

Fate of Mercury and Other Trace Elements in an Oxy Coal Combustion Pilot Plant

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ABSTRACT

The fate of trace elements was evaluated in a 90KW_{th} bubbling fluidized bed (BFB) oxy-combustion pilot plant, fed with anthracites and limestone (bed material). Sampling of solid streams (coal, limestone, bottom ash, cyclones fly ash and bag filter fly ash) and exhaust gases (SO_x, NO_x, CO₂, CO and Hg) was undertaken through 4h operating at 70% load, 70:30 CO₂/O₂ ratio of raw gas and 800-820 °C. The mineralogical and chemical composition of bottom ash and fly ash is similar to that reported for conventional fluidized bed air combustion. The low gas temperature (45°C) in fibber filters promotes condensation of S, NH₄⁺, F, and Cl on fly ash collected in the bag filters resulting in bag filter fly ash enriched in gypsum, HN₄⁺-sulphate, fluoride and chloride species, and reducing emission levels. The composition of exhaust gas (95.8 % CO₂, 3.7% O₂, 0.4% CO, 0.12 µg/m³ NO_x and 0.001 µg/m³ SO_x), corroborates the high abatement of gaseous pollutants on filters and the expected low emissions of gaseous pollutants of oxy-combustion technique. High Hg abatement (92.5%) was also obtained. Mercury concentrations of the exhaust gas attained 0.4 and 1.8 µg/m³N for Hg²⁺ and Hg⁰, respectively. Thus 82% of the emitted Hg is Hg⁰ and 18% Hg²⁺, in accordance with the prevalent condensation of Hg²⁺ in bag filters fly ash promoted by the low temperature and high content of Ca-bearing species.

1. INTRODUCTION

The reduction of CO₂ emissions from power plants is a crucial challenge to control and limit the global warming. The International Panel for Climate Change (IPCC) has concluded that CO₂ emissions must be reduced by 50 to 85% by 2050 if global warming is to be restricted to between 2 to 2.4 °C [1]. The IEA Energy Technology Perspectives 2008 focus on returning emissions back to the level of 2005 and reduce CO₂ emissions by 50% from the level of 2005 by 2050. The European Union (EU) is facing the challenge to reduce the European greenhouse gas emissions by 8% by 2012 compared to 1990 levels, while it is also dealing with security of energy supply, competitiveness and sustainable development in energy policy. About 30% of European power generating capacity is coal-fired and this percentage is much

higher in certain EU countries (90% in Poland and over 50% in the Czech Republic, Greece and Germany).

The International Energy Agency (IEA) Energy Technology Perspectives 2008 shows possible routes to reach the challenging targets of the scenarios. Fuel oxy-firing is the most important new technology for the CO₂ capture and storage (CCS) in power generation industry with an expected CO₂ reduction of 14 to 19% (equivalent to CO₂ savings up to 5000 Mtn/year by 2050). Nowadays oxy-firing technology is under development. There are 6 CCS demonstration projects in EU funded by the European Energy Programme for Recovery (EPR).

Oxy-firing technology is based on using CO₂ and O₂ for combustion instead air to produce CO₂-rich flue gases allowing an easy CO₂ purification from other combustion gases (O₂, NO_x, SO_x, HCl, HF,..) for subsequent geological storage. The CO₂-rich gas is partially re-circulated to the boiler and mixed with O₂ and H₂O for combustion. The CO₂-H₂O rich atmosphere is considerably different to the atmosphere of conventional air combustion (78% N₂ and 16 %O₂). Both, the different composition of flue gas and the re-circulation of the CO₂-rich exhaust gas may change the heat release and heat transfer patterns within the boiler, the behavior of gases and particles, and gas/particle interactions, among others. Furthermore, the different gas composition leads to different operational conditions of the particle and gas cleaning devices than in air-firing. Consequently the physical, mineral, chemical and leachable properties of slag/bottom ash, fly ash and FGD gypsum produced as well as the fate of trace elements in oxy-combustion may be modified with respect to that produced in conventional air firing power plants.

In view of the above issues, a sampling and speciation of gaseous pollutants (with especial emphasis on Hg) and solid streams was devised and executed in a 90KW_{th} bubbling fluidized bed (BFB) oxy-combustion pilot plant. The main goal of this study is to determine the physical, chemical, mineralogical and leachable properties of oxy-coal combustion wastes, the composition of the exhaust gas, and the abatement capacity of gaseous pollutants and particulate matter (PM) with special emphasis on that of Hg. Furthermore the partitioning of major and trace elements among the global outputs was also investigated.

2. EXPERIMENTAL

2.1. Oxy pilot plant description

The oxy pilot plant was designed to operate with conventional air and oxy combustion conditions (using CO₂ from a bundle of cylinders or from a flue gas recirculation) with high feed fuel and bed material flexibility and a wide range of fluidization conditions (700-900 °C and 0.8-1.4 m/s). The reactor is a bubbling fluidized bed combustor, of 90 kW_{th} capacity (under oxy-fuel conditions), with a total height of 2.5m and a bed diameter of 0.203 m. The heating-up of the bed material is achieved by an auxiliary propane burner. The bed is water-cooled (up to 3m³/h depending on fuel load) during stable operation, while the freeboard is refractory lined. Feed fuel system consists of two independent 0.2 m³ hoppers, located besides the reactor, for fuel and limestone, respectively. In the case of co-firing, a mixture of coal and limestone is fed by the same hopper while co-matter enters alone to prevent particle segregation. Each hopper discharges on a separate screw, controlled by a variable-frequency drive, therefore independent flow rates can

be fed from every hopper. These screws discharge into a long mixing screw that introduces the powders in the reactor. The tip of the screw is water-cooled, and a temperature-based control prevents the back-propagation of the burning matter. Fuel and inert/ sorbent are entered 50 mm above the fluidizing plate, in order to reduce the initial elutriation. When operating oxy-fuel, the supply of O₂/CO₂ mixture is initially taken from two blocks of 12 cylinders each. Once the operation is stabilized, the consumption of CO₂ from the cylinders can be replaced by flue gases recirculation, using the forced-draft fan. Oxidant entering the combustor is preheated by means of a 9 KW shell-and-tube heat exchanger, by using the sensible heat of flue gases leaving the reactor. A by-pass can be operated to accommodate the temperature levels.

Before entering the heat exchanger, gases are cleaned up of fly ash particles in a high efficiency Stairmand cyclone, designed for a cut size of 2 μ m (inlet velocity of about 16–24 m/s). At the gas cold end, a fabric-filter bag is located for additional particle retention.

The rig is controlled by a Programmable Logic Controller (PLC), at which all the instruments (thermocouples, pressure gauges, and flow meters), control valves, motor starters and variable frequency drives are connected. Gas composition is on-line measured during the tests by a gas analyzer, determining CO₂, O₂, CO, SO₂ and NO_x concentrations.

2.2. Sampling

Sampling of solid streams (coal, limestone, bottom ash, cyclones fly ash and bag filter fly ash) and exhaust gases (SO_x, NO_x, CO₂, CO and Hg) was undertaken through around 4h operating (including start up and steady oxy-combustion conditions periods) at 70% load, 70:30 CO₂/O₂ ratio of raw gas and 800-820 °C. The plant was fed with anthracitic coals as fuel and limestone as bed material. Limestone was fed during starting and stabilization periods of the plant up to reach the desired height of the bed. When reaching steady oxy-combustion conditions coal was fed to the reactor with a flow of 11.9 kg/h, attaining 87/13 coal/limestone ratio.

Isokinetic measurements of gaseous Hg were performed after gas passes the bag filters and heat exchanger. Sampling and speciation of gaseous Hg (Hg⁰ and Hg²⁺) run lasted 1.5h at steady oxy combustion conditions. This was devised according to EN 13211 and [2]. Accordingly, a sample of 75 mL was withdrawn from the flue gas stream through a filter system, maintained at the right temperature, followed by a train of dark glass bottles in an ice bath. The gas washing-vessel system consists of a washing-bottle filled with HCl to capture Hg²⁺ [2], a gas washing-bottle containing 3 w% H₂O₂ for SO₂ removal, and two bottles containing 4 w% K₂Cr₂O₇ with 20 w% of HNO₃ for Hg⁰ trapping.

Sampling of coal and limestone and bottom ash, cyclone and bag filter fly ash was carried out before and after oxy combustion test run, respectively.

Table 1. Operational conditions of the oxy-combustion plant in sampling.

Load	70%	Exhaust gas flow	52.16 m ³ /h
CO ₂ /O ₂	70:30	Bed temperature	800-820 °C
Coal input	11.9 kg/h	Cyclone temperature	458-525 °C
Limestone input	3.3 kg/h	Bag filters temperature	45 °C

2.3. Analysis

The solid samples were acid-digested in duplicate by using a two-step digestion method devised by Querol et al [3]. The resulting solution was then analysed by Inductively-Coupled Plasma Atomic-Emission Spectrometry (ICP-AES) for major and selected trace elements, and by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) for most of trace elements. The fly ash and coal international reference material (NBS1633b and SARM19) were also digested to determine the accuracy of the analytical and digestion methods.

Mercury analysis were directly analysed on solid streams, solutions from flue Hg gas sampling and filter samples using a LECO AMA 254 gold amalgam atomic absorption spectrometer.

The mineralogy of solid samples was determined by X-ray powder diffraction (XRD) with a 218 Bruker D5005 diffractometer with monochromatic Cu K α 1,2 radiation operated at 40KV and 219 40mA., from 4 at 60° of 2theta range, and a step size of 0.05° and 3s/step.

The European Standard leaching test EN-12457 (according to Council decision 2003/33/EC) was applied to the oxy coal combustion wastes (bottom ash, cyclone fly ash and bag filter fly ash) samples to determine the leaching potential of major, minor and trace elements. The pH and ionic conductivity were determined by conventional methods. The content of major minor and trace elements of the leachates were determined by ICP-AES and ICP-MS. The content of Hg was determined directly on leachates by the same atomic absorption spectrometer described above, while leachable NH $_4^+$ and Cl by selective electrode.

3. RESULTS AND DISCUSSION

3.1. Characterization of feed fuel and bed material

Coal

Coal arises from the anthracitic Bierzo coal basin (Northwest Spain) and it is a low moisture (4%), intermediate ash (17%) and low S (0.4 %) coal. Quartz, illite and traces of kaolinite and gypsum are the mineral phases detected by XRD. The concentrations of a number of trace elements (Hg, Li, V, Mn, Ni, Zr, Nb and Ba) are higher than the mean values reported by Yudovich and Ketris [4] for worldwide coals and those of P, Zn, Sr, Mo, Cs and Th are close to the mentioned worldwide mean values (Table 2).

Limestone

Limestone is of 90% CaCO $_3$ purity with minor occurrence of Mg (0.1%) and trace concentrations of Mn, Sr, and Ba (4 mg/kg) probably present as marginal carbonates or in the calcite structure (Table 2). Since quartz levels are under XRD detection limits (<1% wt) the remaining fraction of limestone (over 10%) should be organic matter. The Hg and Ni concentrations reach 0.01 and 7.7 mg/kg, respectively, while those of other trace elements of environmental relevance (V, Cr, Cu, As, Pb, and U) are around 1 mg/kg (Table 2).

3.2. Characterization of wastes

Bottom ash

The bottom ash shows a very low moisture (<0.01 %) and a coarse grain size (most particles >1mm). Besides the prevalence of calcite, relatively high occurrence of lime and traces of quartz and anhydrite were detected in bottom ash. The XRD intensity calcite/lime ratio attained 4.7. According to this ratio and the bulk Ca concentrations, the relative proportions between calcite, lime and anhydrite are estimated in 89, 10 and 1%. It is noteworthy the content of Al, Fe, K, Na, S and that of a number of trace elements (Ti, Ba, Sr, among others, Table 2).

Cyclone fly ash

The cyclone fly ash shows a very low moisture (<0.01 %), and a relatively coarse grain size (median of 178 μm) with a lognormal and unimodal distribution and low glass content. Quartz and calcite are the major crystalline phases with minor occurrence of anhydrite, illite, K silicates, lime and hematite. This mineralogy and the low glass content are in line with the bed and cyclones temperatures (Table 1). Relic phases from coal such as illite, quartz, and feldspars and from limestone, such as calcite coupled with low contents of glass occur in fly ashes produced in coal combustion at temperatures ranging from 700 to 850 °C. Illite and calcite are stable up to 900°C [5] and quartz, feldspars up to 1100°C. Lime anhydrite and hematites are neomorphic species. The presence of lime is attributable to a partial calcite decomposition and that of anhydrite to the dehydration of bassanite and/or gypsum formed by the reaction of calcite and pyrite (>300°C) and the reaction of organically bound Ca and lime with gaseous SO_x [3, 6]. In coal combustion, the formation of SO₂ (g) and/or SO₃ (g) occurs at temperatures around 730 °C, and the reaction of SO_x with CaO to form CaSO₄ between 730 and 910 °C [7]. Hematite in fly ashes, is predominantly produced by the decomposition reactions of the pyrite and Fe-carbonate species present in coal, during combustion crystallizing at temperatures >500 °C, and [8-10]. Organically bound Fe in coal may be also the source of Fe for the formation of hematite [8, 9]. The mineral characteristics of these fly ashes from BFB oxy-combustion at pilot plant are similar to that produced in FBC [8-11].

With the exception of As and Zn, the concentrations of major and trace elements (Table 2) are lower (by a factor ranging from 0.2 to 0.7) than reported for conventional air FBC [7-8,13-15].

Then it may be concluded that the mineralogical and Chemicals properties of BFB oxy-coal bottom ash and fly ash are similar than produced in conventional air FBC.

Bag filter fly ash

This fly ash is characterized by a notable moisture (4% after air drying) and fine grain size (median of 8.6 μm) with a lognormal and tri-modal size distribution. An intermediate size mode (max. around 5-6 μm) prevails over finest (0.7 μm) and coarsest (110-120 μm) modes. Gypsum and calcite are the main crystalline phases present in this fly ash, with minor contents of illite and traces of quartz anhydrite, ammonium sulphate ((NH₄)₂ S₂O₈), portlandite and hematite. The low gas temperature (45 °C) in bag filters promotes the condensation of water and volatile elements, such as S, Hg and also NH₄⁺ and Cl as indicated by the high leachable levels (406 and 9404 mg/kg for NH₄⁺, Cl, respectively). The condensation gives rise to the formation of gypsum, ammonium sulfate, Cl and F species and to the

hydration of lime particles that escapes the cyclones. The high Hg concentration (2.5 mg/kg, Table 2) in bag filter fly ash is related to: a) the low gas temperature, that promotes huge condensation of Hg and b) the high content of Ca-bearing species that favors the adsorption of Hg^{2+} species [2,3].

3.3. Enrichment Factors

All normalised enrichment factors (EFs) for major and trace elements in and bottom ash/feed fuel (EF_{BA}), cyclone fly ash/feed fuel (EF_{CFA}) and bag filters fly ash /feed fuel (EF_{BFFA}) have been calculated considering Al as a non-volatile element in oxy coal combustion by using the following normalisation formulas [3-12]: (a) $EF_{BA} = [Ci_{BA}/CAI_{BA}]/[Ci_{blend}/CAI_{blend}]$; (b) $EF_{CFA} = [Ci_{CFA} / CAI_{CFA}] / [Ci_{blend} / CAI_{blend}]$ and; (c) $EF_{BFFA} = [Ci_{BFFA} / CAI_{BFFA}] / [Ci_{blend} / CAI_{blend}]$, where Ci is the concentration of a given trace element and CAI is the concentration of aluminium in the oxy-combustion waste considered and in the fed fuel/limestone blend. The mixture of coal and limestone (calculated according the coal/limestone ratio) was considered as input. Using the above normalisation system, elements enriched in fly ash (by volatilisation followed by condensation from flue gas) will yield an enrichment factor ($EF_{fly\ ash} > 1$). Low volatile elements will not be enriched in fly ash, and will yield in an enrichment factor ($EF_{FA} < 1$). Low EFs for both fly ash and slag point to volatilisation processes with very minor condensation from flue gas.

The enrichment of major and trace elements among oxy coal combustion may be summarized as follows: a) elements enriched in bottom ash ($EF_{BA} > 1$), Ca, K, Na, S, Ti, Rb, and U; b) elements simultaneously enriched in cyclone ($EF_{CFA} > 1$) and bag filters FFA ($EF_{BFFA} > 1$) fly ash, P, Li, Be, Co, Cu, Zn, Pb, rare earth elements (REE's) and Fe (with $EF_{CFA} > EF_{BFFA}$) and Mg, B, Sc, Cr, Ti, Ga, As, Sr and Th (with $EF_{BFFA} > EF_{CFA}$). Iron is included in this group but shows enrichment only in cyclone fly ash; c) elements enriched in bag filter fly ash ($EF_{BFFA} > 1$) and depleted in cyclone fly ash ($EF_{CFA} < 1$), Hg, S, Mo, Sb, Sn. Sulfur is included in this group due to the high EF_{BFFA} (1.7) but it is also slightly enriched in BA ($EF_{BA} = 1.1$).

The main issues deduced from the above enrichment factors are: a) high retention of Hg, S, Mo, Sb and Sn (partially volatile after cyclones) in bag filter fly ash due to condensation promoted by the low temperature; b) both the high enrichment of Hg in bag filters fly ash ($EF_{BFFA} = 7.2$) and the high occurrence of Ca-bearing species (gypsum and portlandite) suggest a prevalent condensation of Hg^{2+} than Hg^0 in this fly ash; and c) relatively high efficiency of limestone for S retention in bottom ash.

3.4. Exhaust gas composition

As expected, the exhaust gas is CO_2 -rich (96%) with minor amounts of O_2 (4%). The low levels of CO, SO_2 , NOx and Hg (Table 3) reveal the high abatement of these gaseous pollutants, attaining 99.9 % and 92.5 % retention for gaseous S and Hg, respectively. Most of the Hg present in the exhaust gas is Hg^0 (82%) while only 18% is Hg^{2+} . This speciation is in line with the above suggested prevalent condensation of Hg^{2+} in bag filters. The low PM levels of S ($< 0.25\text{mg}/\text{m}^3$) and Hg ($7\text{ ng}/\text{m}^3$) indicates high retention efficiencies ($> 99.9\%$) for particulate S and Hg species. The PM escaping the bag filters (Table 4) shows remarkable levels ($0.1\text{-}0.5\text{ mg}/\text{m}^3$) of Al, Ca, Fe, Mg and Na. As regards trace elements the levels of Ti, Ba, Mo, Zn, Cr, As, Sn Pb, and Bi in PM may be highlighted (Table 4).

Table 2. Concentrations of major and trace elements in coal, limestone and oxy-combustion ash.

%	Coal	Limestone	Bottom ash	Cyclone fly ash	Bag filter fly ash
Al	1.6	<0.1	2.4	4.1	7.7
Ca	0.2	36.0	30.0	3.2	11.8
Fe	0.9	<0.1	0.8	2.6	2.8
K	0.3	<0.1	0.6	0.8	1.3
Mg	0.1	0.1	0.1	0.4	0.7
Na	0.04	<0.1	0.1	0.2	0.3
P	0.03	<0.1	0.0	0.1	0.2
S	0.4	<0.1	0.7	0.4	5.4
mg/kg					
Hg	0.1	0.01	0.03	0.1	2.8
Li	14.5	<0.01	9.0	94.1	157.1
Be	0.8	<0.01	0.5	2.7	4.9
B	3.1	4.9	4.5	13.6	40.1
Sc	1.1	<0.01	0.5	7.0	15.8
Ti	602.5	4.0	1151.5	585.8	4197.6
V	37.7	0.8	34.0	54.4	126.0
Cr	7.3	1.4	8.0	47.7	125.1
Mn	224.0	31.3	87.0	242.0	285.0
Co	5.5	<0.01	4.1	18.2	33.2
Ni	21.9	7.7	17.5	51.0	93.6
Cu	6.6	1.0	8.0	48.4	71.8
Zn	21.6	<0.01	25.0	98.4	156.9
Ga	4.3	<0.01	6.8	13.2	26.8
Ge		<0.01	0.8	<0.01	3.5
As	1.6	0.6	1.5	23.2	84.0
Se	<0.01	<0.01	<0.01	1.7	3.5
Rb	9.7	<0.01	17.0	46.5	68.0
Sr	98.0	48.6	92.8	316.8	693.8
Y	6.3	2.9	7.4	15.4	34.7
Nb	8.3	<0.01	8.2	5.3	38.7
Mo	1.8	<0.01	2.0	3.6	10.4
Sn	0.4	<0.01	1.6	0.8	6.5
Sb	0.3	<0.01	0.3	0.5	7.7
Cs	0.8	<0.01	0.7	8.4	11.6
Ba	226.9	4.7	250.6	627.2	1209.1
La	7.1	1.4	5.7	27.5	46.3
Ce	17.0	<0.01	11.1	69.6	116.3
Pr	1.6	<0.01	1.1	6.2	10.2
Nd	6.8	0.8	5.0	27.5	45.4
Sm	1.4	<0.01	1.0	5.7	9.5
Gd	1.3	<0.01	1.0	5.4	9.3
Dy	0.9	<0.01	1.0	2.8	5.9
Pb	7.0	1.0	2.2	46.5	57.2
Th	2.9	<0.01	3.2	9.6	20.7
U	1.2	0.8	1.6	2.9	7.0

Table 3. Composition of the exhaust gas

	%	%	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$
	CO ₂	O ₂	CO	SO ₂	NO _x	Hg total	Hg ²⁺	Hg ⁰
exhaust gas	95.8	3.7	1.14	0.001	0.12	2.15	0.39	1.76

Table 4. PM levels in the exhaust gas

	mg/m^3		mg/m^3	
Al	0.5	Mg	0.1	
Ca	0.4	Na	0.2	
Fe	0.1	P	<0.1	
K	<0.5	S	<0.2	
	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$	
Li	0.6	Sb	<0.8	
Be	<0.8	Cs	<0.8	
B	1.8	Ba	37.7	
Sc	<0.8	La	<0.8	
Ti	20.9	Ce	0.95	
V	<0.8	Pr	<0.8	
Cr	2.8	Nd	<0.8	
Mn	1.7	Sm	<0.8	
Co	<0.8	Eu	<0.8	
Ni	2.1	Gd	<0.8	
Cu	0.9	Tb	<0.8	
Zn	14.7	Dy	<0.8	
Ga	<0.8	Ho	<0.8	
Ge	1.0	Er	<0.8	
As	3.4	Tm	<0.8	
Se	<0.8	Yb	<0.8	
Rb	<0.8	Lu	<0.8	
Sr	4.3	Hf	<0.8	
Y	0.8	W	<0.8	
Zr	3.5	Tl	<0.8	
Nb	<0.8	Pb	1.3	
Mo	16.7	Bi	2.2	
Cd	<0.8	Th	<0.8	
Sn	0.2	U	<0.8	
Hg (ng/m^3)	0.7			

3.5. Partitioning of major and trace elements among global outputs.

The partitioning of major and trace elements among the global outputs was obtained normalising the EFs with the production ratio among bottom ash (0.7), cyclone fly ash (0.22) and bag filters fly ash (0.08). The proportion of each element in gas phase was determined by adding up the proportions obtained for each element in each waste. Consequently, values <1 points to a partial occurrence in the exhaust gaseous for a given trace element while values close to 1 indicates no gaseous proportion. It is worth mentioning that an analytical error about 5-10% must be assumed in the determination derived from the method employed.

The partitioning of selected major and trace elements in the global outputs of the studied BFB oxy-coal combustion pilot plant is depicted in Figure 1. Mercury and S are the elements still present in the exhaust gas, but in very low proportions (7 and

5%, respectively). Note the high correlation of gaseous proportion of these elements, especially for Hg, obtained directly from gas measurements and from normalized EFs. Most of Hg (58%) is retained in bag filters fly ash with considerable proportions retained in bottom ash (27%). Sulfur is mainly retained in bottom ash (70%) and in minor degree in bag filters fly ash (14%). Most of the remaining elements are mostly retained in bottom ash, with retention proportions ranging from 99% to 50%. Phosphorus (70%) and Pb, Sc, Be, and Li (50%) are mainly retained in cyclone fly ash. Other elements (As, Sb, and Sn) are highly retained in bottom ash (60%) but show considerably retention in bag filter fly ash (around 20%).

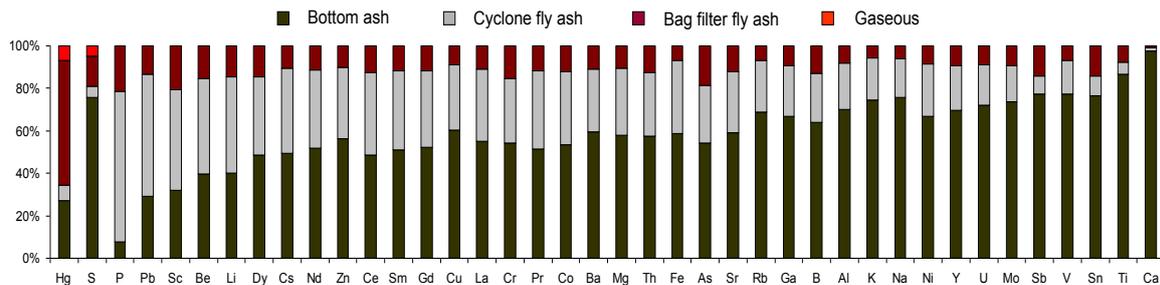


Figure 1. Partitioning of elements among global outputs.

4. CONCLUSIONS

High retention efficiencies for major and trace elements (92-99.9%) are reached in the oxy-combustion of coal in a 90KW BFB reactor. A large number of elements are mostly retained (50-99%) in bottom ash due to the high bottom ash/fly ash ratio (70:30). The fly ash particles and gaseous components (S, Hg, NO_x, NH₄⁺, F, Cl, Sn, Sb,...) escaping the cyclones are efficiently retained in the bag filters. The low temperature of these filters promotes condensation of gaseous components giving rise to high abatement efficiencies, with especial mention to those attained for S (99.9%) and Hg (92.5%). Consequently a CO₂-rich exhaust gas with very low level of gaseous and PM impurities are achieved. Although the high retention of Hg, significant levels of Hg (2.15 µg/m³) still present in the exhaust gas, most of them as Hg⁰ (81%). The temperature and the high occurrence of Ca-bearing species promote the prevalent condensation and capture of Hg²⁺ in the bag filters. The chemical and mineralogical properties of oxy-coal combustion wastes, especially bottom ash and cyclone fly ash are similar to that usually found in conventional air FBC. Especial attention should be paid to the fly ash retained in bag filters. The occurrence of condensate bearing species of S, Hg, F, Cl and NH₄⁺ may give rise to high leachable levels of these elements in this fly ash.

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