Preliminary assessment of heavy metals in street vended foods in the surrounding of elementary school area in Bandung city, Indonesia.

Endah Damastuti1*, Natalia Adventini1, Katerina Oginawati2, Woro Yatu Niken Syahfitri1, Syukria Kurniawati1 and Muhayatu Santoso1.

1Center for Applied Nuclear Science and Technology, National Nuclear Energy Agency (BATAN), Tamansari 71, Bandung 40132, Indonesia.
2Environmental Engineering- Faculty of Civil and Environmental Engineering, ITB, Ganesha 10, Bandung, Indonesia.

*Email: endah_dt@batan.go.id

Abstract. Street vended foods are ready to eat foods sold by the vendors in the street and easily found in the school surrounding area. The availability and affordability of street vended foods made it widely consumed by large of population include children, especially when it is packaged attractively. Unfortunately, the safety of street vended foods especially related to the heavy metal contaminant is still unknown. Therefore, assessing the heavy metal level of street vended foods that widely consumed by children need to carried out. A number of 24 street vended food samples were collected in four elementary school surrounding area in Bandung city. The determination of heavy metal content in this food samples was conducted by neutron activation analysis and atomic absorption spectrometry as well. The quality of analytical results was evaluated using Standard Reference Material (SRM) NIST 1548a Typical Diet and 1567a Wheat Flour. Compare to the maximum permissible limit established by Indonesian Food and Drug Control Agency (BPOM), it was found that Cu, Hg and Zn concentration of street vended foods were below their maximum permissible limit. However, health risk assessment through Hazard Index (HI) formulation indicated that children in Bandung city may possess non-carcinogenic health risk due to heavy metals from the consumption of several street vended foods since the HI value are in the range of 0.06 – 2.32 with more than 10% of the foods observed were have HI > 1. These may be harmful situation to the children health. Further supervision of the preparation and handling of the vended foods are needed and guidance about the importance of hygiene and quality of vended foods to the vendors need to be improved.

1. Introduction

Street vended foods are ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers especially in streets and other similar public places for immediate consumption or consumption at a later time without further processing or preparation [1,2]. This definition emphasizes the retail location ‘on the street’, with foods sold from pushcarts, bicycles, baskets or balance poles, stalls, kiosks or shops. Street vended foods are categorized as follows: food prepared in small factories and sold by mobile vendors; food prepared at mobile vendors home and offered for sale to the public; and food prepared and sold on the street [2]. Street vended food is present even in less developed countries, and has occasionally to be the hallmark of the early development of fast food [3]. These foods vending is very
popular to a large number of people, among commuters and urban dwellers, in many cities and towns in
developing countries because they are usually perceived to be inexpensive, convenient and attractive. It
is also easily accessible, and generally affordable to large parts of the population to meet up their needs
of food [1,2,4,5]. Street foods vending plays an important role in assuring food security for low-income
urban populations [6]. It is a large source of employment in many cities of developing countries [7]
including in Indonesia and it can be easily found in surrounding area of the school. The dependence of
many people on street vended foods, likely or not, has made the enforcement of food safety has been
transferred from individuals and families to the food vendors who rarely conduct of such practices [7].
Most handlers of street food in the developing countries are poor, not adequately educated, and ignorant
of basic food safety. Consequently, street foods are commonly exposed to various contaminants at
different stages of handling [1,2,6,8].

Food safety is a major public concern worldwide. The risks of food safety are contributing to the
burden of illness [9]. During the last decades, the increasing demand of food safety has stimulated
research related to the risk associated with consumption of food stuffs contaminated by pesticides, heavy
metals and/or toxins [10]. The implication associated with heavy metal contamination is of great
concern. Heavy metals, in general are not biodegradable, having long biological half-lives and having
the potential for accumulation in the different body organs leading to unwanted side effects [11]. Heavy
metals have positive and negative effects on the human health, it can be classified as essential for
biochemical reactions in the body (copper, iron, zinc, etc.) and potentially toxic (lead, cadmium, arsenic,
mercury etc.) [10,12]. Long-term exposures to toxic elements can pose a significant health risk even at
low concentration but the intake of too much of essential metals can also cause produce toxic effects
[10,11]. Street vended foods are perceived to be a major health risk and vulnerable to contaminated of
pathogens, toxin and heavy metals as well. Quality assessment of street foods shown that these foods
were positive vectors of food borne illnesses and every person that eating these foods is at the risk of
food borne illness [13].

The contamination of heavy metal can seriously affect the children health as well since children are
the most sensitive and vulnerable age group to any kind of contamination in the food chain [14]. It was
stated by Asiegbu that up to 2 million people per year has died, most of are children, because of diseases
caused by consumption of contaminated food and water [15]. Children is human resources asset and the
future generation of a nation. Efforts to improve the quality of human resources begin with the
fulfillment of basic human needs with primary focus on the process of growth and development of the
child. The nutritional adequacy and safety greatly affect intelligence and work productivity of human.
School-age children, especially in elementary school, represent an important and diverse target group
for health and nutrition interventions. At this age, children do more activities that requires more nutrition
as well. Unfortunately, this requirement does not always fill perfectly. High rushing often makes the
parents do not have time to provide adequate lunches and snacks for their children. This condition, and
also the savvy of tastes and attractive packaging make children more attracted to buy street vended
foods.

Several assessments related to quality, hygiene and sanitation of street vended foods in Indonesia
have been carried out [16]. The chemical contaminants such as coloring agent, additives and
preservatives were also found in abnormal level of some street vended foods. But the assessment related
to the heavy metal contaminant in street vended foods that commonly consumed by children is still
scarce. Therefore, this research of assessing the level and the risk of heavy metals in street vended foods
consumed by school-age children was conducted. The determination of heavy metal was carried out
using Neutron Activation Analysis (NAA) and Atomic Absorption Spectrometry (AAS). In assuring the
quality and reliability of analytical results, several reference materials were analyzed along with the food
samples. The results from this study will provide information that can verify the nature of the nutrition
problem within a society and the effectiveness of the specific solution or intervention as it can be used
as the science-based reference for in charge institutions to develop a better quality of street vended foods.
2. Methodology

2.1. Food Sampling and Preparation

Food samples were collected from 4 elementary schools’ area in Bandung city which are Setiabudi, Pelesiran, Sindanglaya and Soka, as described in Figure 1. The four elementary schools were chosen as they are located in the populated area near the arterial road of Bandung city and supposed to be represent the north, south, east and west of Bandung city. Five to six kinds of food were taken from street vendors in surrounding areas of each school that often consumed by its students. The selection of the foods was based on questionnaire results that previously distributed. As much as 20 types of foods from 24 foods samples were collected as listed in Table 1 and the description of each street vended foods were given in Table 2.

Each part of one type of street fended food were weighing individually and then mashed all parts together with titanium blade blender. Weighing each of a street vended food was used to calculate the total calories of every street vended foods. Food samples that have been smooth and homogeneous were weighted and placed into a small tube, then stored in the freezer until frozen. Tube which contains frozen food sample attached on freeze dryer. Freeze drying was done by the help of vacuum pump and the temperature was set at -55°C. Drying process took 3x24 hours until the samples were dry and had constant weight. Dried samples then refined into fine powder using a Teflon mortar and pestle, and then placed into polyethylene container.

Table 1. List of collected street vended foods

| Sample ID | School Area | Street vended foods     |
|-----------|-------------|-------------------------|
| 1         | Setiabudi   | Bakwan                  |
| 2         |             | Martabak                |
| 3         |             | Potato                  |
| 4         |             | Creepes                 |
| 5         |             | Noodle1                 |
| 6         |             | Cakwe1                  |
| 7         | Sindanglaya | Egg1                    |
| 8         |             | Cireng                  |
| 9         |             | Cilok                   |
| 10        |             | Cakwe2                  |
| 11        |             | Bakso Tahu              |
| 12        | Pelesiran   | Batagor                 |
| 13        |             | Gelatin                 |
| 14        |             | Banana                  |
| 15        |             | Cakwe3                  |
| 16        |             | Sausage                 |
| 17        |             | Egg2                    |
| 18        | Soka        | Bacil                   |
| 19        |             | Lumpia Basah            |
| 20        |             | Noodle2                 |
| 21        |             | Cimol                   |
| 22        |             | ‘Cubit’ cake            |
| 23        |             | Cracker ball            |
| 24        |             | Biting                  |
Figure 1. Sampling location of street vended foods in Bandung city, Indonesia.

Table 2. List of collected street vended foods

| Street vended foods | Description                                                                 |
|---------------------|-----------------------------------------------------------------------------|
| Bakwan              | Deep fried mixture of wheat flour, carrot, cabbage and onion.               |
| Martabak            | Deep fried thick folded creep filled with lot of leek, egg, and some minced meat. |
| Potato              | Fried potato covered by flour and served with spicy powder.                 |
| Creepes             | Filled with many variations such as tuna fish, smoked beef, burger etc.     |
| Noodle              | Fried noodle served with meatball, and some vegetables.                    |
| Cakwe               | Fried bread stick served with chili and sour sauce.                        |
| Egg                 | Fried egg served with chili sauce.                                         |
| Cireng              | Fried cornstarch filled with oncom.                                        |
| Cilok               | Boiled cornstarch served with soy sauce, chili sauce.                      |
| Bakso Tahu          | Steam tofu filled with dough of fish and cornstarch and served with peanut dressing. |
| Batagor             | Fried tofu filled with fish and cornstarch and served with peanut dressing. |
| Gelatin             | Served with variation of fruit flavours.                                   |
| Banana              | Deep fried of folded creep filled with banana and chocolate.               |
| Sausage             | Fried sausage served with chili sauce and mayo.                           |
| Bacil               | Boiled small cornstarch served with soy sauce, chili sauce.                |
| Lumpur Basah        | Folded creep filled with saute bean sprouts, egg and bamboo shoot with sweet and hot sauce. |
| Cimol               | Fried cornstarch ball served with peanut sauce or chili powder.            |
| ‘Cubit’ cake        | Cake made from dough of wheat flour, egg and sugar.                        |
| Cracker ball        | Savory crackers ball with variations of flavour.                           |
| Biting              | Dried oven noodle served with spicy and savory powder.                     |

2.2. Neutron Activation Analysis (NAA) Procedure.
Neutron activation analysis is a method for qualitative and quantitative determination of elements based on the measurement of characteristic radiation from radionuclide formed by neutron irradiation of the material. The elemental concentrations were calculated by the comparative method. In this experiment, as much as 0.1 g powder dried samples were placed into 0.274 mL polyethylene vial respectively and each vial then sealed by heating [17]. An amount of 0.1 g samples was used to analyze long half-life elements such as chromium, iron, zinc and mercury. For long half-life elements, the samples irradiated along with SRM NIST 1548a Typical Diet and mix standard, consist of 0.2, 10 and 20 µg of Cr, Zn and Fe respectively. Irradiation went for an hour at 15MW at rabbit system facilities of multipurpose reactor G.A. Siwabessy, Serpong. Samples then allowed to cooling for a month then counted for 10000s using gamma spectrometer with low resolution of HPGe detector. The resolution (FWHM) of the system was
1.90 keV for 1332 keV gamma-ray of 60-Co. The radionuclides measured were identified according to their half-lives and gamma-ray energies. The spectrum observed using Genie 2000 software at 320.08 keV, 1099.25 keV and 1115.5 keV for Cr, Fe and Zn respectively.

2.3. Atomic Absorption Spectrometry (AAS) Procedure
An amount of 0.5g of food sample powder was dissolved by adding 2.5 mL sterile water; 6.5 mL concentrated HNO₃ solution and 1 mL of HClO₄ using microwave digestion (ETHOS 1, Microwave Digestion, Milestone) for 20 minutes at 150°C and power 1000 W [18]. The same steps were also applied to standard reference material (SRM) NIST 1548a Typical Diet. Measurement of samples were done by flame-AAS methods using GBC Avanta P. The wavelength observed was 324.7 nm and 279.5 nm for Cu and Mn respectively. The dissolved sample then diluted by aquadest into 25 mL flask and transferred to polyethylene container. The optimum working range for Cu and Mn were 1-5 mg/kg and 1-3.6 mg/kg, respectively.

2.4. Estimated Daily Intake
The estimated daily intake (EDI) depends on the metal concentration, ingestion/consumption rate and body weight. The EDI was determined using the following equation [19]:

\[
EDI = (MC \times FCR) \times BW^{-1}
\]  

where MC is metal concentration in food (mg/kg on wet basis), FCR represent the average of food consumption rate per day and BW is the average of the body weight. It was assumed that the children were consuming the street vended food one portion per day which means that the consumption rate will be depend on the kind of the vended foods. And the body weight of the children was assumed to be 30 kg.

2.5. Determination of Target Hazard Quotient (THQ) and Hazard Index (HI)
The health risk from consumption of street vended foods by elementary school children were assessed based on THQ. The THQ is a ratio of the exposure dose to the reference dose (RfD). If the ratio is less than 1, the exposed population is unlikely to experience obvious adverse effects. The THQ value was determined by the following equation [19,20]:

\[
THQ = \left( \frac{(EF \times ED \times CR \times MC \times RfD \times BW \times ATn)}{BW} \right)^{-1} \times 10^{-3}
\]

where EF is exposure frequency (365 days/year), ED is exposure duration (assuming 60 years as life time people still consume street vended foods), CR is consumption rate (g/day), MC is metal concentration (mg/kg wet basis), RfD is reference dose (mg/kg/day), BW is body weight (30 kg, the average weight of elementary school age children), ATn is the average exposure time for noncarcinogens (365 days/year x ED). To evaluate the possible health effects that may cause by the combination of all heavy metals observed, the total Hazard Index were applied. The HI was expressed as the arithmetic sum of the individual metal THQ values [18]. The RfD values used in this study were 0.003; 0.04; 0.7; 0.0005; 0.14 and 0.3 mg/kg/day for Cr, Cu, Fe, Hg, Mn and Zn, respectively [19-21].

2.6. Quality control and data analysis
The standard reference material (SRM) was used as quality control asessment of data validity. The results of analysis SRM were compared with its certificate value and evaluated its accuracy and precission by %Recovery and %CV calculation. Net areas from Genie 2000 were used to calculate the concentrations of elements in the samples using a comparative method as well as absorbance from AAS GBC Avanta P.
3. Results and Discussions

3.1. Quality control and data analysis

To assess the reliability of the results obtained and the accuracy of analytical methods used in this study, the standard reference material (SRM) which has similar properties to the matrix of the samples, was also analyzed under the same conditions as the samples. The results of SRM NIST 1548a Typical Diet and SRM NIST 1567a Wheat Flour for some elements were listed in Table 3. It is shown that the results obtained were in good agreement with its certified values except Cr and Hg since they were not exist in both reference materials. Analytical accuracy, described as %Recovery, were in the range 94 to 103%; while analytical precision, described as %CV were in the range 1-5%. Both analytical accuracy and precision were acceptable according to AOAC guidelines [22].

Table 3. Quality control assessment using SRM NIST 1548a Typical Diet (TD) and SRM NIST 1567a Wheat Flour (WF)

| Element | SRM   | Result    | Certified value | % Rec | % CV |
|---------|-------|-----------|-----------------|-------|------|
| Cu      | WF    | 1.98 ± 0.10 | 2.1 ± 0.2       | 94    | 3    |
| Fe      | TD    | 35.8 ± 1.81 | 35.3 ± 3.77     | 101   | 5    |
| Mn      | WF    | 5.87 ± 0.17 | 5.75 ± 0.17     | 102   | 3    |
| Zn      | WF    | 11.9 ± 0.50 | 11.6 ± 0.4      | 103   | 4    |

3.2. Heavy Metals in Street Vended Foods

The heavy metal concentrations obtained from measurement were in dry mass basis. The heavy metal concentrations of the samples must be converted to wet mass basis to compare with the value of maximum limit of heavy metals content in food by determining the water content of each samples. Figure 2 – 7 presents the concentration, in wet basis, of Copper, Chromium, Iron, Manganese, Mercury and Zinc respectively in street vended foods.

Figure 2. Copper concentration of street vended foods.

Figure 3. Chromium concentration of street vended foods.
Figure 4. Iron concentration of street vended foods.

Figure 5. Manganese concentration of street vended foods.

Figure 6. Mercury concentration in street vended foods.

Figure 7. Zinc concentration of street vended foods.

Figure 2 shows the concentration of Cu and its comparison by maximum permissible limit of Cu in foods issued by National Agency of Drugs and Food Control (BPOM) No 03725/B/SK/VII/89 about the Maximum Limitation of Metal Contamination in Food [23]. The maximum value of Cu contained in the regulation was vary based on the main ingredient of the food. It can be seen that the concentration of Cu in this present study, ranged from 0.004 mg/kg to 1.93 mg/kg, were found to be in lower concentration than the maximum permissible limit value of BPOM, 2-30 mg/kg. This indicated that the foods are still safe to be consumed. Copper has essential function in haemoglobin synthesis as a constituent of some metallo enzymes and metabolic growth as catalysis [6]. In excessive intake, Cu may cause adverse health problems such as liver and kidney damage [21]. The possible contamination of Cu could come from the water of the copper pipe, that used to prepare the food or to wash the cooking utensils [24]. The low quality of cooking utensils itself are also have most probability to contaminate the food, since the material of low quality of cooking utensils is easier to peeled off [24,25].

Meanwhile Figure 3 shows the concentration of chromium (Cr) in street vended food samples. The concentration of chromium in street vended foods was vary from 0.01 – 5.86 mg/kg (wet weight basis). These values can not be compared since Indonesia doesn’t have an established maximum permissible limit of chromium in food. However, we were trying to compare with other countries maximum permissible limit of chromium. The maximum permissible value of Cr issued by Food Adulteration Regulations of Hongkong government is 1 mg/kg [26]. Compared to this, as much as 12.5% of the food samples were above the value. Precautions should be taken since excessive chromium intake has pose a risk of the health, such as decreased body weight, heart liver damages, skin diseases, cancer, headache and respiratory illness [24].
The iron concentration in street vended foods are described in Figure 4. Similar with chromium, Iron was also did not have established maximum permissible value in food of Indonesia. The concentration of Iron in street vended foods were in the range 1.87 – 77.3 mg/kg wet weight basis. Compare to other metals, Fe was found in higher concentration among others since it was the most abundant element [21]. Iron is needed by human body as component of haemoglobin and numerous enzymes and prevent microcytic hypochromic anaemia but at the excessive consumption, it may cause adverse effect to human body such as gastrointestinal distress, heart diseases and others [24,27,28].

Manganese concentrations in street vended foods are describe in Figure 5. The concentration of Manganese was varied 0.2 – 6.6 mg/kg. Similar with Fe, the maximum permissible limit of Manganese is difficult to be find elsewhere. Manganese is also classified as an essential element, it has involvement in bone formation and in metabolism of amino acid, cholesterol and carbohydrate. Though, similar to the other elements, excessive Mn consumption may cause neuropsychiatric disorders [17].

Mercury concentration in street vended foods are presented in Figure 6. Mercury in some of the food samples were below the detection limit of NAA methods due to the inference spectrum with Se-75. The concentration of mercury in street vended foods were in the range n.d (not detectable) – 0.04 mg/kg. The maximum permissible limit of mercury was derived from National Agency of Food and Drugs Control (0.05 mg/kg) [23]. Figure 6 shows that all of street vended foods observed have Hg concentration below the maximum permissible limits, only one of them were close to this value, which is ‘cubit’ cake. Mercury is classified as toxic elements. Due to its high toxicity, excessive intake of it could pose serious health risk. The health risk due to mercury intake through consumption rate will be assessed through THQ value.

Figure 8 presents the zinc concentration of street vended foods. The maximum permissible limit of Zn in foods was derived from National Agency of Food and Drugs control (40 mg/kg) [23]. It was found that Zn concentration were vary from 0.31 to 22.4 mg/kg. All of the samples were still below the limit value. Almost all of 24 vended food samples showed Zn concentration < 15 mg/kg, only one samples, biting, has significant higher Zn concentration among other. The Zn in foods is mostly derived from cooking utensils where this material is commonly used for preparation of the foods. The aging of the cooking utensils could made the leaching out of the material occurred. The zinc contamination in street vended foods could also be caused by road dust pollution since the foods vending in the street have opening stall. Zinc was known to be used as an additives to gasoline and also auto-lubricants [29], The excessive consumption of Zn leads to reducing of copper status in the body, imbalance of electrolyte, nausea and lethargy as well [30].

3.3. Total Hazard Quotient and Hazard Index

The health risk assessment to children in Bandung city from consumption of street vended foods were assessed based on THQ. As mentioned in the previous section of experimental methods, the THQ value less than 1 means the exposed population is unlikely to experience obvious adverse effects. The overall values of THQ and HI for elementary school children population consumer of street vended foods in their surrounding school area were shown in Table 4. The THQ values of Cu, Fe, Hg, Mn and Zn were all found < 1, while for Cr the range of THQ were 0.01 – 1.41. Based on this THQ result for Cu, Fe, Hg, Mn and Zn, the consumer of street vended foods indicated no potential health risk. However, biggest concern should be given for Cr which some of the foods have THQ > 1. Hence, there is a potential of health risk presence due to Cr and exposure of children that consume the foods.

The results of HI, as can be seen in Table 4, were in the range of 0.06 – 2.32 and gives the mean HI value of 0.64. This result gives a clearly view that some of the street vended foods may have potential noncancerogenic risks of heavy metals for children through the consumption of the street vended foods. From 24 kind of street vended foods, as much as 21% have HI value exceed 1. From the Table 4, it can be seen that the major contribution of the high HI values was contributed by Cr THQ which were already > 1, and followed by Hg THQ. The average of Cr THQ (0.33) and Hg THQ (0.20) gives contribution to the average HI as much as 51% and 32% respectively. The possible sources of chromium are cigarette smoke, utensils, fertilizers that contain in raw material of the food and the packaging of the food [24,31].
However, this Cr results need further analysis for its speciation, since Cr that analyzed in this study was Cr total, while the highest toxicity were in the form of Cr (VI) and the one that needed by human body was Cr (III). While the high level of Hg can be due to contamination from soil or water [19]. According to Proietti, the sources of metal contaminant can be various such as from leaching of utensils, the depositions of urban air particulate and unsafe water [4]. These results should be scientific based reason to government and authorized party to make appropriate strategic plan to solve these problems. Further supervision and guidance to the vendors about the importance of hygiene and quality of vended foods should be improved. Children and the family are also should be given understanding of the safety of the foods they eat and accustomed to prefer eating the foods or snacks brought from their home.

**Table 4.** Target Hazard Quotient (THQ) and total Hazard Index (HI) of heavy metals for street vended foods consumption.

| Street vended food | Cr  | Cu  | Fe  | Hg  | Mn  | Zn  | HI  |
|--------------------|-----|-----|-----|-----|-----|-----|-----|
| Bakwan             | 0.21| 0.21| 0.26| 0.26| 0.26| 0.26| 0.26|
| Martabak           | 0.04| 0.04| 0.04| 0.04| 0.04| 0.04| 0.04|
| Cemara             | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Crepe              | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Cracker ball       | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Sausage            | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Bakso Tahu         | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Batagor            | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Gelatin            | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Banana             | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Sausage            | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Bacin              | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Lumpia Basah       | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Cimol              | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| ‘Cubit’ Cake       | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Cracker ball       | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|
| Biting             | 0.12| 0.12| 0.12| 0.12| 0.12| 0.12| 0.12|

*n.d* : not detectable

4. Conclusion

Assessment of heavy metals content in street vended foods that widely consumed by elementary school children in Bandung city has been carried out. Six heavy metals; Cu, Cr, Fe, Hg, Mn and Zn, were determined in 24 samples of street vended foods. It was found that Cu, Hg and Zn concentration of street vended foods were below their maximum permissible limit. The health risk assessment based on THQ and HI showed that high frequent of consumption of some street vended foods may poses non-carcinogenic health risk due to its heavy metals content since the HI values are in the range of 0.06 – 2.32 with 21% of the foods observed were have HI > 1. These may put children in the harmful situation. Preventive and settlement action should be taken and further supervision and guidance to the vendors about the importance of hygiene and quality of vended foods are still needed and have to be improved.
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