

Remediation of Chromium Contamination in and Around Tamilnadu Chromate Chemicals Limited in SIPCOT industrial estate, Ranipet, Vellore District, Tamilnadu, India

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Abstract

Disposal of the huge waste was the next problem to be addressed. It is necessary to suggest remedial measures for containment of the chromium pollution. The chromium containing waste dump is spread inside the factory premises almost on all sides. This sludge is mixed with soil and at some places is compacted. Because of this environmental we had taken initiative to make remediation on-site. As a remedial measure, Geochemical fixation method may be adopted for decontamination of hexavalent chromium.

Keywords: Hexavalent Chromium, Trivalent Chromium, Total Chromium, Contamination, Remediation.

INTRODUCTION

Chromium is utilized in industrial activities like electroplating, fertilizers, varnish, metallurgy which is a major contaminant from the tanning Industry. Chromium is water soluble and extremely toxic to the human body tissue. Breathing hexavalent chromium irritates the nose or mouth of the people. It also cause asthma and lung cancer. With the increase in sense of awareness about the environment, researchers focus the study of transport related to ground water contamination.

The Tamilnadu Chromate and Chemicals Limited (TCCL) was started in 1976 and its main products are Sodium Bi-chromate Crystals and Chromium Sulphate tanning powder. The chromium waste generated was approximately 1,60,000 metric tons which is dumped in the northern side to a height of about 2-4 m containing Hexavalent chromium which has been polluting the environment and ground water. The residential colonies around the factory were facing many problems due to the soil and groundwater being contaminated with chromium. Because of this environmental problem, Tamil Nadu Pollution Control Board (TNPCB) closed TCCL factory in 1996.

STUDY LOCATION

The study area is located 3km Northwest of Ranipet, on the NH4 highway to Bangalore. It lies in North Latitude of 12° 55' 0" to 12° 58' 0" and East Longitude of 79° 17' 30" to 79°

20' 0" and falls in survey of India Topo-sheet No. 57- P/5. The study area is 116 km from Chennai and 43 km before Chittoor Dist. of Andhra Pradesh and sited in Plot No 25 of SIPCOT Industrial Estate along the NH4- Ranipet, Tamilnadu. (Fig. 2.1)

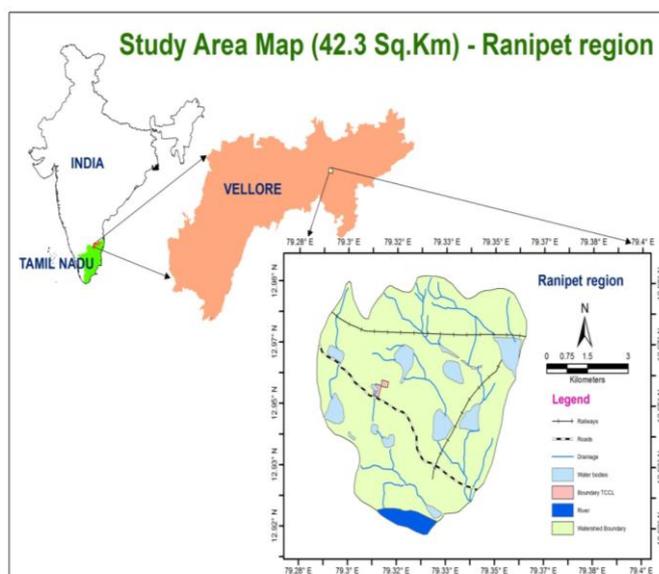


Figure 2.1 Location map of TCCL dumpsite and study area (Ranipet region)

Topographically the area is sloping towards south and southeast side i.e. towards Puliankannu and Karai villages and further down up to Palar river. Entire Northern portion is upland and the entire Southern portion is low-lying land. The study area is surrounded by hillocks in Northern and Western side. Southern portion is highly weathered and acting as pediplain. Palar river, one of the major drinking water source is running from west to east and located at 4.5 km down streamside of the site. Puliankannu and Karai lakes are the major surface water bodies, which are polluted by discharges from various industrial effluents including TCCL dumpsite. Total elevation from south to north range from 162m – 192m (amsl). The chromium waste dump in front and back of the TCCL premises is shown in figure 2.2.



Figure 2.2 Chromium waste dump in front and back of TCCL premises

MATERIAL AND METHODS

The quality of groundwater in any area is controlled by the geology, vegetation and its location with respect to other surface water bodies like streams, canals, tanks and also near by industrial establishment. To evolve a scientific basis for development and management of groundwater resources in different situations in relation to water quality, it is essential to identify the polluted zones in regard to their lateral and vertical extent and the composition of the water. In the present investigation, 25 samples were collected from bore wells, dug

wells and surface water sources in one litre polythene water bottles as per the standard procedure of ALPHA (1998). The chemical analysis results were analysed and tabulated in table 3.1. At the time of collection the details regarding well inventory lithology and other information were noted. The location map of well inventory is shown in figure 3.1. All these samples were analyzed in the laboratory for pH, Total and Hexavalent Chromium. Physico-chemical characteristics of the drinking water standards of WHO and ISI 10500-91 are tabulated in table 3.2.

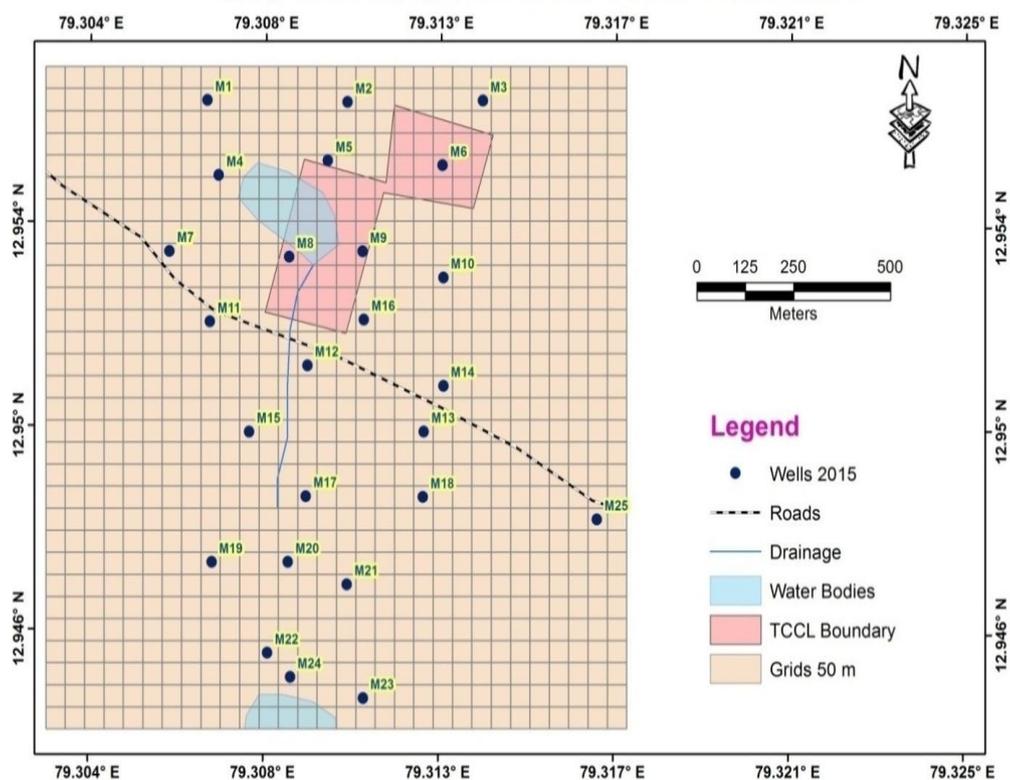


Figure 3.1 Location map of well inventory

Table 3.1 Geographic sample locations and chemical analysis results

SI. No	Sampling Location	Latitude (N)	Longitude (E)	P _H	Total chromium (mg/l)	Cr (VI) (mg/l)
S1	SIPCOT post office	12°57'24.01"	79°18'25.2"	7.4	0.07	< 0.01
S2	Outside TCCL - NE	12°57'23.93"	79°18'37.21"	7.4	0.06	< 0.01
S3	TCCL - Near Temple	12°57'24.11"	79°18'48.8"	7.6	0.06	< 0.01
S4	Near Mukundarayapuram road	12°57'18.49"	79°18'26.19"	7.7	0.07	< 0.01
S5	Inside TCCL - Dump -NE	12°57'19.61"	79°18'35.54"	9.1	81.06	64.06
S6	Near road -Dump	12°57'19.31"	79°18'45.37"	7.2	0.06	< 0.01
S7	Near Mukundarayapuram road	12°57'12.86"	79°18'22.01"	6.8	0.06	< 0.01
S8	Inside TCCL - Dump	12°57'12.5"	79°18'32.28"	10.2	158.6	142.3
S9	Inside TCCL - Dump	12°57'12.94"	79°18'38.56"	8.1	128.7	112.8
S10	Outside TCCL	12°57'11.06"	79°18'45.51"	7.1	0.06	< 0.01
S11	Outside TCCL	12°57'7.69"	79°18'25.51"	7.1	0.07	< 0.01
S12	Outside TCCL	12°57'4.51"	79°18'33.89"	8.0	2.05	1.06
S13	Outside TCCL	12°56'59.59"	79°18'43.9"	6.7	0.06	< 0.01
S14	Outside TCCL	12°57'17.92"	79°18'45.56"	6.6	0.05	< 0.01
S15	Outside TCCL	12°56'59.59"	79°18'28.94"	6.7	0.05	< 0.01
S16	Outside TCCL	12°57'7.92"	79°18'38.72"	7.6	122.48	109.26
S17	Outside TCCL	12°56'54.87"	79°18'33.82"	7.3	107.6	92.5
S18	Outside TCCL - Reliance Petrol Bunk	12°56'54.86"	79°18'43.86"	7.1	0.05	< 0.01
S19	Outside TCCL - Drainage	12°56'49.97"	79°18'25.78"	7.4	77.17	62.76
S20	Outside TCCL	12°56'50.01"	79°18'32.31"	7.5	49.8	41.7
S21	Outside TCCL	12°56'48.39"	79°18'37.38"	6.7	0.05	< 0.01
S22	Outside TCCL- Drainage towards Karai Lake	12°56'43.3"	79°18'30.59"	8.1	111.3	103.8
S23	Outside TCCL	12°56'40.02"	79°18'38.82"	7.1	5.08	3.62
S24	Outside TCCL -Near Karai Lake	12°56'41.83"	79°18'32.56"	7.0	0.07	< 0.01
S25	Outside TCCL	12°56'53.21"	79°18'58.78"	6.8	0.05	< 0.01

Table 3.2 Physico-chemical characteristics of water samples

Standard	P _H	Total Chromium mg/l	Chromium (VI) mg/l
WHO Standard	7-8	0.05	0.05
ISI 10500 -91 standard	6.5 - 7.5	0.05	0.05

Source: WHO standard for drinking water, 1993; ISI 10500-91

RESULT AND DISCUSSION

Total chromium and Hexavalent chromium

Chromium (VI) and chromium (III) are under total chromium whereas chromium (VI) is highly toxic and chromium (III) has less toxicity. The maximum concentration of total chromium is 158.6 mg/l. Hexavalent chromium is one of the oxidation forms of chromium which leads to lung cancer, chromate ulcer, perforation of nasal system and kidney

damage, in humans as well other organisms. Our results show the maximum of 142.3 mg/l. In this study total chromium and hexavalent chromium are much above the permissible limits as per WHO and ISI standards. Disposal of hexavalent chromium contaminated water to the stream cause serious issue to the ground water contamination. The concentration level in different sampling locations is shown in figure 4.1.

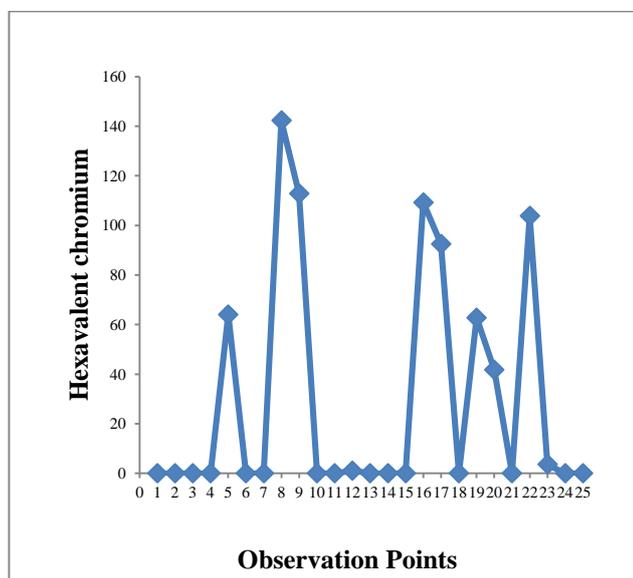
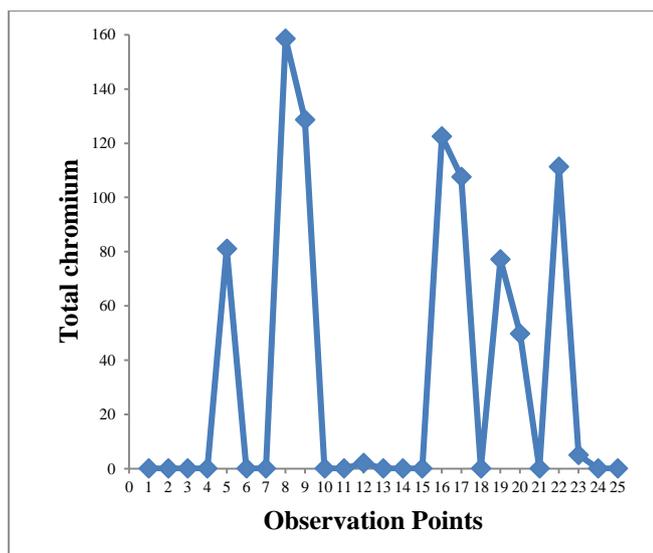


Figure 4.1 Variations of Total chromium and Hexavalent chromium

RECOMMENDED REMEDIAL MEASURE

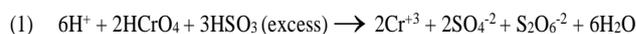
Geochemical fixation

Several *in-situ* treatment and remediation approaches were already reported and successfully used in Super Fund Clean-up Projects in USA. The integrated approach for remediation is to address the dump cleaning and treating the contaminated soil and ground water. The geochemical fixation is chosen for the location of dumpsite. Geophysical investigations, to delineate subsurface lithology, aquifer geometry and verification of subsurface strata through drilling at the dump site has to be carried out. The goal of this technology is to reduce the groundwater and contaminated soil to the more

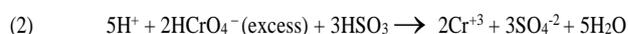
thermodynamically stable Chromium (III). The reduced chromium is expected to geochemically fix onto aquifer solids.

The success of the *in-situ* chromium geochemical fixation technology depends on the ability of the applied reductant to reduce in groundwater to Chromium (III), and on the capacity of the reduced chromium to fix onto the aquifer solids. The total chromium concentration in the aquifer system does not decrease, but chromium gets precipitated and fixed (immobilized) onto aquifer solids as Chromium (III). Some information is available indicating how sodium metabisulfite (SMBS) might act as a reductant in the subsurface. In general, sulfur compounds such as sulfide and sulphite also get reduced. For sulfides to reduce, Fe (II) must be present as a catalyst. Thus, in aquifer systems where iron sulfides are present, reduction may occur. However, if the rate of reaction is slow, the iron sulfide reduction process may not effectively treat large volumes of water.

According to Palmer and Wittbrodt (1991), the following reactions occur. In the presence of excess sulfite, the reduction of follows the reaction in equation 1.



The metabisulfite ($S_2O_6^{-2}$) formed by the above reaction can then reduce oxidized Fe (III) to Fe (II), if it is present. The situation allows for potential reduction of Chromium (VI) by Fe (II), as previously described. In the presence of excess Chromium (VI), the reduction to Chromium (III) by sulfite follows the reaction in equation 2.



Therefore, the process of using sodium metabisulfite should reduce the Chromium (VI) to Chromium (III) *in-situ*, provided there are sufficient iron and manganese oxide adsorption sites within the aquifer treatment zone to which the Chromium (III) can affix.

Using the technology, groundwater is extracted, treated with a chemical reagent, and re-injected along the contaminant plume perimeter. As the treated water is directed towards the centre of the plume, Chromium (VI) is reduced to Chromium (III), its less soluble form. The zone of contamination is driven inward by the reaction front, leaving behind an increasingly larger clean water zone. Alternatively, injection can occur in the high concentration areas (source zones) to effect a more rapid remediation. The schematic diagram of *in-situ* geochemical fixation process is shown in figure 5.1.

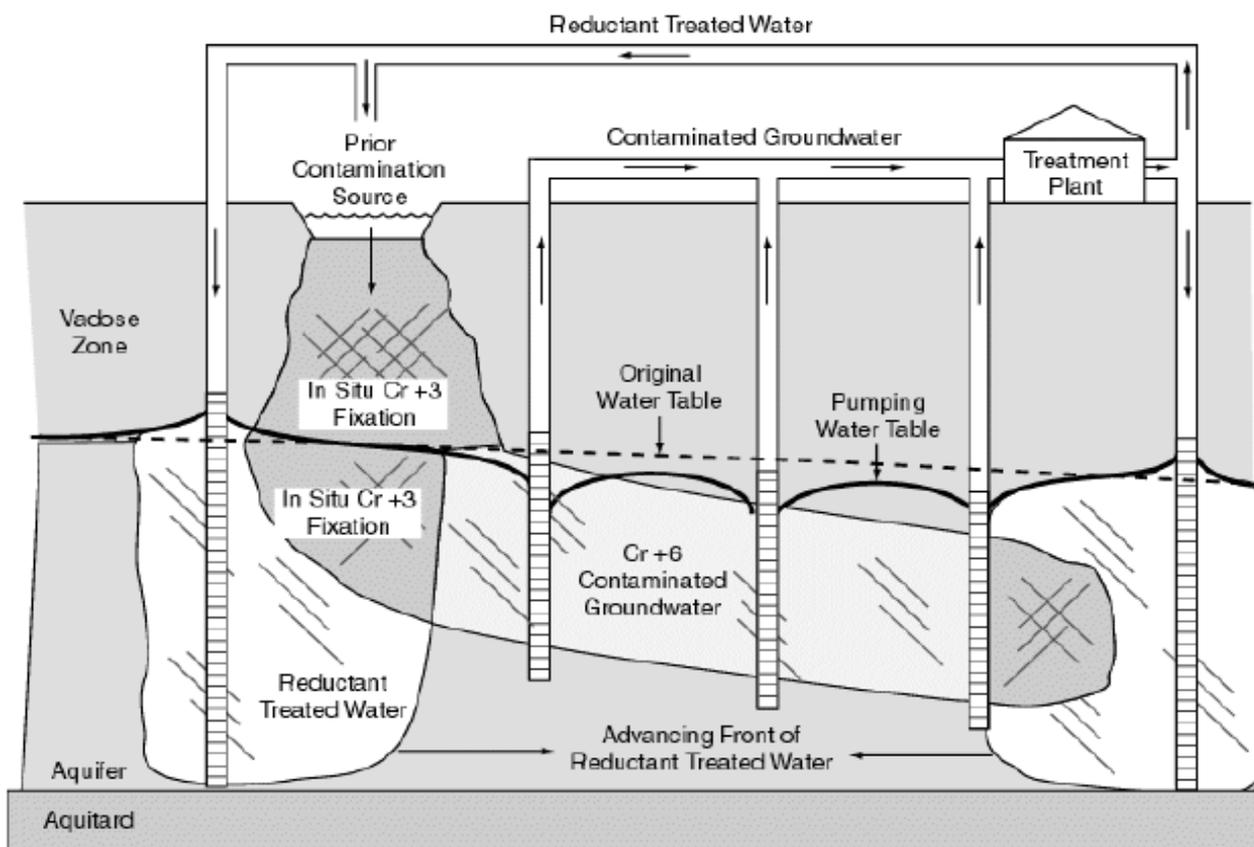


Figure 5.1 Schematic of in-situ Geochemical Fixation

CONCLUSION

As the remediation schedule proceeds, the contamination plume in the aquifers will be reduced and eventually would require less geochemical activity or chemical use. The extent and efficiency of the field-level chemical fixation in the prevailing soil matrix of the TCCL location is important to draw the conclusions on;

- Alternative and optimal dose of redundant chemicals
- Average or maximum extent and times of re-injection of redundant chemicals for geochemical fixation
- Time requirement for achieving the Cleanup Target Concentrations of Chromium (VI) in water.
- Project Costing- Budgetary Estimate.

Hence, the present evaluation and laboratory experiments must be extended to field as demonstration plant to optimize the process of geochemical fixation to remediate the dumpsite.

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