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MICROPLASTIC-INDUCED ENDOCRINE DISRUPTION: AN AYURVEDIC APPROACH VIA DUSHI VISHA

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ABSTRACT
Microplastic have emerged as pervasive environmental contaminants capable of accumulating within biological system and disrupting endocrine homeostasis through oxidative stress, inflammation, endocrine-disrupting chemicals and alteration in hormonal signaling pathways. Increasing evidence that suggest that chronic exposure to microplastics may contribute to reproductive, metabolic, thyroid and neuroendocrine disorders. However, existing biomedical models primarily focus on isolated molecular mechanism are often fail to explain the cumulative, multisystem, and long-term consequences of chronic low-dose exposure. The present review explores microplastic-induced endocrine toxicity through Ayurvedic concept of Dushi Visha, a latent and persistent toxic state characterized by chronic retention of toxic substances, progressive tissue involvement, and delayed disease manifestation. Classical description of Dushi Visha was critically analysed and correlated with contemporary evidence regarding microplastic bioaccumulation, endocrine disruption, oxidative stress, inflammation, and physiological dysregulation. The review proposes a novel conceptual framework termed Endocrine Dushi Visha Syndrome (EDVS), wherein chronic exposure to bio-persistent environmental toxicants leads to Agni impairment, Srotovaigunya, Dhatu Dushti, endocrine axis dysregulation, and progressive depletion of Ojas. Furthermore, the concept of "Toxic Biological Memory" is introduced to explain how prolonged environmental exposure may induce persistent physiological alteration long before overt disease becomes clinically apparent. The proposed model integrates Ayurvedic toxicology with modern environmental health sciences and offers a system-based perspective for understanding the chronic and potentially transgenerational effects of microplastic exposure. Although conceptual in nature, this framework generates testable hypotheses for future interdisciplinary research and highlights the potential role of Environmental Ayurvedic Toxicology as an emerging field of scientific inquiry.

KEYWORDS: Microplastic, Endocrine Disruption, Dushi Visha, Environmental Toxicology, Ayurveda Agni, Ojas, Srotovaigunya, Bio-persistent, Toxic Stress, Endocrine Dushi Visha Syndrome.

INTRODUCTION
Microplastics (MPs), defined as plastic particles smaller than 5 mm, have emerged as one of the most pervasive environmental pollutants of the twenty-first century. Rapid industrialization, increased plastic consumption, and inadequate waste management have resulted in the widespread distribution of microplastics across terrestrial, aquatic, and atmospheric ecosystems. These particles have been detected in drinking water, seafood, table salt, fruits, vegetables, and indoor air, making human exposure virtually unavoidable.

Recent studies have demonstrated the presence of microplastics in human blood, lungs, placenta, breast milk, liver, and reproductive tissues, indicating their ability to cross biological barriers and accumulate within the body. Beyond their physical presence, microplastics function as carriers of numerous toxic substances, including bisphenol A (BPA), phthalates, per- and polyfluoroalkyl substances (PFAS), heavy metals, and persistent organic pollutants. Consequently, microplastics are increasingly recognized not merely as environmental contaminants but as biologically active toxicants capable of influencing multiple physiological systems.

Among the various health concerns associated with microplastic exposure, endocrine disruption has attracted considerable scientific attention. Endocrine-disrupting chemicals associated with microplastics can interfere with hormone synthesis, secretion, transport, receptor binding, and feedback regulation. Experimental evidence

suggests that chronic exposure to microplastics may affect the hypothalamic-pituitary-gonadal (HPG), hypothalamic-pituitary-thyroid (HPT), and hypothalamic-pituitary-adrenal (HPA) axes, contributing to reproductive dysfunction, metabolic disturbances, thyroid abnormalities, immune dysregulation, and altered stress responses. Notably, these adverse effects often arise from prolonged low-dose exposure and may remain clinically silent for years before manifesting as disease.

Although modern toxicology has identified several mechanisms underlying microplastic-induced endocrine toxicity, including oxidative stress, chronic inflammation, mitochondrial dysfunction, epigenetic alterations, and receptor-mediated hormonal interference, existing models largely focus on isolated molecular pathways or organ-specific effects. Such approaches often fail to explain the cumulative, multisystem, and progressive nature of chronic environmental toxicant exposure. Therefore, there is an increasing need for integrative frameworks capable of explaining how persistent low-dose toxicants gradually disrupt systemic homeostasis and contribute to chronic disease development.

Ayurveda offers a unique perspective for understanding chronic environmental toxicity through the concept of Dushi Visha. Classical Ayurvedic texts describe Dushi Visha as a latent form of poison that, despite losing its acute potency, remains retained within the body and produces delayed, cumulative, and multisystem pathological effects. The concepts of Agni, Srotas, Dhatu, and Ojas provide a systems-oriented framework for understanding how persistent toxic influences can impair metabolism, disrupt physiological communication networks, compromise tissue integrity, and diminish adaptive resilience. These characteristics exhibit striking parallels with the biological behavior of microplastics, including persistence, bioaccumulation, delayed manifestation, and widespread physiological consequences.

Despite the rapidly expanding literature on microplastic toxicity and endocrine disruption, most existing studies focus primarily on molecular, biochemical, and organ-specific mechanisms. Although these approaches have significantly improved understanding of microplastic-associated health risks, they often fail to explain the cumulative, latent, multisystem, and progressive nature of chronic low-dose environmental exposure. Similarly, while several Ayurvedic scholars have attempted to correlate modern environmental pollutants with the concept of Dushi Visha, these discussions remain largely descriptive and lack a comprehensive mechanistic framework. To date, no review has systematically integrated contemporary endocrine toxicology, exposome science, and classical Ayurvedic toxicological principles to explain microplastic-induced endocrine dysfunction. Furthermore, the potential relevance of concepts such as Agni impairment, Srotovaigunya, Dhatu Dushti, and Ojas depletion in the context of chronic environmental endocrine disruption remains insufficiently explored.

Therefore, the present review aims to critically examine microplastic-induced endocrine toxicity through the Ayurvedic concept of Dushi Visha and to propose a novel theoretical framework, termed Endocrine Dushi Visha Syndrome (EDVS). By integrating classical Ayurvedic toxicology with contemporary environmental health sciences, this review seeks to provide a systems-based perspective for understanding the chronic, cumulative, and potentially transgenerational consequences of microplastic exposure.

Dushi Visha: Ayurvedic Perspective

The Ayurvedic concept of Dushi Visha represents a remarkably advanced understanding of chronic toxicology that extends beyond the classical notion of acute poisoning. While most toxicological descriptions in ancient and modern medicine focus on immediate and overt manifestations following exposure to harmful substances, Ayurveda recognizes that certain toxic agents may persist within the body in a concealed form, producing subtle physiological disturbances that accumulate over time. This latent and progressive nature of toxicity is encapsulated in the concept of Dushi Visha.

Within Ayurvedic toxicology (Agada Tantra), Dushi Visha is described as unique form of residual or latent poison that persist within the body after losing its acute potency. Acharya Sushruta explains that poison which has become old, partially neutralized by antidotal measures, or weakened by environmental factors such as heat, sunlight, and wind may remain concealed within the body and subsequently manifest as Dushi Visha:

"जीर्णं विषघ्नौषधिभिर्हतं वा दावातपवातादिभिरल्पवीर्यम् ।

विषं हि दूषीविषतामुपैति निहितं कफेनासृक्पथेषु ॥" (सु. स. क. 2)

This classical description highlights the fundamental characteristics of Dushi Visha, namely reduced toxic potency, incomplete elimination, persistence within bodily tissue[]s and channels, and eventual disease manifestation under favourable conditions. The concept therefore extends beyond acute poisoning and provides a framework for understanding chronic, cumulative, and low-grade toxicity.

According to classical Ayurvedic literature, Dushi Visha refers to a poison that has lost its acute potency due to partial neutralization, prolonged storage, environmental influences, or repeated exposure to small quantities. Despite its reduced intensity, it is not rendered harmless. Instead, it remains within the body, escaping complete elimination and becoming embedded within tissues. This residual toxic burden exists in a dormant state and may remain clinically silent for extended periods before manifesting as disease. Thus, the pathological significance of Dushi Visha lies not in its immediate effects but in its ability to produce chronic and cumulative physiological disruption.

A distinctive feature of Dushi Visha is its interaction with the host's internal environment. Classical texts indicate that Dushi Visha remains enveloped by Kapha and localized within various tissues until activated by specific precipitating factors such as improper diet, unhealthy lifestyle, seasonal changes, emotional stress, excessive

exertion, impaired digestion, or weakened immunity. These factors facilitate the mobilization of latent toxicity, allowing it to spread through the body and initiate pathological processes. This understanding demonstrates an early recognition that disease development is influenced not only by the toxic agent itself but also by the susceptibility of the host and environmental conditions.

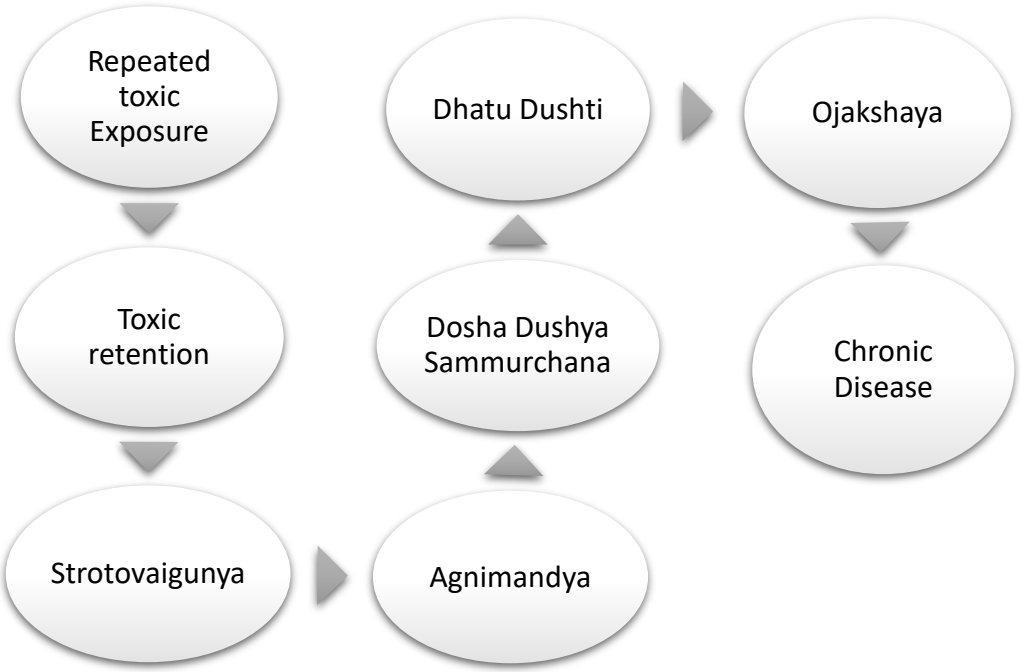
From a mechanistic perspective, Dushi Visha may be interpreted as a disturbance of the body's capacity to maintain internal homeostasis. Ayurveda places great emphasis on Agni, the transformative and regulatory principle responsible for digestion, metabolism, tissue nourishment, and physiological balance. Persistent toxic exposure can compromise Agni, leading to incomplete digestion and metabolism. Consequently, improperly processed metabolites accumulate within the body and interact with retained toxins, amplifying pathological changes. This process creates a self-perpetuating cycle of metabolic dysfunction and toxic retention.

From the perspective of Ayurvedic physiology, persistent Dushi Visha contributes to Srotodushti by causing obstruction, impaired transport, and dysfunction of physiological channels. As the integrity of the Srotas deteriorates, the movement of nutrients, metabolites and regulatory substances becomes compromised resulting in progressive loss of tissue homeostasis and systemic dysfunction.

The pathological progression of Dushi Visha can be understood through a sequence of interconnected events. Initially, chronic exposure results in the retention of toxic substances within bodily tissues. These retained toxins gradually impair the integrity of the Srotas, the channels responsible for transportation, communication, and exchange within the body. Impaired Srotas disrupt the movement of nutrients, waste products, and regulatory signals, thereby compromising tissue homeostasis. As metabolic and transport functions deteriorate, Doshas become vitiated and interact with susceptible tissues (Dushyas), resulting in Dhatu Dushti. Over time, these disturbances culminate in systemic dysfunction and depletion of Ojas, the fundamental determinant of vitality, resilience, and adaptive capacity.

The pathological effects of Dushi Visha may further be understood through the principle of Dosha Dushya Sammurchana. The retained toxin interacts with vitiated Doshas and susceptible Dhatus, initiating a cascade of pathological changes. Depending upon the predominance of the involved Dosha and the vulnerability of specific tissues, the resulting manifestation may vary considerably, accounting for the diverse clinical presentation of Dushi Visha.

This progression may be conceptualized as:



Owing to its chronic and cumulative nature, Dushi Visha gradually penetrates deeper Dhatus. Initially affecting Rasa and Rakta Dhatus, prolonged toxic retention may subsequently involve Mamsa, Meda, Asthi, Majja, and Shukra Dhatus. This progressive tissue involvement ultimately compromises Ojas, the essence of all Dhatus and the basis of Vyadhikshamatwa. As Ojas declines, susceptibility to the chronic disease increases and the body’s adaptive capacity becomes impaired.

Clinical Manifestation of Dushi Visha

The clinical presentation of Dushi Visha is generally insidious and non specific, reflecting its chronic and systemic nature. Classical Ayurvedic texts describe manifestations such as Aruchi, Ajirna, Tandra, gaurava, Kandu, Panduta, and Angamarda. These symptoms indicate the gradual impaorement of physiological functions resulting from persistant toxic burden.

Unlike acute poisoning, which typically produces rapid and organ-specific manifestations, Dushi Visha affects multipal tissues and physiological systems simulataneously.

Although Charak Samhita does not provide a separate chapter on Dushi Visha, it describes the concept of Gara Visha, which exhibits comparable characteristics of cumulative and delayed toxicity.

गरसंयोगजं चान्यद्गरसञ्ज्ञं गदप्रदम् । कालान्तरविपाकित्वान्न तदाशु हरत्यसून् ॥ (च.स.चि.24)

The phrase Kalantara Vipakitva (delayed manifestation after a period of time) is particularly relevant to microplastic exposure, where adverse endocrine and metabolic effects often emerge only after prolonged low-dose exposure

Acharya Charak further describes the progressive involvement of bodily systems by retained toxic influences.

"दूषीविषं तु शोणितदुष्ट्यारुःकिटिमकोठलिङ्गं च । विषमेकैकं दोषं सन्दूष्य हरत्यसून् ॥" (च.स.चि.)

This description suggests that the chronic toxic retention can progressively affect Doshas, Rakta, and Dhatus, producing multisystem dysfunction analogous to systemic effects associated with persistent environmental toxicants

As the retained toxin interacts with vitiated Doshas and susceptible Dhatus, a wide spectrum clinical manifestations may emerge, including digestive disturbances, dermatological disorders, allergic conditions, oedema, fatigue, reproductive dysfunction, cognitive impairement, reduced immunity and generalized debility. The diversity of these manifestation reflects the syatemic dissemination of latent toxicity and its capicity to dirupt multipal biological networks.

From an Ayurvedic perspective, the specific manifestations depends upon the predominance of affected Dosha, the extent of Stroto Dushti and the particular Dhatus involved. Consequently, Dushi Visha should be regarded not as single disease entity but as a pathological state capable of controbuting to develpoment of numerous chronic disorders

A particularly noteworthy aspect of Dushi Visha is its relevance to contemporary concepts of environmental health. Modern toxicology increasingly recognizes that many pollutants do not cause immediate toxicity but instead accumulate within biological systems, exerting low-grade effects over years or decades. Such substances may persist within tissues, induced chronic inflammation, generate oxidative stress, interfere with cellular signaling pathways, and disrupts endocrine regulation. These characteristics closely parallel the Ayurvedic description of Dushi Visha, suggesting that the concept may serve as a valuable framework for understanding modern environmental toxicants.

However, Dushi Visha should not be viewed merely as an ancient equivalent of chronic poisoning. Rather it may be interpreted as a sophisticated model of host-toxin interaction, wherein disease results from the dynamic interplay between toxic exposure, metabolic competence, tissue susceptibility, environmental influences, and adaptive capacity. This perspective aligns closely with emerging systems biology approaches the emphasize network dysfunction rather than isolated pathological events.

In the context of microplastic exposure Dushi Visha offers a particularly compelling conceptual framework. Microplastics are characterized by persistent environmental presence, chronic low-dose exposure, tissue accumulation, delayed biological effects and the ability to interact with multiple physiological systems. These features closely resemble the defining characteristics of Dushi Visha-like state that progressively disrupts metabolic, endocrine, immune and reproductive homeostasis. Consequently, Dushi Visha may be interpreted as an Ayurvedic prototype of chronic environmental toxicodynamic, providing a conceptual bridge between classical toxicology and emerging environmental health challenges.

In the present review, Dushi Visha is redefined as a state of Bio-Persistent Toxic Stress (BPTS), wherein chronic low-dose environmental toxicants evade complete biological clearance, interact with host susceptibility factors, and progressively disrupt systemic homeostasis.

The chronic, latent and cumulative nature of Dushi Visha is further acknowledged in Ashtang Hridaya, where retained toxic influences are recognized as capable of remaining dormant within the body and manifesting disease under favourable pathological conditions. Collectively, the description found in Sushrut Samhita, Charak Samhita and Ashtang Hridaya, indicates the Ayurveda possessed a sophisticated understanding of delayed and multisystem toxicity long before the emergence of modern environmental toxicology.

Microplastic-Induced Endocrine Toxicity: Modern Scientific Evidence

Sources of Microplastic Exposure

Microplastics (MPs), defined as plastic particles smaller than 5 mm, have become ubiquitous environmental contaminants and an emerging threat to human endocrine health. Human exposure occurs predominantly through ingestion, inhalation, and dermal contact. Contaminated drinking water, seafood, table salt, fruits, vegetables, packaged foods, and beverages represent major dietary sources of MPs. Inhalation exposure arises from airborne particles released from synthetic textiles, tire abrasion, household dust, and industrial emissions. Increasing evidence has demonstrated the presence of microplastics in human blood, lungs, placenta, breast milk, and gastrointestinal tissues, confirming systemic exposure and internal accumulation. Their small size, persistence, and resistance to degradation enable prolonged residence within biological systems, raising concerns regarding chronic toxicity.

Unlike conventional pollutants, MPs possess a high surface-area-to-volume ratio that facilitates adsorption and transport of environmental contaminants. Consequently, microplastics function not only as particulate pollutants but also as vectors carrying numerous toxic substances into the human body, thereby amplifying their biological effects.

Endocrine-Disrupting Chemicals Associated with Microplastics

A major concern regarding microplastic exposure is their association with endocrine-disrupting chemicals (EDCs). Plastic polymers contain numerous additives, including bisphenol A (BPA), phthalates, polybrominated diphenyl ethers (PBDEs), perfluoroalkyl substances (PFAS), organotins, polychlorinated biphenyls (PCBs), and heavy metals. Since these compounds are not permanently bound to the polymer matrix, they can readily leach into biological fluids and tissues following exposure.

Many EDCs exhibit structural similarities to endogenous hormones and can interact with estrogen, androgen, thyroid hormone, glucocorticoid, and peroxisome proliferator-activated receptors (PPARs). BPA, for example, binds to estrogen receptors (ERα and ERβ), whereas phthalates interfere with PPAR-mediated regulation of lipid metabolism and steroidogenesis. Through receptor agonism, antagonism, or altered signal transduction, these compounds disrupt hormone synthesis, secretion, transport, metabolism, and feedback regulation, ultimately disturbing endocrine homeostasis.

Molecular Mechanisms of Endocrine Toxicity

Microplastic-induced endocrine disruption is a multifactorial process involving direct particle toxicity, chemical toxicity, oxidative stress, inflammation, and epigenetic modifications.

- Hormone Receptor Interference

Plastic-associated EDCs can bind directly to hormone receptors and alter endocrine signaling pathways. These interactions disrupt transcriptional regulation of hormone-responsive genes and impair physiological feedback mechanisms. Experimental studies demonstrate disturbances in estrogenic, androgenic, thyroidal, and glucocorticoid signaling following MP exposure.

- Oxidative Stress and Mitochondrial Dysfunction

Oxidative stress is considered a central mechanism underlying microplastic toxicity. Cellular uptake of MPs leads to excessive generation of reactive oxygen species (ROS), resulting in lipid peroxidation, protein oxidation, mitochondrial dysfunction, and DNA damage. Endocrine tissues are particularly susceptible because hormone synthesis requires tightly regulated redox balance and high metabolic activity. Persistent oxidative stress impairs steroidogenic enzyme activity and compromises hormone production.

- Chronic Inflammation

Microplastics activate inflammatory pathways, particularly NF-κB-mediated signaling, leading to increased production of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6. Chronic low-grade inflammation disrupts endocrine signaling by altering receptor sensitivity and interfering with hormonal feedback loops. Oxidative stress and inflammation often coexist, creating a self-perpetuating cycle that exacerbates endocrine dysfunction.

- Epigenetic Alterations

Emerging evidence suggests that MPs and associated EDCs may induce DNA methylation, histone modifications, and microRNA dysregulation. Such epigenetic changes can alter endocrine gene expression and potentially contribute to long-term and transgenerational health effects.

Disruption of Major Endocrine Axes

- Hypothalamic–Pituitary–Gonadal (HPG) Axis

The reproductive endocrine system is among the most extensively studied targets of MP toxicity. Experimental studies demonstrate that MPs disrupt hypothalamic secretion of gonadotropin-releasing hormone (GnRH), alter pituitary gonadotropin release, and impair gonadal steroidogenesis. Exposure has been associated with reduced testosterone and estradiol levels, altered luteinizing hormone (LH) and follicle-stimulating hormone (FSH) secretion, impaired spermatogenesis, ovarian follicular degeneration, and reduced fertility. These effects are mediated through oxidative stress, endocrine receptor interference, and disruption of steroidogenic enzymes such as StAR, CYP19A1, and 3β-HSD.

- Hypothalamic–Pituitary–Thyroid (HPT) Axis

Microplastics and their associated EDCs can interfere with thyroid hormone synthesis, metabolism, transport, and receptor signaling. Experimental evidence indicates alterations in circulating triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH) levels following exposure. BPA, PBDEs, and phthalates have been implicated in disruption of thyroid hormone receptor activity and thyroid regulatory feedback mechanisms. Given the crucial role of thyroid hormones in metabolism, growth, and neurodevelopment, chronic HPT-axis disruption may have widespread physiological consequences.

- Hypothalamic–Pituitary–Adrenal (HPA) Axis

The HPA axis regulates stress responses through coordinated secretion of corticotropin-releasing hormone (CRH), adrenocorticotropic hormone (ACTH), and cortisol. Evidence suggests that MPs and associated EDCs can alter adrenal steroidogenesis, cortisol synthesis, and glucocorticoid signaling. Oxidative stress and inflammation further contribute to HPA-axis dysregulation, potentially leading to altered stress responses and neuroendocrine imbalance. BPA and phthalates have also been associated with cortisol dysregulation and adrenal dysfunction.

Reproductive, Metabolic, and Thyroid Effects

- Reproductive Effects

Reproductive toxicity is one of the most consistently reported consequences of MP exposure. Experimental studies have demonstrated reduced sperm count and motility, increased sperm DNA damage, testicular atrophy, ovarian inflammation, follicular loss, impaired oocyte maturation, and reduced fertility. These effects appear to result from combined endocrine disruption, oxidative stress, and inflammatory injury.

- Metabolic Effect

Microplastics are increasingly recognized as potential environmental obesogens. Through interactions with PPAR signaling pathways, insulin regulation, and adipocyte differentiation, MPs may contribute to obesity, insulin resistance, metabolic syndrome, and type 2 diabetes. Chronic inflammation and endocrine disruption further aggravate metabolic dysfunction, suggesting a potential role of MPs in the growing burden of metabolic diseases.

- Thyroid Effects

Disruption of thyroid hormone homeostasis may result in altered metabolic rate, impaired neurodevelopment, growth abnormalities, and systemic endocrine imbalance. Experimental studies consistently report alterations in T3, T4, and TSH levels following MP exposure, highlighting the thyroid gland as a critical target of plastic-associated endocrine toxicity.

Emerging Human Evidence and Research Gaps

Although experimental evidence strongly supports endocrine toxicity of microplastics, direct human evidence remains limited. Human studies have detected MPs in blood, placenta, lungs, and reproductive tissues and have reported associations with biomarkers of endocrine alteration, inflammation, and oxidative stress. However, causal relationships between chronic MP exposure and specific endocrine disorders have not yet been definitively established. Standardized exposure assessment methods, validated biomarkers, and long-term prospective studies are required to clarify the true magnitude of endocrine risk in humans.

Correlation Between Dushi Visha and Microplastic-induced Endocrine Toxicity

Although Dushi Visha and Microplastic-induced endocrine toxicity originate from different epistemological frameworks, both concepts describe chronic low-grade toxic insults capable of producing delayed multisystem dysfunction. A comparative analysis reveals remarkable similarities in their mechanism of persistence, systemic dissemination, tissue involvement, and disease manifestation.

The endocrine-disrupting potential of microplastics presents a unique opportunity to reinterpret the Ayurvedic concept of Dushi Visha beyond conventional toxicology. While Dushi Visha has traditionally been described in terms of chronic toxic retention and multisystem disease manifestation, its underlying principles may also provide insight into the subtle regulatory disturbances characteristic of endocrine dysfunction. Unlike acute toxic insults that produce structural damage, endocrine disruptors primarily interfere with communication networks that coordinate physiological processes. This pattern closely resembles the latent, progressive, and systemic nature of Dushi Visha.

From a modern perspective, endocrine-disrupting chemicals associated with microplastics alter hormonal synthesis, secretion, transport, receptor binding, and feedback regulation. These alterations often occur at extremely low concentrations and may remain clinically silent for prolonged periods before manifesting as metabolic, reproductive, neurobehavioral, or immunological disorders. Such delayed and cumulative effects parallel the Ayurvedic description of Dushi Visha, wherein retained toxins gradually compromise physiological equilibrium without producing immediate symptoms.

A particularly significant correlation may be established through the Ayurvedic concept of Agni. Beyond digestion, Agni represents the transformative intelligence governing metabolism and physiological regulation at multiple levels. Endocrine hormones similarly function as regulatory mediators coordinating growth, energy balance, reproduction, stress adaptation, and tissue maintenance. Persistent microplastic exposure may therefore be interpreted as a factor capable of disrupting the integrity of Agni at both systemic and tissue-specific levels. The resulting impairment of Dhatvagni may contribute to abnormal tissue metabolism, altered nutrient utilization, and defective Dhatu formation, creating conditions conducive to endocrine dysfunction.

The relationship between microplastic-induced endocrine toxicity and Dhatu physiology offers another important dimension of correlation. Hormonal signaling is fundamentally dependent upon the functional integrity of body tissues. Reproductive hormones may be linked to Shukra Dhatu, metabolic regulation to Meda Dhatu, neuroendocrine communication to Majja Dhatu, and circulatory transport of hormones to Rasa and Rakta Dhatus. Chronic toxic burden resulting from Dushi Visha-like exposure may progressively impair these Dhatus, thereby disrupting endocrine homeostasis at multiple levels simultaneously. Such an interpretation provides a systemic explanation for the multisystem effects observed in endocrine-disrupting chemical exposure.

Microplastic-associated endocrine toxicity may also be viewed through the lens of Srotas dysfunction. Hormones exert their physiological effects through complex networks of transport, signaling, receptor interaction, and feedback communication. Ayurveda conceptualizes such biological communication through the framework of Srotas. Persistent toxic accumulation may compromise the integrity of these channels, leading not only to physical obstruction but also to functional disturbances in intercellular and inter-organ communication. Consequently, endocrine disruption may be interpreted as a specialized manifestation of Srotovaigunya characterized by impaired physiological signaling rather than merely impaired material transport.

An additional point of convergence lies in the concept of Ojas. Modern endocrinology increasingly recognizes the interconnectedness of endocrine, immune, neurological, and metabolic systems. Microplastic exposure has been associated with immune dysregulation, chronic inflammation, stress responses, and reproductive abnormalities. Ayurveda regards Ojas as the ultimate determinant of vitality, adaptation, and systemic resilience. The gradual depletion of Ojas induced by persistent Dushi Visha may therefore correspond to the reduced physiological adaptability observed in individuals exposed to chronic endocrine-disrupting pollutants. In this context, endocrine dysfunction is not merely a hormonal imbalance but a manifestation of declining systemic resilience.

Furthermore, the endocrine effects of microplastics frequently involve multiple hormonal axes simultaneously, including the hypothalamic-pituitary-gonadal (HPG), hypothalamic-pituitary-thyroid (HPT), and hypothalamic-pituitary-adrenal (HPA) axes. This widespread dysregulation suggests disruption of a higher-order regulatory network rather than isolated glandular pathology. Ayurvedic pathology similarly emphasizes systemic imbalance arising from disturbances in Dosha, Agni, Srotas, Dhatu, and Ojas. Consequently, the multisystem nature of endocrine toxicity aligns more closely with the concept of Dushi Visha than with conventional organ-specific disease models.

Another noteworthy aspect is the potential transgenerational impact of microplastic exposure. Endocrine disruptors can influence reproductive health, fetal development, and epigenetic regulation, resulting in health effects that extend beyond the directly exposed individual. Ayurveda describes Dushi Visha as a toxin capable of deeply penetrating bodily tissues and affecting the reproductive essence. Through this lens, the reproductive and developmental consequences of microplastic exposure may be interpreted as manifestations of profound Shukra Dhatu impairment resulting from chronic toxic retention.

Based on the above correlations, this review proposes the concept of Endocrine Dushi Visha Syndrome (EDVS). EDVS may be defined as a chronic pathological state arising from prolonged exposure to bio-persistent environmental toxicants that accumulate within the body, impair Agni, disrupt, Srotas-mediated physiological communication, induce Dhatu dysfunction, and ultimately disturb endocrine homeostasis.

Table 1: Conceptual parallels between Dushi Visha and Microplastic-Induced Endocrine Disruption

S. No.	Feature	Dushi Visha	Microplastic-Induced Endocrine Toxicity
1.	Exposure	Repeated low-dose toxin	Chronic environmental exposure
2.	Persistent	Long term retention	Bioaccumulation
3.	Latency	Delayed manifestation	Delayed clinical effects
4.	System involvement	Multisystem	Multisystem
5.	Agni impairment	Present	Metabolic dysregulation
6.	Srotovaigunya	Present	Cellular signaling disruption
7.	Dhatu Dushti	Present	Tissue dysfunction
8.	Ojas depletion	Present	Reduced physiological resilience

Proposed Ayurvedic Model of Microplastic Toxicity: The "Toxic Memory" Hypothesis of Dushi Visha

Classical Ayurvedic toxicology describes Dushi Visha as a latent toxic state capable of persisting within the body long after the initial exposure has occurred. However, the traditional explanation can be expanded to accommodate contemporary environmental toxicants by viewing Dushi Visha not merely as retained poison but as a form of toxic biological memory.

In this context, microplastics do not produce pathology solely through their physical presence. Rather, they initiate persistent alterations in metabolic regulation, tissue responsiveness, endocrine communication, and physiological adaptability that continue even after the original exposure. Thus, the primary pathological event is not the toxin itself but the long-term imprint left by the toxin on biological systems.

This phenomenon may be conceptualized as Toxic Memory Formation, wherein repeated environmental exposure creates a chronic state of physiological dysregulation analogous to the Ayurvedic concept of Dushi Visha.

I.Phase I: Environmental Entry and Biological Recognition

Microplastics enter the body through inhalation, ingestion, and dermal contact. Upon entry, they encounter various physiological defense mechanisms. Unlike classical poisons that provoke immediate responses, microplastics often evade recognition because of their minute size and low acute toxicity.

From an Ayurvedic perspective, such substances behave as Sukshma and Vyavayi toxic entities, possessing the ability to penetrate deeply into tissues before overt manifestations become apparent.

The significance of this stage lies in the silent establishment of toxic burden without immediate disease expression.

II.Phase II: Adaptive Compensation and Hidden Toxicity

One of the most intriguing aspects of endocrine disruption is that the body initially compensates for hormonal disturbances.

For example:

- Mild thyroid disruption may not immediately alter thyroid hormone levels.
- Reproductive impairment may develop years before infertility becomes evident.
- Metabolic abnormalities may remain undetected despite ongoing cellular dysfunction.

Ayurveda similarly describes Dushi Visha as remaining concealed by physiological mechanisms until suitable triggering factors emerge.
Therefore, Dushi Visha may be interpreted as a state of compensated toxicity, wherein normal physiological function is maintained despite the presence of underlying toxic stress.
This interpretation offers a novel explanation for why many environmentally induced diseases have prolonged latency periods.

III.Phase III: Disturbance of Physiological Intelligence

A unique Ayurvedic contribution lies in the concept that physiological regulation depends upon coordinated communication between Agni, Dosha, Dhatu, Srotas, and Ojas.
Microplastic-associated endocrine disruptors interfere with biological signaling rather than causing direct structural destruction. Consequently, the earliest pathological event may be viewed as disruption of physiological intelligence, the body's capacity to appropriately sense, respond, and adapt to internal and external stimuli.
Examples include:

- Impaired hormonal feedback loops.
- Altered receptor sensitivity.
- Dysregulated stress responses.
- Disturbed metabolic adaptation.

This stage is conceptually distinct from tissue injury and corresponds more closely to loss of biological coordination.

IV.Phase IV: Dhatu Informational Dysfunction

Classical Ayurvedic descriptions of Dhatus are often interpreted structurally. However, Dhatus may also be viewed as functional information-processing systems responsible for maintaining tissue-specific activities.
Under chronic microplastic exposure:

- Rasa Dhatu: Loss of systemic regulatory balance and impaired physiological communication.
- Meda Dhatu: Distortion of energy sensing and metabolic signaling.
- Majja Dhatu: Neuroendocrine dysregulation and altered stress adaptation.
- Shukra Dhatu: Compromised reproductive signaling and developmental programming.

Thus, endocrine disruption may represent a form of Dhatu informational dysfunction rather than merely Dhatu depletion. This interpretation provides a more sophisticated explanation for multisystem endocrine effects.

V.Phase V: Collapse of Adaptive Resilience

A defining characteristic of chronic environmental diseases is reduced resilience. Individuals become increasingly vulnerable to:

- Metabolic disorders
- Infertility
- Thyroid dysfunction
- Immune dysregulation
- Neurobehavioral disturbances

Ayurveda attributes resilience to Ojas. Accordingly, prolonged toxic memory eventually erodes Ojas, diminishing the body's ability to maintain equilibrium in the face of environmental challenges. At this stage, disease becomes clinically apparent.

Novel Hypothesis

Microplastic- induced endocrine disruption represents a modern manifestation of Dushi Visha in which persistent environmental toxicants create a state of toxic biological memory, progressively impairing physiological intelligence, Dhatu functionality, and adaptive resilience long before overt disease becomes clinically detectable.

Therapeutic and Preventive Implications

The proposed interpretation of microplastic-induced endocrine disruption as a contemporary manifestation of Dushi Visha suggests that therapeutic strategies should extend beyond conventional detoxification paradigms. Since microplastics act as persistent environmental stressors capable of altering endocrine communication, metabolic regulation, immune function, and physiological adaptability, their management requires a systems-based approach. From an Ayurvedic perspective, the objective is not merely toxin removal but restoration of biological resilience, correction of metabolic dysfunction, preservation of tissue integrity, and enhancement of adaptive capacity. Accordingly, the management of microplastic-associated endocrine toxicity may be conceptualized through six interconnected therapeutic pillars.

1. Nidana Parivarjana: Interrupting the Toxic Exposure Cycle

In classical Ayurveda, successful management begins with elimination of the causative factor. In the context of microplastic toxicity, Nidana Parivarjana assumes even greater importance because exposure is continuous, often involuntary, and environmentally pervasive.
Unlike acute poisons, microplastics create a state of cumulative toxic loading. Therefore, therapeutic interventions may have limited effectiveness if ongoing exposure continues to replenish the toxic burden. The first step is therefore the interruption of the exposure–accumulation cycle.
This includes:

- Avoiding plastic containers for hot food and beverages.
- Minimizing consumption of highly processed and packaged foods.
- Reducing exposure to synthetic textiles that release microfibers.
- Using glass, stainless steel, clay, or copper alternatives where appropriate.
- Improving indoor air quality to reduce inhalation of airborne microplastics.
- Encouraging sustainable lifestyle practices that reduce environmental plastic contamination.

From an Ayurvedic standpoint, Nidana Parivarjana may be viewed as preventing the continuous formation of new Dushi Visha, thereby allowing physiological mechanisms to gradually restore equilibrium.

2. Agni Deepana: Restoring the Metabolic Barrier Against Toxicity

One of the most innovative aspects of the proposed model is the recognition of Agni as a biological defense system against chronic environmental toxicity.

Traditionally, Agni is understood as the principle responsible for digestion and metabolism. However, within the context of environmental toxicology, Agni may be reinterpreted as a metabolic surveillance system that governs the transformation, neutralization, and clearance of potentially harmful substances.

Microplastic-associated endocrine disruptors interfere with metabolic signaling, energy homeostasis, and cellular communication. These disturbances resemble Agnimandya, where physiological transformation becomes inefficient.

Deepana therapy therefore serves not only digestive purposes but also:

- Enhances metabolic adaptability.
- Supports biotransformation pathways.
- Maintains endocrine-metabolic coordination.
- Improves tissue responsiveness.

Particularly relevant Deepana Dravyas include:

- Pippali
- Chitraka
- Shunthi
- Maricha
- Trikatu formulations

Future research may explore whether Agni-enhancing interventions influence xenobiotic metabolism, endocrine regulation, and toxicant clearance.

3. Ama Pachana: Targeting the "Ama–Microplastic Interaction"

A novel hypothesis proposed in this review is that chronic microplastic exposure may promote the formation of an Ama-like biological state.

Ama is traditionally described as incompletely processed material resulting from impaired metabolic transformation. Modern parallels may include:

- Chronic inflammatory mediators.
- Oxidative stress products.
- Dysfunctional metabolic intermediates.
- Cellular debris resulting from persistent toxic stress.

Microplastics may amplify this pathological milieu by continuously stimulating inflammatory and oxidative pathways.

Thus, Ama Pachana becomes more than digestive correction; it becomes a strategy aimed at reducing the biological consequences of chronic toxic exposure.

Potential actions include:

- Reduction of inflammatory burden.
- Improvement of metabolic efficiency.
- Restoration of tissue signaling.
- Prevention of secondary pathological cascades.

Herbs with significant Ama-Pachana potential includes Guduchi, Musta, Haritaki, Vacha, Panchakola etc. In this context, Ama Pachana may be viewed as disrupting the pathological synergy between toxic retention and metabolic dysfunction.

4. Rasayana: Rebuilding Adaptive Resilience

Perhaps the most important therapeutic implication of the proposed model lies in the application of Rasayana therapy.

Microplastic-induced endocrine disruption is increasingly recognized as a disorder of reduced adaptability. Chronic toxic exposure progressively diminishes the body's ability to maintain homeostasis in response to environmental challenges.

Ayurveda conceptualizes this adaptive capacity through Ojas.The therapeutic goal therefore extends beyond toxin removal and focuses on restoration of resilience.

Rasayana therapy may theoretically:

- Improve stress adaptation.

- Enhance immune-endocrine communication.
- Reduce oxidative damage.
- Preserve reproductive health.
- Support neuroendocrine stability.
- Delay toxicant-induced biological ageing.

From a systems perspective, Rasayana may be interpreted as an intervention that strengthens biological robustness against chronic environmental stressors.

Particularly relevant Rasayana agents include:

- Amalaki: Supports antioxidant defense and tissue nourishment.
- Guduchi: Promotes immunological balance and metabolic regulation.
- Ashwagandha: Supports stress adaptation and neuroendocrine function.
- Shatavari: Protects reproductive and endocrine health.
- Yashtimadhu: Provides anti-inflammatory and tissue-protective effects.

A unique research direction would be investigating Rasayana therapy as an adaptogenic strategy for environmental toxicology.

5. Panchakarma: Resetting the Internal Ecosystem

The role of Panchakarma in environmental toxicology extends beyond traditional detoxification concepts.

Modern research increasingly recognizes the importance of biological "reset mechanisms" that restore physiological balance after prolonged stress exposure.

Within the proposed model, Panchakarma may be interpreted as a method for correcting systemic dysregulation, restoring Srotas function, improving metabolic coordination, re-establishing Doshic equilibrium, enhancing adaptive capacity.

- **Virechana:** May be particularly relevant where inflammatory and metabolic disturbances predominate.
- **Basti:** Potentially beneficial in restoring neuroendocrine regulation and systemic communication networks due to its profound influence on Vata.
- **Nasya:** May theoretically support neuroendocrine pathways through its action on the cranial region.

Rather than viewing Panchakarma solely as toxin elimination, future studies may investigate its role in restoring physiological communication networks disrupted by chronic environmental exposure.

6. Environmental Prevention: Expanding Ayurveda Beyond the Individual

A truly novel implication of this review is the extension of Ayurvedic thought from personal health to environmental health. Classical Ayurveda emphasizes harmony between the individual (Purusha) and the environment (Loka). Microplastic pollution represents a disruption of this relationship.

Consequently, management cannot be confined to individual-level interventions. An Ayurvedic environmental prevention strategy should include:

- Reduction of plastic dependency.
- Promotion of biodegradable alternatives.
- Sustainable consumption patterns.
- Environmental conservation initiatives.
- Public health education regarding environmental toxicants.
- Integration of ecological responsibility into healthcare policy.

This approach aligns closely with the Ayurvedic principle that preservation of environmental health is essential for preservation of human health.

Important consideration and limitations

While the therapeutic strategies discussed above are conceptually derived from Ayurvedic principles, their application in microplastic induced endocrine toxicity remains largely hypothetical. Currently, there is insufficient clinical evidence to conclude that Ayurvedic interventions can directly eliminate microplastics or reverse their biological accumulation. Rather, these approaches are proposed as resilience-enhancing, metabolic-supportive, and system-restorative consequences of chronic environmental exposure. Rigorous experimental and clinical studies are require to validate their efficacy in the context of environmental toxicology.

The Future Therapeutic Paradigm: Environmental Rasayana

Environmental Rasayana can be defined as a set of preventive and therapeutic measures aimed at enhancing human resilience against chronic environmental stressors through optimization of Agni, preservation of Ojas, restoration of Dhatu integrity, and reduction of cumulative toxic burden.

Unlike conventional toxicological approaches that primarily focus on identifying and eliminating harmful agents, Environmental Rasayana emphasizes enhancement of host resilience. The central premise is that long term health outcomes are determined not only by the magnitude of toxic exposure but also by organism’s capacity to adapt, cover, and maintain physiological equilibrium. In this sense, environmental Rasayana may represent a resilience based medical model that complements contemporary approaches in preventive medicine, system biology, and environmental health.

Future Research Directions

The proposed reinterpretation of microplastic-induced endocrine disruption through the lens of Dushi Visha opens several avenues for interdisciplinary research. While the present framework remains largely conceptual, it provides a foundation for developing experimentally testable hypotheses that integrate Ayurvedic principles with modern environmental health sciences. Future investigations should focus on validating the biological relevance of Dushi Visha in the context of chronic environmental toxicants and establishing evidence-based models for prevention and management.

I . Biomarkers for Dushi Visha: Toward an Objective Assessment of Chronic Toxic Burden

One of the major challenges in translating the concept of Dushi Visha into contemporary scientific discourse is the absence of measurable biomarkers. Classical descriptions emphasize latent toxicity, progressive tissue involvement, and delayed disease manifestation; however, objective indicators capable of identifying this state before clinical disease develops remain unexplored.

Future research should aim to develop a Dushi Visha Biomarker Signature (DVBS) by integrating Ayurvedic clinical assessment with modern biochemical, endocrine, inflammatory, and metabolomic parameters. Potential candidate markers may include:

- Chronic low-grade inflammatory mediators.
- Oxidative stress indicators.
- Endocrine hormone imbalances.
- Mitochondrial dysfunction markers
- Gut microbiome alterations.
- Epigenetic modifications associated with toxic exposure.

Rather than relying on a single laboratory parameter, Dushi Visha may ultimately be characterized by a multidimensional biomarker profile reflecting cumulative physiological dysregulation. Such an approach could facilitate early identification of individuals at risk for chronic toxin-related disorders.

II. Correlation of Microplastic Burden with Prakriti: An Ayurvedic Precision Toxicology Approach

The health consequences of microplastic exposure vary considerably among individuals despite similar levels of environmental contact. This observation suggests that host susceptibility plays a critical role in determining disease outcomes.

Ayurveda addresses individual variability through the concept of Prakriti, which influences physiological responses, metabolic capacity, tissue resilience, and disease predisposition. Future studies should investigate whether individuals with different Prakriti types exhibit variations in:

- Microplastic accumulation.
- Endocrine sensitivity.
- Inflammatory responses.
- Oxidative stress burden.
- Reproductive outcomes.
- Recovery potential following exposure.

Such investigations may contribute to the development of Ayurvedic Precision Toxicology, a novel field that combines constitutional assessment with environmental risk evaluation. Understanding the interaction between Prakriti and environmental toxicants may help identify vulnerable populations and facilitate personalized preventive strategies.

III. Experimental Validation of Endocrine Dushi Visha Syndrome (EDVS)

The concept of Endocrine Dushi Visha Syndrome (EDVS) proposed in this review represents a theoretical model linking chronic environmental exposure with endocrine dysfunction through the intermediary processes of Agni impairment, Srotovaigunya, Dhatu Dushti, and Ojas depletion. Future research should focus on establishing experimental models capable of validating this hypothesis. Such studies may involve:

- Long-term low-dose microplastic exposure models.
- Assessment of endocrine and metabolic alterations over time.
- Evaluation of chronic inflammatory and oxidative responses.
- Investigation of reproductive and thyroid dysfunction.
- Correlation of biological findings with Ayurvedic indicators of Dushi Visha.

Validation of EDVS would represent a significant step toward bridging classical Ayurvedic toxicology and modern environmental endocrinology, transforming a theoretical construct into a scientifically testable model.

IV. Panchakarma-Based Studies in Environmental Toxicology

Although Panchakarma is traditionally regarded as a purification and restorative therapy, its potential role in managing chronic environmental toxicity remains largely unexplored.

Future investigations should move beyond the simplistic question of whether Panchakarma can “remove toxins” and instead evaluate its effects on systemic physiological regulation. Potential research areas include:

- Influence on endocrine function
- Modulation of inflammatory biomarkers.
- Effects on oxidative stress and mitochondrial health.
- Improvement in metabolic flexibility.

- Changes in gut microbiota composition.
- Restoration of physiological resilience following chronic toxic exposure.

Particular attention should be given to Basti, Virechana, and Rasayana-supported Panchakarma protocols, as these interventions may influence neuroendocrine, metabolic, and immune pathways implicated in microplastic toxicity.

Such studies would provide valuable evidence regarding the role of traditional Ayurvedic interventions in contemporary environmental health challenges.

V. Development of Environmental Ayurvedic Toxicology

The emergence of pollutants such as microplastics, endocrine-disrupting chemicals, heavy metals, nanoparticles, and persistent organic contaminants highlights the need for an expanded toxicological framework capable of addressing modern environmental realities.

Future scholarship should focus on establishing Environmental Ayurvedic Toxicology as a distinct interdisciplinary field integrating

- Agada Tantra.
- Environmental health sciences.
- Endocrinology.
- Systems biology.
- Exposome research.
- Public health.

This discipline would seek to reinterpret classical toxicological concepts—including Dushi Visha, Gara Visha, Agni, Ama, Ojas, and Srotas—in the context of contemporary environmental exposures.

Rather than viewing Ayurveda solely as a therapeutic system, Environmental Ayurvedic Toxicology could provide a conceptual framework for understanding how chronic environmental stressors influence biological systems across the lifespan and even across generations.

VI. Exposome–Dushi Visha Interface: A New Research Paradigm

An important future direction involves exploring the relationship between the modern concept of the human exposome and the Ayurvedic concept of Dushi Visha.

The exposome encompasses the cumulative environmental exposures experienced throughout life, whereas Dushi Visha describes the cumulative physiological consequences of retained toxic influences. Investigating this interface may reveal novel insights into how environmental exposures become biologically embedded and eventually manifest as chronic disease.

This approach could facilitate the development of integrated models that combine environmental exposure assessment with Ayurvedic pathophysiological principles, creating a more comprehensive understanding of chronic disease causation.

VII. Transgenerational Toxicity and Shukra Dhatu Research

Microplastic-induced endocrine disruption has raised concerns regarding reproductive health and potential transgenerational effects. Future studies should investigate whether the Ayurvedic concept of Shukra Dhatu can provide a framework for understanding the inheritance of toxic effects across generations.

- Research in this area may explore:
- Reproductive outcomes following chronic exposure.
- Epigenetic alterations.
- Developmental programming.
- Fertility and offspring health.
- Correlation with classical descriptions of Shukra Dushti.

Such investigations may contribute to a deeper understanding of how environmental toxicants influence not only present health but also future generations.

CONCLUSION

The present review proposes that microplastic-induced endocrine disruption may be interpreted as a contemporary manifestation of Dushi Visha, characterized by bio-persistent toxic stress, Agni-Dhatu-Endocrine Axis Dysregulation, and progressive depletion of physiological resilience. By integrating classical Ayurvedic toxicology with modern environmental health science, the proposed Endocrine Dushi Visha Syndrome (EDVS) model offers a novel framework for understanding the chronic and transgenerational consequences of microplastic exposure.

Unlike conventional toxicological approaches that primarily focus on isolated molecular mechanisms or organ-specific pathology, the Ayurvedic perspective provides a systems-based understanding of how persistent environmental toxicants interact with metabolism, tissue integrity, physiological communication networks, and adaptive capacity. The concepts of Agni, Srotas, Dhatu, and Ojas collectively offer a comprehensive framework for explaining the latent, cumulative, and multisystem nature of endocrine disruption induced by chronic microplastic exposure.

The remarkable parallels between the defining characteristics of Dushi Visha and the biological behavior of microplastics—including persistence, bioaccumulation, delayed manifestation, multisystem involvement, and

progressive physiological deterioration—suggest that classical Ayurvedic toxicology possesses significant relevance in addressing contemporary environmental health challenges. Furthermore, the reinterpretation of Dushi Visha as a state of Bio-Persistent Toxic Stress (BPTS) expands its applicability beyond traditional poisons and positions it as a conceptual model for understanding emerging environmental toxicants.

The proposed EDVS framework also highlights the importance of moving beyond disease-centered approaches toward resilience-centered strategies that emphasize preservation of Agni, maintenance of Dhatu integrity, protection of Ojas, and reduction of cumulative toxic burden. Such an approach aligns with current trends in systems biology, exposome research, preventive medicine, and environmental health sciences.

Although the concepts presented in this review remain theoretical, they generate several testable hypotheses regarding the relationship between chronic environmental exposure, endocrine dysregulation, metabolic dysfunction, and long-term health outcomes. Future interdisciplinary studies integrating Ayurveda, toxicology, endocrinology, molecular biology, and environmental sciences are required to validate these hypotheses and establish their clinical significance.

Ultimately, this review advocates for the emergence of Environmental Ayurvedic Toxicology as a new area of scientific inquiry. By bridging ancient toxicological wisdom with contemporary environmental challenges, this approach may contribute to the development of innovative preventive, diagnostic, and therapeutic strategies for managing the growing burden of microplastic-associated disorders. In an era increasingly defined by chronic environmental exposures, the concept of Dushi Visha may provide not merely a historical analogy but a valuable theoretical framework for understanding the complex relationship between environmental pollutants and human health.

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