Chromium, Cadmium and Lead Accumulation in Biological Indices and Related Occupational Diseases of Tannery Workers of Ranipet, Vellore District

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ABSTRACT:

Like other heavy metals, chromium is also one of the widely used heavy metal in many industries and act as a root causes for many health related problems in humans as well as animals. Now days, chromium released from the chrome plating and tannery industries are highly contaminate the environment than the release from the natural resources and causing serious health problems. Particularly, the worker's who are involving in various tanning process ranging from pretreatment to dying has direct contact with chemicals like chromium were health-wise severely affected by chromium pollution. Hence, the present investigation was carried out to estimate the range of accumulation of chromium in the nail and hair samples of tannery workers of Ranipet Industrial areas, Vellore and the general health data of workers were assessed by giving standard questionnaire. The heavy metals analyses for blood, hair and toe nail samples were analyzed by AAS. The obtained results of chromium in nail and hair samples of workers were compared with their health data to analyze the existence of possible significant correlation between them.

KEYWORDS

Tannery, Skin, Eye, Cardiovascular, Blood, Hair and Toe nail

INTRODUCTION

Metal poisoning as a health issue has been described as a "silent epidemic"(Mielke *et al*, 1999). Particularly, the heavy metals are non biodegradable pollutants in the environment and enter into human bodies through different routes, such as food consumption, drinking water and respiration (Gonzalez-Munoz *et al*,2008; Song *et al*,2017;Song *et al*, 2017), accumulate in the body.(Liu *et al*, 2013) and poisonous to all living organisms including humans due to their biotoxic effects, which could be acute, chronic or sub-chronic, neurotoxic, carcinogenic, mutagenic or teratogenic (Duruibe *et al*, 2007). Among these, the heavy metals such

as Cr, Cd, and Pb are generally used in the leather industries in the tanning and dying process unit are essential to plants and animals at low concentrations and can be toxic to both at high concentration (Haroun *et al*, 2007).Leather manufacturing consists of four steps: pre-tanning and tanning, wet finishing, dry finishing, and packing (Gupta, 1990).The tannery workers who come across all these four steps are contaminated by Cr,Cd and Pb pollutants. The accumulations of all these heavy metals in the body of tannery workers are bio-monitored by analyzing hair, blood, urine and fingernail samples. Biological monitoring of Cr levels by analysis of hair, blood, and urine in tannery workers had been documented (Saner *et al*, 1984; Randall and Gibson, 1987; Randall and Gibson, 1989). In the present investigation, the tannery workers of Ranipet leather industries were bio-monitored by analyzing the hair, blood and toe nail sample to assess the level of accumulation and their respective health data were obtained by appropriate health data questionnaire. The obtained heavy metals data and health data were statistically analyzed to find possible occupational diseases among the tannery workers.

MATERIALS AND METHOD

The 100 male subjects from pre-tanning and tanning, wet-finishing, dry finishing, and packing units of leather industry and another 100 male subjects from office sides were randomly selected from the Ranipet industrial areas. The scalp hair, nail and blood samples were collected from all 200 samples. Most of the workers were denied to give the hair, nail and blood samples for this study. Because, the rural peoples wrongly believe that their enemies will use the evil forces to kill them with the help of human hair samples. So, prior to sample collection, each and every worker was convinced by the researcher by explaining the purpose of the research study and collected the samples. Addition to this, questionnaires with standard questions related to demographic data and health data which contained highlights of information about the gender, age, occupation, , working unit, nature of work, years of experience, distance between residential area and work place, type of food consumed, water source, presence of refuse dump in the area of residence, behavioral pattern, disease symptoms etc. were distributed to respondents. Height and body mass, blood pressure, oxygen saturation, pulse rate and peak expiratory flow rate (PEFR) of the consenting individuals were also taken. The physical

examinations for all workers were done by experienced doctor to identify the skin, pulmonary and cardiovascular disease persons.

Hair sample collection and processing

From each subjects, 2mm of hair samples were cut by using sterilized stainless steel scissors washed with ethanol, a neutral solvent to remove external contamination. These hair samples were stored in plastic bags and labeled for later analysis. At the time of analysis, the hair samples were pre-washed with nonionic detergent and soaked in deionizer water for 5 minutes. Finally, this hair samples were washed in acetone to remove the external contamination and again washed with de-ionized water. The water content of the hair samples were dried in an oven at 110 ℃ for an hour for complete removal of wet content.

Hair sample digestion

2grams of hair samples were weighed and taken in clean crucible. Along with concentrated nitric acid and perchloric acid in the ratio of 6:1 were mixed and heated until complete evaporation. Each digested samples were transferred to 100 mL volumetric flask and made up to mark with deionized water.

Nail sample digestion

1 g of dried nail sample was placed in a furnace at 550C up to 4hours and got ashes. These ashes were taken in a crucible, along with concentrated nitric acid and perchloric acid were taken in the ratio of 6:1 and kept overnight at room temperature to avoid excessive foaming. Thereafter, this ash and acid mixture was heated at 160-180 C upto get 1ml water clear solution. Finally, this solution was diluted with 0.1N nitric acid and made to a volume of 50 ml with deionized water.

RESULTS AND DISCUSSION

Chromium is an environmentally important heavy metal commonly used in various industries including tanneries, textile, chromium plating, steel production, and refractories (Nriagu, 1988). In the tanning process many chemicals such as Chromium oxide, ammonium sulfate, formic acid, sulfuric acid, sodium chloride etc are used which causes solid and liquid wastes (Gain, 2002). In the tannery industries, the chemical such as

chromium, HCl, Sulphuric acid, Formic acid, Caustic soda, Caustic potash, Soda ash, Sodium arsenite, Arsenic sulphite etc are used for different tanning process such as soaking, liming, deliming, tanning etc. (Khatun and Huq, 1994). Hence, in the present investigation, the tannery workers of Ranipet industrial areas were selected to observe accumulation of heavy metals Pb,Cd and Cr in blood, hair and toe nail samples and their impact on formation of skin, respiratory and cardiovascular diseases. For this study, the heavy metals Pb, Cd and Cr concentrations were observed in blood, hair and toe nail of both tannery workers from various tanning process units and official workers. Totally, 100 individuals from tannery units were selected and another 100 from non-tannery official sides.

Hair and nail acts as a biomarker to assess environmental contamination of human by poisonous trace metal (Agahian *et al*, 1990; Chaudhary *et al*, 1995; Das *et al*, 1995; Erry *et al*, 2005; Flynn, 1977; Nowak, 1993). Hair analysis for trace elements is an area of increasing interest in the fields of medical, biological, forensic, and environmental sciences (Chittleborough and Steel,1980; Ashraf *et al*, 1995; Bader *et al*, 1999). Hair provides one of the most accurate records of the health and trace metal status of the human body (Imran *et al.*, 2003; Sanna *et al*, 2007). Besides hair, both finger and toe nails have also been recognized as invaluable tissues for monitoring human environmental exposure, as they provide a good indication of exposure to many toxic metals over a period of time (Nowak and Chmielnicka, 2000;Samatha *et al*, 2004).). In the present study, the Pb,Cd and Cr accumulation in blood, hair and toenails of tannery industrial workers and non-tannery workers were analyzed by using AAS and tabulated in Table 1- 4. According to the table data, the age group-wise observation of blood heavy metals in tannery workers of ranipet showed highest Pb 0.36±0,011 µg/dl at age group 36-40 and the maximum Cd 5.4±0.29 µg/dl µg/l and Cr 6.1±0.38 µg/dl were observed at age group 46-50. In hair, the maximum Pb 2.6±0.11 µg/g ,Cd 5.2±0.208 µg/g and Cr 5.4±0.232 µg/g were observed in age group 46-50. The maximum value 1.02±0.17 for Pb, and 16.5±0.975 for Cr at age group 46-50 and 17.9±1.074 for Cd at age group 41-45 showed an agreement with the wet finishing and dry finishing workers had fingernail Cr, Cd, and Pb levels that were higher by 63.4 %, 53.0 %, and 33.0% (all $p < 0.05$) than those in the controls(Yen –Hsiung Liao, 2015).

Work experience wise sort-out of study population of tannery workers showed 18% population belongs to work experience >5, 26% in work experience 6-10, 30% in 1 work experience 11-15, 20% in work experience 16-20 and 06% in <25. The diseases such as skin, respiratory and cardiovascular affected persons were 0,01 and 0 in >5,02,04 and 0 in 6-10, 04,05 and 0 in 11-15,03,04 and 01 in 16-20 and 01, 02 and 0 in <25. The heavy metals Pb,Cd and Cr in blood were 0.37±0.0222µg/ µg/dl , 5.6±0.28 µg/ µg/dl and 6.5±0.26 µg µg/dl for 16-20, <25 and <25 work experience group respectively. In hair samples, the maximum Pb 0.27±0.0189 µg/g in 6-10 years experience ,Cd 6.7±0.335 µg/g and Cr 8.7± 0.696 µg/g were in <25 years experience. In toe nail samples maximum Pb 1.15±0.0805 µg/g, Cd 7.8±0.546 µg/g and Cr 18.4±1.656 µg/g in <25 years experience populations. Overall observation of the present study results of bio-accumulation of heavy metals Pb,Cd and Cr increased with increasing work experience of tannery workers showed a strong concordance with Chromium (Cr) level in workers who were working from 1-17 years was in range of 0.17 to 0.80 mg/kg with average value 0.384±0.0547 mg/kg, while in age group 18-35 years, Cr level ranged from 0.12 to 0.60 mg/kg with average Cr concentration 0.326 ± 0.0471 mg/kg and in last age group 36-54 years was range from 0.30 to 0.74 mg/kg with average Cr 0.502 ± 0.1337 mg/kg noticed by Moneeza Abbas et al,2017.

Tannery workers have to be in constant exposure to detrimental chemicals revealing them susceptible to serious health issues mainly in class of respiratory disorders and skin diseases (Saif, 2012).A study conducted by Kamran *et al*, 2014 depicted that most of the tannery workers were suffering from blood pressure, headache, skin allergy, respiratory problems and liver disorder and the major cause of these diseases among tannery workers evaluated was the direct exposure of chromium over a long period of time during working. Lead poisoning also causes inhibition of the synthesis of haemoglobin, dysfunctions in the kidneys, joints and reproductive systems, acute and chronic damage to the central nervous system, etc.(Ogwuegbu and . Muhanga,2005)

The numbers of diseased persons were sorted into different groups based on their age and experience from these 100 individuals. According to the diseased data obtained from the present study, in total study

population of tannery workers, 27% of individuals were affected by all three skin, respiratory and cardiovascular diseases. Among these, the skin, respiratory and cardiovascular disease affected persons were 10%, 16 % and 1% respectively. The age group wise analysis of all three diseases affected persons showed 4% for age group 31-35, 9% for age group 36-40, 6% for age group 41-45 and 7% for age group 46-50. No any diseased persons were observed for age group 25-30 because of healthy body in this age group and 51-55 because of number of individuals comes under this age group is low due to mortality before the age of 50. The later showed an agreement with findings suggested that Over 8,000 workers in the tanneries of Hazaribag suffer from gastrointestinal, dermatological, and other diseases, and 90% of this population dies before the age of 50 (Human Rights Watch, 2012). The age and experience wise analysis of skin, respiratory and cardiovascular diseases among the tannery workers of Ranipet area showed a strong positive correlation between the heavy metals accumulation and number of diseased persons and years of experience and number of affected persons. But age of the workers was not found any influence on the formation of diseases. Overall observation of tannery workers showed high level of skin and respiratory diseases when compared to non-tannery official workers. A small, but substantial positive correlation between health status at physiological and psychological stages and working hours (Berniell,2012).Almost all of workers breathed the chromium particles by mouth at their work place and absorbed the chrome dust particles which lead to respiratory problems among workers (Mancuso, 1951). Workers with chronic headache and dizziness have higher levels of Cr and Pb in the scalp hair samples,such as in those working in a fireworks factory (Sukumar and Subramanian,1992).McCluggage *et al*, (1991) reported that severe exposure to cadmium may result in pulmonary oedema and death. Chronic cadmium intoxication may give rise to renal tubular dysfunction, anemia, and skeletal damage (itai-itai disease)((Järup,2003; Horiguchi *et al*,1994).Long-term exposure to lead may cause kidney and liver damage and has an adverse effect on the central and peripheral nervous systems, haemopoietic system, and cardiovascular system (. Liu *et al*, 2014). Rastogi *et al*, 2008 suggested that incidence of respiratory problem

was observed to be more among the leather tanners as compare to non leather tanners. Some studies showed that the chromium exposure in the leather tanning industries is the main cause of variety of distinctive cancers including kidney, lung, nasal, oral cavity, bladder and skin along with dermatitis, ulcers, respiratory problems and damage of nasal septum (Rastogi *et al*, 2007). Lead as a trace metal in the human tissues has received great attention and several studies have examined the physiological and behavioral effects of Pb especially with reference to hyperactivity in children (Wang *et al*, 2002; Koller *et al*, 2004).

Table 1-Age-group wise heavy metals accumulation in the blood, hair and toe nail of the tannery workers in the Ranipet Industrial areas

Table 2.Work experience-wise heavy metals accumulation in the blood, hair and toe nail of the tannery workers in the Ranipet Industrial areas

Years of Experience	Blood			Hair			Toe nail			Number of disease affected persons			
	Pb	Cd	Cr	Pb	Cd	Cr	Pb	Cd	Cr	Skin	Respiratory	Cardio vascular	No. of. persions

Age group	Blood			Hair			Toe nail			Number of disease affected persons			
	Pb	Cd	Cr	Pb	Cd	Cr	Pb	Cd	Cr	Skin	Respiratory	Cardio vascular	No of persons
25-30	0.18 ± 0.007	0.22± 0.08	0.8± 0.012	0.15± 0.005	0.5± 0.02	3.2± 0.194	0.5± 0.017	0.98± 0.049	3.9± 0.172	0	0	0	05
31-35	0.28± 0.009	2.9± 0.02	1.8± 0.041	0.9± 0.007	2.1± 0.126	5.0± 0.241	0.64± 0.021	1.8± 0.072	6.5± 0.38	01	03	0	24
36-40	0.36± 0.011	3.1± 0.08	3.7± 0.25	1.5± 0.041	3.5± 0.175	5.9± 0.271	0.71± 0.032	13.5± 0.675	10.8± 0.527	04	05	0	28
41-45	0.32± 0.015	4.6± 0.07	5.4± 0.36	2.6± 0.11	5.2± 0.208	5.4± 0.232	0.89± 0.045	17.9± 1.074	15.3± 0.461	02	04	01	21
46-50	0.30± 0.013	5.4± 0.29	6.1± 0.38	2.1± 0.14	4.8± 1.44	7.3± 0.4.1	1.02± 0.17	15.4± 0.631	16.5± 0975	03	03	0	20
51-55	0.12± 0.005	0.51± 0.31	2.1± 0.18	1.6± 0.09	1.4± 0.05	2.2± 0.08	0.4± 0.011	2.5± 0.13	2.2± 0.154	0	0	0	02

>5	0.31± 0.0124	0.4± 0.036	1.1± 0.088	0.20± 0.01	0.8± 0.064	4.3± 0.258	0.71± 0.0355	1.5± 0.09	3.7± 0.148	00	01	0	18
6-10	0.35± 0.0175	2.3± 0.184	2.3± 0.207	0.27± 0.0189	3.4± 0.238	5.1± 0.357	0.84± 0.0672	4.5± 0.36	5.7± 0.342	02	04	0	26
11-15	0.37± 0.0222	3.7± 0.259	2.8± 0.168	0.24± 0.0144	4.9± 0.441	6.7± 0.335	0.96± 0.0384	7.5± 0.3	8.6± 0.43	04	05	0	30
16-20	0.28± 0.0196	4.9± 0.294	4.5± 0.315.	0.23± 0.0184	5.8± 0.348	8.3± 0.332	1.04± 0.0936	8.6± 0.43	12.3± 0.861	03	04	01	20
<25	0.33 ±0.0264	5.6± 0.28	6.5± 0.26	0.22± 0.0088	6.7± 0.335	8.7± 0.696	1.15± 0.0805	7.8± 0.546	18.4± 1.656	01	02	0	06

Table 3.Age-group wise heavy metals accumulation in the blood, hair and toe nail of the non-tannery workers in the Ranipet Industrial areas

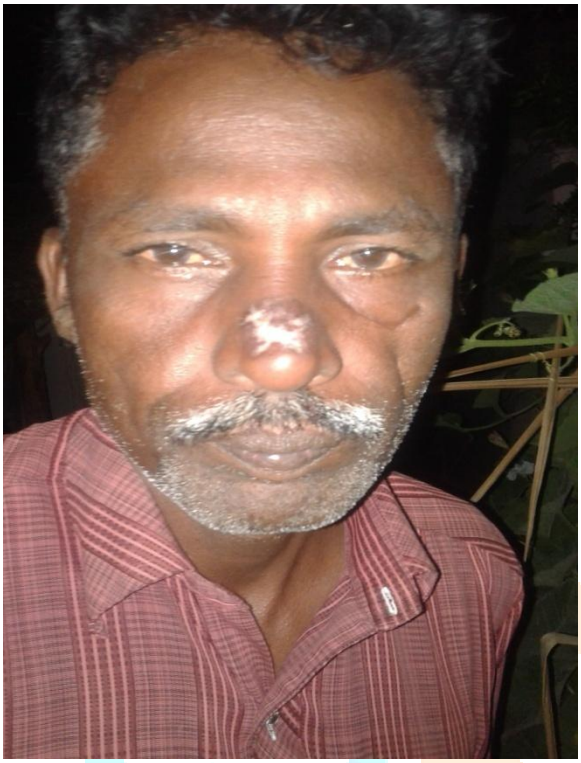
Age group	Blood			Hair			Toe nail			Number of disease affected persons			
	Pb	Cd	Cr	Pb	Cd	Cr	Pb	Cd	Cr	Skin	Respiratory	Cardio vascular	No. of. persions
25-30	0.11± 0.0066	0.14± 0.098	0.77± 0.0462	0.11± 0.0044	0.41± 0.0369	0.60± 0.03	0.78± 0.0312	0.98± 0.0686	0.91± 0.0728	0	0	0	14
36-40	0.08± 0.004	0.12± 0.0072	0.81± 0.0729	0.12± 0.0084	0.76± 0.0304	0.51± 0.0204	0.90± 0.063	0.93± 0.0465	0.74± 0.0666	1	0	0	20
41-45	0.10± 0.007	0.10± 0.005	0.94± 0.0376	0.09± 0.0054	0.85± 0.068	0.62± 0.0434	0.81± 0.0729	0.02± 0.0008	0.86± 0.0516	1	2	0	34
46-50	0.07± 0.0063	0.09± 0.036	0.83± 0.0581	0.07± 0.0056	0.67± 0.0469	0.71± 0.0426	0.85± 0.0425	0.95± 0.076	0.68± 0.0476	2	1	0	27
51-55	0.11± 0.0044	0.17± 0.0136	0.97± 0.0485	0.16± 0.008	0.51± 0.0306	0.68± 0.0612	0.93± 0.0558	1.04± 0.0624	0.91± 0.0455	0	1	0	05

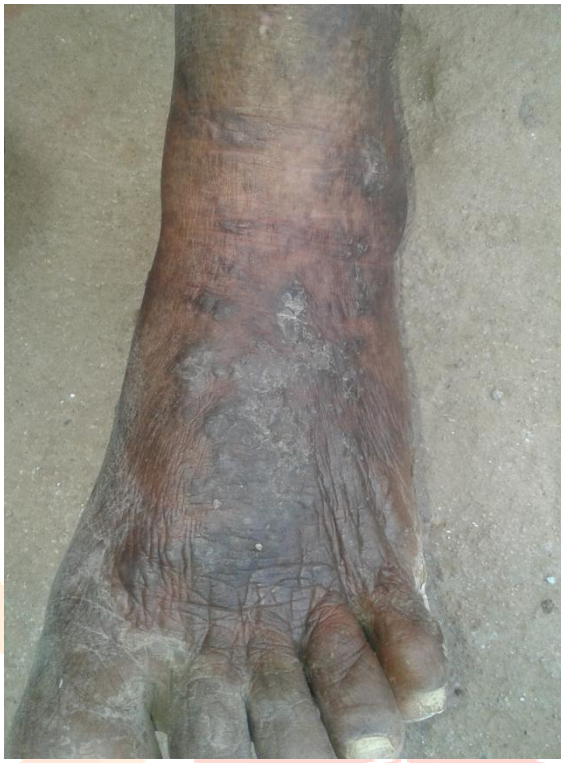
Table 4.Work experience-wise heavy metals accumulation in the blood, hair and

toe nail of the non-tannery workers in the Ranipet Industrial areas

Years of Experience	Blood			Hair			Toe nail			Number of disease affected persons			
	Pb	Cd	Cr	Pb	Cd	Cr	Pb	Cd	Cr	Skin	Respiratory	Cardio vascular	No. of. persions
>5	.0.091± 0.0364	0.031± 0.00279	0.091± 0.00455	0.045± 0.00405	0.067± 0.00536	0.071± 0.00284	0.059± 0.00531	0.062± 0.00496	0.095± 0.0076	0	0	0	05
6-10	0.078± 0.00511	0.028± 0.00224	0.072± 0.00504	0.062± 0.00372	0.064± 0.00256	0.051± 0.00408	0.048± 0.00336	0.073± 0.00292	0.096± 0.00672	0	1	0	25
11-15	0.045± 0.00225	0.011± 0.00044	0.068± 0.00408	0.058± 0.0029	0.058± 0.00522	0.067± 0.00402	0.071± 0.00426	0.045± 0.00405	0.063± 0.00315	2	1	0	39
16-20	0.081± 0.00648	0.042± 0.00294	0.083± 0.00332	0.050± 0.0035	0.062± 0.00372	0.078± 0.00546	0.055± 0.00275	0.064± 0.0032	0.072± 0.00288	1	1	0	25
<25	0.054± 0.00324	0.046± 0.00276	0.076± 0.00608	0.54± 0.00216	0.054± 0.00378	0.037± 0.00296	0.44± 0.0176	0.065± 0.0039	0.081± 0.00729	1	1	0	06

Tannery workers affected by skin diseases at leg region





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