Solid Waste Exposure Effects on Serum Minerals, Antioxidant Vitamins And Oxidative Stress Among Adult Waste Pickers of Dhaka, Bangladesh

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Abstract

In Bangladesh, improper waste disposal is one of the major causes of environmental pollution. It is responsible for a significant health risk, especially people working in solid waste disposal sites and living nearby. Unfortunately, no specific information is available regarding the effect of exposure to occupational hazards in Bangladesh. This study was designed to assess the occupational health risk of male adults working in solid waste dumping landfill in relation to their exposure. Blood samples were collected from exposed (working in the garbage dumping site for at least 6 months) and control subjects (age and gender-matched and never exposed to dumped garbage). Oxidative stress markers (thiobarbituric acid reactive substances and protein carbonyl content), antioxidant vitamins (retinol and α -tocopherol), and most common toxic heavy metal and nutritionally important minerals (lead, iron, and zinc) level were analyzed and compared with unexposed control subjects. Oxidative stress-mediated damage of macromolecules in terms of protein carbonyl group was found to be significantly ($p < 0.001$) increased in the exposed adults. Exposed subjects also contained a significantly ($p < 0.05$) higher level of lead, whereas no significant difference was found in serum vitamin A and E between exposed and unexposed subjects. This study indicated that people working on waste disposal landfills and exposed to solid waste have substantial occupational health risks in terms of lead intoxication and oxidative stress.

1 Introduction

Dhaka, the capital of Bangladesh, is one of the fastest growing megacities in the world. There has been a significant increase in the generation of municipal solid waste (MSW) during the last few decades due to the rapid population and economic development. Hai and Ali¹ reported that Dhaka city generates about 3,500 tons of solid waste each day, 45% of which is collected and disposed of by the Dhaka City Corporation (DCC). Another report stated that around 5492 tons of solid waste are generated daily in Dhaka city². In general, hazardous hospital and industrial wastes are frequently mixed with municipal wastes.

Like other cities³⁻⁵, a large proportion of solid waste is dumped in unplanned landfill sites, and peoples working and leaving surrounding the landfill area may be victims of waste exposure-related health hazards. Medina⁶ reported that the income of

selling the collected materials from the waste dumping sites making the living of up to 2% of the population in Asian and Latin American cities. Exposure and collection of waste materials such as plastics, glass bottles, rubber materials, and metals from dumped garbage results in detrimental health risks to waste pickers. The overall deterioration of health and respiratory complications has been reported in workers disposed of solid municipal wastes^{7,8}. An et al.⁹ also indicated that workers working in the municipal waste disposal sector are exposed to more occupational health risks. The exposure to polluted air highly contaminated with toxic metals displays an inevitable health risk and causes oxidative stress. The oxidative stress, imbalance of pro-oxidant and antioxidant homeostasis, may originate from the intoxication of metals and cause the production of reactive oxygen and nitrogen species (ROS and RNS)¹⁰.

It has been suggested that lead intoxication may be involved in the cellular damage mediated by reactive oxygen species^{11,12}. Patil *et al.*¹³ reported a positive correlation between lead and oxidative stress by measuring the level of plasma MDA in lead-exposed workers.

In Bangladesh, instead of looking at the health risk and social needs of waste pickers, the emphasis was always given to the environmental and economic aspects of waste management. Since a limited amount of information related to solid waste exposure and its health outcome is available, many uncertainties about potential health hazards associated with pathogens, trace metals, and organic contaminants exist¹⁴. Therefore, the levels of heavy metals, antioxidant vitamins, and oxidative stress parameters in blood of waste pickers of Dhaka were determined to evaluate the possible adverse health effects on male adults exposed to a solid waste dumping site in Bangladesh.

2 Material and Methods

2.1 Study Area

The Dhaka City Corporation (DCC) is responsible for the disposal of solid waste in Dhaka city. The study was conducted in Matuail of Dhaka city, at the garbage dumping area of DCC, located 10 km from the city center and 30 km from the farthest boundary at Uttara and Mirpur. Matuail landfill site is located on the north of Dhaka Demra highway which lies between latitude 23°42.97' and 23°43.35' N and longitude 90°26.83' and 90°27.2' E. (Fig.1). Almost all solid wastes of Dhaka city dumped to Matuail. Other two waste disposal sites (Lalbagh and Mirpur) are used when the Matuail site is unapproachable due to heavy rain or damage of driveways and maintenance of unloading platforms.

Fig 1: Location map of Matuail landfill site in Dhaka City

2.2 Study Design and Study Population

The study was conducted among waste pickers, working in a free manner at Matuail waste dumping site in Dhaka and not employed or paid by DCC. A total of 37 adults took part in this study. They were categorized into two groups of exposed (n=28) and unexposed (n=9). The exposed group consisted of those subjects working for more than six months at the Matuail solid waste dumping landfill site as waste pickers. The unexposed group consisted of those of same-aged subjects living in a separate neighborhood, far from the waste dumping site, a distance sufficient enough to ensure that the subjects do not expose to waste. Inclusion criteria for exposed (waste pickers) subjects were: (i) worked at the Municipal solid waste dumping landfill of Matuail; (ii) male, aged 20 to 45 years male (iii) waste pickers for at least 6 months to two years; (iv) healthy at the time of blood collection, without having any disease; and (v) willing to participate in the study. Inclusion criteria for unexposed (control) subjects were: (i) never worked at any waste dumping site; (ii) male, aged 20 to 45 years; (iii) healthy at the time of blood collection, without having any disease; and (iv) willing to participate in the study.

2.3 Analytical Methods

About five (5) mL of venous blood was collected from each individual in a clean tube using a disposable syringe after overnight fasting. Serum samples were obtained by centrifugation of blood and kept at -20 °C until further analysis. The thiobarbituric acid reactive substances (TBARS), a good index of oxidative stress has measured the level of MDA (malondialdehyde), the major lipid oxidation product¹⁵. TBARS in serum was measured by the method of Ohkawa *et al.*¹⁶ and expressed as nanomoles malondialdehyde (MDA) equivalents per milliliter. Serum protein carbonyl value was analyzed by 2,4-dinitrophenylhydrazine (DNPH) method¹⁷ and selected as biomarkers of oxidative stress because of the relative stability of carbonylated proteins compared to other oxidative products. Vitamin A and Vitamin E contents in serum were measured simultaneously using a reversed-phase high-pressure liquid chromatography (HPLC)¹⁸.

After mineralization of blood samples in the microwave system, lead, iron, and zinc were determined using atomic absorption spectrometry (AAS). Standard solutions were prepared using Zn, Fe, and Pb standards (Merck). Deionized distilled water was used as blank. Blank and standard solutions were used for the calibration of atomic absorption spectrophotometer¹⁹. The concentrations of Zn and Fe in serum were measured with a flame atomic absorption spectrophotometer (Perkin Elmer AAS-700 Ueberlinger, Germany). The serum concentration of Pb was determined by atomic absorption spectrophotometer with an HGA graphite furnace (Perkin Elmer AAS-700 Ueberlinger, Germany). The correlation coefficient was found 0.999918, 0.998687, and 0.999276 for Zn, Fe, and Pb, respectively.

2.4 Ethical Issue

This study was approved by the Institutional Ethical Review Committee (ERC) of the Department of Biochemistry and Molecular biology, University of Dhaka (# BMBDU-ERC/EC/17/014). Informed consent was obtained from all participants after explaining the study procedure. The study was conducted according to the declaration of Helsinki and its subsequent revisions²⁰.

2.5 Statistical Analysis

The data were analyzed using the statistical package for social sciences (SPSS; version 17.0; Chicago, IL, USA). Analysis of Variance (ANOVA, Bonferroni test) was done as the test of significance among all the subjects. Unpaired t-test was done as the test of significance between the same age group for exposed and unexposed control subjects. Association among different biochemical parameters were calculated by Pearson correlation. A *p*-value of <0.05 was considered statistically significant.

3 Results

The levels of heavy metals and oxidative stress parameters in human blood represent a vital indicator of health status. As shown in Table 1, the serum lead level is significantly higher in exposed adults (32.9±0.3 µg/dL, *p*<0.05) compared to unexposed subjects (19±0.5 µg/dL) and exceeded the WHO recommended value of <10 µg/dL²¹. Mamtaz and Chowdhury²² reported very high heavy metals concentration in solid wastes in this Matuail landfill site, which could be potentially hazardous and pose a serious threat to air, soil, and water. Recently, Hossain *et al.*²³ reported that Pb concentrations were high in the soil of the Matuail landfill site that exceeded the permissible limits. Begum and Biswas²⁴ reported a substantial amount of Pb in the air of Dhaka city. Further investigation by Woo *et al.*²⁵ reported an elevated level of lead (mean 1.22 µg/m³) in air samples of a rural area of greater Dhaka. Environmental high lead concentration may be responsible for exhibited elevated blood lead in exposed subjects. Additional possibly is that due to direct exposure to gasoline, paints, ceramics, used batteries, and pottery glazing in the solid wastes, all of which are likely sources of lead poisoning. However, lead exposure remains an issue in Bangladesh, where epidemiological investigations have found high blood lead concentrations in children in and near the industrial center of Dhaka.^{26,27} Presently accepted reference value of blood lead concentrations for healthy persons is <10 µg/dL for adults²⁸. In this study, the exposed adults contain a higher serum lead level than that of unexposed adults (Table 1).

The serum level of iron was significantly (*p*<0.05) higher in the case of exposed adults (253±19 µg/dL) than unexposed adults (147±18 µg/dL). Table 1 indicates that exposure to solid landfill somehow increased the serum iron level of adults. The reason for the high concentration of iron in waste pickers is not clear. The high level of Fe could be partly due to the Fe content of soil

and partly due to the high content of Fe-based waste materials, which may increase the blood iron level of exposed subjects.

Table 1: Level of Serum Minerals

Variable (µg/dL)	Exposed (n=28)	Unexposed (n=9)
Lead	32.9±0.3*	19.0±0.5
Iron	253±19*	147±18
Zinc	209±21	145±19

Values are in Mean±SE; **p*<0.05

Like serum iron level, exposed adult (209±21 µg/dL) contains a higher level of zinc compared with unexposed adult (145±19 µg/dL), although not statistically significant (Table 1). Ali *et al.*²⁹ determined the concentration of various heavy metal in the soil of waste disposal sites and found higher mean values of Pb, Cu, Ni, Cr, and Zn at waste disposal sites compared to soil of the control site. Recently, Osibote and Oputu³⁰ also reported a higher concentration of Zn and Cr than other metals in the landfill soil samples from Cape Town, South Africa. These studies revealed that soils in the dumpsite are considerably contaminated by metals with their concentrations beyond the threshold and natural background values and have a high potential of environmental risk³¹. Although we did not determine the soil or zinc level of waste, it may explain the high blood zinc level in exposed subjects.

As shown in Table 2, there was no significant difference in serum levels of TBARS between exposed and unexposed adults. On the other hand, another oxidative stress parameter, protein carbonyl value (801.6±70 nmol/mg of protein) in adults exposed group was significantly higher (*p*<0.01) than that of unexposed groups (420.9±66 nmol/mg of protein). Therefore, exposure to the garbage can alter protein side groups forming protein carbonyl through the production of oxidative stress-mediated ROS. Table 2 shows the antioxidant levels in adults for both exposed and unexposed groups. There was no significant difference in vitamin E between exposed and unexposed adults. Serum vitamin A level is slightly higher in exposed adult (1.1±0.1 µg/dL) than that of unexposed subjects (0.9±0.1 µg/dL), although not statistically significant (Table 2). A significant positive correlation exists between iron & zinc (*p*<0.05, *r*=0.475) and vitamin E & A (*p*=0.000, *r*=0.710), whereas a significant negative correlation (*p*<0.05, *r*= -0.562) exist between lead and TBARS in the exposed adults (Table 3).

4 Discussions

The lead intoxication was much higher in solid waste exposed adults than that of unexposed adults (Table 1), suggested less effective detoxification and/or inability of the body to excrete lead from the blood of repeated exposed landfill solid waste. High blood lead levels (mean of 28 µg/dl) was also reported in Metro

Manila for waste pickers³². The increased protein carbonyl value in the adult exposed group indicated higher oxidation stress and the presence of a high rate of protein oxidation (Table 2). This finding is supported by Davies³³, who reported that protein is the main cellular component target for ROS-induced damage.

Table 2: Level of Antioxidant Vitamin and Oxidative Stress Parameters

Variable	Exposed (n=28)	Unexposed (n=9)
Vitamin A (µg/mL)	1.1±0.1	0.94±0.1
Vitamin E (µg/mL)	2.09±0.2	2.74±0.4
TBARS value (nmol/mL)	1.33±0.4	1.36±0.4
Protein carbonyl value (nmol/mg of protein)	802±70*	421±66

Values are in Mean±SE; *p<0.001. TBARS, Thiobarbituric acid reactive substances

From our result, we speculated that exposure to certain chemicals in waste dumping site are responsible for oxidative stress in the study subjects. In the present study, we found a negative correlation of lead exposure with oxidative stress of subjects, thiobarbituric acid-reactive substances (TBARS) in serum (Table 3), which suggested that adult's exposure to dumping waste had increased level of lead, linked to the oxidative stress compensation mechanism of the body and are in great health risk.

Table 3: Correlation among Minerals, Antioxidant Vitamin and Oxidative Stress Parameters

Variable	Correlate	Exposed Subject (n=28)	
		r value	p value
Iron	Lead	0.028	0.925
	Zinc	0.475	0.046
Vitamin E	Lead	-0.284	0.305
	Vitamin A	0.710	0.000
TBARS value	Lead	-0.562	0.029
	Vitamin E	0.210	0.361

5 Conclusion

Despite the limitations of the small sample size, our findings suggest that the adults working and exposed to solid waste involves substantial occupational health risk in terms of lead intoxication and oxidative stress. Further extensive studies using more biomarkers of oxidative stress with multisite and large study

populations should be conducted to understand the health risks of waste pickers better.

6 Authors' contributions

YK designed the study, and NT performed the research and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

7 Conflicts of interest

The authors declare that they have no conflict of interest.

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10 References

- Hai FI, Ali M. A study on solid waste management system of Dhaka city corporation: effect of composting and landfill location. *UAP J. Civil Environ. Eng.* 2005; 1(1): 18–26.
- Alamgir M, Ahsan A. Municipal solid waste and recovery potential: Bangladesh perspective. *Iran J. Environ. Health Sci. Eng.* 2007; 4: 67–76.
- Uddin SMN, Gutberlet J. Livelihoods and health status of informal recyclers in Mongolia. *Resour. Conserv. Recycl.* 2018; 134: 1–9.
- Schenck CJ, Blaauw PF, Viljoen JMM, Swart EC. Exploring the potential health risks faced by waste pickers on landfills in South Africa: A socio-ecological perspective. *Int. J. Environ. Res. Public Health* 2019; 16: 2059.
- Thakur P, Ganguly R, Dhulia A. Occupational health hazard exposure among municipal solid waste workers in Himachal Pradesh, India. *Waste Manag.* 2018; 78: 483–489.
- Medina M. Scavenger cooperatives in Asia and Latin America. *Resour. Conserv. Recycl.* 2000; 31(1): 51–69.
- Ray MR, Roychoudhury S, Mjkerjee G, Roy S, Lahiri T. Respiratory and general health impairments of workers employed in a municipal solid waste disposal at an open landfill site in Delhi. *Int. J. Hyg. Environ. Health* 2005; 208: 255–62.
- Athanasίου M, Makrynos G, Dounias G. Respiratory health of municipal solid waste workers. *Occup. Med.* 2010; 60: 618–23.
- An H, Englehardt J, Fleming L, Bean J. Occupational health and safety amongst municipal solid waste *Pharm & Biosci J.* 2020; 8(4); 19

- workers in Florida. *Waste Manage. Res.* 1999; 17(5): 369–73.
10. Flora SJS, Mittal M, Mehta A. Heavy metal induced oxidative stress and its possible reversal by chelation therapy. *Indian J. Med. Res.* 2008; 128: 501–23.
11. Ibrahim NM, Eweis EA, El-Beltagi HS, Abdel-Mobdy YE. Effect of lead acetate toxicity on experimental male albino rat. *Asian Pac. J. Trop. Biomed.* 2012; 2(1): 41–6.
12. Wang L, Wang H, Li J, Chen D, Liu Z. Simultaneous effects of lead and cadmium on primary cultures of rat proximal tubular cells: interaction of apoptosis and oxidative stress. *Arch. Environ. Contam. Toxicol.* 2011; 61(3): 500–11.
13. Patil AJ, Bhagwat VR, Patil JA, Dongre NN, Ambekar JG, Jaikhan R, et al. Effect of lead (Pb) exposure on the activity of superoxide dismutase and catalase in battery manufacturing workers (BMW) of Western Maharashtra (India) with reference to heme biosynthesis. *Int. J. Environ. Res. Public Health* 2006; 3(4): 329–37.
14. He P, Xue J, Shao L, Li G, Lee D. Dissolved organic matter (DOM) in recycled leachate of bioreactor landfill. *Water Res.* 2006; 40(7): 1465–73.
15. Samir M, el-Kholy NM. Thiobarbituric acid reactive substances in patients with laryngeal cancer. *Clin. Otolaryngol. Allied Sci.* 1999; 24: 232–4.
16. Ohkawa H, Ohishi N, Yagi K. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. *Anal. Biochem.* 1979; 95: 351–8.
17. Levine RL, Garland D, Oliver CN, Amici A, Climent I, Lenz AG, et al. Determination of carbonyl content in oxidative modified proteins. *Methods Enzymol.* 1990; 186: 464–78.
18. Sayeed MSB, Khanum S, Tul-Kubra K, Ullah MA, Chowdhury JA, Azad MAK, et al. Antioxidant status and oxidative DNA damage of Bangladeshi dockyard laborers. *J. Pharmacy Res.* 2011; 4(10): 3271–4.
19. Brown A, Halls JD, Taylor A. Atomic spectrometry update-clinical materials, foods and beverages. *J. Anal. At. Spectrom.* 1986; 1: 21–35.
20. WMA: World Medical Association (2013). World medical association declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA.* 2013; 310: 2191–4.
21. WHO. International programme on chemical safety (IPCS). *Inorganic lead. Environmental health criteria* 165. Geneva, Switzerland: World Health Organization; 1995.
22. Mamtaz R, Chowdhury MH. Environmental pollution at solid waste disposal site. *Pollut. Res.* 2008; 27: 207–212.
23. Hossain MF, Kamal ASMM, Sikder AHF, Parveen Z. Air quality measurement at the solid waste disposal of Matuail landfill site at Dhaka, Bangladesh. *Am. J. Environ. Sci.* 2019; 15(5): 167v179
24. Begum BA, Biswas SK. Trends in particulate matter (pm) and lead pollution in ambient air of Dhaka city in Bangladesh. *J. Bang. Acad. Sci.* 2008; 32(2): 155–164.
25. Woo MK, Young EY, Mostofa MG, Afroz S, Hasan MOSI, Quamruzzaman Q, et al. Lead in air in Bangladesh: Exposure in a rural community with elevated blood lead concentrations among young children. *Environ. Res. Public Health* 2018; 15: 1947.
26. Mitra AK, Haque A, Islam M, Bashar SA. Lead poisoning: An alarming public health problem in Bangladesh. *Int. J. Environ. Res. Public Health* 2009; 6: 84–95.
27. Mitra AK, Ahua E, Saha PK. Prevalence of and risk factors for lead poisoning in young children in Bangladesh. *J. Health Popul. Nutr.* 2012; 30: 404–409.
28. Wu A. *Tietz Clinical Guide to Laboratory Tests*. 4th ed. St. Louis, MO: Saunders Elsevier; 2006, 658–659.
29. Ali SM, Pervaiz A, Afzal B, Hamid N, Yasmin A. Open dumping of municipal solid waste and its hazardous impacts on soil and vegetation diversity at waste dumping sites of Islamabad city. *J. King Saud Univ.–Sci.* 2014; 26(1): 59–65.
30. Osibote A, Oputu O. Fate and partitioning of heavy metals in soils from landfill sites in Cape Town, South Africa: a health risk approach to data interpretation. *Environ. Geochem. Health* 2020; 42(1): 283–312.
31. Parth V, Murthy NN, Saxena PR. Assessment of heavy metal contamination in soil around hazardous waste disposal sites in Hyderabad city (India): natural and anthropogenic implications. *E. J. Environ. Res. Manage.* 2011; 2(2): 027-034.
32. Cointreau S. Occupational and Environmental Health Issues of Solid Waste Management. World Bank urban papers. Washington, DC: World Bank; 2006, 20–21.
33. Davies KJ. Protein damage and degradation by oxygen radicals. I. General aspects. *J. Biol. Chem.* 1987; 262: 9895–901.