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A REVIEW ON METAL TOXICITY AND ITS TREATMENT THROUGH PHYTO-CHELATION THERAPY

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ABSTRACT

Metals such as cobalt, iron, zinc, copper and manganese, etc. are essential for various physiological and biological processes. However, excess intake of these metals and accidental consumption of other heavy metals induces harmful effects inside the body. The toxicity of metals arises when they present in high amounts or specific chemical form which is unsuitable for human body. The widespread use of metals especially heavy metals due to the industrialization increases their distribution in environment which rising concerns about their impact on human health. Exposure to heavy metals through inhalation, dermal contact and ingestion can cause various health issues since metallic ions interact with human cellular components leading to toxic effects. Cardiovascular diseases, neurobehavioral abnormalities, diabetes, neurological disorders, cancer and blood disorders, etc. are major health issues associated with heavy metal toxicity. Medical science recommends effective therapeutic approaches for combating this issue and phyto-chelation therapy is one such approach. Medicinal herbs can be used in this regard for removing heavy metals and their side effects. This article highlights clinical aspects of heavy metal toxicity and its treatment through phyto-chelation therapy.

KEYWORDS: Agadtantra, Herbal, Metal-Toxicity, Chelation.

INTRODUCTION

Metals are essential for the purpose of nutritional fulfillment and performing various physiological processes. Metals like iron, zinc, cobalt, copper, manganese and chromium, etc. play vital role in human body. However, heavy metals can also become toxic when present in excessive amounts or some heavy metals can induce toxicity even in trace amount. The application of heavy metals in industries results their abundance in environment as well as in human body. This becomes serious concern about the impact of heavy metals on human health. The toxic impact of some heavy metals on human body is as follows[1-4]:

- ✓ Mercury causes sensory disabilities, anorexia, fatigue, cardiovascular disease, hypertension and irritability, etc.
- ✓ Cadmium poisoning leads hair loss, anemia, kidney problems and hypertension, etc.
- ✓ Lead toxicity in children is responsible for delayed mental development, while in adults it may leads anemia, loss of appetite, headaches, insomnia and fatigue, etc.
- ✓ Arsenic exposure causes headaches, fatigue, loss of hair and muscular weakness, etc.

Toxic metals can enter into human body through various modes as depicted in **Figure 1**. After entering in body metals interact with DNA, proteins and other cellular components leading to the severe health effects including cancer, cardiovascular diseases, neurological disorders and metabolic abnormalities, etc.[2-4]

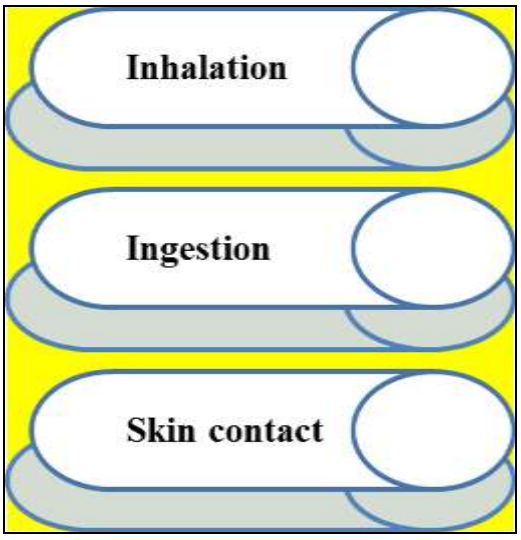

Figure 1: Various mode of entry of heavy metals in human body.

As mentioned above the heavy metals can enter in human body by various means and causes toxic events inside the body if consumed inappropriately or in excess amount. The accidental invasion of these toxic metals is difficult to prevent therefore it is important to identify effective treatment strategies for heavy metal toxicity. The commonly used approach for removing heavy metals from the body involves the administration of chelators. Medicinal plants recently have garnered attention as potential chelators for heavy metal poisoning. Medicinal herbs such as *Allium sativum*, *Silybum marianum*, *Coriandrum sativum*, *Ginkgo biloba*, *Curcuma longa* and *Triphala*, etc. can be used effectively in treating heavy metal toxicity.[5,6]

Phytochelation for Heavy Metal Toxicity

Herbs contain chelating agents that reduce bioavailability and absorption of heavy metals. Herbal treatments may enhance gastrointestinal motility which further facilitates quicker excretion of toxic metals. This becomes effective adjunct method to reducing heavy metal poisoning, particularly when exposure arise due to the ingestion. Plant produces natural chelating compounds, which bind to heavy metals and affect their bioavailability as well as metabolism. These natural chelating agents help in metal detoxification and also reduces their absorptions thus provide care against heavy metal toxicity. Natural polymers and citrus pectin acts as heavy metal absorbents. Additionally sulfur containing dietary substances such as garlic and onions helps in heavy metal elimination. Similarly *Coriandrum sativum* also been noted for its detoxifying properties.[6-8]

Phytochelatins

Phytochelatins, are oligomers of glutathione, synthesized by the enzyme phytochelatin synthase found in fungi, algae and plants. They play vital role in heavy metal detoxification. Phytochelatins consist of amino acids like cysteine, glycine and glutathione are involved in the detoxification of cadmium and other metals like mercury and lead, etc. Phytochelatins works as follows:

- **Activation of Phytochelatin Synthase**: When an organism is exposed to toxic metal ions like cadmium, copper, or lead, these metals can enter cells. Phytochelatin synthase is an enzyme activated in response to the presence of these metal ions. It synthesizes phytochelatins from glutathione, a tripeptide.
- **Formation of Metal-Phytochelatin Complexes**: These phytochelatins bind with metal ions, forming stable complexes that reduce the toxicity of free metal ions by chelating them.
- **Transport to Vacuoles**: The metal-phytochelatin complexes are then transported to vacuoles, specialized cellular compartments that help in sequestering harmful substances.
- **Binding with Sulfides and Organic Acids**: Within the vacuoles, the complexes often interact with sulfides and organic acids, which further aid in the detoxification and immobilization of metals.

The major medicinal herbs effective in treating heavy metal poisoning includes *Silybum marianum*, *Allium sativum*, *Ginkgo biloba*, *Curcuma longa*, *Coriandrum sativum* and *Triphala*, etc. Additionally, cruciferous vegetables, such as cauliflower, cabbage and broccoli, etc. are rich in sulfur-containing compounds thus contribute towards metal detoxification process.[5,6,8-12]

Garlic

Allium sativum (Garlic) contains organosulfur compounds that support process of heavy metal detoxification. Garlic as natural substance helps to prevent toxicity caused by lead and arsenic by sustaining liver function. Heavy metals induces oxidative stress, garlic prevents damage caused by free radicals thus imparts protective effects against heavy metal induced oxidative stress. This protective effect of garlic mainly resists toxicity caused by heavy metals such as cadmium, mercury and lead. Garlic reduces accumulation of these metals in kidneys, bones and liver thus prevent histopathological damage of these tissue. Garlic lowers mercury accumulation in brain and increases its excretion. These all effects of garlic can be attributed to its chemical composition which mainly contains sulfur that helps in detoxification processes. Sulfur components bind to heavy metals and facilitate their excretion *via* bile and feces.

Coriandrum sativum

Coriandrum sativum possesses potential for detoxifying heavy metals, particularly mercury. *Coriandrum sativum* helps in mercury clearance, prevent lead accumulation in bone tissue and prevent oxidative damage.

Ginkgo biloba

Ginkgo biloba is renowned for its antioxidant properties, acts as free radical scavenger and offering protective benefits against sensory disorders caused by metal toxicity along with other factors. *Ginkgo biloba* is effective herbal remedy for treating lead poisoning. It traps free radicals, thereby reduces oxidative stress, restoring glutathione levels and inhibits lead-induced damage. *G. biloba* significantly suppresses lipid peroxidation caused by lead poisoning and mitigating harmful effects of lead toxicity.

Turmeric (*Curcuma longa*)

Turmeric has been used in Ayurvedic medicine for centuries to treat various ailments. Curcumin is well-known for its protective and anti-inflammatory effects. It reduces liver toxicity caused by heavy metals like cadmium, lead, mercury and arsenic, etc. This effect associated with ability of curcumin to prevent lipid peroxidation. Curcumin reduces histological damage, restores glutathione levels and neutralize free radicals due to its chelating properties.

Triphala

Triphala is an ancient Ayurvedic formulation, consists dried powders of *Amalaki*, *Terminalia bellirica* and

Haritaki. *Triphala* is well known for its anti-inflammatory and antibacterial properties. In context to heavy metal toxicity it is effective in improving gastrointestinal motility, which helps in elimination of heavy metals from the body. It facilitate overall detoxification process and removes toxins from the body.

Herbal Fibers

Herbal fibers detoxify heavy metals by enhancing gastrointestinal motility, which accelerates the removal of toxins through the feces and bile elimination. Pectin as herbal fiber binds with heavy metals, thus facilitate their detoxification and prevent their accumulation. Pectin attracts positively charged heavy metals with its negatively charged carboxylic groups and finally eliminates them from body. This chelating action also prevents distribution of heavy metals inside the body.

Algae

Green algae known for their ability to absorb mercury; *Chlorella* is a green algae which effectively clears mercury from the digestive system and connective tissues. Due to its chlorophyll content, it acts as a chelator, thus binds heavy metals like lead and mercury. It also can detoxify neurotoxins like mercury and other harmful substances.

CONCLUSION

Utilization of chelating agents is the most common treatment approach for heavy metal toxicity. *Allium sativum*, *Silybum marianum*, *Coriandrum sativum*, *Ginkgo biloba*, *Curcuma longa*, along with phytochelatins, *Triphala*, green algae and herbal fibers offers therapeutic power for managing heavy metal poisoning. *Allium sativum* is known for excreting lead, cadmium and mercury. *Coriandrum sativum* facilitates removal of mercury and lead. *Ginkgo biloba* helps in the lead detoxification. *Curcuma longa* is effective in excreting arsenic, chromium, lead and cadmium. The key benefits of phytochelators in managing heavy metal toxicity are as follows:

1. **Metal Detoxification:** Phytochelators bind toxic heavy metals (like cadmium, lead, and mercury), reducing their free concentration and minimizing cellular damage.
2. **Prevention of Oxidative Stress:** By chelating metal ions, they prevent metal-induced oxidative stress, which otherwise leads to reactive oxygen species production and cellular damage.
3. **Metal Sequestration:** Phytochelators transport metal complexes into vacuoles, isolating the metals from critical cellular components and reducing their harmful effects.
4. **Stabilization of Metal Ions:** They form stable complexes with metals, preventing the metals from interacting with important biological molecules like proteins and DNA.
5. **Facilitation of Metal Homeostasis:** Phytochelators help in maintaining metal homeostasis, ensuring that essential metals (like zinc and copper) are available in safe, usable forms.
6. **Protection of Enzymes and Cellular Structures:** By binding toxic metals, they protect enzymes and structural proteins from metal-induced inhibition or denaturation.

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