✓ | 85.43 | X | ✓ | X | 0 | ✓ | ✓ | ✓ |

Table 3: Contd.

| | | | | | | | | | | | | | | | |
|-------------------------------------|--------------|-------------|----------------|--------|---|---|---|--------|---|---|---|--------|---|---|---|
| Di (n-octyl) phthalate (DnOP) | (Prohibited) | <10,000,000 | 0 (Prohibited) | 0 | ✓ | ✓ | ✓ | 52.36 | X | ✓ | X | 0 | ✓ | ✓ | ✓ |
| Diisooctyl phthalate (DIOP) | (Prohibited) | <10,000,000 | (Prohibited) | 0 | ✓ | ✓ | ✓ | 2.34 | X | ✓ | X | 0 | ✓ | ✓ | ✓ |
| n-octyl n-decyl phthalate | <100,000 | <10,000,000 | <100,000 | 271.51 | ✓ | ✓ | ✓ | 3.35 | ✓ | ✓ | ✓ | 293.68 | ✓ | ✓ | ✓ |
| Diisononyl phthalate (DINP) | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 20.91 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Di(2-propylheptyl) phthalate (DPHP) | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 251.44 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Diisodecyl phthalate (DIDP) | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 20.99 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Diundecyl phthalate | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 187.33 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Diisoundecyl phthalate | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 246.46 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Ditridecyl phthalate | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 28.66 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| Diisotridecyl phthalate | <100,000 | <10,000,000 | <100,000 | 0 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ | 0 | ✓ | ✓ | ✓ |
| | N/A | N/A | N/A | 2,439 | X | ✓ | X | 1,351 | X | ✓ | X | 1,266 | X | ✓ | X |

Table 4: Systemic Exposure Dose (SED), Hazard Quotient (HQ), and Cumulative Hazard Index (HI) for the Three Cosmetic Products.

| Product | SED Phthalates (µg/kg bw/day) | HQ Phthalates | Total SED (µg/kg bw/day) | Hazard Index (HI) | Risk Level |
|-----------------------------|-------------------------------|---------------|--------------------------|-------------------|---------------|
| 100% Aloe Vera (Cosmetic A) | 495.71 | 4.09 | 495.71 | 4.09 | Moderate Risk |
| Pure White (Cosmetic B) | 225.22 | 2.33 | 225.22 | 2.33 | Moderate Risk |
| Papaya (Cosmetic C) | 234.57 | 1.26 | 234.57 | 1.26 | Moderate Risk |

markets, where concentrations are often maintained below 500 µg/kg (Aldegunde-Louzao et al., 2024). This suggests moderate contamination or less stringent regulatory enforcement within the local market context. Daily dermal exposure estimates (Table 2) indicate that Aloe Vera gel resulted in the highest estimated dermal intake (0.033 µg/kg bw/day), followed by Pure White body cream (0.018 µg/kg bw/day) and Papaya cream (0.017 µg/kg bw/day). Although these values appear low relative to established reference doses, cosmetics are applied chronically and often concomitantly with other personal care products. Biomonitoring frameworks such as the Korean Human Exposure Safety Survey (KoHESS) highlight the importance of evaluating aggregate exposure from multiple consumer sources (Lim et al., 2025). Furthermore, environmental studies demonstrate that phthalates are pervasive contaminants in water systems and plastics, contributing to background exposure (Ghosh et al., 2025; Alibekov et al., 2026). Therefore, cosmetic-derived exposure should be interpreted as one component of a broader exposure network.

From a regulatory perspective (Table 3), compliance varied markedly across jurisdictions. Several phthalates detected such as butyl benzyl phthalate, di-n-hexyl phthalate, DEHP, DnOP, and DIOP are prohibited under EU Regulation (EC) No. 1223/2009 due to their classification as reproductive toxicants and endocrine-disrupting chemicals. Despite this, measurable concentrations of some prohibited substances were identified, particularly in Pure White body cream and Papaya cream, resulting in non-compliance under EU and Nigerian frameworks but general compliance under U.S. Cosmetic Ingredient Review (CIR) thresholds, which are comparatively permissive. This discrepancy underscores the regulatory heterogeneity noted in international chemical governance literature (Knowles et al., 2025) and reflects the regulatory gaps highlighted in developing markets.

The presence of endocrine-disrupting phthalates is toxicologically significant. Phthalates are widely recognized for their capacity to interfere with hormonal signaling pathways, particularly those related to reproductive and developmental systems (Frątczak et al., 2025). The detection of multiple phthalates within single products raises concern regarding mixture toxicity and additive endocrine effects. As emphasized by Pekmezci et al. (2025), cumulative exposure assessment is critical in evaluating dietary and consumer product chemical risks, since individual compounds may fall below regulatory thresholds while combined exposures exceed safety margins.

More concerning are the Systemic Exposure Dose (SED) and Hazard Quotient (HQ) calculations presented in (Table 4). Aloe Vera gel produced an SED of 495.71 µg/kg bw/day and an HQ of 4.09, while Pure White body cream and Papaya cream yielded HQ values of 2.33 and 1.26, respectively. Hazard Index (HI) values exceeding

unity indicate potential health risk, and all three products fell within a “moderate risk” classification. These findings suggest that, although individual dermal exposure estimates appear low, systemic accumulation and toxicological thresholds may be exceeded when bioavailability and cumulative effects are considered. The elevated HQ for Aloe Vera gel reflects its disproportionately high concentration of di-isoheptyl phthalate, reinforcing the importance of compositional dominance in risk characterization.

The environmental dimension of phthalate exposure further contextualizes these findings. Plasticizers are known to migrate from consumer products into environmental matrices, contributing to macro- and microplastic-associated contamination (Arafat et al., 2025). Microplastic-mediated release pathways, as demonstrated in bottled beverage studies (Alibekov et al., 2026), illustrate the dynamic nature of chemical leaching and chronic exposure potential. Thus, cosmetic products represent not only direct dermal exposure sources but also indirect contributors to environmental phthalate burden. In addition, the broader regulatory and public health implications warrant consideration. Systematic evidence mapping approaches have identified consumer products, particularly those used by vulnerable populations, as priority categories for chemical surveillance (Rigutto et al., 2025). Environmental health literacy studies emphasize that public awareness of endocrine-disrupting chemicals remains limited, especially in developing countries (Çınar & Bozkurt, 2025). In Nigeria, while NAFDAC provides general oversight, the absence of clearly defined quantitative limits for all phthalate species may permit low-to-moderate contamination levels to persist in marketed products. The non-compliance patterns observed in (Table 3) substantiate the need for harmonized regulatory thresholds and routine post-market surveillance. Collectively, the results indicate that phthalates are consistently present in locally available cosmetics at concentrations comparable to global reports but exceeding levels typically observed in strictly regulated markets. The moderate risk classification derived from HQ and HI analyses highlights potential cumulative health concerns, particularly under chronic exposure scenarios. Given the established endocrine-disrupting properties of several detected compounds and the likelihood of aggregate exposure from multiple environmental and consumer sources, these findings underscore the necessity for strengthened regulatory enforcement, expanded biomonitoring initiatives, and improved public health risk communication.

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