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Study of Ground Water Contamination at Tamil Nadu Chromate Chemicals Limited, Plant and Its Surrounding Area in SIPCOT Industrial Complex in Ranipet in Vellore District, India

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Abstract: Water is one of the essential commodities of daily life and one of the most misused one since it is not the private owned one. This paper presents groundwater contamination of TCC Ltd., Plant and surrounding area in the SIPCOT Industrial complex in Ranipet in Vellore District, India of about three square kilometers. The samples were collected from five different locations in the study area and compared. The parameters studied were pH, Total Suspended Solids, Total Dissolved Solids, Total Hardness, Chlorides, Sulphate as SO4, Hexavalent Chromium and Total Chromium. The results were compared with WHO and ISI 10500-91 standards. Comparison of the physico-chemical parameters of the water sample with WHO and ISI limits showed that the groundwater is highly contaminated and it is hazardous for human consumption.
Keywords: Groundwater, Physico-Chemical parameters, water quality, Water Contamination, Hexavalent Chromium, Total Chromium.

1. Introduction

Groundwater is used for drinking purpose by majority of the people. The largest use for groundwater is to irrigate crops. Groundwater can be found almost everywhere. The water table may be deep or shallow and may rise or fall depending on many factors. Groundwater is a very important source of freshwater reserves. It supports drinking water supply, livestock needs, irrigation, industrial and many commercial activities. Millions of people in the developing world rely heavily on groundwater, mostly through shallow dug wells. These can be easily become polluted, primarily because of human activities. Such activities can be broadly categorized as municipal, industrial, agricultural, and individual sources. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. Also the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata. In India groundwater is used intensively for irrigation and industrial purposes, a variety of land and water based human activities are causing pollution to ground water. Importantly, groundwater can also be contaminated by naturally occurring sources. Soil and geological formation containing high levels of heavy metals can leach those metals into groundwater. This can be aggravated by over-pumping wells, particularly for agriculture. Industrial pollution of groundwater can come from dumping of wastewater or waste, from mining activities and from leakage or spillage from other industrial processes. Mining primarily affects groundwater through leaching of mine tailing piles. Chemical manufacture and storage similarly present a threat through leakage. Pollution caused by fertilizers and pesticides used in Agriculture often dispersed over large areas, is a great threat to fresh groundwater ecosystems. Health effects from contaminated groundwater depend on the specific pollutants in the water. Pollution from groundwater often causes diarrhea and stomach irritation, which can lead to more severe health effects. Accumulation of heavy metals and some organic pollutants can lead to cancer, reproductive abnormalities and other more severe health effects. So, the knowledge of extent of pollution and the status of water become essential in order to preserve the valuable sources of water for future generation. The main objective of this work has to analyze various physico-chemical parameters of the ground water at Tamil Nadu Chromate Chemical Limited and its surrounding areas of about three square kilometer in Ranipet SIPCOT, Tamil Nadu, India.

2. Materials and Methods

2.1 Study Area

The Ranipet Town is located at 12.56^o Northern latitude and 79.20^o eastern longitude and is 93 KM west of Chennai. It is geographically 25 Km away in the North East of Vellore. Ranipet has been selected by the SIDCO and SIPCOT to establish the estates/complexes, since it is situated at a distance of 3.5 Km from River Palar and adjoining Chennai-Chittoor Bangalore Road (NH-4). Tamil Nadu Chromates Chemicals Ltd. (TCCL) located in the SIPCOT industrial complex located at No.25, SIPCOT Industrial Complex, Ranipet, Walajah Taluk, Vellore District, Tamil Nadu, India. The unit earlier manufactured (i) Sodium Bichromate 150 Tons/Month, (ii) Basic Chromium Sulphate 300 Tons/Month and (iii) Sodium sulphate 240 Tons/Month and it generated about 32 Tons/day of Chromium bearing (both hexavalent and Trivalent) solid waste. Since the inception from the year 1975, the unit had functioned as a joint sector company promoted by TIDCO. From the year 1989 onwards, the unit functioned under various private managements. About 2.27 lakh tons of Chromium bearing solid waste (Figure1.1) got accumulated and dumped at the backyard of the unit's premises. Land, soil, and ground water in the surroundings of the site have been contaminated with chromium. The waste pile covers about two Hectares in area, and in three to five meters height. The factory is not in operation since 1995. The present study focuses on Ground Water contamination at Tamilnadu Chromate Chemicals Ltd., plant and adjoining area of about three square kilometer.

Figure1.1 Solid Waste Site at TCC Limited, Ranipet

2.2 Sample Collection

The samples were collected in plastic canes of two liter capacity without any air bubbles as per standard procedure. The temperatures of the samples were measured in the field itself at the time of sample collection. The water was pumped out from bore wells a few minutes before sample collection. Water samples from five sampling points situated at different places were collected in and around TCC Ltd., plant area. The sampling locations are given inTable 2.1.Samples were analyzed for different physico- chemical parameters such as pH, Total Suspended Solids, Total Dissolved Solids, Total Hardness, Chlorides, Sulphate as SO4, and Hexavalent Chromium, Total Chromium as per standard procedures. The quality of ground water has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking water as prescribed by ISI 10500-91 and WHO Standards as in Table 2.2.

Table 2.1 Sampling Area

Sl.No	Observation Point	Source
1.	Plant site	Open pit
2.	Along NH4	Open Pit
3.	Emerald Nagar Bore Well	Bore Well
4.	Emarald Nagar Open Well	Open Well
5.	MGR Nagar Bore Well	Bore Well

Table 2.2 Physico-chemical characteristics of water samples

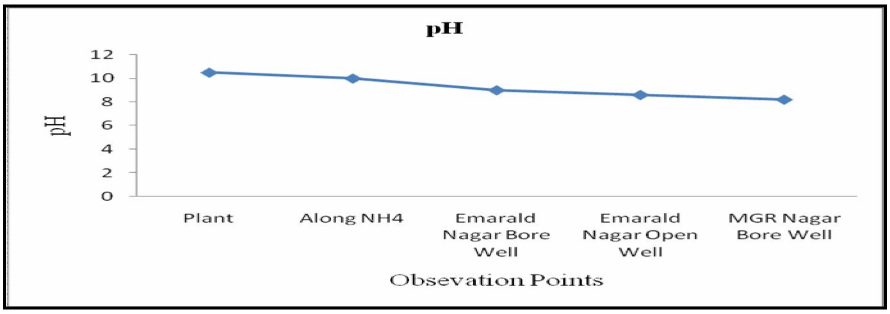
Standard	pH	Total Suspended Solids mg/l	Total Dissolved Solids mg/l	Chlorides mg/l	Sulphate as SO4 mg/l	Total Hardness Mg/l	Hexavalent Chromium mg/l	Total Chromium mg/l
WHO Standard	7-8	300	1000	100	100	250	0.05	0.05
ISI 10500-91 Standard	6.5-8.5	500	500	250	200	300	0.05	0.05

3. Results and Discussion

3.1 pH

pH is an important ecological factor and provides an important information in many types of geochemical equilibrium or solubility calculation(1). pH is one of the important parameter of water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes(1). In the present investigation, the pH values vary from 8.2 to 10.5 (Figure 3.1) in water from the study area. The limit of pH value for drinking water is specified as 6.5 to 8.5. The results indicate that, the ground water source in the study area is alkaline in nature. Higher pH values are observed in all the samples. This may be due to the presence of higher amounts of carbonate and bicarbonate substances in the ground water (1). As per WHO (2) and ISI standards (3) at all the observation points the pH values of the samples are more than the maximum permissible limit.

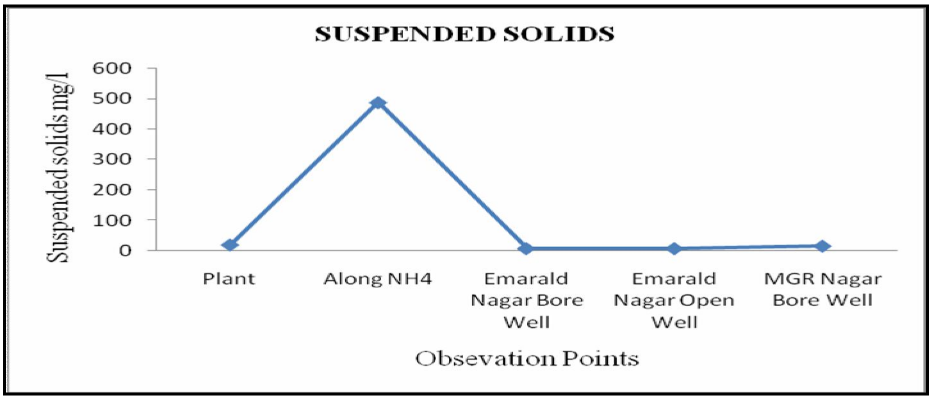
Figure 3.1 Variation of Water pH value



3.2 Total Suspended Solids

Increase in concentrations of Suspended Solids decrease the effectiveness of drinking water disinfection agents by allowing microorganisms to hide from disinfectants. This is one of the reasons the Suspended Solids is removed in drinking water. The Total suspended solids (Figure 3.2) in the present study among all the observation points, the pit water along the NH4 showed high concentration. This may be due rain water runoff at the pit location. All other observation points the Total Suspended Solids found to be below the standards prescribed by ISI 10500-91 and WHO (2,3).

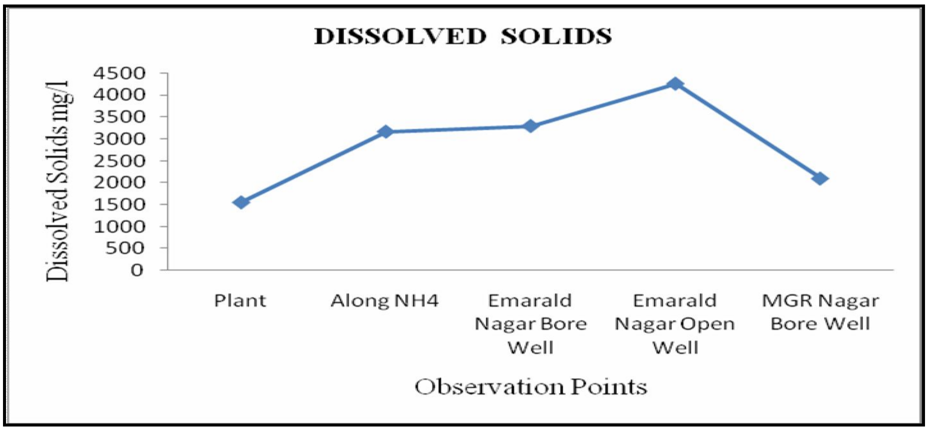
Figure 3.2 Variations of Suspended Solids



3.3 Total Dissolved Solids

Total Dissolved Solids(TDS) are various kinds of mineral substances present in the water. Some dissolved organic matter may also contribute to Total Dissolved Solids. The concentration of Dissolved Solids in water gives an idea about suitability of this water for various uses including that of potable water. It also indicates the salinity of water. Dissolved solids tend to increase with increasing pollution of water (4). Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies as per ISI 10500-91 Standards (3). In the present investigation, the TDS (Figure 3.3) values have varied from 1556 to 4268 mg/l in the study area. These values are more than the WHO standards (2) also.

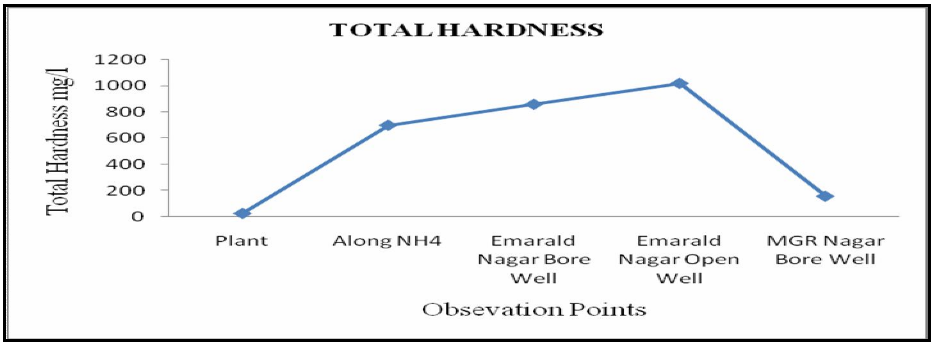
Figure 3.3 Variations of Dissolved Solids



3.4 Total Hardness

Total Hardness (TH) or Hardness of water is commonly understood as a property, which prevents the lather formation with soap (2). It is primarily caused by calcium and magnesium, but any alkaline earth metal such as Iron, manganese, carbonates, bicarbonates, sulphates, nitrates and silicates may contribute to hardness (1). Hardness is of two types, Temporary Hardness and Permanent Hardness. The Temporary Hardness is caused by carbonate and bicarbonate ions, is removed by boiling the water. The permanent hardness is caused by chlorides and sulphates of the metals and it is difficult to be removed (1). Magnesium induced hardness has been suspected to be playing some role in heart disease (4). Calcium and Magnesium induced hardness scales on heat transfer surfaces thus reducing heat exchange rate in the heat exchangers. Most industries employ water softeners to reduce hardness of water (1). In this study area, the Total Hardness (Figure 3.4) in water from all the groundwater resources ranges from 27 and 1020mg/l. These values are well below the maximum permissible limits prescribed by WHO (2) and ISI 10500-91 standards (3) in water samples of plant pit and M.G.R. Nagar bore well water. In the other samples higher values of Total Hardness was observed, may be due to the presence of high amount of calcium and magnesium metals in the water.

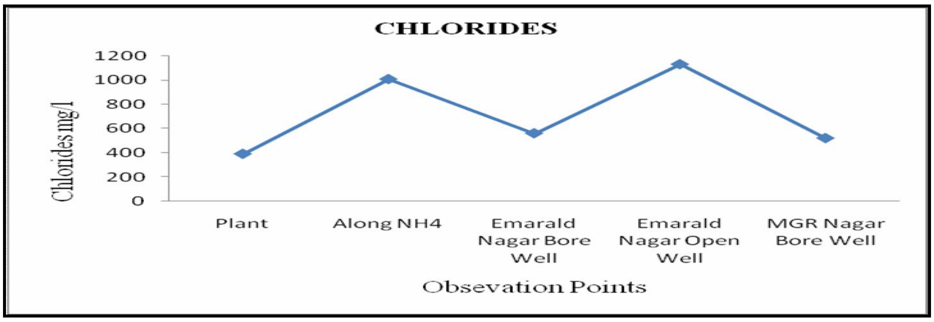
Figure 3.4 Variations of Total Hardness



3.5 Chlorides

Chloride contents in water are influenced largely by evaporation and precipitation. Chlorides are more toxic than sulphates to most of the plants and are best indicator of pollution in the ground water (4). Chlorides affinity towards sodium is high since its concentration is high in ground waters. Soil porosity and permeability also has a key role in accumulation of chlorides concentration in the ground water (4). Chlorides have no reported side effects on humans in the drinking water, whereas as a salt form like Sodium chloride, Calcium chloride and Potassium chlorides either increases the total hardness or toxicity (5, 6). Intake of drinking-water containing Sodium chloride at concentrations above 2.5 g/litre reported to produce hypertension (2). In the present study the chloride concentration (Figure 3.5) was found in the range of 390 mg/l to 1130mg/l. All the values are above the limit prescribed by WHO (2) and ISI 10500-91 standards (3).

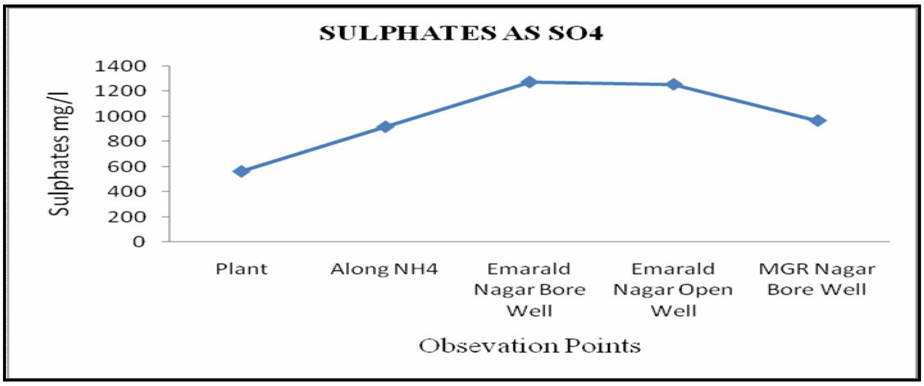
Figure 3.5 Variations Chlorides



3.6 Sulphates as SO4

High concentrations of Sodium and Magnesium sulphate cause Cathartic and Dehydration in human beings (1, 7). Therefore, the recommended concentration of sulphate in drinking water is limited from 100 to 200 mg/l. In the present study, the sulphate concentration (Figure 3.6) in all the water samples varied from 566 to 1273 mg/l. The results indicate that the distribution of sulphate is much above the limit prescribed by WHO (2) and ISI 10500-91 standards (3).

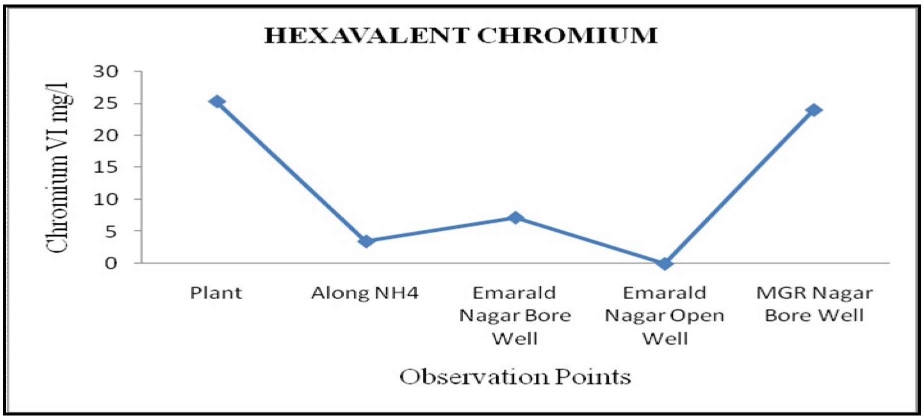
Figure 3.6 Variations Sulphates as SO4



3.7 Hexavalent Chromium

One of the oxidation forms of Chromium is Hexavalent chromium, which is highly toxic than Trivalent Chromium (8). Exposure to Hexavalent Chromium will lead to lung and stomach cancer in the humans (2, 9). In the present study the Hexavalent Chromium was found to be below allowable limit in open well water sampling, which may be due rain water accumulation. On all other sampling sites the concentration varies from 3.5 to 25.33 mg/l which is much above limit prescribed by WHO and ISI 10500-91 standards (2, 3).

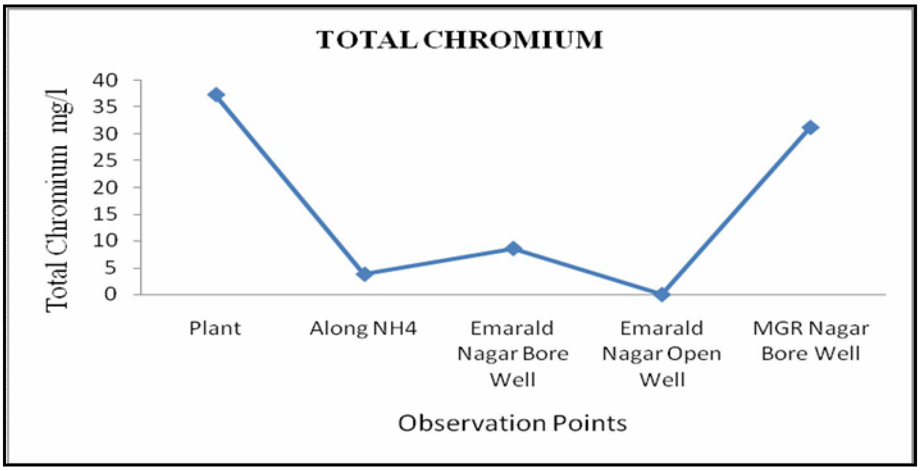
Figure 3.7 Variations Hexavalent Chromium



3.8 Total Chromium

The drinking water standard for total chromium is 0.05 mg/L or 50 parts per billion (2). Chromium-VI and chromium-III are covered under the total chromium drinking water standard because these forms of chromium can convert back and forth in water and in the human body, depending on environmental conditions (9). Chromium-III is a nutritionally essential element in humans and is often added to vitamins as a dietary supplement. Chromium-III has relatively low toxicity and would be a concern in drinking water only at very high levels of contamination (9). Chromium-VI is more toxic and poses potential health risks. People who use water containing total chromium in excess of the maximum contaminant level over many years could experience allergic dermatitis (2, 9). In the present study the total chromium found to be in allowable limit in the open well observation point, which may be due to rain water accumulation. In all other observation points the concentration of total chromium varies from 3.8 to 37.33 mg/l, which is above the limit prescribed by the WHO and ISI 10500-91 standards (2, 3).

Figure 3.8 Variations Total Chromium



4. Conclusion

The pH values of water samples are greater than 7.0, indicating the alkaline nature of waters. All the pH values are above permissible limits. Higher Total Suspended Solids are observed in sample of pit along the

NH4 that may be due to rain water runoff. On all other observation points the Total Suspended Solid concentration found to be below the prescribed limits. Higher Total Dissolved Solid values in all the samples make the waters harmful for human consumption. Total Dissolved Solid values in all the samples are above the red mark. Total Hardness in the highest degree is found in samples of observation points in pit along NH4, Open well nearby and bore well nearby Emarald Nagar. Other observation points the Total Hardness found to be below the permissible level. Chlorides in salt form like Sodium Chloride, Calcium Chloride and Potassium Chlorides either increase the total hardness or toxicity. Chloride concentration is in all the samples are beyond the optimum limit. High concentrations of Sodium and Magnesium sulphate cause harmful effects in human beings. The Sulphate concentration has exceeded the limit in all the ground water samples. One of the oxidation forms of Chromium is Hexavalent chromium, which is highly toxic than Trivalent Chromium. Hexavalent Chromium was found to be below allowable limit in open well water. On all other sampling sites the concentration is much above prescribed limit. Total chromium found to be in allowable limit in the open well observation point. In all other observation points the concentration of total chromium is above the permissible limit. Overall the ground water is critically contaminated at the study area. This is mainly due to dumping of Tamil Nadu Chromate Chemicals waste at the plant site, which is leaching to the ground and contaminates the ground water in the study area. As a first step the waste should be sealed so that leaching stops then the area water quality should be improved by treating for chromium by different chemical methods and Bio-remediation methods.

References

1. Veeragandham Srinivasa Rao, S Prasanthi, Jagarlapudi V Shanmukha K, and Kottapalli R S Prasad, Physicochemical analysis of water samples of Nujendla area in Guntur District, Andhra Pradesh, India, International Journal of ChemTech Research, 2012, 4.2. 691-699.
2. WHO, Guidelines for Drinking Water Quality, 2013, ISBN 92 4 154503 8, 2nd Edition, Volume III, World Health Organization, Geneva.
3. IS10500-91 Standard for Drinking Water Quality.
4. Nirmala B, Suchetan P.A, Darshan D, Sudha A.G, Lohith T.N, Suresh E, and Mamtha, Physico-Chemical Analysis of Selected Groundwater Samples of Tumkur District, Karnataka, International Journal of ChemTech Research, 2013, 5.1. 288-292.
5. Devi S and Premkumar R, Physicochemical Analysis of Groundwater samples near Industrial Area, Cuddalore District, Tamilnadu, India, International Journal of ChemTech Research, 2012, 4.1. 29-34.
6. Saptadeepa Roy and Jogen Chandra Kalita, Identification of Estrogenic Heavy Metals in Water Bodies Around Guwahati City, Assam, India, International Journal of ChemTech Research, 2011, 3.2. 699-702.
7. Rajesh Prasanna P, and Ramesh B.K, Analysis of Water Pollution in The Pazhayar River at Kanyakumari District, International Journal of ChemTech Research, 2013, 5.3. 1267-1280.
8. Ramesh Pun, Prakash Raut and Bhoj Raj Pant, Removal of Chromium(VI) from Leachate using Bacterial Biomass, Scientific World, 2013, 11.11.63-65.
9. Sara Parwin Banu Kamaludeen, Arun Kumar K.R, Avudainayagam S and Ramasami K, Bio Remediation of Chromium Contaminated Environments, Indian Journal of Experimental Biology, 2003, 41.972-985.

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