

SPECIFICATION THE METAL CONTENT OF WASTE GLASS FROM AN OLD GLASS LANDFILL

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ABSTRACT

Glass has been manufactured in Småland region (the “Kingdom of Crystal Glass”) since the 18th century and during all these years a huge amount of heavy metals accumulated in this region. There is more than 25 glassworks in Småland which contain an estimated of 310 tons of arsenic, 19 tons of cadmium and 1600 tons of lead. Recently, the Sweden’s county administrative boards have mapped 20,000 locations that are contaminated with hazardous materials for human and environment. 10 of the 22 acute risks and dangerous locations are glassworks in Småland. The first stage to handle these wastes is to specify the metal content of the waste glass and the contaminated soils. Semi-quantified X-ray fluorescence analysis (XRF) was used to analyze 14 samples of waste glass from an old glassworks landfill in the south of Sweden. The results showed that different amount of metals were detected and with a high concentration like Pb (about 3500 ppm), As (about 500 ppm), Fe (about 30000 ppm), Mn (about 1000 ppm) and others.

KEYWORDS

Waste glass, characterization of waste, XRF analysis, old landfills.

1. Introduction

Småland region with its deep woods (firewood for the furnaces) and water resource was chosen in the 18th century to be the center for the production of glass in Sweden and this was the base for the name “Kingdom of Crystal Glass” [1]. This kingdom is located in the area between Kalmar and Kronoberg Counties and witnessed the buildup of many famous glassworks like that of Kosta Boda and Pukeberg.

Different materials are used in the production of glass like sand, lime, soda ash and heavy metals which are used to give special colors for the produced glass [2]. Since the 18th century, huge amounts of pollutants were released to Småland’s environment due to the use of these raw materials in glass industry. Dust, carbon dioxide and NO_x emitted to air [3]. Waste water from

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grinding, cooling, rinsing and washing was discharged to the surface water [3]. Acid sludge, multi spills, unsorted waste and crashed glass and filter dust were through in a pile near the glassworks as a landfilling [3]. The biggest problem is that these wastes contain huge amounts of heavy metals (an estimated 310 tons of arsenic, 19 tons of cadmium, and 1600 tons of lead [4]) which have been leaching to the surface and the ground water and to the soil and showing a high risk for Småland's environment.

The risk from glassworks landfills is not coming from glass waste because the chemical structure of glass showed that it is impossible for metals to leach out from the structure of glasses but it comes from bad landfilling of the chemicals wastes which were used in the production of glass as raw materials. These chemicals have been leaching to the surface and ground water and diffuse through plants and water to human and enamels.

Different risk assessment studies [5,6,7,8] have been done by Kalmar and Kronoberg Counties to specify the risk effects of the heavy metals from the glassworks and their wastes on the environment. In the first study in 2001 [6] Pukeberg glasswork showed a high risk assessment of class 2. While, in 2007 the investigation done by Höglund et al. [8] classified Pukeberg glasswork with very high risk of class 1 and this was the same result of Elert and Höglund [5] in 2012. The results of these reports were based on the analysis of soil and water in different places inside the glassworks and their landfills. The recommendation from all these reports was that Pukeberg glasswork needs an urgent remediation due to the contamination with arsenic, lead, cadmium, barium, antimony and zinc.

The aim of the present study is to investigate the metals content of waste glass and soil from the Pukeberg glasswork's old landfill in Småland. XRF scanning was used to analyze 14 samples of waste glass from 7 different points inside the old landfill (7 of them over 2 mm and the other 7 samples are less than 2 mm in particle size) to explore the amounts of metals that can be found in each of the two studied particle sizes.

2. Material and methods

2.2. Site description

Pukeberg glasswork was built up in 1871. It is located in about 1.5 km southeast of Nybro's center and the old glasswork's landfill is located to the south of the glasswork buildings. The landfill covers an area of approximately 15,000 m² [5]. The waste glass and other waste materials can be found under a depth of 20 cm, as was noticed during sampling.

The main municipal water supply for Nybro the St. Sigfridsån River is flowing about 150-200 m from the north side of the Pukeberg landfill. And the whole area is surrounded by large spaces of natural forests.

The chosen points for sampling were inside the old landfill south of the glassworks buildings.

2.3.Sampling and analysis

Soil and waste glass samples were collected from 7 different points inside the glasswork's landfill. After digging for about 30 cm the samples were collected and saved in plastic bags. The saved samples were stored in cold room in about 4 C and for about 6 months before further analysis. The samples were dried first and then sieved with 2 mm mechanical sieving before using XRF to analyze the 14 samples for the metal contents. Three different points in each bag were scanned with Olympus DS-4000 (Innov-X system, USA) XRF analyzer and the average were taken as the final value for each bag.

3. Results and discussion

The metal content results for the particle sizes over 2 mm and less than 2 mm are shown in figures 1 and 2 respectively. While, the metal content mean values for all the studied 7 sampling points and for the both particle sizes compared to the Swedish EPA benchmark value for wastes [5] and the results of Höglund et al [8] are shown in table 1.

The results showed that higher contents of zinc, arsenic, barium and lead were detected for the both studied particle and with contents higher than that of the Swedish EPA. As shown in table 1, the metal content in the particle sizes over 2 mm was higher than that for the less than 2 mm particle sizes and that's maybe because during the scanning with the XRF and for the particle sizes over 2 mm it was hard to find a smooth area to make the scanning over it. These results showed that the Pukeberg landfill is highly contaminated with lead, zinc, arsenic and barium and for the both studied particle sizes. These results were in agreement with that of Höglund et al [8], though, Höglund et al used ICP-MS technique to analyze the metal content.

The cobalt content was about (250 mg/kg) in the particle sizes less than 2 mm while the XRF did not detect the cobalt in the particle sizes over 2 mm. This result did not match with that of Höglund et al [8] which showed a low content of cobalt of (4.7 mg/kg) only. This result could show the importance of studying the waste glass according to particle sizes.

Higher contents of lead were found in the both studied particle sizes and this was expected because lead used extensively as a raw material in Småland glass during the past time.

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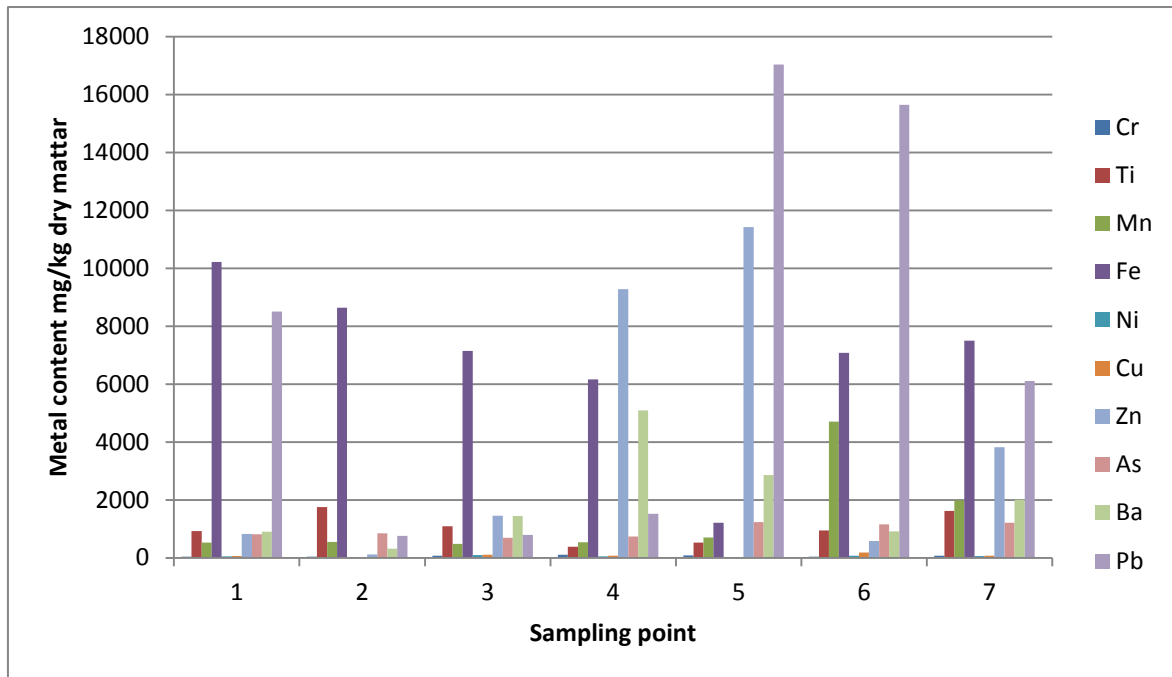
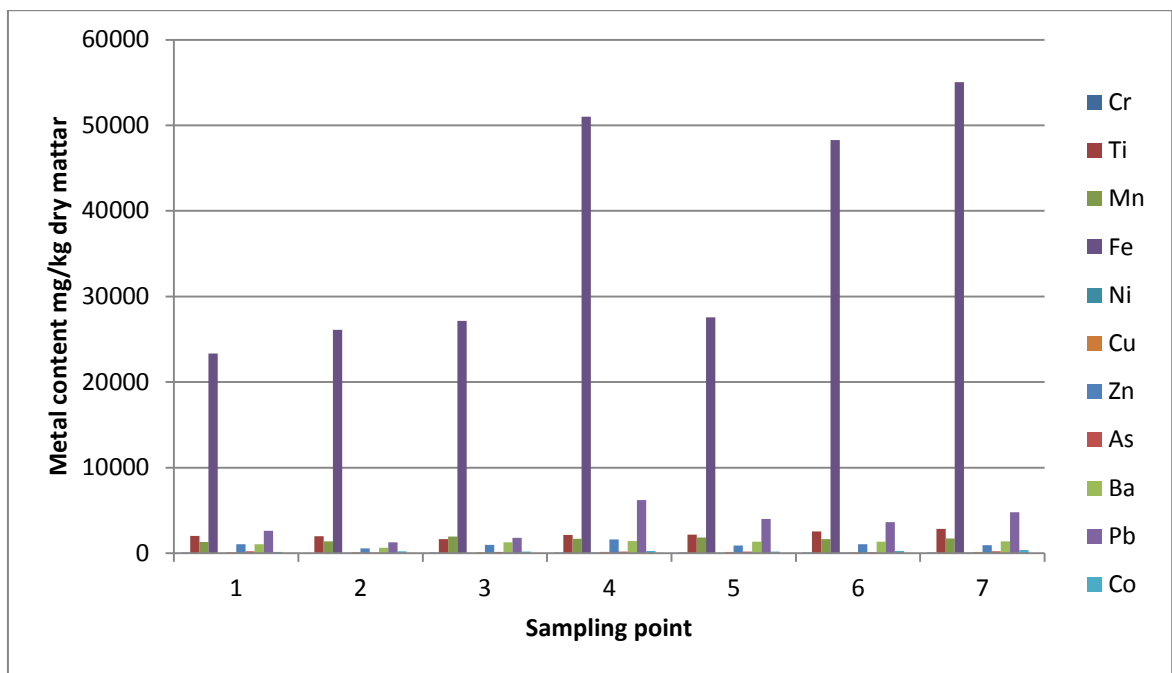


Figure 1. The metal content for the waste samples with particle sizes over 2mm



Linnaeus ECO-TECH '14
Kalmar, Sweden, November 24-26, 2014

Figure 2. The metal content for the waste samples with particle sizes less than 2 mm.

Table 1. The mean value of the metals content (SD) for all the samples in the fractions over 2 mm and less than 2 mm compared to the Swedish EPA benchmark value [5].

Metal	Mean value mg/kg Over 2 mm	Mean value mg/kg Less than 2 mm	Mean value Höglund et al[9] mg/kg	SEPA Benchmark value mg/kg [5]
Cr	65 (25.98)	76.85 (11.76)	41.7 (14.7)	-
Ti	1034.57 (511)	2206.14 (391.16)	-	-
Mn	1354.14 (1569.63)	1662.57 (223.20)	0	-
Fe	6848.28 (2807.51)	36929 (13784)	-	-
Co	ND	251.14 (76.73)	4.7 (2.8)	30
Ni	53.57 (26.38)	61.42 (23.62)	13.7 (11.7)	-
Cu	78.57 (54.28)	144.57 (18.40)	83.4 (140.3)	200
Zn	3928.57 (4586.18)	1034.57 (307.77)	791.5 (1008.9)	500
As	956.71 (235.47)	182.14 (65.02)	147.3 (309.2)	25
Ba	1931.57 (1620.92)	1219.42 (276.77)	3361 (2785.6)	300
Pb	7193 (6898.76)	3483.71 (1733.30)	1196.2 (2101.7)	400

4. Conclusions

The results from the present study showed that Pukeberg glasswork landfill needs an urgent remediation due to the contamination with high contents of lead, zinc, arsenic, barium and cobalt. These heavy metals can affect Småland's environment by leaching from soil to the surface and the ground water and through them to plants, animals and human beings. Heavy metals with such concentration can be highly poisons to human beings and animals and as known that these heavy metals are also having cancerous effects on human.

Studying the metal content of the waste glass according to the particle sizes of this waste could be able to give a broad picture for all the metals that can be found in that waste.

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