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Review Article

Bioremediation of Chromium by Bacteria

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Abstract

Chromium (VI) is a thoughtful and common environmental chemical. In nature, chromium can be found both as chromium (VI) or as chromium (III).Chromium (III) is less lethal and definitely adsorbed ins oils and waters, whereas chromium (VI), which is the most toxic form, is not eagerly adsorbed and maximum of its salts are soluble. Numerous bacteria have been noticeable that can change extremely water-soluble and toxic Cr(VI) to unsolvable and rather non-toxic Cr(III), bacterial bioremediation of Cr(VI) contamination is controlled by a number of difficulties, in precise chromium poisonousness to the remediating cells. Cr (VI) is a lethal, resolvable environmental contaminant. Bacteria can decrease chromate to the unsolvable and less poisonous Cr (III). The Hexavalent form of chromium is the most toxic and cancer-causing and produces health dangerous effect. Hexavalent chromium is of specific environmental worry due to its toxicity and flexibility and is thought-provoking to remove from industrial waste water. Reducing Cr (VI) to Cr (III) makes simpler its removal from effluent and also reduces its poisonousness and mobility. So, we can apply the modern biotechnology for the elimination of numerous toxic complexes.

Key words: Chromium, Metals, bacteria.

INTRODUCTION

Chromium is important for life in trace amounts, but is extremely lethal to maximum organisms at low concentrations [1]. Chromium compounds are used widely in many industrial methods, such as leather-tanning, metal plating and finishing, wood treatment, corrosion inhibition in power plants and nuclear facilities, and in the industrial of refractory materials, pigments, dyes, textiles and mining apparatus, amongst others [2]. Resolvable Hexavalent chromium, Cr (VI), is very toxic and revelations mutagenic and carcinogenic effects [3].

Yeasts are known to play a significant role in the elimination of poisonous heavy metals [4]. Microorganisms convert heavy metals by numerous mechanisms like metal absorption, metal accumulation and metal resistance. In detail, the bacterial enzymes which decrease Cr6+ species are not mainly the Cr6+ reductases they also accomplish other biological functions in addition to Cr6+ reduction [5]. These organisms can be engineered to reduction Cr (VI) pollution [6]. While microorganisms of the species Pseudomonas, Arthrobacter, Escherichia and Bacillus have been described to reduce Cr (VI) through soluble chromate reductase [7]. Cr(VI) reduction capability in Pseudomonas spp. grown under anaerobic circumstances [8]. Meanwhile the first description on chromium-reducing Pseudomonas strains isolated from chromate-contaminated manure mud in the 1970s [8].

Chromium-reducing bacteria normally function under both aerobic and anaerobic decrease of chromate. Numerous species use Cr (VI) as a terminal electron acceptor in their respiratory chains and these contain Pseudomonas aeruginosa, Bacillus subtilis [9]. New microbes that catalyze Cr (VI) removal under changing conditions [10]. Bacterial Cr(VI) struggle has been connected with lessened intracellular buildup of chromium, may before of active elimination of Cr(VI) from the cytosol [11] and (or) the peripheral reduction of Cr(VI) to the less poisonous chromium (Cr(III)),which does not come in the cell [12]. The use of bacteria in bioremediation of Cr (VI)-contaminated atmospheres has attained growing attention, as the biological reduction of Cr (VI) does not require high-energy contribution or poisonous chemical components and consents the possibility of using natural, harmless strains [13].

Chromium is a broadly used industrial metal extracted commercially from the inorganic chromate [14]. It is a solid oxidizing agent, mutagenic as well as teratogenic in nature [15]. Chromium (Cr) is an important constituent of polluted soil and groundwater done a variety of environmental experiences from its extensive use in metallurgy and industrial procedures [16]. Hexavalent chromium is used widely in industrial procedures such as electroplating, tanning, textile dyeing, corrosion inhibition and wood treatment, all of which yield release of chromium-containing wastes [17].

Chromium and is expansively used in leather tanning procedure [18]. Cr (VI) and whole aqueous Fe were determined by uniform UV–via spectroscopy methods [19]. Chromium is also an vital trace element in human nutrition. Cr (III) is an important element in human metabolism and performs an important character in sugar and lipid metabolism [20]. Lacking human interference, Cr (VI) has been probable to persist at risky levels at such waste places for well over 1000 years [21]. Chromium occurs in the environment in numerous various forms Cr (III) and Cr (VI), of which Cr (VI) is carcinogen and a probable soil, surface water and ground water poison and also long period contact at level above extreme toxin can cause dermatitis, injury to liver. These poisonous metals ions not only reason potential human health risks but also affect other life forms [22].

Employees working in areas highly polluted with chromium suffer from nasal impatience and ulceration, skin impatience, tympanum perforation, lung carcinoma [23]. Bronchial asthma, kidney necrosis, and allergic responses in the skin [24]. At advanced level, chromium is also create to cause oxidative injury to cell membrane, change of enzyme specificity, and structural distortion in DNA [25]. The injurious properties of Cr (VI), the reduced form Cr(III) is an important trace nutrient in plants and animals, essential for fat and glucose metabolism, amino and nucleic acid synthesis, and accurate insulin function [26].

Methods of chromium reduction:

One way of detoxifying Cr (VI) is reduction of Cr (VI)–Cr (III), which is possible by chemical or microbial means [27]. This decrease may be through (the bacteria use the Cr (VI) as an electron acceptor) or indirect (the bacteria produce an environment suitable for Cr (VI) reduction) [28]. Chromium reduction has also been detected in Gram-positive bacteria species [29].

Different bacterial strains

Chromium reducing bacteria and their source

Chromate reducing ability has been established in numerous bacterial species including A chromo bacter sp., She wanella sp., Pseudomonas sp. and others [30]. Self-designed microbial ecology is temporary to convert dangerous Cr (VI) species into less risky and less moveable Cr (III) species [31]. Therefore, two distinct reduction systems (one membrane bound and the other soluble) and mechanisms (one aerobic and one anaerobic) must occur within the Pseudomonas genus. It is not clear in what way bacteria such as P. ambigua and P. putida PRS 2000 can decrease chromate under both aerobic and anaerobic circumstances [32].

Table-01: Chromium reduction by using bacteria

Bacteria.	**% of chromium reduction**.	**Reference.**
Streptomyces	98.4%	**[33]**
Arthrobacter sp.	64%	**[34]**
Staphylococci spp.	90%	**[35]**
Halomonas sp.	98.9 %	**[36]**
B. pumilus, A. faecalis and Staphylococcus sp.	95%, 97% and 91%.	**[37]**

Bacterial chromium (VI) elimination from solutions characteristically includes the following stages: (a) the binding of chromium to the cell. (b) Translocation of chromium inside the cell. (c) Decrease of chromium (VI) to chromium (III) [38].

Aerobic Cr (VI) Reduction

Aerobic Cr (VI) reduction is generally associated with soluble proteins utilizing NADH as an electron donor, either as a requirement or to enhance activity [26]. Aerobic reduction is thought to be a detoxification where cells use a soluble enzyme to reduce Cr (VI) to Cr (III) internal or external to the plasma membrane [39]. A chromate resistant mutant of Enterobacteraerogenes manifested its chromate resistance only under aerobic conditions [40].

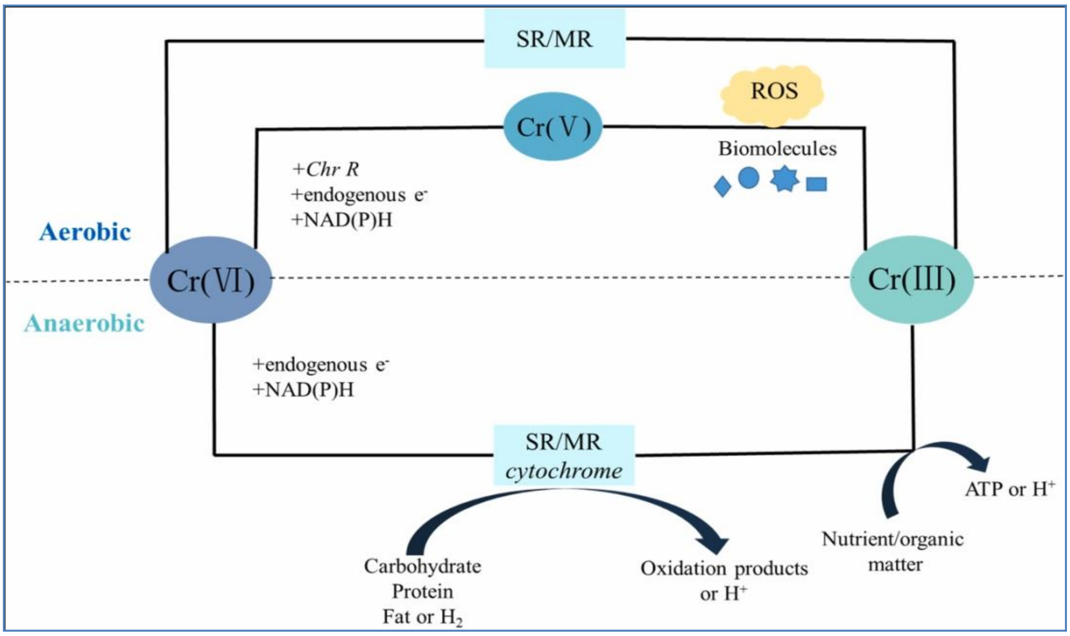

Fig-01: Mechanism of Cr (VI) bioreduction under the aerobic and anaerobic conditions [50]

Anaerobic reduction

In anaerobic condition, Cr (VI) can act as the terminal electron acceptor through membrane-bound reductase activity [12]. Anaerobic reduction of Cr(VI) by six strains of Cr-resistant Pseudomonads was also reported [41].

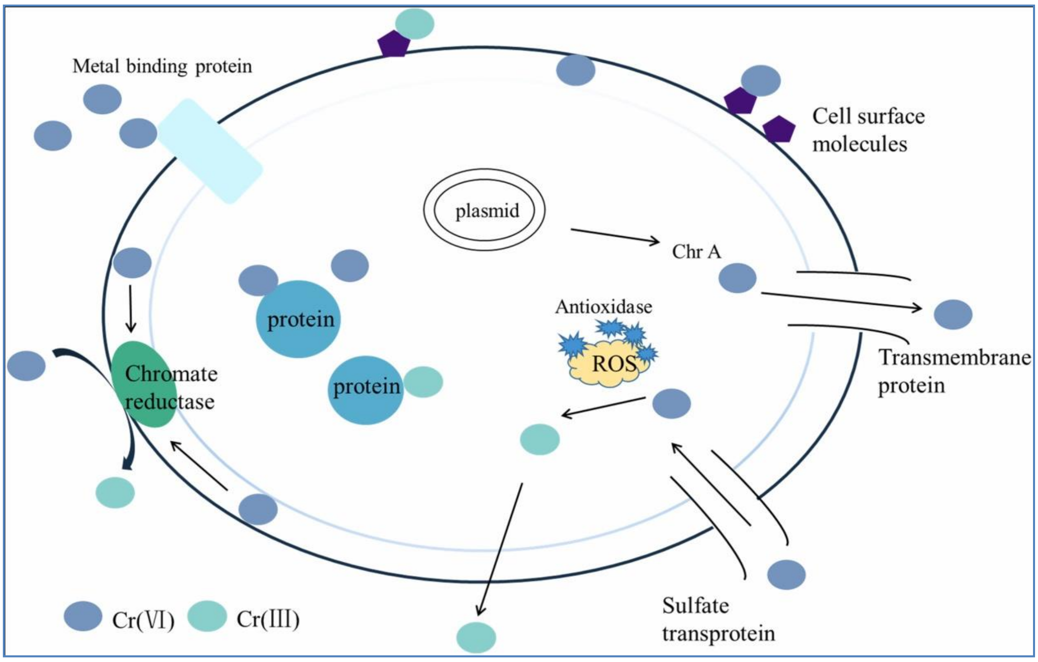

Fig-02: Mechanism of Cr (VI) detoxification and reduction [49].

Chromium reduction from wastewater

Wastewaters from these industries have permanent toxic effects to humans and environment. [42]. Industrial wastewaters contain both chromium and salt ions which have toxic effects on the microbial consortia of wastewater treatment systems [43]. Several methods to remove Cr (VI) from the effluent and wastewaters have been developed in recent decades and these are primarily based on direct removal of oxyanion of Cr (VI) or reduction of Cr (VI) to Cr(III) followed by precipitation to insoluble Cr(III) hydroxide, Cr(OH)3 [44].

Actinomycetes like Arthrobacter capable of reducing chromate is not uncommon in chromium polluted waste water treatment plants. [45] Cr (VI)-containing industrial wastewater and sugar-rich and cheap industrial waste as feed for the bacteria needs to be carried out [46]. The high removal rates of hexavalent chromium that were achieved indicate a feasible, economical and efficient technique for biological hexavalent chromium removal from industrial wastewater effluents [47]. The microbial reduction of Cr042 - is of interest because of the potential applications of this activity in biological removal of toxic Cr042 - from waste waters. [48].

CONCLUSION

A wide variety of mechanisms exist for the removal of heavy metal from aqueous solution by bacteria, fungi, ciliates, algae, mosses, macrophytes and higher plants. Heavy metals can be toxic to microorganisms and to humans alike due to their strong affinity to form complexes with the cell membrane constituents, causing loss of integrity and impairment of their functions. KSUCr9a showed the ability of repeated bio-reduction of chromate without any addition of exogenous nutrients, indicating its possible application in chromate detoxification. Resistance against toxic Cr is more protruding between prokaryotes than the eukaryotes. Some gram-positive bacteria have been informed to be able to detoxify Cr VI by reducing it to Cr III. Cr also harmfully affects the growth of microbes and interferes with nucleic acid synthesis.

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