# Heavy metals identification and exposure at workplace environment its extent of accumulation in blood of iron and steel recycling foundry workers of Lahore, Pakistan

**Muhammad Ahsan Riaz*[1], Amtul Bari Tabinda Akhtar[1], Ayesha Riaz[2], Ghulam Mujtaba[3], Muhammad Ali[4] and Beenish Ijaz[1]**

[1]Sustainable Development Study Centre (Environmental Sciences), Government College University, Lahore, Pakistan
[2]Department of Zoology, Government College Women University Faisalabad, Pakistan
[3]Institute of Nuclear Medicine and Oncology (INMOL), Lahore, Pakistan
[4]Department of Zoology, University of the Punjab, Lahore, Pakistan

**Abstract**: The determination of heavy metals in blood is an important occupational environmental toxicology screening procedure. The aim of study was to determine the concentrations of Pb, Cd, Cr and Ni in blood samples of iron and steel foundry workplace exposed workers under routine clinical laboratory conditions. The method was employed for the quantitative determination of lead, cadmium, chromium and nickel in workplace environment particulate matter blood samples from iron and steel foundry workers and in unexposed controls. The results indicate that lead, chromium and nickel levels of the exposed workers are significantly higher those of the controls. Nickel Concentration (µg/L) in high P value=0.0306 and Chromium Concentration (µg/L) in P value=0.0295in worker population as compared to controls. Lead showed highest Absorption concentration in serum from particulate matter to Serum 47.3(µg/L). Absorption concentration of nickel in serum 16.5(µg/L) was lower than lead observed in worker's population. Absorption concentration of cadmium and chromium in serum from particulate matter -152(µg/L) observed very low. The results also show the need for immediate improvements in workplace ventilation and industrial hygiene practices.

**Keywords**: Heavy metals pollution, foundry workers, inorganic, lead, nickle, chromium.

## INTRODUCTION

Iron and steel factory workers exposed to metallic dust are at risk of exposure to a wide range of potential health problems. Aspects strictly depend on their capacity of penetration into human body tissues and fluids (IARC, 1984; William, 1995; Adzersen *et al.,* 2003; Chen *et al.,* 2006; Fubini and Fenoglio, 2007; Andersson *et al.,* 2009; Bala and Tabaku, 2010; Harrison *et al.,* 2010; Moroni *et al.,* 2014). Some effects are acute while others may take years and even decades to develop in work population (Kiely *et al.,* 1997; Masoud *et al.,* 2009).

In the foundry environment, CO and metallic dust is mainly produced by cupola melting and casting operations (Koskela *et al.,* 2000). Metal fumes are formed by evaporation, condensation and oxidation of metals in air. Recent studies found the high concentrations of heavy metals in the blood and urinary execration of foundry workers (Apostoli *et al.,* 1988; Triger *et al.,* 1989; Lander *et al.,* 1999; Horng *et al.,* 2003).

Potential health effects based on the size and number of particles, the physical and chemical composition of the particulate matter, the concentration and toxicity of the exposure and distance the duration of the exposure at workplace (Fang *et al.,* 2000; Kazuro *et al.,* 2005; Cheng and Lin, 2010; Begum *et al.,* 2010).

Heavy metals effluent of steel furnaces cause effect on blood feature, irritation to the nose, lung carcinoma and holes in the nasal septum, cardiovascular diseases, silicosis and cardiovascular diseases in the steel industry workers (Leem *et al.,* 2000; Masoud *et al.,* 2009). Exposure to nickel, chromium and lead has been related with pulmonary cancer and impacts on the blood hemoglobin level and even involve in brain tumor induction (Narlawar *et al.,* 2006).

Parveen *et al.,* 2010) reported that environment of foundries is hazardous and characterized by multiple simultaneous chemical hazards. Overall depiction is that the hemoglobin concentration is comparatively low as compared to laboratory reference value. In Lahore Pakistan recent study found that foundry workplace environmental has a significant effect on blood protein profile in steel foundry workers in finding the enhancement or reduction and appearance or disappearance of particular protein fractions for comparison between the occupationally exposed and the control subjects (Roohi *et al.,* 2005). In accordance with the effects of heavy metals on the health status of re-rolling steel mill workers, found that anemia leukopenia, neutropenia lymphocytosis, decreased Hct, MCV and MCH in the experimental sub groups. Decreased MCH, MCHC and Hb concentration are indirectly related to the

*Corresponding author: e-mail: ayeshariazrana@gmail.com

iron status in the body and their decline in the blood results in hypochromic anemia due to absorption of certain heavy (Hwang *et al.,* 2009; Sheikh *et al.,* 2011). Health status of ironworkers is particularly neglected in Pakistan and needs special attention. Comparison between countries is critically important tool to support the creation of nationwide preventive programs (Michaels *et al.,* 1985; Roohi *et al.,* 2005; Malik and Cheema, 2010).

Present studies conducted in Wahga town an industrial town in the south east of Lahore, known for the recycling of iron and steel and more than 200 small and large scale iron and steel recycling units exist here was selected as a site for investigation and male workers (n=50) aged between 20-50 years were taken as experimental subjects because of the environmental problem due to burning of tires and indiscriminate disposal of air pollutants. Healthy male non-exposed with similar mean ages group selected as control subjects (n=50). For analysis of the four metals Cr, Pb, Ni and Cd in airborne particulate matter and bioaccumulation in blood of worker were investigated.

## MATERIALS AND METHODS

***Sampling sites***

*Study protocol*

The present study include total 100 individuals participated and subdivided in two groups:

Foundry workers subject group.1 (n=50)

Controls subject group. 2 (n=50)

Worker was included in the study when he was (a) a healthy male; (b) full time steel re-rolling foundry worker and working hours between 8-10 hr; (c) non-smokers or ex-smokers with less than 10 packs/year history; (d) Donate no blood from last 120 days; (e) no injury from last 120 days; (f) No aliments and diseases from last 120 days. (g) Use no supplement and medicine from last 120 days. (h) Age group between 20-50 years. (i) Nonsmoker and nondrinker. For analysis of the four metals Cr, Pb, Ni and Cd in airborne particulate matter and bioaccumulation in blood of foundry environment exposed and worker and non-exposed controls were investigated.

***Determinations of blood metal levels***

Finally agreed participant donated venous bloods used for laboratory testing. In that regard genuine and credible quality of disposal syringes were used. Prior to sampling health status of each of the subject was confirmed. The subject's peripheral vein was made sterilized with rectified spirit, disposable syringe was taken out of its securing wrapping and the needles were carefully exposed and pushed into a peripheral vein at 45 angles. Creating negative pressure in syringe drew blood. Plasma separated from blood cells by centrifugation at 3380xg for 15 minutes. Plasma was stored at -20°C until further analyzed and methodology related to (Hwang *et al.,* 2009). For heavy metal analyses take 3 ml of serum and digest according to standardized international protocols by wet digestion method (2:1 HNO3: HClO4) and methodology related to Hwang. Atomic Absorption Spectrophotometer (AA 7000 F with Auto sampler and Hydride Vapour Generator, Shimadzu, Japan) used to detection and concentration of heavy metals in particulate matter.

***Collection of particulate matter***

The High volume sampler was used for sampling of particulate a`vailableat Sustainable Development Study Centre G.C University, Lahore. A high flow rate blower (1.13m3/min) was used which draws the air sample through a covered housing on to a (20cm x 25cm) rectangular glass fiber filters. The intake dimension and normal flow rate are believed to limit aerosol collection to particulate matter less than 100µm diameters. Glass fiber filters were used because of their gradual head loss build up characteristics and non-hygroscopic properties. At the end of sampling filters were folded in such a way that surface containing the deposit face each other. The filter was weighted to get a net weight of deposit. It replaced in an airtight polythene bag after being labeled and stored. The mass of TSP was measured by weighting the filters before and after sampling using analytical balance. From the mass of the filter paper and the volume of air sample, the mass of concentration of TSP in the ambient air was calculated in microgram per cubic meter.

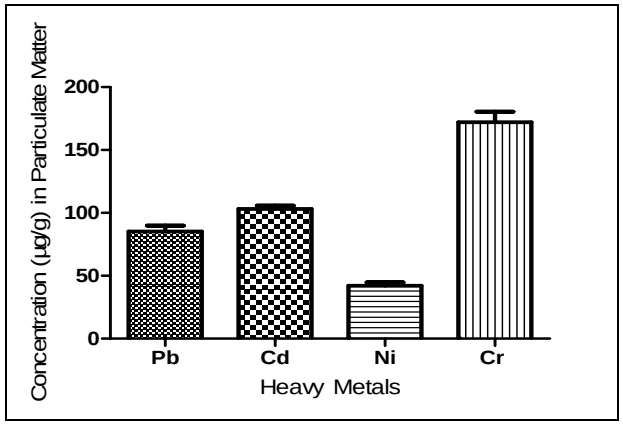


**Fig. 1**: Concentration of metals (µg/g) in particulate matter.

The dust monitoring analyzer was calibrated once every 24 hours. Sibata High Volume Air Samplers (Sibata High Volume Air Samplers HV-1000F) were used for Total Suspended Particulate (TSP). Air sampling method was conducted according to the standard "Specifications of Air Sampling for Hazardous Substances Monitoring on the Workplace" (GBZ159-2004). Particulate matter samples were collected on cellulose and glass fiber filters (20.4×25.4 cm). These samplers have maximum capacity of sucking air at the rate of 800 liters/min and adjusted according to the requirement of investigation.

**Table 1**: Comparison among heavy metals in Concentration of metals (µg/g) in particulate matter

| Comparison among heavy metals in PM | Mean Diff. | Summary P<0.05? | 95% CI of diff |
|---|---|---|---|
| Pbvs Cd | -17.70 | Ns | -43.11 to 7.714 |
| Pbvs Ni | 43.30 | ** | 17.89 to 68.71 |
| Pbvs Cr | -86.70 | *** | -112.1 to -61.29 |
| Cd vs Ni | 61.00 | ** | 35.59 to 86.41 |
| Cd vs Cr | -69.00 | ** | -94.41 to -43.59 |
| Ni vs Cr | -130.0 | *** | -155.4 to -104.6 |

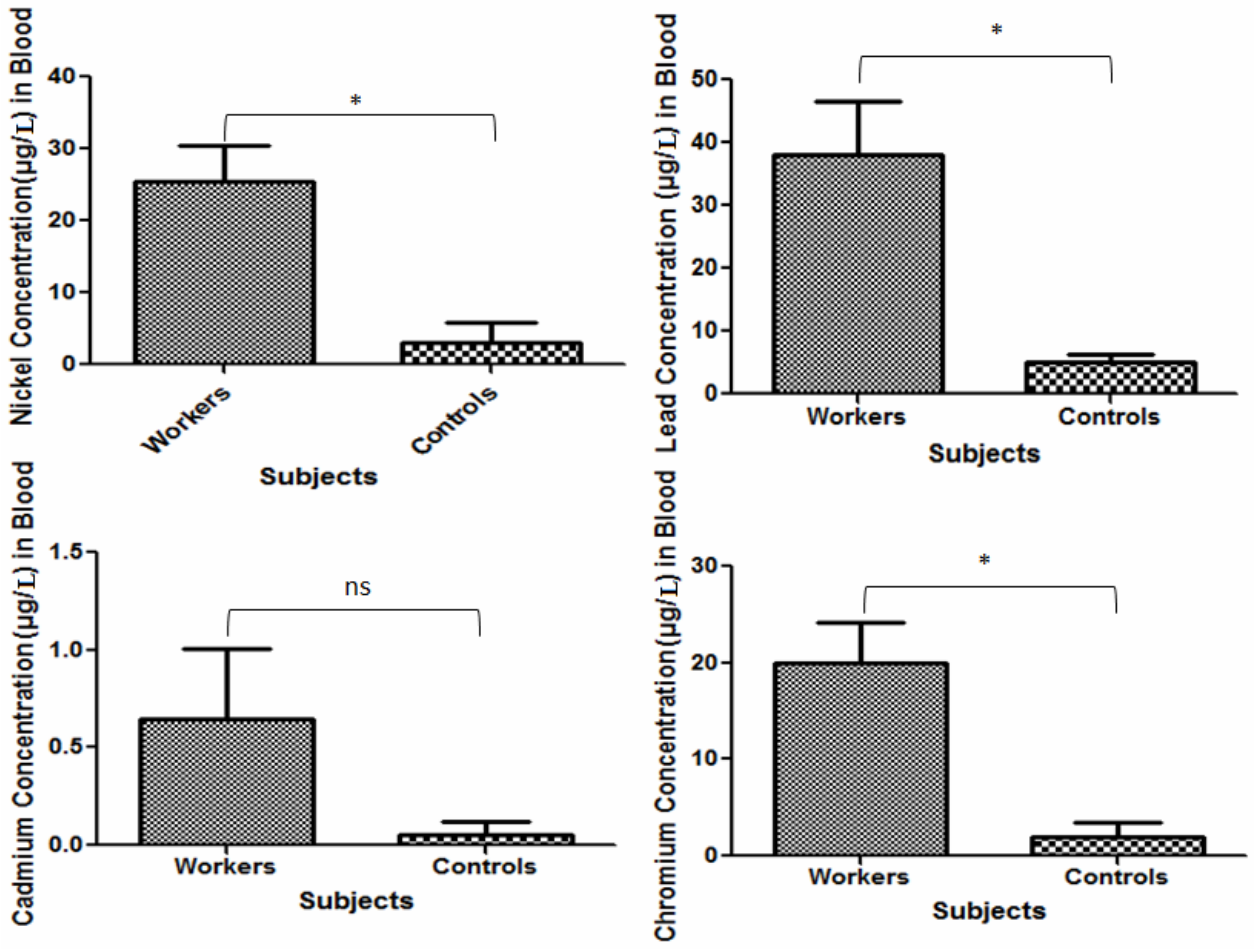


**Fig. 2**: Comparison of heavy metals concentration in blood among study groups

After collection of samples, filters were being preserved in the refrigerator. A steel cutter of 2 cm diameter was used on three pieces of folded paper. The filters pieces were place in inner Teflon container of 45mL capacity. Using pipette 2mL of concentrated nitric acid, 4mL of hydrofluoric acid, and 0.5mL of hydrogen per oxide were added to filters pieces in the digester vessel and stored in a refrigerator for further analysis by atomic absorption spectrometer. From samples, the heavy metal concentration was measured in term of µg/m$^3$ of air samples according to prescribed method Hiniches *et al.*, (2002); Niaz *et al.*, (2013) Maryam *et al.*, (2012) studies.

## RESULTS

After analysis of the 4 metals Cr, Pb, Ni and Cd in airborne particulate matter and bioaccumulation in blood of worker following conclusions were reached. In the analysis of the characteristics of 4 metals, the following metals were identified heavy metals lead was present at high concentrations in particle matter. In blood mean concentration of lead significantly high. Among exposed subject's Ni and Cr were also found in experimental subject with noticeable concentration. Cd concentration is minor detectable.

Nickel Concentration (µg/L) in Blood mean ± std. deviation in control subjects 3.0±2.8 and 25.5±4.9 in workers population and P value=0.0306. Chromium Concentration (µg/L) in Blood mean ± std. deviation in control subjects 20.0±4.24and 2.0±1.41in workers population and P value=0.0295. Cadmium concentration (µg/L) in Blood mean ± std. deviation in control subjects 0.65±0.3536and 0.05±0.07 in workers population and P value=0.1429. Lead Concentration (µg/L) in Blood mean ±std. deviation in control subjects 38.00±8.48 and 5.0±1.41in worker's population and P value=0.0323. Lead showed highest Absorption concentration of in serum from particulate matter to Serum 47.3 (µg/L). Absorption concentration of nickel in serum 16.5 (µg/L) lower then lead observed in workers population. Absorption concentration of Cadmium in serum from particulate matter minor observed -102.4 (µg/L). Absorption concentrations of chromium in serum from particulate matter-152 (µg/L).

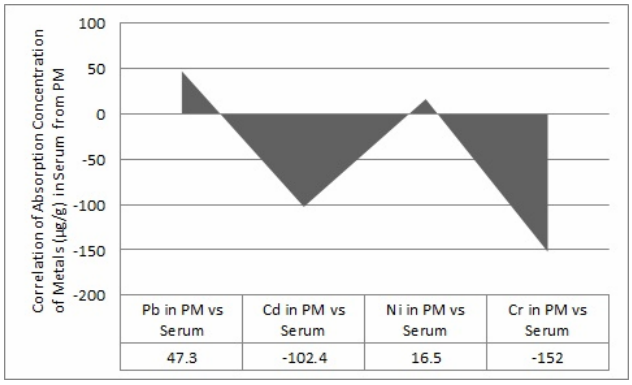


**Fig. 3**: Transfer rate of concentration of metals (µg/g) in serum from particulate matter.

## DISCUSSION

In this study, occupational exposure to selected toxic heavy metals was investigated and exposure to heavy metal pollution has been identified as a major occupational hazard in iron and steel recycling foundries. Chronic low-level exposure to toxic metals is an increasing global health problem. The symptoms caused with the slow accumulation of toxic metal are multiple and rather nondescript and overt expression of toxic effects may not appear until later in life (Fang *et al.*, 2006). Toxic exposure heavy metals stimulate anemia due to insufficient production of erythropoietin; a hormone involved in erythropoiesis Horiguchi *et al.* (2000) that diminishes the stimulation of erythrocyte progenitor stem cells to produce erythrocytes (Guenter *et al.*, 2005).

Lead and its compounds are potentially toxic; its toxicity can cause aberrant function to multiple human organs. It inhibits many enzymes, including pyruvate dehydrogenase and enzymes of the heam synthetic pathway. Blood lead is the most reliable index of exposure, because 90 percent of lead in blood is bound to red blood cells (Aposhian 1983; Gray *et al.*, 1985; Shilu *et al.*, 2000). All known effects of lead on biological system are deleterious. Many physiological system including those of the renal, nervous, heamopoietic, immune, reproduction and endocrine are principal targets of this environmental toxicant (Granjean, 1975; Anetor *et al.*, 2002; Skerfving, 2005).

The correlation between serum lead level and the duration of work at the investigated group is result of prolonged exposure or inhalation of car exhaust. Excessive amounts cause anemia, renal tubular nephrosis, diminished intellectual capacity, headache, drowsiness, and gastrointestinal upset (Aposhian 1983). Nickel has key role in physiological processes as a co-factor in the absorption of iron from the exposed external environmental. Increased levels of nickel were found in the blood of workers inhaling nickel (Kollmeier *et al.*, 1987; Andersen *et al.*, 1989). Animal data indicated that after inhalation, nickel particles can remain in the lungs (nickel oxide) or be absorbed and then excreted in the urine (nickel sulphate). High levels of nickel were also found in the liver, heart, lungs, fat, peripheral nervous tissue, and brain (Whanger *et al.*, 1973; Ambrose *et al.*, 1976; Dieter *et al.*, 1988; Borg *et al.*, 1989). Nickel is known to bind to specific proteins and/or amino acids in the blood serum and the placenta and ligands are involved in the transport and distribution of nickel in the body. Ni has accumulation potential by air to living tissues (Man *et al.*, 2010; Zheng *et al.*, 2010a, b). High loading for Cd, suggesting an influence from industrial processes (Fang *et al.*, 2010).

Maples *et al.*, (1982) and Porru *et al.* (1993) described that training or health education motivation program and safety analysis are fundamental tool in the spontaneously prevention of heavy metal pollution at workplace.

## CONCLUSION

Health effects due to exposure to re-rolling foundry furnace workplace are significant on workers. Re-rolling foundry workers are under continuous environmental health stressors e.g. metallic fumes, metallic dust, high level of hazardous gaseous, high noise level, ergonomics factors and high temperature levels in comparison to a control group. The results indicate that lead, chromium and nickel levels of the exposed workers are significantly higher those of the controls. Nickel Concentration (µg/L) in high P value=0.0306 and Chromium Concentration (µg/L) in P value=0.0295 in worker population as compared to controls. Lead showed highest Absorption concentration in serum from particulate matter to Serum 47.3(µg/L). Absorption concentration of nickel in serum 16.5(µg/L) was lower than lead observed in worker's population. Absorption concentration of cadmium and

chromium in serum from particulate matter -152(µg/L) observed very low. Unacceptable work condition (unhygienic, noisy, and dark work environment) may also contribute to an increased risk of these problems. The results of this study reveal the need for improvement of the work condition for the well-being of the workers. Generating and advance awareness among the workers to use safety equipment's is also another preventive measure that needed to be undertaken. Equipment of safety at workstations should be house kept and corrected reduced this exposures of workplace pollutants. Periodic medical inspection of workers needs to be incorporated as mandatory health and safety management programs. The top management should take actions on these issues seriously for the well-being of the workers.

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