38/15
Blasenbauer, D.; Purgar, A.; Winter, F. (2015) “A MSW incineration fly ash washing procedure in lab scale”, In: CD-Proceedings “ERIN, The 9th International Conference for Young Researchers and PhD Students”, May 4-6, 2015, Monínec, Czech Republic, p. 1-7.

ERIN, The 9th International Conference for Young Researchers and PhD Students
May 4-6, 2015, Monínec, Czech Republic

A MSW INCINERATION FLY ASH WASHING PROCEDURE IN LAB SCALE

ERIN 2015, 4-6 MAY, 2015, MONÍNEC, CZECH REPUBLIC

Dominik BLASENBAUER [1,2], *Amon PURGAR* [1,2], *Franz WINTER* [2]

[1] *Christian Doppler Laboratory for Anthropogenic Resources, Vienna University of Technology, Karlsplatz 13/226, 1040 Vienna, Austria*

Email:dominik.blasenbauer@tuwien.ac.at

[2] *Institute of Chemical Engineering, Vienna University of Technology, Getreidemarkt 9/166, 1060 Vienna, Austria*

In Austria approximately 2 million tons of municipal solid waste, hazardous waste and communal sewage sludge are incinerated annually. Beside slag and filter cake, more than 40 thousand tons of fly ash emerges, which are considered to be hazardous waste due to Austrian and European Union Law. As a result, if their non-hazardous character cannot be proven, these fly ashes have to be disposed of in landfills for hazardous wastes or have to be stabilized prior to their disposal on a landfill for non-hazardous waste. There are two types of criteria a waste has to fulfil to be valid for landfilling on a non-hazardous waste landfill in Austria. The total contents and the eluate properties. Eluate testing is a leaching test, measuring the mobility of certain components in aqueous environments. This work focuses on inorganic components in the fly ash.

Washing procedures like the MR, 3R or the FLUWA process are alternatives to the stabilization process. All of these procedures require a wet flue gas cleaning system, which is installed in all Austrian MSW incineration plants, except for one. These treatment methods have been developed, realized and investigated for decades, though it is almost impossible to precisely predict the characteristics of the washed fly ash regarding landfill criteria. Lab scale investigations for a fly ash stream are necessary prior to a realization in industrial scale.

Major components of all the named processes are a liquid-solid extraction of the fly ash and a subsequent separation of the solid and the liquid phase. A lab scale facility for the wet chemical treatment of MSW incineration fly ashes was built and operated to investigate the effect of the washing process on different fly ash samples. Within this work it is shown that a minor fraction of heavy metals is extracted by this washing procedure. Though a major amount of salts, preventing the fly ash from being landfilled, are extracted. The results of the investigation indicate that depending on the fly ash treated a simple washing procedure might produce residues that are allowed to be disposed of at a non-hazardous waste landfill.

Keywords: MSW incineration, fly ash, landfilling, liquid-solid extraction

1 INTRODUCTION

In Austria 12 waste incineration plants with a total capacity of around 3,1 million tons/a are operated [1]. These plants incinerate mainly municipal solid waste (MSW), commercial and industrial waste, hazardous waste and sewage sludge. Although waste incineration causes a major reduction of waste mass to be landfilled, approximately 20 % remain as slag, 3-4 % as fly ash and less than one percent as filter cake [2]. This work focuses on fly ashes, which are subtracted from the flue gas in the boiler flues and the subsequent filter system.

According to the Austrian Register for Hazardous Waste (ARHW), *fly ashes or dusts from MSW waste incineration plants (No. 31309)* are classified as hazardous waste and therefore have to be disposed of on landfills for hazardous waste [3],[4]. To get a general exemption of this classification it is obligatory that all criteria of enclosure 2 of the ARHW are not fulfilled. Concerning fly ash, criteria H13 seems to be the most critical preventing an exemption from this regulation. The major parameter of this criterion is the content in the eluate, where the elements As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn and Zn have to be considered. Additionally the total content of Hg, As, Pb and Cd in the fly ash have to be considered. Besides the mentioned inorganic elements, the total dissolved solids (TDS) and the pH-value of the eluate are important characteristics concerning the ARHW. A summary of the named parameters can be found in Tab. 1 (total contents) and in Fig. 3 (eluate values). Also requirements on organic compounds, cyanide, nitrite, fluoride and phosphate can be found in the ARHW, but are not discussed within this work. The ARHW often refers to the Austrian Landfill Ordinance (ALO) where certain criteria are specified in detail.

Except fly ashes from fluidized bed combustors, non-treated fly ashes from MSW incineration plants generally do not meet the criteria for disposal on a landfill for non-hazardous waste [5]. Therefore processes for treating fly ashes have been investigated and realized for decades [6]. In Austria the most common approach is a solidification/stabilization (S/S) process [2]. Ashes, which do not meet the criteria for a disposal on a landfill for non-hazardous waste, are either going to subsurface landfills for hazardous waste or to the S/S process. Fly ash, cement, slag and water are mixed together to form a matrix that stabilizes the elements to prevent leaching at the landfill. Fly ashes that are meeting the criteria for a disposal on a landfill for non-hazardous waste without prior treatment are going to a conditioning process. Mixed with water to reduce the formation of dust at the landfill, these ashes can be disposed of on a residue landfill.

An alternative to the S/S process is a wet chemical fly ash treatment process like the 3R, MR or FLUWA process. All these processes have one particular thing in common. They are using the acidic scrubber water from the wet flue gas cleaning system for a liquid – solid extraction. After the extraction step, the solid and liquid phases are separated on a vacuum band filter [2].

Since it is hard to predict if washed fly ash is meeting the criteria for the disposal on a landfill for non hazardous waste, it is necessary to investigate each fly ash stream individually. An experimental setup based on a solid-liquid extraction of the fly ash with a subsequent separation of the solid and the liquid phase in lab scale is introduced. The aim of

this work is to introduce an experimental setup that allows the investigation of the influence of a fly ash washing procedure on fly ash quality regarding landfilling.

2 EXPERIMENTAL

Fig. 1 shows a scheme of the experimental setup. Centre of the setup is an open continuous flow stirred tank reactor that has a volume of 402ml. Fly ash and extracting agent are fed into the vessel using a dosing feeder for the fly ash and a piston pump for the extracting agent. A variation of the liquid to solid (LS) ratio and the residence time can be achieved by regulating the piston-pump and the dosing feeder. A HDPE stirrer agitates both, the fly ash and the extracting agent to ensure a homogenous environment. Also the pH value is measured in the tank reactor. The experimental unit is designed as a stationary system, the fed suspension is flowing over a level drain into a standard buechner funnel where the solid and the liquid phase are separated. The washed fly ash stays at the filter as filter cake, while the liquid phase is collected in the vacuum flask. The vacuum is provided by a standard laboratory vacuum pump. Also the pH value in the filter flask is measured.

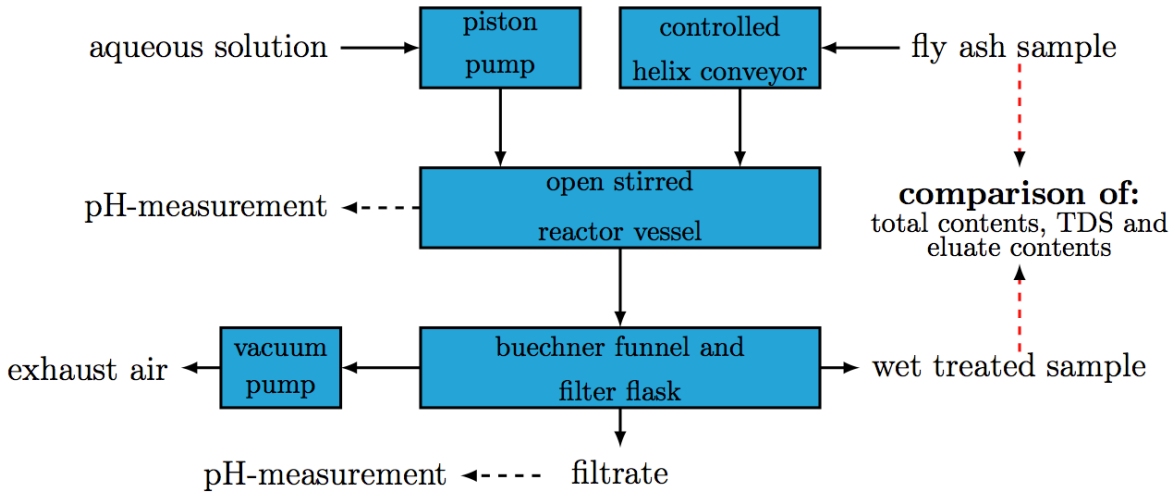

Fig. 1 *Scheme of the experimental setup. TDS…total dissolved solids*

To express the applicability of the setup a fly ash sample was taken from the electrostatic precipitator (ESP) of a grate furnace and treated with the above described setup with a LS of 10 and a residence time in the tank reactor of 10 minutes. Extracting agent in the experiment was deionised water. The treated and untreated samples were investigated for their relevant parameters concerning landfilling. The total content has been determined by aqua-regia digestion according to standard [7] and [8]. The content in the eluate has been determined following the standard [9] for producing the eluate and standard [8] for analysing it with ICP-OES. [10] was followed to determine the total dissolved solids (TDS). Fig. 2 shows a scheme of the measuring and analysing procedure. As ICP-OES a Jobin Yvon Ultima 2 analyser was used.

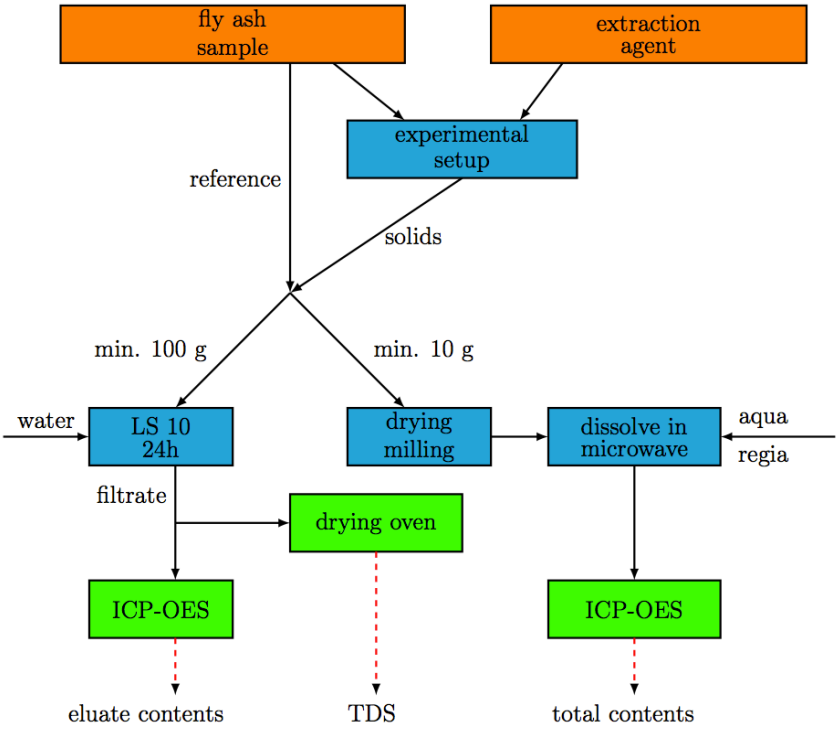

Fig. 2 *Scheme of the experimental setup and measurement techniques; TDS… total dissolved solids; dashed red lines: Information on the results of measurements;*

3 RESULTS

Tab. 1 *Eluate properties of untreated and treated (deionised water, at LS 10) fly ash sample. LV…limiting values given by the ALO; LS…liquid to solid ratio; LOD…limit of detection, DM dry matter.*

Element [-]	LV [mg/kg DM]	untreated [mg/kg DM]	treated [mg/kg DM]	LOD [mg/kg DM]
TDS	100000	260000	43000	-
pH value	12	11	11	-
Ag	1	0.01	0.09	0.01
As	2	0.1	0.1	0.06
Ba	300	4	2	0.01
Cd	1	0.05	0.02	0.01
Co	5	0.03	0.03	0.03
Cr	20	17	21	0.02
Cu	50	0.01	0.03	0.01
Hg	0.1	0.05	0.05	0.05
Mo	30	7	4	0.02
Ni	10	0.03	0.03	0.03
Pb	30	0.6	2	0.12
Sb	2.1	0.1	0.1	0.06
Se	1.5	0.2	0.2	0.06
Sn	20	0.1	0.1	0.07
Zn	100	2	1	0.03

Tab. 1 represents the result of one selected experiment. It shows the eluate properties of the treated and untreated fly ash sample and the limiting values in the eluate given by the ALO [4]. For quality evaluations of the experimental setup the limit of detection (LOD) was determined and is shown in the very right column.

The total content of several elements of the treated and untreated sample are given in Tab. 2. Limiting values for As, Cd and Hg are the values of the ALO for the deposition on a residue landfill [4].

Tab. 2 *Total content of the untreated and treated fly ash sample. DM…dry matter; LV…Limiting values given by the ALO; LOD…limit of detection*

Element [-]	LV [mg/kg DM]	untreated [mg/kg DM]	treated [mg/kg DM]	LOD [mg/kg DM]
Ag	-	76	45	0.2
As	5000	3	2	1.2
Ba	-	1300	1600	0.2
Ca	-	190000	201000	0.2
Cd	5000	310	390	0.2
Co	-	42	51	0.6
Cr	-	330	400	0.4
Cu	-	1000	1300	0.2
Fe	-	11400	14600	6
Hg	20	<1	<1	1
K	-	49300	8100	12
Mo	-	19	24	0.4
Na	-	44200	7170	6
Ni	-	60	80	0.6
Pb	-	4600	5300	2.4
Sb	-	1200	1600	1.2
Se	-	3	4	1.2
Sn	-	660	840	1.4
Zn	-	18900	24100	0.6

4 DISCUSSION

Tab. 1 shows that a washing process at this certain LS ratio lowers the value of the total dissolved solids in the eluate almost six times, compared to the untreated sample. As the TDS is an important eluate criterion of the ALO this result can be pointed out as a positive effect of the washing procedure. Explanation for this can be the high amount of water-soluble compounds such as salts from K and Na in the fly ash. A negative effect of the washing procedure can be seen for Cr in this sample. Close to the limiting value in the untreated sample, it exceeds the limiting value after the washing process.

Regarding the total content of As, Cd and Hg it can be seen that the values in the observed sample are not exceeding the limiting values of the ALO. The total content in the untreated fly ash sample is not high enough so that the washing procedure would effect it in a negative way. Therefore follows that the total contents can be seen as a non-critical criterion for exclusion regarding landfilling.

In Tab. 2 it can be seen that the concentrations of several elements are increasing caused by the washing procedure. At the washing procedure major parts of the water soluble compounds have been removed, which is indicated by the decrease of the TDS in the eluate in Tab. 1. So the increase of some concentrations is caused by the decrease of the mass by constant load of these water insoluble elements.

The limits of detection for eluate analysis, as well as the total content analysis are listed in Tab. 1 and Tab. 2. It is seen that they are low enough to draw conclusions whether a fly ash sample can be landfilled on a residue landfill or not.

5 CONCLUSION

With the introduced lab scale fly ash washing procedure, together with the selected analysis techniques, it is possible to investigate the influence of a washing procedure on a fly ash samples quality regarding landfilling. The determined parameters are the content of the total dissolved solids and the pH value in the eluate. The eluate of the fly ash samples is also determined for its contents of Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn and Zn. Organic compounds in the eluate are not investigated. The selected analysis techniques allow determining the total content of the elements As Cd and Hg, which are relevant regarding landfilling on an Austrian residue landfill (“Reststoffdeponie”). Furthermore the total content of the elements Ag, Ba, Ca, Co, Cr, Cu, K, Mo, Na, Ni, Pb, Sb, Se, Sn and Zn can be determined, gaining general information on a fly ash leaching procedure.

ACKNOWLEDGMENT

The presented work is part of a large-scale research initiative on anthropogenic resources (Christian Doppler Laboratory for Anthropogenic Resources). The financial support of this research initiative by the Federal Ministry of Economy, Family and Youth and the National Foundation for Research, Technology and Development is gratefully acknowledged. Industry partners co-financing the research center on anthropogenic resources are Altstoff Recycling Austria AG (ARA), Borealis group, voestalpine AG, Wien Energie GmbH, Wiener Kommunal-Umweltschutzprojektgesellschaft GmbH, and Wiener Linien GmbH & Co KG.

REFERENCES

[1] S. Böhmer, I. Kügler, H. Stoiber, B. Walter: Abfallverbrennung in Österreich, Statusbericht 2006, Austria, (2006).
[2] A. Chandler, T. Eighmy, J. Hartln, O. Hjelmar, Studies in environmental science/ Municipal Solid Waste Incinerator Residues, Vol. 67, ELSEVIER, (1997).
[3] Austrian Register for Hazardous Waste - Verordnung des Bundesministers für Umwelt, Jugend und Familie über die Festsetzung von gefährlichen Abfällen und Problemstoffen (Festsetzungsverordnung gefährliche Abfälle), Austria, (1997).
[4] Landfill Ordinance - Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Deponien, Austria, (2008).
[5] A. Purgar, J. Fellner, J. Lederer and F. Winter, Effect of Combustion Technology and Waste on Fly Ash, ISWA World Congress, Vienna (2013)
[6] K. Thome-Kozmienky, Aschen - Schlacken - Stäube aus Abfallverbrennung und Metallurgie, TK Verlag, Neuruppin (2013)

[7] EN13657, Characterization of Waste, Digestion for subsequent determination of aqua regia soluble portion of elements (2012).
[8] EN11885, Characterization of Waste, Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES) (2009).
[9] EN 12457/4, Characterization of waste - Leaching; Compliance test for leaching of granular waste materials and sludges - Part 4: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 10 mm (2002).
[10] EN15216, Characterization of waste - Determination of total dissolved solids (TDS) in water and eluates (2007).