CONFIDENTIAL.

First Draft.

NITEP PHASE 1 TESTING AT THE PRINCE EDWARD ISLAND ENERGY FROM WASTE FACILITY

ASSESSMENT OF ASH CONTAMINANT LEACHABILITY

Prepared for Industrial Programs Branch

by

T.R. Bridle
Environment Canada
Environmental Protection Service
Wastewater Technology Centre
Burlington, Ontario

The Appendix containing detailed data has been omitted. If you feel you require the raw data it will be made available.

Steve.

P.S. If you have any further questions, please call me at 637-4204.

INTRODUCTION

Environment Canada's Wastewater Technology Centre (WTC) has conducted a preliminary study to assess the leachability of organic and inorganic contaminants in selected ash samples from the Prince Edward Island Energy from Waste (PEI-EFW) facility. This municipal incinerator was the first one studied under Environment Canada's National Incinerator Testing and Evaluation Program (NITEP). The PEI-EFW plant is classified as a two-stage combustion facility consisting of three two-stage Consumat CS.1600 incinerators with a total capacity of 100 tonnes of garbage per day. A common exhaust manifold leads to a waste heat recovery boiler, followed by an economizer and hence to the exhaust fan and stack.

The facility, depicting one incinerator, is shown schematically in Figure 1. It can be seen that three ashes are generated in this facility, namely incinerator, boiler and economizer ash. The incinerator ash comprises the bulk of the ash generated, since without any air pollution control devices, very little boiler and economizer fly ash is collected.

Twelve performance tests were conducted at the PEI-EFW facility, representing four sets of operating conditions run in triplicate. Ash from one of the triplicated runs for each set of operating conditions was assessed for leachability. Identification of the operating conditions is shown in Table 1.

TABLE 1. INCINERATOR OPERATING CONDITIONS

Ash Sample Number	Condition	Settings		
		Primary Temp (°C)	Secondary Temp (°C)	Feed Cycle (min)
PT3	Normal Operation	695	1000	8.5
PT5(6)*	Low Feed Rate	690	1000	12
PT9	High Temp	700	1135	8.5
PT12	Low Temp	675	900	8.5

*There was insufficient boiler ash from run PT5, so the PT6 ash was used.

EXPERIMENTAL AND ANALYTICAL METHODS

Leachability was assessed using the WTC Multiple Batch Leaching Procedure (MBLP). This test procedure comprises six batch extractions conducted at two liquid to solid ratios (20:1 and 4:1) and using three leaching media [deionized water (DW), an acetic solution (AS) and a synthetic leachate (SL)]. The solid and leaching media are gently rotated in square bottles for a 24 hour period. Details of the test procedure are presented elsewhere (1). For the organic contaminants a limited MBLP was conducted, using only the DW 20:1 leaching test. Insufficient boiler and economizer ash samples were available for a complete MBLP for the inorganic contaminants and all tests at a 4:1 L/S ratio were omitted.

Analysis of the ash and leachates for contaminants of interest, with the exception of chlorinated dioxins and furans was conducted by the principal NITEP analytical contractors (Zenon Inc. and Concord Scientific). Detailed analytical methods are presented in the NITEP report (2). The dioxin and furan analyses were conducted by Environment Canada's River Road Laboratory. The WTC also analysed all ashes and leachates for a broad spectrum of inorganic contaminants.

Unfortunately, the incorrect boiler ash samples for runs PT3, 6, and 9 and incorrect economizer ash samples for runs PT3 and 5 were analyzed by the contract laboratories. Hence no inorganic data and no organic data, with the exception of dioxins and furans are available for these samples. Because of this we have elected to use the WTC inorganic analyses (both ash and leachates) exclusively.

Leaching results are expressed in three formats. First, the leachate concentrations are displayed, followed by a release number and finally, a leaching efficiency. Contaminant release is the mass of contaminant released divided by the weight of sample leached. It is calculated by multiplying the leachate concentration by the liquid to solid ratio. Leaching efficiency is the contaminant release divided by the contaminant concentration in the solid, times 100.

DISCUSSION OF RESULTS

The raw data for inorganic contaminant leachability is presented in Tables 1-36 of Appendix I and the organic data is presented in Tables 37-39 of Appendix II. Abbreviated leaching data (DW 20:1) for all the ash samples is shown in Tables 2, 3, 4 and 5 and the data is discussed in more detail below.

Inorganic Contaminants

Incinerator ash - The incinerator ash samples contained moderate concentrations of heavy metals of environmental concern (Cd, Cr, Cu, Co, Ni, Pb, Zn). Concentrations varied from 30 ppm for Cadmium to 5900 ppm for Zinc. The leachability of these metals was however, very low, with less than 0.1% of any heavy metal leached in the DW 20:1 leach test. Surprisingly, as shown in Appendix I, use of more aggressive leaching media

PT-3 ASHES

Boiler		Economizer	
sh	Release	Ash	Release
,400	10	23,200	20.4
8000	0	12,000	0
,300	27,230	47,300	25,780
63	0	42	0
295	10	160	16
1260	980	935	860
303	0	330	0.6
10	2	10	1.2
704	74	591	8
80	1.6	95	2.4
440	0	470	0
<0.1	0	<0.1	0
,000	88,240	121,000	73,780
72.5	ND	173.8	16.0
13.1	ND	49.6	0
NA	ND	NA	0
NA	ND	NA	0
NA	13.5	NA	10.0
NA	18.7	NA	26.5

n µg/g and organic data in ng/g.

TABLE 3. ABBREVIATED LEACHING DATA FOR PT-5 ASHES

	Incinerator		Boiler (PT-6)		Economizer	
Parameter	Ash	Release	Ash	Release	Ash	Release
Lead	1700	0.4	33,600	13.6	15,500	15.4
Titanium	5812	0	7000	0	8000	0
Zinc	5900	1.4	46,400	28,600	52,400	25,720
Arsenic	12	0.3	54	0	58	0
Boron	94	1.6	325	5.4	235	13.4
Cadmium	30	0	887	920	929	800
Chromium	320	0	330	0	248	0
Cobalt	94	0	8	2	10	1.2
Copper	1624	0.8	495	178	602	42
Nickel	398	0	73	3	63	2.2
Tin	326	0	490	0	427	0
Vanadium	33	0	<0.1	0	<0.1	0
TS	2100	0	149,000	77,040	132,000	90,400
Total Cl Dioxins	ND	0	288	0	1299	26
Total Cl Furans	ND	0	22.4	0	38.5	0
PCB's	ND	NA	NA	0	NA	0
Chlorophenols	ND	NA	NA	0	NA	0
Chlorobenzenes	35.5	NA	NA	8.04	NA	6.44
PAH's	1905	NA	NA	23	NA	52.6

Note: All inorganic data is expressed in µg/g and organic data in ng/g.

TABLE 4. ABBREVIATED LEACHING DATA FOR PT-9 ASHES

	Incinerator		Boiler		Economizer	
Parameter	Ash	Release	Ash	Release	Ash	Release
Lead	4300	0.6	19,900	9	28,300	14.6
Titanium	9289	0	8000	0	10,000	0
Zinc	4800	2.6	40,100	17,680	41,800	15,600
Arsenic	11	0	57	0	53	0
Boron	149	0.6	250	3.6	300	16
Cadmium	46	0	746	660	835	720
Chromium	139	0	385	0	413	0.6
Cobalt	62	0	7.5	2.4	10	0
Copper	2202	0.8	402	34	531	8.4
Nickel	226	0	65	2	63	1.6
Tin	322	0	468	0	484	0
Vanadium	58	0	<0.1	0	<0.1	0
TS	4788	0	147,000	77,960	136,000	86,480
Total Cl Dioxins	ND	0	49.3	0	161.3	52
Total Cl Furans	ND	0	5.3	0	46.5	0
PCB's	ND	0	NA	0	0	0
Chlorophenols	ND	0	NA	0	14	0
Chlorobenzenes	36	10.4	NA	320	23.0	9.20
PAH's	11,969	40.3	NA	243.5	245	74.4

Note: All inorganic data is expressed in µg/g and organic data in ng/g.

TABLE 5. ABBREVIATED LEACHING DATA FOR PT-12 ASHES

	Incinerator		Boiler		Economizer	
Parameter	Ash	Release	Ash	Release	Ash	Release
Lead	1600	0.4	32,800	9	36,100	17.6
Titanium	6780	0	8000	0	8,000	0
Zinc	7600	0.4	46,800	29,920	46,800	28,600
Arsenic	10	0.2	42	0.2	100	0
Boron	252	5	312	5	242	16
Cadmium	16	0	992	1060	945	840
Chromium	108	0	330	0	330	0
Cobalt	48	0	7.5	2.4	10	1
Copper	700	0	512	148	605	98
Nickel	180	0	60	3	58	3
Tin	308	0	466	0	504	0
Vanadium	38	0	<0.1	0	<0.1	0
TS	3352	500	155,000	85,960	139,000	83,200
Total Cl Dioxins	ND	0	201.6	0	324.1	240
Total Cl Furans	ND	0	16.5	0	76.6	0
PCB's	64.4	NA	0	0	0	0
Chlorophenols	0	NA	14.4	0	0.3	0
Chlorobenzenes	14.3	NA	47.2	7.87	295	30.4
PAH's	13,819	NA	24.0	35.5	27.0	28.5

Note: All inorganic data is expressed in µg/g and organic data in ng/g.

generally had little effect on contaminant release, with the exception of Zn, Pb, and Cu, where up to 80% of these metals were leached by the aggressive synthetic leachate.

Boiler and economizer fly ash - The fly ashes showed significant concentrations of most heavy metal. Compared to the incinerator ash, there was significant classification of lead, zinc, arsenic, boron, cadmium and chromium to these fly ashes. However, compared to the incinerator ashes the fly ashes had lower concentrations of cobalt, copper and nickel.

In contrast to the results from the incinerator ashes, a simple DW leach solubilized up to 100% of the cadmium, 63% of the Zn, 36% of the Cu and 32% of the cobalt in the fly ashes. Use of more aggressive acidic and synthetic leachates increased the solubilization of copper, up to 60%.

Process trends/interactions - The leachability of selected heavy metals in boiler and economizer fly ashes, as a function of secondary chamber temperature, are depicted in Figures 2 and 3. It is evident that leachability decreases as secondary chamber temperature increases. The trend appears to be stronger for the economizer fly ashes. This trend is probably due to respeciation of the metals as less soluble oxides or silicates at the higher temperature.

Organic contaminants

The organic contaminant data base is not as complete as for the inorganics due to the fact that not all leachates were analyzed and that many of the boiler and economizer fly ash samples analyzed were not those leached at the WTC. Nonetheless some data interpretation is possible.

Incinerator ash - Chlorinated dioxins and furans were not detected in any of the incinerator ash samples, and not surprisingly, no dioxins or furans were detected in the leachates. The only leachate sample

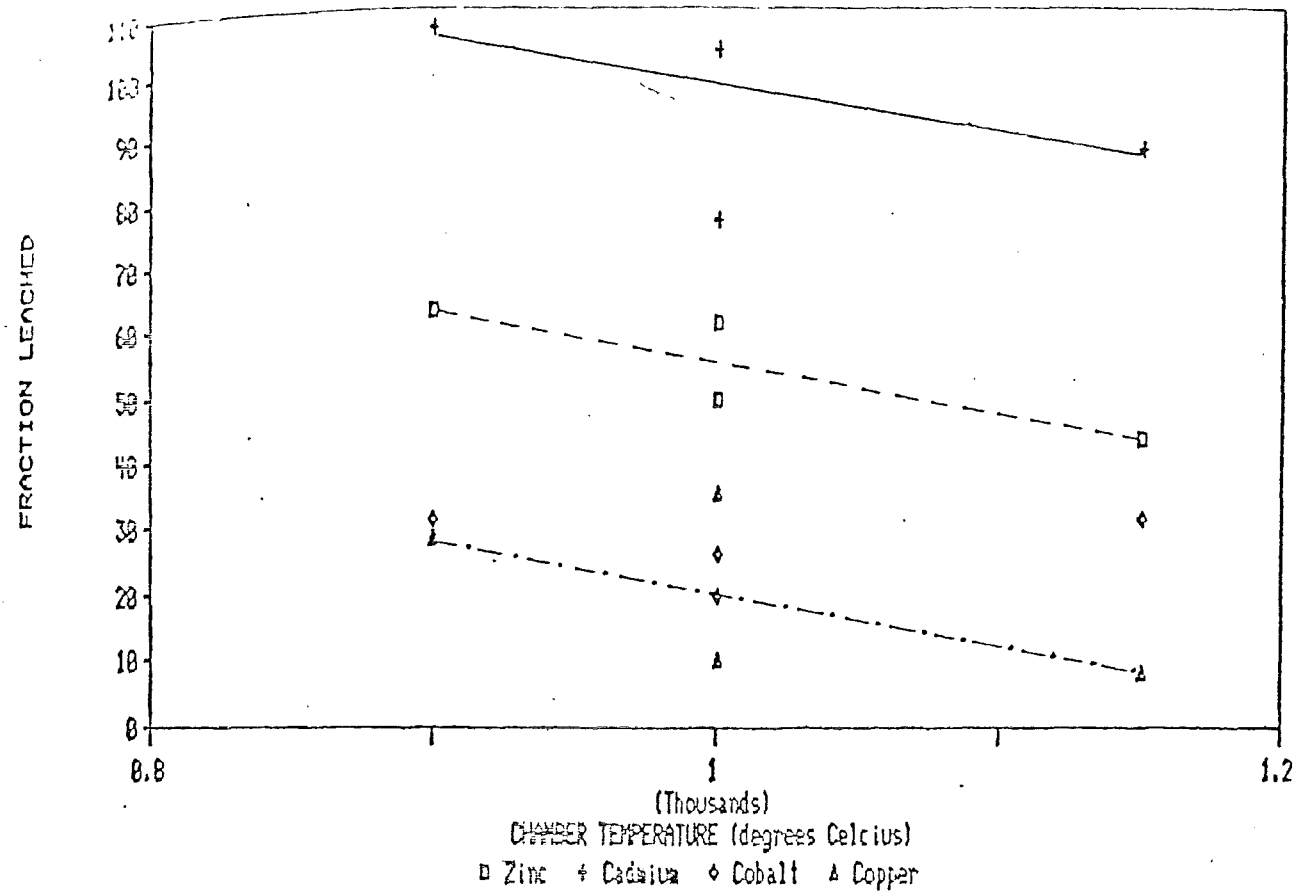

FIGURE 2. BOILER ASH METAL LEACHABILITY

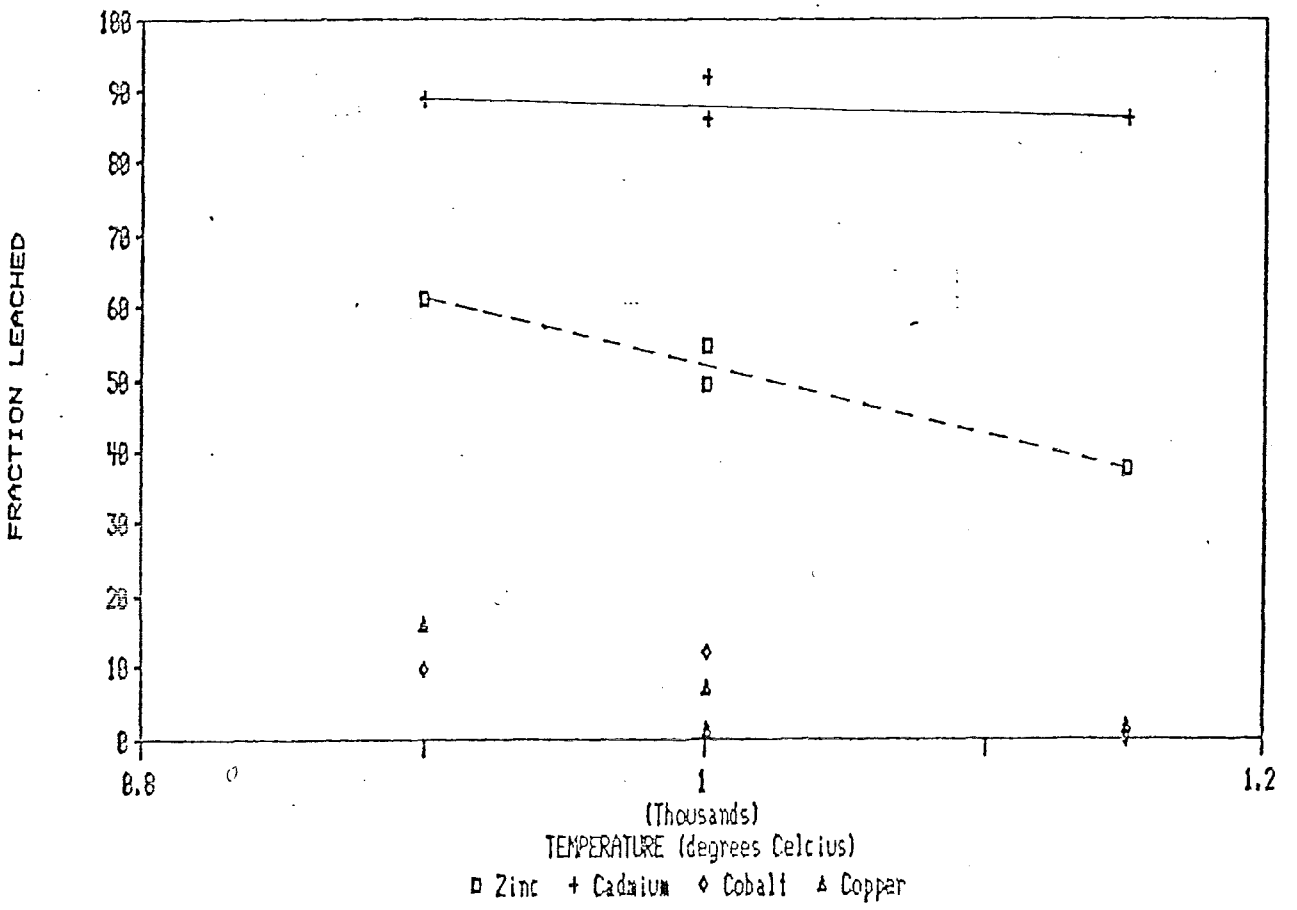

FIGURE 3. ECONOMIZER ASH METAL LEACHABILITY

analyzed for other organics (PT9) revealed low levels PAH's and chlorobenzenes to be present. One surprising fact was the very low concentrations of PAH's in the incinerator ashes. Review of Tables 2, 3 4 and 5 indicate maximum total PAH's of only 14 µg/g.

Boiler and economizer fly ashes - Significant quantities of both dioxins and furans were detected in these ashes. Surprisingly, however, dioxins but not furans, were detected only in economizer fly ash leachates. Also surprising, is the fact that up to 79% of the economizer fly ash dioxin content could be leached (PT12). Compared to the incinerator ashes, the fly ashes had much lower PAH concentrations but higher chlorobenzene concentrations. Also, significant fractions of both the PAH's and chlorobenzenes were leached.

Process interactions - Figure 4 depicts the dioxin leaching efficiencies from the economizer fly ash as a function of secondary chamber temperature, indicating a minimum at 1000°C. There is no apparent explanation for this observation.

SUMMARY AND CONCLUSIONS

Based on this limited assessment of ash contaminant leachability it appears that the incinerator ash is a relatively benign solid waste. The inorganic contaminants are not readily solubilized, even with aggressive leaching media. No chlorinated dioxins or furans were detected in these ashes. By contrast, the boiler and economizer fly ashes contain very high concentrations of heavy metals, many of which are readily solubilized by a non-aggressive leaching media. Of most concern is the fact that in excess of 80% of the cadmium in these ashes is water soluble. Furthermore, significant concentrations of chlorinated dioxins and furans

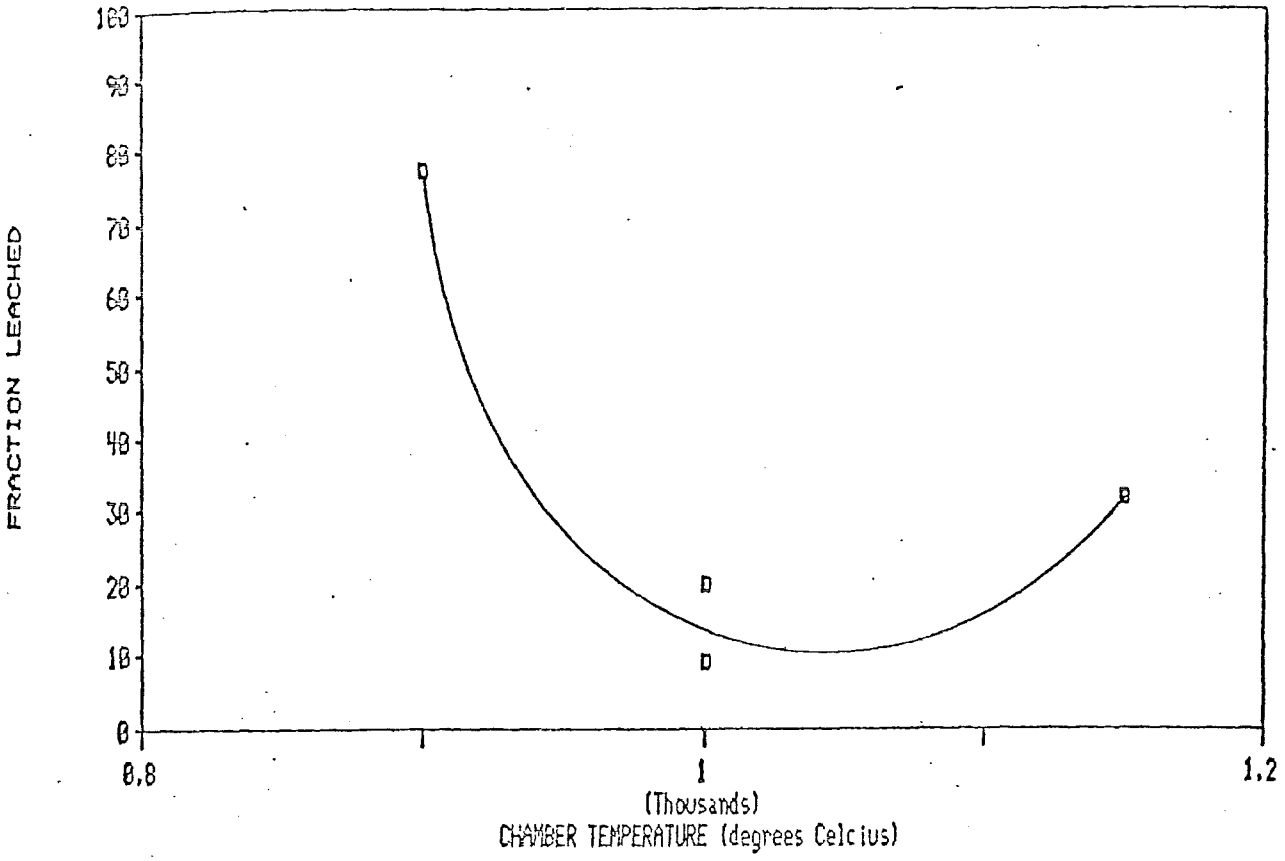

FIGURE 4. ECONOMIZER ASH DIOXIN LEACHABILITY

were detected. Surprisingly, up to 70% of the dioxins in the economizer fly ashes were water soluble.

RECOMMENDATIONS

1. In future NITEP ash leachability studies it is recommended that tests be conducted to identify how the metals are speciated. A test such as the WTC Sequential Chemical Extraction is suggested.
2. Abbreviated MBLP testing is indicated. There is apparently no value in conducting leaching tests using acidic or synthetic leaching media.
3. Organic contaminant analyses should be minimized in future leaching studies. If possible, dioxin, furan, PAH and chlorobenzene concentrations should only be reported as totals.
4. Based on the preliminary findings, it is recommended that IPB consider developing solid waste management criteria for fly ashes from MSW incinerators.

REFERENCES

1. P.L. Côté and T.W. Constable, "Development of a Canadian Data Base on Waste Leachability", Resources and Conservation 9, 1982.
2. NITEP Contractors Report.