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Assessment of Arsenic and Iron in Road Dust in Khulna City of Bangladesh

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Abstract—Atmospheric arsenic and iron has been an increasing concern worldwide due the negative impacts on human health and the environment. This study reveals that arsenic was not detected in the road dust samples in Khulna city of Bangladesh. Iron concentration had in all the sampling areas with range of 290.3±25.9 µg/g to 836.7±98 µg/g. Bioavailable Iron concentration had in all the sampling areas with range of 27.7±4.2 µg/g to 45.3±8.5 µg/g. Percentage of bioavailability had in all the sampling areas with range of 8.0 to 9.6 %. This study suggested that iron metal pollutants in the road dust in Khulna city could be originated from automobile emission, welding of metal and exhaust from surrounding diesel generators.

Index Terms—Road dust, arsenic, iron, bioavailable iron

1 Introduction

ROAD dust is generally composed of automobile exhausts particles and particles transported by wind. Most of the road dust is coarser than the inhalable fraction but can be further disintegrated into finer fractions by vehicle action. Strong link between arsenic in road dust were found with varieties of health problems such as heart disease, hypertension, peripheral vascular disease, diabetes, immune suppression, acute respiratory infections, intellectual impairment in children, and skin, lung, prostate, bladder, kidney and other disease which indicates in literature review [1], [2], [3].

Iron is essential for the physiological process in all living organisms however, iron can be toxic to cells because it catalyzes the production of the hydroxyl radical [4]. Street dust with its high Iron contents has a high vulnerability of causing cough/ breathing in both children and adults during inhalation. The Iron in urban roadside dust take their origin from sources such as vehicles, road wear, activities of roadside artisans (battery charging, vehicle repairs, iron-bending, vehicle painting and panel beating) and emissions and or discharges from industries [5]. Iron adsorption by water when contact with dust uptake by via skin contact is referred as bioavailable iron. Over a period of time, adverse toxic effects may occur due to iron inhalation exposure of long term low dose.

Although there have been considerable number of studies on the concentration of Arsenic and Iron in street dust in developed countries, no studies have been carried out in developing countries like Bangladesh so far. The available data on iron concentration of street dust in these areas are extremely scarce. In Khulna, street dust has become the major source of pollution in the metropolitan areas. This article focuses on the concentration of arsenic and iron in Khulna road dust at five different locations such as New market, Ferighat, Shibbari, Fulbarigate, Sonadanga. The major objectives of this study are to analyze the arsenic and iron content in road dust in Khulna city, to compare the arsenic and iron concentration in road dust with other studies, to review the sources of iron and arsenic in road dust and their health effects and to investigate the iron bioavailability in road dust.

2 MATERIALS AND METHODS

Khulna is an industrial city in south-west corner in Bangladesh. Sample was collected during in dry season being the period of height pollution of air in the city. Samples were collected from Fulbarigate, New market, Shibbari, Sonadanga, Ferighat which is the most populous area in the Khulna city, shown in Figure 1.

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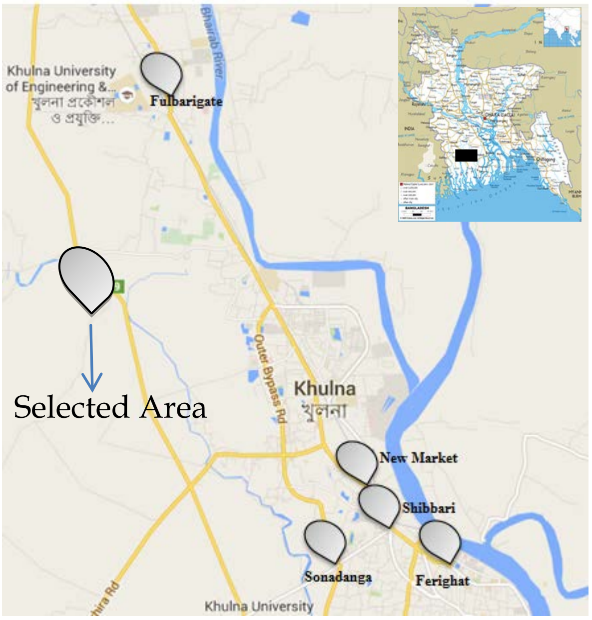

Figure 1: Sampling locations

Road dust samples were sampled using broom and brush to collect the settled dust on plastic bottle in each of the study areas. Sample was collected during in dry season being the period of height pollution of air in the city. Dust samples were collected and transferred to clean plastic bottle. Samples were sieved through 75 micron sieve. The processed dust samples were digested using acid digestion method to perform As and Fe analysis. Arsenic analysis was performed using HACH EZ Arsenic Reagents Set method. Iron analysis was performed using FerroVer Iron Reagent Method'. Then the dust samples were mixed with distilled water and mix them with magnetic stirrer for a day to determine the bioavailable iron.

3 RESULTS AND DISCUSSION

3.1 Arsenic analysis

Arsenic can be released from both natural sources such as volcanic activity, exudates from vegetation and wind-blown dusts and anthropogenic sources such as is smelting of metals, the combustion of fuels, mining and quarry operations, waste incineration, metallurgical industries and fuel consumption, cement manufacturing, glass manufacturing, agricultural burning etc. Arsenic concentration in road dust is not detected as shown in Table 1.

Table 1: Arsenic concentration in road dust (μg/g)

Location	Arsenic concentration, μg/g		
	Sample 1	Sample 2	Sample 3
Fulbarigate	*nd*	*nd*	*nd*
New market	*nd*	*nd*	*nd*
Ferighat	*nd*	*nd*	*nd*
Sonadanga	*nd*	*nd*	*nd*
Shibbari	*nd*	*nd*	*nd*

nd: not detected

In this study, cement manufacturing, glass manufacturing, agricultural burning, geothermal steam development and secondary lead smelting activity are not significant in the sampled road side area. It is worthy to mention that the minimum detection limit of arsenic measurement kit was 5 ppb. Any value below this limit (5 ppb) was expressed as not detected (nd). Table 2 presents the comparison of Arsenic concentration with other studies. Shinggu et al. (2014) [7] was found higher Arsenic concentration (70.36 - 199.94 μg/g) compared with other studies where dominant source was smelting of metals.

Table 2: Comparison of Arsenic in road dust

Reference	As in μg/g (Min-Max)
This study	*nd*
Shinggu et al. (2007) [6]	*nd*
Shinggu et al. (2014) [7]	70.36-199.94
AduGyamfi et al. (2014) [8]	0.07-0.31

nd: not detected

3.2 Iron analysis

Table 3 shows the concentration of iron in road dust in various places of Khulna city. Iron concentration higher in New market is 941.16 μg/g and lower in Sonadanga is 262.08 μg/g. Iron sources in roadside dust such as metal construction works, iron bending, welding of metals, Iron fillings from this metal works, exhaust emissions from vehicles, oil spillage of gasoline, diesel, engine oil, lubricating oils, tyre wear, wear of brake linings and studded tyres [5]. In New market areas the high concentration of iron in the roadside dust samples attributed to metal construction works, iron bending and welding of metals, which is a common practice alone the major roads and mechanical workshops. Other areas also have metal construction works, iron bending and welding of metals but the quantity is less than New market. Iron fillings from this metal works, exhaust emissions from vehicles, oil spillage of gasoline, diesel, engine oil and lubricating oils also contributed to the high concentration of Iron which activity is more in New market area than any other study area. Although all the roads are polluted by Iron as it exceeds the maximum permissible limit of 37.5μg/g [9]. This dust with its Iron concentration has a high vulnerability of causing cough in both children and adults during inhalation.

Table 3: Iron concentration in road dust (μg/g)

Location	Iron concentration, μg/g			
	Sample 1	Sample 2	Sample 3	Avg. ± SD
Fulbarigate	273.87	360.99	312.93	315.93±43.64
New mar-	941.16	822	747.03	836.73±97.9

ket				
Ferighat	606.6	495	538.2	546.6±56.27
Sonadanga	312.96	262.08	295.8	290.28±25.89
Shibbari	383.04	361.26	362.88	369.06±12.13

Table 4 presents the comparison of iron concentration with other study. Iron in this study area are higher compared to other studies in [5], [8], [10]. The result of this study indicates that metal construction works, iron bending, welding of metals, Iron fillings from this metal works, exhaust emissions from vehicles, oil spillage of gasoline, diesel, engine oil and lubricating oils in Khulna city is higher in quantity than these of study. In Gbadebo et al. (2007) [11] study iron concentration is 9500 μg/g which has higher concentrations of iron than dust samples from other areas. The source of iron in roadside dust samples in this area attributed to metal construction works, iron bending welding of metals, road wear, activities of roadside artisans (battery charging, vehicle repairs, iron-bending, vehicle painting and panel beating) and emissions and or discharges from industries tyre wear, brake wires and radiators and the various types of deicing chemicals and friction materials used on road surfaces for slipperiness [12]. Although all the roads are polluted by Iron as it exceeds the maximum permissible limit of 37.5μg/g [9].

Table 4.1: Comparison of Iron concentration in road dust

Reference(s)	Iron concentration, μg/g	
	Min-Max	Avg.± SD
This study	290.28-836.73	471.72±227.25
Ayodele et al.(2007) [13]	598.61-874.27	730.37±90.96
Abechi et al.(2010) [5]	141.80-159.0	150.4±12.16
Gbadebo et al.(2007) [11]	20-9500	1509.55±3297.4
Shinggu et al.(2014) [6]	3460-5800	4952±970.83
Alhasan et al.(2012) [10]	75.46-242.16	196.91±68.5
AduGyamfi et al.(2014) [8]	188.8-198.98	191.45±0.58

3.3 Bioavailable iron analysis

Table 5 shows the concentration of Bioavailable Iron in road dust in various places of Khulna city. In Fulbarigate, bioavailable iron concentration varies from 23 to 31 μg/g. Bioavailable Iron concentration higher in New market (85 μg/g) and lower in Sonadanga (25 μg/g). This study shows the possibility of Iron uptake through human skin is higher in New Market area with long term exposure mostly in wet condition. Over a period of time, adverse toxic effects may occur as a result of long-term low-level exposure. Table 6 shows the iron bioavailability percentage in road dust in various places of Khulna city. Iron Bioavailability in road dust varies from 8.0% to 9.6%.

Table 5: Bioavailable Iron concentration in road dust (μg/g)

Location	Bioavailable iron concentration, μg/g			
	Sample 1	Sample 2	Sample 3	Avg. ± SD
Fulbarigate	23	31	29	27.67±4.16
New market	85	72	69	75.33±8.5
Ferighat	52	41	43	45.33±5.86
Sonadanga	30	25	28	27.67±2.48
Shibbari	31	29	29	29.67±1.15

Table 6: Iron bioavailability in percentage

Location	Iron bioavailability, %			
	Sample 1	Sample 2	Sample 3	Avg. ± SD
Fulbarigate	8.4	8.58	9.26	8.75±0.45
New market	9.03	8.76	9.23	9.01±0.24
Ferighat	8.57	8.28	7.98	8.28±0.30
Sonadanga	9.58	9.53	9.46	9.52±0.06
Shibbari	8.09	8.02	7.99	8.03±0.05

4 CONCLUSIONS

This study deals with the concentration of arsenic and iron in road dust in Khulna city of Bangladesh. The concentration of Arsenic is not detected in the samples collected from study areas. Iron concentration is found higher in New Market area which was 941.2μg/g and lower in Sonadanga area which was 262μg/g. This decrease might indicate aerial deposition of metal particulates in the street dust environment from extraneous sources and not only a function of soil type. Automobile and metal construction works could be responsible for the buildup of the higher concentration of Iron in the road dust along the Khulna-Jessore Highways. Bioavailable Iron concentration is also found similar trend for both New Market and Sonadanga samples. This study shows the possibility of Iron uptake through human skin is higher in New Market area with long term exposure mostly in wet condition. The roadside dust was found with rich amount of iron comparing with other studies and could be increased with increasing traffic volume, windblown dust containing rich iron minerals, welding of metals, and other sources.

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