Environmental Impact of a Tanning Industrial Cluster on Groundwater Quality of Bangalore, India, with Special reference to Chromium

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Abstract—Tanneries use a large number of chemicals during the process of leather making, such as chromium sulphate, sodium chloride, and calcium hydroxide. The salts present in the effluent seep into the ground surface and thereby cause the pollution of ground water sources in the area. Chromate poisoning causes severe skin disorders such as allergic dermatitis and liver and kidney damage and there is considerable evidence that chromium is carcinogenic. In view of this, it is of paramount importance to look for and to evaluate the chromium levels in the drinking waters of the area and assess their status of potability in the light of the criteria laid by Bureau of Indian Standards (B.I.S). Thirty groundwater samples were identified for sampling and chromium analysis, from the area covering about 1.4 Square km, in and around a tannery cluster. The analysis reveals that 53.33% of the samples are non-potable due to the presence of excess chromium and the results show that there is a definite correlation between the ill health faced by the residents of the area and ground water contamination.

Keywords—Contamination, chromium, groundwater, pollution, tanneries.

I. INTRODUCTION

The Tanning industry is one of the oldest industries in India. In the recent years, the concentrated growth of this industry in certain localities has shown how the waste from this industry can cause irreversible damage to the water environment in the vicinity [1]. It is estimated that 30-35 litres of water is used per Kilogram of leather processed, generating about 680 million litres of effluent daily. In India alone about 2000-3000 tons of chromium escapes into the environment annually from tanning industries. Most of the tanneries present here are located in the outskirts of several major cities such as Delhi, Kanpur, Mumbai, Calcutta, Chennai etc. Ref [3] indicated that groundwater in Dindigul area of Tamil Nadu, India is heavily polluted due to the disposal of treated effluent from the tanneries into open drains that do not comply with the disposal standards. The effluents from the tanning processes are sent to the common effluent treatment plant (CETP) by large scale industries after the formulation of stringent laws in 1991. Although CETP helps to some extent for the treatment of effluent, it is still not fit for re-use due to high concentration of many ions. In addition, there is also huge quantity of solid waste generated as sludge from water treatment. Since the solid waste rich in chemicals is improperly disposed of, the resulting leachate finds its way into the groundwater during rainfall recharge [4]. This problem persists especially in developing and under developed countries where proper treatment of waste is not carried out. Impact on the environment by the tanning industries has been reported in several countries [5] - [9]. Leather is manufactured in a number of steps involving about 170 types of chemicals, which include several chemicals like chromium sulphate, sodium chloride, and calcium hydroxide. Therefore, the resultant effluent is enriched with chromium and salts. All tanneries need a large amount of water for processing leather and depend on nearby ground/surface water sources for their daily requirements. The discharged effluents from the processing unit are either discharged into the nearby river or stored in large lagoons and pollution occurs as the dissolved salts percolate into the surrounding soil [10]. Indiscriminate disposal of chemicals rich tannery effluent has resulted in extensive degradation of productive land, surface and groundwater. The industrial effluent standards are stringent as compared to disposal on land for irrigation. Therefore, industries prefer to discharge their effluents on land. Continuous irrigation using even treated effluents may lead to groundwater and soil degradation through accumulation of pollutants. Apart from disposal of industrial effluents on land and other surface water bodies, untreated/improperly treated effluents are also injected into the groundwater through ditches and wells in some locations in India to avoid pollution abatement costs. As a result, groundwater resources of surrounding areas become unsuitable for drinking and agricultural purposes. Continuous application of polluted groundwaters for irrigation can also increase the soil salinity and alkalinity problems in farmlands.

A. Genesis of Chromium and Effects on human health

Chromium is absorbed through both the gastrointestinal and respiratory tracts [11]. Chromium enters environmental waters from anthropogenic sources such as electroplating factories, leather tanneries and textile manufacturing facilities. Chromium also enters groundwater by leaching from soil.

B. Toxicological effects of chromium

The harmful effects of chromium in mass are associated with hexavalent chromium. In high doses, chromium cause digestive tract cancer in humans and there is evidence that there is an increased risk of lung cancer to workers who are exposed to high levels of chromium. Chromate poisoning causes severe skin disorders such as allergic dermatitis and liver and kidney damage. Chromium VI is a human carcinogen, as determined by the International Agency for Research on Cancer (IARC), the U.S. Environmental Protection Agency (U.S. EPA), and The Office of Environmental Health Hazard Assessment, OEHHA [12].

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C. Toxicological effects of chromium on human

All reports of humans acutely poisoned by chromium compounds have involved compounds of chromium VI [13]. A 14-year old boy died in the hospital eight days after ingesting 7.5 mg CrVI/kg as potassium dichromate. Death resulted from gastrointestinal ulceration and severe damage to the liver and kidneys [14]. Other reports of humans dying from ingestion of chromium VI involved large amounts of the chemical [15]. Effects on the cardiovascular, respiratory, gastrointestinal, hematological, hepatic and renal systems are observed in humans who die after ingestion of large amounts of chromium VI.

A village in the People’s Republic of China had a drinking water well contaminated from a nearby alloy plant with 20 mg CrVI/L. A cross sectional study of people living in this village revealed that they suffered from leukocytosis and immature neutrophils. Cross sectional epidemiological studies have been conducted on villagers in China who consumed water from wells contaminated with chromium VI [16]. Drinking water from one of these wells contained 20 mg chromium VI/L. The villagers who drank this water experienced oral ulcer, diarrhea, abdominal pain, indigestion and vomiting.

In a mortality study regarding groundwater contamination with hexavalent chromium (Cr+6) in the JinZhou area of China between 1965 and 1978, a significant excess of overall cancer mortality was observed in five Cr (+6)-contaminated villages combined. adjacent to the source of the contamination, where 57% of the wells exceeded the European Community safe drinking water standard of 0.05 ppm [17].

A Recent analysis has revealed that 38% of municipal sources of drinking water in California have detectable levels of hexavalent chromium [18]. This observation provided new impetus to characterize the carcinogenic risk associated with oral exposure to hexavalent chromium in drinking water. In the present study, discussions held by the authors with the Health Centre authorities revealed that, between January and November 2014, 12 residents were treated for dermatitis, 6 for indigestion and vomiting and 5 cases of septum perforation were identified in the tannery industrial area (study area), using the chromium contaminated water. It is in this regard, that the present study assumes great importance.

D. Details of Bangalore City

Bangalore city, the state capital of Karnataka, is situated in the southernmost part of India and lies between North Latitude 12°52’ 21” E 13°60’ and East Longitude 77°0’45” to 77°32’25”, covering an area of approximately 400 square km. The study area is covered in part of the Survey of India Toposheet Number 57 G/12.

E. Background of Tanneries

The tannery area is located in the North-east part of Bangalore city and is encompassed by a cluster of leather industries. According to reports, sixteen industries were functioning some two decades back. Recently, the Government regulations and requirements to meet the International standards for exporting the leather has made a severe impact on the production and sales of leather and its goods, both in India and abroad. As a result, presently only five such leather industries are working with fulltime operations [19]. Previously, these industries did not have effluent treatment units and used to discharge the effluents on open land directly. From the past few years, these industries have formed an association to have a Common Effluent Treatment Plant (CETP) and the same has been established and is now working. All these industries have collectively formed an underground drainage system for conveying their industrial effluents to the CETP, which operates fulltime. But a lot of damage has already been done to the groundwaters in the area and the present arrangement has revived the situation only partially.

F. Details of the study area

The study area in and around the tannery industrial area measures about 1.4 Sq km, covering quite a few important localities of the city such as Kadugondanahalli, Devarajeevana halli, Lingarajapuram, Shampura and Kammanahalli. Though there are some of the better settled establishments in the area, most of the population is living in unhygienic conditions in slums and the industrial cluster is located very near to the residential area. The site top soil is loamy and the groundwater table is more than 35m below ground level. The soil has moderate permeability. Most of the open wells in the area are dry. Though some of the localities are covered by the BWSSB (Bangalore Water Supply and Sewerage Board) supplies, a large majority of the population are dependent on private suppliers for their drinking water supplies at heavy cost [19].

II. MATERIALS AND METHODS OF ANALYSIS

Thirty water samples were collected from the borewells and open wells in and around the industrial cluster, covering 1.4 Square km area and located very near to the residential area during both pre-monsoon (April 2014) and post-monsoon (November 2014) periods. The samples were taken from the area covering the entire residential populace using this water and were analyzed for chromium in the lab using an U-V-visible spectrophotometer in accordance with the Standard methods for examination of water and wastewater of American Public Health Association (APHA, 2002) [20]. The results obtained were evaluated in accordance with the standards prescribed under ‘Indian Standard Drinking Water Specification’ (BIS 10500: 2003) of Bureau of Indian Standards [21]. The location map of the study area along with the sampling stations is presented in Fig. 1.
III. RESULTS AND DISCUSSIONS

Thirty groundwater samples were drawn from the borewells which included hand pumps, piped water supplies and mini water supply schemes in the months of April and November 2014 and the water samples were analyzed for chromium. The analysis results are presented in Table I. Out of the thirty samples analyzed for chromium, 16 (53.33%) were found to be non-potable as per Bureau of Indian Standards. The maximum concentrations of chromium are
found to be 1.48mg/l and 1.41mg/l in post-monsoon and pre-monsoon seasons while the average concentrations are found to be 0.182 and 0.173 respectively (Table I). No appreciable differences in values are observed in the two seasons, though post-monsoon values are marginally higher. Chromium in several samples is alarmingly high, when compared to BIS permissible limit of 0.05mg/l. A high percentage (sixteen instances) of contamination due to chromium was observed, with a peak concentration of 1.48mg/l in post-monsoon, as against BIS permissible limit of 0.05mg/l.

Chromium is one of the main pollutants from tanning operations. This may be the main reason for chromium contamination of groundwater in the study area, along with the anthropogenic activities, domestic sewage and wastewater run-off, which help in the percolation of chromium along with the percolating water and finally reaching the groundwater.

Discussions held by the authors with the Local Primary Health Centre authorities revealed that the excessive concentrations of chromium leading to severe skin problems such as dermatitis is evidenced by several residents in the area for chromium has shown that nearly 54% of the samples are contaminated and unfit for domestic use and that the groundwater is getting contaminated alarmingly. The ill-health faced by the residents.

The analysis of groundwater samples from the industrial area for chromium has shown that nearly 54% of the samples are contaminated and unfit for domestic use and that the groundwater is getting contaminated alarmingly. The investigations along with the discussions held with the health centre officials and general public of the area, clearly point out to the serious chromium contamination of the groundwater in the vicinity of the tanneries cluster and the ill-health faced by the residents.

The less stringent effluent discharge standards for land application are a direct threat to the soil and water quality. Hence there is an urgent need for regulation of water quality for land application. Adopting cleaner technologies, such as organic tanning agents and going for engineered landfill for solid waste disposal to prevent infiltration of leachate can reduce the pollution. Setting up of a local area environmental monitoring committee could go a long way in abating the problem.

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