eISSN 2581-8996
[Date]
THE INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN MULTIDISCIPLINARY SCIENCES (IJARMS)
A BI-ANNUAL, OPEN ACCESS, PEER REVIEWED (REFEREED) JOURNAL
Vol. 3, Issue 01, Jan 2020

Toxicity Of Chromium On The Environment

[1]Dr. Shailendra Kumar Shukla

[1]Associate Professor, Department Of Chemistry, DBS College, Kanpur, Uttar Pradesh

Received: 12 Jan 2020, Accepted: 19 Jan 2020, Published on line: 30 Jan 2020

Abstract

Hexavalent chromium [Cr(VI)] is a known carcinogen when inhaled. However, inhalational exposure to Cr(VI) affects only a small portion of the population, mainly by occupational exposures. In contrast, oral exposure to Cr(VI) is widespread and affects many people throughout the globe. In 2008, the National Toxicology Program (NTP) released a 2-year study demonstrating that ingested Cr(VI) was carcinogenic in rats and mice. The effects of Cr(VI) oral exposure is mitigated by reduction in the gut, however a portion evades the reductive detoxificationand reaches target tissues. (1)

Chromium (Cr) is a trace element critical to human health and well-being. In the last few decades, its contamination, especially hexavalent chromium [Cr(VI)] form in both terrestrial and aquatic ecosystems, has amplified as a result of various anthropogenic activities. Chromium pollution is a significant environmental threat, severely impacting our environment and natural resources, especially water and soil. Excessive exposure could lead to higher levels of accumulation in human and animal tissues, leading to toxic and detrimental health effects. Several studies have shown that chromium is a toxic element that negatively affects plant metabolic activities, hampering (2)

Crop growth and yield and reducing vegetable and grain quality. Thus, it must be monitored in water, soil, and crop production system. Various useful and practical remediation technologies have been emerging in regulating chromium in water, soil, and other resources. A sustainable remediation approach must be adopted to balance the environment and nature.

Keywords: Chromium; Contamination; Environment; Human health; Plant;

Introduction

Chromium is used mainly in metal alloys such as metal-ceramics, stainless steel, and is used as chrome plating. It has high value in the industrial world because it can be polished to a mirror-like finish, and provides a durable, highly rust resistant coating, for heavy applications. On the flip side, chromium can also provide health benefits to humans.

Chromium is a naturally occurring heavy metal found in the environment commonly in trivalent, Cr(III), and hexavalent, Cr(VI), forms. The reduction of Cr(VI) to Cr(III) results in the formation of reactive intermediates that contribute to the cytotoxicity, genotoxicity and carcinogenicity of Cr(VI)-containing compounds. The major non-occupational source of chromium for humans is food such as vegetables, meat, urban air, hip or knee prostheses and cigarettes [3,4] . Cr(VI) is a widely used in industrial chemicals, extensively used in paints, metal finishes, steel including stainless steel manufacturing, alloy cast irons, chrome and wood treatment. On the contrary, Cr(III) salts such as chromium polynicotinate, chromium chloride and chromium picolinate (CrP) are used as micronutrients

and nutritional supplements and have been demonstrated to exhibit a significant number of health benefits in animals and humans [5].

Transport of Chromium into the Environment

Chromium enters the environment through both natural processes and human activities. Increases in Chromium III are due to leather, textile, and steel manufacturing; Chromium VI enters the environment through some of the same channels such as leather and textile manufacturing, but also due to industrial applications such as electro painting and chemical manufacturing. Groundwater contamination may occur due to seepage from chromate mines or improper disposal of mining tools and supplies, and improper disposal of industrial manufacturing equipment.

Chromium toxicity in plants

Due to its wide industrial use, chromium is considered a serious environmental pollutant. Contamination of soil and water by chromium (Cr) is of recent concern. Toxicity of Cr to plants depends on its valence state: Cr(VI) is highly toxic and mobile whereas Cr(III) is less toxic. Since plants lack a specific transport system for Cr, it is taken up by carriers of essential ions such as sulfate or iron. Toxic effects of Cr on plant growth and development include alterations in the germination process as well as in the growth of roots, stems and leaves, which may affect total dry matter production and yield. Cr also causes deleterious effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition. Metabolic alterations by Cr exposure have also been described in plants either by a direct effect on enzymes or other metabolites or by its ability to generate reactive oxygen species which may cause oxidative stress. The potential of plants with the capacity to accumulate or to stabilize Cr compounds for bioremediation of Cr contamination has gained interest in recent year.(6)

Toxicity of chromium in human body

Hexavalent chromium, also called chromium(VI), is hemotoxic, genotoxic, and carcinogenic. When hexavalent chromium enters the bloodstream, it damages blood cells by causing oxidation reactions. This oxidative damage can lead to hemolysis and, ultimately, kidney and liver failure. Patients might be treated with dialysis.[7]

The median lethal dose of hexavalent chromium is 50–150 mg/kg.[6] The World Health Organization recommends a maximum allowable concentration of 0.05 milligrams per litre of chromium(VI) in drinking water.[7] In Europe, the use of hexavalent chromium is regulated by the Restriction of Hazardous Substances Directive.

Hexavalent chromium can be found in some dyes and paints, as well as in some leather tanning products. Primer paint containing hexavalent chromium is widely used in aerospace and automobile refinishing applications. Metal workers (such as welders)—as well as people with a surgical implant made from cobalt-chromium alloy—may also be exposed to hexavalent chromium.[8] Chromium concentrations in whole blood, plasma, serum, or urine may be measured to monitor for safety in exposed workers, to confirm the diagnosis in potential poisoning victims, or to assist in the forensic investigation in a case of fatal overdosage.[9]

In the U.S. state of California, an epidemic of hexavalent chromium exposure led to a class-action lawsuit in 1993: Anderson, et al. v. Pacific Gas and Electric. The Pacific Gas and Electric Company had dumped more than 1.4 billion litres (370 million gallons) of wastewater tainted with hexavalent chromium into the Mojave Desert. This contaminated the groundwater, and caused widespread illness among the people of Hinkley, California, a small community nearby. As of May 2017, the mandated environmental remediation measures are ongoing.[10]

Conclusions

This paper includes an overview of the literature about Cr toxicity in the environment, especially in water and soil and provides new insights about Cr toxicity in plants. Chromium is a naturally occurring heavy metal and is an essential micronutrient required to promote the action of insulin in body tissues so that the body can use sugars, proteins and fats. Clinical and laboratory evidences indicate that hexavalent chromium, Cr(VI), is responsible for most of the toxic actions. Cr(0) is the metallic form, the forms of Cr(III) and Cr(VI) are the most preponderant in soils and water. Once in water/soil, Cr suffers a variety of transformations such as oxidation, reduction, sorption, desorption, precipitation, and dissolution. Chromium is very toxic by inhalation and dermal route and causes lung cancer, nasal irritation, nasal ulcer and hypersensitivity reactions like contact dermatitis and asthma. Chromium affects various components of the immune system and may result in immunostimulation or immunosuppression. The reduction of Cr(VI) to Cr(III) results in the formation of reactive intermediates that together with oxidative stress and oxidative tissue damage and a cascade of cellular events including modulation of apoptosis regulatory gene p53 contribute to the cytotoxicity, genotoxicity and carcinogenicity of Cr(VI)-containing compounds. Exposure to Cr(VI) can result in various point mutations in DNA and to chromosomal damage, as well as to oxidative changes in proteins.

REFERENCE

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4522702/
2. https://pubmed.ncbi.nlm.nih.gov/33607566/#:~:text=Several%20studies%20have%20shown%20that,soil%2C%20and%20crop%20production%20system
3. HertelR.F(1986)SourcesofexposureandbiologicaeffectsofchromiumIARCSci.Publ.71, 63–77
4. US Environmental Protection Agency (1984) Health effects assessment for hexavalent chromium. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria, EPA/540/1-86–019 Cincinnati, updated 1998.
5. Anderson R.A. (2000) Chromium in the prevention and control of diabetes. Diabetes Metab.26, 22–27.
6. https://www.sciencedirect.com/science/article/pii/S0160412005000231
7. Dayan AD, Paine AJ (September 2001). "Mechanisms of chromium toxicity, carcinogenicity and allergenicity: review of the literature from 1985 to 2000". Human & Experimental Toxicology. 20 (9): 439–451. doi:10.1191/096032701682693062. PMID 11776406. S2CID 31351037. ^ "WHO Guidelines on Drinking-Water Quality" (PDF). WHO.int. World Health Organisation. Section 12.30: Chromium.

8. ^ Merritt K, Brown SA (May 1995). "Release of hexavalent chromium from corrosion of stainless steel and cobalt-chromium alloys". Journal of Biomedical Materials Research. 29 (5): 627–633. doi:10.1002/jbm.820290510. PMID 7622548.
9. ^ Baselt R (2008). Disposition of Toxic Drugs and Chemicals in Man (8th ed.). Foster City: Biomedical Publications. pp. 305–7. ISBN 978-0962652370.
10. ^ Izbicki JA, Groover K. "Natural and Man-Made Hexavalent Chromium, Cr(VI), in Groundwater near a Mapped Plume, Hinkley, California—Study Progress as of May 2017, and a Summative-Scale Approach to Estimate Background Cr(VI) Concentrations" (PDF). Open-file Report. United States Geological Survey. ISSN 2331-1258. Retrieved 2018-05-15.