Comparison of Extractants for Toxic Metals in Dust Causing Environmental Pollution and their Analysis in Close and Open System

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Summary: The aim of this work was to look for an ideal extractant for toxic metals in dust. Twelve extractants were tested in close and open systems. Atomic absorption spectrophotometer was used to determine the concentrations of cadmium, chromium, copper, cobalt, lead, nickel and zinc. Excess of all these are toxic to living organisms and are regarded as pollutants. Nitric acid 2M was found to be the best extractant.

Introduction

The analysis of environmental samples for heavy and toxic metals have become increasingly important in recent years due to the concern over the potential health hazards of the uptake of small amounts of heavy and toxic metals ingested with food, water and inhaled from air. Therefore, there is a need for an accurate, safe, simple and rapid methods of analysis that can readily be applied routinely by laboratories to a large number of samples. Keeping in mind, above criteria and availability of instrumentation and relative freedom from inter-element effect, atomic absorption spectrophotometer was selected as a measurement technique [1,2]. Various reagents have been reported for the wet digestion of soil/dust and these include nitric acid, hydrochloric acid, nitric-sulphuric acid [3,4] nitric-perchloric acid [3,4] nitric-hydrochloric acid [3-5] nitric acid-hydrogen peroxide [4] hydro-chloric acid-hydrogen peroxide [6] hydrofluoric acid in combination with other acids.

Results and Discussion

The wave length, slit width, lamp current and flame settings for any particular metal was done according to the atomic absorption manual book [7]. The concentration of metals in dust sample was calculated by using "Tony Curve" computer programme. The concentrations of metals in dust sample are given in Table-1 and 2 in open and closed systems respectively.

Various digestion techniques were examined for the extraction of heavy toxic metals in dust. It can be seen from the Table-2 that the values obtained by close system are quite steady, but it is not easy and simple to handle, therefore, not recommended. It is clear from the Table-1 the dust contains the highest concentration of Lead (Pb) followed by Zn, Cu, Cd [8]. Lowest concentration is that of Ni and Cr the concentration of Pb is exceptionally high because the samples were collected from near the highway i.e. Manchester Ashton-under-Lyne in U.K.

Table-1: Extractant and metal concentration (PPM) in open system.

Metal/ Extrac-tants	Pb	Co	Ni	Cu	Zn	Cd	Cr
1	3224.5	12.42	3.33	159.6	1255.2	22.80	7.50
2	3002.4	12.98	4.23	153.0	1191.6	21.23	11.28
3	2939.0	7.99	7.29	158.57	1744.35	24.20	18.63
4	2580.46	12.48	2.9	213.87	1744.35	20.10	9.40
5	2936.0	14.18	7.68	212.60	1744.35	21.10	11.24
6	1987.37	v.low	2.96	188.32	1103.25	12.68	11.21
7	640.23	v.low	2.97	148.63	1031.11	19.53	8.46
8	573.30	9.2	3.97	151.65	1052.62	11.01	9.38
9	2083.23	10.45	3.22	183.52	1744.35	22.36	9.36
10	2974.20	17.92	4.98	216.50	1220.15	23.00	15.30

Above concentration is average of 12 observations and S.D is ranging 1 to 5 at 95% confidence level.

Table-2: Extractant and metal concentration (PPM) in close system.

Extrac-tants	Pb	Co	Ni	Cu	Zn	Cd	Cr
11	3100.44	25.98	7.38	197.87	1284.70	20.41	14.50
12	3343.31	19.94	6.70	214.50	1179.75	18.70	14.60

It shows the pollution of lead through tetraethyl lead which is used as an antiknocking and antifreezing agent. Lead being heavy metal may settles down quickly on or near the high way.

2M nitric acid in open system is the best extractant for cadmium, chromium, nickel and zinc. It is not that good for other three metals but it is safe, rapid and simple extractant for toxic metals in dust samples and these results agree with that of Thompson and Wagstaff [9]. Hydrofluoric acid and aqua regia [9-11] in close system has no significant difference in extraction of toxic metals from dust samples. In fact close system which is inconvenient to use had no real advantage over open system, therefore, not recommended. Aqua regia and concentrated acids are dangerous to use and have no real advantage. Therefore, 2M nitric acid is the most ideal extractant for toxic metal and is recommended.

Experimental

Standard solution

Standard solutions were prepared by serial dilution of a 1000 $\mu g/dm^3$ stock solutions provided by Hopkins and Williams, using Eppendorf pippettes. All standard solutions were prepared in matrix solutions. Glass wares were cleaned by soaking or boiling with 10-20% HNO_3 at least three time.

Sample area

Dust from closed houses were collected from Manchester, Ashton-under-Lyne and Rochdale Lancashire, U.K.

Sample preparation

224 g of dust samples were mixed in 8000 cm^3 deionised water boiled for four hours on a hot plate cooled and filtered. The dust sample was dried in an oven at 105°C overnight. Next day it was sieved first through aperture 0.0493 cm followed by 0.0356 cm. This sample was used for all extractants.

A. Digestion method open system

0.50 gm of powdered dust samples obtained after the above treatment were weighed and transferred to 150 cm^3 conical flask, 50 cm^3 of respective acids were added from burette. The acidic solutions of dust samples were heated between 60-65°C for half an hour on water bath then cooled and filtered through a glass fibre filter into a 100 cm^3 volumetric flask to remove any residue. The above sample was rinsed twice with deionised water, filtered and collected in the 100 cm^3 volumetric flask. The blanks were made by taking 50 cm^3 of respective extractants and diluted to 100 cm^3 with deionised water.

Extractants

1: HNO_3 (Conc.)
2: HCl (Conc.)
3: HNO_3 (2M)
4: HCl (2M)
5: Aqua Regia.
6: Concentrated, nitric-hydrochloric acid 1:1 [8].
7: Concentrated nitric-sulphuric perchloric acid (3:1:1).
8: Concentrated hydrochloric-nitric-sulphuric acid (6:1:1).
9: Concentrated sulphuric-nitric-hydrochloric acid (10:5:2).
10: Concentrated sulphuric nitric acid (2:1)

B. Close systems

11: Aqua Regia

0.10 gm dust sample was taken into pressure dissolution vessel (bomb), 25 cm^3 of aqua regia was

added and the vessel was closed and heated to 145°C for 45 minutes, cooled, opened, filtered and diluted to 50 cm^3.

12: Hydrofluoric acid

0.20 g of dust sample was taken into pressure dissolution vessel (bomb) 5 cm^3 of water, 2 cm^3 of aqua regia and 1 cm^3 of 40% hydrofluoric acid was added. The vessel was closed, heated at 145°C for 45 minutes, cooled, opened and added to it 10 cm^3 of 4% boric acid solution quickly. The vessel was closed, reheated at 145°C for half an hour; cooled, filtered and solution was made up to 100 cm^3.

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