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Effects of Hexavalent Chromium Exposures and Control Measures through Phytoremediation

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ABSTRACT

Chromium is a mineral that humans require in trace amounts, although its mechanisms of action in the body and the amounts needed for optimal health are not well defined. It is found primarily in two forms trivalent chromium (Cr^{3+}), which is biologically active and found in food and hexavalent chromium (Cr^{6+}), a toxic form that result from industrial pollution. The present view shows phytoremediation technology and its applications used for controlling the heavy metal pollution including hexavalent chromium exposures from tannery and other industries.

PACs: Nil

Keywords: Oxidation, Reduction, Trivalent, Hexavalent, Metallic element, Carcinogen, Genetic effect

INTRODUCTION

The chromium (Cr^{6+}) compounds are mostly lemon yellow to orange to dark red in colour and second most stable oxidation state of chromium. They are typically solid (crystalline, granular or powdery) although one compound (chromyl chloride) is a dark red liquid that decomposes into chromate ion and hydrochloric acid in water (OSHA,2006). Hexavalent chromium is a form of the metallic element and naturally occurs in rocks, animals, plants, soil, volcanic dust and gases. The Cr^{6+} can be reduced to the more stable chromium (Cr^{III}) in the presence of reducing agents or oxidizable organic matter. It comes in several different forms including trivalent chromium and hexavalent chromium.

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Trivalent chromium (Cr^3) and is an essential nutrient for the body. Hexavalent chromium (Cr^{6+}) is generally used or produced in industrial processes and has been demonstrated to be a human carcinogen when inhaled.

OCCURRENCE OF (Cr^{6+})

Chromium (VI) can occur naturally in the earth's crust, although it is primarily emitted to the environment as result of anthropogenic activities. The occurrence and distribution of chromium in the environment has been extensively reviewed (Krystek & Ristsema, 2007).

Natural occurrence of (Cr^{6+})

The natural occurrence of hexavalent chromium only in the lead chromate and potassium dichromate are known to occur in nature (IARC, 1990).

Air

Chromium (VI) is reported to account for approximately one third of the 2700-2900 tons of chromium emitted to the atmosphere annually in the USA (ATSDR,2008a).Based on U.S data collected from 2106 monitoring stations during 1977-84, the arithmetic mean concentrations of total chromium in the ambient air (Urban, Suburban, and rural) were in the range of 0.005-0.525 $\mu\text{g}/\text{m}^3$ (ATSDR,2000).

Water

The concentration of chromium (VI) in uncontaminated water is extremely low (<1 $\mu\text{g}/\text{L}$) or (0.02 $\mu\text{mol}/\text{L}$). Anthropogenic activities (e.g electroplating, leather tanning) and leaching of waste water such as landfills may cause contamination of the drinking water (EVM, 2002).

Soil

Chromium is present in most soils in its trivalent form, although chromium (VI) can occur oxidation conditions (ATSDR, 2008a). In the USA, the geometric mean concentration of total chromium was 37.0 mg/kg(range 1.0 - 2000 $\mu\text{g}/\text{kg}$ based on 1319 samples collected in contaminated soils (ATSDR, 2000).

Food and Smoking

There is little information available on chromium (VI) in food and most of the chromium ingested with food is chromium (III) (EVM, 2002). Tobacco smokes contain chromium (VI) and indoor air polluted by cigarette smoke can contain hundreds of times the amounts of chromium (VI) found in outdoor air.

CHEMICAL AND PHYSICAL PROPERTIES

Figure.1.The hexavalent chromium of different chemical compounds of the physical and chemical properties

Compounds	Molecular weight	Boiling point (°C)	Melting point (°C)	Solubility		
				Cold water g/100cc	(°C)	Other
Ammonium chromate	152.07	–	Decomposes at 180	40.5	30	Insoluble in alcohol, Soluble in NH_3 , Acetone.
Ammonium dichromate	252.06	–	Decomposes at 170	30.8	15	Soluble in alcohol, Insoluble in acetone

Barium chromate	156.07	–	-2H ₂ O,200	0.00034	160	Soluble in mineral acid
Chromic acid	99.99	Decomposes at 170	–	16.3	20	Soluble in acid alcohol
Lead chromate	323.19	Decomposes at 844	–	67.45	100	Soluble in alcohol, ether, H ₂ SO ₄ ,NH ₃
Lead chromate oxide	546.39	–	–	0.0000058	25	Soluble in acid, Alkali, Insoluble in acetic acid.
Potassium chromate	194.19	–	968.3	Insoluble	–	Soluble in acid alkali
Potassium dichromate	294.18	Decomposes at 500	241.6	62.9	20	Insoluble in alcohol
Silver chromate	331.73	–	398	4.9	–	Insoluble in alcohol
Sodium chromate	161.97	–	19.92	0.0014	–	Soluble in NH ₄ OH, KCN.
Sodium dichromate	261.97	Decomposes at 400	–	87.3	30	Slightly soluble in alcohol; soluble in MeOH
Strontium chromate	203.61	–	–	238	20	Insoluble in alcohol. Soluble in HCl, HNO ₃

Source: The Merck Index (2006)

POTENTIAL EXPOSURES

Air born exposures

The Cr (VI) is formed as a by-product include those utilizing metals containing metallic chromium including welding, thermal cutting of metals, steel mills and iron and steel foundries. In welding process metals are heated to the melting point, and a fraction of the melted metal that escapes the welding – arc area quickly condenses and oxidizes into welding fume and an appreciable fraction of the chromium in this form of Cr(VI) (Fiore 2006, Heung et al.2007).

Dermal exposures

The many other industries are at risk of dermal exposure if there is any splashing, spilling or other skin contact with material containing Cr⁶⁺. In welding, steel, tannery and other industries with reported dermal exposure include chromate production (Gibbe et.al.,2000a); electroplating (Makinen and Linnainmaa 2004a).

RISK ASSESSMENTS

Hexavalent chromium is one of 20 chemicals that are currently being reviewed by USEPA for possible further regulation. In September 2010, the USEPA issued a draft risk assessment of hexavalent chromium in its Integrated Risk Information system (IRIS) database, which specifically addressed the health risk of hexavalent chromium ingestion from drinking water. The risk assessments also demonstrated an elevated risk of lung cancer death to workers exposed to Cr(VI) at the previous NIOSH REL (1 µg Cr (VI) /m³ over a working lifetime.

USES

The hexavalent chromium compounds are used widely in industrial applications of pigments for textile dyes , paints, inks, plastics, corrosion inhibitors, wood preservatives, metal finishing, chrome plating and leather tanning (OHCOW,2005)

HEALTH EFFECTS

Cancer

The chromium (VI) compounds as encountered in the chromate production, tannery, pigment and chromium plating industries, IARC categorise “group I carcinogen” (IARC 1990.) The IARC reviewed studies of workers in those industries and compounds were reaffirmed as an IARC-group 1 carcinogen (Straif et.al., 2009; IARC2012).

PHYTOREMEDIATION

Polluted soil poses a severe problem for both ecosystem health and land development. Because soil lies at the confluence of many natural systems, Phytoremediation is the currently developed processes of using green plants to grown under polluted soils. And plants are tolerating the heavy metal pollutions. It’s accumulating the metal toxicity from polluted soil into plant.

CONCLUSION

In the present strategy of industrialization is grown among the globe and developed economically for the production of various kinds of industrial products such as leather products, textile products, paints, inks, stainless steel and plastic products. A t the same time lose our ecosystem for the over developments and usage of synthetic industrial products. And hexavalent chromium compounds are creates health effects of human being as well as plants and animals development. It is mainly focussed on these point of view phytoremediation technology of applications are controlling the heavy metal pollution from the soil.

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