

## SHORT COMMUNICATION

### Environmental contamination of lead in dairy farms in Narayangonj, Bangladesh

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#### ABSTRACT

**Objective:** In recent years, lead (Pb) has arisen as a foremost contaminant due to overpopulation, rapid industrialization, and expansion that could contaminate the human food chain. However, the correlation between the environmental contamination of Pb and its spatial transfer to the dairy products is still unmapped. In this paper, we intend to evaluate the concentration of environmental Pb and its spatial distribution in dairy feed and products in Narayangonj, a highly polluted district of Bangladesh.

**Materials and Methods:** A total of 125 samples of soil, water, forage, and milk were collected from five upazilas (Narayangonj Sadar, Bondor, Rupgonj, Araihasar, and Sonargoan) of Narayangonj. The samples were digested by acid digestion, and Pb was detected by flame atomic absorption spectrophotometer and graphite furnace atomic absorption spectrometer. The bioconcentration factor of the samples was also calculated.

**Results:** In this study, 25% of the soil, 20% of the water, 5% of the forage, and 2% of the milk samples contained Pb at a variable level. Among the environmental samples, the highest concentration (26–39 µg/kg) of Pb was detected in the soil, followed by in the water (0.023–0.059 µg/kg) and forage (0.017–0.035 µg/kg). The contamination (0.041–0.068 µg/kg) in the milk, however, was lower than the soil but higher than the water and forage. The concentration of Pb in all the samples was within a safer limit. None of the forage samples was the potential bioaccumulator.

**Conclusion:** Although no linear correlation was established between the environmental samples, forage, and milk, the study identifies the potentials of the spatial distribution of Pb from the environment to the dairy feed and products. Therefore, feasible procedures should be adapted to cease the residue to the human food chain.

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## Introduction

Environmental contamination with heavy metals and metalloids is the most critical distress in the modern era, especially in the developing world [1]. Components from natural and anthropogenic sources uninterruptedly pass in the environments, where they pose a grave hazard for their toxicity, extended persistence, bioaccumulation, and biomagnification in the food cycle [2]. In the environment, the raised concentration of metals and metalloids is an eventual outcome from waste dumping, smelter stacks, manufacturing discharge, fertilizer, tannery waste, manure, pesticides, fossil fuel, municipal waste, mining waste, waste

of ship-breaking yards, animal waste, contaminated water, and sewage sludge in the arable land [3,4]. Among the metals, Pb is considered to be a major environmental contaminant. Lead (Pb)-containing compounds are commonly used in storage batteries, sheet metal, piping, ammunition, and paints [5] and have been more widely described as a reason for accidental poisoning in individuals and livestock than any other element [6].

The explosion of mechanization makes use of Pb materials more prevalent in modern times. It is, therefore, puzzling to plot precisely the ways by which exposure generally happens [7]. Exposure can transpire via consumption,

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breathing, and dermal contact. The most common path of exposure of the common population to Pb is the ingestion of contaminated water and food [8] or inhalation in the workplace [9].

Apart from human pollution, Pb poisoning, in livestock, is one of the most dangerous metal toxicants, especially in bovine species, primarily due to excitement, leaching, and unpleasant eating behavior [10]. The acute lethal oral dose of lead for calves is 200–400 mg/kg body weight (BW) and 600–800 mg/kg BW for adult cattle [10]. Adult cattle pose a high risk of chronic toxicity following extended exposure to more than 6 mg lead/kg per day [11]. Young calves and lambs with lower regular doses in milk may be infected, potentially as low as 1 mg/kg per day. The dietary and physiological status may also influence the exact dosage, at which a specific adverse effect occurs [10]. Acute exposure to Pb could contribute to brain injury, kidney damage, and gastrointestinal disorders. On the contrary, chronic exposure can adversely affect the skin, central nervous system, blood pressure, kidneys, and vitamin D metabolism [9]. In animals, Pb poisoning causes colic, staggering gait, rolling eyes, muscle spasms, blindness, uncoordinated attempts to climb obstacles, excessive response to external stimuli, head pressing and convulsions, abdominal pain, diarrhea, and finally, death [6]. A portion of lead-exposed cattle can survive acute intoxication, but their consumption can be a source of lead in the human [10].

The contamination of the human food chain with metals and other toxins is a major issue in the developing world. Many researchers studied the health risks of Pb [7]. However, Pb exposure is less emphasized in emerging countries, particularly in Bangladesh. The spatial distribution of Pb from the environment to the livestock products and the human food chain is mostly unmapped. This study provides significant importance in terms of public health hazards. Here, the samples collected from a polluted district–Narayangonj [12] assess the correlation between environmental Pb and exposure in animal products. The objective of this study was, therefore, to quantify the concentration of Pb in soils, water, forage (environmental samples), and milk (animal product) and assess the spatial pattern of Pb from the environment to the human food chain through animal food.

## Materials and Methods

### Selection of the study area

To estimate the concentration of Pb in the habitat and animal products, five upazilas of the Narayangonj such as Sadar, Bondor, Rupgonj, Araihasar, and Sonargaon were selected for the sampling. Samples were collected from

the polluted industrial area or close vicinity of the industrial area. In total, 100 samples were collected from each upazila.

### Collection and preparation of samples

From February to March 2018, the water, soil, forage, and milk samples were collected from the selected upazilas and examined for Pb contamination in the Department of Pharmacology, Faculty of Veterinary Science, and the Department of Agricultural Chemistry, Faculty of Agriculture, Bangladesh Agricultural University.

From each upazila, 25 samples of each type [100 ml of water, 500 gm of soil from a depth of 15 cm, 500 gm of grasses (*Cynodon dactylon*), and 100 ml of milk from morning milking] were collected in an acid-washed sterile screw cap vials (water and milk) and plastic zip lock bags (soil and forage). About 0.5 ml of nitric acid was added in vials before fill up to 100 ml (for water and milk).

The soil samples were air-dried at room temperature, finely powdered, and sieved to remove large debris, stones, and pebbles through a 2-mm nylon net. The samples (500 gm of soil) were then dried for 2 days at 70°C to extract moisture content. The lower fraction was then homogenized using a mortar and pestles and was processed for chemical analysis.

Plant samples were washed to eliminate the mud by shaking along with a dry pre-cleaned vinyl brush. Then, the plant bodies were sectioned. Plants were then washed with tap water and then dipped for 5 min in 0.01 N HCl acid followed by extensive washing in purified and de-ionized water to eliminate airborne contaminants. The samples were then cut into 2-cm pieces. Samples were then dried in a hot air oven at 70°C–80°C until the weight was constant. The dried samples were ground in a stainless steel blender before passing through a 2-mm-size sieve. All samples were stored at –20°C until further use.

### Digestion of the samples

The samples (1 gm of soil and forage, 10 ml of milk, and 50 ml of water) were digested at 120°C (wet acid digestion) with 10 ml of di-acid mixture (concentrated HNO<sub>3</sub> and HClO<sub>4</sub> in 2:1 for all samples) and 2 ml of H<sub>2</sub>SO<sub>4</sub> (only for soil samples) until a clear solution was achieved. The Digestion System 6-1007 Sample digester was used. The final digested sample volume was adjusted with distilled and de-ionized water to 3 ml (for soil) or 50 ml (water) or 100 ml (forage and milk). The digested samples were filtered through the Whatman No. 42 filter paper (pore size of 25 µm). Finally, the solution was stored at 4°C for further analysis.

### Quantification of Pb in the sample

The samples were analyzed using a graphite furnace atomic absorption spectrophotometer (Model: SHIMADZU, GFA-7000, Japan). Mono element hollow cathode lamp was employed for the determination of Pb. Just before running the samples, the atomic absorption spectrophotometer was calibrated following the company's endorsement.  $Mg(NO_3)_2$  and  $Pd(NO_3)_2$  were used as the matrix modifier to prevent the evaporation loss of metals during analysis. Exactly, 1.45 ml of filtered samples and 0.29 ml of matrix modifiers were taken in a tube and run for the determination Pb in the samples. The data for each element were recorded thrice.

### Bioconcentration factor (BF)

The BF has been described as the ratio of heavy metal concentration in the edible part of the plant to the heavy metal concentration in the soil sample [13]. The bioaccumulation factor was determined according to the formula as described previously [14] and given in Eq. (1).

$$BCF = C_{\text{plant}}/C_{\text{soil}} \quad (1)$$

where  $C_{\text{plant}}$  was heavy metal content in the edible part of the plant, and  $C_{\text{soil}}$  was heavy metal content in the respective soil. A value of BF > 1 indicates that the plant is a prospective accumulator of the metal.

### Data processing

All recorded data were stored in Microsoft Excel 2010 files and analyzed with the Statistical Package for the Social Sciences (SPSS) IBM 20 for descriptive statistics (IBM Corp. Released 2011, IBM SPSS Statistics for Windows, Version 20, Armonk, NY: IBM Corp).

## Results and Discussion

### Pb in soil samples

In this study, about 25% of the soil sample (31/125) contained a variable level of Pb. The highest concentration of Pb was recorded in the soil of Arahazar Upazila, followed by Bondor and Rupgonj (Table 1). Soil contamination of Pb in Sadar and Sonargaon was 31%–44%, which is lower

than other Upazilas. The variations of Pb concentration in different Upazilas were probably due to the difference in the level of urbanization in different locations, contributing to soil pollution [15]. However, Pb concentration in all Upazilas was lower than the maximum permissible level [16]. Factors such as traffic density in the area, discarded battery pits, sampling distance from the road [17], vegetation growth [14] on the polluted field, irrigation [18], or other agricultural operations may have contributed to the concentration of Pb in soil.

### Pb in water samples

About 20% (26/125) of samples were positive with Pb. Pb contamination in water was much lower than soil in the sample area. The highest contamination of Pb in the water sample was recorded in Bondor and Rupgonj Upazilas (~0.059 µg/l). Pb concentration in water in three other Upazilas was much lower (~0.02 µg/l). The recorded Pb concentrations in water samples were within safe limits, as recommended by the WHO [19]. Usually, most of the farmers provide tube well-drinking water to the dairy cows—a potential source for As but not Pb contamination [20]. Environmental water may contain a higher concentration of Pb but was not collected as those were not used for a water source in farms. However, a higher Pb concentration in soil and water will be manifested in fodders grown in the same area. Furthermore, seasonal variations influence Pb concentration in water [21]. Sampling location, along with the distance from polluted sources such as industrial waste, waste from roadsides, and battery factories, may play a significant role in water contamination with Pb [22].

### Pb in forage samples

Pb was detected in 5% of samples (7/125). The level of contamination of forage is much lower than the soil in the same area (Table 1). The highest contamination of Pb in the forage sample was recorded in Rupgonj Upazila (0.034 ± 0.0020 µg/kg). All other upazilas exhibit a lower level of contamination in forage samples (0.0114–0.022 µg/kg). Therefore, we predicted that a less amount of Pb bioaccumulation has occurred in that area. However, a controlled study growing grass in contaminated soil, which showed a variable amount of Pb, could

**Table 1.** Concentrations of Pb (µg/kg or µg/l) in different samples collected from the five upazilas of Narayanganj district, Bangladesh

SAMPLES	CONCENTRATIONS OF PB (MG/KG OR MG/L) IN DIFFERENT UPAZILAS					AVERAGE	THE WHO RECOMMENDED LEVEL [25]
	Sadar	Bondor	Rupgonj	Arahazar	Sonargaon		
SOIL	25.96 ±3.31	35.75 ±3.47	31.90 ±2.02	38.22 ±1.07	26.65 ±2.49	32.09 ± 2.47	1–7 mg/100 g of dry soil
WATER	0.0228 ±0.00376	0.059 ±0.00495	0.0598 ±0.01075	0.0256 ±0.00622	0.0246 ±0.0047	0.0382 ± 0.0060	0.01 mg/l
FORAGE	0.022 ±0.123	0.0176 ±0.0035	0.0346 ±0.0020	0.0229 ±0.0066	0.0114 ±0.0087	0.0217 ± 0.028	0.3 mg/kg
MILK	0.0628 ±0.007	0.0687 ±0.0092	0.066 ±0.012	0.0412 ±0.008	0.0374 ±0.0113	0.0552 ± 0.0095	0.02 mg/l

be accumulated [23]. The published literature mostly assessed the bioaccumulation of Pb in vegetables, which could not be compared in this study [17]. Furthermore, the accumulation pattern of Pb in forages may be varied due to seasonal differences, variation in accumulation pattern, species variation, and distances of samples from the contaminated area.

### Bioaccumulation factor

The movement and deposition of heavy metal from soil to edible plant parts serve as the primary route for the entry of potentially harmful metals into animal and human food. The BF for forage is found to be 0.000847, 0.000492, 0.000108, 0.00599, and 0.000427 for Sadar, Bondor, Rupgonj, Arihazar, and Sonargaon, respectively. BF shows that none of the forage samples is a potential bioaccumulator of Pb. However, BF is usually considered for vegetables, mostly edible vegetables. Here, we considered that *C. dactylon* is edible for dairy cows. The soluble content, soil pH, plant growth stages, and species types may influence the absorption of metals from the soil [24].

### Pb in milk samples

In this study, only five samples were positive with Pb. The concentration of Pb in the milk sample varied from ~0.65 µg/l (for Sadar, Bondor, and Rupgonj) to ~0.37 g/l (for Arihazar and Sonargaon, Table 1). Pb contents in all milk samples were within the WHO recommended level [25]. In this study, the Pb concentration in milk was slightly higher than those in the forage sample. The inconsistencies in the Pb levels may be accredited to differences in feed types and other sources of pollution. Heavy metal pollution in milk is influenced not only by the forage but also the concentrate feed, Pb sources in farms, and inhalation in the polluted environment. However, Pb pollution in the air was not recorded in this study. Furthermore, when the concentration of Pb is higher in milk, the plasma concentration should be higher, which may lead to clinical lead toxicity [9].

### Correlation of Pb concentration in soil, water, forage, and milk

The Pearson's correlation coefficient was calculated to establish any relationship between environmental samples and milk (Table 2). The hypothesis was that if a higher concentration of Pb was found in soil and water, it could be transferred into forage and milk. However, no such relationship could be established. Even though a higher concentration of Pb was detected in soil, it was not transferred into forage and milk. During the collection of samples, measures were taken to collect the sample from the same ecosystem, but how much of metal forages could absorb

**Table 2.** The correlation of Pb concentration in environmental samples and milk.

WATER R-VALUE (V) P-VALUE	FORAGER-VALUE (V) P-VALUE	MILK R-VALUE (V) P-VALUE
-0.08 (S/W) 0.89	-0.52366 (S/F) 0.36	-0.70903 (S/M) 0.17
	0.477721 (W/F) 0.416	0.719044 (W/M) 0.17
		0.501773 (F/M) 0.38

*r* = correlation coefficient; V = variables, S = soil; W = water; F = forage; M = milk.

depends on numerous factors such as its soluble material, soil pH, stages of plant development, and the form of the crop [24]. Furthermore, concentrate feed and feed additives along with air pollution contribute toward the concentration in the milk.

### Conclusion

We showed that a higher concentrations but within the WHO safer limit of Pb was present in the soil, water, forage, and milk samples in and around industrial areas of Narayanganj district of Bangladesh. These observations indicate the future threat of Pb accumulation in the environment. Therefore, adequate and effective measures should be taken to cease Pb residue in dairy feed and products and to protect the ecology and environment as a whole.

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### Conflicts of interest

There is no conflict of interest, as declared by the authors.

### Authors' contribution

SS and YAS designed the study, sample collection, interpretation of data, and drafting the write up of the article. SS, JF, and ZAN contributed to sample collection and manuscript preparation. MHS prepared and critically checked the manuscript.

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