

Evaluation of Ground Water Contamination at Tamil Nadu Chromate and Chemicals Limited and its Surrounding Areas in SIPCOT Industrial Complex, Ranipet, Vellore District, India

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Abstract: Water beneath the ground has been used for domestic use, livestock and irrigation, since, the earliest times. Ground water are been polluted by the municipal, industrial and other commercial activities. Industrial disposal of effluents in land and the subsequent pollution of ground water, soil of surrounding housing lands and farmlands is relatively a new area of research. Tanneries in an Industrial zone of Ranipet (India) manufactured sodium bi-chromate and chromium sulphate tanning powder. Tamil Nadu Chromate and Chemicals Limited (TCCL) factory generated approximately 1,60,000 metric tons of chromium waste which is dumped in the factory premises to a height of 2-4 m of hexavalent Chromium (Cr^{6+}). Disposal of this waste, face a threat for the people residing in around the area for the past 40 years. Major ions and hexavalent Chromium (Cr^{6+}) were analysed and compared with the WHO and ISI 10500-91 Standards. Evaluation result shows that the ground water is highly contaminated and a threat for the people residing around the area.

Key words: Physio-chemical parameters, water contamination, hexavalent chromium, total chromium, WHO, ISI 10500-91 standards

INTRODUCTION

Ground water is utilized for drinking and agriculture by majority of the people. Ground water is an important source of fresh water reserves. It supports drinking water supply, irrigation, industrial and many commercial activities. Ground water becomes polluted primarily because of human activities such as municipal, industrial and agricultural sources. Ground water in general is less susceptible of contamination and water pollution when compared to surface water bodies. Ground water is been contaminated by the naturally acquiring sources. Soil and the geological formation which contains higher levels of heavy metals can leach to the ground water.

Accumulation of heavy metals and some organic pollutants can lead to abnormalities or any other severe health effects. Chromium is utilized in industrial activities like electroplating, fertilizers, metallurgy which is a major contaminant from the tanning industry. Chromium is water soluble, extremely toxic to the human body. Breathing Cr^{6+} irritates the nose or mouth of the people and also cause asthma and lung cancer. With the increase in sense of

awareness about the environment, researchers focus the study of transport related to the ground water contamination. The object of the research is to analyze various physico-chemical parameters of the ground water in and around Tamil Nadu chromate and chemical limited, SIPCOT, Ranipet, Tamil Nadu (Table 1).

Tamil Nadu Pollution Control Board (TNPCB) made a report in 1996, estimated that 1,60,000 metric tons of solid chromium waste was dumped to a depth of 4-5 m in an area of about 8.0 acres of land within TCCL premises. The leachate which generated from the infiltration of rain water pollutes the ground water in the downstream areas. Soil contain higher levels of chromium can leach into the ground water. This can be moved by pumping wells particularly for the agriculture. Health effects from contaminated ground water depends upon the specific pollutant.

Study area: The study area is located in 3.0 km North West of Ranipet on NH4 highway to Bangalore lies Northern latitude $12^{\circ}55'00''$ - $12^{\circ}58'00''$ and Eastern longitude of $79^{\circ}17'30''$ - $79^{\circ}20'00''$ and falls in Survey of India Topo-sheet No. 57-P/5 (Fig. 1). This study area is

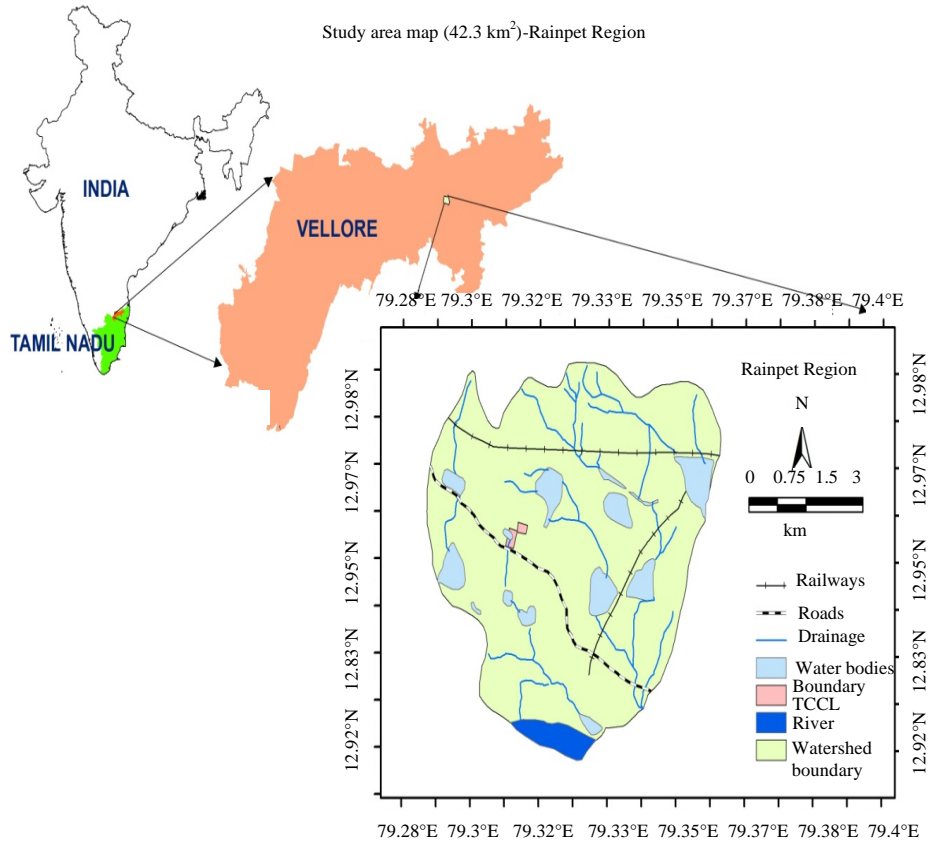


Fig. 1: Location map of TCCL dumpsite and study area

Table 1: Physico-chemical characteristics of water samples

Standard	pH	Total suspended solids (mg/L)	Total dissolved solids (mg/L)	Chlorides (mg/L)	Sulphate as SO ₄ (mg/L)	Total hardness (mg/L)	Cr ⁶⁺ (mg/L)	Total Cr (mg/L)
WHO	7-8	300	1000	100	100	250	0.05	0.05
ISI 10500-91	6.5-7.5	500	500	250	200	300	0.05	0.05

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

116 km from Chennai and 43 km before Chittoor District of Andhra Pradesh and sited in Plot No. 25 of SIPCOT Industrial Estate along the NH4 Ranipet, Chennai. Topography of the watershed varies from 190-162 m above the Average Mean Sea Level (AMSL). Our study area covers 42.3 km² of Ranipet Region whereas the samples were taken in highly contaminated area 2.25 km² in and around TCCL.

Geomorphologically, the area depicts undulating topography falling in pediment zone of the denudational and structural hills rising in the northern side. The flat to undulating pediplain nature continue and extend upto the flood plain of Palar River. Near the TCCL dump site, the NH₄ national highway acts as the boundary. Preliminary geological studies were carried out by geological survey of India (GSI Report 1996) and NGRI in 2005.

MATERIALS AND METHODS

A total of 25 bore holes were drilled in and around the contaminated dump site in different locations and the water samples were collected in plastic cans. The location of bore holes is shown in Fig. 2. A total of 8 bore holes were done into the premises of TCCL site where others in the open land around the premises of TCCL. The water samples were tested in Dr. M.G.R. Educational Research Institute for different physico-chemical parameters such as PH, TSS, TDS, Chlorides, Sulphates, total hardness, hexavalent chromium and total chromium as per standard procedures of Table 1. The quality of the ground water is assessed by comparing each parameters with the standard desirable limit of the parameter in drinking water as prescribed by ISI 10500-91 and WHO (2002) standards in Table 2.

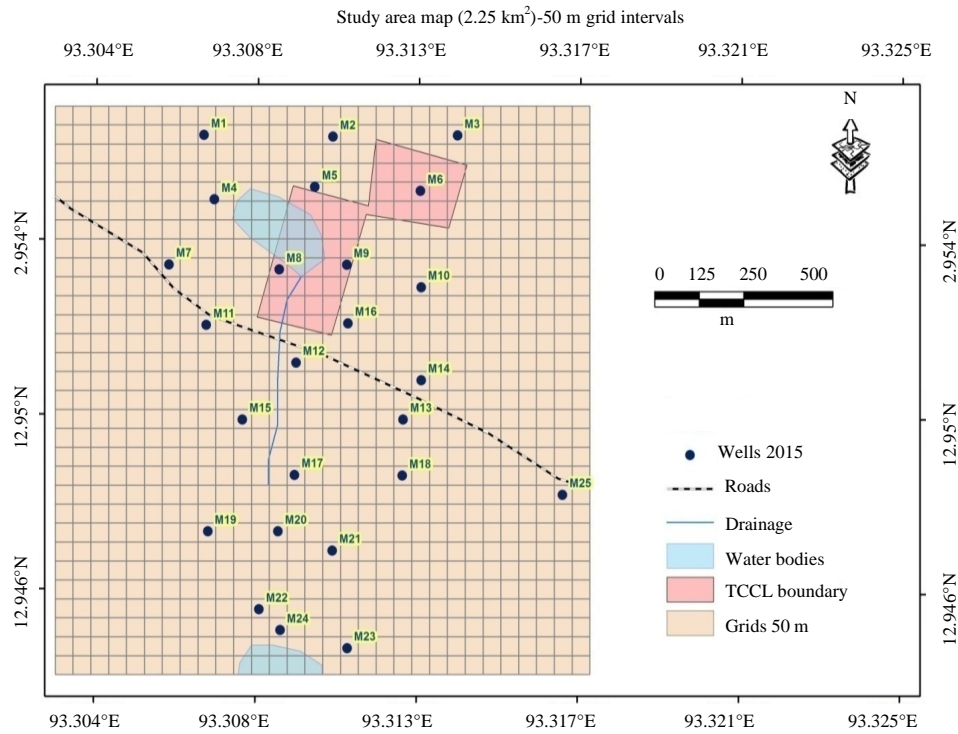


Fig. 2: Locations of water samples in 2015

Table 2: Major ions and hexavalent Chromium (Cr⁶⁺) concentrations in ground water (2015)

Well No.	Latitude	Longitude	pH	TSS (mg/L)	TDS (mg/L)	Chlorides (mg/L)	Sulphate (mg/L)	Total hardness (mg/L)	Cr ⁶⁺ (mg/L)	Total chromium (mg/L)
M1	12°57'24.01"	79°18'25.2"	7.4	72	1920	72	292	258	<0.01	0.07
M2	12°57'23.93"	79°18'37.21"	7.4	68	1130	108	306	262	<0.01	0.06
M3	12°57'24.11"	79°18'48.8"	7.6	21	1490	110	416	278	<0.01	0.06
M4	12°57'18.49"	79°18'26.19"	7.7	68	1338	182	319	248	<0.01	0.07
M5	12°57'19.61"	79°18'35.54"	9.1	262	3480	473	592	412	64.06	81.06
M6	12°57'19.31"	79°18'45.37"	7.2	27	1905	112	218	308	<0.01	0.06
M7	12°57'12.86"	79°18'22.01"	6.8	57	1818	148	224	217	<0.01	0.06
M8	12°57'12.5"	79°18'32.28"	10.2	410	3812	472	708	918	142.30	158.60
M9	12°57'12.94"	79°18'38.56"	8.1	210	3124	219	316	712	112.80	128.70
M10	12°57'11.06"	79°18'45.51"	7.1	19	2520	118	224	207	<0.01	0.06
M11	12°57'7.69"	79°18'25.51"	7.1	112	1820	132	236	247	<0.01	0.07
M12	12°57'4.51"	79°18'33.89"	8.0	68	1810	149	168	292	1.06	2.05
M13	12°56'59.59"	79°18'43.9"	6.7	72	1680	112	192	292	<0.01	0.06
M14	12°57'17.92"	79°18'45.56"	6.6	21	1910	116	198	308	<0.01	0.05
M15	12°56'59.59"	79°18'28.94"	6.7	71	1720	128	174	314	<0.01	0.05
M16	12°57'7.92"	79°18'38.72"	8.1	118	3410	372	416	619	109.26	122.48
M17	12°56'54.87"	79°18'33.82"	7.3	122	3100	348	215	761	92.05	107.16
M18	12°56'54.86"	79°18'43.86"	7.1	96	1760	128	168	306	<0.01	0.05
M19	12°56'49.97"	79°18'25.78"	7.4	63	2820	346	732	492	62.76	77.17
M20	12°56'50.01"	79°18'32.31"	7.5	65	2914	321	598	480	41.70	49.80
M21	12°56'48.39"	79°18'37.38"	6.7	192	798	108	408	252	<0.01	0.05
M22	12°56'43.3"	79°18'30.59"	8.1	311	3080	234	690	690	103.80	111.30
M23	12°56'40.02"	79°18'38.82"	7.1	168	2960	192	421	520	3.62	5.08
M24	12°56'41.83"	79°18'32.56"	7.0	172	647	109	312	301	<0.01	0.07
M25	12°56'53.21"	79°18'58.78"	6.8	149	710	112	293	308	<0.01	0.05

RESULTS AND DISCUSSION

pH is one of the important parameter of water body, since, most of the aquatic organisms are adopted to an average pH. In this investigation, pH values vary from 6.6- 10.2 whereas the pH value of drinking water

specified is 6.5-8.5 as per ISI 10500-91 (Fig. 3). The results indicate the ground water source in our study area is alkaline in nature.

Increase in suspended soils decrease the effectiveness of drinking water disinfection agents by allowing microorganisms to hide from disinfectants. The

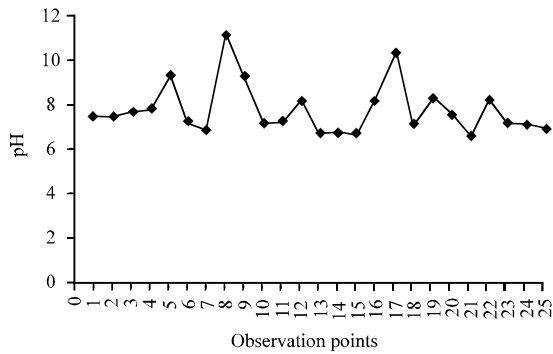


Fig. 3: Variation of water pH value

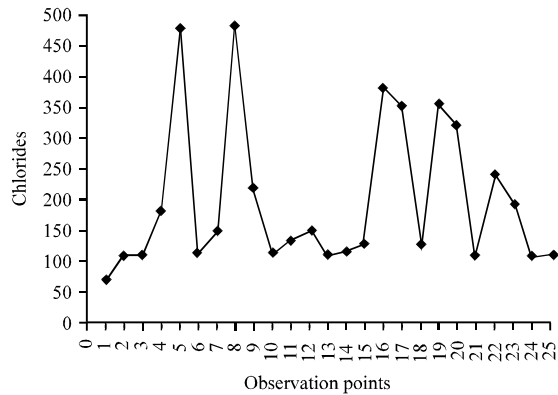


Fig. 6: Variation of chlorides

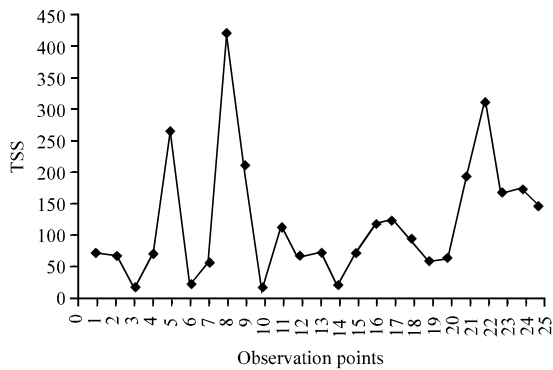


Fig. 4: Variation of TSS

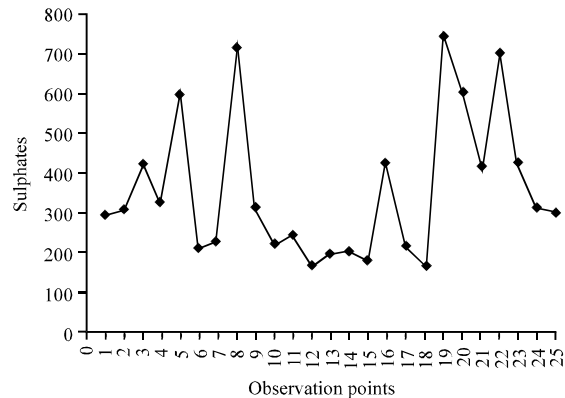


Fig. 7: Variation of sulphates as SO₄

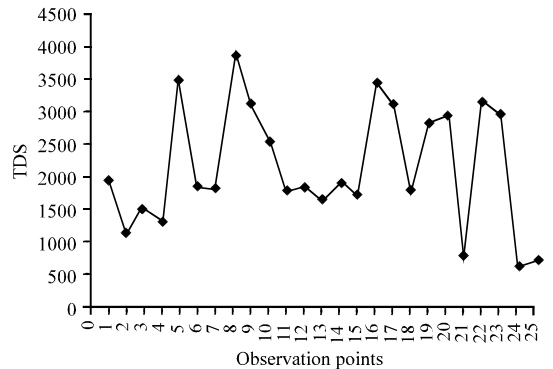


Fig. 5: Variation of TDS

total suspended solids (Fig. 4) shows high concentration when compared with the standards prescribed by ISI 10500- 91 and WHO (2002).

Total Dissolved Solids (TDS) are various mineral substances and some dissolved organic matters. Dissolved solids tend to increase with increasing pollution of water. In this present investigation, the TDS (Fig. 5) show values from 647-3812 mg/L. The values are more than the ISI 10500- 91 and WHO (2002) standards.

Chlorides are highly toxic than sulphates and best indicator of ground water pollution. Permeability of soil plays a key role in accumulation of chloride concentration in the ground water (Nirmala *et al.*, 2013). Drinking water

which contains sodium chloride concentration above 250 mg/L may cause hypertension. In this study, chloride concentration (Fig. 6) is found in a range from 72-473 mg/L. All the values are above the limit prescribed by ISI 10500-91 and WHO (2002) Standards.

High level concentration of sodium and magnesium sulphate causes dehydration in human beings (Prasanna and Ramesh, 2013). Therefore, the recommended concentration of sulphate in the drinking water ranges from 100-200 mg/L. The results are much above prescribed by ISI 10500- 91 and WHO (2002) Standards (Fig. 7).

Total Hardness (TH) is primarily caused by the presence of calcium and magnesium. The permanent hardness is caused by sulphate of metals which is difficult to be removed. This study shows the total hardness (Fig. 8) ranges from 207-761 mg/L. These values are below the maximum permissible limit prescribed by and ISI 10500-91 and WHO (2002) Standards. However, in 3 bore wells higher values of total hardness was observed.

Oxidation form of chromium is hexavalent Chromium (Cr⁶⁺) which is highly toxic (Pun *et al.*, 2013; Rao *et al.*, 2012); Roy and Kalita, 2011. This leads to lung and

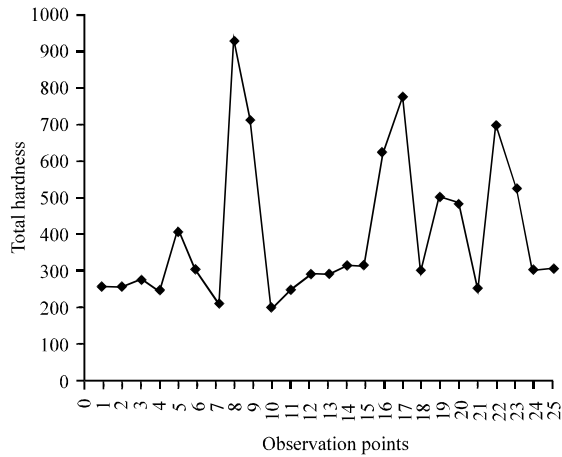


Fig. 8: Variation of total hardness

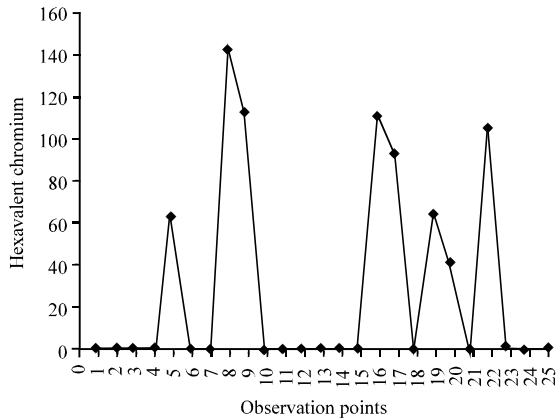


Fig. 9: Variation of hexavalent chromium

stomach cancer for humans. Based on the drill, hexavalent chromium was analyzed and the results are tabulated. In the present study, hexavalent chromium was found below the permissible limit in most of the bore well samples. Higher contamination was noticed in 9 bore wells in and around the TCCL site of 2.25 km². The result shows higher concentration of 1.06-142.3 mg/L which is much above the prescribed limits of ISI 10500-91 and WHO (2002) Standards. The results of the study were compared with the results of NEERI-NGRI findings in 2005.

Chromium (III) and (VI) are covered under total chromium. Chromium (III) is nutritionally essential for human and is often added to vitamins (Kamaludeen *et al.*, 2003; Devi and Premkumar, 2012). People who use the water containing excess total chromium experience allergic dermatitis. In the present study, total chromium found to be within allowable limit in most of the bore wells. The concentration of total chromium varies from 0.06-158.6 mg/L which is above the permissible limits of ISI 10500-91 and WHO (2002) standards (Fig. 9 and 10).

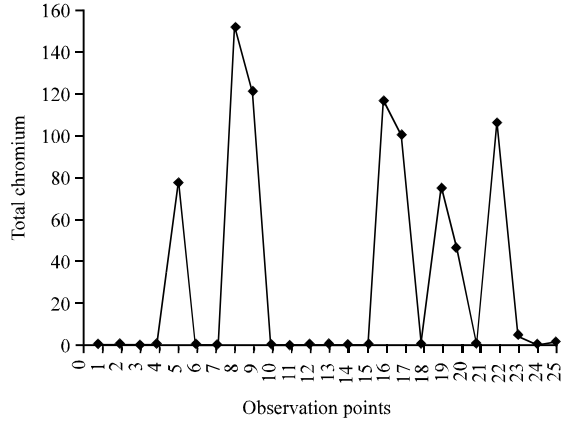


Fig. 10: Variation of total chromium

CONCLUSION

The pH values of water samples are much greater than 8.0, indicating alkaline nature of water. Majority of the observed samples are above permissible limits. The suspended solids concentration is found to be below the permissible limit except one sample (M8). The total dissolved solid values in the samples are above permissible limit. Chlorides in salt form like sodium chloride, calcium chloride and potassium chloride show higher values in five samples (M5, M8, M16, M17 and M19). The sulphate concentration exceeds in all the water samples. One of the oxidation form of chromium are hexavalent chromium which is high toxic was found to be below the permissible limit except 10 sampling points (M5, M8, M9, M16, M17, M19, M20, M22 and M23). Cr⁺⁶ and Cr⁺³ covered under total chromium are beyond the permissible limit in all the sampling points. In general, the ground water in and around the TCCL site is highly contaminated due to the dumping of TCCL waste. As an initial step to improve the quality of ground water, chemical and bio-remediation methods can be adopted.

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