International Journal of Nursing Information (IJNI)
ISSN: 2964-4585 (Online)
Vol. 3, No. 2, pp. 9-21

The Hidden Dangers: How Synthetic Organic Compounds Impact Health and the Environment

Ashima Jha[1], Meena Jha[2]
[1]Department of Biomedical Research, Dr. B. R. Ambedkar Center of Biomedical Research, University of Delhi, India
[2]Health Sciences, Lincoln University College, Malaysia

Article Info
Article history:
Received: Oct 9, 2024
Revised: Dec 13, 2024
Accepted: Dec 29, 2024

DOI: 10.58418/ijni.v3i2.104

How to cite this article:
Jha, A., & Jha, M. (2024). The Hidden Dangers: How Synthetic Organic Compounds Impact Health and the Environment. *International Journal of Nursing Information*, *3*(2), 9–21. https://doi.org/10.58418/ijni.v3i2.104

Read online:

Scan this QR code with your smart phone or mobile device to read online.

ABSTRACT
Human health care and environmental preservation are two interconnected aspects of modern life. Synthetic organic compounds have significantly contributed to various industries, including agriculture and cosmetics, offering notable benefits. However, these compounds also pose risks to human health and environmental sustainability. This study aims to review synthetic organic compounds from multiple perspectives, comprehensively understanding their toxicological impacts and focusing on their potential risks to human health and the environment while exploring safer alternatives and mitigation strategies. A literature review approach was employed by sourcing primary articles using keywords related to synthetic organic compounds and their impacts. Databases such as PubMed, Google Scholar, ResearchGate, and Elsevier were utilized, alongside more than 50 secondary sources, for in-depth analysis. The findings highlight the potential adverse effects of exposure to these compounds and evaluate existing regulatory measures, underscoring the urgent need for enhanced strategies to mitigate associated risks. By emphasizing the principles of green chemistry, this review advocates for sustainable practices to reduce long-term contamination, thus protecting human health and the environment. This study contributes to nursing and health science by raising awareness about toxic exposures to synthetic compounds daily and offers valuable insights to inform policy frameworks and practical interventions. These insights aim to minimize health risks while supporting nurses' roles in health promotion and disease prevention, enhancing their capacity to effectively address environmental and chemical health concerns.

Keywords: Health Risks, Human Health, Environmental Health Concerns, Synthetic Organic Compounds, Toxic Exposures

This is an open access article under the CC BY-SA 4.0 license.

Corresponding Author:
Ashima Jha
University of Delhi, India
Email: ashimajhaofficial@gmail.com

1. INTRODUCTION

In our modern world, the pervasive use of synthetic organic compounds has brought about numerous conveniences and advancements across various industries (Geyer, 2020). From preservatives in our food to solvents in industrial applications, these chemicals have become indispensable. However, their widespread use has also raised significant concerns regarding their potential adverse effects on human health and the environment (FoodSafety4EU, 2022; WHO, 2023). As these compounds permeate various facets of our lives, understanding their toxicological implications becomes imperative.

Nurses are pivotal in mitigating the health risks (Al-Shahri et al., 2024) associated with synthetic organic compounds (SOCs) through comprehensive patient education. By informing patients about potential sources of SOCs exposure, such as specific personal care products, household cleaners, and

processed foods, nurses can empower individuals to make informed choices that reduce their contact with these chemicals. Recent studies have demonstrated that interventions focusing on reducing the use of products containing synthetic phenols, glycol ethers, and phthalates can effectively lower biomarker concentrations of these substances in the body (Rousseau et al., 2022; Yang et al., 2023)

In clinical settings, nurses are instrumental in implementing and advocating for stringent decontamination protocols to protect both patients and healthcare workers from chemical exposures (Hill, 2024; Shaban et al., 2024). Ensuring thorough decontamination prior to medical interventions is crucial when dealing with individuals exposed to hazardous chemicals (Downing, 2009). Additionally, nurses should advocate for the use of less toxic alternatives and the adoption of green chemistry principles (Tickner et al., 2021) within healthcare facilities to minimize the presence of harmful SOCs.

Furthermore, nurses should engage in holistic assessments that consider environmental factors contributing to patient health (Fu et al., 2020). By incorporating environmental health into patient evaluations, nurses can identify potential SOCs exposures and provide tailored interventions. Holistic nursing practices emphasize the importance of addressing environmental health concerns, recognizing that exposure to environmental toxins can significantly impact overall well-being (Izah et al., 2023; Moghbeli et al., 2024). Through such comprehensive care, nurses can play a critical role in reducing the health impacts of SOCs on their patients.

In recent years, the impact of chemical additives in food has become a growing area of concern. Studies have linked certain preservatives and colorants to adverse health effects, including allergic reactions and long-term health risks such as cancer and neurotoxicity (WHO, 2023). For example, synthetic food dyes have been associated with hyperactivity in children, leading to calls for stricter regulations and the adoption of natural alternatives (Mota et al., 2023).

Occupational exposure to hazardous chemicals is another critical issue, with workers in industries such as manufacturing and agriculture facing elevated risks (ILO, 2021). Chronic exposure to certain solvents and pesticides has been linked to respiratory issues, neurological disorders, and even cancer (Anderson & Meade, 2014; ILO, 2021). These health risks underscore the need for stringent workplace safety regulations and the promotion of safer chemical alternatives.

The use of solvents, particularly in industrial and laboratory settings, presents significant health and environmental challenges. Volatile organic compounds (VOCs) released from solvents contribute to air pollution and pose direct health risks to individuals through inhalation (David & Niculescu, 2021; Duan et al., 2023). Innovations in green chemistry have led to the development of less toxic and more sustainable solvents, yet widespread adoption remains a challenge (Dwivedi et al., 2021).

Pesticides, while crucial for modern agriculture, have far-reaching environmental and health impacts. The persistence of these chemicals in the environment leads to contamination of soil and water, affecting both wildlife and human populations (Kaur & Garg, 2014; Pathak et al., 2022). Recent regulatory measures aim to mitigate these risks, but the effectiveness of these regulations varies widely across regions (Pathak et al., 2022).

Cosmetic products, often overlooked in toxicological discussions, contain a myriad of synthetic chemicals that can have detrimental effects (Johnson et al., 2022). Ingredients such as phthalates, parabens, and formaldehyde releasers have been scrutinized for their potential endocrine-disrupting and carcinogenic properties (Bilal et al., 2020). Increased consumer awareness has driven demand for safer, non-toxic beauty products (Faber, 2020).

The abuse of synthetic drugs represents another alarming facet of chemical toxicity. Novel psychoactive substances (NPS) are continually emerging, often circumventing existing drug laws and posing severe health risks (Santos et al., 2024). Addressing this issue requires robust legal frameworks and public health strategies.

This research aims to review synthetic organic compounds from a variety of perspectives in order to provide a comprehensive overview of their toxicological impacts, focusing on understanding their potential risks to human health and the environment and exploring strategies for safer alternatives and mitigation measures. By examining current research and regulatory efforts, we highlight the importance of adopting green chemistry principles and sustainable practices to safeguard human health and the environment.

2. METHOD

This article employs a literature review approach by analyzing primary and secondary sources using content analysis. The process involved several steps to ensure a comprehensive review. First, a keyword selection was conducted using terms such as synthetic organic compounds, chemical additives, food additives, cosmetics safety, drugs of abuse, solvent toxicity, pesticide exposure, environmental contamination, toxic substances, public health risks, green chemistry, health, and environment. Next, search engines and databases, including PubMed, Google Scholar, ResearchGate, and Elsevier, were utilized to retrieve relevant peer-reviewed articles, reports, and abstracts. Additionally, reputable websites containing articles and reports were reviewed to ensure broad topic coverage by employing Google to find supplementary materials.

Over 50 scientific articles were studied and cited to deepen the analysis and provide a detailed and balanced perspective on the topic. Foundational toxicological knowledge was further supplemented by referring to secondary sources, such as "Casarett and Doull's Toxicology: The Basic Science of Poisons (8th edition)," to enhance understanding of toxicology principles. Finally, integrating both primary and secondary sources allowed for a comprehensive examination of synthetic organic compounds' health risks and environmental impacts, alongside current regulatory strategies. This methodology ensured a well-rounded discussion, offering valuable insights into health science and environmental studies.

3. RESULTS AND DISCUSSION

3.1. Chemical Additives in Food

Chemicals are incorporated into food products for a variety of purposes, each serving a specific role in enhancing or maintaining the quality, safety, and appeal of the food. These additives are carefully selected and regulated to ensure that they do not pose harm to consumers (Sambu et al., 2022; WHO, 2023). Table 1 summarizes the major reasons for adding chemicals to food (McGraw-Hill Education, 2013; Thorne, 2019).

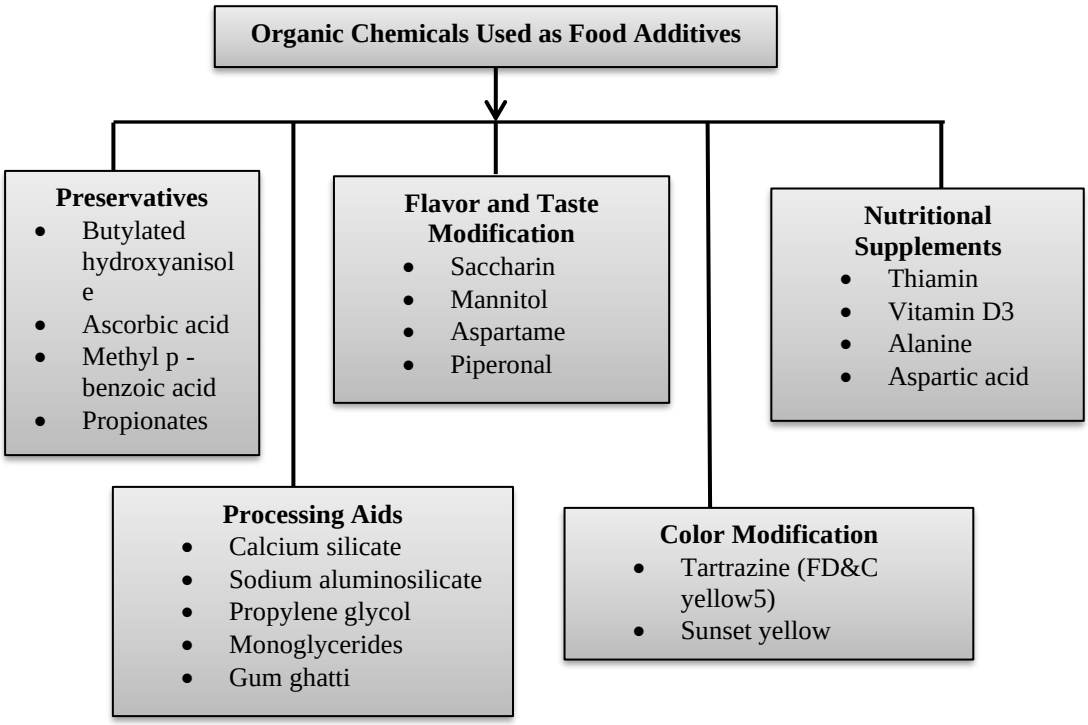
Table 1
Reasons for Chemical Additives in Food and Explanation

No.	Reasons for Chemical Additives in Food	Explanation
1.	Preservatives	• To extend the shelf life of food products by preventing the growth of bacteria, fungi, or oxidative reactions. • Anti-bacterial preservatives inhibit the growth of harmful microorganisms, ensuring that the food remains safe for consumption. • Antioxidants protect against the deterioration of fats and oils, which can lead to rancidity, by reducing the harmful effects of oxygen exposure.
2.	To modify the physical characteristics of food	• Certain additives aid in emulsifying, thickening, stabilizing, or even preventing crystallization. • These modifications can enhance the texture, appearance, and overall quality of the final product.
3.	Taste Enhancement	• This may include sweeteners to add sweetness without the calories of sugar, or flavor enhancers to improve the overall taste experience. • Such additives contribute to the palatability of the product.
4.	Color	• They can make food more visually appealing, which is essential in the marketing and consumer acceptance of many products. • Coloring agents, both natural and synthetic, are added to achieve desired shades and hues.
5.	Odor	• Changing the odor of food can be important in ensuring that the product is appetizing to consumers. • Some additives are used to enhance or modify the aroma of food, making it more enticing.

Sources: Sambu et al. (2022); McGraw-Hill Education (2013)

Food additives, while serving important roles in preserving, flavoring, and enhancing the appearance of food, come with potential risks. These include allergic reactions and sensitivities in some individuals, potential links to hyperactivity in children, concerns about carcinogenicity and long-term health effects, metabolic issues related to certain additives, gastrointestinal disturbances, headaches, and intolerance (Thorne, 2019). Excessive salt intake from sodium-based additives can impact blood pressure and heart health, and toxicity can occur when additives are consumed in high quantities. While regulatory agencies (Sambu et al., 2022; WHO, 2023) establish safety guidelines, individuals may benefit from reading food labels, avoiding additives they are sensitive to, and consulting healthcare professionals for personalized guidance. Figure 1, gives an outlook of the major organic chemicals used as food additives.

Figure 1
Various Organic Chemicals Used as Food Additives.



It is important to note that regulatory agencies, such as the Food and Drug Administration (FDA) in the United States, and their counterparts in other countries, rigorously evaluate and approve food additives for safety. Extensive testing is conducted to ensure that these additives are safe for consumption, and they are subject to ongoing monitoring. In general, food additives have been found to be safe when used within established guidelines, however, it is essential to use them in accordance with recommended levels and for their intended purposes to ensure their safety.

3.2. Chemicals in the Workplace

For centuries the work environment has played a significant role in the occurrence of adverse human health effects due to chemical and biological hazards. There was a general awareness of the toxic nature of mining, smelting, and metallurgy exposures as indicated in the early writings of Agricola and Paracelsus (Thorne, 2019).

Diseases that originate in occupational settings typically result from exposure primarily through inhalation, ingestion, or dermal absorption. In most workplace scenarios, the primary focus is on the potential inhalation of harmful substances. Inhalation exposures can manifest in various forms, including gases, vapors, liquid aerosols, particulate aerosols, fumes, and combinations thereof. Dermal exposures are equally significant, stemming from air-dispersed substances, liquid splashes on the skin, immersion incidents, or contact during material handling (Anderson & Meade, 2014).

Many industries rely on synthetic chemicals for manufacturing processes, which can expose workers to hazardous substances. Occupational exposure to chemicals like heavy metals, carcinogens, and volatile organic compounds can lead to long-term health issues, including respiratory problems, cancer, and organ damage (McGraw-Hill Education, 2013).

Moreover, the International Agency for Research on Cancer (IARC) identifies certain agents that have been carcinogenic to humans upon exposure. This list includes agents such as asbestos, arsenic, benzene, vinyl chloride, and coal tars (Ahmed et al., 2022; Naghibzadeh-Tahami et al., 2022).

Hence, strict workplace safety regulations and education about proper handling and protective measures are crucial for mitigating these risks.

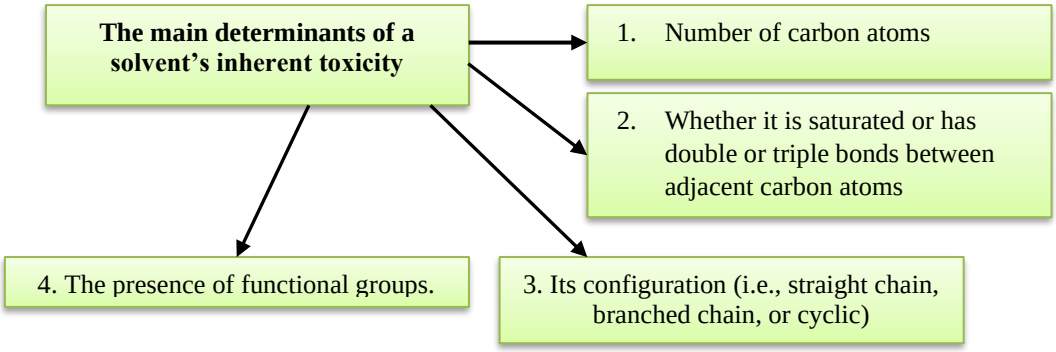
3.3. Solvents

The term "solvent" encompasses a category of liquid organic compounds with varying degrees of fat solubility and volatility (Chang, 2020). These characteristics, in combination with their small molecular size and lack of electrical charge, predominantly render inhalation as the primary pathway for solvent exposure. Furthermore, these features facilitate efficient absorption through the lungs, gastrointestinal (GI) tract, and skin (A. Zhang et al., 2020; S. Zhang et al., 2023). Figure 2 shows the four main determinants of solvent’s inherent toxicity.

Almost everyone is exposed to solvents in their day-to-day lives. Comprehensive investigations of both indoor and outdoor air quality, exemplified by initiatives like the Environmental Protection Agency's Total Exposure Assessment Methodology (TEAM) and the National Human Exposure Assessment Survey (NHEXAS) studies, consistently reveal that exposure to airborne solvents is an inevitable occurrence (Robertson et al., 1999). Solvent exposure through drinking water is prevalent, primarily stemming from the release of solvents into surface and groundwater systems, as well as the presence of disinfection by-products. These by-products include chloroform ($CHCl_3$), an animal carcinogen, as well as trichloroacetic acid (TCA) and dichloroacetic acid (DCA).

Figure 2

The Four Main Determinants of Solvent's Inherent Toxicity



Industrial solvents, such as benzene, toluene, and xylene (Soleimani, 2020), pose serious health risks (Ullah et al., 2024). Long-term exposure can lead to neurological damage, respiratory issues, and even cancer. Proper ventilation, personal protective equipment, and the substitution of less harmful alternatives are effective strategies to reduce solvent-related health hazards.

Solvent Abuse: The term "Solvent abuse" involves individuals intentionally inhaling vapor concentrations to mimic alcohol intoxication, achieved through methods such as "sniffing," aerosol spraying, "bagging," or "huffing" (Hannigan & Bowen, 2010; McGraw-Hill Education, 2013).

3.4. Pesticides

Pesticides are chemical substances used to control, repel, or eliminate various pests that can damage crops, harm livestock, or pose health risks to humans. Synthetic organic compounds play a crucial role in the formulation of pesticides, as they are designed to target specific pests or unwanted organisms while minimizing harm to non-target species (Ahmad et al., 2024). These compounds are synthesized through chemical processes and are often tailored to enhance their effectiveness in pest control (Sparks et al., 2021).

Synthetic pesticides are widely used in agriculture to protect crops, but their residues can end up in our food supply and pose health risks (Benbrook et al., 2021). Some pesticides have been linked to chronic health issues like cancer, developmental disorders, and endocrine disruption. Figure 3 illustrates different classes of synthetic organic compounds used as pesticides and their potential effects (Araújo et al., 2023; C et al., 2023; Damalas & Eleftherohorinos, 2011).

DDT, the widely recognized insecticide, consists of various isomers, with p,p'-DDT responsible for its insecticidal properties. It exhibits moderate acute oral toxicity with an LD50 of about 250 mg/kg. Dermal absorption of DDT is limited and poses low risks, with LD50 values exceeding 1000 mg/kg. In humans, oral doses of 10–20 mg/kg lead to illness, but accidental ingestion of up to 285 mg/kg rarely results in fatalities (McGraw-Hill Education, 2013; McInnes et al., 2023). DDT is distributed throughout the body, with the highest concentrations in adipose tissue. It is slowly metabolized, primarily forming DDE, DDD, and DDA, with excretion through bile, urine, and milk (Keswani et al., 2022).

Pesticide exposure can happen through ingestion, skin contact, or inhalation. High oral doses, which can lead to severe poisoning or death, result from intentional or accidental pesticide ingestion. Accidental ingestion often occurs due to improper pesticide storage. In contrast, chronic low doses are typically consumed by the general population as pesticide residues in food or contaminants in drinking water (El-Nahhal & El-Nahhal, 2021).

In 1990, the World Health Organization (WHO) had reported approximately three million hospital admissions due to pesticide poisoning annually, leading to approximately 220,000 fatalities (Daraban et al., 2023; Masood et al., 2024; McGraw-Hill Education, 2013)

Figure 3
Different Classes of Synthetic Organic Compounds Used in Pesticides

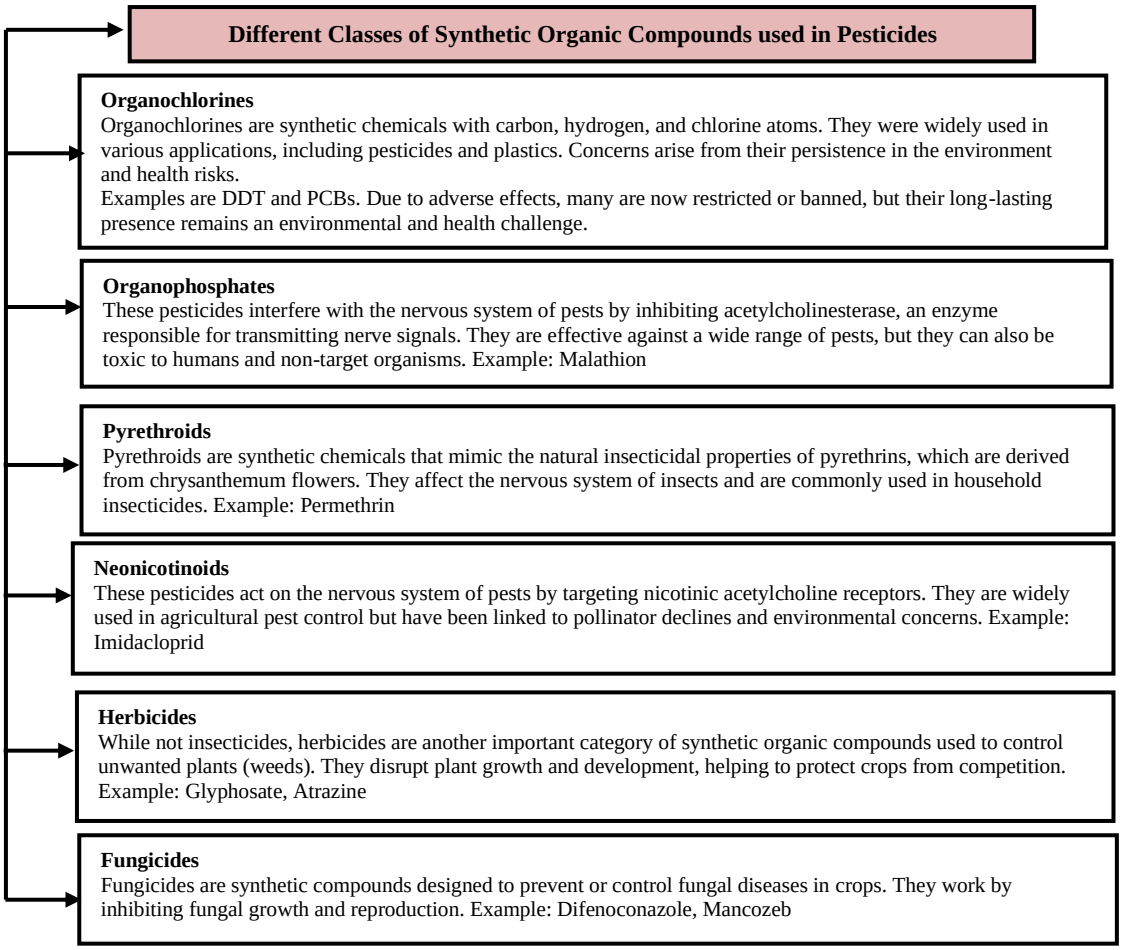
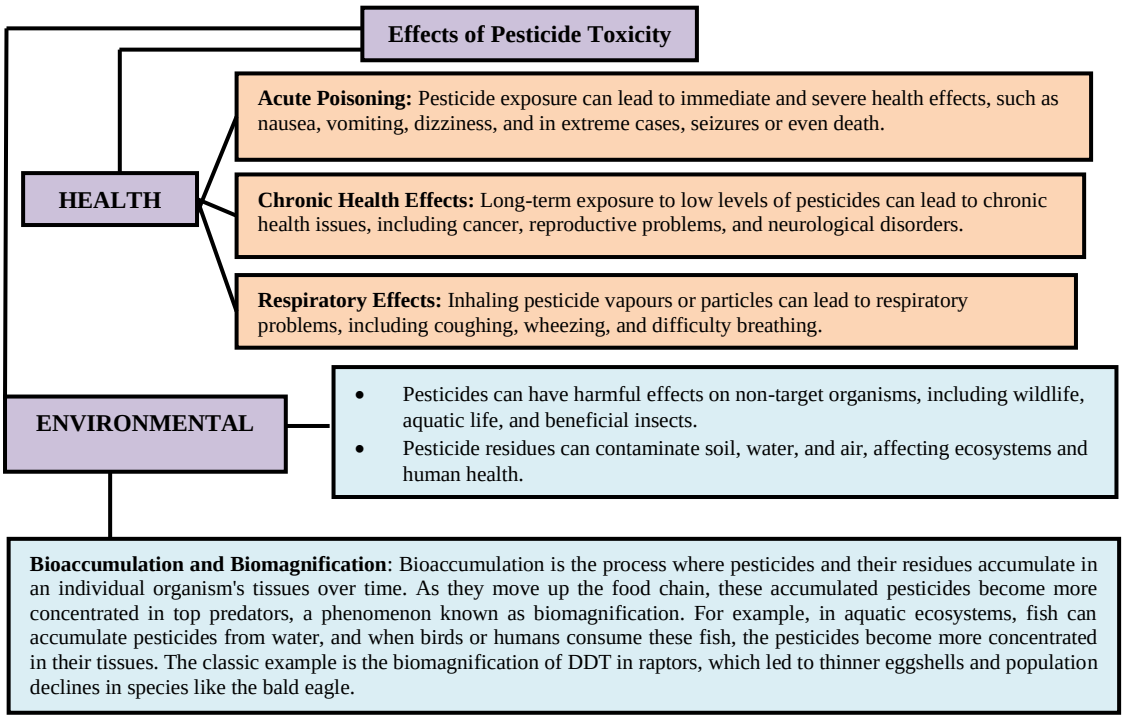


Figure 4
Effects of Pesticide Toxicity



The figure 4 explains the various health and environmental effects of pesticide toxicity (Lushchak et al., 2018). It also elaborates the phenomenon of bioaccumulation and biomagnification as adverse effects on the environment (Kesic et al., 2021).

The use of synthetic organic compounds in pesticides has raised environmental and health concerns (Rani et al., 2021). Pesticides can have unintended consequences, including harming non-target species, contaminating soil and water, and leading to pesticide resistance in pests. As a result, there is ongoing research and development of more environmentally friendly and sustainable pest control methods, including the use of biological controls and integrated pest management strategies (Baker et al., 2020; Deguine et al., 2021; Frank et al., 2022). At the same time, the promotion of integrated pest management and organic farming practices can help reduce reliance on synthetic pesticides.

3.5. Cosmetics

Cosmetic products often contain synthetic chemicals like parabens, phthalates, and formaldehyde-releasing preservatives. Prolonged use of such products can lead to skin irritation, allergies, and potential long-term health concerns (Alnuqaydan, 2024; Halla et al., 2018; Panico et al., 2019). Table 2 shows various synthetic organic toxic compounds in cosmetics and their potential toxicities.

Table 2
Synthetic Organic Toxic Compounds in Cosmetics and Their Potential Toxicities

No.	Synthetic Organic Toxic Compounds in Cosmetics	Examples	Toxic Effects
1.	Parabens	Methylparaben, Propylparaben	Potential links to endocrine disruption, breast cancer, reproductive issues, and hormonal imbalances.
2.	Phthalates	Diethyl Phthalate, Dibutyl Phthalate	Linked to reproductive and developmental issues, endocrine disruption, and hormone imbalances.
3.	Formaldehyde	DMDM Hydantoin, Imidazolidinyl Urea	Classified as a human carcinogen, and may cause skin irritation and allergic reactions.
4.	Heavy Metals	Lead, Cadmium	Accumulation can affect the nervous system and potentially lead to various health issues, with lead being linked to neurotoxicity.
5.	Coal Tar Dyes	P-phenylenediamine	Associated with skin sensitization, allergies, and potential carcinogenicity.
6.	Sunscreen Chemicals	Oxybenzone, Octinoxate	Oxybenzone may cause skin irritation, and allergies, and has environmental concerns regarding coral reefs.

Sources: Kaushik et al. (2023); Barrett (2005)

Based on Table 2, various synthetic organic toxic compounds used in cosmetics are: a) Parabens. Parabens are synthetic preservatives commonly used in cosmetics to prevent the growth of microorganisms. They are under scrutiny due to their potential endocrine-disrupting properties and associations with health concerns. b) Phthalates. Phthalates are plasticizers used in cosmetics to enhance flexibility and durability. Some phthalates, such as diethyl phthalate (DEP), have been linked to potential health risks, including reproductive and developmental issues. c) Formaldehyde. Formaldehyde and its releasing compounds are used as preservatives in cosmetics. Formaldehyde is a known human carcinogen, and its presence in cosmetics is regulated due to health concerns. d) Heavy Metals (e.g., Lead, Cadmium). Some cosmetics may contain heavy metals as impurities or contaminants, such as lead in lipstick or cadmium in coloring agents. These metals can pose health risks if ingested or absorbed through the skin. e) Coal Tar Dyes: Coal tar dyes are synthetic colorants used in cosmetics, particularly in hair dyes and some lipsticks. They have been associated with potential carcinogenicity and may trigger allergic reactions in some individuals.

The regulatory agencies, such as the U.S. Food and Drug Administration (FDA) and the European Union, set guidelines and restrictions on the use of synthetic organic compounds in cosmetics to ensure their safety (Manful et al., 2024; Rathee et al., 2023). However, consumers are encouraged to read ingredient labels and be aware of their sensitivities to certain compounds. Additionally, the cosmetic

industry is continuously working to develop safer and more environmentally friendly alternatives to these synthetic chemicals.

3.6. Drugs of Abuse

Drugs of abuse often contain synthetic organic compounds designed to produce mind-altering effects, leading to addiction and a range of health risks (Nawi et al., 2021; Santos et al., 2024). These substances are created with the intent of imitating the effects of naturally occurring drugs, but their synthetic nature can make them especially potent and unpredictable. Recreational drugs, such as synthetic cannabinoids and opioids, are highly toxic substances (Alves et al., 2020; Bukke et al., 2021). These drugs can lead to addiction, overdose, and various physical and mental health issues.

Synthetic organic toxic compounds in drugs of abuse present significant risks to users, each with distinct toxic effects. Synthetic cannabinoids, designed to mimic natural marijuana, can induce severe anxiety, paranoia, hallucinations, and seizures, with a high potential for addiction and adverse mental health outcomes (Cohen & Weinstein, 2018). Synthetic cathinones, often sold as "bath salts," are stimulants that can cause extreme agitation, paranoia, delirium, and violent behavior, posing a high risk of addiction and health complications (Riley et al., 2020). Synthetic opioids, including fentanyl analogs, are potent pain relievers that carry a high risk of overdose and respiratory depression, with even small amounts potentially being lethal (Patocka et al., 2024). Methamphetamine, a powerful stimulant, can lead to severe dental issues, cardiovascular problems, cognitive impairments, and addiction with chronic use (Edinoff et al., 2022). Synthetic hallucinogens, like NBOMe compounds, mimic LSD but can result in extreme hallucinations, paranoia, and a risk of self-harm (Schifano et al., 2023). Lastly, synthetic stimulants, such as MDPV and Alpha-PVP, produce effects similar to cocaine or amphetamines, leading to extreme agitation, paranoia, and cardiovascular issues, with a significant risk of addiction and overdose (Ciucă Anghel et al., 2023).

Understanding the dangers associated with synthetic organic compounds used in drugs of abuse is essential for public awareness and prevention efforts. These substances can lead to serious health consequences, including addiction, mental health issues, and even fatal overdose, making it crucial to address the challenges they pose. Hence, effective substance abuse prevention and treatment programs, coupled with harm reduction strategies, are crucial for addressing this public health crisis.

3.7. Recent Research Trends

Recent research trends in the field of synthetic organic toxicological compounds have been focused on several key areas, driven by advancements in technology, increasing environmental concerns, and the need for a better understanding of the impact of these compounds on human health and the environment (Khan et al., 2022).

a) Emerging Contaminants. Researchers are actively investigating the presence and effects of emerging contaminants, such as per- and polyfluoroalkyl substances (PFAS), pharmaceuticals, and personal care products in the environment. These compounds can have long-lasting ecological and health impacts (Khan et al., 2022). b) Nanotoxicology. With the rise of nanotechnology, there's a growing interest in understanding the potential toxicity of engineered nanoparticles. Researchers are exploring the effects of nanoparticles on biological systems, including the development of safe nanomaterials (Kahru & Mortimer, 2021). c) Toxicogenomic. The integration of genomics and toxicology is leading to a better understanding of how specific genes and genetic pathways are affected by exposure to synthetic compounds (Singh et al., 2023). This allows for more precise risk assessment. d) Environmental Risk Assessment. There is a growing emphasis on assessing the environmental risks posed by synthetic compounds, including the impact on ecosystems, biodiversity, and the potential for bioaccumulation and biomagnification (Mitra et al., 2022). e) Public Awareness and Policy. The interaction between scientific research, public awareness, and policy development is a growing trend. Research findings play a crucial role in influencing regulatory decisions and public perception of synthetic toxic compounds (Jangjou et al., 2023; Marx-Stoelting et al., 2023).

Recent research in the realm of synthetic organic toxicological compounds has witnessed a dynamic and transformative evolution. As we continue to unlock the secrets of synthetic organic compounds, these research trends empower us with knowledge and insight, steering us toward responsible and informed actions that protect both human health and our fragile environment.

4. CONCLUSION

Synthetic organic compounds are a double-edged sword, offering convenience and innovation but also presenting significant risks to human health and the environment. Mitigating these risks necessitates a multifaceted approach, involving stricter regulation, safer alternatives, and greater consumer awareness. Public advocacy and education play a pivotal role in promoting safer practices and products across various industries, ultimately contributing to a healthier and more sustainable future.

This review contributes to the scientific discourse by offering a comprehensive analysis of the toxicological effects of synthetic compounds found in food additives, cosmetics, solvents, pesticides, and

drugs of abuse. This article provides a foundation for policy discussions and practical interventions to reduce the health and environmental risks associated with these substances by evaluating current research trends and regulatory frameworks. Raising awareness among the general public is crucial in addressing the risks posed by synthetic organic compounds. Educating consumers about these substances' potential health hazards and environmental impact empowers them to make safer, more informed choices in their daily lives.

This review underscores the critical role of nursing in mitigating the health impacts of synthetic organic compounds. Nurses, as patient educators and advocates, are essential in disseminating knowledge about the risks associated with these substances and promoting behavioural changes that prioritize safety. By incorporating the findings of this review into nursing practice, healthcare providers can enhance patient education efforts, particularly in vulnerable populations, to reduce exposure to harmful chemicals. Moreover, this review supports the development of nursing interventions to prevent diseases linked to toxic exposures and strengthen public health initiatives.

The study also emphasizes the importance of green chemistry principles in fostering sustainable development. However, the limitations of this research should also be acknowledged. While the article draws on a wide range of sources, some areas, such as long-term epidemiological studies and region-specific regulatory practices, may not be fully addressed due to the scope of available literature. Future research is needed to explore emerging synthetic compounds and their impact in greater depth and track the effectiveness of implemented regulatory measures over time. By integrating nursing and health science insights, this review offers practical strategies for improving public health and environmental sustainability.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to all those who contributed to the completion of this review article. Special thanks go to our colleagues and mentors at the University of Delhi, India, and Lincoln University College, Malaysia, for their guidance and unwavering support throughout the writing process. We also acknowledge the contributions of the editorial team for their valuable guidance. The use of various databases and reference management tools greatly facilitated the research process, and their roles are highly appreciated. Furthermore, we extend our appreciation to ChatGPT, an AI language model developed by OpenAI, for its assistance in polishing the content of this article, which helped refine the language and ensure clarity in the communication of complex ideas. Lastly, we are grateful to our family and friends for their constant encouragement and support, which have been instrumental in the completion of this work.

REFERENCES

Ahmad, M. F., Ahmad, F. A., Alsayegh, A. A., Zeyaullah, M., AlShahrani, A. M., Muzammil, K., Saati, A. A., Wahab, S., Elbendary, E. Y., Kambal, N., Abdelrahman, M. H., & Hussain, S. (2024). Pesticides impacts on human health and the environment with their mechanisms of action and possible countermeasures. *Heliyon*, *10*(7), e29128. https://doi.org/10.1016/j.heliyon.2024.e29128

Ahmed, S., Islam, M. M. T., & Kabir, Y. (2022). Cancer: A Major Public Health Issue Associated with Occupational Environment and Safety. In N. Rezaei (Ed.), *Handbook of Cancer and Immunology* (pp. 1–20). Springer International Publishing. https://doi.org/10.1007/978-3-030-80962-1_101-1

Al-Shahri, G. M. H., Alharthi, A. A. M., Hassani, Y. M. Y., Alasiri, M. A. M., Alamri, J. Q. G., Al-Bishi, M. D. S., Muqrini, A. H. I., Aamri, H. M. H., & Khormi, I. Y. A. (2024). Analyzing the Epidemiology of Respiratory Diseases: Implications for Nursing Care. *Journal of International Crisis and Risk Communication Research*, *7*(S10), 2299–2317. https://jicrcr.com/index.php/jicrcr/article/view/1395

Alnuqaydan, A. M. (2024). The dark side of beauty: an in-depth analysis of the health hazards and toxicological impact of synthetic cosmetics and personal care products. *Frontiers in Public Health*, *12*. https://doi.org/10.3389/fpubh.2024.1439027

Alves, V. L., Gonçalves, J. L., Aguiar, J., Teixeira, H. M., & Câmara, J. S. (2020). The synthetic cannabinoids phenomenon: from structure to toxicological properties. A review. *Critical Reviews in Toxicology*, *50*(5), 359–382. https://doi.org/10.1080/10408444.2020.1762539

Anderson, S. E., & Meade, B. J. (2014). Potential Health Effects Associated with Dermal Exposure to Occupational Chemicals. *Environmental Health Insights*, *8s1*, EHI.S15258. https://doi.org/10.4137/EHI.S15258

Araújo, M. F., Castanheira, E. M. S., & Sousa, S. F. (2023). The Buzz on Insecticides: A Review of Uses, Molecular Structures, Targets, Adverse Effects, and Alternatives. *Molecules*, *28*(8), 3641. https://doi.org/10.3390/molecules28083641

Baker, B. P., Green, T. A., & Loker, A. J. (2020). Biological control and integrated pest management in organic and conventional systems. *Biological Control*, *140*, 104095.

https://doi.org/10.1016/j.biocontrol.2019.104095
Barrett, J. R. (2005). Chemical Exposures: The Ugly Side of Beauty Products. *Environmental Health Perspectives*, *113*(1). https://doi.org/10.1289/ehp.113-a24
Benbrook, C., Kegley, S., & Baker, B. (2021). Organic Farming Lessens Reliance on Pesticides and Promotes Public Health by Lowering Dietary Risks. *Agronomy*, *11*(7), 1266. https://doi.org/10.3390/agronomy11071266
Bilal, M., Mehmood, S., & Iqbal, H. M. N. (2020). The Beast of Beauty: Environmental and Health Concerns of Toxic Components in Cosmetics. *Cosmetics*, *7*(1), 13. https://doi.org/10.3390/cosmetics7010013
Bukke, V. N., Archana, M., Villani, R., Serviddio, G., & Cassano, T. (2021). Pharmacological and Toxicological Effects of Phytocannabinoids and Recreational Synthetic Cannabinoids: Increasing Risk of Public Health. *Pharmaceuticals*, *14*(10), 965. https://doi.org/10.3390/ph14100965
C, F. C., Kamalesh, T., Senthil Kumar, P., & Rangasamy, G. (2023). An insights of organochlorine pesticides categories, properties, eco-toxicity and new developments in bioremediation process. *Environmental Pollution*, *333*, 122114. https://doi.org/10.1016/j.envpol.2023.122114
Chang, S. H. (2020). Utilization of green organic solvents in solvent extraction and liquid membrane for sustainable wastewater treatment and resource recovery—a review. *Environmental Science and Pollution Research*, *27*(26), 32371–32388. https://doi.org/10.1007/s11356-020-09639-7
Ciucă Anghel, D.-M., Nițescu, G. V., Tiron, A.-T., Guțu, C. M., & Baconi, D. L. (2023). Understanding the Mechanisms of Action and Effects of Drugs of Abuse. *Molecules*, *28*(13), 4969. https://doi.org/10.3390/molecules28134969
Cohen, K., & Weinstein, A. M. (2018). Synthetic and Non-synthetic Cannabinoid Drugs and Their Adverse Effects-A Review From Public Health Prospective. *Frontiers in Public Health*, *6*. https://doi.org/10.3389/fpubh.2018.00162
Damalas, C. A., & Eleftherohorinos, I. G. (2011). Pesticide Exposure, Safety Issues, and Risk Assessment Indicators. *International Journal of Environmental Research and Public Health*, *8*(5), 1402–1419. https://doi.org/10.3390/ijerph8051402
Daraban, G. M., Hlihor, R.-M., & Suteu, D. (2023). Pesticides vs. Biopesticides: From Pest Management to Toxicity and Impacts on the Environment and Human Health. *Toxics*, *11*(12), 983. https://doi.org/10.3390/toxics11120983
David, E., & Niculescu, V.-C. (2021). Volatile Organic Compounds (VOCs) as Environmental Pollutants: Occurrence and Mitigation Using Nanomaterials. *International Journal of Environmental Research and Public Health*, *18*(24), 13147. https://doi.org/10.3390/ijerph182413147
Deguine, J.-P., Aubertot, J.-N., Flor, R. J., Lescourret, F., Wyckhuys, K. A. G., & Ratnadass, A. (2021). Integrated pest management: good intentions, hard realities. A review. *Agronomy for Sustainable Development*, *41*(3), 38. https://doi.org/10.1007/s13593-021-00689-w
Downing, P. (2009). Exposure to chemicals. In P. Downing (Ed.), *Emergencies in Adult Nursing*. Oxford University Press. https://doi.org/10.1093/med/9780199226573.003.0017
Duan, C., Liao, H., Wang, K., & Ren, Y. (2023). The research hotspots and trends of volatile organic compound emissions from anthropogenic and natural sources: A systematic quantitative review. *Environmental Research*, *216*, 114386. https://doi.org/10.1016/j.envres.2022.114386
Dwivedi, S., Fatima, U., Gupta, A., Khan, T., & Lawrence, A. (2021). Green Solvents for Sustainable Chemistry: A Futuristic Approach. *Indian Journal of Advances in Chemical Science*, *9*(4), 329–335. https://doi.org/10.22607/IJACS.2021.904014
Edinoff, A. N., Kaufman, S. E., Green, K. M., Provenzano, D. A., Lawson, J., Cornett, E. M., Murnane, K. S., Kaye, A. M., & Kaye, A. D. (2022). Methamphetamine Use: A Narrative Review of Adverse Effects and Related Toxicities. *Health Psychology Research*, *10*(3). https://doi.org/10.52965/001c.38161
El-Nahhal, I., & El-Nahhal, Y. (2021). Pesticide residues in drinking water, their potential risk to human health and removal options. *Journal of Environmental Management*, *299*, 113611. https://doi.org/10.1016/j.jenvman.2021.113611
Faber, S. (2020). *The Toxic Twelve Chemicals and Contaminants in Cosmetics*. https://www.ewg.org/the-toxic-twelve-chemicals-and-contaminants-in-cosmetics
FoodSafety4EU. (2022). *What are preservatives and what are common examples used in food?* https://www.eufic.org/en/whats-in-food/article/what-are-preservatives-and-what-are-common-examples-used-in-food
Frank, S., Bradley, L., & Moore, K. (2022). Integrated Pest Management (IPM). In K. A. Moore & L. K. Bradley (Eds.), *North Carolina Extension Gardener Handbook*. NC State University. https://content.ces.ncsu.edu/extension-gardener-handbook/8-integrated-pest-management-ipm
Fu, M. R., Kurnat-Thoma, E., Starkweather, A., Henderson, W. A., Cashion, A. K., Williams, J. K., Katapodi, M. C., Reuter-Rice, K., Hickey, K. T., Barcelona de Mendoza, V., Calzone, K., Conley, Y. P., Anderson, C. M., Lyon, D. E., Weaver, M. T., Shiao, P. K., Constantino, R. E., Wung, S.-F., Hammer, M. J., … Coleman, B. (2020). Precision health: A nursing perspective. *International*

Journal of Nursing Sciences, *7*(1), 5–12. https://doi.org/10.1016/j.ijnss.2019.12.008

Geyer, R. (2020). Production, use, and fate of synthetic polymers. In *Plastic Waste and Recycling* (pp. 13–32). Elsevier. https://doi.org/10.1016/B978-0-12-817880-5.00002-5

Halla, N., Fernandes, I. P., Heleno, S. A., Costa, P., Boucherit-Otmani, Z., Boucherit, K., Rodrigues, A. E., Ferreira, I. C. F. R., & Barreiro, M. F. (2018). Cosmetics Preservation: A Review on Present Strategies. *Molecules*, *23*(7), 1571. https://doi.org/10.3390/molecules23071571

Hannigan, J. H., & Bowen, S. E. (2010). Reproductive Toxicology and Teratology of Abused Toluene. *Systems Biology in Reproductive Medicine*, *56*(2), 184–200. https://doi.org/10.3109/19396360903377195

Hill, B. (2024). Improving infection control and combating antimicrobial resistance in nursing practice. *British Journal of Nursing*, *33*(2), 66–68. https://doi.org/10.12968/bjon.2024.33.2.66

ILO. (2021). *Exposure to hazardous chemicals at work and resulting health impacts: A global review*. https://www.ilo.org/publications/exposure-hazardous-chemicals-work-and-resulting-health-impacts-global

Izah, S. C., Sylva, L., & Hait, M. (2023). Cronbach's Alpha: A Cornerstone in Ensuring Reliability and Validity in Environmental Health Assessment. *ES Energy & Environment*, *23*, 1057. https://doi.org/10.30919/esee1057

Jangjou, A., Moqadas, M., Mohsenian, L., Kamyab, H., Chelliapan, S., Alshehery, S., Ali, M. A., Dehbozorgi, F., Yadav, K. K., Khorami, M., & Zarei Jelyani, N. (2023). Awareness raising and dealing with methanol poisoning based on effective strategies. *Environmental Research*, *228*, 115886. https://doi.org/10.1016/j.envres.2023.115886

Johnson, P. I., Favela, K., Jarin, J., Le, A. M., Clark, P. Y., Fu, L., Gillis, A. D., Morga, N., Nguyen, C., & Harley, K. G. (2022). Chemicals of concern in personal care products used by women of color in three communities of California. *Journal of Exposure Science & Environmental Epidemiology*, *32*(6), 864–876. https://doi.org/10.1038/s41370-022-00485-y

Kahru, A., & Mortimer, M. (2021). Advances in Nanotoxicology: Towards Enhanced Environmental and Physiological Relevance and Molecular Mechanisms. *Nanomaterials*, *11*(4), 919. https://doi.org/10.3390/nano11040919

Kaur, H., & Garg, H. (2014). Pesticides: Environmental Impacts and Management Strategies. In M. L. Larramendy & S. Soloneski (Eds.), *Pesticides - Toxic Aspects*. InTech. https://doi.org/10.5772/57399

Kaushik, M., Farooq, U., Ali, M. S., Ansari, M. J., Iqbal, Z., & Mirza, M. A. (2023). Safety Concern and Regulatory Status of Chemicals Used in Cosmetics and Personal Care Products. *Dermato*, *3*(2), 131–157. https://doi.org/10.3390/dermato3020011

Kesic, R., Elliott, J. E., Fremlin, K. M., Gauthier, L., Drouillard, K. G., & Bishop, C. A. (2021). Continuing Persistence and Biomagnification of DDT and Metabolites in Northern Temperate Fruit Orchard Avian Food Chains. *Environmental Toxicology and Chemistry*, *40*(12), 3379–3391. https://doi.org/10.1002/etc.5220

Keswani, C., Dilnashin, H., Birla, H., Roy, P., Tyagi, R. K., Singh, D., Rajput, V. D., Minkina, T., & Singh, S. P. (2022). Global footprints of organochlorine pesticides: a pan-global survey. *Environmental Geochemistry and Health*, *44*(1), 149–177. https://doi.org/10.1007/s10653-021-00946-7

Khan, S., Naushad, M., Govarthanan, M., Iqbal, J., & Alfadul, S. M. (2022). Emerging contaminants of high concern for the environment: Current trends and future research. *Environmental Research*, *207*, 112609. https://doi.org/10.1016/j.envres.2021.112609

Lushchak, V. I., Matviishyn, T. M., Husak, V. V, Storey, J. M., & Storey, K. B. (2018). Pesticide toxicity: a mechanistic approach. *EXCLI Journal*, *17*, 1101. https://pmc.ncbi.nlm.nih.gov/articles/PMC6295629/

Manful, M. E., Ahmed, L., & Barry-Ryan, C. (2024). Cosmetic Formulations from Natural Sources: Safety Considerations and Legislative Frameworks in the European Union. *Cosmetics*, *11*(3), 72. https://doi.org/10.3390/cosmetics11030072

Marx-Stoelting, P., Rivière, G., Luijten, M., Aiello-Holden, K., Bandow, N., Baken, K., Cañas, A., Castano, A., Denys, S., Fillol, C., Herzler, M., Iavicoli, I., Karakitsios, S., Klanova, J., Kolossa-Gehring, M., Koutsodimou, A., Vicente, J. L., Lynch, I., Namorado, S., … Sanders, P. (2023). A walk in the PARC: developing and implementing 21st century chemical risk assessment in Europe. *Archives of Toxicology*, *97*(3), 893–908. https://doi.org/10.1007/s00204-022-03435-7

Masood, M. A., Khaled, R., Bin-Ismail, A., Semerjian, L., & Abass, K. (2024). Occupational health in the Gulf Cooperation Council (GCC): A systematic review and call for comprehensive policy development. *PLOS ONE*, *19*(12), e0312251. https://doi.org/10.1371/journal.pone.0312251

McGraw-Hill Education. (2013). *Casarett and Doull's Toxicology: The Basic Science of Poisons* (C. D. Klaassen (ed.); 8th ed.). McGraw-Hill Education. http://accesspharmacy.mhmedical.com/content.aspx?aid=1100083589

McInnes, E. F., Papineni, S., Rinke, M., Schorsch, F., & Marxfeld, H. A. (2023). Agrochemicals. In W. M. Haschek, C. G. Rousseaux, M. A. Wallig, & B. Bolon (Eds.), *Haschek and Rousseaux's Handbook of Toxicologic Pathology, Volume 3* (4th ed., pp. 727–763). Elsevier. https://doi.org/10.1016/B978-0-443-16153-7.00011-3

Mitra, S., Chakraborty, A. J., Tareq, A. M., Emran, T. Bin, Nainu, F., Khusro, A., Idris, A. M., Khandaker, M. U., Osman, H., Alhumaydhi, F. A., & Simal-Gandara, J. (2022). Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity. *Journal of King Saud University - Science*, *34*(3), 101865. https://doi.org/10.1016/j.jksus.2022.101865

Moghbeli, G., Soheili, A., Ghafourifard, M., Shahbazi, S., & Karkan, H. A. (2024). Ecological care in nursing practice: a Walker and Avant concept analysis. *BMC Nursing*, *23*(1), 614. https://doi.org/10.1186/s12912-024-02279-z

Mota, I. G. C., Neves, R. A. M. Das, Nascimento, S. S. D. C., Maciel, B. L. L., Morais, A. H. D. A., & Passos, T. S. (2023). Artificial Dyes: Health Risks and the Need for Revision of International Regulations. *Food Reviews International*, *39*(3), 1578–1593. https://doi.org/10.1080/87559129.2021.1934694

Naghibzadeh-Tahami, A., Khosravi, Y., Es'haghi, M., & Haghdoost, A.-A. (2022). Scoping Review of 5 Common Occupational Cancers and Their Related Exposures. *Medical Journal of the Islamic Republic of Iran*. https://doi.org/10.47176/mjiri.36.84

Nawi, A. M., Ismail, R., Ibrahim, F., Hassan, M. R., Manaf, M. R. A., Amit, N., Ibrahim, N., & Shafurdin, N. S. (2021). Risk and protective factors of drug abuse among adolescents: a systematic review. *BMC Public Health*, *21*(1), 2088. https://doi.org/10.1186/s12889-021-11906-2

Panico, A., Serio, F., Bagordo, F., Grassi, T., Idolo, A., De Giorgi, M., Guido, M., Congedo, M., & De Donno, A. (2019). Skin safety and health prevention: an overview of chemicals in cosmetic products. *Journal of Preventive Medicine and Hygiene*, *60*(1), E50. https://pmc.ncbi.nlm.nih.gov/articles/PMC6477564/

Pathak, V. M., Verma, V. K., Rawat, B. S., Kaur, B., Babu, N., Sharma, A., Dewali, S., Yadav, M., Kumari, R., Singh, S., Mohapatra, A., Pandey, V., Rana, N., & Cunill, J. M. (2022). Current status of pesticide effects on environment, human health and it's eco-friendly management as bioremediation: A comprehensive review. *Frontiers in Microbiology*, *13*, 962619. https://doi.org/10.3389/fmicb.2022.962619

Patocka, J., Wu, W., Oleksak, P., Jelinkova, R., Nepovimova, E., Spicanova, L., Springerova, P., Alomar, S., Long, M., & Kuca, K. (2024). Fentanyl and its derivatives: Pain-killers or man-killers? *Heliyon*, *10*(8), e28795. https://doi.org/10.1016/j.heliyon.2024.e28795

Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Grewal, A. S., Srivastav, A. L., & Kaushal, J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. *Journal of Cleaner Production*, *283*, 124657. https://doi.org/10.1016/j.jclepro.2020.124657

Rathee, P., Sehrawat, R., Rathee, P., Khatkar, A., Akkol, E. K., Khatkar, S., Redhu, N., Türkcanoğlu, G., & Sobarzo-Sánchez, E. (2023). Polyphenols: Natural Preservatives with Promising Applications in Food, Cosmetics and Pharma Industries; Problems and Toxicity Associated with Synthetic Preservatives; Impact of Misleading Advertisements; Recent Trends in Preservation and Legislation. *Materials*, *16*(13), 4793. https://doi.org/10.3390/ma16134793

Riley, A. L., Nelson, K. H., To, P., López-Arnau, R., Xu, P., Wang, D., Wang, Y., Shen, H., Kuhn, D. M., Angoa-Perez, M., Anneken, J. H., Muskiewicz, D., & Hall, F. S. (2020). Abuse potential and toxicity of the synthetic cathinones (i.e., "Bath salts"). *Neuroscience & Biobehavioral Reviews*, *110*, 150–173. https://doi.org/10.1016/j.neubiorev.2018.07.015

Robertson, G. L., Lebowitz, M. D., O'rourke, M. K., Gordon, S., & Moschandreas, D. (1999). The National Human Exposure Assessment Survey (NHEXAS) study in Arizona—introduction and preliminary results. *Journal of Exposure Science & Environmental Epidemiology*, *9*(5), 427–434. https://doi.org/10.1038/sj.jea.7500053

Rousseau, M., Rouzeau, C., Bainvel, J., & Pelé, F. (2022). Domestic Exposure to Chemicals in Household Products, Building Materials, Decoration, and Pesticides: Guidelines for Interventions During the Perinatal Period from the French National College of Midwives. *Journal of Midwifery & Women's Health*, *67*(S1). https://doi.org/10.1111/jmwh.13426

Sambu, S., Hemaram, U., Murugan, R., & Alsofi, A. A. (2022). Toxicological and Teratogenic Effect of Various Food Additives: An Updated Review. *BioMed Research International*, *2022*, 1–11. https://doi.org/10.1155/2022/6829409

Santos, I. C., Maia, D., Dinis-Oliveira, R. J., & Barbosa, D. J. (2024). New Psychoactive Substances: Health and Legal Challenges. *Psychoactives*, *3*(2), 285–302. https://doi.org/10.3390/psychoactives3020018

Schifano, F., Vento, A., Scherbaum, N., & Guirguis, A. (2023). Stimulant and hallucinogenic novel psychoactive substances; an update. *Expert Review of Clinical Pharmacology*, *16*(11), 1109–1123.

https://doi.org/10.1080/17512433.2023.2279192

Shaban, M. M., Alanazi, M. A., Mohammed, H. H., Mohamed Amer, F. G., Elsayed, H. H., Zaky, M. E., Ramadan, O. M. E., Abdelgawad, M. E., & Shaban, M. (2024). Advancing sustainable healthcare: a concept analysis of eco-conscious nursing practices. *BMC Nursing*, *23*(1), 660. https://doi.org/10.1186/s12912-024-02197-0

Singh, A. V., Chandrasekar, V., Paudel, N., Laux, P., Luch, A., Gemmati, D., Tisato, V., Prabhu, K. S., Uddin, S., & Dakua, S. P. (2023). Integrative toxicogenomics: Advancing precision medicine and toxicology through artificial intelligence and OMICs technology. *Biomedicine & Pharmacotherapy*, *163*, 114784. https://doi.org/10.1016/j.biopha.2023.114784

Soleimani, E. (2020). Benzene, toluene, ethylbenzene, and xylene: Current analytical techniques and approaches for biological monitoring. *Reviews in Analytical Chemistry*, *39*(1), 168–187. https://doi.org/10.1515/revac-2020-0116

Sparks, T. C., Crouse, G. D., Benko, Z., Demeter, D., Giampietro, N. C., Lambert, W., & Brown, A. V. (2021). The spinosyns, spinosad, spinetoram, and synthetic spinosyn mimics - discovery, exploration, and evolution of a natural product chemistry and the impact of computational tools. *Pest Management Science*, *77*(8), 3637–3649. https://doi.org/10.1002/ps.6073

Thorne, P. S. (2019). Occupational Toxicology. In C. D. Klaassen (Ed.), *Casarett & Doull's Toxicology: The Basic Science of Poisons* (9th ed.). McGraw-Hill Education. https://accesspharmacy.mhmedical.com/content.aspx?bookid=2462&sectionid=202679247

Tickner, J. A., Simon, R. V., Jacobs, M., Pollard, L. D., & van Bergen, S. K. (2021). The nexus between alternatives assessment and green chemistry: supporting the development and adoption of safer chemicals. *Green Chemistry Letters and Reviews*, *14*(1), 23–44. https://doi.org/10.1080/17518253.2020.1856427

Ullah, N., Haseeb, A., & Tuzen, M. (2024). Application of Recently used Green Solvents in Sample Preparation Techniques: A Comprehensive Review of Existing Trends, Challenges, and Future Opportunities. *Critical Reviews in Analytical Chemistry*, *54*(8), 2714–2733. https://doi.org/10.1080/10408347.2023.2197495

WHO. (2023). *Food additives*. https://www.who.int/news-room/fact-sheets/detail/food-additives

Yang, T. C., Jovanovic, N., Chong, F., Worcester, M., Sakhi, A. K., Thomsen, C., Garlantézec, R., Chevrier, C., Jensen, G., Cingotti, N., Casas, M., McEachan, R. R., Vrijheid, M., & Philippat, C. (2023). Interventions to Reduce Exposure to Synthetic Phenols and Phthalates from Dietary Intake and Personal Care Products: a Scoping Review. *Current Environmental Health Reports*, *10*(2), 184–214. https://doi.org/10.1007/s40572-023-00394-8

Zhang, A., Meng, K., Liu, Y., Pan, Y., Qu, W., Chen, D., & Xie, S. (2020). Absorption, distribution, metabolism, and excretion of nanocarriers in vivo and their influences. *Advances in Colloid and Interface Science*, *284*, 102261. https://doi.org/10.1016/j.cis.2020.102261

Zhang, S., Liu, Y., Javeed, A., Jian, C., Sun, J., Wu, S., & Han, B. (2023). Treatment of allergy: Overview of synthetic anti-allergy small molecules in medicinal chemistry. *European Journal of Medicinal Chemistry*, *249*, 115151. https://doi.org/10.1016/j.ejmech.2023.115151