



Impact of toxic chemicals in cosmetic products and the necessity of behavioral change for sustainable consumer practices

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Abstract

The widespread use of cosmetic products has raised significant concerns regarding the presence of toxic chemicals, such as parabens, phthalates, heavy metals, and synthetic fragrances, which pose risks to human health and the environment. This study aims to investigate the prevalence of these harmful substances in commonly used cosmetic products and examine the behavioral factors influencing consumer choices toward sustainable alternatives. A mixed-methods approach was employed, combining laboratory analysis of 50 popular cosmetic products for chemical content with a structured survey of 400 consumers assessing their awareness, attitudes, and purchasing behaviors. The chemical analysis revealed that 68% of tested products contained at least one toxic compound exceeding recommended safety thresholds, while 42% contained multiple harmful substances. Survey findings indicated that although 72% of respondents expressed concern about chemical safety, only 34% actively sought out sustainable or non-toxic alternatives. Key barriers to sustainable consumption included limited awareness of product labels, higher costs of eco-friendly products, and habitual reliance on familiar brands. The study further identified that targeted educational interventions and clear product labeling could significantly enhance consumer willingness to adopt sustainable cosmetic choices. The findings highlight a critical need for both regulatory oversight to limit toxic chemical content in cosmetics and behavioral interventions to promote conscious consumer practices. By fostering increased awareness and accessibility of non-toxic alternatives, the cosmetic industry can achieve a dual benefit of protecting public health and reducing environmental harm. This research underscores the importance of integrating chemical safety evaluation with consumer behavior analysis to inform policies and strategies that encourage the transition toward sustainable cosmetic consumption.

Keywords: Toxic chemicals, cosmetics, consumer behavior, sustainable consumption, public health, environmental impact, behavioral change, eco-friendly products

Introduction

The global cosmetic industry has experienced unprecedented growth over the past two decades, with market estimates exceeding \$500 billion in 2024 and projected to continue expanding due to rising consumer demand for personal care and beauty products. Cosmetic products, including skincare, haircare, makeup, and personal hygiene items, have become integral to daily routines worldwide. While these products offer aesthetic and self-care benefits, mounting evidence indicates that many commercially available cosmetics contain toxic chemicals that pose significant risks to human health and the environment. Ingredients such as parabens, phthalates, formaldehyde-releasing preservatives, heavy metals like lead and mercury, and synthetic fragrances have been identified as endocrine disruptors, allergens, and potential carcinogens. Chronic exposure to these substances can lead to skin irritation, hormonal imbalances, reproductive issues, and, in severe cases, long-term systemic effects. In addition, the environmental consequences of these chemicals—such as water contamination, bioaccumulation in aquatic organisms, and soil degradation—highlight the urgent need for a shift toward sustainable cosmetic practices.

Despite growing public concern, consumer behavior remains largely inconsistent with the principles of sustainability. Studies indicate that while a significant portion of consumers express awareness of chemical safety, fewer individuals actively seek out non-toxic or eco-friendly alternatives. For instance, a 2023 survey conducted across

urban populations in Europe and North America revealed that approximately 70% of consumers were aware of harmful ingredients in cosmetics, yet only 30–35% regularly purchased products labeled as natural, organic, or free from synthetic chemicals. Behavioral factors such as brand loyalty, price sensitivity, limited availability of sustainable products, and inadequate labeling contribute to this disparity between awareness and action. The gap suggests that addressing toxic chemicals in cosmetics is not solely a matter of product reformulation but requires a comprehensive understanding of consumer attitudes, decision-making processes, and behavioral interventions.

Previous research has primarily focused on the chemical analysis of cosmetic products, highlighting the prevalence and toxicity of harmful ingredients. Studies have identified the presence of parabens in over 60% of mass-market skincare products and detected heavy metals in both imported and locally manufactured makeup. Parallel research in consumer behavior has examined awareness levels and purchasing intentions toward “green” or sustainable cosmetics. However, existing literature reveals notable gaps. Many studies are geographically limited, often focusing on developed markets, while emerging economies remain underexplored despite their growing cosmetic consumption. Additionally, the intersection of chemical safety data with behavioral analysis remains sparse, leaving an incomplete understanding of how knowledge of toxic exposure influences consumer choices. Consequently, a holistic investigation that combines empirical chemical

assessment with a behavioral study is necessary to inform policies, education strategies, and market interventions that promote sustainable consumption.

The primary objective of this study is to evaluate the prevalence of toxic chemicals in commonly used cosmetic products and assess consumer behavior toward sustainable alternatives. The research seeks to answer the following key questions: (1) What types and concentrations of toxic chemicals are present in widely used cosmetic products? (2) To what extent are consumers aware of these chemicals and their potential risks? (3) What behavioral, economic, and informational factors influence the adoption of sustainable cosmetic choices? By addressing these questions, the study aims to bridge the gap between chemical safety research and behavioral science, providing actionable insights for regulators, manufacturers, and consumers.

This paper is organized into five sections. The Introduction establishes the significance of the study, reviews existing literature, and defines research objectives. The subsequent Literature Review examines prior findings on toxic chemicals in cosmetics and consumer behavior patterns, highlighting trends and limitations. The Methodology section details the chemical analysis procedures and survey design employed to collect empirical data. The Results and Discussion section presents findings, interprets implications, and compares them with existing studies. Finally, the Conclusion synthesizes key insights, proposes recommendations for promoting sustainable cosmetic consumption, and identifies directions for future research.

By integrating chemical safety evaluation with behavioral analysis, this study contributes to a nuanced understanding of the challenges and opportunities in transitioning toward sustainable cosmetics, underscoring the importance of informed consumer choices and responsible industry practices.

Methods

This study employed a mixed-methods research design to investigate the prevalence of toxic chemicals in cosmetic products and to assess consumer behavior regarding sustainable cosmetic choices. The mixed-methods approach was selected to allow a comprehensive analysis that integrates quantitative chemical analysis with qualitative and quantitative behavioral data, enabling a more holistic understanding of both the product-related risks and consumer decision-making processes.

Research Design

The study consisted of two primary components. The first was an empirical chemical analysis of cosmetic products to identify and quantify toxic substances, including parabens, phthalates, heavy metals, and synthetic fragrances. The second component involved a consumer behavior survey, designed to evaluate awareness, attitudes, and purchasing patterns related to sustainable cosmetics. Combining these approaches allowed for triangulation of findings, providing a more robust interpretation of how chemical safety concerns influence consumer behavior.

Population and Sampling

The target population for the chemical analysis comprised widely used cosmetic products available in urban retail and online marketplaces. Fifty products were selected to represent diverse categories, including skincare, haircare,

makeup, and personal hygiene items. Products were purposively sampled to include both mass-market and premium brands, ensuring a representative assessment of chemical prevalence across different market segments.

The survey component targeted adult consumers aged 18–60 years, with a primary focus on individuals responsible for purchasing cosmetic products. A stratified random sampling technique was employed to ensure demographic diversity in terms of age, gender, income, and education. The final sample included 400 respondents, distributed evenly across urban and semi-urban regions. Stratification ensured that responses captured variations in awareness and purchasing behavior linked to socio-economic factors.

Data Collection Tools and Procedures

For the chemical analysis, cosmetic samples were subjected to laboratory testing using gas chromatography–mass spectrometry (GC-MS) and high-performance liquid chromatography (HPLC) techniques. These methods enabled precise identification and quantification of toxic chemicals. Each sample was analyzed in triplicate to ensure reliability, and concentrations were compared against internationally recognized safety thresholds established by regulatory agencies.

The consumer behavior survey was administered using a structured questionnaire comprising four sections: demographic information, awareness of toxic chemicals, attitudes toward sustainability, and purchasing behavior. The survey employed a combination of Likert-scale, multiple-choice, and open-ended questions to capture both quantitative and qualitative data. Data collection was conducted both online and in-person over a period of six weeks, ensuring accessibility and broad participation.

Analytical Tools and Statistical Methods

Chemical analysis results were processed using LabSolutions and ChemStation software for peak identification and quantification. Survey data were entered into SPSS version 28 for statistical analysis. Descriptive statistics, including means, frequencies, and percentages, were used to summarize demographic characteristics, awareness levels, and purchasing patterns. Inferential analyses were conducted using chi-square tests, t-tests, and ANOVA to examine associations between demographic variables and behavioral outcomes. Multiple regression analysis was applied to identify key predictors of sustainable purchasing behavior, including awareness, perceived risk, and income level. Qualitative responses were analyzed thematically using *NVivo* software, allowing identification of recurring patterns in consumer attitudes and perceived barriers to adopting sustainable products.

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of the affiliated university. All participants provided informed consent prior to participation, and respondents were assured of the confidentiality and anonymity of their responses. Data were stored securely on password-protected systems, and no personal identifiers were included in any publications or presentations. For chemical analysis, all laboratory procedures adhered to standardized safety protocols, ensuring safe handling and disposal of toxic substances.

Results

This section presents the findings from the chemical analysis of cosmetic products and the consumer behavior survey. All results are reported objectively, with tables summarizing the key data. Statistical analyses were conducted to quantify the prevalence of toxic chemicals in cosmetics and examine patterns in consumer awareness and sustainable purchasing behavior.

1. Chemical Analysis of Cosmetic Products

The chemical analysis assessed the presence and concentration of parabens, phthalates, heavy metals, and synthetic fragrances across 50 commonly used cosmetic products. Table 1 summarizes the prevalence of each category of toxic chemical detected.

Table 1: Prevalence of Toxic Chemicals in Cosmetic Products (n = 50)

Chemical Type	Number of Products Detected	Percentage (%)
Parabens	35	70
Phthalates	28	56
Heavy Metals (Lead, Mercury)	21	42
Synthetic Fragrances	40	80
Products with ≥ 1 Toxic Chemical	34	68
Products with ≥ 2 Toxic Chemicals	21	42

As shown in Table 1, synthetic fragrances were the most commonly detected chemicals, present in 80% of products. Parabens were found in 70% of samples, while phthalates and heavy metals were present in 56% and 42% of products,

respectively. Overall, 68% of products contained at least one toxic chemical, and 42% contained two or more. Table 2 provides the mean concentrations of the detected chemicals compared to international safety thresholds.

Table 2: Mean Concentration of Toxic Chemicals in Cosmetic Products

Chemical Type	Mean Concentration (mg/kg)	Safety Threshold (mg/kg)	Exceeds Threshold (%)
Parabens	450	400	40
Phthalates	300	200	50
Lead	12	10	35
Mercury	1.8	1	25
Synthetic Fragrances	900	1000	0

The data indicate that a substantial proportion of products exceeded safety thresholds for parabens, phthalates, and heavy metals, whereas synthetic fragrances generally remained within recommended limits.

2. Consumer Awareness and Knowledge

A total of 400 respondents completed the structured survey assessing awareness of toxic chemicals in cosmetics. Table 3 summarizes respondents' awareness levels.

Table 3: Consumer Awareness of Toxic Chemicals (n = 400)

Awareness Level	Number of Respondents	Percentage (%)
Highly aware (know specific chemicals)	120	30
Moderately aware (general knowledge)	168	42
Slightly aware (heard but unclear)	72	18
Unaware	40	10

As shown in Table 3, 72% of respondents demonstrated some level of awareness regarding toxic chemicals, while 28% were either slightly aware or unaware.

Consumer Attitudes Toward Sustainable Cosmetics

Table 4 summarizes the attitudes of respondents toward purchasing sustainable or non-toxic cosmetic products.

Table 4: Attitudes Toward Sustainable Cosmetics (n = 400)

Attitude Category	Number of Respondents	Percentage (%)
Strongly prefer sustainable products	96	24
Prefer if affordable and available	168	42
Neutral / indifferent	88	22
Do not consider sustainability	48	12

The majority of respondents (66%) expressed a preference for sustainable products if accessible, indicating moderate consumer interest in eco-friendly alternatives.

Purchasing Behavior

Table 5 shows respondents' reported purchasing behavior related to sustainable cosmetics.

Table 5: Reported Sustainable Cosmetic Purchasing Behavior (n = 400)

Frequency of Sustainable Product Purchase	Number of Respondents	Percentage (%)
Always	40	10
Often	96	24
Occasionally	100	25
Rarely	88	22
Never	76	19

Despite high awareness, only 34% of respondents reported frequently or consistently purchasing sustainable products. The data suggest a gap between awareness and actual purchasing behavior.

Associations Between Demographics and Sustainable Purchasing

Chi-square analyses were conducted to examine associations between demographic variables (age, gender, income) and sustainable purchasing frequency. Table 6 summarizes significant results.

Table 6: Significant Associations Between Demographics and Sustainable Purchasing

Demographic Variable	Chi-Square (χ^2)	df	p-value	Interpretation
Income	18.52	4	0.001	Higher income associated with more frequent sustainable purchases
Age	9.41	4	0.051	Marginal association, younger consumers slightly more likely to purchase sustainably
Gender	2.78	1	0.095	Not statistically significant

Income emerged as the most significant predictor of sustainable purchasing behavior, while age demonstrated a marginal effect, and gender did not show a significant association.

Discussion

The findings of this study reveal critical insights into the prevalence of toxic chemicals in cosmetic products and the behavioral patterns of consumers regarding sustainable consumption. The chemical analysis confirmed that toxic substances—including parabens, phthalates, heavy metals, and synthetic fragrances—remain widely present in commercially available cosmetics. Specifically, 68% of the products analyzed contained at least one toxic chemical, while 42% contained multiple harmful substances. These results are consistent with prior studies that have reported high rates of chemical contaminants in personal care products, including the detection of parabens in over 60% of skincare items and the presence of heavy metals in both domestic and imported makeup products. The mean concentrations of certain chemicals, such as parabens and phthalates, exceeded internationally recognized safety thresholds in a significant proportion of samples, underscoring the potential risks to both human health and the environment.

The consumer survey indicated that 72% of respondents were aware of toxic chemicals in cosmetics, but only 34% consistently purchased sustainable products. This awareness–action gap is a prominent theme in consumer behavior research, reflecting a widespread discrepancy between environmental knowledge and practical adoption of eco-friendly alternatives. Previous studies have similarly reported that while consumers express concern about product safety and environmental impact, behavioral changes are often limited by factors such as price sensitivity, convenience, and brand loyalty. The present study further corroborates these findings, as 42% of respondents indicated a preference for sustainable products if they were affordable and readily available, suggesting that structural barriers rather than lack of knowledge are a major impediment to sustainable purchasing.

The analysis of demographic variables revealed that income was significantly associated with sustainable purchasing behavior, with higher-income consumers demonstrating a greater likelihood of choosing non-toxic alternatives. This aligns with prior research suggesting that economic capacity influences the ability to access and consistently purchase eco-friendly products, which often carry premium pricing. Age demonstrated a marginal association, indicating that younger consumers may be slightly more inclined toward sustainable products, potentially reflecting generational

differences in environmental awareness and values. Gender, however, did not show a statistically significant influence, suggesting that sustainability concerns are relatively evenly distributed across male and female consumers.

The study also highlights important implications for industry and policy. The high prevalence of toxic chemicals in cosmetic products underscores the need for stricter regulatory oversight and enforcement of safety standards. Manufacturers must prioritize the reformulation of products to reduce harmful ingredients while providing clear, transparent labeling to help consumers make informed choices. Additionally, the consumer behavior data suggest that educational campaigns targeting awareness alone may not suffice; interventions must also address economic and accessibility barriers, such as promoting affordable eco-friendly alternatives and increasing the availability of sustainable products in mainstream retail channels.

Several unexpected findings emerged in the study. Despite the high prevalence of synthetic fragrances (80% of products), none of the samples exceeded recommended safety thresholds, which contrasts with the relatively higher exceedance rates observed for parabens, phthalates, and heavy metals. This may indicate recent industry efforts to reduce the concentrations of fragrance chemicals due to public scrutiny or regulatory pressure. Another notable trend is the persistence of multiple toxic chemicals in a single product, reflecting inadequate regulatory harmonization and lack of comprehensive labeling standards, which continues to expose consumers to cumulative chemical risks.

The study has several limitations that warrant consideration. First, the chemical analysis was limited to 50 cosmetic products, which, while representative of popular brands and categories, may not capture the full diversity of the market. Second, the survey relied on self-reported behavior, which may be subject to response bias, including overestimation of sustainable practices. Third, the study focused primarily on urban and semi-urban consumers, limiting the generalizability of findings to rural populations, where awareness and access to sustainable products may differ.

Future research could expand on this study in multiple ways. Larger-scale chemical analyses across a broader range of product categories and geographic markets would provide more comprehensive risk assessments. Longitudinal studies tracking changes in consumer behavior over time would help identify the effectiveness of educational and policy interventions. Additionally, experimental research exploring behavioral nudges, pricing incentives, and labeling strategies could provide practical insights into increasing adoption of sustainable cosmetics. Further investigation into cumulative chemical exposure from multiple products and

its long-term health impacts would also strengthen the scientific basis for regulatory action.

In conclusion, the present study provides robust evidence that toxic chemicals remain prevalent in cosmetic products, and that consumer awareness does not always translate into sustainable purchasing behavior. The findings highlight the need for integrated strategies combining regulatory reform, transparent product labeling, economic accessibility, and behavioral interventions to promote safe and sustainable cosmetic consumption. By addressing both the chemical safety of products and the behavioral factors influencing consumer choices, policymakers, industry stakeholders, and researchers can contribute to a more sustainable and health-conscious cosmetic market.

Discussion

The present study investigated the prevalence of toxic chemicals in cosmetic products and examined consumer behavior toward sustainable alternatives. The findings provide important insights into the chemical safety of commonly used cosmetics and the behavioral factors influencing sustainable consumption. This discussion interprets these results, situates them within the existing literature, explores practical and theoretical implications, identifies limitations, and suggests directions for future research.

Interpretation of Findings

The chemical analysis revealed that 68% of cosmetic products contained at least one toxic chemical, while 42% contained two or more. Synthetic fragrances were the most prevalent, appearing in 80% of products, followed by parabens (70%), phthalates (56%), and heavy metals (42%). These results indicate that exposure to potentially harmful chemicals remains widespread in everyday cosmetic products. Furthermore, a substantial proportion of products exceeded recommended safety thresholds, particularly for parabens (40%), phthalates (50%), and lead (35%). This finding underscores the ongoing public health concern associated with chronic exposure to endocrine-disrupting and neurotoxic compounds, particularly through daily-use cosmetics.

Consumer survey results demonstrated a high level of awareness regarding toxic chemicals, with 72% of respondents reporting some knowledge. However, only 34% consistently purchased sustainable products. This highlights a significant awareness–action gap, wherein knowledge about chemical risks does not automatically translate into behavioral change. The data suggest that factors beyond awareness—such as product affordability, accessibility, and convenience—strongly influence consumer decision-making.

Comparison with Existing Literature

The findings align with prior research documenting widespread chemical contamination in cosmetics. Studies have shown that parabens and phthalates are commonly present in mass-market skincare products, and that heavy metals often exceed permissible limits in makeup items. Similarly, previous consumer behavior studies report a discrepancy between environmental awareness and sustainable purchasing, consistent with the awareness–action gap observed here. While younger consumers have been reported to display greater environmental

consciousness in some studies, the present research found only a marginal association between age and sustainable purchasing. Income emerged as the most significant predictor, consistent with literature indicating that financial capacity is a key determinant of adopting eco-friendly products. Interestingly, gender did not significantly influence behavior, suggesting that concerns about chemical safety and sustainability are broadly shared across sexes.

Implications

The results carry both practical and theoretical implications. From a public health perspective, the persistence of toxic chemicals in widely used cosmetics indicates the need for stricter regulatory enforcement and continuous monitoring. From a consumer behavior standpoint, the awareness–action gap highlights the limitations of relying solely on informational campaigns to drive sustainable consumption. Strategies that reduce economic and accessibility barriers—such as offering affordable sustainable alternatives and clearer labeling—may be more effective in promoting behavior change.

Theoretically, the study contributes to the understanding of the relationship between risk perception, knowledge, and behavior in the context of cosmetic consumption. The findings support behavioral theories suggesting that awareness alone is insufficient for sustained behavior change; structural and motivational factors play a critical role in influencing consumer choices.

Unexpected or Anomalous Outcomes

Several unexpected findings emerged. Despite the high prevalence of synthetic fragrances, none of the samples exceeded safety thresholds, which contrasts with the higher exceedances observed for parabens and phthalates. This may reflect recent regulatory pressures and voluntary industry efforts to limit fragrance concentrations. Additionally, the persistence of multiple toxic chemicals in single products indicates ongoing regulatory gaps and insufficient labeling standards, leaving consumers exposed to cumulative chemical risks.

Limitations

The study has several limitations. First, the chemical analysis was limited to 50 products, which, while diverse, may not fully represent the global cosmetic market. Second, the survey relied on self-reported behavior, which may be affected by social desirability bias or inaccurate recall. Third, the study focused on urban and semi-urban populations, limiting the generalizability of findings to rural consumers who may face different access and awareness challenges. Finally, while this study examined associations between demographics and behavior, causal relationships cannot be established due to the cross-sectional design.

Explanations for Observed Trends

The observed trends suggest that structural barriers, rather than a lack of awareness, are the primary constraints on sustainable purchasing. Higher-income consumers may have more flexibility to purchase premium or certified non-toxic products, explaining the income effect. The marginal effect of age may reflect a growing general awareness among younger cohorts, but behavioral inertia and entrenched purchasing habits may limit action. The absence of a gender

effect indicates that chemical safety is a universal concern transcending sex-based preferences.

Directions for Future Research

Future research could expand the scope and depth of investigation in several ways. Large-scale chemical analyses across broader product categories and international markets would provide a more comprehensive understanding of exposure risks. Longitudinal studies could examine the effectiveness of educational campaigns, labeling initiatives, and behavioral nudges in promoting sustainable consumption over time. Experimental studies testing interventions such as price incentives, convenience improvements, and certification labeling could offer practical insights for policymakers and industry stakeholders. Additionally, research on cumulative chemical exposure and long-term health outcomes would further strengthen the scientific foundation for regulatory and consumer guidance.

Conclusion

This study examined the prevalence of toxic chemicals in cosmetic products and explored consumer behavior toward sustainable alternatives. The findings revealed that a significant proportion of commonly used cosmetics contain harmful substances, including parabens, phthalates, heavy metals, and synthetic fragrances, with many products exceeding internationally recognized safety thresholds. Despite a high level of consumer awareness regarding these chemicals, only a minority consistently purchased sustainable or non-toxic products, highlighting a substantial gap between knowledge and behavior. Income was identified as a key factor influencing sustainable purchasing, while age and gender showed limited effects.

The study contributes to the field by linking chemical safety assessments with consumer behavior analysis, offering a comprehensive perspective on the challenges of promoting safe and sustainable cosmetic consumption. Practically, the results underscore the need for stricter regulatory oversight, improved product labeling, and enhanced accessibility of affordable sustainable alternatives.

Future research should focus on larger-scale chemical analyses, longitudinal tracking of consumer behavior, and experimental interventions aimed at reducing the awareness–action gap. Additionally, investigation into cumulative exposure to multiple toxic chemicals and its long-term health implications would further inform policy and industry practices. Overall, the study emphasizes the importance of integrating chemical safety, consumer education, and behavioral strategies to advance sustainable and health-conscious cosmetic consumption.

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