G-BOOK$_2$

Engaging insights into cosmetic abrasives and micropollutants

GreenGATE$_2$

FACULTY OF ENVIRONMENTAL PROTECTION

Co-funded by the European Union

Colophon

G-BOOK$_2$

Engaging insights into cosmetic abrasives and micropollutants.
Created in the project GreenGate$_2$.

Authors: Anja Bubik & Katrin Školnik Škrabe
Editor: Anja Bubik
Issued by: Faculty of Environmental Protection
Responsible person: Gašper Gantar
E-book
URL: https://green-gate.eu/downloads/GreenGate2-G-Book2-en.pdf
Typesetting and Design: Petr Miloš/GreenScan
Velenje, 2025

The GreenGate$_2$ project (reg. n. 2023-2-CZ01-KA220-YOU-000174554) was implemented in the period 2024–2026 as part of the Erasmus+ programme with financial support from the European Union.

Content

Chapter 1

ABOUT ABRASIVES

WHAT ARE ABRASIVES?

Abrasives are hard, rough materials used to remove or process softer substances through friction. By grinding, rubbing, or polishing, they smooth surfaces, level uneven textures, or clean unwanted layers. While commonly associated with industrial applications, abrasives also play a vital role in everyday products, particularly in skincare. From coarse materials like pumice stones—used to slough off calloused skin—to finer variants such as pumice powder, which gently exfoliate in facial scrubs, abrasives come in a range of textures suited to different needs. Even harsher abrasives like ground walnut shells or silica can be found in body scrubs designed for more intense exfoliation. Whether found in body scrubs, facial cleansers, or toothpaste, abrasives are a hidden and often unrecognized ingredient in many of the products that help us look and feel fresh [1].

ABRASIVES IN COSMETICS

The use of abrasives dates back to ancient civilizations. In Ancient Egypt, pumice stones were widely used for exfoliation, while during the Middle Ages, wine containing tartaric acid served as a chemical exfoliant. These early methods laid the groundwork for modern exfoliation, evolving from natural materials to more advanced formulations tailored to various skincare needs [1].

Today, abrasives are a key component of many cosmetic products, including facial scrubs, body scrubs, and exfoliating soaps. They facilitate the **exfoliation** process by removing dead skin cells, unclogging pores, and refining rough patches. This not only improves skin texture but also enhances the absorption of moisturizers and other skincare products.

Abrasives are materials with a rough texture used for physical scrubbing of the skin. **Exfoliants** are a broader category that includes both mechanical and chemical methods of removing dead skin cells.

G–FUN FACT: All abrasives used in cosmetics are physical exfoliants, but not all exfoliants are abrasives—chemical exfoliants work without friction.

FIGURE 1: Abrasives in Cosmetics

There are different types of exfoliants:

Physical exfoliants contain fine particles that mechanically remove dead skin cells from the skin's surface through friction. These particles are often abrasives, such as sugar, salt, ground seeds, or plastic microbeads, which were commonly used in the past.

Chemical exfoliants work at a cellular level. They contain active ingredients like AHA (Alpha Hydroxy Acids) and BHA (Beta Hydroxy Acids), which dissolve the bonds between dead skin cells, allowing for their gentle removal without any scrubbing.

Enzymatic exfoliants are often considered a gentler form of exfoliation and may be suitable for people with sensitive or dry skin, although they can be used on a variety of skin types. They may also be beneficial in addressing concerns such as redness, broken capillaries, blackheads, and hardened skin.

FIGURE 2: Skin Exfoliation

Facial scrubs, for example, contain fine abrasive particles that gently rub against the skin, lifting away dirt, impurities, and dead skin cells. Regular exfoliation helps remove dead skin cells from the skin's surface, which may contribute to a smoother skin texture and a more even appearance. When incorporated into a weekly skincare routine, it can contribute to a healthier, more radiant complexion. However, balance is key—over excessive exfoliation may damage the skin's natural barrier, leading to irritation and sensitivity [1, 2].

G–NOTE: Exfoliation can be mechanical, chemical, or enzymatic. Mechanical exfoliants typically contain fine abrasive particles, chemical exfoliants dissolve dead skin cells at a cellular level, while enzymatic exfoliants gently break down dead cells using natural enzymes.

EXFOLIANTS AND SENSITIVE SKIN

Sensitive skin is highly reactive and has a low tolerance for external and internal factors, making it prone to irritation. Environmental triggers, skincare products, and individual predisposition can all affect its balance. Symptoms such as dryness, redness, and discomfort—often accompanied by stinging, burning, or itching—are common indicators of sensitivity [3, 4].

FIGURE 3: Sensitive skin.

For individuals with problematic skin, such as acne-prone skin, abrasives can provide effective treatment by removing excess oil and impurities from the surface. However, it is important to use abrasives that are gentle on the skin to avoid irritation, especially for those with sensitive or inflamed skin. But over-exfoliation can compromise the skin barrier by accelerating cell turnover too quickly, leaving new skin cells without enough time to develop essential protective lipids.

While exfoliation is key to maintaining a smooth and radiant complexion, excessive use—whether too frequent or too strong—can lead to irritation, dryness, and increased sensitivity. Without adequate recovery time, the skin becomes more vulnerable to environmental stressors and inflammation. To prevent this, it's important to use exfoliants in moderation, allowing the skin time to heal and gradually build tolerance for optimal results [4].

G–ADVICE: Exfoliation is beneficial, but more isn't always better. Give your skin time to recover between treatments to maintain a healthy balance and avoid irritation. Moderation is key to achieving smooth, resilient skin!

SYNTHETIC VS. NATURAL ABRASIVES

Abrasives used in personal care and cosmetic products (PCCPs) can come from natural sources or be produced synthetically. **Natural abrasives** include materials such as crushed walnut shells, bamboo powder, sugar, and pumice, which have traditionally been used for exfoliation.

Synthetic abrasives cover a wide range of materials and are generally divided into polymer-based and mineral-based abrasives. **Polymer-based abrasives** include small plastic particles commonly referred to as microbeads. These intentionally added solid particles enhance the abrasive properties of personal care and cosmetic products such as facial scrubs, soaps, lotions, toothpastes, and shampoos. They are engineered to be smooth, uniformly sized, and effective in delivering consistent mechanical action during use. However, because they do not break down in the environment, plastic microbeads have become a major ecological concern, leading many countries to restrict or ban their use [5, 6, 7, 8].

Mineral-based synthetic abrasives are inorganic particles designed to deliver steady and controlled exfoliation. Their performance depends on characteristics such as particle size, shape, and surface properties, which influence how they act on the skin. Because of their predictable behavior and alignment with current sustainability trends, mineral-based synthetic abrasives are an important component in many contemporary exfoliating products [8].

In addition to their abrasive function, particulate ingredients in cosmetic formulations may also serve other technical purposes, such as viscosity regulation, stabilization of emulsions, emulsification, or optical blurring effects. These functions are not necessarily directly related to abrasion [5, 6, 7].

Synthetic materials gained popularity in cosmetic formulations during the 1990s due to their consistent quality, ease of production, and relatively low manufacturing costs [9]. However, natural abrasives continue to be widely used in many cosmetic products, and increasing environmental awareness—together with stricter regulations on intentionally added microplastics—has renewed interest in biodegradable, naturally derived exfoliating materials.

ENVIRONMENTAL CONCERNS

One of the biggest concerns surrounding synthetic abrasives, particularly microbeads, is their environmental impact. These tiny plastic particles do not biodegrade and easily pass through water filtration systems, leading to pollution in oceans, rivers, and lakes. They accumulate in marine ecosystems, where they can be ingested by fish and other wildlife, potentially entering the food chain and posing risks to both animals and humans [e.g. 10].

FIGURE 4: Environmental Concerns of Nondegradable Exfoliant Materials are big.

G-ADVICE: Choosing skincare products with natural, biodegradable exfoliants not only benefits your skin but also helps protect the environment. Look for ingredients like crushed nutshells, fruit seeds, or bamboo powder as sustainable alternatives to microplastics.

REFERENCES:

1. Behalpade S., Gajbhiye S. (2022). Review article: skin care with exfoliation process. International Journal of Current Science 12(2).
2. Raut M. R., Misar K. S., Bokde M. P., Gajbhiye E. S. (2023). Formulation and development of facial scrub with natural exfoliants. International Journal of Researches in Biosciences and Agriculture Technology. https://doi.org/10.29369/ijrbat.2023.02.1.0021
3. Fan L., He C., Jiang L., Bi Y., Dong Y., Jia Y. (2016). Brief analysis of causes of sensitive skin and advances in evaluation of anti-allergic activity of cosmetic products. International Journal of Cosmetic Science, 38(2), 120–127. https://doi.org/10.1111/ics.12283
4. Vasilescu, A. (2022). Why Is Your Skin So Sensitive All Of A Sudden And How To Manage It. https://womensconcepts.com/skincare/skin-is-suddenly-sensitive (accessed in February 2025).
5. Eixarch H., Andrew D., (2017). Microbeads and the industry's environmental responsibility. Personal care Europe.
6. Hirst, D., Bennett, O. (2017). Microbeads and microplastics in cosmetic and personal care products. Briefing paper. House of commons library, 2017, 7510.
7. Leslie H. A. (2014). Review of Microplastics in Cosmetic. Scientific background on a potential source of plastic particulate marine litter to support decision-making. IVM Institute for Environmental Studies.
8. Singh S., Rai D. (2026). Advanced formulation strategies for face scrubs: Role of abrasives, excipients, and skin compatibility. International Journal of Pharmaceutical Sciences (IJPS), 4(5). https://doi.org/10.5281/zenodo.20001899
9. Bushwick S. (2015). What Are Microbeads And Why Are They Illegal?. Popular Science investigates. https://www.popsci.com/what-are-microbeads-and-why-are-they-illegal/ (accessed in February 2025).
10. Ghosh, S. (2021). Tiny Microbeads – Threat to Human Life, Threat to Environment. International Journal of Engineering Research & Technology (IJERT), 10(1).

IMAGE SOURCES:

11. FIGURE 1: ChatGPT (September 2025)
12. FIGURE 2: Pexels (September 2025)
13. FIGURE 3: Pexels (August 2025)
14. FIGURE 4: ChatGPT (August 2025)

Chapter 2

RESTRICTIONS ON MICROPLASTIC ABRASIVES

MICROPLASTICS - FROM THE EVERYDAY PRODUCT TO THE ENVIRONMENT

Microplastics, tiny plastic particles measuring less than 5 mm in size, have become a global environmental concern due to their ubiquity in and impact on various ecosystems. They do not degrade easily and can accumulate in water, soil, air, and living organisms.

Microplastics originate in two main ways:

1. **Primary microplastics** are intentionally manufactured in small sizes for use in consumer products such as cosmetics, cleaning agents, textiles, and rubber products like tires. These particles are often released into the environment through wastewater or wear and tear.
2. **Secondary microplastics** are formed by the breakdown of larger plastic items due to environmental factors like UV radiation, mechanical abrasion, and biological activity. The majority of secondary microplastics originate from plastic products that are discarded, mismanaged or inadequately removed from the environment [1-3].

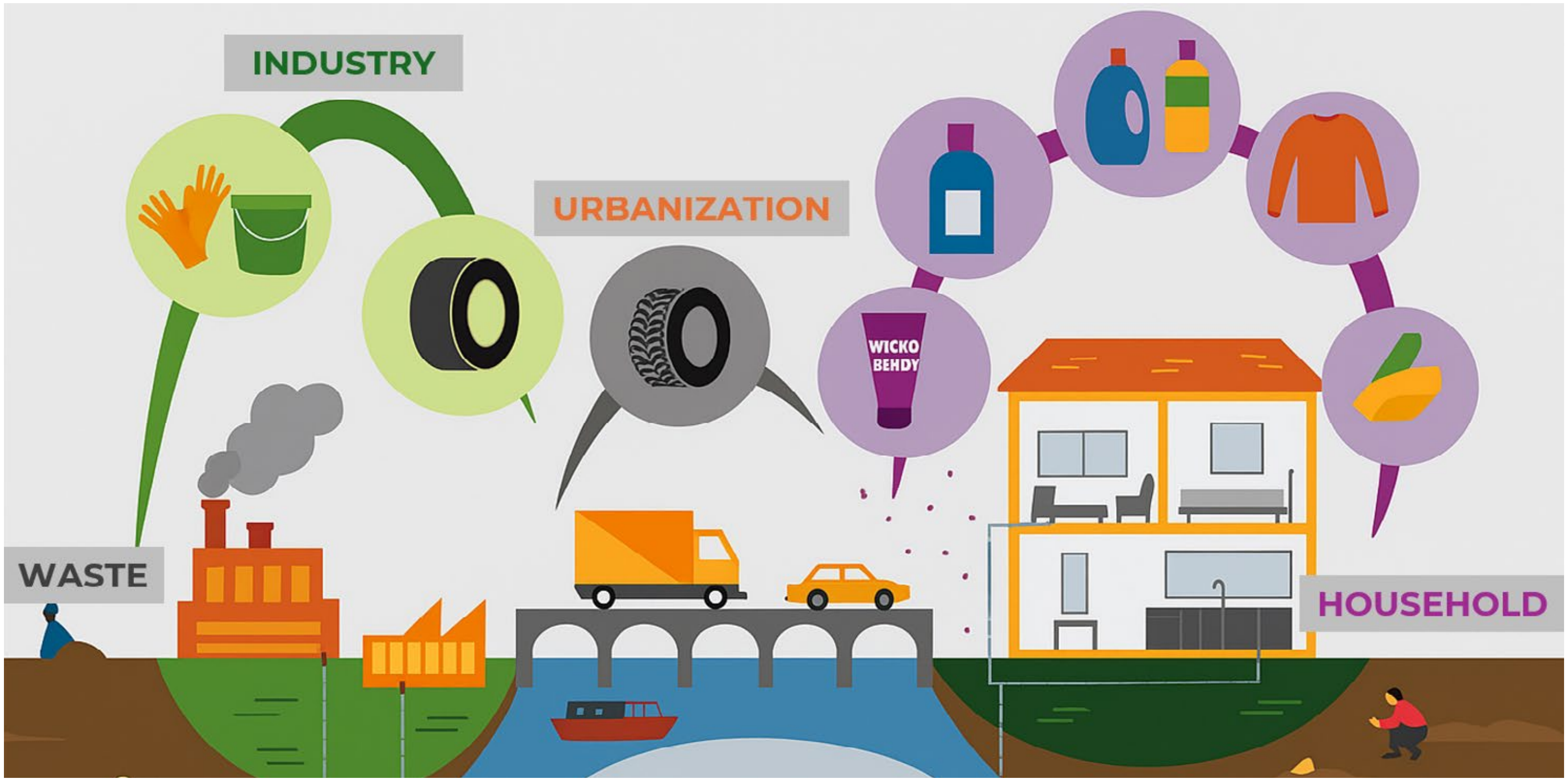


FIGURE 1: Sources of Microplastics

In cosmetics, **microbeads**—a type of primary microplastic— were widely used in exfoliating products such as facial scrubs, body scrubs, and even toothpaste [1-4]. Their small size and smooth texture made them ideal abrasive agents for physically removing dead skin cells, contributing to the effectiveness of mechanical exfoliants. However, their tiny size also made them extremely difficult to filter out during wastewater treatment, allowing them to enter rivers, lakes, and oceans, where they pose a threat to aquatic life and food chains. Yet, unlike natural exfoliating particles (e.g., sugar, salt, or ground seeds), microbeads are non-biodegradable and persist in the environment for decades. This has led to increasing regulation and bans in many countries, encouraging the shift toward eco-friendly alternatives in cosmetic formulations.

FIGURE 2: Microbeads in cosmetics.

Today, microplastic pollution is a widespread issue across all regions of the European Union, as the presence of microplastics has been documented in various ecosystems, including oceans, rivers, lakes, soils, and even the air. While the extent of microplastic pollution may vary in different regions based on population density, industrial activities, and waste management practices, it is considered as a pervasive and cross-cutting environmental challenge.

G-FUN FACT: It is estimated that 42,000 tons of microplastics intentionally added to products are released in the EU every year [5].

These particles persist for decades, entering the food chain and harming both ecosystems and human health. Recent studies have confirmed the widespread presence of microplastics in personal-care and cosmetic products, with microbeads being a notable contributor. These particles not only pose a risk of water contamination but have also prompted a growing shift toward sustainable alternatives made from biodegradable polymers. Their detection in urban water systems further highlights the global scale of the issue and the need for stronger regulation and wastewater treatment solutions [6, 7].

EU'S FIRST DIRECT BAN ON MICROPLASTICS IN EVERYDAY PRODUCTS

Efforts to address microplastic pollution often involve coordinated actions at the national and EU levels to implement regulations, promote research, and encourage sustainable practices. Such collaborative actions may reduce the environmental impact of microplastics and work towards a cleaner and more sustainable future for all EU regions. The EC is committed to fighting microplastics pollution, as stated in the European Green Deal and the new Circular Economy Action Plan. In the Zero Pollution Action Plan, the EC set the target to reduce microplastics released into the environment by 30% by 2030 [8-10].

On September 25th, 2023, the EU adopted the restriction on microplastics intentionally added to products under the EU chemical legislation REACH – Registration, Evaluation, Authorization and Restriction of Chemicals [11] – a regulatory framework ensuring the responsible use of chemicals for human health and environmental protection. The definition of microplastics used is broad in scope, covering **all synthetic polymer particles measuring less than 5 millimeters (mm) that are organic, insoluble and resist (bio)degradation.** The restriction is based on evidence and recommendations from the European Chemicals Agency (ECHA) and its scientific committees, which carefully assessed the risk posed by microplastics intentionally added to products. In their estimation, the new rules will prevent the release to the environment of about half a million tons of microplastics in the next few years [12].

G-NOTE: This marks the first direct ban on microplastics within the EU, a pivotal move in addressing the pervasive issue of microplastic pollution.

The proposed regulation under REACH covers products intentionally containing microplastics, such as cosmetics and rubber particles used in sports fields and playgrounds. The first measures applied already on October 17th, 2023, when the restriction entered into force. In other cases, the sales ban will apply after a longer period to give affected stakeholders the time to develop and switch to alternatives. In cosmetics, **an immediate ban is enforced for those containing microbeads used for exfoliation**, while a 4–12-year phase-in applies to other cosmetics based on complexity, reformulation needs, and alternative availability [12]. This means that microbeads intended for exfoliating, polishing or cleaning purposes are prohibited without transition periods, whereas other intentionally added microplastics remain allowed only temporarily, under extended deadlines that differ for rinse-off products, leave-on formulations, and make-up, lip or nail products. These staggered timelines are designed to give manufacturers sufficient time to adapt formulations and secure safe, sustainable alternatives.

G-FUN FACT: Did you know that glitter in cosmetics can be classified as microplastic? Under EU Regulation 2023/2055, synthetic glitter that is small, insoluble, and non-biodegradable is being phased out to protect the environment. The ban starts with rinse-off cosmetics in 2027, followed by leave-on products in 2029, and makeup, lip, and nail products in 2035. Until then, products must be labeled if they contain microplastics. Eco-friendly glitter made from cellulose, mica, or other biodegradable materials remains allowed.

FIGURE 3: Glitters in cosmetics.

THE ROAD AHEAD...

This milestone marks a significant advancement in reducing plastic pollution and promoting sustainable alternatives, particularly in the cosmetics industry, where biodegradable exfoliants are increasingly replacing microplastics. However, while the ban on microplastics is a crucial step toward a cleaner future, it also reveals the complexity of fully eliminating these pollutants from our daily lives and the environment. The transition demands innovation, regulation, and consumer awareness to ensure long-term impact and meaningful change.

G-ADVICE: Microbeads used as abrasive materials, or even glitter, may seem fun, but they don't break down and can harm the environment. To make better choices, look for products labeled "microplastic-free," choose natural exfoliants, check ingredient lists carefully, and support eco-friendly options.

REFERENCES:

1. Li, W., Zu, B., Yang, Q., Guo, J., & Li, J. (2023). Sources, distribution, and environmental effects of microplastics: A systematic review. RSC Advances, 13(23), 15566. https://doi.org/10.1039/D3RA02169F
2. Kochanek, A., Grąz, K., Potok, H., Gronba-Chyła, A., Kwaśny, J., Wiewiórska, I., Ciuła, J., Basta, E., & Łapiński, J. (2025). Micro- and nanoplastics in the environment: Current state of research, sources of origin, health risks, and regulations—A comprehensive review. Toxics, 13(7), 564. https://doi.org/10.3390/toxics13070564
3. Toussaint B., Raffael B., Angers-Loustau A., Gilliland D., Kestens V., Petrillo M., Rio-Echevarria I. M., Van den Eede G. (2019). Review of micro- and nanoplastic contamination in the food chain. Food Additives & Contaminants: Part A, 36(5), 639–673. https://doi.org/10.1080/19440049.2019.1583381
4. Bubik, A., Hvastja, Š., Krajnc, A., & Špeh, N. (2023). G-BOOK: Educational support for safe and responsible cosmetic product use (A. Bubik, Ed.). GreenGate project. Faculty of Environmental Protection. https://green-gate.eu/downloads/G-book-en.pdf
5. European Chemicals Agency. (2023). Microplastics. Retrieved from https://echa.europa.eu/hot-topics/microplastics
6. Bikiaris, N., Nikolaidis, N. F., & Barmpalexis, P. (2024). Microplastics (MPs) in cosmetics: A review on their presence in personal-care, cosmetic, and cleaning products (PCCPs) and sustainable alternatives from biobased and biodegradable polymers. Cosmetics, 11(5), 145. https://doi.org/10.3390/cosmetics11050145
7. Dung, T. T. T., Ngoc, H. N., & Trinh, N. N. (2024). Microbeads in exfoliating products: Occurrence, abundance, and potential for water contamination in Ho Chi Minh City, Vietnam. Discover Environment, 2, Article 92. https://doi.org/10.1007/s44274-024-00120-7
8. European Commission. (n.d.). The European Green Deal. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
9. European Commission. (2020). A new Circular Economy Action Plan: For a cleaner and more competitive Europe (COM(2020) 98 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098
10. European Commission. (2021). Zero pollution action plan – 2050: A healthy planet for all. https://environment.ec.europa.eu/publications/zero-pollution-action-plan-2050-healthy-planet-all_en
11. European Parliament & Council of the European Union. (2006). Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Official Journal of the European Union, L 396, 1–849. https://eur-lex.europa.eu/eli/reg/2006/1907/oj/eng
12. Commission Regulation (EU) 2023/2055: https://eur-lex.europa.eu/eli/reg/2023/2055/oj/eng

IMAGE SOURCES:

13. FIGURE 1: Faculty of Environmental Protection (adapted from [3])
14. FIGURE 2: Faculty of Environmental Protection
15. FIGURE 3: Faculty of Environmental Protection

Chapter 3

ALTERNATIVES TO PLASTIC ABRASIVES

Unlike synthetic abrasives such as microplastic particles, natural alternatives are derived from plant, mineral, or other natural sources and are often considered to have lower environmental persistence compared to synthetic polymers. However, it is important to note that not all of them are biodegradable. Many plant-based materials are biodegradable, whereas mineral-based ingredients such as pumice, clay, silica, and calcium carbonate do not biodegrade in the same way. Nevertheless, they do not behave like microplastic particles and do not contribute to microplastic pollution. But the overall environmental impact of natural abrasives is not negligible and depends on factors such as sourcing, extraction, processing, transport, and land use.

The use of natural abrasives offers numerous benefits—they are gentler on the skin, provide effective yet mild cleansing, and often contain additional beneficial substances such as minerals, vitamins, or antioxidants. Due to their wide range of options, they can be tailored to different skin types and needs, from coarse body scrubs to gentle facial exfoliators or even dental hygiene products.

Content

There are many alternatives of natural plant or mineral origin, which seem to be technically and economically feasible for our personal use and the industry:

Mechanical abrasives	
Sugar (cyclodextrins)	dissolves easily and gently exfoliates while moisturizing
Sea salt	helps remove dead skin and improve texture/ naturally rich in minerals, supports skin renewal
Coffee grounds	coarse exfoliation and stimulates circulation
Bamboo powder	exfoliates and is rich in silica
Almond or walnut or pecan ground shells	strong exfoliation and are biodegradable
Apricot kernels	moderate exfoliation and skin smoothing
Argan pit shells	exfoliate and are rich in antioxidants.
Olive stone powder	medium exfoliation and Mediterranean skincare
Poppy seeds	gentle scrubbing action
Cocoa beans	mild exfoliation and antioxidant benefits
Loofah powder	biodegradable, antimicrobial and provides effective exfoliation
Mineral abrasives	
Silica	gently exfoliate without damaging the skin
Charcoal powder	mild exfoliation and helps draw out impurities from the skin
Clay	cleansing & soothing exfoliation
Calcium carbonate	gentle abrasive
Pumice Powder	volcanic mineral, mild exfoliation
Wax based and plant based alternatives	
Jojoba beads or waxes	gently exfoliate
Hydrogenated castor oil	exfoliate and moisturize
Hydrogenated vegetable oil	skin-friendly
Cellulose	mild exfoliation, biodegradable

Chemical and enzymatic exfoliants	
Citric acid	chemical exfoliation by dissolving dead skin cells
Fruit enzyme granules (papain, bromelain)	enzymatic exfoliation by breaking down dead skin cells

SUGAR, SALT OR COFFEE

Natural abrasives like sugar, salt, and coffee have become popular in cosmetic products thanks to their exfoliating power and eco-friendly origins. And the best part? You probably already have these at home! They're affordable, safe (as long as they're food-grade), and hard to mess up. Just be mindful of allergies and avoid overly coarse grains. Plus, if you're a coffee lover, the aroma during your skincare routine might be a bonus treat!

These ingredients help remove dead skin cells, boost circulation, and improve skin texture—without relying on synthetic microbeads that harm the environment. Sugar, with its small, rounded crystals, is gentle on the skin and acts as a natural humectant, drawing moisture in. Salt, especially sea salt, provides a more intense scrub and contains minerals like magnesium and potassium that nourish the skin. Coffee grounds are packed with antioxidants like caffeic acid, which not only exfoliate but also stimulate collagen production and reduce inflammation [1].

FIGURE 1: Salt, Coffee and Sugar

PUMICE POWDER

Pumice is a natural volcanic abrasive that is valued as a mild and effective exfoliant in cosmetics. Its porous structure and natural exfoliating properties make it a common ingredient in skincare products designed to remove dead skin cells and smooth the skin. When finely ground, pumice provides gentle yet effective exfoliation, helping to remove calluses and dry patches on areas such as the hands, feet, and elbows. Its neutral pH ensures it can be used without irritation, making it particularly suitable for sensitive skin [2-4].

FIGURE 2: Pumice Powder

G-FUN FACT: Pumice forms when silica-rich lava cools very quickly and gases escape, creating a highly porous volcanic rock. Its unique structure is so light that pumice can even float on water, and floating pumice rafts have been observed at sea following explosive volcanic eruptions [2].

In cosmetic formulations, pumice is commonly found in scrubs, foot files, and facial masks. Its natural abrasiveness helps smooth and soften the skin by eliminating impurities, unclogging pores, and reducing the appearance of acne, blackheads, and whiteheads. Additionally, pumice powder is rich in minerals such as silica, potassium, and magnesium, which aid in preventing signs of aging, boosting collagen production, and enhancing skin hydration. It also contributes to regulating oil levels and enhancing the absorption of skincare products, making it a useful ingredient in various cosmetic formulations [3, 4].

BAMBOO POWDER

Bamboo, often associated with Asian gardens and pandas, hides a surprising property: its stems can be processed into a fine powder that works as a natural exfoliant for the skin. Bamboo powder is a natural abrasive obtained from the stems of Bambusa arundinacea (INCI: Bambusa Arundinacea Stem Powder). Due to its fine granulation, it acts as a gentle mechanical exfoliant, suitable for sensitive skin, while effectively removing dead skin cells. In addition to exfoliation, bamboo powder also functions as a natural absorbent, absorbing excess sebum and moisture, giving the skin a matte appearance [5-7].

FIGURE 3: Bamboo Powder

Its natural composition and environmentally friendly production make it a popular ingredient in natural cosmetics. Compared to other natural abrasives, such as walnut shells or volcanic ash, bamboo powder is softer, reducing the risk of skin irritation while maintaining effective exfoliating performance. It is commonly used in facial, body, and foot scrubs, as well as masks and other cosmetic products, where gentle yet effective exfoliation is desired [6, 7].

CLAY

Clay is a natural abrasive that has been used in cosmetics for centuries because of its unique ability to both cleanse and care for the skin. It gently polishes away dead skin cells and impurities without scratching or irritating, which makes it safer than many rough scrubs. At the same time, clay is rich in minerals like silica, magnesium, and calcium that support healthy skin.

Because of these properties, it has become a versatile ingredient in skincare, with different types of clay offering unique benefits. Some absorb excess oil, others calm sensitive skin, and some help tighten pores or restore balance to combination skin [8, 9].

Let's take a look at a few of them:

FIGURE 4: Grey Clay

- *Kaolin (white clay)* is the gentlest and works well for dry or sensitive skin, providing mild cleansing and soft exfoliation without irritation.
- *Bentonite clay*, formed from volcanic ash, is highly absorbent and known for its swelling ability, which makes it excellent for facial masks and deep detox treatments that draw out excess oil and impurities.
- *French Green clay*, colored by natural plant matter and minerals like magnesium and calcium, helps detoxify the skin, tighten pores, and is best for oily or blemish-prone complexions.
- *Rhassoul (Moroccan clay)* is rich in silica and magnesium, softens and smooths the skin, and is often used not only in face masks but also in hair care for its balancing and nourishing effects.

Clay is composed of non-toxic minerals, making it safe for most skin types. Its natural properties help cleanse, nourish, and improve skin texture, while different types of clay offer specific benefits, from gentle care for sensitive skin to deep cleansing and pore tightening. This combination of versatility and mineral richness makes clay a widely used and valued ingredient in cosmetic formulations [9, 10].

CHARCOAL POWDER

Activated charcoal is a versatile natural abrasive valued in both skincare and oral care. In cosmetics, it is used in facial masks, cleansers, scrubs, pore strips, and soaps, where it helps unclog pores and detoxify the skin. Some products claim benefits for acne, minor skin infections, and seborrheic dermatitis, although clinical evidence for these effects is limited, and it should be used carefully to avoid over-drying or irritation, especially on sensitive skin [11, 12]. In oral care, charcoal powder is commonly added to whitening toothpastes, where it helps remove surface stains, dirt, and impurities from teeth. Its high porosity and adsorption capacity allow it to bind pigments and toxins, contributing to a cleaner and brighter appearance. Its abrasive nature can slightly whiten teeth, but care is needed to avoid affecting enamel over time [13, 14].

G-NOTE: Activated charcoal is a natural detoxifier. Its microporous structure traps toxins and impurities, helping to unclog pores and leave the skin feeling refreshed [12].

CALCIUM CARBONATE

Calcium carbonate ($CaCO_3$) is a naturally occurring mineral and a gentle, versatile abrasive commonly used in cosmetics and personal care products. In toothpaste, it helps remove plaque and surface stains, polishing teeth without damaging enamel. In deodorants, it absorbs moisture, while in powders and foundations, it enhances texture, opacity, and pigment longevity. Its mild abrasive action and multifunctional properties make it a valuable natural ingredient for oral care and cosmetic formulations [15, 16].

FIGURE 5: Calcium Carbonate

WALNUT SHELL

Finely ground walnut shells are a natural powerhouse for scrubbing away dead skin cells and revealing a smoother, fresher complexion. They're commonly used in scrubs, soaps, and exfoliating masks—and the best part? They're completely natural and biodegradable! Walnut shells provide a slightly more robust exfoliation than sugar, making them great for rough patches like elbows or knees. Just be gentle and let the shells do the work—they polish the skin, leaving it soft, glowing, and naturally refreshed [17].

G-ADVICE: While natural abrasives like walnut shells, sugar, and coffee can give your skin a healthy glow and smooth texture, it's important to use them in moderation. Over-exfoliating can irritate the skin, damage its protective barrier, and even accelerate premature aging. A gentle touch goes a long way—think of these natural scrubs as a treat for your skin, not a daily workout.

Natural alternatives to plastic abrasives can be a better option, but "natural" does not automatically mean safe, gentle or environmentally harmless. The suitability of each ingredient depends on its particle size, shape, hardness, concentration and intended use. Gentle plant based or wax based particles may be suitable for facial products, while stronger abrasives such as pumice or ground shells are better suited for rougher areas of the body. Equally important are the origin and processing of these natural materials, including how they are sourced, extracted, milled and especially cleaned, as impurities or inadequate purification can introduce additional environmental or safety concerns.

FIGURE 6: Walnut Shell

REFERENCES:

1. Liu J.-K. (2022). Natural products in cosmetics. Natural Products and Bioprospecting, 12(40). https://doi.org/10.1007/s13659-022-00363-y
2. Duffin, C. J. (2012). History of the pharmaceutical use of pumice. Geological Society, London, Special Publications, 375, 157–169. https://doi.org/10.1144/SP375.8
3. Balo F. (2011). Castor oil-based building materials reinforced with fly ash, clay, expanded perlite and pumice powder. Ceramics - Silikáty, 55(3), 268–272. https://www.irsm.cas.cz/materialy/cs_content/2011/Balo_CS_2011_0000.pdf
4. Kacie L., N-essential Team (2022, January 28). Know the benefits of fine pumice powder. https://n-essentials.com.au/blog/know-the-benefits-of-fine-pumice-powder/?srsltid=AfmBOoqzfVGVRzxJQ64ke4Cey7hKKpki9llqfxr3JKJj1i9d9A3lT9SB (accessed in August 2025).
5. Smith H. (2023, July 26). Bamboo powder: The green secret to radiant skin. Bareluxe Skincare. https://www.bareluxeskincare.com/blogs/elevated-simplicity/bamboo-powder (accessed in August 2025).
6. Lavera natural beauty. (n.d.). Bamboo powder - The plant-based alternative to mineral powder https://www.lavera.com/uk/products/ingredients/bamboo-powder (accessed in August 2025).
7. Tovarna Organika. (n.d.). Bambus v prahu (fini). https://www.tovarnaorganika.si/trgovina/kozmeticne-surovine/bambus-v-prahu-fini/ (accessed in September 2025).
8. SpecialChem. (n.d.). Clay. https://www.specialchem.com/cosmetics/inci-ingredients/clay (accessed in September 2025).
9. Priya. (2023). Types of Cosmetic Clay in Skincare. Learn Canyon. https://learncanyon.com/types-of-cosmetic-clay-in-skincare/ (accessed in September 2025).
10. Kendle. (2019). Guide to Types of Cosmetic Clay & Their Uses. Mountain Rose Herbs. https://blog.mountainroseherbs.com/cosmetic-clay-comparison (accessed in September 2025).
11. SpecialChem. (n.d.). Charcoal powder. https://www.specialchem.com/cosmetics/inci-ingredients/charcoal-powder (accessed in September 2025).
12. Sajjad M., Sarwar R., Ali T., Khan L., Mahmood S. U. (2021). Cosmetic uses of activated charcoal. International Journal of Community Medicine and Public Health, 8(9), 4572–4574. https://doi.org/10.18203/2394-6040.ijcmph20213569
13. Montero Tomás D. B.., Pecci-Lloret M. P., Guerrero-Gironés J. (2023). Effectiveness and abrasiveness of activated charcoal as a whitening agent: A systematic review of in vitro studies. Annals of Anatomy, 253, 151998. https://doi.org/10.1016/j.aanat.2022.151998
14. Ghajari M. F., Shamsaei M., Basandeh K., Galouyak M. S. (2021). Abrasiveness and whitening effect of charcoal-containing whitening toothpastes in permanent teeth. Dent Res J 2021; 18:51.
15. SpecialChem. (n.d.). Calcium carbonate. https://www.specialchem.com/cosmetics/inci-ingredients/calcium-carbonate (accessed in September 2025).
16. Tovarna Organika. (n.d.). Calcium carbonate powder (Ph. Eur.). https://www.tovarnaorganika.si/trgovina/kozmeticne-surovine/kalcijev-karbonat-v-prahu-ph-eur/ (accessed in September 2025).
17. Tovarna Organika. (n.d.). Orehove lupine – fino mlete. https://www.tovarnaorganika.si/trgovina/mleko-v-prahu-in-naravni-pilingi-eksfolianti/orehove-lupine-fino-mlete/ (accessed in September 2025).

IMAGE SOURCES:

18. FIGURES 1–6: Faculty of Environmental Protection

Chapter 4

LABELLING ABRASIVES

In cosmetic products, abrasives play a significant role, most notably in exfoliating preparations for the skin and in oral care formulations such as toothpaste. Since these substances come into direct contact with the body, it is essential that they are clearly identified on product labels. Proper labeling not only informs consumers but also allows scientists, health professionals, and regulators to track the use, safety, and regulatory compliance of such ingredients across different countries. The need for precision in naming has led to the adoption of international systems that eliminate confusion and ensure transparency.

The most important framework in this respect is the **International Nomenclature Cosmetic Ingredient (INCI)** system. Introduced in 1973, INCI provides a standardized, internationally recognized method for naming cosmetic ingredients, including abrasives. The names are **developed by the International Nomenclature Committee (INC)** and **published by the Personal Care Products Council (PCPC)** in the *International Cosmetic Ingredient Dictionary and Handbook*, which is also available electronically through the wINCI database [1].

Also natural abrasive alternatives to microbeads are clearly identifiable through their INCI names. For example:

- bamboo powder (INCI: Bambusa Arundinacea Stem Powder),
- fine ground walnut shells (INCI: Juglans regia (Walnut) Shell Granules),
- pumice powder, also known as volcanic ash (INCI: Pumice Powder 240 Mesh),
- black clay (INCI: Montmorillonite C.I. 7749).

In the European Union, cosmetic product labelling is regulated by *Regulation (EC) No 1223/2009 on Cosmetic Products*. According to this regulation, all ingredients in a cosmetic product must be listed on the label in descending order by weight, so that the first ingredient represents the largest proportion of the product. Ingredients present at concentrations below 1% must still be included in the ingredient list, but may be listed in any order after those present at higher concentrations. This ensures that consumers and professionals can clearly identify the main substances in a formulation [2]. In addition, ingredients present in the form of nanomaterials must be indicated in the ingredient list with the word “nano” in brackets after the ingredient name.

Asterisks next to ingredients in an INCI list are not part of the standard INCI nomenclature and are not universally regulated. They are sometimes used by natural or certified cosmetic brands as an additional labelling system. In such cases, a single asterisk may indicate that the ingredient is derived from organic farming, while a double asterisk may refer to an ingredient obtained as a natural by-product during the extraction of organic essential oils used in the formulation. However, the exact meaning of asterisks depends on the relevant certification standard or the manufacturer’s own explanation provided on the product label [3].

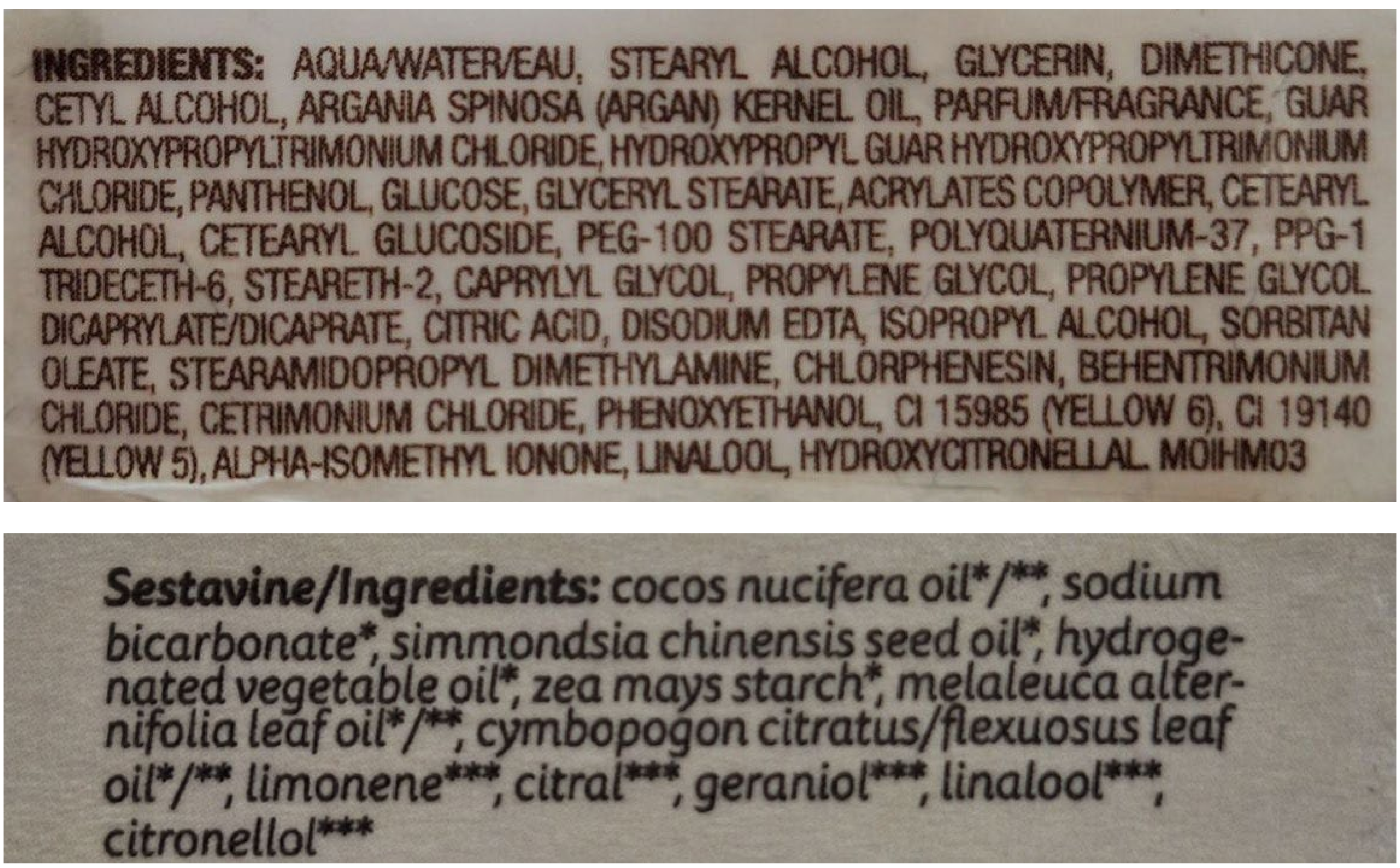


FIGURE 1: Two random examples of ingredient lists, each containing a different number of ingredients

G-FUN FACT: A study conducted at the Faculty of Environmental Protection (Slovenia), analyzing 500 randomly selected cosmetics and personal care products found that a single product contained, on average, 19 ingredients. The number of ingredients per product ranged from a minimum of

13 to a maximum of 51. The most chemically diverse category was decorative cosmetics.

It is important to note, however, that an INCI name **does not constitute regulatory approval or a safety guarantee**. Assigning an INCI name to an ingredient does not confirm that it is legally authorized for cosmetic use or that it is inherently safe. Responsibility for ensuring the ingredient's safety and compliance with local regulations lies with the manufacturer, who must demonstrate adherence to applicable laws in each market where the product is sold [1].

The INCI system provides a standardized framework for identifying and labeling ingredients. While it ensures clarity and consistency, responsibility for ingredient safety and compliance with local regulations remains with the manufacturer.

UNDERSTANDING INGREDIENT LABELS AND THEIR IMPACT

Although the INCI system provides standardized names for cosmetic ingredients, many consumers may not know what these substances are or how they affect human health and the environment. Understanding this information is essential for making informed choices about personal care products.

There are various **databases** and **mobile applications** that allow consumers to quickly and easily check the properties of a product's ingredients in real time, enabling them to make informed decisions before purchasing. These tools provide information on the safety, potential health effects, and environmental impact of individual ingredients, helping users to choose products more responsibly and consciously.

Here are two accessible and practical solutions that can help anyone identify abrasive ingredients in cosmetics—whether you're researching at home or scanning products on the go.

PubChem - Scientific Database

PubChem is a free and publicly accessible chemical database maintained by the U.S. National Institutes of Health. It contains millions of chemical compounds, each with detailed information about its structure, properties, safety, and biological effects. Users can search for any ingredient listed on a cosmetic label to find out whether it's abrasive or potentially harmful. Each entry includes safety profiles, links to scientific studies, and regulatory status. PubChem is especially helpful for those who want to understand ingredients based on verified scientific data—no chemistry degree required [4].

GreenScan Mobile Application

GreenScan is a user-friendly mobile application developed within the EU co-funded Erasmus+ projects GreenGate and GreenGate$_2$. It helps users better understand the ingredients found in cosmetics and personal care products by scanning the product barcode and translating complex ingredient lists into clearer information about possible effects on human health and the environment.

GreenScan is designed as a transparent, free and independent educational tool. Any ingredient evaluation in the app is kept separate from commercial activities and is not influenced by paid product promotion, brand partnerships, manufacturer requests or commercial ranking. The app focuses on the ingredient list and available scientific knowledge about individual substances [5].

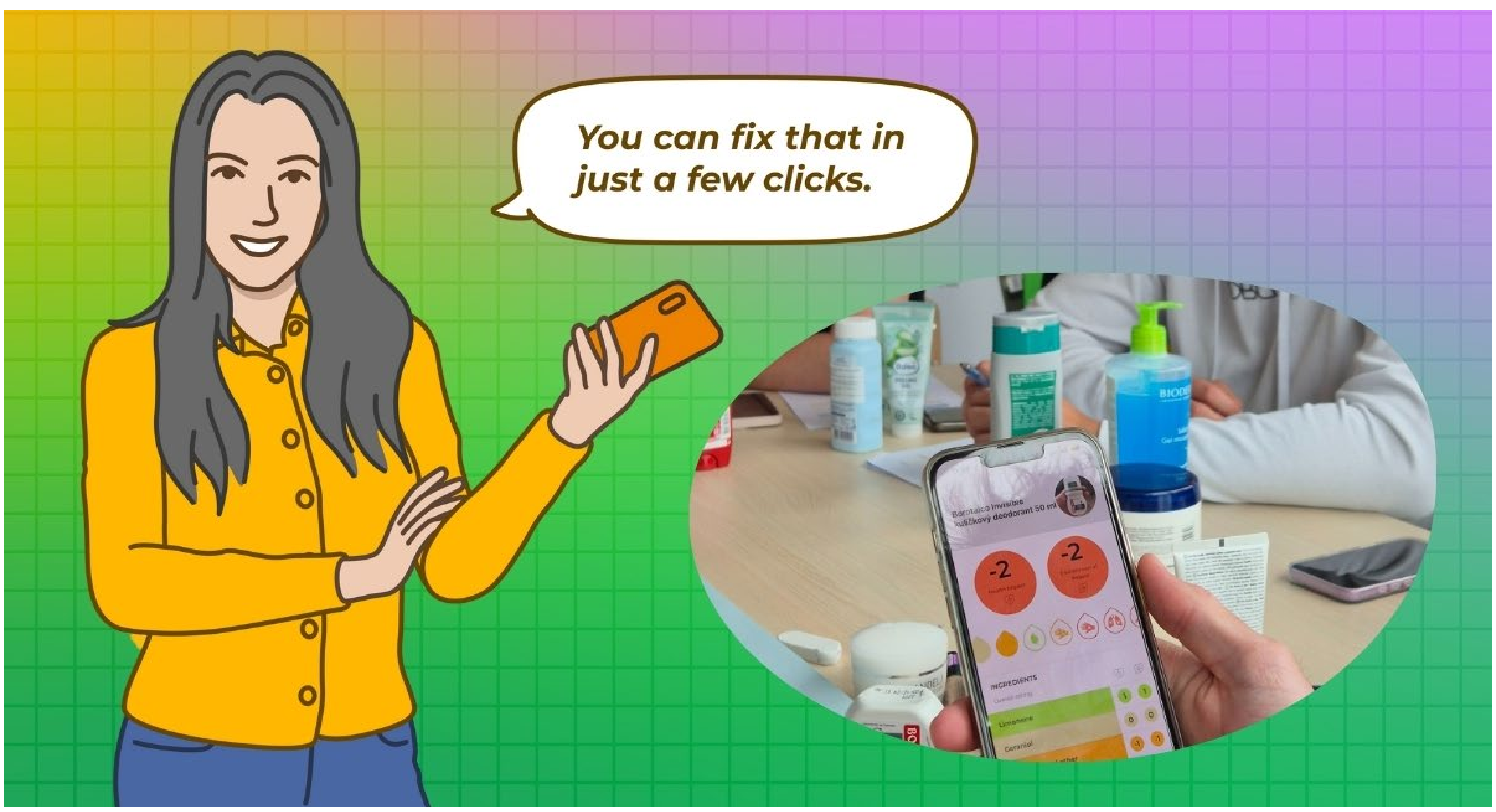


FIGURE 2: Scanning cosmetics using GreenScan App.

G-NOTE: Knowing what's inside your cosmetics is easier than ever: INCI provides the names, and tools like GreenScan help you understand their impact on your health and the environment.

In addition, you can also use other applications such as Yuka, INCI Beauty, CodeCheck, INCIDecoder, Think Dirty, or EWG Skin Deep.

CosIng - Cosmetic ingredient database

CosIng is an online database created by the European Commission that provides clear information about cosmetic ingredients used in the EU. It brings together ingredient names used on product labels, details from EU cosmetic laws, and scientific safety opinions. The database includes both current and older ingredient entries, which are marked as “active” or “not active”. It helps users look up ingredients and understand how they are used in cosmetic products, making it a useful tool for students, consumers, and people working with cosmetics [6].

REFERENCES:

1. *Personal Care Products Council. (n.d.). INCI – International Nomenclature Cosmetic Ingredient.* https://www.personalcarecouncil.org/resources/inci/ *(accessed in September 2025).*
2. *European Union. (2009). Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products (recast)* https://eur-lex.europa.eu/legal-content/SL/TXT/?uri=CELEX:32009R1223 *(accessed in September 2025).*
3. *SisneoBioscience. (n.d.). How to read the INCI of a cosmetic.* https://sisneo.com/en/blog/how-to-read-the-inci-of-a-cosmetic/ *(accessed in September 2025).*
4. *PubChem. (n.d.). National Center for Biotechnology Information.* https://pubchem.ncbi.nlm.nih.gov
5. *GreenGate$_2$. (n.d.). Analyze cosmetics with GreenScan App.* https://green-gate.eu/greenscan-app/ *(accessed in September 2025).*
6. *European Commission. (n.d.). Cosmetic ingredient database (CosIng). Internal Market, Industry, Entrepreneurship and SMEs.* https://single-market-economy.ec.europa.eu/sectors/cosmetics/cosmetic-ingredient-database_en *(accessed in September 2025).*

IMAGE SOURCES:

7. *FIGURE 1: Faculty of Environmental Protection*
8. *FIGURE 2: Faculty of Environmental Protection*

Chapter 5

OTHER MICROPOLLUTANTS FROM COSMETICS

Cosmetic products are used daily by millions of consumers worldwide, but their environmental footprint is increasingly under scrutiny. While microplastic abrasives, like microbeads, have received significant attention, a broader range of substances—particularly those used in decorative cosmetics such as makeup, nail polish, and perfumes— can also act as environmental micropollutants. These substances include **endocrine-disrupting chemicals (EDCs), nanomaterials, synthetic dyes, preservatives, UV filters, allergens, and fragrance compounds,** many of which are **persistent, bioaccumulative, and toxic (PBT).**

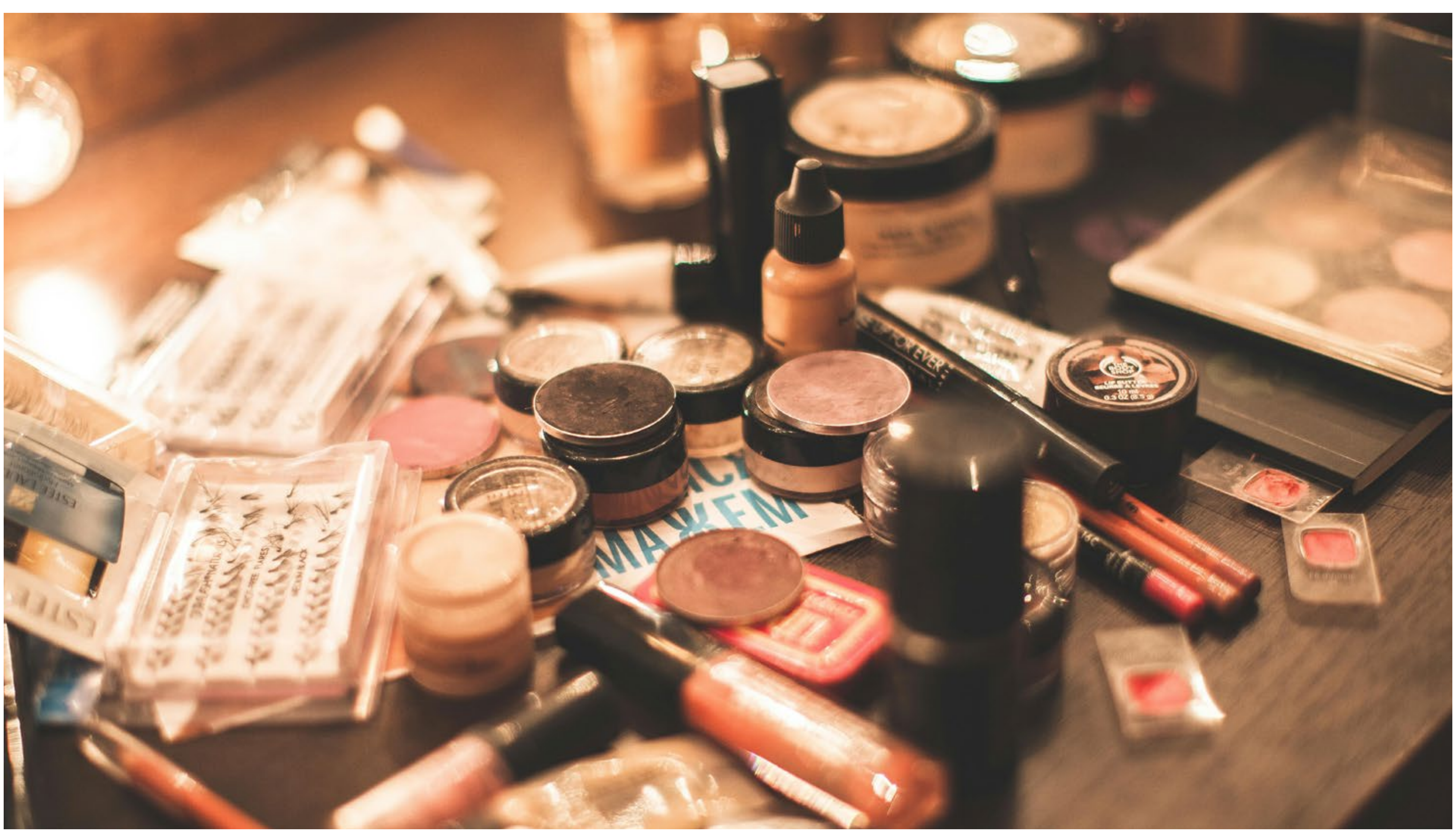


Figure 1: The makeup we see and the chemistry we don't.

WHAT DOES IT MEAN FOR A SUBSTANCE TO BE PBT?

PBT substances are chemicals that are Persistent (do not break down easily), Bioaccumulative (build up in living organisms), and Toxic (harmful even at low concentrations). Because they remain in the environment for long periods and accumulate in food webs, they pose long-term risks to ecosystems and human health.

During regular use and washing, these substances enter wastewater systems and frequently evade removal by conventional treatment technologies. Their presence in urban wastewater poses risks to aquatic ecosystems and potentially to human health. In response to these concerns, the revised Urban Wastewater Treatment Directive (EU) 2024/3019 introduces stricter regulations targeting micropollutants, including mandatory advanced treatment and extended producer responsibility for cosmetic manufacturers [1–4] (Chapter 6). Extended producer responsibility means that producers from relevant sectors, including cosmetics and pharmaceuticals, may be required to contribute to the costs of advanced wastewater treatment needed to remove micropollutants. This reflects the polluter pays principle and helps shift part of the financial burden from wastewater operators and citizens to sectors that place micropollutant containing products on the market.

DECORATIVE COSMETICS AS A SOURCE OF MICROPOLLUTANTS

Decorative cosmetics, like foundations, lipsticks, eyeshadows, mascaras, and nail polishes, contain a wide range of synthetic compounds that can act as micropollutants. These include:

- Inorganic mineral pigments (e.g., CI 77891 – titanium dioxide), which are highly stable and resistant to degradation.
- Organic synthetic dyes (e.g., CI 42090), which provide intense colour but may persist in aquatic environments.
- Metal-containing pigments and complexes used for specific colour effects, which can introduce trace metals into wastewater.
- Plastic-based film formers (e.g., acrylates copolymers) which are used in long-wear makeup and waterproof formulations and contribute to the presence of polymeric microparticles in effluents.

- Silicones and polymers (e.g., dimethicone, cyclopentasiloxane) that enhance texture and spreadability but are often poorly biodegradable.
- Preservatives (e.g., parabens, phenoxyethanol) that prevent microbial growth but may exhibit endocrine-disrupting properties.
- Fragrance compounds (e.g., limonene), which can act as allergens and contribute to the formation of secondary organic aerosols and volatile organic compound (VOC) emissions.
- Solvents (e.g., ethanol), which facilitate formulation stability and evaporation but also increase VOC loads.

Studies have shown that decorative cosmetics contribute to the load of micropollutants in urban wastewater, especially in densely populated areas with high cosmetic usage [1-3]. Fragrance substances and polymeric ingredients are increasingly recognised as environmentally relevant due to their persistence, incomplete removal in wastewater treatment plants and potential toxicity to aquatic organisms.

ENDOCRINE-DISRUPTING CHEMICALS (EDCS)

Personal care products and decorative cosmetics are indispensable components of daily routines, which makes them a significant and often underestimated source of exposure to various contaminants. Among these, **endocrine-disrupting chemicals (EDCs)** are of **particular concern**. These substances can mimic endogenous hormones, block hormone receptors, or interfere with hormone synthesis, metabolism, and transport. Because endocrine systems rely on highly sensitive feedback mechanisms, even very low concentrations of hormonally active compounds can elicit measurable biological responses, especially under chronic exposure typical of cosmetic use [e.g. 5-7].

Some EDCs are intentional ingredients in cosmetic formulations, while others are unintentionally present, arising from manufacturing processes or migrating from plastic packaging materials, as is the case with bisphenols and certain per- and polyfluorinated compounds. Due to their potential health impacts, several of these endocrine disruptors have already been restricted or banned in cosmetics [8].

Such cosmetic-related substances possessing possible endocrine activity, include selected benzophenone UV filters such as benzophenone-2 and benzophenone-3/oxybenzone, some longer-chain parabens such as propylparaben and butylparaben, certain phthalates, and some synthetic musks. However, the evidence and regulatory status differ substantially between individual substances, so these groups should not be presented as uniformly harmful. Each substance requires individual assessment based on dose, concentration, exposure route, product type and current scientific evidence.

Parabens, for example, represent a diverse group with different toxicological profiles: while some (e.g., methyl- and ethylparaben) are permitted under specific concentration limits, others (e.g., propyl- and butylparaben) are restricted, and several additional parabens are banned in cosmetic products. Therefore, they should not be treated as a single category with uniform endocrine-disrupting potential.

EDCs from cosmetics enter wastewater primarily through daily washing and removal of makeup. Conventional wastewater treatment technologies are not optimized to eliminate hormonally active compounds, meaning that a portion of these substances passes into surface waters, sediments, and aquatic organisms. Monitoring studies consistently report endocrine-active cosmetic ingredients downstream of urban wastewater treatment plants, and ecotoxicological and biological effect studies demonstrate effects such as altered reproductive behaviour, reduced fertility or developmental disturbances in aquatic species [e.g. 9-12].

From a human-health perspective, exposure to cosmetic-related EDCs is well documented. Biomonitoring studies detect hormonally active cosmetic ingredients in urine and blood, indicating systemic absorption and widespread population exposure. Current research highlights that the most relevant risk does not stem from individual substances alone but from **mixture effects**, where multiple low-dose chemicals act additively or synergistically. This is particularly important for decorative cosmetics, which often contain complex formulations of preservatives, fragrances, UV filters, and polymers that may each contribute to overall endocrine activity [e.g. 9, 11, 12].

ENVIRONMENTAL FATE AND TRANSPORT OF COSMETIC MICROPOLLUTANTS

Once released, cosmetic micropollutants undergo various physical, chemical, and biological transformations. Many are designed to be chemically stable, water-resistant, and long-lasting, which means they persist rather than degrade. Some degrade only partially, forming transformation products that may be equally or more harmful. As a result, they can persist for long periods and accumulate in different environmental compartments. Several cosmetic ingredients, including UV filters, preservatives, and fragrances, are frequently detected in wastewater, surface waters, and sediments, confirming their widespread environmental presence and persistence [13].

Figure 2: Decorative cosmetics do not beautify the environment, but create a chemical burden.

G-NOTE: Once cosmetic chemicals enter the environment, they don't simply disappear — they move, settle, transform, and sometimes return to us through water or food.

Some adsorb onto sludge during wastewater treatment, which may later be spread on agricultural soils, introducing pollutants into terrestrial ecosystems. From there, they can leach into groundwater and drinking water sources or be absorbed by plants. Others remain in water during the treatment and are released with the effluent into rivers and lakes, where they can settle into sediments and enter the food web. Some of these substances remain dissolved or suspended in the water column and can also be transported downstream with the water flow, allowing them to disperse far from the original point of discharge. Because many of these substances are highly persistent, they can remain in the environment for years and accumulate in aquatic organisms [e.g., 13,14].

G-FUN FACT: A single drop of sunscreen containing oxybenzone can be toxic to coral larvae in concentrations as low as one part per billion—that's like one drop in an Olympic-sized swimming pool! Because of this, places like Hawaii and Palau have banned certain UV filters in sunscreens [16].

HUMAN EXPOSURE AND HEALTH CONCERNS

Decorative cosmetics can contribute to micropollutants through specific ingredient classes, such as pigments from eyeshadows, film formers from mascara, resins and solvents from nail polish, UV filters in SPF-containing makeup, and fragrance compounds in perfumes. These examples help illustrate how everyday products can contribute to environmental loads even when used in small quantities.

People are exposed to micropollutants both directly (through skin absorption, inhalation, or ingestion of cosmetics) and indirectly (through contaminated food and water). Trace concentrations of cosmetic ingredients, including parabens and UV filters, and fragrance compounds, have been detected in drinking water, blood, and urine samples, demonstrating that these substances can move beyond the bathroom [13, 14]. Although the detected levels are usually low, scientists are increasingly concerned about chronic exposure to mixtures of chemicals. Even small amounts can contribute to subtle but cumulative effects, such as hormonal imbalance, reduced fertility, and developmental disorders, especially when exposure occurs over many years [e.g. 15]. Everyday habits can contribute to this: for example, people who apply lip balm or lipstick several times a day may ingest small quantities without realizing it.

G-FUN FACT: Emerging studies also show that long-term use of some lipsticks, eyeliners, and other pigmented products may contribute to low-level heavy metal exposure depending on contamination levels, product quality, frequency of use, and regulatory control. These may include trace amounts of lead, cadmium, or chromium, which can accumulate in the body over time and may pose neurotoxic or developmental risks [17].

CONSUMER AWARENESS AND EDUCATIONAL IMPLICATIONS

As awareness of cosmetic micropollutants grows, consumers increasingly encounter claims such as “microplastic-free”, “biodegradable”, “natural”, or “eco-friendly”. However, many of these terms function primarily as marketing language and are not based on harmonised scientific criteria. In contrast, regulated or criteria-based labels, such as the EU Ecolabel, provide clearer guidance because they rely on defined standards and independent verification. Consumers are also showing greater interest in products marketed as sustainable, and many brands are replacing synthetic polymers with natural alternatives such as cellulose, starch derivatives, plant-based waxes, or mineral particles. Yet natural materials are not automatically safer for ecosystems; their environmental impact depends on sourcing, processing, biodegradability, ecotoxicity, concentration in the product, and full life-cycle considerations.

Tools like GreenScan mobile app (Chapter 4) and certification schemes such as EU Ecolabel, help consumers identify safer products and support brands committed to responsible production. These systems make it easier to navigate marketing claims and avoid misleading “green” terminology.

Despite the popularity of eco-friendly branding, scientific validation remains essential. Terms like natural, clean, or microplastic-free are often used inconsistently, and true safety must be assessed through science: life-cycle analysis, biodegradability testing, toxicological and ecotoxicological studies.

Environmental pathways also differ between product categories. Rinse-off cosmetics (e.g., cleansers, shampoos, scrubs) enter wastewater directly during use, whereas leave-on products (e.g., foundations, lipsticks, perfumes) may reach the environment through washing, makeup removal, textile laundering, volatilisation, product disposal, or indirect exposure routes.

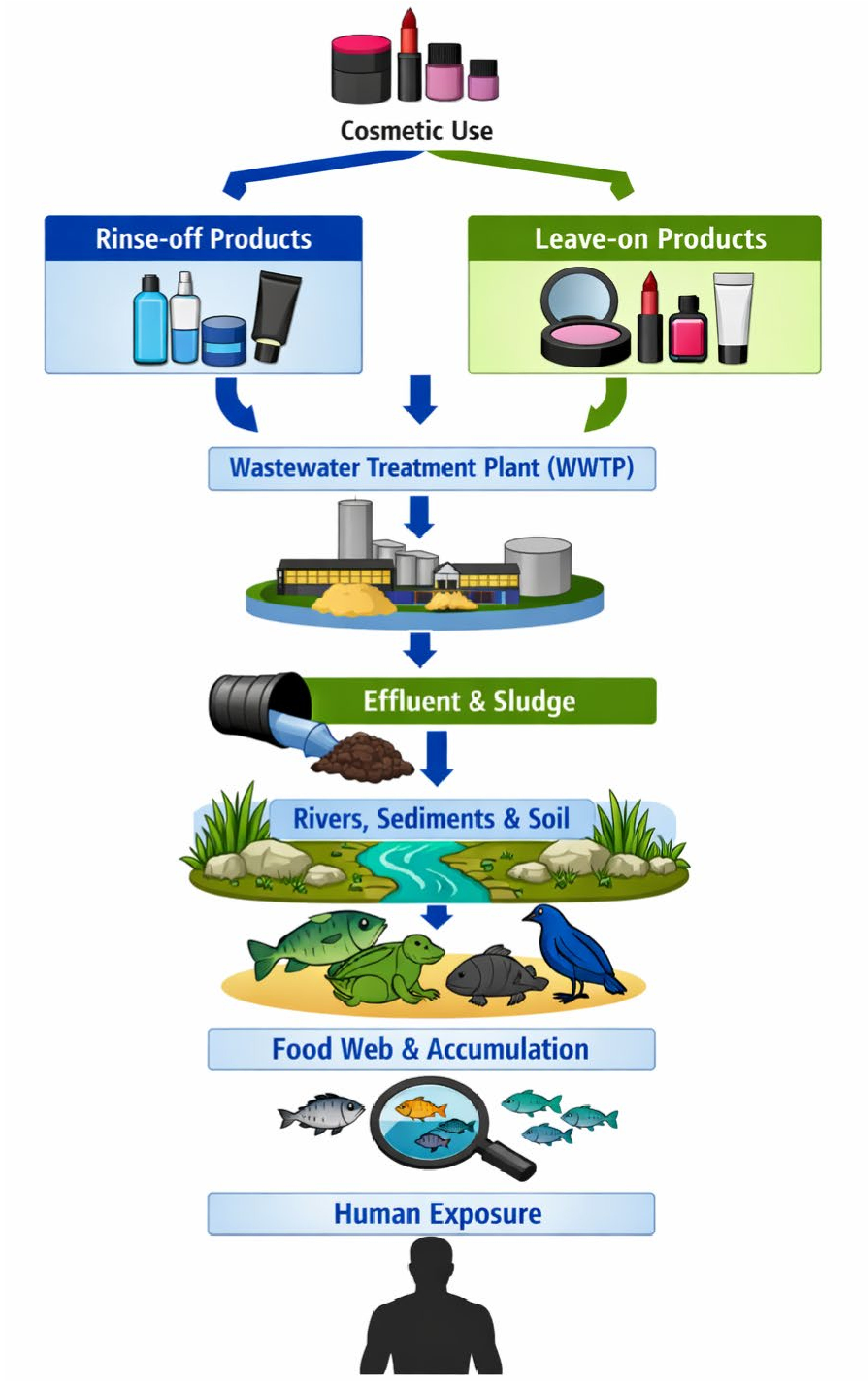

Cosmetic Use
Rinse-off Products
Leave-on Products
Wastewater Treatment Plant (WWTP)
Effluent & Sludge
Rivers, Sediments & Soil
Food Web & Accumulation
Human Exposure

Figure 3: Environmental Fate of Cosmetic Micropollutants

G-NOTE: Teaching about micropollutants in makeup can empower future scientists, consumers, and policymakers to make informed decisions and advocate for cleaner, safer products.

Cosmetic products can be a source of micropollutants, but the level of risk depends on the specific substance, product type, way of use, amount used, biodegradability, toxicity and whether the substance can pass through wastewater treatment. It is not appropriate to present all cosmetic ingredients as equally problematic. However, it is important to show that even everyday personal care and cosmetic products can have an environmental footprint.

REFERENCES:

1. *Hirst, D., & Bennett, O. (2017). Microbeads and microplastics in cosmetic and personal care products (Briefing Paper No. CBP-7510). House of Commons Library.*
2. *Petrie, B., Barden, R., & Kasprzyk-Hordern, B. (2015). A review on emerging contaminants in wastewater. Water Research, 72, 3–27.*
3. *Gago-Ferrero, P. et al. (2021). Micropollutants in wastewater from personal care products. Water Research, 188, 116523.*
4. *European Parliament and Council of the European Union. (2024). Directive (EU) 2024/3019 of 27 November 2024 concerning urban wastewater treatment (recast). Official Journal of the European Union, L 3019, 1–XX.*
5. *Nicolopoulou-Stamati, P., Hens, L., & Sasco, A. J. (2015). Cosmetics as endocrine disruptors: Are they a health risk? Reviews in Endocrine and Metabolic Disorders, 16, 373–383.*
6. *Chantelouve, M., & Ripoll, L. (2022). Endocrine disruptors in cosmetics: a review. Molecules.*
7. *Kalofiri, P., Biskanaki, F., Kefala, V., Tertipi, N., Sfyri, E., & Rallis, E. (2023). Endocrine Disruptors in Cosmetic Products and the Regulatory Framework: Public Health Implications. Cosmetics, 10(6)*
8. *Martín-Pozo, L., Gómez-Regalado, M. D. C., Moscoso-Ruiz, I., & Zafra-Gómez, A. (2021). Analytical methods for the determination of endocrine disrupting chemicals in cosmetics and personal care products: A review. Talanta, 234, 122642.*
9. *Maddaleno, A. S., Guardia-Escote, L., Vinardell, M. P., Teixidó, E., & Mitjans, M. (2025). Assessment of Endocrine-Disrupting Properties in Cosmetic Ingredients: Focus on UV Filters and Alternative Testing Methods. Cosmetics (2079-9284), 12(4).*
10. *Haman, C., Dauchy, X., Rosin, C., & Munoz, J.-F. (2015). Occurrence, fate and behavior of parabens in aquatic environments: A review. Water Research, 68, 1–11.*
11. *Tomar, C., Singh, P., & Yadav, S. (2025). Endocrine-disrupting chemicals in cosmetics: mechanistic insights and their impact on human and skin health. Reviews in Endocrine and Metabolic Disorders, 1-16.*
12. *M. Peinado, F., M. Iribarne-Durán, L., Ocón-Hernández, O., Olea, N., & Artacho-Cordón, F. (2021). Endocrine Disrupting Chemicals in Cosmetics and Personal Care Products and Risk of Endometriosis. In Endometriosis. IntechOpen.*
13. *Juliano, C., & Magrini, G. A. (2017). Cosmetic Ingredients as Emerging Pollutants of Environmental and Health Concern. A Mini-Review. Cosmetics, 4(2), 11.*
14. *Mota S., Sousa E., Cruz M.T., Martins de Almeida I. (2025). Occurrence and ecotoxicity of cosmetic ingredients in aquatic systems: A review. Emerging Contaminants 11, 100512.*
15. *Kortenkamp A. (2008). Low dose mixture effects of endocrine disrupters: implications for risk assessment and epidemiology. International journal of andrology, 31(2), 233–240.*
16. *Downs, C. A., Kramarsky-Winter, E., Segal, R., Fauth, J., Knutson, S., Bronstein, O., Ciner, F., Jeger, R., Lichtenfeld, Y., Woodley, C. M., Pennington, P., Cadenas, K., Kushmaro, A., & Loya, Y. (2016). Toxic Pathological effects of the sunscreen UV filter oxybenzone on coral planulae and cultured primary cells. Archives of Environmental Contamination and Toxicology, 70(2), 265–288.*
17. *Al-Saleh, I., Al-Enazi, S., & Shinwari, N. (2009). Assessment of lead in cosmetic products. Regulatory Toxicology and Pharmacology, 54(2), 105–113.*

IMAGE SOURCES:

18. *FIGURE 1: Pexels (November 2025)*
19. *FIGURE 2: Faculty of Environmental Protection*
20. *FIGURE 3: Copilot (March 2026)*

Chapter 6

REMOVAL OF MICROPOLLUTANTS FROM WASTEWATER

At first glance, wastewater treatment may sound technical and boring—but it actually connects directly to our daily lives. Every time we wash our hands, flush the toilet, or use cleaning products, traces of what goes down the drain can eventually reach rivers, lakes, or even the ocean. Many of these substances are invisible but can still affect ecosystems and human health.

Over the past decades, wastewater treatment plants (WWTPs) have primarily focused on removing organic carbon, nitrogen, and phosphorus, in line with standards like the EU Urban Wastewater Treatment Directive 91/271/EEC [1]. While conventional treatment also reduces many pollutants through sorption and biodegradation, WWTPs remain a major entry point for persistent and mobile contaminants into aquatic environments [1].

FIGURE 1: Pathway of micropollutants from domestic sources to surface waters

Global chemical use has steadily increased, resulting in a growing presence of micropollutants (pharmaceuticals, biocides, pesticides, household and industrial chemicals, microplastics, and engineered nanoparticles) that can disrupt ecosystems and pose risks to human health even at very low concentrations [2,3]. Micropollutants enter sewers through a variety of urban activities, from detergents and personal care products to food additives and plastics, and some also originate from industrial sources [2,3].

Their fate in WWTPs depends on their chemical properties: they may be removed, persist in effluents, or accumulate in sludge. When sludge is reused in agriculture, it can become a secondary pathway for environmental release, prompting regulatory restrictions in certain regions [2].

G-NOTE: Conventional WWTPs are often unable to fully remove certain compounds, such as endocrine-disrupting chemicals (EDCs) and pharmaceuticals [3].

To tackle these persistent contaminants, advanced treatment technologies, such as activated carbon adsorption and ozonation, can significantly enhance micropollutants removal. However, these approaches come with higher demands on resources and energy. Greenhouse gas emissions, costs, and operational challenges must be considered, meaning large-scale implementation requires careful balancing of environmental benefits against economic and technical feasibility [1].

Awareness is equally important: what we release into sinks and drains can eventually reach rivers, lakes, and oceans. Simple daily choices like using cleaning agents, cosmetics, or medicines may seem minor individually, but collectively they contribute to micropollutant loads in wastewater.

FIGURE 2: Hands-on activity building a gravity filter as an example of student engagement in practical learning

Educating society about these hidden pathways is crucial for reducing pollution at its source. Hands-on activities, such as building a DIY gravity filter with sand, gravel, and charcoal, demonstrate water purification principles in a fun and memorable way, helping young people connect everyday behavior with the larger goal of protecting aquatic environments.

G-FUN FACT: Simple physical filtering can make water look clear—but clear water can still be microbiologically unsafe or chemically contaminated, so appearance alone is not a reliable indicator of water quality.

URBAN WASTEWATER TREATMENT DIRECTIVE (UWWTD) 2024 – FOCUS ON MICROPOLLUTANTS

Recognizing the limitations of conventional treatment and growing micropollutant risks, the EU enacted a major update to the UWWTD at the end of 2024, marking its first significant revision since 1991. The updated directive aims to protect human health and ecosystems from untreated wastewater, with a strong emphasis on micropollutants such as pharmaceuticals, hormones, cosmetics, and microplastics. It sets stricter treatment standards and mandates quaternary treatment in large WWTPs, with full implementation expected by 2045 [4-6].

Key measures:

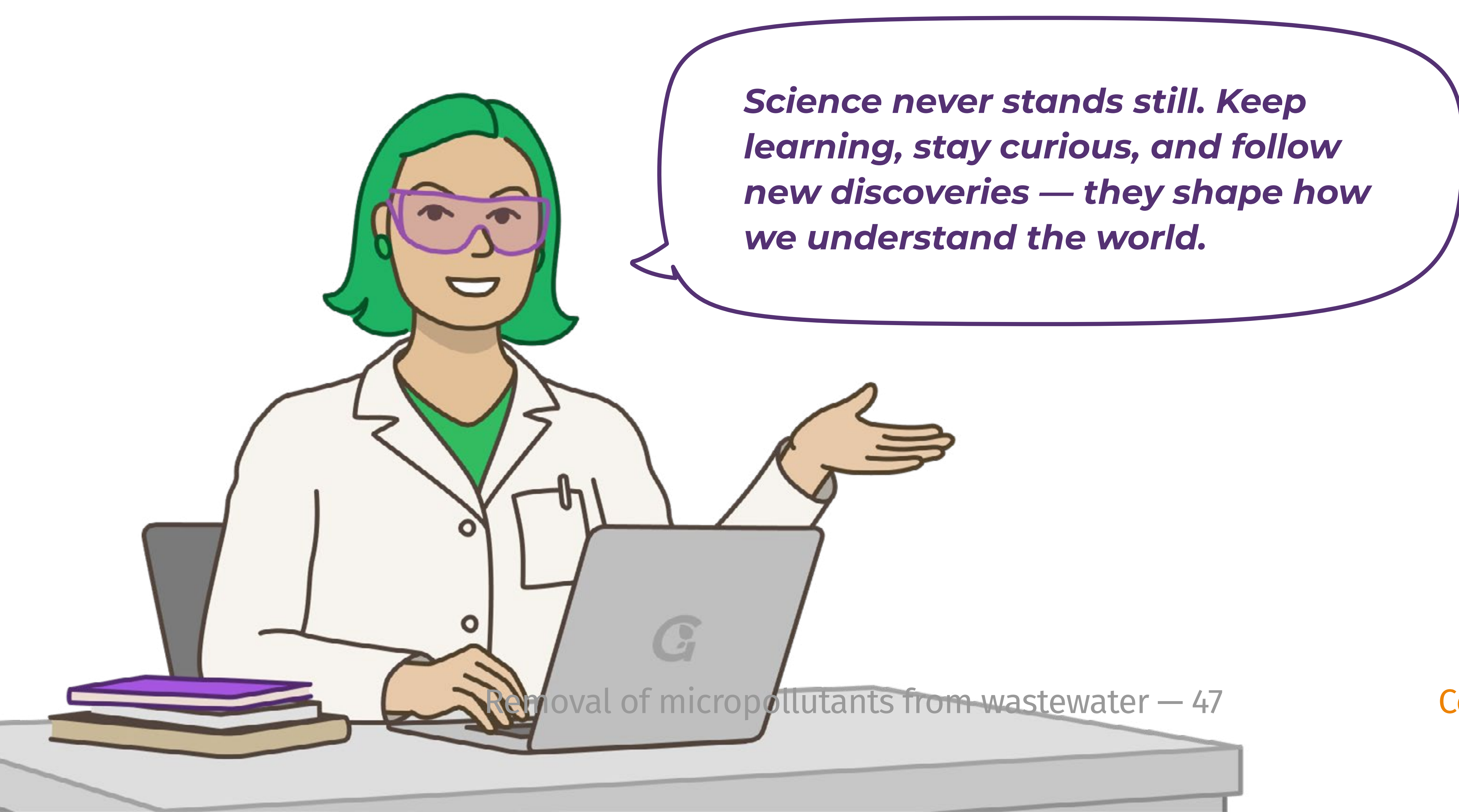
- Wastewater treatment plants serving a load of 150,000 population equivalents and above must implement quaternary treatment by 2045. This includes methods such as ozonation or activated carbon filtration to reduce a broad spectrum of micropollutants, including pharmaceutical residues, hormones, and personal care product ingredients. The revised directive also addresses emerging pollutants such as PFAS and microplastics through strengthened monitoring and broader pollution control measures [5].
- The directive enforces extended producer responsibility, placing the primary financial responsibility for advanced treatment on pharmaceutical and cosmetic producers, who are required to cover at least 80% of the additional costs for quaternary treatment [5].
- All agglomerations above 1,000 population equivalents (p.e.) must have proper wastewater collection and treatment, while very small settlements remain exempt or follow national regulations [5].

G-NOTE: The revised Urban Wastewater Treatment Directive (EU) 2024/3019 introduces new obligations for producers and wastewater treatment facilities to address these pollutants, marking a shift toward more sustainable cosmetic production and wastewater management. At the same time, for cosmetics and cleaning products, using appropriate amounts and paying attention to product composition can further contribute to reducing the environmental burden associated with these substances.

Integration with existing infrastructure:

Conventional treatment processes removing organic carbon, nitrogen, and phosphorus remain essential, but tertiary and quaternary steps are now crucial to address persistent and mobile pollutants. Advanced technologies also support energy-efficient operation and circular resource recovery, such as phosphorus extraction from sludge or energy generation from anaerobic digestion [6].

The 2024 UWWTD revision directly tackles micropollutant challenges while promoting sustainable, energy-efficient, and socially responsible wastewater management. This update reflects a shift in perspective: wastewater is increasingly seen as a valuable resource rather than mere waste, with advanced treatment offering environmental protection and opportunities for energy and nutrient recovery [4-6].



REFERENCES:

1. *Pistocchi A., Andersen H.R., Bertanza G., Brander A., Choubert J.M., Cimbritz M., Drewes J.E., Koehler C., Krampe J., Launay M., Nielsen P.H., Obermaier N., Stanev S., Thornberg D. (2022) Treatment of micropollutants in wastewater: Balancing effectiveness, costs and implications. Science of The Total Environment. Volume 850, 2022, 157593.* https://doi.org/10.1016/j.scitotenv.2022.157593.
2. *Hammoudani Y.El., Dimane F., Haboubi K., Benaissa C., Benaabidate L., Bourjila A., Achoukhi I., Boudammoussi M.El, Faiz H., Touzani A., Moudou M., Esskifati M. (2024). Micropollutants in wastewater treatment plants: A bibliometric - bibliographic study. Desalination and Water Treatment. Volume 317, 2024, Article 100190.* https://doi.org/10.1016/j.dwt.2024.100190
3. *Rogowska J., Cieszynska-Semenowicz M., Ratajczyk W., Wolska L. (2019). Micropollutants in treated wastewater. Ambio A Journal of Environment and Society. Volume 49, 487–503.* https://doi.org/10.1007/s13280-019-01219-5
4. *European Parliament and Council of the European Union. (2024). Directive (EU) 2024/3019 of 27 November 2024 concerning urban wastewater treatment (recast). Official Journal of the European Union, L 3019, 1–XX.*
5. *Cambi. (2025, May 27). Urban Wastewater Treatment Directive: A guide for EU utilities.* https://www.cambi.com/blog/urban-wastewater-treatment-directive *(accessed in September 2025).*
6. *European Commission. (n.d.). Urban wastewater.* https://environment.ec.europa.eu/topics/water/urban-wastewater_en *(accessed in September 2025)*

IMAGE SOURCES:

7. *FIGURE 1: ChatGPT (November 2025)*
8. *FIGURE 2: Faculty of Environmental Protection*