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Original Research Article

Biological Samples as Potential Indicators of Heavy Metal Exposure in Coal Miners

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Abstract: The impact of mining activities on environmental and human health has become a matter of serious concern. Human health and vegetation is affected by decline in the biological, physical, and chemical quality of the environment. On-site pollution in coal mines due to dust, gases, noise, and polluted water is receiving increasing attention because it is affecting coal miners' health as well as those living in close proximity. Toxic pollutants released in vicinity by such processes include lead, nickel, chromium and cadmium. Focus of research was on the fate of toxic heavy metals in mining areas to evaluate and compare the heavy metal status in directly exposed persons (coal miners) of two different mining regions of Punjab (Pakistan). High significant difference was observed for cadmium, lead, chromium and nickel in nail and serum samples of coal miners. Comparison of metal concentration in biological samples of chakwal and soon valley area shows that soon valley coal mine area is more polluted than chakwal coal mine area.

Keywords: Coal, Mining, Lead, Cadmium, Lead, Nickel, Chromium, Nails, Serum, Human.

INTRODUCTION

Mining process has potential adverse environmental impacts by releasing significant amount of toxic metals [1]. A large group of diverse pollutants are the trace elements contained in coal especially the heavy metals. Their sufficient exposure levels negatively affect the human health. Some are known to cause cancer, damage reproduction and the normal growth of children, nervous and immune systems and are also respiratory irritants that can cause asthma [1]. The largest toxic pollutant coal used to generate electricity is the dirtiest of all fuels.

Coal mining releases many toxic pollutants into air, water and into our lands [2]. Thus people living near the coal mines or mine workers exposed to such environment are at high risk to become victim of unknown toxicity caused by mines [4]. Lethal and carcinogenic substances present in coal, including lead, mercury, nickel, cadmium, arsenic, manganese, beryllium, and chromium are becoming cause of variety of negative health impacts [3].

Mining activities annually release tons of these toxic metals into air and water. From there, local residents face contact by way of inhalation or consumption. The latter may occur by way of drinking water wells abounding by groundwater aquifers, or from fish, wildlife or other food sources. The impacts of coal are also prevalent, and have been known to cause respiratory illnesses, unusual cancers, birth defects, heart disease and other serious health problems [5].

Cadmium is a cause of lung cancer in coal exposed workers. Cadmium also causes intestinal, kidney and lung damage [6]. Cadmium is an aeroallergen strongly associated with the pulmonary disparities in coal miners. Chromium and lead are heavy metal pollutants which are hazardous to the human health. Bellinger [7] reported that lead destroys brain and nerve cells. Exposure to lead cause abnormal and reduced physical and mental growth. Nickel increases the risk of nasal and lung cancers in occupational exposed workers [8].

MATERIAL AND METHODS

500mg nails sample and 3ml blood sample from each coal miner was collected on the same day. Nails samples were cut with sterile nail cutter and stored into self sealing coded plastic bags before further process. Blood samples were stored in anticoagulant free test tube and then serum was separated by centrifugation method. Serum was stored into eppendorfs and stored below 4^0C till further processing.

Wet acid digestion of nail and serum samples was carried out. Standard solution of Cadmium (Cd), Chromium (Cr), Lead (Pb), and Nickel (Ni) were prepared. Metal analysis was carried out with the help of atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Present study was conducted to monitor heavy metal pollution in biological samples of coal miners of chakwal and soon valley area. We analyzed concentration of Cd, Pb, Ni and Cr in biological samples.

Significant difference for cadmium concentration in nails samples was observed in chakwal and soon valley miners. Mean value for chakwal and soon valley miners were as 0.702±0.168µg/g and as 6.125±5.05 respectively.

Comparison of geometric means revealed highest level of lead in soon valley coal miners (0.2017±0.004) as compared to chakwal coal miners (0.1212±0.024). Statistically significant difference $p<0.05$ was observed among both groups for lead concentration. Studies conducted by Ghazali *et al*., [9] found that lead level was high among exposed group than normal with mean value of 0.874±0.74µg/g. which was higher than our findings. Ghazali *et al*., [9] also reported level of lead with mean value of 6.611±5.170 µg/g while in our results lead mean level was as 0.1212±0.024µg/g and as 0.2017±0.004µg/g in nails samples of miners which was lower than Ghazali results.

Low level of nickel was found in nails samples of chakwal coal miners with geometric mean of 0.098±0.020 µg/g. High significant difference $p<0.01$ was present among both groups.

The geometric mean of chromium in nails sample of chakwal miners and soon valley miners group were recorded as 1.145±0.399µg/g and 7.233±5.948µg/g respectively. The highest level of chromium was observed in nails samples of soon valley miners with a high statistically significant difference.

The geo mean of 0.0147± 0.003mg/l of cadmium concentration was observed in serum of chakwal miners. In soon valley miners the concentration of cadmium had geo mean of 0.102±0.005mg/l. High significant difference for the concentration of cadmium $p<0.01$ was observed.

High level of lead was found in the serum samples of soon valley coal miners with geometric mean of 0.009±0.001 mg/l as compared to that of chakwal coal miners. Significant difference $p< 0.01$ was observed among both groups.

Nickel level was high in serum sample of soon valley miners reported as 0.311. Statistical analysis for nickel in serum was significant at $p<0.05$.

The highest level of chromium was observed in serum sample of soon valley miners group with highly significant difference at $P<0.01$ among both groups.

Table 1: Concentration of heavy metals in nail samples of chakwal and soon valley coal miners (µg/g)

Metal	Chakwal miners	Soon valley miners	t-value	Probability
Cadmium	0.702	6.125	-3.870	0.002
Lead	0.121	0.201	-9.854	0.000
Nickel	0.098	0.311	-2.649	0.014
Chromium	1.145	7.233	-3.682	0.003

Table 2: Concentration of heavy metals in serum samples of chakwal and soon valley coal miners (mg/l)

Metal	Chakwal miners	Soon valley miners	t-value	Probability
Cadmium	0.014	0.102	-48.30	0.000
Lead	0.001	0.009	-29.47	0.000
Nickel	0.002	0.008	-29.15	0.000
Chromium	0.027	0.140	-20.66	0.000

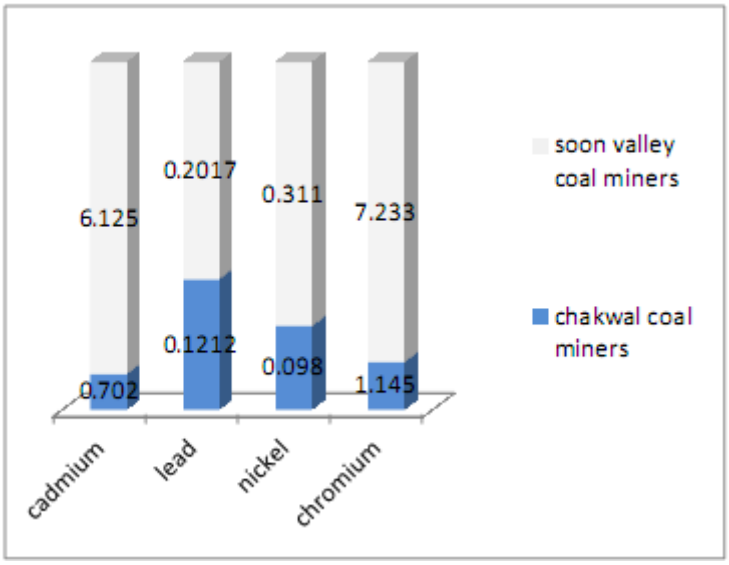

Fig-1: Comparative levels of cadmium, lead, nickel and chromium in nail samples of chakwal and soon valley coal miners

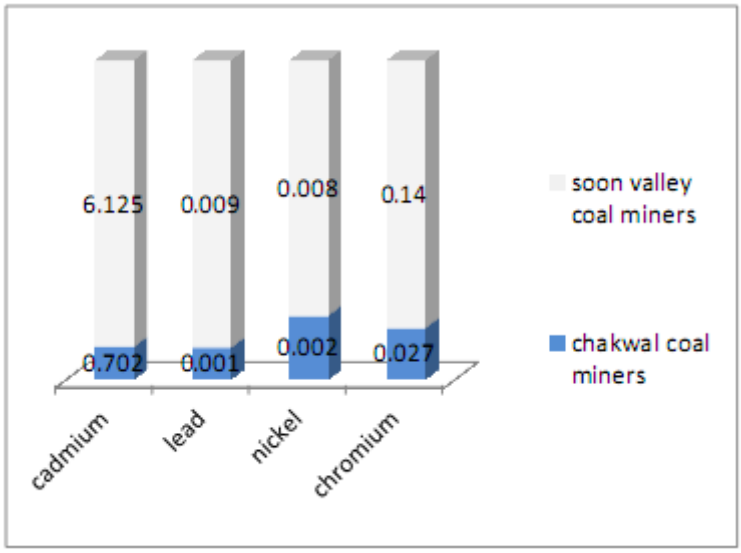

Fig-2: Comparative levels of cadmium, lead, nickel and chromium in serum samples of chakwal and soon valley coal miners

CONCLUSIONS

Comparison of metal concentration in biological samples of chakwal and soon valley area shows that soon valley coal mine area is more polluted than chakwal coal mine area. Biomonitoring potential evaluation of studied samples indicated that these samples were better for heavy metals contamination monitoring. Humans (directly exposed miners) can be considered suitable biomonitor for environmental contamination in examined area. Our findings suggested that coal mining process could supply heavy metals in environment and these elements gathered in the biological samples. While controlled environmental level of these metals to avoid unfavorable health effects in coal mining area is still an important community health issue.

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