The impact of hazardous substances in cosmetics, and treatment measures

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Abstract-Humans have studied numerous environmental pollution issues and improved treatment in the past, but few people are aware that cosmetics are also potential environmental pollution factors. This article first discusses that most cosmetics contain hazardous substances, and then examines the effects of these hazardous substances on the natural environment, organisms, and humans. According to studies, cosmetics primarily contain heavy metals, organics, and other hazardous substances, which can pollute the environment's water and soil, limit organism reproduction and growth, and cause a variety of physiological ailments in humans. The article then proposes two technologies for effectively treating hazardous substances in cosmetics: biosorbent and activated carbon fiber-polyethersulfone (ACF-PES) ultrafiltration composite membrane, both of which adsorb and effectively degrade hazardous substances via their respective physical and chemical properties. Moreover, this article examines the necessity and feasibility of measures for the government, corporations, and the general public to participate in the treatment of hazardous substances in cosmetics. Legislation to regulate and supervise cosmetics production should be strengthened by the government. Corporations should manufacture green cosmetics and promote the use of green cosmetics. To limit the impact of hazardous substances in cosmetics, the general public can employ strategies such as using less or purchasing cosmetics containing less dangerous substances. The article promotes a greater understanding of the dangers of harmful substances in cosmetics and offers some suggestions for reducing their effects.

1. Introduction
Cosmetics have become an essential aspect of people's lives in recent times. In the previous three decades, the market demand for cosmetics has always been on the increase [1]. While cosmetics enrich our quality of life, some inescapable issues have arisen. The majority of cosmetic items are over-packaged. In the preservation and packaging of cosmetics, a great number of paper goods, plastics, and glass are utilized, resulting in a large amount of waste. This issue has been identified by scientists and the government. Scientists have conducted extensive research on cosmetic plastics, and some governments have restricted or prohibited the use of plastic goods to package cosmetics in order to address environmental concerns. Many people, however, overlook the cosmetics themselves. Cosmetics are human beauticians, but they are also potential environmental and organism killers. Some cosmetics ingredients used to enhance the effect may be dangerous. However, if these hazardous substances enter nature and exceed the carrying capacity of organisms and the environment, they will have an impact not
just on humans but also on the entire ecosystem. Because of hazardous substances in cosmetics, the system and the entire global ecosystem may be severely harmed and difficult to restore.

There are many cosmetics-related articles, such as those analyzing a specific hazardous ingredient in cosmetics, the influence of cosmetic hazardous substances in a specific area, and the harm caused by cosmetic hazardous substances to a specific organism. However, these articles frequently investigate only one type of cosmetic or one type of cosmetic hazardous ingredient, and there are few complete evaluations. Furthermore, most articles only analyze the types of hazardous substances in cosmetics and the harm they cause, rarely providing relevant technologies for scientific treatment, and ignoring the fact that the government, corporations, and the general public can all play an important role in dealing with hazardous substances in cosmetics.

This article discusses the hazardous substances found in cosmetics and the effects they have on the environment, organisms, and humans. Two technologies for efficiently dealing with hazardous substances in cosmetics are advocated, as well as the participation of the government, corporations, and the general public. The article aims to raise awareness of the public for the dangers of hazardous substances in cosmetics, as well as what possible technologies and ways exist to improve or solve the problem.

2. Hazardous substances in cosmetics

2.1 Heavy metal
Mercury, lead, cadmium, chromium, arsenic, cobalt, and nickel are common heavy metals in cosmetics [2], and there are generally heavy metals in cosmetics such as lipstick, blush, foundation, eye shadow, and so on. Heavy metals are not intentionally added to cosmetics, yet many talc and pigments used in cosmetics contain heavy metals, making heavy metals in cosmetics unavoidable. The most prevalent is whitening cosmetics, which frequently include excessive amounts of heavy metals, particularly mercury, which is thousands or even tens of thousands of times greater than safety standards.

2.2 Organics
Hormones are one of the organics added to cosmetics that are primarily used for the skin and are generally steroid hormones. Steroid hormones can be split into two categories based on pharmacological analysis: sex hormones and adrenal corticoids. Because glucocorticoids are the most commonly utilized form of steroid hormone, they are the primary detection object in the cosmetics detection procedure, and the common hydrocortisone and dexamethasone in cosmetics are all glucose metabolic corticoids [3]. In addition, several other organic chemicals are added to cosmetics to boost their effects. To begin with, phthalates are widely used in daily necessities. They serve a number of purposes, the most important of which is as a solubilizer. Phthalates, for example, are utilized in shampoos to stabilize the substance in liquid form [3]. Phthalates are humectants that are used in cosmetics to improve the moisturizing and hydrating properties of emollient products [4]. Second, because of their low cost, parabens are used as preservatives and antibacterial agents in cosmetics, and they are stable at different temperatures and have a good sterilizing action [3,5]. Furthermore, triclosan is a common bacteria inhibitor found in soaps and cosmetic cleansers [3].

2.3 Others
With the exception of heavy metals and organics, some cosmetic microorganisms exceed minimum standards and contain pathogenic microbes that cause significant harm to life. Some cosmetics, for example, include Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, and Bacillus [6]. The emergence of microbes can be attributed to a variety of factors. Cosmetic raw materials are not thoroughly disinfected, cosmetic manufacturing equipment is not cleaned and disinfected regularly, and personnel does not adhere to hygiene standards. Cosmetics may be contaminated by microorganisms found in hair, perspiration, or hands. At the same time, cosmetics are good areas for microorganisms to live. Cosmetics are often neutral or mildly acid-alkaline, and they are typically stored at ambient
temperature to provide an external environment for microorganisms. Cosmetics include a lot of water and a lot of nutrients for microorganism growth. Furthermore, there is a class of minerals, such as mica, talc, and quartz, that are ground into powder and used in cosmetics such as compacts or sprays, and which typically have a function in increasing skin gloss. These minerals are made up of numerous elemental compounds that may undergo chemical interactions throughout the cosmetics manufacturing process, resulting in higher harm.

3. The impact of hazardous substances

3.1 Environment

3.1.1 Water pollution
Hazardous substances enter the water body in essentially the following ways. The first is that cosmetics are dumped directly into the oceans, rivers, and lakes along with sewage. The second type of circumstance is more common by the coast or in densely populated places. Cosmetics containers are dumped in the oceans or rivers, releasing hazardous substances from the cosmetics into the water body. Water pollution is classified as surface water pollution and groundwater pollution, and the two are interconnected [7]. Surface water will permeate the earth and create groundwater, and groundwater can also be delivered upwards to the surface water source. As a result, when hazardous substances spill, they pollute both the surface and groundwater. When hazardous substances enter the water, their concentration gradually decreases at a very slow rate due to water's self-regulation ability, but the rate of concentration degradation is not even faster than the rate of discharge. So, whether heavy metals or hormones are dumped into water bodies, they will have irreversible impacts. For rivers and oceans, continuously accumulating hazardous substances in rivers and oceans will spread from a single area to the world's oceans along with currents or ocean currents; for lakes, because their self-regulation ability is far less than that of rivers and oceans, hazardous substances continuously entering the lake will lead to the disintegration of the lake's ecological environment; for groundwater, although groundwater is less likely to be contaminated by hazardous substances than other bodies of water, it is frequently utilized for animal or human drinking and agricultural irrigation, which can easily injure humans, animals, and plants.

3.1.2 Soil pollution
The poisoning of the soil with hazardous cosmetic substances is mostly caused by the penetration of cosmetics into the soil combined with sewage or solid waste. These hazardous substances will be absorbed due to the presence of pores in the soil. Hazardous substances, such as heavy metals and hormones, might react with the soil's natural components and kill microorganisms. These are the most essential factors influencing soil fertility and activity. Plants grown in this type of soil will absorb nutrients through their roots while also inhaling a significant number of hazardous substances, which may affect advanced organisms along the food chain, and the soil itself may degenerate and change as hazardous substances accumulate. If it is unsuitable for planting, it will result in a slew of issues relating to a lack of available land for agricultural development.

3.2 Organisms

3.2.1 The way of spreading
Animals and plants living in nature will inevitably be harmed if dangerous cosmetics ingredients are released into the environment. Heavy metals and hormones are mostly absorbed into the bodies of animals through two routes: foraging or direct touch, and they are continuously deposited in the animals' liver and kidneys. In the process of absorbing water and nutrients from the soil, plant roots absorb hazardous substances in the soil by ion exchange, and hazardous substances are delivered to each section of the plant via the plant's channel organization. The process of bioaccumulation is the accumulation of
dangerous substances in the body of a single organism. Bioaccumulation occurs when an organism absorbs hazardous substances quicker than the rate of catabolism and excretion to eliminate hazardous substances, and toxic substances are frequently digested extremely slowly in the organism, causing them to accumulate [8]. Hazardous substances will enter the food chain and be biomagnified, affecting the entire biosphere. The term "biomagnification" refers to the continuous accumulation of hazardous substances in the food chain, i.e., the accumulation of hazardous substances from the lowest producer to the most evolved predator [9].

3.2.2 The harm on organisms
Hazardous substances in cosmetics have a significant impact on the organism. First, consider heavy metals. According to the research of Zwolak et al. and Wang et al., the biological risks of different heavy metals can be arranged in the following order: Hg>Cu>Zn>Ni>Pb>Cd>Sn>Fe>Mn>Al [10-11]. Take the fish as an example. Fish growth can be hindered in heavy metal-rich water, making growth inhibition one of the most visible indicators of metal toxicity in fish larvae [12]. Water bodies with low heavy metal concentrations will not directly kill the fish but will create chronic stress, resulting in a drop in fish weight and size. Heavy metals can affect juvenile fish survival and growth, as well as produce atypical behaviors such as impaired athletic ability or structural damage, particularly spinal malformations. As a result, their ability to compete for food and habitat is reduced, perhaps leading to fish death or extinction. Then there are hormones. As an example, consider estrogen (E2). It has been determined that estrogen residues can affect the animal endocrine activity and impair sexual performance [13]. Among them, E2 residue is a type of endocrine disruptor with significant influence, with a particularly deleterious effect on fish [14-16]. E2 can accumulate in fish bile, ovaries, and testes, destroying natural fish activities [17]. Male fish in rivers can produce feminine features, such as Vitellogenin induction and gonadal alterations, when estrogen is present [18].

3.3 Humans
Humans are also at risk from hazardous substances included in cosmetics. The first category is heavy metals. Humans exposed to high amounts of cadmium (Cd) in a short period of time may have a variety of health problems such as diarrhea, vomiting, fever, lung damage, muscle soreness, and so on [19]. If you eat cadmium over an extended period of time, it can lead to more serious ailments such as kidney disease and bone damage, reproductive issues, and even cancer [20]. Chromium (Cr) is essential in the body's metabolic process, regulating blood sugar levels and assisting insulin in delivering glucose to cells [20]. However, only a very little quantity of chromium is required, and surpassing a specific threshold, particularly hexavalent chromium, is associated with a significant injury to the human body. Chromium is not hazardous in and of itself, but its compounds are poisonous and can cause widespread disease in the kidneys, liver, nervous system, and blood, ultimately leading to death. Lead (Pb) is one of the most common heavy metals found in cosmetics, and it can directly harm the body's major organs and systems. Lead-related disorders include kidney failure, hematological system diseases, cardiovascular diseases, nervous system diseases, and immune system impacts [20]. Humans exposed to low amounts of arsenic (As) may experience vomiting, irregular heartbeat, blood vessel damage, abdominal pain, diarrhea, numbness, and muscle cramps [20]. When humans are exposed to high levels of arsenic for an extended period of time, the symptoms mainly emerge in the skin, including changes in pigmentation, skin damage, and hard areas on the palms, and in extreme circumstances, it can cause lung cancer, skin cancer, bladder cancer, and kidney cancer. Furthermore, heavy metals in cosmetics, such as nickel, can damage immunity, memory, and exercise ability, as well as induce many types of cancer, which can be extremely harmful to people.

Furthermore, several organic substances found in cosmetics have varying degrees of effect on the human body. Long-term glucocorticoid therapy has been shown in trials to cause a variety of adverse effects, including "full moon face," obesity, delayed growth and development, metabolic abnormalities, decreased bone density, and anxiety and depression, particularly in younger children [21]. Phthalates have a negative impact on the male reproductive system in animals, causing hypospadias and
cryptorchidism, which diminish testosterone production and sperm counts. Phthalates are also endocrine disruptors.

4. Measures

4.1 Scientific technologies

4.1.1 Biology sorbents

Biosorbents are used in cosmetics to deal with heavy metal pollution. Biological adsorbents are more environmentally friendly and less expensive than chemical resins, which use chemical resins as the primary chemical adsorbents [22]. Biosorbents are classified into two types. The first comes from plants and agricultural byproducts like corn cobs and corn husks [23-24]. The second form of biosorbent is microorganisms, which are also the most common. Microorganisms have a far higher capability for metal adsorption than plants. Plant biology sorbents use holes between tissues to adsorb metal ions, whereas microorganisms use the nature of their cell wall components and metal-binding functional groups to collect metal ions [25]. As shown in Fig. 1, the mechanism of microbial biosorbents to adsorb heavy metals relies on tube energy groups such as carboxyl groups, phosphate groups, amine groups, and hydroxyl groups to achieve heavy metal adsorption via methods such as diffusion, surface adsorption, ion exchange, and complexation [26], and the presence of functional groups greatly improves the ability of microbial biosorbents to adsorb heavy metals.

![Fig 1. The mechanism of biology sorbents [26].](image)

4.1.2 Ultrafiltration composite membranes

Cosmetics hormone pollution can be effectively dealt with using ultrafiltration composite membranes. Because of its large adsorption capacity, activated carbon (AC) can absorb a wide range of dissolved
organic matter and can thus be utilized as one method of organic matter removal [27]. Among these, the ACF-PES ultrafiltration composite membrane stands out as being more capable of adsorbing and extracting hormones than pure AC membranes [28]. As shown in Fig. 2, there is a procedure for producing ACF-PES ultrafiltration composite membranes. In the first phase, cellulose fibers are transformed into short activated carbon fibers (ACF) via two processes of carbonization and activation [28-29]. The next stage is the fabrication of ACF-PES composite membranes, which is accomplished using a simple filtration procedure in which the ACF is deposited on the support layer of the polyethersulfone ultrafiltration membrane to produce the ACF-PES composite membrane with a sandwich structure [28]. Take 17-estradiol (E2) as an example of a hormone studied by Zhang et al. The capacity of the ACF-PES composite membrane to remove E2 under static conditions surpasses 97 percent, and the inclusion of PES greatly improves the rate [28]. The benefit of the interaction between E2 and ACF, such as hydrophobic contact, hydrogen bonding, and - buildup, explains why the ACF-PES composite membrane has a high clearance of hormone [28].

4.2 Government, corporation, public participation

4.2.1 Government

Relevant government departments, as legislators and corporate regulators, must assure the quality and safety of cosmetics. The first step is to put in place legally binding regulations for the cosmetics industry, such as manufacturing process standards and waste disposal methods, the maximum use of various chemical additives in cosmetics, the highest content of hazardous substances in cosmetics, and some cosmetics-related regulations and laws. As shown in Table 1, certain nations have implemented necessary laws that regulate the cosmetics industry's production standards and strictly limit the content of hazardous substances in cosmetics. The second task is to monitor the cosmetics sector. Check if cosmetics on the market fulfill regulatory standards at random, or whether cosmetic factories release wastewater and hazardous substances at will, remove non-compliant items from the shelves, and penalize enterprises that make non-compliant cosmetics.

| Countries | Regulations and laws                         |
|-----------|---------------------------------------------|
| Australia | The Industrial Chemicals Act 2019           |
| Canada    | The Food and Drugs Act; Cosmetic Regulations|
| China     | Regulation on Supervision and Administration of Cosmetics |
| EU        | Cosmetics Regulation (EC) No. 1223/2009     |
| India     | The Drugs and Cosmetics Act 1940            |
| Japan     | Pharmaceutical and Medical Devices Law      |
| USA       | The Federal Food, Drug & Cosmetic Act       |
4.2.2 Corporation
Cosmetics companies should follow national rules and regulations, accept oversight from relevant government departments and consumers, and promote the concept of purchasing eco-friendly products and appropriate purchases to consumers. The most essential task of the cosmetic industry is to manufacture green cosmetics. When manufacturing green cosmetics, it is critical to guarantee that the product adheres to green chemistry principles [30]. Green chemistry encompasses the full process of chemical design, manufacture, and application, and adhering to green chemistry principles can effectively decrease or remove hazardous substances and lessen cosmetics' environmental impact [30-31].

4.2.3 Public
The general public, as customers, should also be involved. The first is to refuse to purchase cosmetics that contain excessive levels of hazardous substances in order to safeguard the environment while also preserving our safety. Natural cosmetics, also known as green cosmetics, are made from extracts and concentrations of plants or fruits [32]. Green cosmetics do not employ chemical substances or other non-natural mixes in the manufacturing process, and they require less water, raw materials, and energy than conventional cosmetics, resulting in less pollution of the natural environment [33-34]. The second is reasonable garbage disposal cosmetics. As an example, when we go to the beach, we often witness individuals throwing away sunscreen bottles after using them, generating pollution. Cosmetics containers may have residual cosmetics. It is simple to pollute water or soil if they are discarded at will. Choose to dispose of cosmetics in the trash can, and the reusable plastic or paper box will be recycled by the garbage disposal station, which is a more environmentally responsible practice.

5. Conclusion
Cosmetics are widely utilized in daily life, and the influence of their hazardous constituents on the overall environment is frequently disregarded. This study shows that cosmetics contain harmful substances such as heavy metals, organic substances, and microorganisms. When they enter the environment, they may cause water and soil pollution, and may also accompany the food chain, causing health effects and even death at all levels of the organism. The article proposed two technologies to alleviate the pollution problem caused by hazardous substances: biosorbents and ACF-PES ultrafiltration composite membrane. At the same time, the article examines the government's, corporations', and individuals' responsibilities and obligations in the face of hazardous substances in cosmetics, as well as proposed solutions to the problems. If more equipment and advanced technology can be applied to the research on hazardous substances in cosmetics in the future, it may be possible to avoid the current research on only a single type of hazardous substance in cosmetics rather than all hazardous substances. This makes determining if there may be secondary reactions between hazardous substances that cause other effects impossible. The purpose of writing this article was to raise general awareness, provide a theoretical foundation to demonstrate the harmfulness of hazardous substances, and offer specific strategies to eliminate them in cosmetics.

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