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Indian Knowledge System and Chemistry: Unveiling the Science Behind Traditional Practices: A Review Paper

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Abstract: ***The Indian Knowledge System (IKS) has a wealth of scientific knowledge, especially in the field of chemistry, which was closely related to customs in everyday life, metallurgy, medicine, and alchemy. The scientific underpinnings of traditional Indian chemical methods, their validation by contemporary research, and their applicability today are all examined in this paper. Ayurvedic medicine, sustainable material science, metallurgical developments, and Rasayana Shastra (alchemy) are important fields. The study emphasizes sustainability and creativity while highlighting how ancient Indian scientists created complex chemical processes that are consistent with modern scientific ideas.***

Keywords: IKS, ayurvedic, chemistry, bhasmas, neel, haridra

1. Introduction

Chemistry, broadly defined as the study of matter and its interactions, has a rich history within the Indian Knowledge System (IKS). Ancient Indian texts like the Vedas and other classical literature provide insights into various chemical processes, including metallurgy, medicine, and the manufacture of dyes and cosmetics. In order to comprehend its distinct viewpoint on chemistry, IKS also places a strong emphasis on a holistic approach to knowledge, combining philosophical ideas, spiritual insights, and scientific observations. Advanced knowledge of chemical processes can be found in India's traditional knowledge systems, which are recorded in Vedic literature, Ayurveda, and classical Sanskrit works.

Unlike Western alchemy, which sought to transform base metals into gold, Indian Rasayana focused on therapeutic and metallurgical applications. This paper reviews: Ancient Indian contributions to material science and metallurgy. Ayurvedic herbo - mineral formulations and their modern validation, traditional techniques in dyeing, perfumery and cosmetics and the sustainability aspect of ancient Indian chemistry.

Historical Development of Chemistry in India

Vedic and Post - Vedic Period Atharva Veda mentions metals like gold (Hiranya), silver (Rajata), and iron (Ayas). Charaka Samhita (300 BCE–200 CE) and Sushruta Samhita (600 BCE) describe chemical processes for drug preparation. Kautilya's Arthashastra (4th century BCE) details metal testing, dyeing, and poison detection methods. The Classical and Medieval Period Nagārjuna (8th–9th century CE) documented pioneer of Rasayana Shastra, authored Rasendra Mangala and Rasarnava. Alchemical texts like Rasaratnakara and Rasahrdaya Tantra discuss mercury processing, metal purification, and bhasma preparations.

Key Contributions of Indian Chemistry

Rasayana Shastra (Indian Alchemy) depicts how the Ancient Indians developed processing techniques for mercury (Parada) such as Shodhana (purification), Jarana (incineration), and Marana (calcination). Transmutation claims i. e., attempts to convert metals, though not scientifically validated, indicate early experimentation. Siddha and Ayurvedic Rasayanas formulations like Makardhwaja and Swarna Bhasma used nanoparticle - like structures for enhanced bioavailability. The Delhi Iron Pillar erected during the Gupta Empire (4th - 5th century CE), is renowned for its corrosion resistance. The pillar is found to contain high phosphorus (0.1–0.25%) and low sulfur/manganese, forming a protective passive layer of misawite (δ - FeOOH). This contrasts with modern stainless steel, which uses chromium. Wootz Steel originating in South India around 300 BCE–300 CE, Wootz (from Tamil "ukku" or Kannada "uruku") was a high - carbon crucible steel. Produced by melting iron with carbonaceous materials in sealed crucibles, it created layered microstructures (carbides) that gave Damascus swords their strength and distinctive patterns. Centers like Kodumanal and Mel - siruvalur were key production sites. Wootz steel influenced Middle Eastern Damascus blades and later European metallurgy. The Zawar mines in Rajasthan (6th–12th century CE) pioneered large - scale zinc extraction using downward distillation. Zinc ore (sphalerite) was heated in retorts to vaporize zinc, which was then condensed, avoiding oxidation. This method predated European zinc production by centuries. Zinc distillation techniques from Zawar were precursors to industrial methods. Panchaloha, a five - metal alloy (gold, silver, copper, zinc, iron) used in sacred idols, was believed to have spiritual and durability benefits. Brass (copper - zinc) and bronze (copper - tin) were found to be widely used. The Chola bronzes (9th–13th century CE), crafted via lost - wax casting, exemplify intricate metal working. Kautilya's Arthashastra (4th century BCE) treatise details state management of mines, metal purification, and alloying. Nagarjuna's alchemical text, Rasa Ratnakara (7th–8th century CE) covers metal transmutation and mercury use, blending chemistry and metallurgy. With regard to construction materials, ancient structures employed durable lime mortars and stonework. Temples like those at Khajuraho used weathering - resistant sandstone and intricate masonry.

Ayurvedic herbo - mineral formulations, known as Rasa Shastra, combines herbs, metals, minerals, and animal products. These formulations have been used by Indians for centuries to treat chronic diseases, enhance immunity, and rejuvenate the body. Key herbo - mineral formulations include:

Bhasmas, which was calcined metals/minerals processed via Shodhana (purification) and Marana (incineration) to reduce toxicity. Examples include *Swarna Bhasma* (gold), *Tamra Bhasma* (copper) and *Yashada Bhasma* (zinc). Swarna Bhasma (Gold ash) was a bioavailable gold nanoparticles used in rejuvenation therapy. Tamra Bhasma was used for liver disorders; modern studies confirm antioxidant properties. *Rajata Bhasma,* a nanoparticulate silver in Bhasmas demonstrates antibacterial properties akin to colloidal silver. Neuroprotective effects like *Mandura Bhasma* (iron), was later found to improves cognitive function in iron - deficiency models by modulating brain iron homeostasis. *Rasayana***,** was a rejuvenating formulations like Chyawanprash (herbs + minerals) and Brahma Rasayana. *Sindoora* was a mercury sulfide - based pigment formulations (e. g., Kajjali, a mercury - sulfide compound). *Lauha Kalpas***,** an Iron - based tonics (e. g., *Loha Bhasma* for anemia). *Asava - Arishta* was a fermented medicines which was alcohol - based extractions for enhanced potency.

Indian traditional techniques in dyeing, perfumery, and cosmetics are deeply rooted in ancient wisdom, sustainability, and cultural heritage. These practices reflect a profound understanding of natural materials and their applications, blending artistry with chemistry. India was famed for cotton textiles and indigo dye. Advanced dyeing techniques, including mordant use, created vibrant, colorfast fabrics traded globally. Indigo (Neel), was extracted from *Indigofera tinctoria*, used for deep blue hues. India was the primary global supplier until synthetic dyes emerged. The fermentation process to extract indigo is still practiced in regions like Tamil Nadu and Andhra Pradesh. Its chemical structure was later identified as indigotin. Turmeric (Haridra) which was found to contains curcumin, produces vibrant yellow shades, used for ritual garments and Holi celebrations. It is now studied for its anti - inflammatory effects. Kajal a soot - based eyeliner was later found to possess antimicrobial properties due to carbon nanoparticles

Scientific Validation of Traditional Practices

Ancient calcination and grinding techniques produced nanoparticles (confirmed via SEM/TEM studies). TEM/SEM studies reveal that Bhasmas are often nanocrystalline (10–100 nm), enhancing bioavailability and reducing toxicity. For example, *Swarna Bhasma* contains gold nanoparticles (AuNPs) with anti - inflammatory effects. Copper water storage (Tamra Jal) Ayurveda recommends storing water in copper vessels. This system is now proven to have antimicrobial effects (oligodynamic action). Ancient use of turmeric and Curcumin as an anti - inflammatory aligns with modern research on curcumin's antioxidant and anticancer properties. Herbs in formulations like *Arogyavardhini Vati* (mercury, iron, herbs) act as reducing/capping agents during metal processing, stabilizing nanoparticles.

Sustainability and Green Chemistry in IKS Zero - Waste Approaches

The Indian Knowledge System (IKS) embodies a holistic approach to sustainability, deeply rooted in traditional practices that align with modern green chemistry principles and zero - waste goals. This integration is evident across diverse domains such as medicine, agriculture, crafts, architecture, and daily rituals, reflecting a harmonious relationship with nature. Ayurveda utilizes natural herbs and minerals, emphasizing non - toxic, biodegradable substances. For example, *Triphala* (a blend of three fruits) and *Ashwagandha* processing methods often use the whole plant, minimizing waste and can thus be considered as renewable resources. Traditional distillation techniques capture volatile oils efficiently, aligning with green chemistry's atom economy principle i. e., waste prevention. By - products like herbal residues are repurposed as compost or animal feed. Textual foundations of the *Charaka Samhita* advocates sustainable harvesting of medicinal plants, ensuring ecological balance. Traditional methods minimized waste (e. g., use of cow dung in metal purification). Natural dyes and herbal medicines were biodegradable materials i. e., eco - friendly.

2. Challenges and Future Directions Standardization

There is need for scientific validation and quality control of traditional formulations. However, modernization pressures such as industrialization and chemical - intensive agriculture threaten traditional practices. Balancing scalability with authenticity now remains critical. Policy initiatives and programs like *Swachh Bharat Abhiyan* and organic farming schemes integrate IKS with modern waste management, bridging tradition and innovation. Integration of IKS with modern science has a high thoughput potential for ayurvedic nanomedicine and sustainable metallurgy.

3. Conclusion

Ancient India's contributions to material science and metallurgy were marked by empirical innovation and technical prowess. From corrosion - resistant iron to high - carbon steel and zinc distillation, these advancements reflect a deep understanding of material properties and their applications, leaving a lasting legacy in both Eastern and Western technological traditions.

Ayurvedic herbo - mineral formulations represent a sophisticated interplay of ancient wisdom and material science. Modern studies validate their potential in targeted therapies, particularly through nanotechnology and synergistic herb - mineral interactions. However, addressing toxicity concerns, standardization, and mechanistic clarity remains critical for global acceptance. As integrative medicine grows, these formulations may bridge traditional knowledge and evidence - based science, offering novel solutions for chronic and complex diseases.

Indian traditions in dyeing, perfumery, and cosmetics are a testament to the synergy between nature, art, and science especially in chemistry. These practices not only shaped global trade and aesthetics but also offer sustainable solutions

for modern industries. By preserving these techniques, India continues to celebrate its cultural identity while contributing to the global demand for eco - conscious luxury.

The Indian Knowledge System in chemistry as a whole was not merely empirical but deeply scientific, with many practices now validated by modern research. Rediscovering and integrating these traditions can lead to innovative, sustainable solutions in medicine, material science, and environmental chemistry. The Indian Knowledge System offers timeless strategies for sustainability, resonating with green chemistry's emphasis on hazard reduction and resource efficiency. By revitalizing these practices through education, policy, and community engagement, India can lead in global zero - waste transitions, proving that ancient wisdom and modern science can coexist for planetary well - being.

References

[1] *The Wonder That Was India* by A. L. Basham.
[2] *Delhi Iron Pillar: New Insights* (R. Balasubramaniam).
[3] Archaeological Studies at Zawar Mines (J. S. Kharakwal).
[4] *Rasa Ratnakara* (Nagarjuna) and *Arthashastra* (Kautilya).
[5] Umapati C. Baragi, Jyoti M. Ganer (2025). Bridging Ancient Wisdom and Modern Learning: The Shift in Ayurvedic Curriculum and NCISM Innovations. *Journal of Ayurveda and Integrated medical Sciences.* Vol No 10 (3).73 - 110.
[6] Baby Shalini C, Doss A, Ahamed Kabir N (2025). Quantification of the Ethnomedicine Data Collected from the Kanikkars in Kanyakumari District, Tamil Nadu, India. *International Journal of Ayurvedic Medicines*. Vol.16 (1), 106 - 129.
[7] "*Chemistry And Chemical Techniques In India*": (History of Science, Philosophy and Culture in Indian Civilization: Vol. IV, Part 1). B. V. Subbarayappa.
[8] "*Indian Knowledge Systems: A Comprehensive Analysis of Various Contexts*". Dr. Shashikant Awasthi.
[9] "*Indian Knowledge Systems*". Kapil Kapoor.
[10] "*Introduction to Indian Knowledge System: Concepts and Applications*". B. Mahadevan.
[11] *"Exploring the Indian Knowledge System: Chemical Sciences in Tradition and Modernity"*. Yashi Goyal
[12] *Iron pillar and nanopowder.* Prakash, B. G. (2002, August 29). The Hindu, 16.
[13] *Rasashala: Ancient Indian Alchemical Lab* - Google Arts & Culture. (n. d.). Google Arts & Culture. https: //artsandculture. google. com/story/rasashala - ancient - indian - alchemicallab - national - council - of - science - museums/VAVBaP1RF0y - KQ?hl=en
[14] Sriram, M. S. (2021, February 11). Chemistry in Ancient India, from Harappan to Ayurvedic period. The New Indian Express. https: //www.newindianexpress. com/opinions/2021/Feb/11/chemistry - inancient - india - from - harappan - to - ayurvedic - period - 2262489. html