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BIOMAGNIFICATION AND BIOACCUMULATION IN ENVIRONMENTAL TOXICOLOGY: AN AYURVEDIC INTERPRETATION THROUGH DUSHIVISHA AND GARAVISHA"

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ABSTRACT

Biomagnification refers to the progressive concentration of toxic substances as they move up the food chain, whereas bioaccumulation describes the gradual build-up of toxins within an organism over time. Modern environmental toxicology identifies these mechanisms as major contributors to chronic toxicity arising from pesticides, heavy metals, persistent organic pollutants (POPs), microplastics, and synthetic chemicals. Ayurveda, particularly Agadatantra (toxicology), presents comparable concepts through Dushivisha and Garavisha—forms of slow-acting, cumulative, and artificial poisons. This narrative review provides a comparative analysis of modern toxicological principles and Ayurvedic constructs, highlighting shared mechanisms, clinical manifestations, public health implications, and integrative detoxification strategies. Recognizing these intersections may contribute to more comprehensive approaches for addressing chronic environmental toxicity and developing preventive and therapeutic strategies.

KEYWORDS: Biomagnification, bioaccumulation, Dushivisha, Garavisha.

INTRODUCTION

In today's world, humans are exposed to various toxic substances on daily basis such as pesticides, industrial effluents, vehicle emission, and plastics. Air, soils, and water supplies are polluted with toxic elements and organic compounds. Along with chemical contamination there exists the problem of radioactive pollution.[1,2]

These toxins persist in the environment and infiltrate the food chain, leading to long-term retention within biological systems. Environmental toxicology recognizes biomagnification and bioaccumulation as two critical mechanisms responsible for chronic exposure and multi-system health effects.

Ayurveda offers an ancient yet strikingly relevant framework to understand similar pathological states. Agadatantra describes chronic poisoning mechanisms through Dushivisha (cumulative poison) and Garavisha (artificial chemical poison) which closely parallel modern toxicological interpretations. This article bridges these classical and contemporary concepts to provide a holistic understanding of chronic environmental toxicity and cumulative poisoning.

MATERIALS AND METHODS

Classical Ayurvedic textbooks such as Sushrutha Samhitha, Caraka Samhitha, Astanga Sangraha, Astanga Hridaya and scientific articles were reviewed for documenting the information on Gara visha and Dushi visha.

A thorough review of the research articles and published literature were done using online scientific search engines for information on Bioaccumulation, Biomagnification and related concepts.

Bioaccumulation

Bioaccumulation can be defined as the net accumulation of a trace element in a tissue of interest or a whole organism that results from exposure. Trace element bioaccumulation can apply to the entire organism (including both the trace element adsorbed to surfaces or absorbed by the organism) or to specific tissue. The bioaccumulation of trace elements arises from all environmental sources, including air, water, solid phases, and diet.[3]

Bioaccumulation is the gradual collection of toxic substances within the tissues of a living organism over time. The rate of toxin uptake exceeds the rate of elimination, causing progressive build-up. Bioaccumulation is significantly influenced by the nature of the substances involved, including their chemical properties and the organism's ability to metabolize them. Studies show that persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs) and mercury, tend to bioaccumulate in human tissues over time[4] (Fig. 1).

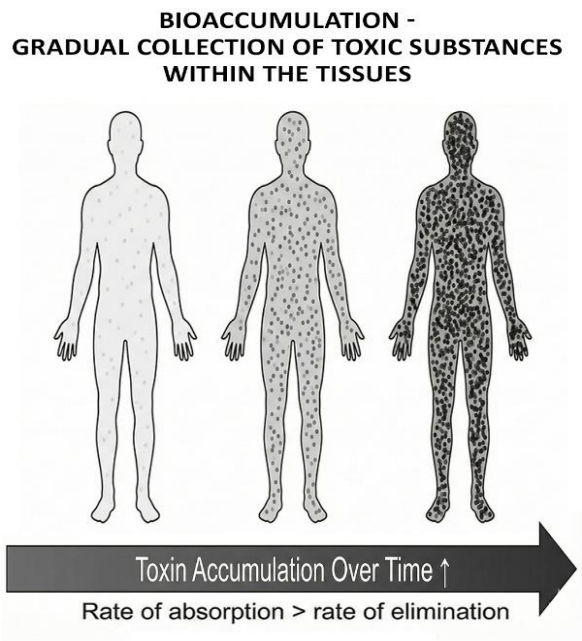

FIG. 1

Biomagnification

Biomagnification is an increase in the concentration in an organism from a lower trophic level to a higher trophic level within the same food web due to bioaccumulation from the diet. Biomagnification describes the increasing concentration of a substance as it moves up the food chain. This process is particularly relevant for persistent organic pollutants (POPs) and certain heavy metals.[5] As these substances move through trophic levels, their concentrations can increase dramatically, potentially posing significant risks to top-level consumers, including humans.[4]

Biomagnification refers to the amplification of toxin concentration from one trophic level to the next in a food chain. Substances that are chemically stable, lipid-soluble, and resistant to metabolism—such as DDT, dioxins, PFAS chemicals, and mercury—become more concentrated in organisms higher up the ecological pyramid.[6] Humans, being apex consumers, sustain the highest toxic load. (Fig. 2).

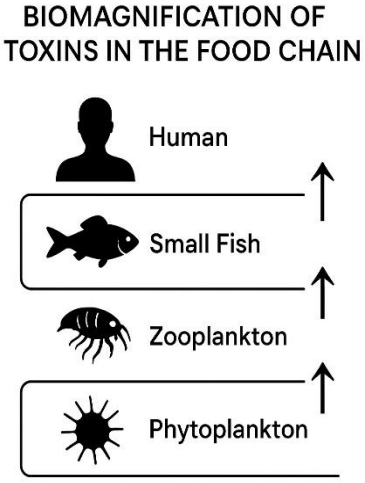

FIG. 2

Health effects of bioaccumulated and biomagnified toxins include

The health implications of bioaccumulation and biomagnification in humans are substantial. Exposure to bioaccumulated contaminants has been associated with various adverse health effects, including neurodevelopmental disorders, endocrine disruption, and increased cancer risk. Moreover, the biomagnification of certain pollutants in the food chain can lead to higher exposure levels in populations relying on contaminated food sources.[4]

Ayurvedic Parallels: Dushivisha and Garavisha

Dushivisha: Any poison either Sthavara (inanimate), Jangam (animate) or Kritim Visha (artificial), which has not eliminated completely from the body or partially nullified after the using of anti-poisonous remedies, after exposure to fire, the wind, the sun etc. and also the Visha devoid of ten qualities is called Dushi Visha. It does not cause immediate fatality because of its alpa veerytwa(mild potency) and due to avarana by kapha it stays inside the body for a long time.[7]

According to other definition of Sushruta, frequent exposure to dushita(contaminated, polluted) desha (Habitat), kaala (season), food (Anna) and day sleep (Diwaswapna) leads to vitiation of bodily tissues and is called dushi visha.[8] The symptoms are followed by sense of intoxication after consuming food, indigestion, anorexia, appearance of red patches all over the body, oedema of the face and extremities, urticaria, fainting, ascites, vomiting, diarrhoea,

discoloration, epileptic attacks, intermittent fever and increased thirst.[9]

Garavisha: Garavisha is a combination of poisonous or non-poisonous substance which exerts toxic effect after sometime and it doesn't kill the person instantly. Gara visha may be given through anna (food), Pana (drinks), Utsadana (massage), Anulepana (application), Anjana (eye lid application), pariseka (bath). Pandu(anemia), poor digestion, udarrog(GI disorders), Grahani(sprue), Fever, Gulma(tumours), Odema on hands and feet, flatulence, wasting are explained the clinical features of garavisha.[9]

Table 1: Showing parallel description of ayurvedic and modern concepts.

Ayurvedic Concept	Description	Modern Equivalent
Dushivisha	Mild, degraded, or attenuated poison that remains latent and accumulates over time; triggers symptoms during stress, seasonal changes or low immunity	Bioaccumulation
Garavisha	Artificial toxic combinations created from unnatural substances; potent but slow acting	Industrial chemicals, pesticides, preservatives, synthetic pollutants & microplastics
(Combined) Sannipataka Effects	Multisystem chronic damage	Systemic chronic toxicity

Both Dushivisha and Garavisha exhibit

- Delayed manifestation of symptoms
- Progressive accumulation in tissues
- Triggered toxicity during physiological vulnerability

Table 2: Showing Comparison of Pathophysiology.

Modern Toxicology	Ayurvedic Toxicology
Oxidative stress	Agnimandya (weak digestive-metabolic fire)
Free radical damage	Dhatu kshaya (tissue depletion)
Endocrine disruption	Dhatvagni vikriti (disrupted tissue metabolism)
Cellular and mitochondrial injury	Srotorodha (blockage of microchannels)
Bioaccumulated chemical load	Dushivisha–Garavisha retention

Clinical Correlation

Common chronic toxicity features in both frameworks include:

- Fatigue and brain fog
- Skin diseases and allergies
- Poor appetite and digestive disturbance
- Infertility and menstrual disorders
- Mood changes, irritability, anxiety
- Hepato-renal dysfunction These match modern observations from mercury exposure, pesticide ingestion, microplastic toxicity, and heavy metal accumulation

Ayurvedic Interventions

- Shodhana: Detoxification through procedures such as Vamana (emesis) or Virechana(purgation)
- Administration of Agadas: Agada are specific formulations explained for treatment of toxicity in Ayurveda ex: Bilwadi agada, Dushi vishari agada etc.
- Rasayana therapy – rejuvenation and organ repair

Modern Interventions

To minimize the risks associated with bioaccumulation and biomagnification, comprehensive environmental management strategies are necessary. Regulations aiming to limit the release of heavy metals and POPs into water bodies are crucial. Additionally, public awareness campaigns can help educate communities, particularly those reliant on fishing and aquaculture, about the risks of consuming contaminated fish. Furthermore, advancements in remediation technologies offer promising avenues for detoxifying contaminated environments.

Other Interventions Include

- Source elimination and dietary modification
- Chelation therapy (for heavy metals)
- Antioxidant supplementation

DISCUSSION

This review demonstrates substantial conceptual overlap between modern environmental toxicology and Ayurvedic constructs of *Dushivisha* and *Garavisha*. Both describe slow-acting, cumulative toxic states that arise from prolonged exposure to low-grade toxins and manifest as multisystem disorders.

Modern science identifies lipid solubility, protein binding, oxidative stress, and impaired xenobiotic metabolism as key drivers of toxin accumulation. These observations parallel Ayurvedic ideas of Agnimandya (impaired digestion), **Ama accumulation** (toxic residue) **Srotorodha**: blockage of cellular channels causing

Dhatu**vikriti**: representing disruptions in tissue-level metabolism.

The rise of POPs, PFAS, plasticizers, and endocrine disruptors highlights the urgent need to reassess ancient principles under contemporary environmental challenges. Conditions described as *Dushivisha-induced*—such as allergies, metabolic instability, and chronic inflammatory states—are increasingly prevalent in polluted urban environments. Ayurvedic preventive measures offer practical frameworks for exposure reduction. Public health initiatives may benefit from integrating Ayurvedic lifestyle practices to mitigate toxin burden.

Ayurveda provides both *Shodhana* (biological purification) and *Shamana* (palliative) approaches for toxin removal. Agadas are known to have anti oxidant, anti inflammatory, cytoprotective effects to revers the damage caused by toxin exposure.

CONCLUSION

Bioaccumulation and biomagnification represent major yet often overlooked causes of chronic toxicity. Ayurveda's Dushivisha and Garavisha provide a classical model parallel to contemporary toxicology, illustrating that ancient scholars recognized cumulative and artificial poisoning processes long before modern science. Integrating both approaches may help achieve a more comprehensive understanding of environmental illness, enabling preventive healthcare and holistic detoxification strategies.

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