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1 Influence of moisture content and temperature on degree of
2 carbonation and the effect on Cu and Cr leaching from
3 incineration bottom ash

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21 ABSTRACT: This study investigated the influence of moisture content and temperature on
22 the degree of carbonation of municipal solid waste (MSW) incineration bottom ash (IBA)
23 from two different incineration plants in Singapore. The initial rate of carbonation was
24 affected by the nominal moisture content used. Carbonation temperature seemed to play a
25 part in changing the actual moisture content of IBA during carbonation, which in turn
26 affected the degree of carbonation. Results showed that 2 hours of carbonation was sufficient
27 for the samples to reach a relatively high degree of carbonation that was close to the degree
28 of carbonation observed after 1 week of carbonation. Both Cu and Cr leaching also showed
29 significant reduction after only 2 hours of carbonation. Therefore, the optimum moisture
30 content and temperature were selected based on 2 hours of carbonation. The optimum
31 moisture content was 15% for both incineration plants while the optimum temperature was
32 different for the two incineration plants, at 35°C and 50°C. The effect on Cu and Cr leaching
33 from IBA after accelerated carbonation was evaluated as a function of carbonation time.
34 Correlation coefficient, Pearson's R, was used to determine the dominant leaching
35 mechanism. The reduction in Cu leaching was found to be contributed by both formation of
36 carbonate mineral and reduction of DOC leaching. On the other hand, Cr leaching seemed to
37 be dominantly controlled by pH.

38

39 KEYWORDS: Incineration bottom ash; Accelerated carbonation; Degree of carbonation;
40 Leaching; Municipal solid waste

41

42 1. INTRODUCTION

43 Over the past three decades, the population of Singapore has increased tremendously. This
44 growth has inevitably brought about the challenge of handling an exponential increase of
45 municipal solid waste (MSW). Currently in Singapore, incineration is used concurrently with

46 landfilling and other alternative waste management technologies. However, incineration
47 produces undesirable end products, i.e. incineration bottom ash (IBA) and fly ash (IFA),
48 which have to be disposed of properly. In Singapore, both IBA and IFA are now landfilled. In
49 recent years, Singapore has been exploring ways to utilise IBA due to the scarcity of land.

50 According to European Waste Catalogue, IBA is classified as a non-hazardous waste and
51 hence, can be utilised after proper treatment. Natural weathering, a simple IBA treatment
52 process, is one of the treatment technologies commonly used in countries that utilise IBA
53 (Chandler et al., 1997). However, natural weathering is a slow process that takes months to
54 complete. In view of the difficulty of finding a sufficient large land to age IBA in land-scarce
55 Singapore, accelerated carbonation would be a more attractive alternative treatment
56 technology instead. The main advantage of accelerated carbonation over natural weathering is
57 that the process can be expedited to days or even hours while still achieving similar efficacy
58 in heavy metal leaching reduction. This will avoid the need of a large piece of land for
59 weathering.

60 The accelerated carbonation process can be shortened through optimising operating
61 conditions, such as concentration of CO₂, pressure, moisture content, and temperature, to
62 expedite the carbonation process (Fernández Bertos et al., 2004a).

63 The influence of these operating conditions on the kinetics of accelerated carbonation has
64 been studied individually. Generally, the rate of carbonation increases with increasing CO₂
65 concentration, but this does not increase the amount of CO₂ sequestered (Rendek et al.,
66 2006). The effect of moisture content and temperature on accelerated carbonation had been
67 investigated for their optimum operating range (Rendek et al., 2006; Fernández Bertos et al.,
68 2004b, Van Gerven et al., 2005). Moisture is necessary for the dissolution of CO₂ and
69 Ca(OH)₂ in aqueous phase and for the carbonate formation at ambient temperature (Sun et al.,
70 2008). Mostbauer (2014) showed that dry wood ashes did not react with CO₂ while Prigiobbe

et al. (2009) showed that carbonation can take place in the gas-solid phase for APC residues, but the process was only effective above 300°C. However, when moisture content is too high, the carbonation reaction will be retarded due to the low diffusivity of CO₂ in water to the IBA particle surface (Sun et al., 2008). Higher temperature increases the dissolution of Ca²⁺ ions but decreases the solubility of CO₂ (Fernández Bertos et al., 2004a). In summary, studies have shown that the optimum range for moisture content was between 5-60% (Costa et al., 2007), and temperature was best below 60°C (Fernández Bertos et al., 2004a).

However, the range of the optimum operating conditions is still wide and varies across studies. Fernández Bertos et al. (2004b) found that the optimum moisture content was 30-40% for IBA size fraction <710 µm. Van Gerven et al. (2005) carried out accelerated carbonation treatment on 0.1-2 mm size fraction of IBA. In terms of leaching results, the optimum moisture content and temperature was 13-25% and 50°C respectively. Rendek et al. (2006) reported the optimum moisture content for <4 mm IBA was 15% at a pressure of 2 bar using pure CO₂. The reasons for the slight difference in the optimum moisture content reported in these studies could be attributed to the different IBA size fractions and temperature studied. Furthermore, although steps were taken to ensure that the moisture content remained unchanged in these studies, Van Gerven et al. (2005) showed that moisture content decreased over the carbonation period. This would have an impact on the efficiency of carbonation.

The aim of this study is to investigate the influence of moisture content and temperature on the degree of carbonation. The actual moisture content after carbonation was monitored to determine the impact on carbonation efficiency. This investigation was carried out using IBA size fraction 0-2 mm to obtain the optimum operating conditions for future study. Since industrial emission with 10-20% CO₂ has been suggested to be the source of CO₂ for accelerated carbonation (Arickx et al., 2006), this study used 20% CO₂ at atmospheric

pressure as it would be more realistic than using pure CO₂. These operating conditions were selected for investigation in consideration of minimising energy consumption and cost of the process. The leaching behaviour of Cu and Cr was evaluated as a function of carbonation time. This study focused on the impact of degree of carbonation and pH on the leaching mechanism by studying their correlations with the leaching level of Cu and Cr.

2. MATERIALS AND METHODS

2.1 Characterisation of IBA

Approximately 50 kg of wet, freshly quenched IBA was collected separately from two incineration plants in Singapore (denoted as S and T samples). To ensure a representative sampling, IBA was collected from the full cross section of the conveyor belt of incineration plant S and from a falling stream of the conveyor belt in plant T. In both circumstances, the conveyor belts are near to the exit of quenching tank. Due to the design of the incineration plants, grate sifting, boiler and economizer ash are mixed with grate ash at quenching tank, forming the wet IBA collected for this study. Immediately after collection, the wet IBA was dried at 40°C for 3 days. The dried IBA was sieved to obtain size fraction 0-2 mm. This was further ground using a ball mill to <425 µm to homogenize the sample as total carbon test uses <1 g subsample only.

Total element content of IBA (Table 1) was determined by digesting IBA with aqua regia followed by HF, and the solution was analyzed using Inductively Coupled Plasma–Mass Spectrometer (ICP-MS Nexlon 300D, Perkin Elmer). Triplicate IBA samples were used for the total element analysis.

2.2 Accelerated carbonation experiments

The accelerated carbonation experiments were carried out in CO₂ incubator (Sanyo MCO-18AIC). 20% CO₂ at 1 atm was used for all the experiments. The nominal moisture contents were set at 5, 15, 18.8 and 25% in weight percentage. The investigated temperatures were 35,

42.5 and 50°C. Deionised (DI) water was added to the dried IBA to obtain the required moisture content. A tray of DI water was placed at the bottom of the incubator to maintain a constant atmospheric humidity. IBA sample was spread on plastic petri dishes to no more than 2 mm thick. Samples were collected after different carbonation durations at 2, 4, 6, 8, 24, and 168 hours, and the actual moisture content was measured.

2.3 Determination of degree of carbonation

The total carbon (TC) and total organic carbon (TOC) content of IBA was measured by Analytik Jena Multi N/C 2100/2100S (solid module). TOC content was determined by acidifying the sample with HCl to remove the inorganic carbon while no acid was added when testing TC content. The total inorganic carbon (TIC) content of IBA was then calculated by subtracting TOC from TC. TC and TOC analysis were carried out in triplicates. The absolute increase in TIC is defined as the degree of carbonation (1), which is determined by subtracting TIC of the untreated sample from the TIC at sampling time t.

$$\text{Degree of carbonation (mg/g)} = \text{TIC}_t - \text{TIC}_{\text{untreated}} \quad (1)$$

2.4 Leaching study

Two leaching tests were used to study the leaching behaviour of IBA. EN 12457-2 was used to evaluate the leaching behaviour of IBA before and after carbonation as a function of time. The leaching test was carried out in triplicates for each sample at different carbonation durations. CEN/TS 14429 was done to investigate IBA leaching dependence on pH of leachant. This pH-static leaching test was carried out for untreated S and T samples only. At the end of leaching, the leachate was filtered through 0.45 µm nylon membrane. The pH of the leachate was measured by Mettler-Toledo G20 Compact Titrator. A portion of the leachate was analysed for dissolved organic carbon (DOC) content by Analytik Jena Multi N/C 2100/2100S (liquid module). Another portion of the leachate was acidified to pH 2 and

analysed for cations using Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES from Perkin Elmer Optima 8300).

2.5 Linear correlation coefficient

The relationship between leachability and its possible influencing factors was evaluated by calculating the linear correlation coefficient, i.e. Pearson's R. Pearson's R is a measure of the strength of the relationship between two random variables. The value of the correlation coefficient varies between -1 to +1, whereby ± 1 means the two variables have absolute positive or negative correlation, and 0 means no correlation. The Pearson's R was calculated using Originlab software.

3. RESULTS AND DISCUSSION

3.1 Degree of carbonation as a function of time

Figure 1 shows the degree of carbonation under different operating conditions, as a function of carbonation time. Samples with 5% and 15% moisture content both showed significant increase in the degree of carbonation after 2 hours of carbonation, regardless of temperature and source of IBA. Beyond 2 hours of carbonation, the increase in degree of carbonation was minimal. 18.8% moisture content showed similar trend at 42.5°C. Only samples with 25% moisture content showed an initial lag in carbonation degree. This shows that 25% moisture content was too high, hindering the diffusion of CO₂ through water to reach IBA particle surface for effective carbonation, in particular for IBA ground to <425 μm . Sun et al. (2008) reported similar low carbonation efficiency for air pollution control ash of particle size <300 μm when carbonated at a water to solid ratio of 0.5. But in this study, they subsequently caught up with other samples with lower moisture content after 8 hours of carbonation, and reached a plateau thereafter. The onset of plateau in the degree of carbonation implies that the samples had reached saturation in carbonation under the given operating conditions. This saturation in carbonation is due to the formation of a layer of

calcite (CaCO_3) around the IBA particle, which according to Sun et al. (2008), causes the rate of reaction to decrease as the CO_2 diffusion is now dependent on the porosity of the newly formed calcite layer. With prolonged carbonation, i.e. 1 week of carbonation, the IBA from the same plant reached similar degree of carbonation under different operating conditions. This could be associated with the amount of Ca available for carbonate formation. The total Ca content for 0-2 mm size fraction of S and T samples were 180,333 mg/kg and 139,667 mg/kg respectively, which corresponds to higher degree of carbonation attained by S sample.

Our study has shown that 2 hours of carbonation was sufficient for the samples to reach a relatively high degree of carbonation that was close to the degree of carbonation observed after 1 week of carbonation. Although the degree of carbonation at 2 hours was not the highest in this study, 2 hours of carbonation was the most efficient in terms of the rate of carbonation. In terms of heavy metals leaching, 2 hours of carbonation was also found to be effective in causing significant reduction in leaching (refer to Section 3.5). Hence for this study, 2 hours of carbonation was chosen as one of the optimum operating conditions. The optimum moisture content and temperature were then selected based on the highest degree of carbonation at 2 hours of carbonation, which is 15% moisture content for both S and T, and 35°C and 50°C for S and T respectively. These findings were similar to the study done by Van Gerven et al. (2005), whereby they reported that the optimum moisture content and temperature was 13-25% and 50°C respectively, for IBA 0.1-2 mm size fraction. However, the higher moisture content of 25% reported by Van Gerven et al. (2005) did not show any lag at the beginning of carbonation, unlike in this study. This could be due to the difference in particle size as the IBA used in Van Gerven et al. (2005) was not ground (i.e. 0.1-2 mm). Compared to this study, IBA was ground to <425 μm , of which 25% moisture content was shown to be too high for effective carbonation. Baciocchi et al. (2010) reported that the significant carbonate increase lasted 8 hours and the finest size fraction (<0.150 mm) had

approximately 14% of CO₂ uptake. In the study done by Van Gerven et al. (2005) on IBA size fraction 0.1-2 mm, the significant increase in carbonate content occurred in the first 6 hours of carbonation with an increase of around 100%. Compared with other studies, we observed the steep increase in degree of carbonation after only 2 hours of carbonation, followed by a plateau. The degree of carbonation after 2 hours of carbonation was 1.3 times higher compared to the degree of carbonation at 0 hour, with operating condition of 50°C and 15% moisture content for T sample.

3.2 Effect of actual moisture content on rate of carbonation

The initial retardation in carbonation for samples with 25% moisture content showed that 25% moisture content was too high for effective carbonation to take place for IBA with particle size ground to <425 µm. The duration of lag for 35°C lasted longer than 50°C, for both S and T samples. The initial retardation and the difference in the lag period for 25% moisture content can be explained by observing the actual moisture content of the samples. It was found that the moisture content changed throughout the carbonation period (Figure 1).

Generally, moisture content decreased during the first 8 hours of carbonation, except for samples with 5% moisture content of which moisture was gained. As a tray of DI water was placed inside the incubator, the evaporation of water had resulted in an atmosphere saturated with moisture within the enclosed environment. Moisture was then gained by samples with low moisture content, i.e. 5%, but not by samples with higher nominal moisture content. At 50°C, the rate of moisture gain for 5% moisture content was the slowest while the rate of moisture loss for 25% moisture content was the highest. This is logical since at 50°C, water tends to evaporate. After 8 hours of carbonation, the moisture content of all the samples with different nominal moisture contents would coincide at certain time between 8 to 24 hours of carbonation, with respect to their temperatures. This equilibration in moisture content continued to the end of 1 week of carbonation. Again, at 50°C, the actual moisture contents

after 24 hours of carbonation for all the three nominal moisture contents were the lowest among the three temperatures.

This change in the moisture content during carbonation had an impact on the initial rate of carbonation. Our study has shown that by using an unfavourable high nominal moisture content of 25%, significant carbonation will only take place after the moisture content has decreased to a certain threshold. For 35°C, the sharp increase in degree of carbonation for 25% moisture content occurred between 6 to 8 hours, which corresponded to an actual moisture content decrease from 17.1% to 11.6% for S sample, and from 20.3% to 17.7% for T sample. As for 50°C, the increase in degree of carbonation started after 2 hours of initial lag, whereby the actual moisture content had decreased to 14.0% and 21.4% for S and T samples respectively. Thus, for significant carbonation to take place, the actual moisture content range should be 12-17% for S sample and 18-21% for T sample. This observation is in agreement with samples with 18.8% moisture content, whereby the carbonation did not display an initial lag like those with 25% moisture content. Hence, 18.8% moisture was still effective as nominal moisture content for significant carbonation to take place. However, after factoring in the change in moisture content, the carbonation experiment has shown that the best nominal moisture content for the highest rate of carbonation at 2 hours was 15% for IBA with particle size ground to <425 µm. On the other hand, although 5% nominal moisture content did not show any lag in carbonation, the degree of carbonation was lower compared to 15% nominal moisture content and remained lower compared to other moisture contents, as the gain in moisture was not sufficient to reach the threshold level discussed earlier.

This study has shown that the initial rate of carbonation was strongly dependent on the nominal moisture content of IBA. The rate of moisture loss or gain seems to be affected by the carbonation temperature, which in turn indirectly affects the rate of carbonation.

3.3 pH profile as a function of time

Figure 2 shows the profile of pH as a function of carbonation time at the operating conditions 35°C and 50°C at 15% moisture content, for brevity. The pH of untreated IBA was found to be 12.4 and 12.6 for S and T samples respectively. There was a significant decrease in pH for most of the samples during the first 2 hours of carbonation period, at least 1 to 2 units of reduction. The pH continued to decrease with carbonation time, reaching pH 8.5 at the end of 1 week of carbonation for both sources of IBA.

The decrease in pH was dependent on the degree of carbonation for the different operating conditions investigated, as shown by the relatively high correlation coefficient in Figure 3. This observation shows that a lower pH can be achieved by applying the optimum operating condition to obtain the highest degree of carbonation.

3.4 Leaching profile as a function of time

The evolution of Cu and Cr leaching as a function of carbonation time was monitored by carrying out leaching tests at each sampling time. The amount of Cu and Cr released was converted to per dry mass (i.e. mg/kg) in the following discussion. Similar to pH, the graphs for the leaching behaviour with carbonation time only show the results based on the optimum operating conditions discussed earlier, i.e. 35°C and 50°C at 15% moisture content, for brevity.

3.4.1 Cu

Cu leaching decreased significantly after just 2 hours of carbonation and reached a plateau with further carbonation (Figure 4a), regardless of the operating conditions. A possible reduction mechanism in Cu leaching could be degree of carbonation, which results in the formation of less soluble carbonate, as shown from the relatively high correlation coefficient in Figure 5 (a, c). The Cu leaching as a function of measured pH from carbonated samples were also compared to the pH-static leaching of untreated samples (Figure 5 (b, d)). It can be seen that below pH 10, Cu leaching continued to decrease for the carbonated samples

whereas under the influence of pH, Cu leaching has increased. This decrease in Cu leaching as pH decrease with carbonation time showed the possibility of Cu forming a less soluble mineral (such as carbonate) during the carbonation process. Hence, pH did not contribute significantly to the decrease in Cu leaching. Van Gerven et al. (2005) had reported similar findings.

Many researches had suggested the leaching behaviour of Cu was affected by the presence of DOC in IBA due to Cu affinity to form organic ligands, which increase Cu solubility (Van Zomeren and Comans, 2004; Olsson et al., 2007). Hence, DOC leaching as a function of carbonation time was investigated. Generally, DOC leaching decreased with carbonation time, as shown in Figure 4b. It is likely that the decrease in DOC leaching could be due to the adsorption to Fe/Al (hydr)oxides formed during carbonation, as reported by Meima et al. (1999), Dijkstra et al. (2006), and Arickx et al. (2010). This is supported by our study shown in Figure 6 that compares the DOC leaching as a function of measured pH from carbonated samples to the pH-static leaching of untreated samples.

The contributions from both DOC and degree of carbonation have affected the Cu leaching, however, to different extent. For S sample, the contribution from DOC (Figure 7a) and degree of carbonation (Figure 5a) seems to affect Cu leaching equally as the R values were considered high for both factors. For T sample, the contribution from degree of carbonation (Figure 5c) seems to be higher than that of DOC (Figure 7b), based on the higher R value between Cu leaching and degree of carbonation, and lower R value between Cu leaching and DOC. This could imply that while DOC may have influenced Cu leaching, there are other factors, such as degree of carbonation, that contribute more to the decrease in Cu leaching. In the modeling done by Meima et al. (1999), they suggested that malachite ($\text{Cu}_2(\text{OH})_2\text{CO}_3$) and sorption to amorphous Fe/Al (hydr)oxides could be controlling leaching of Cu in carbonated IBA, although the oversaturation with respect to malachite was up to 1.5 orders of magnitude.

It is possible that the higher R correlation between the degree of carbonation and Cu leaching for T sample was contributed from the formation of insoluble carbonate mineral like malachite after carbonation.

3.4.2 Cr

Cr leaching was slightly higher for untreated S sample than untreated T sample at 3.59 mg/kg and 2.30 mg/kg respectively (Figure 4c). Unlike Cu, Cr leaching did not decrease for all the operating conditions. Only samples with 15% moisture content consistently showed the most significant decrease in leaching for all the investigated temperatures. However, Cr leaching increased for S and T samples with 25% and 5% moisture content respectively, which corresponded to lower degree of carbonation as compared to that at 15% moisture content at 2 hours of carbonation. After 1 week of carbonation, Cr leaching decreased for all the samples to concentration below the untreated samples, including those samples that showed an initial increase in leaching. This finding was similar to studies done by Van Gerven et al. (2005) and Rendek et al. (2006), who reported a decrease in Cr leaching with prolonged carbonation. Cornelis et al. (2008) suggested that the decrease in Cr leaching could be due to the adsorption by Fe oxides.

Figure 8 shows the relationship between Cr leaching with two other factors, i.e. degree of carbonation and pH. The correlation coefficient between Cr leaching and degree of carbonation were relatively low at $R = -0.5765$ and -0.5500 for S and T samples respectively, as shown in Figure 8 (a, c). Figure 8 (b, d) shows that the leaching mechanism of Cr could be more dependent on pH, instead of the formation of carbonate. This is supported by the similarity in the measured pH profile of carbonated sample and pH-static leaching test sample. Furthermore, Figure 8 (b, d) shows that Cr leaching increased initially during carbonation due to the slight decrease in pH. After prolonged carbonation, the pH decreased further to around pH 9, whereby the solubility of Cr becomes lower. Hence, to reduce Cr

leaching significantly, the pH of carbonated IBA has to reach pH 7, which is the minimum solubility of Cr based on the pH-static leaching test. However, pH 7 cannot be attained through accelerated carbonation treatment alone. The use of chemical agents has to be considered.

4. CONCLUSION

This study aims to address two issues pertaining to treatment of IBA by accelerated carbonation: the influence of operating conditions on the degree of carbonation, and possible factors influencing the leaching mechanism of Cu and Cr.

In our study, the moisture content was found to strongly affect the initial rate of carbonation. The actual moisture content was found to change during carbonation. The rate of moisture loss and gain was dependent on the carbonation temperature, which indirectly affected the initial rate of carbonation. At IBA particle size ground to $<425\ \mu\text{m}$, 15% nominal moisture content achieved the highest degree of carbonation after 2 hours of carbonation. The optimum temperature was found to differ for the two sources of IBA, i.e. 35°C and 50°C for S and T samples respectively. The first part of this study has shown that the lost (or gain) of moisture content during accelerated carbonation would have a significant impact on the carbonation efficiency on the industrial scale. It is possible that the moisture content of IBA be adjusted accordingly on the industrial scale. However, this study has shown that an optimised nominal moisture content can be obtained so as to avoid moisture content adjustment. This requires further study which has to take into other considerations such as the volume of IBA on the industrial scale, method of accelerated carbonation (i.e. enclosed or gas flow through system) and temperature of flue gas as CO_2 source. In summary, it is possible to conclude that a higher nominal moisture content would be more suitable for a higher carbonation temperature.

344 Based on the input of 20% CO₂ in an enclosed incubator system, 3.8% of CO₂ was taken up
345 by T sample after 2 hours of carbonation at 15% nominal moisture content and 50°C, which
346 increased the degree of carbonation by 1.3 times , as compared to 0 hour of carbonation.

347 After carbonation, the leaching mechanism of Cu and Cr was examined for the 0-2 mm size
348 fraction. For Cu leaching, the contributing factors are mainly degree of carbonation and
349 DOC. The dominant contributing factors for Cu leaching after carbonation for the two
350 sources of IBA were different. For S sample, degree of carbonation and DOC seem to affect
351 Cu leaching equally. However, for T sample, the contribution from degree of carbonation
352 seems to be higher than that of DOC. For Cr, pH seems to affect Cr leaching more than
353 degree of carbonation. Through the investigation of leaching as a function of carbonation
354 time, our study reveals that various factors, including temperature, moisture content, pH,
355 DOC, and source of IBA, contribute to the leaching level of each element to different extent.

356

358 Figure 1. Degree of carbonation (solid line at top) and corresponding actual moisture content
 359 (dotted line at bottom) for S and T samples at various operating conditions.

362 Figure 2. pH as a function of carbonation time at 35°C and 50°C with 15% moisture content
 363 for both S and T samples.

364

365

366 Figure 3. Correlation between pH and degree of carbonation for (a) S and (b) T samples.

367
368

369 Figure 4. (a) Cu, (b) DOC and (c) Cr leaching as a function of carbonation time at 35°C and
 370 50°C with 15% moisture content for both S and T samples.

373 Figure 5. Correlation between Cu leaching and degree of carbonation for (a) S and (c) T
 374 samples. Cu leaching as a function of measured pH for carbonated sample and pH-static
 375 leaching of untreated (b) S and (d) T samples.

Incineration plant S

Incineration plant T

378 Figure 6. DOC leaching as a function of measured pH for carbonated sample and pH-static
 379 leaching of untreated (a) S and (b) T samples.

382 Figure 7. Correlation between Cu and DOC leaching for (a) S and (b) T samples.

383

384 Figure 8. Correlation between Cr leaching and degree of carbonation for (a) S and (c) T
 385 samples. Cr leaching as a function of measured pH for carbonated sample and pH-static
 386 leaching of untreated (b) S and (d) T samples.

Incineration plant S

Incineration plant T

387
 388

389

390 TABLE

391 Table 1. Weight percentage and total element content of the 0-2 mm size fraction IBA

392 (Adapted from Lin et al., 2015).

Properties	Incineration plant S	Incineration plant T
Weight percentage (wt%)	34.2	29.7
Total element content (mg/kg)		
Ag	19	18
Al	32,467	32,033
As	20	64
Ba	81	65
Be	0.9	1.2
Ca	180,333	139,667
Cd	11	5.3
Co	52	48
Cr	235	206
Cu	2,453	2,437
Fe	51,467	111,000
K	9270	9857
Mg	10,113	10,633
Mn	895	1600
Mo	17	121
Na	15,333	13,067
Ni	183	169
Pb	611	199
Sb	246	85
Sn	161	95
Sr	340	327
Ti	6720	5267
V	27	55
Zn	3,073	4,050
Cl	11,200	5900
SO ₄	8307	6987

393

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