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Assessment of Trace Elements from Biomass Burning and Household Dusts: Effects on Health and Environment

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Abstract: *The study was conducted to investigate the emissions of trace metals from biomass burning at the cooking stoves and in household dusts. Black solid materials deposited from different types of biomass burning at the cooking stoves were collected from inside the roofs of the kitchens. Household dusts were collected repeatedly from different parts of houses such as top of furniture, roof of refrigerator and floor. Lead, cadmium, zinc, copper, potassium and iron were identified in black solid materials, and lead, cadmium, chromium, nickel and zinc were identified in household dusts. The average contents of Pb, Cd, Zn, Cu, K and Fe were 38.565, 1.885, 155.793, 21.358, 141.1 and 13892.05 ppm respectively in black solid materials. The average concentrations of Pb, Cd, Cr, Ni and Zn were 66.591, 3.25, 60.825, 43.921, 99.794 ppm, respectively in rural household dusts and 86.78, 3.95, 84.247, 50.795, 164.2 ppm respectively in metropolitan household dusts. In addition, the average concentration of Pb, Cd, Cr, Ni and Zn were 52.768, 2.788, 57.604, 43.83 and 79.562 ppm, respectively in rural household dust away from road as well as 80.414, 3.71, 64.046, 44.012, 120.03 ppm, respectively in roadside rural household dust. The Concentration of all trace elements was higher in metropolitan household dust than the rural household dust. As a result of the detrimental impact of trace elements on health and environment, many government and non-government organizations, international organizations and researchers should develop different strategies aimed at reducing trace elements from biomass burning as well as household dust.*

Keywords: *Heavy metal pollution, Biomass burning, Household dusts, Rural area, Urban area, Atomic Absorption Spectrophotometry.*

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I. Introduction

Indoor air pollution in the developing world from biomass smoke is considered to be a significant source of public health hazard; particularly to the peoples those are working in the kitchen. Biomass burning is producing a lot of pollutants those are harmful for human health and also have effects on the climate change. It increases the risk of respiratory tract infections and lung cancer among the housewives [1]. In the developing countries, household use of solid fuels is the biggest source of indoor air pollution. At present 2.8 billion people, still use solid fuels as household energy source, often in low efficiency traditional stoves, leading to excessive levels of indoor air pollution. The majority of these households are in low to middle-income countries mainly in Asia, Africa and Latin America [2]. In 2012, approximately 4.3 million premature deaths were attributable to household air pollution: mostly from low and middle-income countries [3]. Among the range of hazardous air contaminants, particulate matter (PM) is responsible for huge burden of disease in both developed and developing countries [2, 4].

Biomass burning emissions represent an important global source of particulate matters and gaseous pollutants to the atmosphere [1]. They may alter the properties of the atmosphere since the particles can absorb and reflect solar radiation [5]. Biomass burning could be responsible for about 45% of the global emission of black carbon (BC) to the atmosphere, which is highly efficient in absorbing solar radiation [6-7]. However, Biomass is considered as one of the important alternative fuels. About half of the population in the developing world is estimated to use solid bio fuels like animal dung, crop residues, wood and coal for cooking daily meals. Exposure to biomass smoke estimated to cause a global death toll of 1.5 million every year [8]. Unfortunately, most of the cooking with biomass is done indoor, without efficient ventilation. Biomass is the only fuel using for cooking daily meals in most of the rural and semi-rural areas in Bangladesh. Varieties of bio fuels include cow dung, jute stick, rice straw, rice husks, bagasse, twigs, bamboo, dry leaves, woods, etc. are using in Bangladesh commonly [9].

Indoor air quality is an environmental health concern because people spend up to 90% of their time indoors in places, such as homes, offices and schools. Indoor settled dusts contain various hazardous materials including different heavy metals, which can affect human health [10-11]. Heavy metals in indoor dusts are an important indicator of pollution in urban environment also[12]. Heavy metals have long been recognized as serious pollutants in environment due to their toxicity, persistence and non-degradability [13-14]. Metals of indoor dust can enter the human body via inhalation, ingestion and dermal contact absorption routes, and then can accumulate [15]. The home dust ingestion is one of the most common routes of exposure to heavy metals for general population [16].

Moreover, biomasses burning are producing toxic gaseous pollutants, PAH and heavy metals (Pb, Cu, Fe, Zn, and Cd etc). Biogeochemical cycles of trace elements in tropical regions may also be changing due to biomass burning emissions. Emission of heavy metals can cause local and regional pollution of the atmosphere as well as hydrosphere. Exposure to indoor air pollutants from burning biomass fuels, adversely affects the specific and non-specific host defenses against pathogens especially in the respiratory tract of children. On the contrary, many of heavy metals such as Cr, Cd, Cu, Fe, Pb, Hg, Zn etc., are considered toxic to living organisms and even trace metals considered essential for life can be toxic when present at excessive levels that impair important biochemical processes and pose a threat to human health, plant growth and animal life [17]. It has also been suggested that dust can be an important source of metal intake for young children due to inadvertent ingestion of the dust. Consequently, in recent years, public and scientific attention has increasingly focused on heavy metal contamination and its effect on humans and other living creatures[10, 18-19]. In the household dust, such pollutants are commonly found that can be potentially harmful to human beings [20].

This study was conducted to assess indoor air pollution and health risk of heavy metals in household dust samples. In addition, assessments of trace metals that released after burning of biomass fuel. The objectives of the study are to identify and quantify trace elements in the household dusts and black solid material collected from households as well as kitchen and to be aware about the health and environmental hazards of trace metals from household dusts and biomass burning.

II. Materials and Methods

2.1.Study area

Khilkhate is one of the *Upazila* of Dhaka(largest city of Bangladesh) and the world's most populated cities, with a population of 17 million people.*Basail*is one of the *Upazila* of Tangail districtin Bangladesh. Above 2 sites (*Khilkhate*and *Basail*) were the study sites of the present research work.

2.2. Sample collection

Total 60 samples (with 3 replicates from each site) in that 20 samples for black solid material and 40 samples for household were sampled from rural & metropolitan areas during 1st February 2016 to 28th February 2017. Sampling locations were selected keeping in view of kitchen types, roadside houses and houses away from roadside.Black Solid Materials (BSM) from biomass burning at cooking stoves were collected using hand gloves after deposited on the inside surface of the roof at the rural house kitchen. After collection, the samples were placed in glass bottle and transported to the laboratory, Soil Science Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The samples were stored in dry place to avoid any contamination and kept free from any kind of moisture absorption.

Household dusts were collected in adequate quantities by using hand gloves from different parts of houses such as furniture, roof of refrigerator, roof of fan and floor as well as transferred into a glass bottle. The samples were brought to the laboratory and then sieved to exclude particles larger than 30 mesh. A portion of each of the three replicate samples was dried at 105°C for 24 hrs and weighed for analytical purpose.

2.3. Digestion of samples

For the determination of total trace metal concentrations, exactly 0.25 gm of sample was digested with aquaregia also known as di acid mixture (HNO_3: $HClO_4$ =2:1). Again 10 ml of aquaregia was added and allowed to stand overnight with covering the vessel to vapor recovery device. On the following day, the digestion vessel was placed on a heating block and was heated at 250^0 C temperatures for 3 hours. After cooling, 1 ml of perchloric acid ($HClO_4$)was added and kept for few minutes. Again, the vessel was heated at 250^0 C temperatures. Heating was momentarily stopped when the dense white fumes occurred, after which the volume was reduced to 2-3 ml. The digest was cooled, diluted to 25 ml of final volume with de-ionized water and filtered through Whatman No # 42 filter paper into plastic bottles.

2.4. Determination of trace elements

An Atomic Absorption spectrophotometer (AAS), (Model PG990, England) was used to determine the trace elements (Cd, Cr, Cu, Fe, K, Ni, Pb and Zn) at soil science division laboratory, BINA.Mono element

Hollow Cathode Lamp (HCL) was employed for the determination of each heavy metal. At first, the AAS was calibrated followed by the manufacture's recommendation. Then the sample was diluted and directly run in AAS for the determination of heavy metal. A standard curve was prepared by plotting the absorbance reading on Y–axis versus the concentration of each standard solution of metal on X–axis. Then the concentration of metals was calculated in the samples by plotting the AAS reading on the standard curve.

2.5. Statistical Analysis

The obtained data were compiled, tabulated and analyzed accordingly. Various descriptive statistical measures such as average, standard deviation (SD), independent–test were used for categorization and describing the variables and level of significance. Different tables, graphs, charts etc were used or the presentation for findings.

III. Results and Discussion

3.1. Physical characteristics of black solid materials

The samples were solid crystalline powder, black in color, and odorless. They were not soluble in either cold or hot water, or dilute hydrochloric acid, or nitric acids. They were soluble only in concentrated sulfuric acid. The samples were characterized for the chemical identification with semi-micro qualitative inorganic analysis.

3.2. Trace elements concentrations in black solid materials

Selected trace elements concentrations were determined in black solid materials deposited after biomass burning at the cooking stoves. It was found that the ranges of trace elementsassessed in black solid materials were 21.6 to 59.83 mg kg^{-1} for Pb,1.24 to 2.68 mg kg^{-1} for Cd, 105.13 to 192.48 mg kg^{-1} for Zn, 10433.68 to 16181.58 mg kg^{-1} for Fe, 16.96 to 25.96 mg kg^{-1} for Cu and 103 to 186 mg kg^{-1} for K, respectively (Table 1).The average concentrations for lead, cadmium, zinc, copper, potassium and iron were 38.565, 1.885, 155.793, 21.358, 141.1 and 13892.05 mg kg^{-1} respectively in black solid materials for mixture of biomasses (Fig. 1). However, the concentrations of trace elements were followed the sequences, Fe >Zn >K >Pb>Cu>Cd.

Table 1: Comparison between trace element contents of rural and metropolitan dust away from roadsides.

Rural and metropolitan household dust away from road									
Pb (ppm)		Cd (ppm)		Cr (ppm)		Ni (ppm)		Zn (ppm)	
Rural	Metro	Rural	Metro	Rural	Metro	Rural	Metro	Rural	Metro
63.91	74.49	3.38	3.04	69.33	86.87	46.96	40.66	83.3	144.89
46.29	73.52	2.85	2.87	47.11	84.18	35.22	43.79	89.25	149.41
38.67	83.26	2.58	2.74	50.65	89.15	44.32	42.08	82.76	193.42
60.74	79.78	2.44	3.52	62.36	72.63	49.31	39.29	77.5	133.31
54.23	76.44	2.69	2.97	58.57	83.55	43.34	38.80	75.00	125.53
P = 0.001092		P = 0.2861		P = 0.000789		P = 0.2895		P = 0.0108	

- P denotes independent test

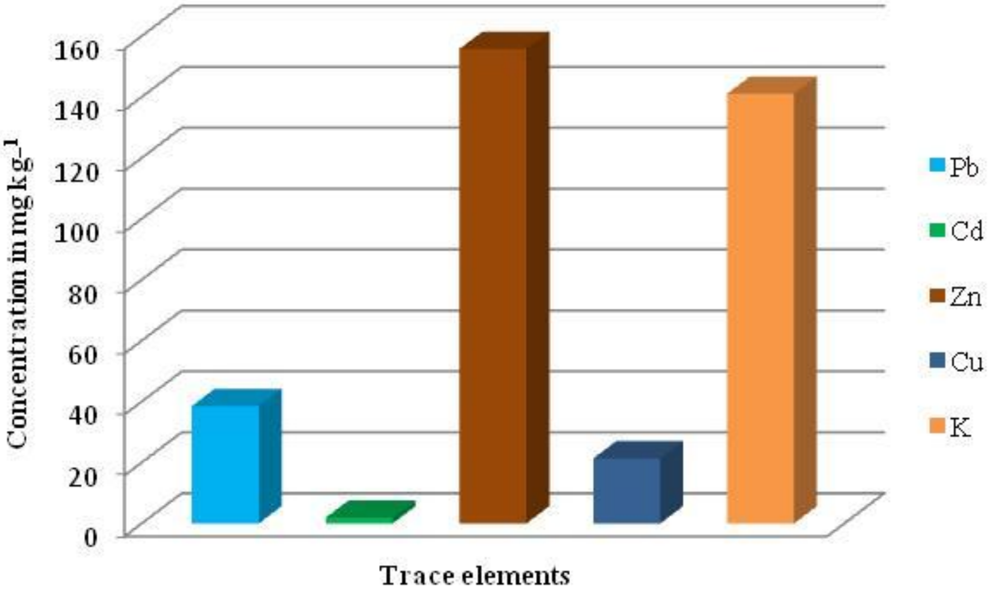

Fig. 1: Trace element contents in black solid materials deposited from biomass burning in household.

Another study in *Narsingdi*, Dhaka, Bangladesh by Hasan*et al.*[21] reported that the average concentrations of lead, cadmium, potassium, iron, calcium and magnesium were 125.2, 12.0, 21.5, 12360, 1648 and 534.2 mg kg^{-1}, respectively found in black solid materials from biomass (mixture) burning deposited inside the roof of the kitchen either of the street vendor's shade (kind of kitchen) or the rural house kitchen. They also reported that the average concentrations of lead, cadmium, potassium iron, calcium, and magnesium were 95.6, 8.33, 17.1, 11520, 1635 and 443.1 mg kg^{-1}, respectively in black solid materials after burning rice husk coils [21]. However, the concentration of heavy metal depends on the types of biomasses or condition (wet or dry) of biomass or area of sample collection.

3.3. Trace elements concentration in rural household dust away from road

High elemental concentration was observed in Zn, followed by Cr, Pb, Ni, and Cd in all the samples. In all the samples, the average concentrations of Pb, Cd, Cr, Ni and Zn in rural indoor dust away from road were 52.768, 2.788, 57.604, 43.83 and 79.562 mg kg^{-1} respectively (Fig. 2). The concentration of trace elements ranged from 38.67 to 63.91 mg kg^{-1} for Pb,2.44 to 3.38 mg kg^{-1} for Cd, 47.11 to 69.33 mg kg^{-1} for Cr, 35.22 to 49.31 mg kg^{-1} for Ni and 75 to 83.3 mg kg^{-1} for Zn was observed (Appendix I). The average concentration of trace metals were similar in the study area that was reported byNasir*et al.*[22] during a study on the concentration of heavy metals in rural house dust in Lahore, a residential area of Pakistan. In addition, the concentrations of trace metals in the present study were lower than recently reported from house dust in a Chinese town except Cd. They reported concentrations for As, Cd, Pb, Cu and Mn were 31.97 (μg/g), 0.56 (μg/g), 300.46 (μg/g), 93.44 μg/g) and 600.51 (μg/g), respectively. Although, the Pb concentrations were four times higher than found in rural household dust of study area [14].

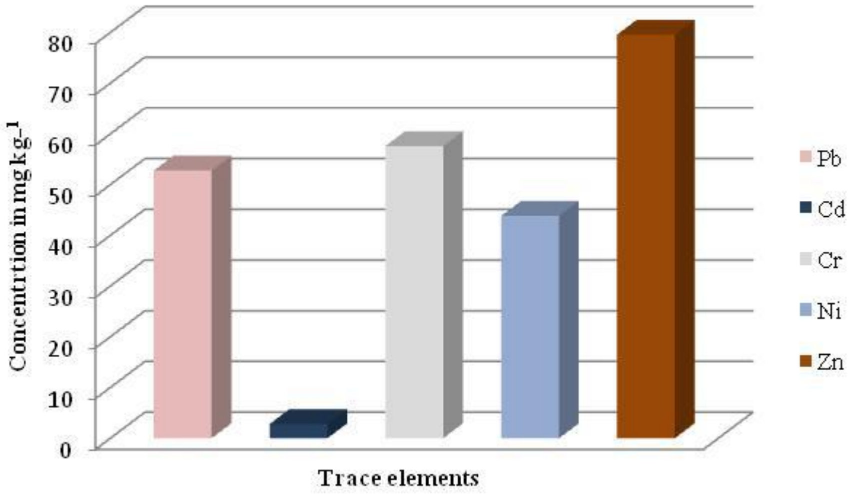

Fig. 2: Average concentration of trace elements in rural household dust away from road.

3.4. Trace elements concentration in roadside rural household dust

The average values of trace elements in the dust samples were found to be in order of their abundance as Zn>Pb>Ni >Cr>Cd. The metal levels in the household dust of rural roadside area were 80.414 mg kg^{-1} for Pb, 3.71 mg kg^{-1} for Cd, 64.046 mg kg^{-1} for Cr, 44.012 mg kg^{-1} for Ni, 120.03 mg kg^{-1} for Zn (Fig. 3). The highest concentration was observed for Zn ranged from 109.13 to 131 mg kg^{-1}, whereas the lowest concentration was observed for cadmium ranged from 2.9 to 4.32 mg kg^{-1}(Appendix II). The concentration of trace metals were lower than those found in roadside metropolitan household dust. Zinc, copper and lead are three of the most common heavy metals released from road travel, accounting for most of the heavy metals in road runoff [23].

The average concentrations of heavy metals were lower except chromium than reported by Ahmed and Ishiga[24] during a study on the trace metal concentrations in street dusts of Dhaka city in Bangladesh. Another study showed that the house dusts contained higher concentrations of Cd, Cr, Cu, Ni, Pb and Zn than either street dusts or garden soils. Using diesel fuel for heating by metal furnaces was the main source leading to increase the concentrations of Ni, Pb and Zn in the house dusts [25]. The concentrations of all trace metals were lower in rural household dust than metropolitan household dust.

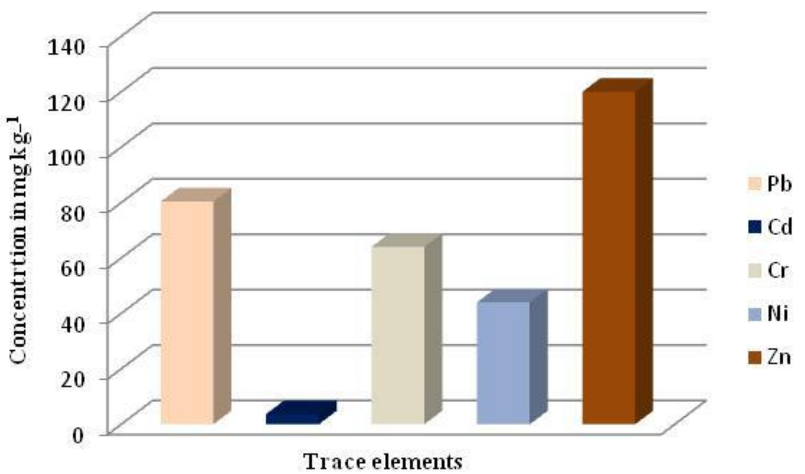

Fig. 3: Average concentration of trace elements in roadside rural household dust.

3.5. Trace elements value in metropolitan household dust away from road

The mean values for lead, cadmium, chromium, nickel and zinc were 77.498, 3.028, 83.276, 40.924 and 149.312 mg kg^{-1}, respectively in metropolitan indoor dust away from road (Fig. 4). The highest concentration was observed for Zn whereas the lowest concentration was observed for cadmium. However, the concentrations of trace elements were followed the sequences, Zn>Cr>Pb>Ni> Cd. The metal levels in the household dust (mean of all locations) of Kathmandu metropolitan area were 40.6 mg/kg for Pb, 8.2 mg/kg for Cd, 29.9 mg/kg for Cr, 23.9 mg/kg for Ni and 76.2 mg/kg for Zn [26]. Again, the concentrations of heavy metals were higher than the present study area [26-27] except the value of Cd.

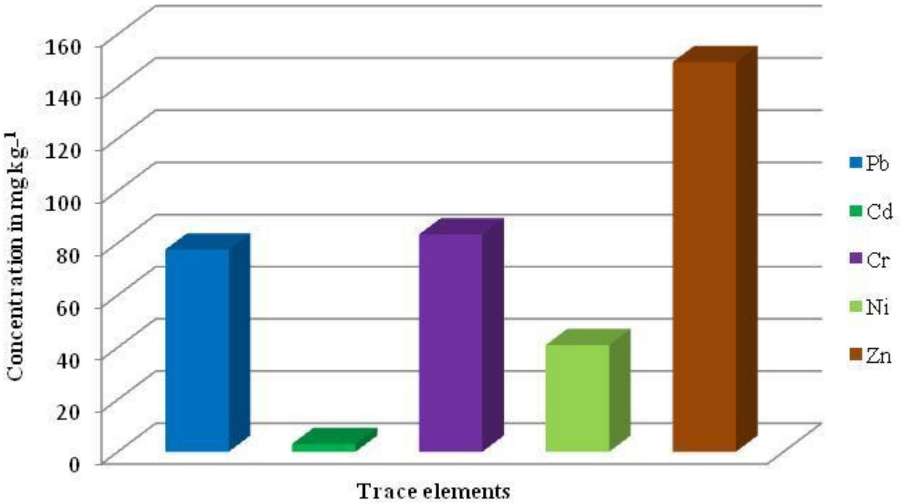

Fig. 4: Comparison of trace elements content in metropolitan household dusts away from road.

3.6.Trace elements concentration in roadside metropolitan household dust

The average values of Pb, Cd, Cr, Ni and Zn were 96.062, 4.868, 85.218, 60.666, 179.09 mg kg^{-1} respectively in metropolitan household dust besides road has been illustrated in Table 2 and Fig. 5. The highest concentration was observed for Zn, whereas the lowest concentration was observed for cadmium. The average concentration of all trace metals is higher in metropolitan household dust besides road than metropolitan indoor dust away from road.The concentration ranged from 88.32 to 103.79 for Pb,3.13 to 7.01 for Cd, 76.02 to 99.86 for Cr46.17 to 72.44 for Ni, and 154.24 to 212.37 for Zn mg kg^{-1} was found (Appendix II). Higher level of trace metals at that sampling site is due to excess vehicles, traffic jam, construction activities, strong winds and presence of dry atmospheric condition, which re-suspended the road dust and soil particles. Whereas the mean concentrations of metals in the household dust were Pb, 85.2 mg/g; Cd, 1.9 mg/g; Cr, 64.3 mg/g; Ni, 15.6 mg/g; Zn, 437 mg/g; Cu, 103 mg/g; Fe, 2740 mg/g and Mn, 54 mg/g respectively found in the Sydney metropolitan area [28]. The concentration of Cd and Ni were lower in the Sydney metropolitan area than present study but the concentration Pb and Cr was higher in Sydney. In the study area, the concentration of Pb was lower for rural household dust but the concentration of Pb was similar for metropolitan household dust. On the other hand, concentration of Zn in household dust was much higher in Sydney metropolitan area than Dhaka metropolitan area but the Cd and Ni concentration were lower.

Table 2: Comparison of trace elements between rural and metropolitan roadside household dusts.

Rural and metropolitan roadside household dusts									
Pb (ppm)		Cd (ppm)		Cr (ppm)		Ni (ppm)		Zn (ppm)	
Rural	Metro	Rural	Metro	Rural	Metro	Rural	Metro	Rural	Metro
81.44	94.56	3.72	4.59	66.53	79.95	40.99	64.22	109.13	177.5
65.04	88.32	3.48	3.13	64.99	92.98	54.17	72.44	131	154.24
92.11	103.79	2.9	7.01	77.58	99.86	47.41	46.17	129	184.65
70.29	91.65	4.13	5.1	54.84	77.28	37.84	53.45	113	212.37
93.19	101.99	4.32	4.51	56.29	76.02	39.65	67.05	118	166.68
P = 0.03999		P = 0.1248		P = 0.009654		P = 0.01828		P = 0.0004993	

- P denotes independent test

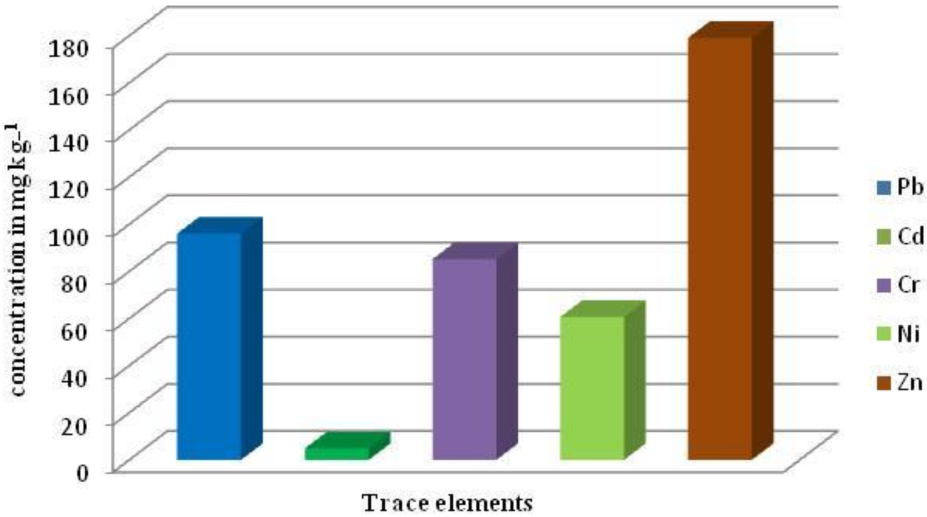

Fig. 5: Average concentration of trace elements in roadside metropolitan household dust.

3.7. Overall comparison of trace elements concentration between rural and metropolitan household dust

The comparison of average concentrations for lead, cadmium, chromium, Nickel and Zincbetween rural and metropolitan household dusts has been exhibited in Fig. 6. The average concentrations for lead, cadmium, chromium, nickel and zinc were 66.59, 3.828, 60.83, 43.92 and 99.79 mg kg^{-1}, respectively found in rural household dust (Appendix III). On the other hand, the average concentrations of lead, cadmium, chromium, nickel and zinc were 86.78, 3.369, 84.25, 50.80 and 164.2 mg kg^{-1}, respectively found in metropolitan household dust (Appendix III).The difference of value of Zn was much between rural and urban household dust but the concentration of Cd and Ni were similar shown in Fig.6.Again, the concentration of Cd and Cr was higher in metropolitan household dust. However, the average concentrations of the determined trace elements followed the sequences Zn>Pb>Cr>Ni>Cd for household dust of both area.

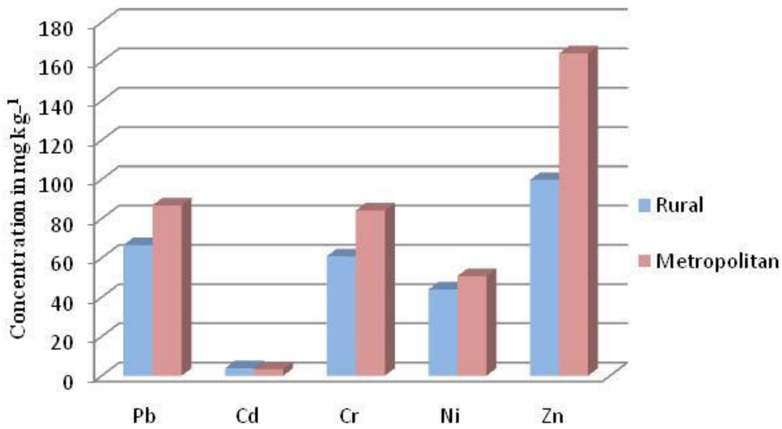

Fig. 6: Comparison of trace elements between rural and metropolitan household dusts.

In recent years, several studies were conducted to analyze heavy metals in indoor dusts, such as household, office and classroom dusts, which was higher than the present study. The mean concentration values were in the range of 85-492 mg kg^{-1} for Ba , 0.80-6.5 mg kg^{-1} for Cd, 37-254 mg kg^{-1} for Cr, 91-2740 mg kg^{-1} for Cu, 0.20-3.63 mg kg^{-1} for Hg, 76-772 mg kg^{-1} for Mn, 26-471 mg kg^{-1} for Ni, 28-406 mg kg^{-1} for Pb, 396-3104 mg kg^{-1} for Zn [23, 25, 28-30].

3.8. Comparison of trace elements concentration between household dust away from road and roadside in rural area

The average concentration of Zn and Pb was higher in roadside rural household dust than rural household dust away from road. In addition, the average concentration of Cd was almost double in roadside rural household dust than household dust away from road. On the other hand, the concentrations of Ni and Cr were statistically similar for both households (Fig. 7).Overall, all trace elements were higher in roadside rural household dust than rural household dust away from road. Moreover, three main factors known to influence the level of trace elements in dust have been reported as road traffic (automobiles), industry and weathered materials. The effect of the road traffic on trace metal contents of dust samples have been investigated for various purposes such as agricultural studies and different pollution studies [31].

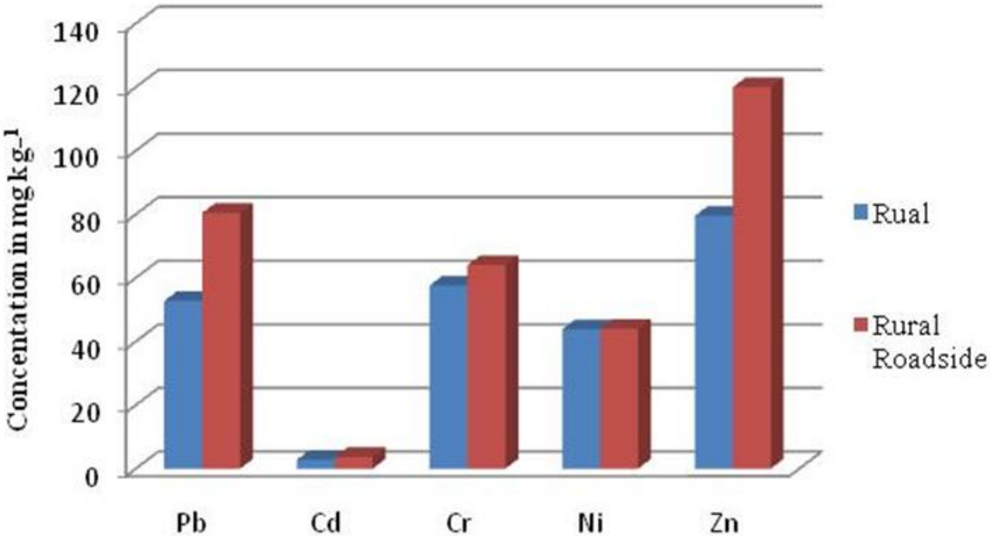

Fig. 7: Comparison of trace elements in rural household dusts between roadside and away from roadsides.

3.9. Comparison of trace elements concentration in metropolitan household dusts between away from road and roadsides

The mean concentrations for lead, cadmium, chromium, nickel and zinc were 77.498, 3.028, 83.276, 40.924 and 149.312 mg kg^{-1}, respectively in metropolitan indoor dust away from road. On the contrary, average values of Pb, Cd, Cr, Ni and Zn were 96.062 4.868, 85.218, 60.666, 179.09 mg $kg^{-1,}$ respectively in metropolitan household dust besides road (Fig. 8). The average concentration of Pb, Ni and Zn was higher in roadside metropolitan household dust than metropolitan household dust away from road. Moreover, the average concentration of Cd and Cr was similar for both part of metropolitan household dust. The trace elements (lead, nickel and zinc) were higher in roadside metropolitan household dust due to movement of vehicles, construction activities, waste incineration and contaminated soil. The metal levels in the household dust of Kathmandu metropolitan area were 40.6 mg/kg for Pb, 8.2 mg/kg for Cd, 29.9 mg/kg for Cr, 23.9 mg/kg for Ni and 76.2 mg/kg for Zn [26].

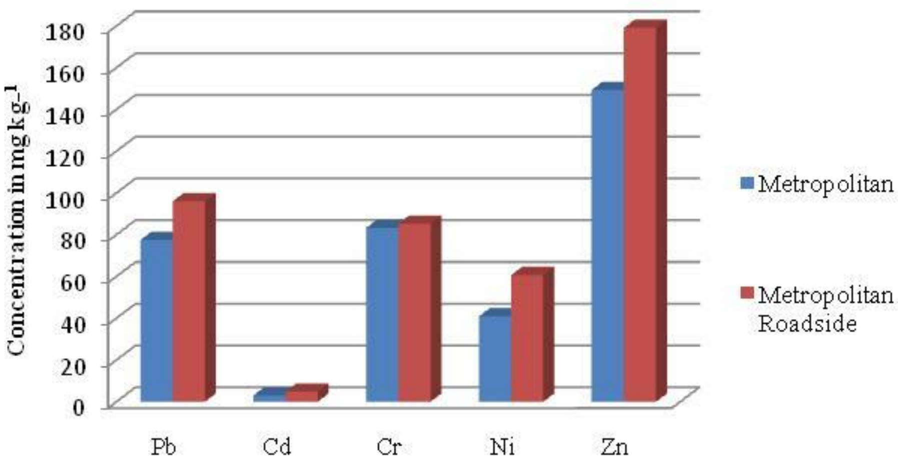

Fig. 8: Comparison of trace elements in metropolitan household dusts between roadside and away from roadsides.

3.10. Comparison of trace elements concentration between rural and metropolitan household dust away from road

In metropolitan household dust away from road, the average concentrations of Pb, Cr, Zn were higher than rural household dust away from road although, the average concentrations for Cd and Ni were almost similar for rural and metropolitan household dust away from road (Fig. 9).An independent t-test was conducted to observe difference of metal concentration between rural and metropolitan household dust away from road as well as the results showed significance difference for Pb, Cr and Zn (Table 4.2). The trace elements were higher in metropolitan household dust away from road because the houses have been made using sand, cement and paint. Paints have been recognized as serious sources of heavy metals. Yellow paint is associated with higher concentrations of Cd, Cu, Pb and Zn in indoor dusts [28]. In another report [32], the range of heavy metals observed in residential buildings at *SeberangPrai Tengah* were in the range of 2.20-14.00 mg/kg, 1.50-32.70 mg/kg, 1.50-76.80 mg/kg and 14.60-54.40 mg/kg for Cu, Ni, Pb and Zn, respectively. The range of heavy metals was lower at *SeberangPrai Tengah* than present study for both areas.

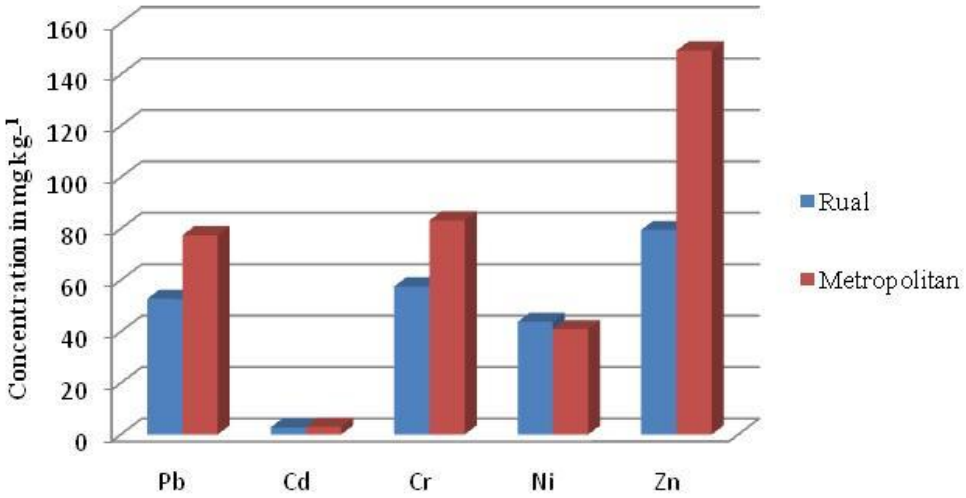

Fig. 9: Comparison of trace elements between rural and metropolitan household dusts away from road.

3.11. Comparison of trace metals concentration between rural and metropolitan roadside household dust

The observed average trace elements concentration of roadside household dust in rural were 80.414 mg kg^{-1} for Pb, 3.71 mg kg^{-1} for Cd, 64.046 mg kg^{-1} for Cr, 44.012 mg kg^{-1} for Ni, 120.03 mg kg^{-1} for Zn respectively. On the other hand, the average values of Pb, Cd, Cr, Ni and Zn were 96.062 4.868, 85.218, 60.666 and 179.09 mg kg^{-1}, respectively in metropolitan household dust besides road (Fig. 10). The concentrations of Pb, Cr Ni and Zn were higher in roadside metropolitan household dust than roadside rural household dust but the concentration of Cd was similar for both areas. Overall, the average concentrations of trace elements were lower in roadside rural household dust than household dust of metropolitan area.An independent t-test was conducted to observe difference of metal concentration between rural and metropolitan roadside household dust as well as the results showed significance difference for Pb, Cr, Ni and Zn (Table 2).

The highest average heavy metal concentrations at a primary school in Sri *Serdang*, Malaysia were found in windows, followed by floor and fan. Pb concentrations ranged from 34.17 mg/g to 101.87 mg/g, Cd concentrations ranged from 1.73 mg/g to 7.5 mg/g, and Cu concentrations ranged from 20.27 mg/g to 82.13 mg/g. Ventilation and cleaning process were found as the possible factors that contributed to heavy metal concentration in window, floor and fan [33]. Although, the possible of getting higher concentration in window, floor and fan but the concentration range of trace elements was lower in *Sri Serdang*, Malaysia than metropolitan area of present study.

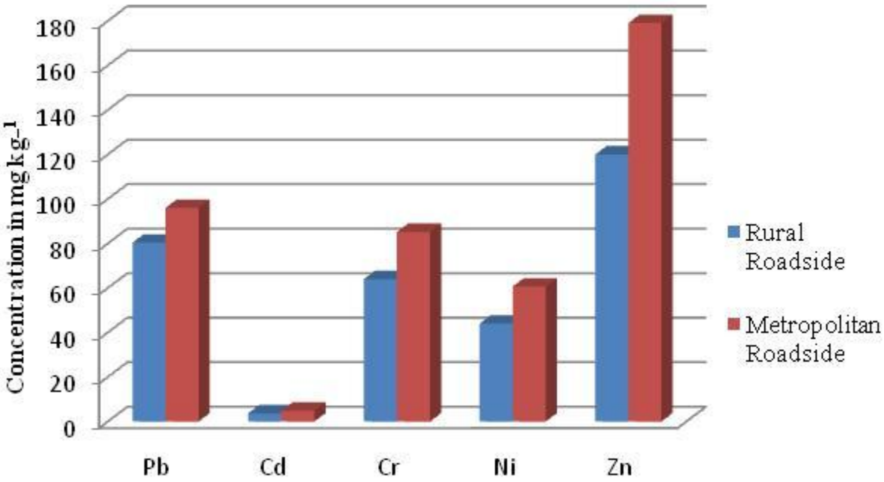

Fig. 10: Comparison of trace elements between rural and metropolitan roadside household dusts.

3.12. Health and environmental hazard of trace metals for household dusts

In the study area, the household dust samples divided into two parts where the average concentrations of Pb, Cd, Cr, Ni and Zn were 66.591, 3.25, 60.825, 43.921, 99.794 mg kg^{-1}, respectively in rural household dust and 86.78, 3.95, 84.247, 50.795, 164.2 mg kg^{-1}, respectively in metropolitan household dust. In addition, the average concentrations of Pb, Cd, Cr, Ni and Zn were 52.768, 2.788, 57.604, 43.83 and 79.562 mg kg^{-1}, respectively in rural household dust away from road as well as 80.414, 3.71, 64.046, 44.012, 120.03 mg kg^{-1}, respectively in roadside rural household dust. The average concentrations of pb, Cd, Cr, Ni and Zn were 77.498, 3.028, 83.276, 40.924 and 149.312 mg kg^{-1}, respectively in metropolitan household dust away from road as well as 96.062 4.868, 85.218, 60.666, 179.088 mg kg^{-1}, respectively in roadside metropolitan household dust.

The metals in the dust can be accumulated in human body via direct inhalation, ingestion and dermal contact absorption and pose potentially deleterious effects on the health of human beings. Children in particular are at higher risk compared to adults, because they engage in greater hand to mouth activity, while their neurological system is still developing and they having much higher absorption rate of heavy metal than adults [34]. Pb and Cd have carcinogenic potential in humans [13]. In addition, they suspected to have some adverse effects on human health such as cardiovascular, nervous system, blood and bone diseases [35-36]. Zn and Cu are essential for human health, but excessive intake of them may be responsible for adverse effects in both humans and animals [37]. House dust has long been recognized as a major source of Pb for children [38]. Contaminated house dust could be ingested by infants and children by normal hand-to-mouth activity resulting in Pb poisoning [39]. Another study [40] estimated that 50% of daily Pb exposure of Japanese children was from house dust based on the analyses of Pb in house dust, soil and duplicated diet.

3.13. Health and environmental hazard of trace metals for black solid materials from biomass burning

The average concentrations for lead, cadmium, zinc, copper, potassium and iron were 38.565, 1.88, 155.79, 21.36, 141.1 and 13892.05 mg kg^{-1}, respectively in black solid materials for biomass burning. From the result of the present study, it was found that the ranges of trace element observed in black solid materials were 21.6 to 59.83 mg kg^{-1} for Pb,1.24 to 2.68 mg kg^{-1} for Cd, 105.13 to 192.48 mg kg^{-1} for Zn, 10433.68 to 16181.58 mg kg^{-1} for Fe, 16.96 to 25.96 mg kg^{-1} for Cu and 103 to 186 mg kg^{-1} for K, respectively. The concentration of Fe was so higher in black solid materials. Iron may cause Conjunctivitis, choroiditis, and retinitis if it contacts and remain in tissues. Chronic inhalation of excessive concentrations of iron oxide fumes or dust may result in development ofbengin pneumoconiosis. Indoor air pollution is a major cause of ill health in developing countries. In some regions it is mostly due to the burning of biomass fuel, particularly wood, dung, straw and charcoal used as sources of heat and light [41].

Globally, solid fuel use is estimated to cause 3.5 million premature deaths per year, around one million of which are attributed to acute respiratory infections in young children [42]. There is also strong evidence of linking of solid fuel use with chronic obstructive pulmonary disease [43], pneumonia in children under five [44], lung cancer [45] etc. Lack of research on exposure to air pollution causing biomass burning and human health burden, despite poor air quality, is a situation common in many countries, like Bangladesh.

IV. Conclusion

The concentrations of trace elements in metropolitan household dust were much higher than those found in rural household dust samples. On the other hand, more trace elements were found in roadside household dust samples than dust away from roadside houses, in both cases (rural and metropolitan household dust). Most probably, it might be due to movement of vehicles and construction activities. This is a very important message for people those who are working at the kitchen and used biomass as fuel for cooking, especially for the women and their children. The amount of heavy metals in home environment may still be able to reduce by restricting the use of frequent windows and by practicing better housekeeping such as frequent wet mopping and vacuuming. To conclude, different government, non-government and international organizations should develop strategies or monitoring plans to evaluate the evolution of metal concentration in dust for reducing the risk of inhalation and ingestion of dust and protecting environment from air pollution.

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