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Research Note

Heavy Metal Levels from some Biomass Emissions in Indoor Environment of selected Kitchens in Jos, Nigeria

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A B S T R A C T

Since actual metal emissions can be assessed using Particulate matter (PM) as a proxy, monitoring and controlling metal compounds in biomass emissions is essential for determining their quantities and potential health effects. Using a low volume respirable dust sampler, indoor ambient metal-bearing particles were quantified in-situ and collected from nine (9) randomly selected public kitchens of boarding secondary schools in Jos, Plateau State. Atomic absorption spectrometry (AAS) was used to determine the amounts of specific heavy metals in these collected samples. Additionally, 114 responders' blood samples underwent a biochemical lead assay study. The mean concentrations of the samples taken for Mn, Cd, Cu, Fe, Cr, Zn, Ni, Pb, and Co were 0.097, 0.015, 0.254, 0.314, 1.027, 0.000, 0.076, 0.106, and 0.169 μg/m^3, respectively. The results of the blood lead assay analysis showed that 54% of the subjects had B-Pb levels above 80 μg/dL, 33% had B-Pb levels between 40 μg/dL and 80 μg/dL, 8% between 25 μg/dL and 40 μg/dL, 4% between 10 μg/dL and 25 μg/dL, 4% below 10 μg/dL, and 15% below 10 μg/dL. In general, elevated levels of metal-bearing particles in the indoor environment public kitchens expose kitchen staff to several occupational hazards.

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INTRODUCTION

According to Singh and Singh [1], causes of air pollution are numerous, which include industrial, domestic, vehicular, as well as emissions from tobacco products. In a Swedish cohort research, it was observed that an elongated duration of exposure to air pollution could result in diabetes [2]. Short-term exposure to air pollution is directly linked to shortness of breath, asthma, COPD, cough, wheezing, morbidity and respiratory disease.

Of the domestic pollution emitting sources, combustion of solid fuels release among others; suspended particles (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur (IV) oxide (SO_2) and heavy metals [3, 4]. Biomass combustion is a number of complicated physical and chemical reactions [5]. In combustion of biomass, metal congeals on the surface residual particles as fly ash and are always contained in the exhaust gas, while some volatile metals in trace quantities are left behind in the firing compartment ash [6]. The measure of emissions is determined by the combustion process and is also related to the characteristics of the biomass and the method and devices for burning [7, 8]. To obtain a high level of accuracy in evaluating deposition rates in the respiratory tract, in-situ assessment of the particulate levels of sizes $PM_{2.5}$ and PM_{10} in the breathing zone of receptors being observed. Among the components of air pollution, heavy metals are of huge concern due to their deleterious effects on both environmental and public health [9–14]. It was

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reported that about 3.5 million untimely deaths result worldwide annually from air pollution [14].

Globally, a series of studies have been undertaken and documented on levels of heavy metal in dusts in domestic settings, though these studies were carried out in urban settings and offices [15–24], preschools and elementary schools [25, 26] with limited agrarian settings [20, 27, 28]. The long-term exposure to heavy metals results in chronic deposition in tissues and internal organs leading to serious health risks [20, 25]. Human exposure to airborne metals in the microenvironments of public kitchens could be caused by metal-bearing particulates from the solid fuels being used. In several assessments, metals trapped in samples of PM_{10} collected from stationary sources are often used in in-situ metal evaluation for environmental risk assessment purpose. While several criteria pollutants' levels have been assessed and quantified, many metals are yet to be discovered or even regularly assessed in solid fuels' emissions. In fact, the majority of them are usually not measured; rather, they are aggregated with other pollutants which are easily and routinely measured or associated with other indicators. Hence, the concentration of metals from several emission sources such as industrial or domestic in which PM are used as surrogate for metals are often unclear and uncertain since they are not directly and actually assessed at all; thereby making it difficult for determining their in-situ levels and planning interventionist strategies for remediating their exposure in the environment.

Even though metals come in trace quantities, fuel combustion sources can be prominent sources of metals that can be identified in atmospheric PM [29]. Hence, to attain high degree of air quality standards, emission of heavy metals in the environment need to be mitigated [30–32] However, evaluating their potential risk within the microenvironments of public kitchens is challenging because humans have always been exposed to metals, unlike anthropogenic chemicals and have developed various means of responding to metals. For example, lead, cadmium, mercury and arsenic when emitted are easily diffused in the environment without any desirable impacts on humans [33]. Rather, their trace quantities are known to have neuroactive toxins and carcinomatous actions [34, 35]. In fact, it has been reported that lead is a potentially harmful heavy metal with severe poisoning effect and is a major source of environmental pollution [36]. This is corroborated by Guo et al. [37] and Jangirh et al. [38], who opined that heavy metals emitted from biomass burning sources induce carcinomatous and noxious effects.

In Nigeria, there are yet to be documented comprehensive reports of levels of heavy metals such as lead, arsenic, cadmium, and nickel emitted from solid fuels used for cooking despite the fact that their toxicity has been shown to pose serious hazards with associated health consequences [39]. Several literatures have reported that indoor air pollution is associated with specific health outcomes among the kitchen workers. The presence of specific pollutants, such as carbon monoxide, sulfur (IV) oxide, and particulate matter from well-known point sources have often being linked to some health outcomes. For example, according to Anjorin et al. [40], of the 116 kitchen workers investigated in the indoor environment of selected public kitchens, 69 (59.48%) suffers from joint pain, 50 (58 %) eye irritations, running nose 42 (36.21%), nasal congestion 7 (6.03%), dyspnea 17 (14.66), 52 (44.83%) dizziness, 79 (68.70%) headache, myalgia 40 (34.48%), 34 (29.31 %) joint stiffness and joint swelling 9 (7.79%). However, the composition and concentration of heavy metals in commercial or public kitchens in Nigeria have not been adequately described and little is known about the health risks from such environments.

Meanwhile, the possible health effects of occupational exposure to cadmium, lead, and mercury have been studied for a long time using experimental animals and people who have been exposed to environmental pollution. Furthermore, a number of studies have found that lead exposure in humans occurs most commonly through food or water [41], with little attention paid to lead exposure in humans from the biomass fuel combustion plume. Today, whole blood lead measurements are the main method used in laboratories to determine lead exposure.

This study examined the level of heavy metals and their health effects from biomass sources in selected kitchens in Jos, Plateau State, Nigeria. It is believed that the baseline data provided by this study will aid in creating awareness of the burden and effects of some heavy metals in workplace settings.

MATERIALS AND METHODS

Study area

This study was conducted in randomly selected public kitchens of secondary schools operating boarding system in Jos North Local Government Area of Plateau State. The Plateau State's capital, Jos, is located in Nigeria's North Central Geopolitical Zone. Plateau State, Kaduna, Taraba, and Nassarawa form its borders. The largest local government area in Plateau State, Jos North, is home to a number of secondary schools. The Ministry of Education is in charge of overseeing secondary school activities. In the Jos North Local Government Area, there are roughly nineteen (19) secondary schools that use a boarding system [40]. Of these, two are owned by the federal government, one by the state of Plateau, seven are private, and nine are mission schools. The majority of these schools use biomass fuels like charcoal and fuel wood in their kitchens because cooking gas is expensive and the electricity supply is unstable. The investigation was carried out in schools that use biomass cooking.

Data collection and sampling

Methods of sampling for emissions from biomass combustion vary according to the criteria pollutants being investigated [42]. Sources for the data on indoor ambient air pollution included nine (9) randomly chosen public cooking facilities at a few chosen boarding secondary schools in Jos, Plateau State. An active sampling tool called the CW HAT 200 Particulate Sampler was used to measure the concentrations of particulate matter with an aerodynamic diameter of 2.5 µm and 10 µm in situ. As shown in Figure 1, these sources were also examined and evaluated for the presence of a few specific heavy metals using the Respirable Dust Sampler and Air Chek Sampler. SKC 224-XR Series Pumps were used with this sampler (Model 224-PCXR8.

For two hours in each location, this sampler was positioned on a platform 1.5 meters above the ground (see Figure 1). According to Oladoye et al. [43] and Liu et al. [44] the level of heavy metal is assessed by an atomic absorption spectrophotometer. In this work, Atomic Absorption Spectrometry (AAS) was used to examine the trapped emission samples for particulate-associated heavy metals (including Cd, Co, Cr, Cu, Pb, Mn, Ni, Fe, and Zn). Atomic Absorption Spectrometry (ASS) is frequently used to examine the heavy metal contents of indoor air particles in the kitchen environments. This calls for the fusion or digestion of powerful acids to dissolve the heavy metals in solution. The microwave digestion method was specifically used for this procedure to digest the PTFE membrane filter and Kim wipes tissue. The reagent with 7 mL HNO_3 was employed in the initial digestion tests. The filter solutions were diluted to 100mL with the ultra-pure water in a volumetric flask and kept at 4°C in a polyethylene bottle until analysis was conducted. Within 45 minutes, 65% and 3 mL HCl with 37% begin to digest using a microwave digester. Next, 4 mL of HNO_3 (nitrate) and 1 mL of hydrogen peroxide (H_2O_2) were utilized in the second experiment.

Blood sampling and biochemical analysis

From the respondents, blood samples were taken. Blood lead levels were measured using three milliliters of blood taken into an EDTA vacutanier. For a month, blood lead samples were kept at -20°C in a freezer that was under close observation before being subjected to Atomic Absorption Spectrometry, or AAS, analysis. Blood lead concentrations can be determined using a variety of laboratory techniques. The most popular ones are inductively coupled plasma mass spectrometry (ICP-MS), anodic stripping voltammetry (ASV), and atomic absorption spectrometry (AAS).

Ethical consideration

Informed consent was obtained from all participants after proper explanation of the research work and procedure; anonymity and confidentiality of the information obtained from the participants in this study were assured and maintained; and approval was obtained from the Ethical Committee of the Jos University Teaching Hospital (JUTH).

Data processing and statistical analysis

The Statistical Package for Social Sciences (SPSS® Incorporated Chicago Version 18.0) program was used to export the data from Microsoft Excel® version 2.0 for analysis. Standard deviation (SD) plus mean values were used to show descriptive statistics. The bar chart for the heavy metals analyzed in the chosen kitchens was obtained using Microsoft Excel software, which was analyzed as well.

RESULTS AND DISCUSSION

Heavy metal concentrations in the selected kitchens

As shown in Table 1, domestic biomass burning produces heavy metal emissions that are primarily released into the ambient air of public kitchens. These pollutants include cadmium, lead, nickel, and copper. The 25th, 50th, and 75th percentiles of the manganese, Mn, sampled in the indoor microenvironments of the selected kitchens were 0.071, 0.080, and 0.121 µg/m^3, respectively. The mean average was 0.097 µg/m^3 (SD, 0.054). The 25th, 50th, and 75th percentiles of the Cadmium, Cd, concentration were 0.005, 0.008, and 0.010 µg/m^3, respectively. The mean average was 0.015 µg/m^3 (SD, 0.024). The 25th, 50th, and 75th percentiles of Copper, Cu, were 0.183, 0.260, and 0.344 µg/m^3, respectively. The mean average was 0.254 µg/m^3 (SD, 0.101). The 25th, 50th, and 75th percentiles of iron content were 0.184, 0.263, and 0.476 µg/m^3, respectively, with the mean average being 0.314 µg/m^3 (SD, 0.189). The 25th, 50th, and 75th percentiles of the mean value for chromium, Cr, were 0.446, 1.083, and 1.554 µg/m^3, respectively. The 25th, 50th, and 75th percentiles of Zinc, Zn, were 0.000, 0.000, and 0.000 µg/m^3, respectively, with the mean average being 0.000

Figure 1. Air Chek sampler (Model 224-PCXR8) with SKC 224-XR series pumps

Table 1. Indoor levels of particulate and heavy metals of concerns in selected public kitchens in Jos-Nigeria

SCH.	$PM_{2.5}$	PM_{10}	Blood Lead	Mn	Cd	Cu	Fe	Cr	Zn	Ni	Pb	Co
	(μg/m³)		(μg/dL)			(μg/m³)						
ESS	82.30	176.10	85.28	0.220	0.005	0.337	0.241	0.479	N/A	0.047	0.130	0.099
RPA	17.10	36.20	90.38	0.073	0.078	0.271	0.333	1.181	0.001	0.093	0.076	0.005
STC	200.90	234.70	83.00	0.076	0.010	0.15	0.628	1.775	N/A	0.135	0.201	0.039
FGC	95.90	201.20	91.00	0.080	0.007	0.351	0.233	0.964	N/A	0.070	N/A	0.02
SLC	71.20	149.70	78.00	0.068	0.009	0.215	0.399	1.332	N/A	0.103	0.099	N/A
BHS	61.50	128.40	51.00	0.142	0.003	0.26	0.135	0.413	0.004	0.036	0.071	0.077
ABS	44.80	93.60	31.00	0.033	0.004	0.077	0.039	0.112	0.005	0.016	0.026	0.028
GCJ	56.10	117.70	106.00	0.084	0.008	0.229	0.263	1.083	0.002	0.067	N/A	1.083
SJC	67.90	140.20	105.00	0.100	0.009	0.399	0.552	1.903	N/A	0.113	0.136	0.002
Mean	77.52	141.98	80.07	0.097	0.015	0.254	0.314	1.027	0.000	0.079	0.106	0.169
Std.Error of Mean	17.14	19.59	8.18	0.018	0.008	0.034	0.063	0.203	0.000	0.013	0.021	0.131
Standard Deviation	51.42	58.77	24.53	0.054	0.024	0.101	0.189	0.609	0.000	0.039	0.057	0.371
Occupational Limits for Metals (μg/m³) (IDHL)				500000	900	100,000		250,000		10,000	100,000	20,000
Occupational Limits for Metals (μg/m³) (OSHA PEL for 8-hr TWA)				5000	0.005	1		1		1000	50	0.1
NIOSH REL (μg/m³)(10-hr TWA)				1000	N.E.	1		0.5		15	50	0.05
Carcinogen				No	Yes	No		No		Yes	No	No

- IDLH= Immediate Detrimental to Life and Health
- NIOSH= National Institute of Occupational Safety and Health
- REL= Recommended Exposure Limit
- OSHA= Occupational Safety and Health Administation
- PEL=Permissible Exposure Limit

μg/m³ (SD, 0.000). The 25th, 50th, and 75th percentiles of Nickel, Ni, were 0.042, 0.070, and 0.108 μg/m³, respectively. The mean average was 0.076 μg/m³ (SD, 0.039). The 25th, 50th, and 75th percentiles of Lead, Pb were 0.071, 0.099, and 0.140 μg/m³, respectively, and the mean average was 0.106 μg/m³ (SD, 0.0057). The mean average of Cobalt, Co was 0.169 μg/m³ (SD, 0.371), while the 25th, 50th, and 75th percentiles were 0.009, 0.034, and 0.094 μg/m³.

It is clear from Table 1 that the spectrum of heavy metal analyzed have significant values within the indoor kitchen microenvironments. However, only cobalt, chromium and cadmium have their concentrations exceeding the occupational standards by Occupational Safety and Health Administration (OSHA) for 8-hour TWA as presented in Table 1 and depicted in Figure 2. The observed concentration of Copper, Manganese, Iron, Lead, and Nickel and their compounds although significant did not exceed the standards by OSHA. Among these, Zinc, and its compounds are insignificant components of the biomass plume-impacted emissions.

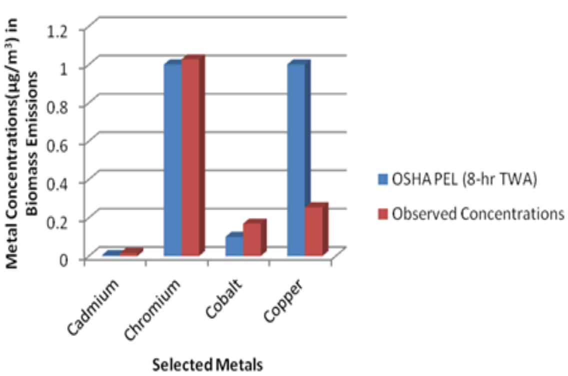

Figure 2. Comparison of metal concentrations (μg/m³) in indoor biomass emission and their OSHA standards

According to their report, [45] observed that the order of heavy metal levels in biomass emission in household settings is as follows: Al > Fe > Mn > Zn > Cr > Pb > Ni > Co. Further, it was observed that Co, Cr, Pb, and Ni concentration levels were lower than the background values. However, in this work, the order of heavy metal assessed in the indoor environments of public kitchens using biomass for cooking is as follows: Cr> Fe> Cu> Co > Pb > Mn > Ni>Cd > Zn. This is a variation in the order observed by Yaparla et al. [45], however, Cr> Pb>Ni order is in consonance.

Metal-bearing particulate emissions from biomass combustions

For accuracy in ascertaining the deposition rates in the respiratory tract, it is imperative to sample particle sizes in the breathing zone of receptors being investigated because metal-bearing particulate is the primary source of human exposure to airborne metals in the microenvironments of public kitchens. In the previous century, vehicular emissions and industrial combustions were the primary sources of air pollution in most cities in Nigeria, and highest in the cities of Nigeria. According to these observed levels, the particle levels exceed WHO guidelines (5.0 µg/m^3 and 15.0 µg/m^3, respectively, for $PM_{2.5}$ and PM_{10}) for indoor particulates of aerodynamic diameters 2.5 µm and 10.0 µm from biomass fuels.

Given that metals are present in trace amounts in PM, there should be some association between the quantity of heavy metals and the levels of particle emissions from biomass combustion. Figure 3 illustrates the association between lead (Pb) and the total suspended particulate ($PM_{2.5}$ and PM_{10}) samples taken in these kitchens. The correlation coefficient was 0.7109. It was discovered that, despite the fact that lead (Pb) is a trace component of PM, emissions from biomass fuel play a significant role in the lead (Pb) levels in public kitchens.

However, when compared to the OSHA limits, levels of Zn, Mn, and Fe were lower in all the selected kitchens from the spectrum of heavy metals analyzed (see Figure 2). Additionally, an adequate impact of these found metals was derived by contrasting their concentrations with the NAAQS for the United States, which are shown in Table 2 and corroborated by Figure 4. This comparison analysis showed that the observed levels of zinc were below the NAAQ Standards for rural, urban, and industrial settings, whereas the levels of iron and copper were above those for rural settings but below the NAAQ Standards for urban and industrial settings.

Table 2. Community metals concentrations of concern (µg/m^3)

S/N	Metal	Typical U.S. National Ambient Air Quality Concentrations		
		Rural	Urban	Industrial
1	Antimony[a]	<0.001	0.032	0.55
2	Arsenic[a]	0.002	0.02	7.6
3	Beryllium[a]	0.0001	0.002	0.01
4	Cadmium[a]	0.001	0.008	0.6
5	Chromium[a]	0.002	0.02	0.4
6	Chromium (VI)[a]	0.0001	0.0016	0.0153
7	Cobalt[a]	0.0001	0.0005	0.61
8	Copper	0.01	0.29	0.87
9	Iron	0.3	1.6	7.00
10	Lead[a,b]	0.02	0.04	0.76
11	Manganese[a]	0.001	0.02	0.3
12	Mercury[a]	0.0001	0.014	0.041
13	Nickel[a]	0.006	0.02	0.17
14	Selenium[a]	0.0001	0.015	0.03
15	Silver	0.0005	0.004	0.037
16	Vanadium	0.0008	0.065	0.5
17	Zinc	0.006	0.103	5.00

[a] Metals designated as Hazardous Air Pollutants by EPA

[b] National Ambient Air Quality Standard for Lead is 15µg/m3 as a rolling three months average

[c] Typical Urban Ambient Air Concentration procured from EPA, ATSOR, the Hazardous Substance Database and/or WHO

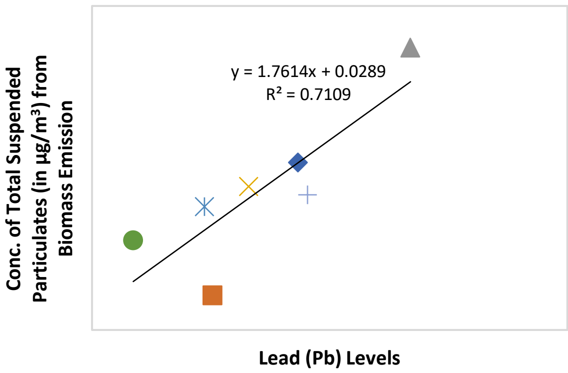

Figure 3. Correlation of lead (Pb) levels of kitchen staff and total suspended particulate levels in the selected kitchens

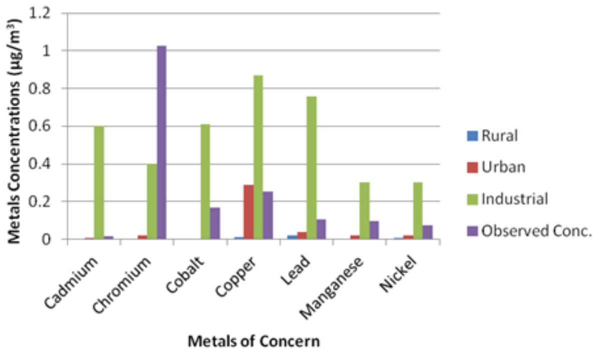

Figure 4. Comparison of metal concentrations (µg/m^3) in indoor biomass emission and their NAAQ standards

Furthermore, Figure 4 shows that the concentration of chromium in rural, urban, and industrial areas surpasses the NAAQ Standards. Nickel, Manganese, Lead, Cobalt, and Cadmium, however, all were below the NAAQ criteria for industrial environments although exceeding the criteria for urban and rural settings. It is evident from the heavy metals' analysis that nickel, manganese, lead, cobalt, and cadmium are equally dangerous but had less severe occupational effects while chromium posed the most detrimental consequences from indoor biomass combustion in the selected kitchens.

The environmental and health impacts of lead

From several literatures, lead has always been chosen for biochemical analysis because, it is one of the systemic toxicants that affects a number of body organs, including the kidneys, liver, central nervous system, hematological system, endocrine system, and reproductive system. In this study, blood samples from 114 participants were analyzed using a biochemical lead assay. In this investigation, 54% of the participants had B-Pb levels over 80 µg/dL, 33% had B-Pb levels between 40 µg/dL and 80 µg/dL, 8% between 25 µg/dL and 40 µg/dL, 4% between 10 µg/dL and 25 µg/dL, 4% below 10 µg/dL, and 15% below 10 µg/dL. Even without symptoms (significantly elevated), serious health harm may be happening between 40 and 80 µg/dL. Regular exposure occurs between 25 and 40 µg/dL, and there is some evidence of potential physiologic issues (elevated). Lead builds up in the body between 10 and 25 µg/dL and there is some exposure.

There is no disputing the fact that 46% of the respondents in this study were exposed to lead levels that are extremely harmful, according to the description of the elevated levels of lead provided by Nicolas and Descotes [46]. 8% of people were exposed to lead levels that are elevated, while 33% were exposed to levels that are substantially elevated. 15% of the respondents had lead levels that were within the background level, whereas 4% had lead exposure levels that indicated lead was accumulating in their bodies. A blood lead level of more than 25 µg/dL indicates significant lead exposure. Additionally, there is mounting evidence that this blood lead level may have negative impacts on health [46].

The mean blood lead (Pb) levels of the respondents within each selected kitchen were collected, further demonstrating the site-specificity of lead levels from biomass emissions in kitchen contexts. Since all respondents within a particular kitchen are subjected to similar indoor pollution from the combustion of biomass fuel, they were connected with the lead levels in the tested particles from the individual kitchens. A significant correlation coefficient of 0.4583 was obtained, as demonstrated in Figure 5. This showed that even in trace amounts, lead (Pb) levels in indoor air pollution inside the microenvironments of the kitchens contribute to the exposure of the kitchen staff to excessive lead

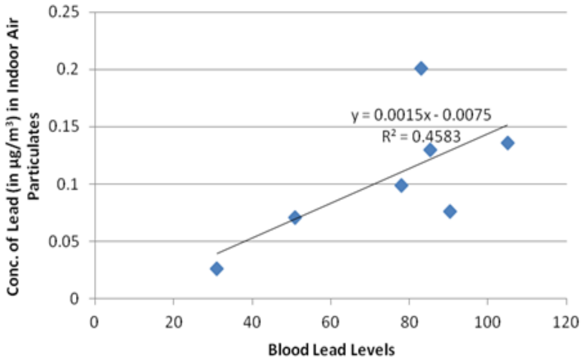

Figure 5. Correlation of blood lead (Pb) levels of kitchen staff and indoor lead (Pb) levels in the selected kitchens

consumption into their blood. This is so that the assessment of exposure to pollution levels in each kitchen could take into account the various exposure routes as well as ambient and anthropogenic concentrations. In public kitchens, people are typically exposed to some lead through direct airborne contamination. Deposition of lead on the surface particles, intake via inhalation, ingestion or through skin contact are some indirect channels through which lead can be taken in by humans. Of these pathways, ingestion of lead-bearing surface particles tends to be the primary instigator of human health risk. However, this may not always be the case when airborne lead (Pb) has led to environmental contamination. Lead (Pb) that is inhaled may have a substantially higher bioavailability than lead that is consumed in other ways. Even when lead intake by inhalation are comparable to intakes from other routes, this can lead to significantly high internal dosages by inhalation. In this study, it was shown that the levels of ambient lead (Pb) in the kitchens did not exceed OSHA standards. However, nearly 95% of the respondents had B-Pb concentrations above 25 g/dL, which supports the significant correlation coefficient of 0.4583. This may imply that the primary routes for ingesting lead (Pb) may not be through direct inhalation of contaminated air from biomass combustion fumes, but rather through deposition of lead-bearing surface particles and soot impacted on cooking platforms and pot surfaces, as well as intake through ingestion, inhalation, or skin contact. These might be the main causes of the respondents' increased B-Pb levels.

In actuality, lead is a highly hazardous metal whose widespread usage has resulted in substantial environmental damage and health issues in many regions of the world, according to Jaishankar et al. [39]. Long-term impacts of exposure to lead can result in blood-related issues, central nervous system, abnormal blood pressure and kidneys dysfunction. Short-term consequences of lead exposure can also result in brain impairment and gastrointestinal distress. Workers have complained of neurological issues, and adults have reported impaired nerve transmission in peripheral nerves. Children that are exposed to lead on a regular basis may experience developmental impacts such as hearing loss, diminished growth, slower cognitive development, and IQ reduction. Lead exposure can also have negative consequences on reproduction, such as lowered sperm counts, spontaneous miscarriages, low birth weight, and slower postnatal neurobehavioral development.

Blood lead (B-Pb) levels of approximately 100-150 µg/L are consistently linked to consequences in children, according to epidemiological research conducted by Nicolas and Descotes [46]. According to some evidence, lead may be detrimental at B-Pb concentrations much lower than 100 µg/l; there may be no upper limit to these effects. The blood lead content deemed to be of clinical concern has steadily decreased in several nations. This is in line with mounting research that suggests there may not be a lead level in the body beyond which there are no harmful effects on health.

CONCLUSION

The microenvironments of public kitchens in Jos Plateau State have significant levels of metal-bearing particles, which exposes kitchen employees who spend the majority or all of their working hours in indoor kitchen environments to a number of occupational hazards. This necessitates tackling this public health issue right away. When compared to the usual regulatory limits, it is evident from the analysis of the heavy metals that chromium posed the biggest risk from indoor biomass burning in the chosen kitchens. Nickel, Manganese, Lead, Cobalt, and Cadmium are all similarly dangerous but have only minor effects on workplace health. Although kitchen staff can be exposed to contaminated air anywhere, it was shown that the main issue is emissions connected to their job activities (for example, emissions from biomass combustion).

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Persian Abstract

چکیده

از آنجایی که انتشار واقعی فلز را می‌توان با استفاده از ذرات معلق (PM) به عنوان شاهد ارزیابی کرد، نظارت و کنترل ترکیبات فلزی در انتشار زیست‌توده برای تعیین مقادیر و اثرات بالقوه سلامت آنها ضروری است. با استفاده از یک نمونه‌بردار گرد و غبار قابل تنفس با حجم کم، ذرات حاوی فلز در محیط داخلی در محل اندازه‌گیری شدند و از نه (۹) آشپزخانه عمومی به‌طور تصادفی انتخاب شده از مدارس متوسطه شبانه‌روزی در جوس، ایالت پلاتو جمع‌آوری شدند. از طیف سنجی جذب اتمی (AAS) برای تعیین مقدار فلزات سنگین خاص در این نمونه های جمع‌آوری شده استفاده شد. علاوه بر این، ۱۱۴ نمونه خون پاسخ‌دهندگان تحت یک مطالعه سنجش سرب بیوشیمیایی قرار گرفتند. میانگین غلظت نمونه‌های گرفته شده برای منگنز، کادمیوم، مس، آهن، کروم، روی، نیکل، سرب و کو، به ترتیب، ۰/۰۹۷، ۰/۰۱۵، ۰/۲۵۴، ۰/۳۱۴، ۱/۰۲۷، ۰/۰۰۰، ۰/۰۷۶، ۰/۰۷۶ میکروگرم، ۰/۱۰۶ میکروگرم و ۰/۱۰۶ میکرومتر بود. نتایج تجزیه و تحلیل سنجش سرب خون نشان داد که ۵۴ درصد از افراد دارای سطوح B-Pb بالای ۸۰ میکروگرم در دسی لیتر، ۳۳ درصد دارای سطوح B-Pb بین ۴۰ میکروگرم در دسی لیتر و ۸۰ میکروگرم در دسی لیتر، ۸ درصد بین ۲۵ میکروگرم در دسی لیتر و ۴۰ میکروگرم در دسی لیتر، ۴ درصد بین ۱۰ میکروگرم در دسی لیتر و ۲۵ میکروگرم در دسی لیتر، ۴ درصد زیر ۱۰ میکروگرم در دسی لیتر، و ۱۵ درصد زیر ۱۰ میکروگرم در دسی لیتر بودند. به طور کلی، افزایش سطح ذرات فلزی در محیط داخلی آشپزخانه‌های عمومی کارکنان آشپزخانه را در معرض خطرات شغلی متعددی قرار می‌دهد.