



Memo: Chemical composition of European bio ashes

Introduction

The purpose of the BioCrete project is to increase the reuse of bio ash (sewage sludge incineration ash) for the production of concrete by improving the characterization and documentation of technical and environmental properties of bio ash concrete. The tests and the examinations of bio ash concrete have been performed on samples with bio ash from two different Danish WWTPs.

The used types of Danish bio ash have been analyzed as part of the project, and in order to evaluate how these types compare to other European bio ashes, an effort has been made to collect analytical bio ash data from a number of European WWTPs with sludge incineration.

Method

Using our own network as well as new useful contacts established during the conference in Moncton June 2007¹ requests and questionnaires have been sent to contact persons at institutes or WWTPs in Austria, Denmark, England, France, Germany, Holland, Italy and Switzerland.

We got answers from most contact persons. Not all were able to supply us with data, mainly because they did not analyze the ash (or may be only heavy metals). Others gave us data, but preferred to be anonymous (except for the country). For 5 of the ash samples (ID no. 2, 4, 5, 6 and 16) the received information and identification is presented in the questionnaire format, and for all 17 samples, most of the received chemical analytical data are shown in the table 1 (next page).

It must be emphasized that the data should be considered just to give an order of magnitude. No attempt has been made in order 'dig in' behind the data, i.e. evaluate possible differences between the WWTP sludges, sampling routines and the used analytical methods, preconditions which do influence the comparisons.

Results

The chemical composition of the 17 samples of European bio ash is quite uniform and consistent.

With respect to the abundant elements, phosphorus is an important component, because a major purpose of WWTPs is to remove phosphorus from the wastewater; the typical level is 15 – 25 weight percent as P₂O₅. This removal is partly based on the hardness of the water, i.e. calcium (and magnesium), and mainly on the addition of iron or aluminium salts. Thus, some ashes are high in iron content and low in aluminium content – and vice versa. A high content of calcium can be attributed to the use of alkaline calcium compounds for the cleaning of the incineration flue gas.

The sum of the oxides of silicon, aluminium and iron is shown in the table, because this is used as a quality parameter for the use of fly ash for concrete production.

The levels for the more important heavy metals also seem to be quite consistent, mercury being the only exception. All modern (and legal) incineration plants remove mercury from the flue gas in a separate second stage, i.e. it is possible to produce an ash with < 0.1 mg/kg mercury. However, in some cases the mercury containing secondary ash or residue is mixed in with the primary ash.

¹ IWA Specialist Conference on Wastewater Biosolids. Moncton, New Brunswick, Canada. 24-27 June 2007, where the BioCrete project was presented as a Danish case study.

Memo: Chemical composition of European bio ashes. Table 1

Analytical Parameter		Bio ash sample ref. ID number and origin (country)																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Name	Unit	EU	DK	DK	DK	DK	NL	NL	NL	DE	DE	DE	CH	CH	CH	CH	FR	UK
Iron as Fe ₂ O ₃	% w/w	10	15	6,5	11	4,1	16	5	16	2,8	23	21	27	3	14		4	
Aluminium as Al ₂ O ₃	% w/w	10	6,5	13	8	20	6,5	9	6,5	15,5	6,5	6,5	8	34	13		11	
Fe/(Fe+Al)	w/w	0,6	0,8	0,4	0,6	0,2	0,8	0,4	0,8	0,2	0,8	0,8	0,8	0,1	0,6		0,3	
Silicon as SiO ₂	% w/w	35	23	35	28	31	22	19	23	38	24	21	25	25	15		38	
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	% w/w	56	45	55	47	55	45	33	46	56	53	48	60	62	42		53	
Calcium as CaO	% w/w	23	20	16	14	14	16	19	13	16	15	12	14	11	32		20	
Phosphorus as P ₂ O ₅	% w/w	16	27	22	24	18	24	25	23	20	19	25	20	20	9	14	15	
Zinc as Zn	mg/kgTS		1800	1500	2300	1700	2300	2100	2200	1800	2200	1600	1800	2400	1200	2600	3000	3700
Copper as Cu	mg/kgTS		700	450	600	600	1100	1000	1000	950	1250	500	550	900	750	900		1200
Lead as Pb	mg/kgTS		120	180	170	130	270	200	260	120	135	110	270	250	550	170	450	1100
Chromium as Cr	mg/kgTS		90	40	50	40	120	110	130	70	90	90				110	150	700
Nickel as Ni	mg/kgTS		75	45	40	28	70	75	100	45	40	40				60		140
Arsenic as As	mg/kgTS		15	11	4		22	17	40	13	16	4					15	50
Cadmium as Cd	mg/kgTS		5	3	3	3	4	3	4	4	3	2				3	7	8
Mercury as Hg	mg/kgTS		4	7	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	0,2	< 0,1	< 0,1				< 0,1	10	5

Country code
CH Switzerland
DE Germany
DK Denmark
EU 'Europe'
FR France
NL Holland
UK England

Ref. ID	1	Average/typical data for 15 European ashes, see Christian Schaum paper in Moncton IWA Conference Proceedings p. 583
	2-4	The "BioCrete" Project: 2 AWS, 3 light bio ash (see task 3b), 4 LYNIS, see questionnaires for no. 2 and 4
	5	Sabina Lind personal communication: see questionnaire for no. 5
	6	Leon Korving personal communication: see questionnaire for no. 6
	7-11	Christian Adam personal comm.: Data from table 1 in paper (september 2007) from the "SUSAN" project
	12-14	Simone Nanzer personal comm.: Data for 3 types of ashes (Fe, Al and Ca) from the "PHOSKRAFT" project
	15	Natalija Miladinovic personal comm.: Data from the "NEPTUNE" project
	16	Typical data from 4 French incineration plants, see questionnaire for no.16
	17	Mike Farrimond (from UKWIR) personal comm.: Average/typical data for approx. 10 English incineration plants



Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants (Bio ash ID no. 2)

1. Contact

- 1.1 Name of plant: *Avedoere Wastewater Services (Spildevandscenter Avedøre I/S)*
- 1.2 Town and country: *Copenhagen, Denmark*
- 1.3 Contact person: *Dan Kjersgaard*
- 1.4 Phone and e-mail: *+45 3634 3854. dk@spvand.dk*
- 1.5 Homepage: *www.spildevandscenter.dk*

2. Wastewater Treatment Plant

- 2.1 Load (e.g. PE_{BOD60}): *250.000 PE_{BOD60} and 26.000.000 m^3 /year (2006).*
- 2.2 Main processes: *Mechanical, biological/chemical treatment, mesophilic sludge digestion.*
- 2.3 Precipitant for P removal: *Fe as $FeClSO_4$ -solution, i.e. iron in the oxidation state of +3.*
- 2.4 Additional comments: *The wastewater composition: 75% household and 25% industry.*

3. Sludge Incineration Plant

- 3.1 Type of process: *Fluid-bed oven operated at 850°C; electro filter and bag filter.*
- 3.2 Amount of ashes: *2.200 t/year (2006).*
- 3.3 Ashes disposal/use: *50% for controlled land filling and 50% for concrete production (2006).*

4. Analytical data for the ashes

Average values 2006

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
<i>Iron as Fe_2O_3</i>	<i>% w/w</i>	<i>15</i>	<i>Zinc as Zn</i>	<i>mg/kg</i>	<i>1800</i>
<i>Aluminium as Al_2O_3</i>	<i>% w/w</i>	<i>6,5</i>	<i>Copper as Cu</i>	<i>mg/kg</i>	<i>700</i>
<i>Silicon as SiO_2</i>	<i>% w/w</i>	<i>23</i>	<i>Lead as Pb</i>	<i>mg/kg</i>	<i>120</i>
<i>Calcium as CaO</i>	<i>% w/w</i>	<i>20</i>	<i>Chromium as Cr</i>	<i>mg/kg</i>	<i>90</i>
<i>Phosphorus as P_2O_5</i>	<i>% w/w</i>	<i>27</i>	<i>Nickel as Ni</i>	<i>mg/kg</i>	<i>75</i>
			<i>Cadmium as Cd</i>	<i>mg/kg</i>	<i>5</i>
			<i>Mercury as Hg</i>	<i>mg/kg</i>	<i>4</i>

Date for completing the questionnaire: 2007-08-28



Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants (Bio ash ID no. 4)

1. Contact

- 1.1 Name of plant: *Lynettefællesskabet I/S, WWTP Lynetten and WWTP Damhusåen*
- 1.2 Town and country: *Copenhagen, Denmark*
- 1.3 Contact person: *Kim Rindel*
- 1.4 Phone and e-mail: *+45 3268 5640. kr@lyn-is.dk*
- 1.5 Homepage: *www.lyn-is.dk*

2. Wastewater Treatment Plant (sum of both plants)

- 2.1 Load (e.g. PE_{BOD60}): *1.300.000 PE_{BOD60} and 94.000.000 m^3 /year (2006)*
- 2.2 Main processes: *Mechanical, biological/chemical treatment, mesophilic sludge digestion.*
- 2.3 Precipitant for P removal: *Fe as JKL ($FeClSO_4$ -solution) and aluminium as PAX-14.*
- 2.4 Additional comments:

3. Sludge Incineration Plant

- 3.1 Type of process: *Multiple hearth oven followed by electro filter and bag filter*
- 3.2 Amount of ashes: *6.600 t/year (2006)*
- 3.3 Ashes disposal/use: *Controlled land filling and various reuse (2006)*

4. Analytical data for the ashes Average values 2006

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	% w/w	11	Zinc as Zn	mg/kg	2300
Aluminium as Al_2O_3	% w/w	8	Copper as Cu	mg/kg	600
Silicon as SiO_2	% w/w	28	Lead as Pb	mg/kg	170
Calcium as CaO	% w/w	14	Chromium as Cr	mg/kg	50
Phosphorus as P_2O_5	% w/w	24	Nickel as Ni	mg/kg	40
			Cadmium as Cd	mg/kg	3
			Mercury as Hg	mg/kg	< 0,1

Date for completing the questionnaire: 2007-08-30 by DK



Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants (Bio ash ID no. 5)

1. Contact

- 1.1 Name of plant: *WWTP Lundtofte*
1.2 Town and country: *Lyngby, Denmark*
1.3 Contact person: *Palle Jørgensen, Sabina Lind*
1.4 Phone and e-mail: *+45 4587 8691. sl@ltk.dk*
1.5 Homepage: *www.renslundtofte.dk*

2. Wastewater Treatment Plant

- 2.1 Load (e.g. PE_{BOD60}): *110.000 PE_{BOD60}*
2.2 Main processes: *Mechanical, biological/chemical treatment, anaerobic sludge digestion*
2.3 Precipitant for P removal: *Aluminium as PAX*
2.4 Additional comments:

3. Sludge Incineration Plant

- 3.1 Type of process: *Fluid-bed oven followed by cyclone and bag filter*
3.2 Amount of ashes: *440 + 330 t/year (cyclone ash + bag filter ash, 2005)*
3.3 Ashes disposal/use: *In big bags to RGS90*

4. Analytical data for the ashes *Heavy metals: cyclone ash average values 2005*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
<i>Iron as Fe_2O_3</i>	<i>% w/w</i>	<i>4,1</i>	<i>Zinc as Zn</i>	<i>mg/kg</i>	<i>1700</i>
<i>Aluminium as Al_2O_3</i>	<i>% w/w</i>	<i>20</i>	<i>Copper as Cu</i>	<i>mg/kg</i>	<i>600</i>
<i>Silicon as SiO_2</i>	<i>% w/w</i>	<i>31</i>	<i>Lead as Pb</i>	<i>mg/kg</i>	<i>130</i>
<i>Calcium as CaO</i>	<i>% w/w</i>	<i>14</i>	<i>Chromium as Cr</i>	<i>mg/kg</i>	<i>40</i>
<i>Phosphorus as P_2O_5</i>	<i>% w/w</i>	<i>18</i>	<i>Nickel as Ni</i>	<i>mg/kg</i>	<i>28</i>
<i>(Data for 1 sample of cyclone ash 020301)</i>			<i>Cadmium as Cd</i>	<i>mg/kg</i>	<i>3</i>
			<i>Mercury as Hg</i>	<i>mg/kg</i>	<i>< 0,1</i>

Date for completing the questionnaire: *2007-08-29 based upon interview by DK 2006-09-06*



Project BioCrete

Task ID: 3a
Date: 2007-09-24
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants (Bio ash ID no. 6)

1. Contact

- 1.1 Name of plant: *N.V. Slibverwerking Noord-Brabant*
- 1.2 Town and country: *Moerdijk, Holland*
- 1.3 Contact person: *Leon Korving*
- 1.4 Phone and e-mail: *korving@snb.nl*
- 1.5 Homepage: *www.snb.nl*

2. Wastewater Treatment Plant

- 2.1 Load (e.g. PE_{BOD60}): *Approx. 4 million PE, and approx. 50 WWTP's*
- 2.2 Main processes:
- 2.3 Precipitant for P removal: *Fe as well as Al*
- 2.4 Additional comments:

3. Sludge Incineration Plant

- 3.1 Type of process: *Fluid bed incinerator (4 lines)*
- 3.2 Amount of ashes: *36.000 t/y*
- 3.3 Ashes disposal/use: *Asphalt filler (70%), German salt mine filler material (30%).*

4. Analytical data for the ashes

Average values 2004-2006

SiO₂ as balance

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
<i>Iron as Fe₂O₃</i>	<i>% w/w</i>	<i>14</i>	<i>Zinc as Zn</i>	<i>mg/kg</i>	<i>2300</i>
<i>Aluminium as Al₂O₃</i>	<i>% w/w</i>	<i>10</i>	<i>Copper as Cu</i>	<i>mg/kg</i>	<i>1100</i>
<i>Silicon as SiO₂</i>	<i>% w/w</i>	<i>26*</i>	<i>Lead as Pb</i>	<i>mg/kg</i>	<i>270</i>
<i>Calcium as CaO</i>	<i>% w/w</i>	<i>21</i>	<i>Chromium as Cr</i>	<i>mg/kg</i>	<i>120</i>
<i>Phosphorus as P₂O₅</i>	<i>% w/w</i>	<i>19</i>	<i>Nickel as Ni</i>	<i>mg/kg</i>	<i>70</i>
			<i>Cadmium as Cd</i>	<i>mg/kg</i>	<i>4</i>
			<i>Mercury as Hg</i>	<i>mg/kg</i>	<i>< 0,1</i>

Date for completing the questionnaire: *2007-09-10 (and 2007-09-24 by DK)*



Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants (Bio ash ID no. 16)

1. Contact

- 1.1 Name of plant: *4 plants: Saint-Fons and Pierre-Benite, Petit-Quevilly and Strasbourg*
- 1.2 Town and country: *Lyon, Rouen and Strasbourg, France*
- 1.3 Contact person: *Eric Guibelin from Veolia Water / OTV*
- 1.4 Phone and e-mail: *+33 (0)1 7133 3196. eric.guibelin@veoliaeau.fr*
- 1.5 Homepage: *None. Research Program CIBSTEP 1999-2000 (reuse for concrete)*

2. Wastewater Treatment Plant

- 2.1 Load (e.g. PE_{BOD60}):
- 2.2 Main processes:
- 2.3 Precipitant for P removal:
- 2.4 Additional comments:

3. Sludge Incineration Plant

- 3.1 Type of process: *Fluid bed ovens built by Veolia Water (?)*
- 3.2 Amount of ashes: *40.000 t/year (?) as the product "Fluofill™ Le filler actif"*
- 3.3 Ashes disposal/use: *Concrete production and Road constructions (?)*

4. Analytical data for the ashes

Values probably from 1999

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
<i>Iron as Fe₂O₃</i>	<i>% w/w</i>	<i>4</i>	<i>Zinc as Zn</i>	<i>mg/kg</i>	<i>270-6200</i>
<i>Aluminium as Al₂O₃</i>	<i>% w/w</i>	<i>11</i>	<i>Copper as Cu</i>	<i>mg/kg</i>	
<i>Silicon as SiO₂</i>	<i>% w/w</i>	<i>38</i>	<i>Lead as Pb</i>	<i>mg/kg</i>	<i>220-680</i>
<i>Calcium as CaO</i>	<i>% w/w</i>	<i>20</i>	<i>Chromium as Cr</i>	<i>mg/kg</i>	<i>90-200</i>
<i>Phosphorus as P₂O₅</i>	<i>% w/w</i>	<i>15</i>	<i>Nickel as Ni</i>	<i>mg/kg</i>	
			<i>Cadmium as Cd</i>	<i>mg/kg</i>	<i>3-12</i>
			<i>Mercury as Hg</i>	<i>mg/kg</i>	<i>0-47</i>

Date for completing the questionnaire: *2007-08-30, ref. Fluofill and CIBSTEP brochures 2001.*