Journal of Environmental Biology **April 2007,** 28(2) 405-408 (2007)

Chromium exposure study in chemical based industry

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(Received: Septemebr 15, 2003 ; Revised received: July 02, 2004 ; Accepted: August 31, 2004)

Abstract: *176 chromium-exposed and 30 control subjects were selected for this study. Blood samples (3 ml) were collected for the estimation of chromium. The data on chromium concentration indicated a significant higher level of chromium in the blood of the exposed workers as compared to the control. There was no significant correlation between the mean blood and environmental chromium level. This study suggests that exposure to chromium may have some effect on the health of workers, even though the dose response relationship could not be established between blood chromium and environmental chromium levels. This study suggests that exposure to chromium may have some effect on the health of workers, even though the dose response relationship could not be established between blood chromium and environmental chromium levels. Study also indicates that the environmental levels to Cr are well below the permissible levels at all the sites of the industry at the time of survey, even though the blood Cr levels were observed high in 14.8% of workers and some of them were having Cr related morbidity. Therefore, preventive and engineering control measures are suggested to minimize the chromium exposure in the chromium based industry located in Gorwa industrial estate at Baroda, Gujarat. About three months period was taken to complete this study.*

Key words: *Chromium, Environment, Air, Blood, Health*

Introduction

Chromium (Cr), a toxic trace metal, occurs in environment in different forms. Severe exposures to chromium compounds are usually accidental or suicidal, and are rarely occupational or environmental (ATSDR, 2004). Short term, high level exposure to Cr (VI) produces irritation at the site of contact, including ulcers on the skin, irritation of the nasal mucosa, perforation of the nasal septum, irritation of the gastrointestinal tract, impairment of olfactory sense and discoloration (yellowing) of teeth and tongue (Cefalu and Hu, 2004; Huvinen *et al.*, 2002; Lee *et al.*, 2002; NIOSH, 1973, 1992).

In occupational settings, the most commonly reported effects of chronic chromium exposure are contact dermatitis, irritation and ulceration of the nasal mucosa. Less common are reports of hepatic and renal damage and pulmonary effects. The reproductive effects observed in the physiochemical properties of the semen *viz.* deterioration of sperm morphology, semen volume, alterations in viability *etc.* (Danadevi *et al.*, 2003; Kumar *et al.*, 2005). Primarily chromium (VI), by inhalation may cause nasal septum ulceration and perforation and other irritating respiratory effects. (ATSDR, 2004 and IARC, 1980). In addition to this respiratory allergic response in human exposed occupationally to high levels of chromium or its compounds are also observed. More over, lung cancer is a potential long term effect of chronic Cr (VI) exposure. It has been shown in the literature that the possible effects on cardiovascular, gastrointestinal, hematological, liver and kidney may be observed after long and short term exposure in workers (Kalahasthi *et al.,* 2006; Norwood *et al.*, 2006 and Toxicol. Profile, 2000).

Potential health effects from chromium exposure are dependent on many factors. These include chemical form, the amount, the length of time the individual was exposed and route of exposure (ingested, inhaled, or absorbed through skin). Once chromium enters the body, numerous biochemical reactions occur. These reactions and their potential effects are highly dependent on age, sex, weight and health of the individual.

The Cr (VI) form is important from the human health point of view. The respiratory tract in man is a major target organ of inhalation to Cr compounds. Hence, environmental and biological monitoring was carried out to assess the Cr exposure and the health impact among the workers at Baroda.

Materials and Methods

The plant is designed to produce the finished products like basic chromium sulphate and sodium sulphate as a coproduct. The monthly production of basic chromium and sodium sulphate and consumption of related raw materials like chrome ore, soda ash, lime stone, sodium chromate solution, sulphuric acid, molasses, sodium bisulphate, liquid ammonia *etc.* are given in Table 1. There are about 176 employees engaged with various activities under different departments like ore mixing, furnace, distillery, reaction and packing which are shown in (Table 2). They are exposed to Cr dust and fumes through inhalation and ingestion due to bad habits.

To evaluate chromium exposure through environmental monitoring, ambient air samples at different locations of the industry and for biological monitoring, blood samples of workers were collected and analysis. The details are as follows:

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Work environment sample: Air samples (48) were collected from various departments of industry to evaluate Cr levels. The samples were collected on membrane filter (37mm, 0.8µm pore size) and in 1M HNO_3 (analytical grade) using personal samplers (APM 820, Envirotech, New Delhi) at a flow rate of 1-2 LPM for about 8 hr in day shift. The collected air samples were wet digested using concentrated HNO_3 and then they were analyzed for Cr using atomic absorption spectrophotometer (AAS), [Double Beam 3100 model, Perkin Elmer, USA] (Harrison *et al.*, 1969; Petering, *et al.*, 1993).

Table - 1: Particulars of productions, raw materials and chemicals consumed during the year 1999-2000

Raw materials	Monthly consumption (mts)	Product	Monthly production (mts)
Chrome ore	80	Basic Chromium sulphate	150
Soda ash	60	Sodium sulphate	60
Lime stone	80		
Sodium chromate solu.	150		
Sulphuric acid 98%	30		
Spent sulphuric acid	150		
Molasses	10		
Sodium bi-sulphide	2		
Liquid ammonia	1000 liter		

Table - 2: Departments and worker's strength of the chromium industry

Departments	Strength of workers	Control workers
Ore mixing	55	0
Furnance	26	0
Distillary	21	0
Reaction	29	1
Packing	1	8
Misc	44	21
Total	176	30

Biological samples: 176 workers (All the chromium industrial workers) and 30 control subjects from a near by industry which does not manufacture any chromium related compounds were included in the study. The criteria such as age, sex, weight and health of the individual was also considered for selections of control subjects.

3 ml venous blood samples were collected in haparinized plastic vials with utmost care to avoid contamination. The samples were transported in frozen condition and stored in deep freezer up till analysis. These samples were wet digested in Microwave digestive system (Ethos 1600, Advanced Microwave Lab Station Made of Italy) using concentrated HNO_3 and were analyzed using Atomic Absorption Spectrophotometer (AAS), [Double Beam 3100 model Perkin-Elmer, USA] (Harrison *et al.*, 1969; Petering, *et al.*, 1993).

Table - 3: Group wise abnormals observed on clinical and boold and/or chromium level examination

	Control	Exposed
Total no. of workers clinically studied	30	176
No. of workers investigated for biochemical tests	30	176
Workers showing clinical morbidity in association with evidence of raised chromium levels	1/30 (3.3%)	26/176 (14.8%)

Results and Discussion

The results of chromium exposure:

Environmental monitoring: The levels of Cr were found higher at basic chromium sulphate (BCS) (45.87±20.4 µg/m^3), biochromate plants (33.08±13.15 µg/m^3), followed by furnace (22.49±11.18 µg/m^3), filtration (22.48±11.25 µg/m^3), spray dyer (22.43±10.7µg/m^3) and office/lab (4.21±0.61µg/m^3). The Cr levels were observed lowest in office and laboratory areas. The overall results show that Cr levels in the plant were observed lower than the threshold limit value (*i.e.* 500 µg/m^3). Cr levels in various departments are given in Fig. 1.

Cr (VI) compounds are emitted into the air, water, and soil by a number of different industries. In the air, chromium compounds are present mainly as fine dust particles that eventually settle over the land and water (Rowbotham *et al.*, 2000; Morello Frosch *et al.*, 2000).

The occupational safety and health administration (OSHA) and the national institute for occupational safety and health (NIOSH) establish permissible exposure limits (PELs) and recommend exposure limits (RELs), respectively, for hazardous substances in the workplace. PELs are based on the feasibility of controlling the exposure in question within the workplace, while RELs are based on requirements for preventing occupational disease. Although employers are legally bound only by PELs, they are encouraged by NIOSH to follow whichever limit is the more protective. The PEL for Cr (VI) in workplace air during an 8hr work day, 40hr work week is 100 µg/m^3, while the REL for carcinogenic Cr (VI) compounds in workplace air is much lower, only 1µg/m^3. Moreover, recently by Smith *et al.* (2006) found after research on children's health suggested that the increased mortality from lung cancer and bronchiectasis in young adults after exposure to Arsenic *in Utero* and in early childhood.

Biological monitoring: The mean blood Cr level in the exposed workers was 6.41µg/100ml, which was considerably higher as compared to control subjects *i.e.* 2.96 µg/100ml (Fig. 2). The 14.8% of exposed workers had high Cr values and exceeded than the prescribed levels (*i.e.* 0.65–5.00 µg/100ml). During the medical examination, a total of 22 cases (16 in furnace staff, 4 in supervisory staff and 2 in maintenance staff) were observed with

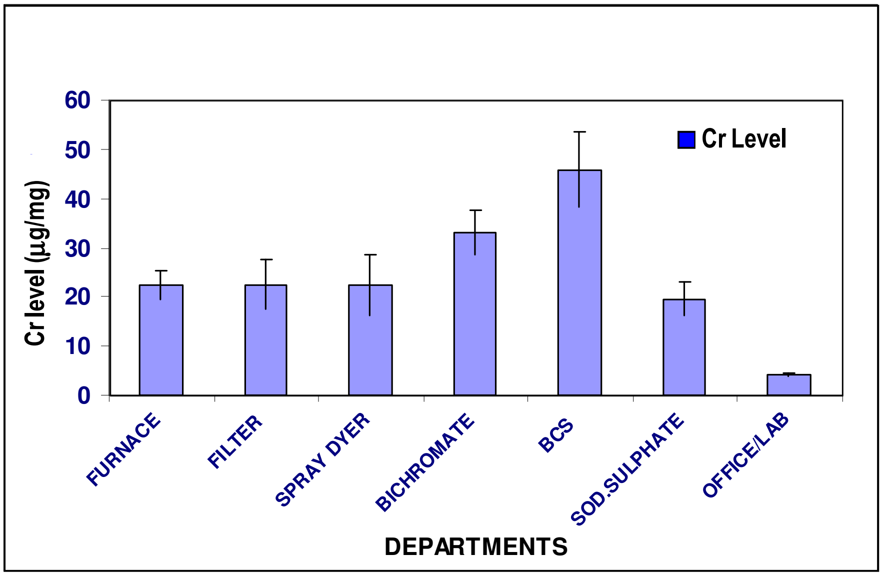

Fig. 1: Chromium level in different departments of chemical based industry

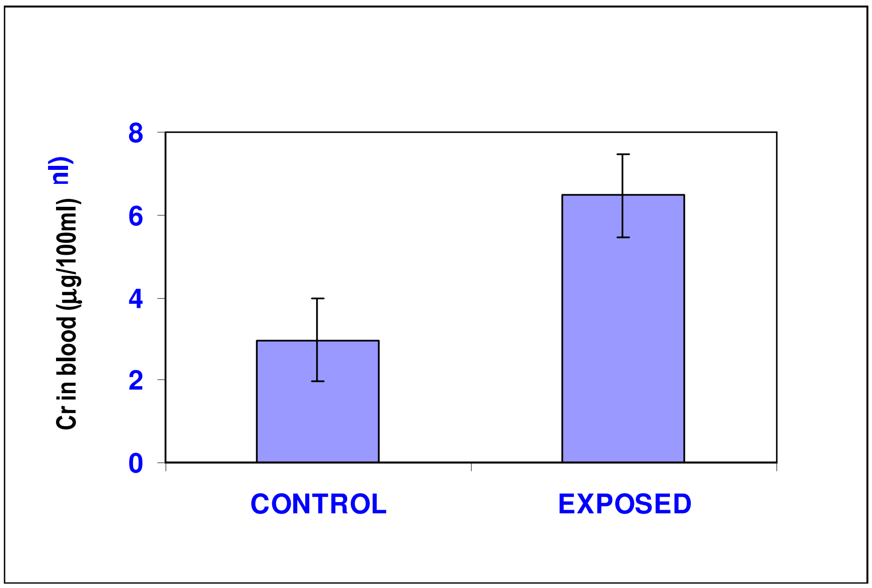

Fig. 2: Blood chromium levels in exposed and control subjects

nasal perforation, with no such cases in control subjects. It is also observed that 14.8% of subjects who had high chromium levels (above permissible level), also had positive signs and symptoms related to Cr toxicity.

In the absence of chromium (known/unknown) exposure, the lower blood chromium concentrations occur in rural areas and higher levels occur in large urban centers, which in the whole blood ranges from 2.0 µg/100 ml to 3.0 µg/100 ml. Blood distribution of chromium appears to be divided evenly between plasma and erythrocytes. Values above background levels are considered potentially toxic, but levels have not been correlated with specific physiologic effects. Chromium rapidly clears from the blood and measurements relate only to recent exposure. In a recent review, (Danadevi *et al.*, 2004; Huvinen *et al.*, 2002) a chromium exposure up to about 5000 µg/m^3 in the chromium plating industry was mentioned, but most exposure levels reported were in the range of 100-200 µg/m^3 (NIOSH, 1973). In modern plants, values are often less than 10 µg/m^3 (IARC, 1980)

Previously reported normal levels of chromium in blood of 2-3 µg/100ml (Feldman *et al.*, 1967) have probably been too high. At present the concentration of chromium in plasma has been reported to be 0.014 µg/100 ml. (Kayne *et al.*, 1978). In Encyclopedia of occupational Health and Safety, 4th edition (1998) published by the international labour office has mentioned the values in serum and urine does not exceed 0.05 µg/100ml and 2.00 µg/g creatinine, respectively (ILO, 1998).

The qualified and experienced doctor of our institute carried out the medical examination during environmental and biological monitoring.

Morbidity pattern: Observations reported in Table 1 have shown that there is positive evidence of chromium exposure in high risk group above permissible chromium levels in blood in 14.8% of subjects investigated.

In conclusion, there is no clear evidence to relate exposure to environmental levels of chromium with adverse health effects in the general population or subgroups exposed to chromium around industrialized sites.

Based on results of ambient air monitoring and biological monitoring, following recommendations are made to minimise chromium exposure to workers at work places and to protect the health of individuals.

Avoid the spillage of chromium at ground floor with the help of better house keeping and better industrial hygiene practices. Workers employed for sweeping, cleaning, distillation, ore mixing of chromium and furnace workers should be provided personal protective device like certified masks, aprons, gloves etc. during the work shift. All the workers/staff should be made aware of health hazards due to chromium and its salts. Practice of personal hygiene may help to reduce the exposure risk due to chromium. It is necessary to organise workers education and awareness campaign. There is a need for periodical air monitoring (at least every three-month) and medical surveillance including biological monitoring (every year) of exposed workers of industry.

Acknowledgment

Authors thank and acknowledge the co-operation and assistance rendered to the scientists by workers and management of Chemicals as well as Pharmaceutical Industry, Baroda for making this study possible.

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