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Health Risk Assessment of Heavy Metal Exposure from Soil Dust at Selected Fuel Filling Stations in Accra

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ABSTRACT

Heavy metal contamination in soil dust at fuel filling station and the human health risk was investigated in this work. Using energy dispersive X-ray fluorescence analysis technique (EDXRF), 18 elements were identified in each soil sample collected from three fuel filling stations at diesel and gasoline pump locations. The results of the enrichment factors ranged from insignificant to moderate contamination of heavy metal elements at the stations. The hazard quotient (HQ) evaluation, in the case of noncarcinogenic effects, showed ingestion to be the route of exposure to soil dust that results in a higher risk for heavy metals, followed by dermal contact. The effect due to inhalation of resuspended dust particles through the mouth and nose is relatively low. The hazard Index (HI) obtained for the heavy metals (V, Cr, Mn, Cu, Zn and Pb) were generally below 1.0, indicating noncancer adverse health effects to be most unlikely. Cancer risk index evaluated for Pb was below 1.0 which shows little or insignificant cancer adverse effect.

Keywords: *Human Health Risk, Enrichment Factors, Carcinogenic, Hazard Index, Cancer Risk, Heavy Metals.*

1. INTRODUCTION

Heavy metals (HMs) may come from many different sources in urbanized areas, including vehicle emissions, industrial discharges and other activities [1, 2, 3]. Vehicle emissions contribute to air pollution generated from the combustion of fossil fuels from many other sources, including the burning of coal and oil in power plants, incinerators, home heating, and construction equipment. The combustion of gasoline and diesel fuels produces greenhouse gases that contribute to local, regional and global climatic changes. Heavy metal pollution in soil has become an important environmental issue because of their non-biodegradable nature and long biological half-live for elimination from the body [4]. Excessive accumulation of HMs in soils may pose serious health risks to humans and may exert adverse impacts on the ecosystem itself [5, 6].

Heavy metal pollutants in soils can enter the human body and pose health risks. The process of a chemical entering the body can be described in two steps: contact (exposure), followed by actual entry (crossing the boundary). Absorption, either upon crossing the boundary or subsequently, leads to the availability of an amount of the chemical to biologically significant sites within the body (internal dose).
The two major ways by which a chemical can cross the boundary from outside to inside the body are the Intake and Uptake processes. Intake involves physically moving the chemical in question through an opening in the outer boundary (usually the nose or mouth), typically via inhalation, or ingestion (eating, /drinking) [7]. Normally the chemical is contained in a medium such as air, food, or water. The estimate of how much of the chemical enters into the body is determined by how much of the carrier medium enters. In this process, mass transfer occurs by bulk flow, and the amount of the chemical itself crossing the boundary can be described as a chemical intake rate [7]. Uptake involves absorption of the chemical through the skin or other exposed tissues such as the eye. Although the chemical is often contained in a carrier medium, the medium itself typically is not absorbed at the same rate as the chemical, so estimates of the amount of the chemical crossing the boundary cannot be made in the same way as for intake [7]. Dermal absorption is an example of direct uptake across the outer boundary of the body. The conceptual process of contact, then entry and absorption, can be used to derive the equations for exposure and dose for all routes of exposure. The major public health concern of soil HM exposure for the general population is accumulation over a lifetime and possible renal dysfunction and bone disease through food chain ingestion [8].

Recent studies have shown that the direct soil exposure, through soil ingestion, dermal adsorption and inhalation exposure, is a major pathway of the intake of HMs and is particularly important for children [9]. Children's behavior can expose them to more toxic effects of soil HMs. For example, young children often play on the ground and therefore come into contact with polluted soils outdoors and with contaminated dust on surfaces and carpets indoors. Moreover, the developing structure and function of organs for children may result in higher inhalation rates per unit of body mass than adults [10]. Research has shown that long-term health and development issues can arise from intrauterine and early childhood exposures to heavy metals, which are often undetectable early on and manifest later in life [11, 12]. Estimating the source and spatial distribution of pollutants is crucial to quantifying the level of environmental risks [13]. The objective of this work is to ascertain the natural and anthropogenic contributions to heavy metals in soil dust and to estimate occupational health risk due to heavy metal exposure to the fuel station attendants from soil dust.

2. METHODOLOGY

2.1. Sampling

Two fuel filling stations were chosen for this study. These were selected based on vehicular density. Care was also taken not to select areas characterised by intense human activity to avoid other sources of pollution to the fuel filling stations. These fuel filling stations are of one particular petroleum company located within Ga East District of Accra [14]. The dust samples were gathered and collected into self-sealed polythene bags, using soft touch brush and plastic dust pan. The self-sealed polythene bags were pre-cleaned with acetone. The dust was sampled from two different areas within the vicinity of the fuel filling stations; these are the Gasoline (Petrol) and Diesel (Gas Oil) fuel pump locations. In order to avoid cross contamination, different brushes and dust pans were used for the different locations at each fuel station. Sampling was done once every month for five months (October to February).

2.2. Sample Preparation

The dust samples were dried overnight in a Fisher Isotemp Vacuum Oven Model 281; at 35^0C to ensure that the samples were dried at ambient temperature. The samples were then sieved using meshes (metric test sieve Bs 410 WS Tyler) with geometric diameters 500 µm, 200 µm, 100 µm, and 45 µm on a mechanical shaker (Retsch AS 200) for 15 minutes at amplitude of 10 mm/g to separate them into two particle size fractions. As a measure of avoiding cross contamination, the sieves were cleaned with acetone between samples. The size fraction between 500 µm and 200 µm was labelled as A200 µm. Between 200 µm and 100 µm was labelled as A100 µm. Between 100 µm and 45 µm was labelled as A45 µm", and those less than 45 µm was labelled as "B45 µm".

Each of the four particle size fractions was then pulverised for 15 minutes into fine powder using the Fritsch Pulverisette 2. About 10 grams of each of the pulverised sample was weighed and pressed into pellets of 2.5 cm in diameter under 10 ton pressure using the hydraulic press without any chemical treatment.

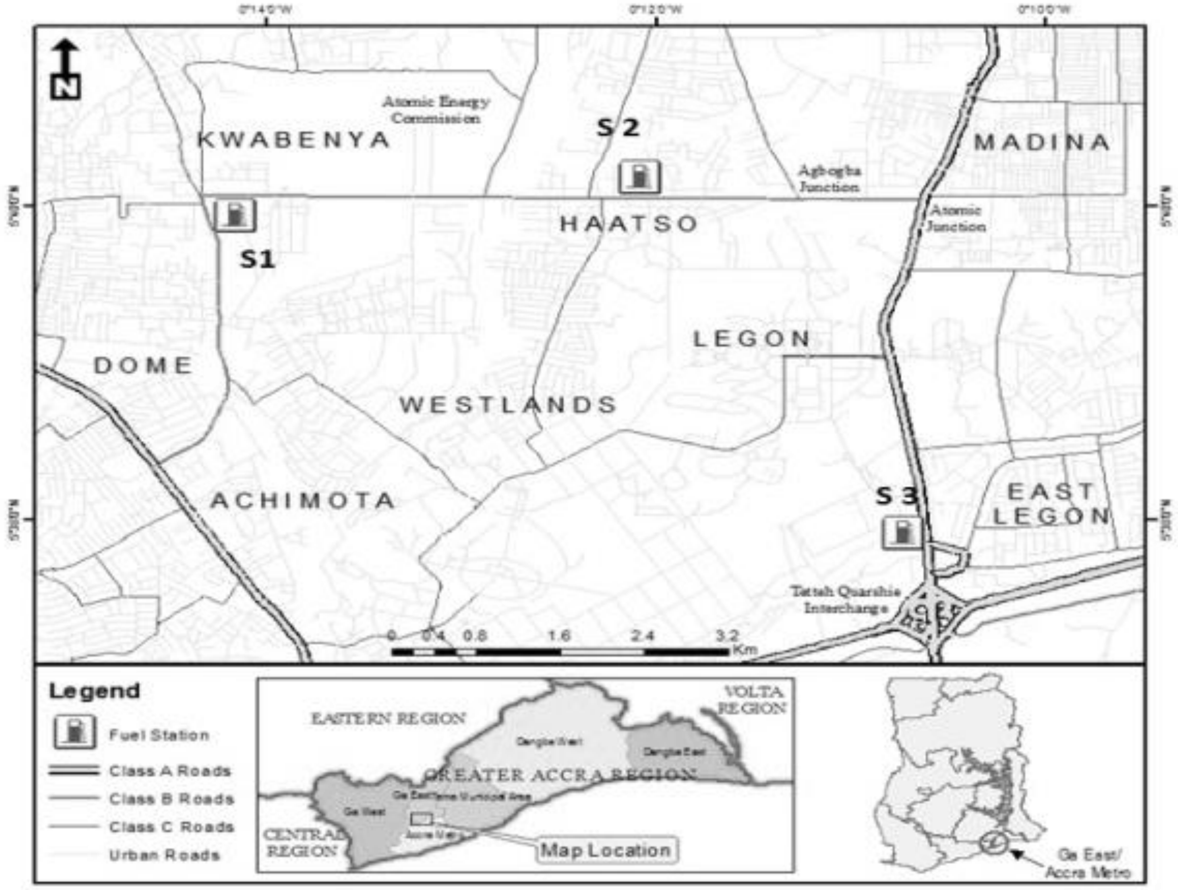

Fig. 1: Sampling locations

2.3. Sample Analysis

Energy Dispersive X-ray Fluorescence (EDXRF) technique was used for the elemental analysis of the soil dust samples. Each sample pellet was put on a sample holder in a secondary target arrangement and irradiated for 600 seconds. The samples were irradiated at a voltage of 45 kV and a current of 10 mA with both Molybdenum (Mo) and Titanium (Ti) secondary targets. A silicon drift detector (SSD) with a resolution of 135 eV FWHM at Manganese Kα (Mn-K α) energy of 5.9 keV was used for the detection of the X-ray photon. AXIL software in the Quantitative X-ray Analysis System (QXAS) package was used for the determination of peak intensities and elemental concentrations using the fundamental parameters approach.

2.4. Enrichment Factors

The Earth's crust and the Sea are significant contributors to the aerosol composition near the earth's surface. A comparison of sampled soil dust compositions with natural source compositions can reveal elements resulting from human-made sources. This type of comparison is often made by the calculation of "enrichment factors" (EF) for various elements in the soil dust relative to the crust, normalized to a clear indicator of the source material. The equation for the calculation of enrichment factors to roughly separate trace elements from crustal and non–crustal sources is shown below;

$$EF = \frac{(X_{sol} / C_{sol})}{(X_{crust} / C_{crust})}$$

In the above equation, *EF* is the enrichment factor [15, 16] X_{sol} is the concentration of the element of interest in the examined environment, and C_{sol} is the concentration of reference element in the examined environment. X_{crust} and C_{crust} are the crustal averages [17] of elemental concentrations for the element of interest and reference element respectively. The most common reference elements are Si, Al and Fe [18]. Five contamination categories are recognized on the basis of the soil enrichment factor:

EF < 2 – depletion to minimal enrichment,
EF = 2-5 – moderate enrichment,
EF = 5-20 – significant enrichment,
EF = 20-40 – very high enrichment,
EF > 40 – extremely high enrichment [19].

Despite certain shortcomings [20], the enrichment factor, due to its universal formula, is a relatively simple and easy tool for assessing enrichment degree and comparing the contamination of different environmental media [15].

2.5. Risk Assessment Model

The conceptual process of contact, then entry and absorption, can be used to derive the equations for exposure and dose for all routes of exposure. According to EPA's guideline on risk assessment, different considerations were made for carcinogenic and non-carcinogenic effects because the methods used are different for these two modes of chemical toxicity. The long term chronic non-carcinogenic and carcinogenic effects were estimated for the occupational exposure of the fuel attendants to heavy metal in soil dust at the fuel stations using the Outdoor On-site industrial exposure (to soil pathways) scenario.

2.6. Noncancer Effect Evaluation

Occupational exposure of fuel attendants to heavy metals in dust at fuel filing stations can occur via three main pathways: (a) direct ingestion of particles (D_{ing}); (b) inhalation of re-suspended particles through mouth and nose (D_{inh}); and (c) dermal absorption of trace elements in particles adhered to exposed skin (D_{derm}), The average daily dose or intake (ADD, mg/(kg/day) for non-carcinogenic through each of the three exposure pathways to soil was calculated using the three following equations [21, 22].

$$ADD_{inh} = (C \times R_{inh} \times EF \times ED)/(PEF \times BW \times AT)$$

$$ADD_{ing} = (C \times R_{ing} \times EF \times ED\times 10^{-6})/ (BW \times AT)$$

$$ADD_{derm} = (C \times SL \times SA \times ABS \times EF \times ED \times 10^{-6}) /(BW \times AT)$$

ADD_{inh} , ADD_{ing} and ADD_{derm} are the average daily dose for inhalation, ingestion and dermal contact respectively.
R_{ing}: ingestion rate, in this study is 200 mg day^{-1} for children and 100 mg day^{-1} for adults [23]. R_{inh}: inhalation rate, in this study is 10 m^3 day^{-1} for children and 20 m^3 day^{-1} for adults [24]. EF: exposure frequency, in this study is 250 days year^{-1} [25]. ED: exposure duration, in this study is 6 years for children and 25 years for adult worker [23]. SA: exposed skin area; in this study is 2800 cm^2 for children and 3300 cm^2 for adult worker [23]. SL: skin adherence factor, in this study is 0.2 mg cm^{-2}h^{-1} for children and 0.2 mg cm^{-2} h^{-1} for adult worker [23]. ABS: dermal absorption factor (unitless), in this study is 0.001. PEF: particle emission factor, in this study is 1.316×10^{-9} m^3 kg^{-1} [23]. BW: average body weight; in this study is 15 kg for children and 70 kg for adults [22]. AT: averaging time; for non-carcinogens is ED×365 days; for carcinogens is 70×365=25,550 days.

The potential health risk of individual soil heavy metal is characterized using a hazard quotient (HQ). The noncancer hazard quotient (HQ) assumes that there is a level of exposure known as the reference dose (RfD), which is a daily oral intake rate that is estimated to pose no appreciable risk of adverse health effects, even to sensitive populations, over a 70-year lifetime [26]. The reference dose is an estimate of a daily exposure to the human population (Acceptable daily intake).

Hazard quotient (HQ) is defined as the ratio of the average daily intake or dose (ADD) (mg/(kg/day)) to the reference dose (RfD, mg/(kg/day)) [27].

HQ for ingestion and dermal = ADD /RfD, HQ for inhalation = EC /RfC

HQ = Hazard quotient (unitless), ADD = Average daily dose (mg/kg-day), RfD = Reference dose (mg/kg-day), EC = Exposure air concentration (mg/m^3), RfC = Reference concentration (mg/m^3)

RfD_{inh} = RfC x 20 m^3 per day /70 kg - for adult [28, 29].

RfD_{inh} = RfC x 10 m^3 per day /15 kg - for children [28, 29].

The overall potential risk posed by a mixture of heavy metals, expressed as a hazard index (HI), is determined from the sum of the HQs for each heavy metal.

$HI = HQ_1 + HQ_2 \ldots\ldots + HQ_n$

If the HI is less than 1.0, it is highly unlikely that significant additive or toxic interactions would occur, so no further evaluation is necessary. When the HI exceeds 1.0, there may be concern for potential noncancer health effect.

2.7. Cancer Effect Evaluation

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (i.e., incremental or excess individual lifetime cancer risk (ELCR)). The associated dose is called the Lifetime Average Daily Dose (LADD) or Chronic Daily Intake (CDI).

Excess Lifetime Cancer Risk (ELCR) for ingestion and dermal = CDI x slope factor (SF)

Excess Lifetime Cancer Risk (ELCR) for inhalation = CDI x Unit Risk Factor (URF)

Cancer slope factor for inhalation (CSF_{inh}) = URF x 1000 µg/mg x 70kg /20 m^3 per day [29]. The slope factor converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer. The lifetime average daily dose (LADD) or chronic daily intake (CDI) is estimated by averaging the total exposure over the life-time of the individual (expected 70 years) [21, 23].

$$CDI = \frac{(Concentration) \times (Intake\ rate) \times (Days\ of\ Exposure/Lifetime)}{(Lifetime)}$$

CDI for the three exposure pathways can be deduced from their respective ADD by considering the following equation.

CDI = Total dose /(70y*365d/y*kgBW)/ mg/kg/d.

3. RESULTS AND DISCUSSION

The mean concentrations of seventeen (18) elements in the four different size fractions (A200 um, A100 um, A45 um and B45 um) of the soil samples from the diesel and gasoline pump locations are shown in Table 1. Aside from Si, there is an observed increasing trend in concentration levels with decreasing particle size. This shows that the anthropogenic contributions to the soil dust contaminants are mostly of fine sizes.

Table 1 Mean concentration of the elements (mg/kg).

ELEMENT	A200um		A100um		A45um		B45um	
	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Si	326642.0	341196.0	314035.5	355626.0	286075.5	331534.0	260684.0	297415.3
K	5555.3	4838.0	6029.3	6445.8	7236.1	7618.9	10092.1	9274.0
Ca	11038.6	7767.1	12669.5	13518.4	17963.6	18296.0	36312.2	27062.6
Ti	1320.2	853.5	1796.4	1578.4	2773.0	2596.3	4835.0	4147.1
V	101.7	96.5	117.3	124.8	194.2	209.2	351.7	280.5
Cr	64.3	78.6	45.8	60.7	75.8	71.0	106.4	102.6
Mn	127.1	121.7	142.3	153.8	216.3	232.7	419.9	369.4
Fe	16711.0	14164.3	17162.4	18237.3	30622.1	27568.2	59247.0	50925.3
Ni	36.0	87.3	35.8	36.5	46.5	46.3	71.9	62.4
Cu	18.6	15.8	24.8	19.5	48.0	30.9	111.5	100.5
Zn	58.4	39.4	68.0	62.9	131.8	98.1	246.3	230.9
Ga	3.2	3.2	3.1	3.2	5.1	4.9	9.2	8.4
Br	1.2	1.0	1.3	1.2	2.3	1.8	4.8	3.9
Rb	7.1	6.1	8.5	8.6	15.8	14.1	31.6	26.5
Sr	47.9	42.9	54.2	66.9	83.0	92.8	169.1	126.1
Y	2.7	1.9	4.3	4.0	9.9	9.0	19.3	16.8
Zr	100.8	75.9	212.0	172.5	530.0	561.3	833.5	701.7
Pb	15.5	14.4	19.1	18.5	31.5	27.7	59.6	55.9

For particle sizes below 45 µm diameter (B45µm), the diesel pump locations had consistently slightly higher concentration levels for all elements apart from Si. Table 2 shows the enrichment factors of elements for the soil particle sizes for diesel and gasoline pump locations. The values of the enrichment factors show that generally there is no significant contamination at both diesel and gasoline pump locations.

Table 2 Enrichment factors of elements for the different size fractions

Element	A200um		A100um		A45um		B45um	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Si	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K	0.19	0.23	0.24	0.26	0.31	0.34	0.42	0.52
Ca	0.15	0.23	0.26	0.27	0.37	0.43	0.62	0.94
Ti	0.12	0.20	0.22	0.28	0.39	0.48	0.69	0.92
V	0.59	0.65	0.73	0.78	1.32	1.42	1.97	2.81
Cr	0.64	0.55	0.48	0.41	0.60	0.75	0.97	1.15
Mn	0.11	0.12	0.13	0.13	0.21	0.22	0.37	0.48
Fe	0.21	0.26	0.26	0.27	0.42	0.54	0.86	1.14
Ni	0.96	0.41	0.39	0.43	0.52	0.61	0.79	1.04
Cu	0.24	0.29	0.28	0.40	0.48	0.86	1.73	2.19
Zn	0.46	0.72	0.71	0.87	1.19	1.85	3.12	3.80
Ga	0.18	0.18	0.17	0.18	0.28	0.33	0.53	0.66
Br	0.33	0.42	0.39	0.45	0.61	0.89	1.49	2.07
Rb	0.06	0.07	0.08	0.08	0.13	0.17	0.28	0.38
Sr	0.09	0.11	0.14	0.13	0.21	0.22	0.32	0.49
Y	0.05	0.07	0.10	0.12	0.23	0.30	0.48	0.63
Zr	0.38	0.53	0.83	1.15	2.89	3.16	4.02	5.46
Pb	0.95	1.07	1.17	1.37	1.88	2.48	4.23	5.15

A200 um and A100 µm size fractions had all EF values for both gasoline and diesel below 2, indicating no enrichment. B45 µm size fraction had EF for Zn, Pb and Zr above 3, showing moderate enrichment. There was no enrichment for the crustal elements [30]. This shows that generally on the average there is not much surface soil contamination at both diesel and gasoline pump locations.

3.1. Risk Assessment

This work specifically aims at the on-site industrial (worker) exposure scenario which ideally should be for only adults. The child scenario was considered to ascertain the possible health effect on children exposed to similar conditions. Table 3 shows the HQs and HI for the elements V, Mn, Cu, Zn and Pb for both adult and child for the three exposure pathways (inhalation, ingestion and dermal contact). The exposure pathway which on the average resulted in the highest levels of risk for adults and children exposed to soil dust is ingestion followed by dermal contact with inhalation being the least [24]. HQ (noncancer risk) due to inhalation of dust particles is on the average about 3 orders of magnitude lower than the other two exposure pathways, and it is quite unlikely that this exposure route would pose a significant risk. Inhalation of re-suspended particles through the mouth and nose is almost negligible compared with the other routes of exposure. HIs for V, Pb, Mn, Zn and Cu to children and adults decreased in the order, V> Pb>Mn>Zn>Cu (Table 3). The potential health risk from Cu was the least. Adult health risk due to heavy metal exposure to dust from both diesel and gasoline locations was consistently lower than that of child. The most sensitive subpopulation are the young children, because of their hand-to-mouth activity, whereby contaminated dust can be readily ingested [31]. The exposure of the soil dust to children could therefore exhibit more potential health risk. The HI values observed for Pb, Mn, Zn and Cu for both adult and child was generally less than 1.0 indicating that there is little adverse health risk. The HI value of V for child at diesel and gasoline pump locations were 1.40 and 1.1 respectively which are close to 1.0. It is generally most unlikely for children to be exposed to such conditions as pertain to the fuel attendants (adult worker) at the fuel station. Considering adult exposure scenario alone at the fuel stations, there is generally no concern for potential noncancer health effect for exposure with regards to these five heavy metal in the soil dust.

The low values of EF and HI for Mn have shown that the manganese levels are still within the natural background levels since the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive in gasoline in Ghana in 2004 [32].

Table 4 shows the cancer risk index for the exposure pathways for Pb. The cancer risk index for Pb was below 1.0 for adult and between 3 and 4 for child. Similarly, children will not be exposed in like manner as adult worker at the fuel

Table 3 HQs and HI for the three exposure pathways

Element	Location	Age group	Inhalation			Ingestion			Dermal			HI=ΣHQ
			Maximum Daily Dose (mg/kg/d)	Reference Dose (mg/kg/d)	HQinh	Maximum Daily Dose (mg/kg/d)	Reference Dose (mg/kg/d)	HQing	Maximum Daily Dose (mg/kg/d)	Reference Dose (mg/kg/d)	HQderm	
V	Diesel	Adult	1.2E-08	-	1.2E-08	8.3E-04	7.0E-03	1.2E-01	3.3E-05	7.0E-05	4.7E-01	5.9E-01
		Child	2.2E-08	-	2.2E-08	7.7E-03	7.0E-03	1.1E+00	2.2E-05	7.0E-05	3.1E-01	1.4E+00
	Gasoline	Adult	9.7E-09	-	9.7E-09	6.6E-04	7.0E-03	9.4E-02	2.6E-05	7.0E-05	3.8E-01	4.7E-01
		Child	1.7E-08	-	1.7E-08	6.1E-03	7.0E-03	8.8E-01	1.7E-05	7.0E-05	2.5E-01	1.1E+00
Mn	Diesel	Adult	1.5E-08	1.4E-05	1.0E-03	1.0E-03	4.6E-02	2.2E-02	3.9E-05	1.8E-03	2.1E-02	4.4E-02
		Child	2.6E-08	1.4E-05	1.8E-03	9.2E-03	4.6E-02	2.0E-01	2.6E-05	1.8E-03	1.4E-02	2.2E-01
	Gasoline	Adult	1.3E-08	1.4E-05	8.9E-04	8.7E-04	4.6E-02	1.9E-02	3.5E-05	1.8E-03	1.9E-02	3.9E-02
		Child	2.3E-08	1.4E-05	1.6E-03	8.1E-03	4.6E-02	1.8E-01	2.3E-05	1.8E-03	1.2E-02	1.9E-01
Cu	Diesel	Adult	3.9E-09	6.9E-04	5.6E-06	2.6E-04	2.1E-01	1.2E-03	1.0E-05	4.0E-02	2.6E-04	1.5E-03
		Child	6.8E-09	6.9E-04	9.9E-06	2.4E-03	9.1E-01	2.7E-03	6.8E-06	1.2E-02	5.7E-04	3.3E-03
	Gasoline	Adult	3.5E-09	6.9E-04	5.0E-06	2.4E-04	2.1E-01	1.1E-03	9.4E-06	4.0E-02	2.4E-04	1.4E-03
		Child	6.2E-09	6.9E-04	8.9E-06	2.2E-03	9.1E-01	2.4E-03	6.2E-06	1.2E-02	5.1E-04	2.9E-03
Zn	Diesel	Adult	8.5E-09	-	8.5E-09	5.8E-04	3.0E-01	1.9E-03	2.3E-05	6.0E-02	3.8E-04	2.3E-03
		Child	1.5E-08	-	1.5E-08	5.4E-03	3.0E-01	1.8E-02	1.5E-05	6.0E-02	2.5E-04	1.8E-02
	Gasoline	Adult	8.0E-09	-	8.0E-09	5.4E-04	3.0E-01	1.8E-03	2.2E-05	6.0E-02	3.6E-04	2.2E-03
		Child	1.4E-08	-	1.4E-08	5.1E-03	3.0E-01	1.7E-02	1.4E-05	6.0E-02	2.4E-04	1.7E-02
Pb	Diesel	Adult	2.1E-09	-	2.1E-09	1.4E-04	3.5E-03	4.0E-02	5.6E-06	5.3E-04	1.1E-02	5.1E-02
		Child	3.6E-09	-	3.6E-09	1.3E-03	3.5E-03	3.7E-01	3.7E-06	5.3E-04	7.0E-03	3.8E-01
	Gasoline	Adult	1.9E-09	-	1.9E-09	1.3E-04	3.5E-03	3.8E-02	5.2E-06	5.3E-04	1.0E-02	4.7E-02
		Child	3.4E-09	-	3.4E-09	1.2E-03	3.5E-03	3.5E-01	3.4E-06	5.3E-04	6.5E-03	3.6E-01

stations. There is little adverse health risk due to Pb for the adult worker.

Table 4 Cancer Risk Index (Carcinogenic)

Element	Location	Age group	Inhalation		Ingestion		Dermal Contac^{t}		Risk	Risk index^{2}
			CDI	Unit risk factor	CDI	Slope Factor	CDI	Slope Factor		
			(mg/kg/d)	(mg/kg/d)	(mg/kg/d)	(mg/kg/d)	(mg/kg/d)	(mg/kg/d)		
			a	b	c	d	e	f	(a*b)+(c*d)	$\frac{(a*b)+(c*d)}{1.0E-06}$
PB	Diesel	Adult	7.50E-10	1.20E-05	5.00E-05	8.50E-03	2.00E-06	-	4.25E-07	0.43
		Child	1.29E-09	1.20E-05	4.64E-04	8.50E-03	1.32E-06	-	3.95E-06	3.95
	Gasoline	Adult	6.79E-10	1.20E-05	4.64E-05	8.50E-03	1.86E-06	-	3.95E-07	0.39
		Child	1.21E-09	1.20E-05	4.29E-04	8.50E-03	1.21E-06	-	3.64E-06	3.64

Notes; 1: The lifetime average daily dose for dermal contact corresponds to an absorbed dose and is not considered for the risk characterization.

2: The Risk Index is based on an acceptable risk of 1E-06.

4. CONCLUSION

This study has investigated the heavy metal contents and human health risk due to exposure to soil pathways at some selected fuel filling station in the Ga East district of Accra in Ghana. The elemental concentration for the eighteen (18) elements identified from EDXRF analysis shows that generally, the anthropogenic contributions to the soil dust contaminants are mostly of fine sizes.

Results of the enrichment factors showed that generally there is no significant contamination at both diesel and gasoline pump locations.

The exposure pathway which resulted in the highest levels of risk is ingestion followed by dermal contact while inhalation is the least. The Hazard indices (HIs) obtained for the metal elements considered shows that there was generally no concern for potential non-cancer health effect. Manganese levels are still within the natural background levels since the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive in gasoline in Ghana in 2004. The cancer risk of Pb due to dust exposure at the fuel stations was low and therefore poses little or insignificant health concern for adult worker. This gives an indication that the use of non-leaded fuel has drastically improved the Pb conditions in the natural environment.

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