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CHARACTERIZATION OF LEAD IN THE COPY CENTERS OF TEHRAN

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ABSTRACT:

Introduction: Heavy metals have been an effect on biochemical mechanisms, especially because they can be bio accumulated. The aim of this study was, survey of lead in the five copy centers of Tehran.

Materials and methods: Five copy centers were chosen as the object of characterization of lead. All samples were taken during working hours, Non-working hours and ambient air. Concentrations of Pb were determined by inductively coupled plasma (ICP). Samples have been analyzed statistically using Excel.

Results: During Working hours, fine particulate matters and lead will be increased. Lead concentration in working hours was 10 to 20 times greater than ambient air.

Conclusions: The concentration of lead depended on the number of printing devices and ventilation rate.

INTRODUCTION

In recent decades general concern has been increased about the effects of indoor air pollution on health. This concern is increasing because people spend about the 90 % of their time in the indoor area. Some studies indicated that the concentration of some hazardous pollutants in indoor is higher compared to outdoor [1]. Heavy metals as a dangerous group of air pollutants have sever physiological impacts on health and also cause renal failure, impaired stomach, cardiovascular diseases, etc., due to accumulation of various tissues. Long- term effects of lead on body are consisted of effect on blood, central nervous system, blood pressure, kidneys, and metabolism [2, 3]. Absorption of lead does not distributed uniformly throughout the body. The absorption in soft tissues is faster compared to the other parts of body. Then absorption in the bone is impressive. Lead can affect various organs of body such as kidney, digestive system, nervous system, genitalia, immunity, cardiovascular, and hematopoiesis [4]. Today, the amount of lead in human's body is

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500 to 1000 times more than its concentration in human before the age of industrialization. Some direct occupational exposures to dust and lead fumes occur in working with powders, liquids or lead- based pulps, sweeping or dry cleaning of lead polluted environments, melting, burning, cutting, punching, machining, sand blasting, scrubbing, kneading, polishing, lead welding. Lead is most often used in manufacturing of electric storage batteries, lead- based radiators, printing industry, ammunition, cable manufacturing and leaded wires, manufacturing lead sheets for chemical industry, dyeing and casting. In Iran, the history of studies on lead is devoted to ambient air. [5- 7]. During 2012 to 2013, heavy metals were surveyed in Khorramabad, Sanandaj, and Andimeshk and it was observed that the concentration of heavy metals was more in Sanandaj compared to Andimeshk and Khorramabad [8]. In 2007, the concentration of lead was measured in Tehran municipality zone 1, by atomic absorption and low volume system. In this study, the concentration of lead was 308 µg/m^3 [7]. According to a study, a printing device was studied at low temperatures and it was observed that the particles size distribution was about 15 – 20 mm [9]. Regarding to a study in Canada on concentration of heavy metals in homes, the age of building, smoking, and home location were the factors affecting the concentration of heavy metals [10]. Due to the lack of studies on concentration of lead in indoor and occupational environments and it's risks, the concentration of lead in air of Tehran copy centers is surveyed in this study. The results of this study can be directly applied by relevant organizations.

MATERIALS AND METHODS

In this study, 5 copy centers were selected randomly for measuring and monitoring the concentrations of particulate matters (PM) and lead. The high- volume air sampler was installed in copy centers to sample in two mode: working hours and rest time. Data were analyzed using Inductively Coupled Plasma (ICP) and were processed by Excel. Sampling method and analysis are shown as following:

Sampling

High volume air sampler is applied to sample the PM in ambient air. Based on the mechanism of this method, particles were sucked from a specific volume of air by a vacuum pump, then the particles were deposited on a porous paper filter (fiberglass). The pump of this device is able to suck a high volume of air (1.7 – 1.3 m^3/ min), therefore the results will be highly reliable.

The high volume air sampling is applied for all size of particles in air. This method is compatible with the National Ambient Air Quality Standards (NAAQS). Depending on type of the applied filter, the collected particles can be used to analyze the amount of heavy metals, various ions, organic and inorganic carbon, extractable materials, elements, radioactive substances, mineral compounds and other particles. The guide book for operation is given by the manufacturer. The United States Environmental Protection Agency (USEPA) and various state agencies have provided the extensive range of standardized methods and guidelines to collect data, planning, maintenance, and inspection.

Filters are made of fiberglass. The flow rate of air is about 1 m^3/ min, which absorbs about 1400 m^3 air for 24 h. The filter texture should be capable to collect 0.3 µg particles up to 99%. Fiberglass filters are used widely for this purpose. The filter alkality should be less than 25 µeq/g and weight gain or loss over a 24 h sampling time should be 50 g/m^3 according to USEPA. Other errors may be caused by the reaction between gases at the filter surface or by evaporation of particles after sampling [11].

Analysis and quantification

After calibration curve preparation, air sampling can be started. Sampling specifications are as following:

The inlet air flow rate in device: 1.3- 1.7 m^3/min; size of the fiberglass filter: 254 * 203 mm ; and the sampling time :24 h.

First, filter should be placed in oven under the 105 ºC for 24 h in order to omit the humidity. After drying, it is placed in desiccator containing silica gel. The filter is weighted with a laboratory weighing scale up to 0.1000 with the accuracy of

0.1 mg and prepared for sampling of particulate matters. Then filter is transferred to the site and is installed on device with caution to prevent any damage. After sampling, to remove humidity, filter is reheated in oven at 105 ºC for 24 h, then it is weighed according to the previous method. The difference in primary and secondary weigh of filter indicates the amount of collected particles. The general equation for calculating the concentration of suspended particulates is as follow:

$$TSP = \frac{(w_f - w_i) \times 10^6}{V} \quad (1)$$

Where;
TSP: mass concentration of total suspended particulate matters (µg/m^3)
w_f:final weigh of exposed filter (g)
w_i:initial weigh of clean filter (g)

V: air volume sampled, converted to standard conditions, std m^3

Total air volume is calculated as:

$$V = Q_{std} \times \quad t \quad (2)$$

V: total air volume sampled, in standard volume units, std m^3
Q_{std} : average standard flow rate, std m^3/min
t: sampling time, min

RESULTS AND DISCUSSION

Table 1 shows the specifications of copy centers. As it shows, the internal temperature of copy centers is around 19 – 24 ºC , while the air conditioning and air circulation rates of all copy centers are low, considering the area. Since copy centers are located in underground, lack of the window toward outside is one of the important reasons of low ventilation rate. On the other hand about 40 000 – 70 000 pages were printing daily in copy centers (equal to 8 – working hours).
As it can be seen in Fig. 1, the concentration of TSP in working hours (8 am – 4 pm) is several times more than the non- working hours (5am – 12 pm). Since copy centers were close to residential area, sampling was not done at 12 pm – 7 am due to the noise pollution of the device.
Results show that the concentration of suspended particulates in copy center during working hours is higher than non- working hours and less than the average concentration of suspended particulates in ambient air (Fig. 1).

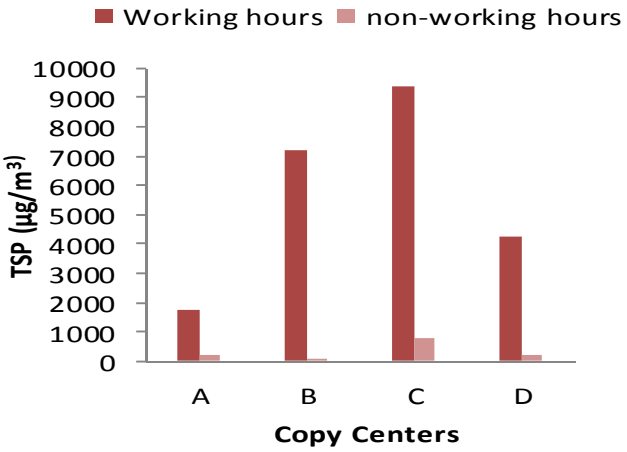

Fig. 1. The concentration of TSP in working hours and non- working hours

Table 1. Physical characteristics of the investigated copy centers

Code	Specification	Temperature (° C)	Pressure (hpa)	Humidity (%)	Ventilation rate
A	Underground- with 3 device	19.3	895	26	2.5
B	Underground- with 2 device	21	891	43	1.4
C	Underground- with 3 device	24	890	24	3.2
D	Underground- with 2 device	22	877	29	5

The concentration of lead in the environment of copy centers during working hours and non-working hours is shown in Fig. 2. The concentration of lead in the first sampling site was higher than the other sites regarding to the higher numbers of printing and less ventilation. This amount is higher than the maximum permissible occupational exposure (50 µg / m^3) [10]. Copy centers are one of the main sources of heavy metals emission, especially lead. The concentration of lead is higher in the operation mode of device compared to the off mode in all copy centers. Since the sampling in non- working hours was taken immediately after working hours, the concentration of lead in non- working hours is high. In addition the ink used for copy centers was different.

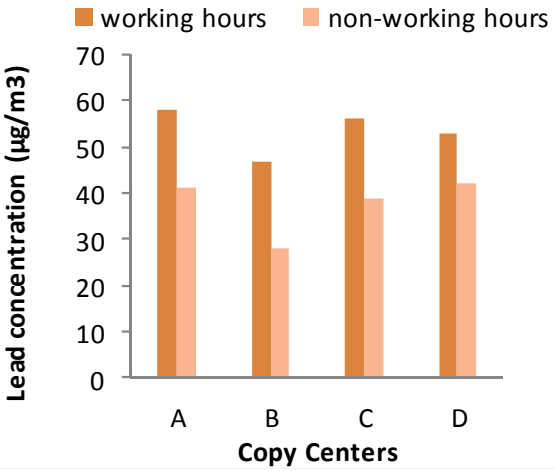

Fig. 2. The comparison of lead concentration in the air of copy centers during working hours and non -working hours

Based on a study in China (2012) on the particulate matters and heavy metals in the atmosphere of copy centers, the risk factor was calculated. In this research, fiberglass filters were used with the flow rate of 100 L/min. Then the ICP device was applied for analysis. In the mentioned study, the highest concentrations were obtained for zinc, copper, lead, nickel and cadmium, and the carcinogenicity risk was less than 10^{-6}. The correlation coefficient of lead in PM_{10} and $PM_{2.5}$ was 0.966. According to this study, it has been proven that the concentration of particulate and heavy metals increases in the operating mode of device [12]. As samples were taken in non- working hours immediately after working hours, the high concentration of particulate and heavy metals was indicated. In addition the ink used for each of copy centers varied. However the concentration of particulate matters in the third copy center was higher than the other sampling sites, the concentration of lead was less than the first copy center. The descriptive analysis of lead in copy centers during working hours shows that the average and standard deviation of lead concentration are 5.53 and 8.4 µg/m^3, respectively. The minimum and maximum concentrations of this heavy metal in copy centers during working hours are 47 and 58 µg/m^3, respectively.

The concentration of lead in first copy center (A)

Table 2. The concentration of lead in copy centers (working hours and non- working hours) related to outdoor air

Code of copy centers	Time of sampling	Lead
A	Working hours	19.94
	Non- Working hours	16.15
B	Working hours	19.25
	Non- Working hours	18.21
C	Working hours	14.09
	Non- Working hours	9.62
D	Working hours	13.4
	Non- Working hours	14.43

was higher compared to the other ones, and it can be attributed to the more number of printing device and low ventilation in comparison with the other copy centers. As it can be seen in Table 2, the concentration of lead in copy centers is about 10- 20 times higher than the outside. Therefore, the concentration of lead in copy centers is not affected by outside air, and the concentration of lead in external air is much less than the internal air in copy centers. It shows that copy centers are one of the main sources of lead production. Based on a study (2013) on particulate matters and heavy metals and assessing the risk factor in the recycling site for tv accessories, the average concentration of $PM_{2.5}$ was found 5.98 μg/m^3 and the concentration of lead was the most among heavy metals with 20 – 6.935 μg/g. This concentration was exceed than the health limit so that it was carcinogen for the workers. In this study, the most absorption ways for the lead were announced: digestion, skin, respiration [13]. According to a study on heavy metals in battery factory located in Yazd, Iran, it was observed that the concentration of heavy metals was due to the batteries and electronical wastes which were the human made and unnatural sources [14]. Based on a study in USA, which was done on ventilation in industrial environments, it was found that health and the efficiency of workers were increased by using an appropriate ventilation up to 39% and 45% , respectively. In fact, the economic justification of this study led to convince the employers for installing the high efficiency ventilation systems [15].

CONCLUSIONS

Ventilation rate, type of printing device, physical working environment, type of ink were the important variables to determine the concentration of lead in copy centers. The concentration of lead in copy centers depends on the ventilation rate and the number of printers. Regarding the correlation coefficient of lead presence (0.966) in $PM_{2.5}$ and PM_{10}, controlling the particulate matters will result to reduce the absorption of lead by breathing in people working in these copy centers. Moreover, reducing the working hours and the high efficiency ventilation can reduce the risk of carcinogenesis and increase the work efficiency in these workers. The limitation of this study was not to cooperate the printing and publishing industry, so that the number of surveyed copy center was less the initial estimate. People who worked in printing and publishing industry didn't cooperate enough with the research, so it was a limitation of this study.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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ETHCAL CONSIDERATION

The authors state that they have no ethical considerations.

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