Solid waste incineration of residues- a clean technology

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Abstract: Waste is ecologically a major risk for the environment, but still can be reused as energy source. The co-combustion of municipal waste or even the independent use, according to its lower calorific value represents a challenge that is state or art already. Thus clean energy is resulting, as the emitted CO_2 can be considered neutral. Advantages and disadvantages are presented. But still the major problem of using the ash and reducing the local pollution, in air or soil, remains a risk. The present paper brings some solutions concerning the use of the dense slurry technology as well for the case of waste incinerators. Waste management gives thus a solution for such residues that are normally ending in land filling disposal. One of the major problems arise from land filling is the contamination of the environment with harmful substances that can be transmitted by leaching.

Key words: waste incineration, leaching, landfill disposal, dense slurry.

1. Introduction

Waste is both an energy resource and an environmental pollution source for air, soil and underground water. For many years, especially in East European countries, no reasonable solutions were applied in order to take benefit from the potential heat energy of the waste. Open landfill waste deposits are extremely harmful to the environment, despite that they are continuous sources for methane generated by biodegradation [1]. Against this backdrop, co-firing of waste/fossil fuel in existing fossil-fuel fired power plants is a promising near term option to reduce high costs and efficiency disadvantages of existing biomass energy generation. Reasons are the lower capital and operating costs, higher electrical efficiencies and increased fuel flexibility and the avoidance of additional generation capacity. Another driving force of gaining importance is the ban to dump combustible wastes. Co-firing refers in practice to introducing biomass as a supplementary energy source in high efficiency boilers. The technique of co-firing has been practiced, tested or evaluated for a variety of biomass types and co-firing shares in combination with different combustion technologies and processes, including grate firing, fluidized bed combustion and pulverized combustion. In most of the co-combustion installations currently in operation, waste is directly combusted together with fossil fuels, mostly coal. In the pulverized coal fired installations such as those operating in Central and Eastern Europe waste is a good candidate to be used, as additional fuel, to contribute thus to solving the damaging and aggressive waste environmental problems (determined by lack of management) Clean energy supposes not only use of renewable energy, but means also to apply all state of the art technology to clean the flue gases from the waste incinerator, directly, or concurrently with those from the main fossil boiler, that normally should be equipped with such standard cleaning systems (denox, desox, particles' filter, etc.).

The directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market indicates that is necessary ”to facilitate trade in electricity produced from renewable energy sources and to increase transparency for the consumer's choice between electricity produced from non-renewable and electricity produced from renewable energy sources as it represents the guarantee of origin of such electricity is necessary. It is important that all forms of electricity produced from renewable energy sources are covered by such guarantees of origin”. [1]

In Romania, energy providers of renewable sources: wind, solar, biomass, biogas, including biodegradable waste and modern micro hydro-electric power plants providers, receive for each MWh a green certificate. These certificates will then be transacted on a specific market, where electric non-renewable energy suppliers are supposed to purchase. These suppliers are compelled to buy the certificates within a share limit. For 2013 the share limit was established at min 10 %. By this way the electric energy suppliers are obliged to acquire annually a number of green certificates equal to the quantity of the energy supplied to the final consumers multiplied with the established share limit in that year. For example, if an electric energy supplier supplies 100 MWh/year, one must buy 7 green certificates with a price between 24 and 42 euro (in Romania). In order to calculate the share of waste or renewable energy in the total production, one proposes the following formula:

$$E_O = \frac{M_W H_{iW}}{M_W H_{iW} + M_C H_{iC} + M_G H_{iG}} E \qquad (1)$$

where:

E_0 – waste share derived power (electricity or heat) from the total, in MWh or GJ;

E – total plant power (produced electricity or heat), in MWh or GJ;

M_W – mass of waste, in kg;

M_C – mass of coal, in kg;

M_G – mass of gas, in $m^3{}_N$;

H_{iW} – lower heating value of waste, in reference to humid state, in J/kg;

H_{iC} – lower heating value of coal, in reference to humid state, in J/kg;

H_{iG} – lower heating value of support gas, in $J/m^3{}_N$.

Also such cumulative calculations are necessary to evaluate the pollutant emission limits and the oxygen concentration as reference, when analyzing the flue gases in the exhaust, as delivered from the clean co-combustion or coupled waste incinerator-fossil boiler, when the flue gases are exhausting through the same stack. Notable is the addition of several supplementary goals such as concentration of dioxin in the flue gases. Even if waste is not totally renewable energy its incineration is useful for the population, not only because its energy output, but also because solutions to destroy it exist, by turning it through recycling and incineration to an integrated profitable waste management system. That is why a study in connection to an existing boiler, that has sufficient life time to go, and is supposed to work with additional heat input from flue gases generated by a waste incinerator in its neighborhood, has been studied. One knows from literature that several configurations are possible.

Main advantages and disadvantages are presented in Table 1 [1, 12].

Configuration	Advantages	Disadvantages
Direct co-combustion	Low investment cost	Biomass ashes are mixed with main fuel ashes
Indirect co-combustion	Ashes are kept largely separate from main fuel	Relatively high investment cost
Parallel combustion	High pressure steam generation is possible Ashes are kept separate	Very high investment costs

Table 1. Advantages and disadvantages of different waste co-combustion configurations [1, 12]

Waste incinerators are often turned into economic industrial support if they are coupled to main power plants, mainly of offering thus advantages concerning the energy utilization and further supply to customers [3, 11].

Co-combustion is practiced with different types and amounts of wastes in different combustion and gasification technologies, configurations and plant sizes. One can distinguish direct and indirect co-combustion and parallel firing.

- For direct co-combustion, all components of the secondary fuel enter the boiler together with the primary fuel since both fuels enter the boiler (eventually in a separate feeder). Currently, this is the most commonly applied co-combustion principle. The cheapest variant of direct co-combustion in a pulverized coal power plant is through mixing pre-treated biomass and coal in the coal yard or on the coal conveyor belt, before combustion in the same boiler. Many coal- and oil-fired boilers at power stations have been retrofitted to permit multi-fuel flexibility. Another option is to install a biomass grate in an existing pulverized coal burner. Sludge-types of waste can be directly co fired using an oil lance.
- Indirect co-combustion by pre-gasification is applied in a number of demonstration plants. The investment costs are significantly higher as compared to a direct co-combustion installation. One of the major advantages is that ashes of the main fuel and the co combusted fuel are kept separate.
- For parallel firing, a fully separate combustion installation issued for the biomass/waste and the steam produced is fed to the main installation where it is upgraded to higher conditions, resulting in higher conversion efficiencies. Though the investment in indirect co-firing and parallel firing installations is significantly higher than in direct co -combustion installations, advantages such as the possibility to use relatively difficult fuels with high alkali and chlorine contents and the separation of the ashes are reasons why this can be justifiable.

2. Sate of the art

The most common thermal treatment process for MSW is incineration by mass-burn technology. Fluidized bed incineration and refuse derived fuel systems are less common in municipal solid waste treatment. Aside from combustion, other thermal processes exist, including pyrolysis, gasification, sintering, vitrification and melting.

In this article, one focuses on the land filling technique, studying the possibility to integrate the MSWI solid residues into fired coal power plant solid residues disposal.

2.1. Waste incineration

Incineration is used as a treatment for a very wide range of wastes. Incineration itself is commonly only one part of a complex waste treatment system that altogether, provides for the overall management of the broad range of wastes that arise in society. Basically, waste incineration is the oxidation of the combustible materials contained in the waste. Waste is generally a highly heterogeneous material, consisting essentially of organic substances, minerals, metals and water. Temperature range of oxidation process is generally between 800 and 1,450 °C. Depending on the composition of the material incinerated and on the operating conditions, smaller amounts of CO, HCl, HF, HBr, HI, NOX SO2, VOCs, PCDD/F, PCBs and heavy metal compounds (among others) are formed or remain. These substances are transferred from the input waste to both the flue-gas and the fly ash it contains. A mineral residue fly ash (dust) and heavier solid ash (bottom ash) are created.

In municipal waste incinerators, bottom ash is approximately 10 % by volume and approximately 20 to 30 % by weight of the solid waste input. Fly ash quantities are much lower, generally only a few percent of input [1]. Emissions and consumptions at waste incinerators are mainly influenced by:

- waste composition and content
- furnace technical measures (design and operation)
- design and operation of flue-gas cleaning equipment.

Emissions resulted after the MSWI are distributed to air, to water and as solid residues that usually are used for land filling. The emissions to air and water are very dependent of the flue-gas cleaning performance. Solid residues arise after incineration process is included the residues resulted from the flue gas treatment (FGT) and waste water treatment, and can be summarized as:

- bottom ash or slag – mainly the incombustible fraction of the waste
- boiler ash – the ash that accumulates and is removed from the boiler
- fly ash – the light ash that travels with the flue-gas and is then removed by FGT equipment
- air pollution control residues accumulated, reacted and un-reacted that are accumulated in the FGT equipment
- waste water treatment [1], [9]

Emissions generation in the waste management system is depicted in Figure 1. Some typical data on the residues from MSWI plants are presented in Table 2.

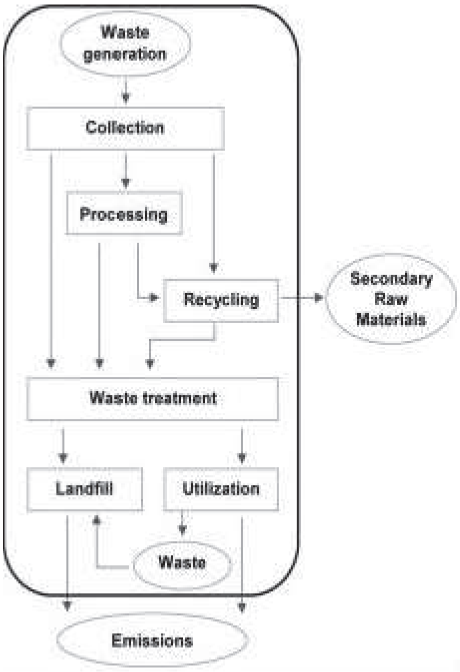

Figure 1. Integrated waste management system [9, 17].

Types of waste*	Specific amount(dry) (kg/t of waste)
Slag/ash (including grate siftings/riddling)	200 – 300
Dust from boiler and de-dusting	20 – 40
FGC residues, reactions products only:	
Wet sorption	18 – 15
Semi-wet sorption	15 – 35
Dry sorption	7 – 45
Reaction products, and filter dust, from:	
Wet sorption	30 – 50
Semi-wet sorption	40 – 65
Dry sorption	32 – 80

Loaded activated carbon	0.5 – 1

***Note: wet sorption residue has a specific dryness e.g 40-50 % by mass d.s [1]**

Table 2. Typical data on the quantities of residues arising from municipal waste incineration plants [1]

Most published numbers include the grate siftings, which only recently (and only in some countries) have been kept separate from the bottom ash. The mass flow of siftings depends on the type of grate and its time of operation. The production of boiler ash depends on the type of boiler and on the amount of dust originally released from the grate [1]. The mass flow of flue-gas treatment residues shows the highest variation of all residues. In semi-wet or dry lime systems the amount is increased because of unreacted additives, while the dry sodium bicarbonate process gives the lower values [1].

Table 3 gives mass streams of solid residues for various substances per tonne of MSW incinerated. The data given is average data for 12 MSWI in the Flanders Region of Belgium in 1999:

Types of solid residue	Percentage (%)
Bottom ash	21
Fly ash + gas cleaning residue + sludge from wet scrubbers	4.2
Scrap recuperated from bottom ash	1.2

Table 3. Mass streams of solid residues from MSWI expressed per tone of MSW incinerated [1].

Directive 2000/76/EC (Art. 6.1) includes an operational condition requiring that incineration plants achieve a level of incineration such that, in slag and bottom ashes, the loss on ignition is ≤ 5 % or the TOC is ≤ 3 %. In modern well-operated MSWI plants the TOC in bottom ashes can be below 1 wt %. Combustion trials have demonstrated that an increase in heating value of the waste feed and resulting higher bed temperatures improve the burnout of bottom ash [1].

Typical concentrations of organic compounds in the various solid residues are compiled in Table 4:

Parameter	Bottom ash	Boiler ash	Filter ash
PCDD/F (I-TEQ)	< 0.001 – 0.01	0.02 – 0.5	0.2 – 10
PCB	< 5 – 50	4 – 50	10 – 250
PCBz	< 2 – 20	200 – 1000	100 – 4000
PCPh	< 2 – 50	20 – 500	50 – 10000
PAH	< 5 – 10	10 – 300	50 – 2000

All values in ng/g

Table 4. Concentration ranges of organic compounds in bottom, boiler and filter ashes [1]

Only data from modern facilities have been used in this table. Total organic carbon (TOC) determination in accordance with the standard EN 13137 also detects elementary carbon as TOC, which does not cause any problems on landfills. The TOC of bottom ashes comprises mainly elementary carbon, but to a certain extent, organic compounds are also found (coming e.g. from sifting of plastics). These cover the spectrum from short-chain compounds up to low volatile species such as PAH or PCDD/F. The I-TEQ (Toxic Equivalent Quantity) levels detected in the bottom ashes of modern incineration plants are in the same order of magnitude as those found in some urban and industrial soils.

Residue	Range of values	Units
Bottom ash	1 – 68	ng TEQ/kg dry solid
Boiler ash	< 40 – 600	ng TEQ/kg dry solid

Fly ash (ESP)/filter dust	140 – 5720	ng TEQ/kg dry solid

Note: in this table the peak high and low values have been removed

Table 5. Range of PCDD/F concentrations in MSWI residues (excluding peak high and low values) [1]

Table 5 gives survey data of an overview of the PCDD/F content in residues from MSWI plants. The data excludes peak high and low results. It is important to note that the risks associated with bottom ash are not indicated only by the presence or absence of substances – their chemical and physical form, as well as the nature of the environment where the material will be used is also important to prevent emissions from the ashes to the environment [1]. The important thing is, therefore, not the fact that the bottom ashes contain pollutants but to check possible emissions from the ashes to the environment.

Table 6 gives the average values for Dutch MSW incinerator bottom ash after mechanical treatment, as measured from 1993 to 1997. Data have been taken from regular quality controls performed by the national organization of waste managers (VVAV) at all MSW incinerators and from the National Institute for Environmental Protection (RIVM).

Compound	**Leaching value (mg/kg)**
Sb	0.22
As	0.022
Ba	0.6
Cd	0.003
Cr	0.08
Co	0.05
Cu	3
Hg	0.001
Pb	0.07
Mo	1.52
Ni	0.13
Se	0.01
Sn	0.04
V	0.23
Zn	0.09
Br^-	7.6
Cl^-	2615
CN^- (free)	0.01
CN^- (total)	0.048
F^-	14.1
$(SO_4)^{2-}$	5,058

Table 6. Leaching properties of mechanically treated bottom ash, measured using NEN7343 [1]

As compared to stony or inert materials, the following compounds may be considered critical for MSW bottom ash: Cu, Zn, Sb, Mo, chloride, and sulphate. Treatment techniques aim to reduce the leachability of these critical compounds. Thus, solid residues from thermal waste treatment warrant significant environmental concern.

2.2. Fired coal power plant incineration (FCPPI)

Basically the MSWI process is very similar with the ones that are developing in fired coal power plants. The combustion chamber does the same oxidation process, but the material that burns is different types of coals instead of municipal solid waste. The technology and all the processes that are developing in a fired coal power plant are well known in our days. Solid residues that arise from FCPPI can be summarized as follows:

- raw ash – collected from the economizer and air preheater areas of the steam boiler
- fly ash – collected from the electrostatic precipitator and de-dusting ducts of the flue gas
- bottom ash – provided from the burning chamber of the boiler that contains boiler ash and incombustible fraction of coal.

- air pollution control residues, reacted and un-reacted that are accumulated from the Flue Gas Desulphurization (FGD) plant.

As can be seen the solid residues arise from FCPPI are similar with those from the MSWI, the difference between them are in the chemical composition and quantities. Typical compositions of main solid residues arise from coal incineration are compiled in table 7:

Compound	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Others	
FCPP Turceni							
Fly ash	46.2 %	21.1	9.9	9.3	4.7	8.8	%
Bottom ash	44.4 %	20.5	9	9	4.5	12.6	%
FCPP Isalnita							
Fly ash	48.3 %	23.9	7.3	10.8	2.6	7.1	%
Bottom ash	46.3 %	23	7	10.3	2.5	10.9	%
FCPP Rovinari							
Fly ash	47.2 %	22.1	10.2	8.7	4.7	7.1	%
Bottom ash	45.3 %	21.2	9.8	8.3	4.5	10.9	%
FCPP Craiova II							
Fly ash	46.1 %	21.3	10.8	10.6	5.2	5.7	%
Bottom ash	46.1 %	21.4	10.9	10.65	5.24	5.74	%

Table 7. Chemical composition of main solid residues of FCPPI [14]

The values from up table were taken from FCPP from Romania, where is implemented dense slurry technology. FCPPI solid residues can be used in different applications like filling material in constructions sectors, or fly ash in cement industry if the chemical composition of it is proper. Most part of the solid residues is used for landfilling because of the huge quantities that are produce [14, 16].

2.3. Dense slurry technology

Regarding the environmental issue produced by the land filling of the FCPPI solid residues it was develop dense slurry technology (DST) which has proven its efficiency as environmental friendly, and so is already implemented at several FCPP worldwide.

DST presumes to create a homogenous mixture between solid residues arise from FCPPI and water in a controlled proportions with aim to activate the cementing reactions of the elements contain in the ash. The final product of DST is the “ash rock” that encapsulate and prevent the leaching of the harmful elements contain in FCPPI solid residues.

The cementing reactions develop in DST are strong influenced by:

- intense mixing of the solid residues with a smaller quantity of water than solid mass , which dissolving the calcium (CaO) and magnesium (MgO) oxides. The resulted solution partially enables the surface of the ash particles.
- the calcium hydroxide (CaOH) that has been formed is reacting with the minerals dissolved in slurry, and with the silicate dioxide (SiO_2) and aluminum oxide (Al_2O_3) having as a result the formation of the calcium hydrates and/or calcium aluminate known in the cementing process.
- presence of the reducing substances as sulfates and sulphurs enable a lower value of the pH and the massive precipitation of calcium carbonate resulting the calcium and aluminum sulphate which is participate also to the cementing reaction of the dense slurry.

The main chemical reactions characteristic for cementing chemical process are:

- generation of calcium and sulfate ions (fast reactions):

$$CaO + H_2O \rightarrow Ca(OH)_2 \quad (2)$$

$$CaSO_4 + H_2O \rightarrow Ca^{++} + SO_4^{--}$$

(3)

- ash rock formation:

$$Ca^{++} + OH^{-} + SO_4^{--} + Al_3O_3 + H_2O \rightarrow$$
$$\rightarrow 3CaO \cdot 3CaSO_4 \cdot 31 - 32H_2O \quad (4)$$

(at the begining is a fast reaction)

- formation of calcium silicate hydrates (slow reaction):

$$Ca^{++} + OH^{-} + SiO_2 + H_2O \rightarrow CSH \quad (5)$$

On cementing process arise new undissolved minerals compounds. New formed mineral crystals are gradually deposited by joining to others particles in the slurry mass encompassing them. In landfilling deposit, the new formed compounds are solidified by cementation reactions, and so are created the “ash rock” that encapsulates the undisolved elements in slurry [14].

2.4 Land filling disposal goal

One objective of landfilling of waste, including MSWI residues, is to remove from general circulation materials and products that are no longer useful in any respect. It is preferable to do this in a manner that ultimately returns the basic constituents of the waste to the ecological cycle, possibly after they have undergone chemical and/or physical reactions and transformations.

A second and equally important objective of waste disposal is to ensure that the waste does not cause any unacceptable short- or long-term impact on the environment or on human health. Disposal methods must ensure that this is accomplished in a sustainable manner, i.e. without excessive and/or prolonged maintenance or operation requirements and without a prolonged need for aftercare. Yet, the major environmental concerns in relation to the short-and long-term impact of landfilling of MSWI residues are connected with the risk of leaching and subsequent release of potentially harmful substances, particularly inorganic salts and metals/trace elements, into the environment.

As incineration residues are produced by high-temperature processes, they are thermodynamically unstable under ambient conditions. This renders incineration residues highly reactive, especially under wet conditions. This means that they change their mineralogical and physico-chemical characteristics as well as their leaching behavior as long as thermodynamic equilibrium conditions with the surrounding environment are attained. The specific environmental conditions influence and change the leaching behavior and contaminant release from such materials during utilization or final land disposal. To assess the discharge behavior of a specific waste, it is necessary to take the specific conditions (scenarios) into account. To arrive at a conclusion, the following methodology should be applied (ENV 12920):

- formulate the task and the sought-after solution,
- specify the scenario,
- evaluate the waste characteristics,
- determine the influence of the scenario conditions on the variation of waste characteristics over time, as well as on their environmental behavior,
- model the environmental behavior of the waste,
- validate the model by calibration with the results from laboratory tests and field experiments and by comparing it to natural analogues.

Such a methodology will also help identify the most appropriate mitigating measures to be undertaken before, during or after utilization or final land disposal. The EU Landfill Directive (LFD) distinguishes technically between three main classes of landfills (landfills for inert waste, landfills for non-hazardous waste and landfills for hazardous waste), but only in terms of the contamination potential of the waste and the environmental protection measures required at each class of landfill. The LFD does not include any landfill strategy or guideline on the design and operation of landfills aiming at the minimization of the period during which active aftercare will be necessary [9, 16]. Dense slurry technology is meant to reduce the leachability of the landfill disposal, and is reducing the aftercare period of the disposal. By cementing process that end with the formation of the ash rock, the dust emissions of the disposal are eliminated.

3 Leaching production

The potential environmental impact of leaching includes contamination of soil, groundwater and surface water bodies. Leaching can be defined as the dissolution of a soluble constituent from a solid phase into a solvent. Leaching occurs as a consequence of the chemical reactions taking place at the scale of the individual waste particles as well as of the contaminant transport processes via the fluid moving through the solid particles. As far as MSWI residues disposal is concerned (see Figure 2), the transport medium of pollutants is mainly represented by water, so that the overall water balance will determine the actual amount of water reaching the application site. The application site itself then modifies the water infiltration pattern as a result of the physical and hydrological characteristics of the material. Thus, the discharge pattern also depends on the pore type, pore distribution, homogeneity, permeability and field capacity of the material as well as on the presence of preferential flow paths. Water balance models can also be used to analyze the effect of different vegetation/covering scenarios on leachate generation.

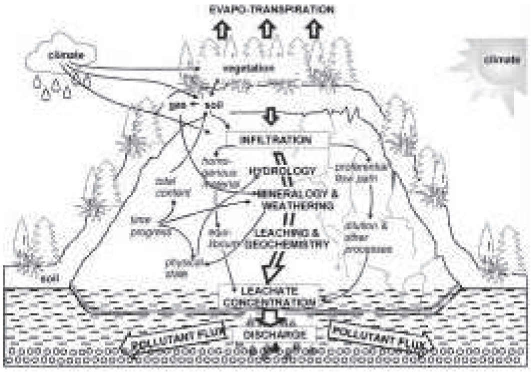

Figure 2. Schematic layout of water balance and geochemical processes and factors affecting the discharge and pollutant flux from a landfill containing residues from thermal waste treatment [9].

Together vegetation and physical barriers (top cover, liners) reduce the amount of leachate from the landfill but cannot completely prevent leachate formation over a long time scale. Some physical factors also affect the percolation pattern (advection, diffusion) and hence the modes of contact between leachate and waste, which can be caused by leachate flowing around the waste, leachate flowing through the waste or by a combination of the two [9, 16].

Dense slurry technology minimizes the leachate flowing through disposal filling material and so the contamination of the pollutant substances on the environment.

Indicator, mg/kg d.s.	Dense slurry (fly ash + bottom ash) (1 :1)	Dense slurry Fly ash + bottom ash + lime) (1 :1)	Maximum allowable value for inert residues
As	< 0,01	< 0,01	0,1
Ba	< 0,5	< 0,5	7
Cd	< 0,01	< 0,01	0,03
Cr_{total}	0,07	0,07	0,2
Cu	< 0,01	< 0,01	0,9
Hg	< 0,001	< 0,001	0,003
Mo	< 0,01	< 0,01	0,3

Ni	0,17	0,19	0,2
Pb	0,08	0,17	0,2
Sb	< 0,01	< 0,01	0,02
Se	< 0,01	< 0,01	0,06
Zn	0,12	0,07	2
Chlorides	28,4	35,5	550
Fluorides	< 0,1	< 0,1	4
Sulfates	495	530	560
Phenol index	< 0,05	< 0,05	0,5
DOC	4	7	240
TDS	1620	1750	2500

Note: water/solid = 2 litters/kilogram

Table 8. Leaching properties of dense slurry ash rock W/S=2l/kg

Laboratory tests of leaching properties for ash rock formed in dense slurry technology are summarized in Tables 8 and 9.

Indicator, mg/kg d.s.	Dense slurry (fly ash + bottom ash) (1 :1)	Dense slurry Fly ash + bottom ash + lime) (1 :1)	Maximum allowable value for inert residues
As	< 0,01	< 0,01	0,5
Ba	< 0,5	< 0,5	20
Cd	< 0,01	< 0,01	0,04
$\mathrm{Cr}_{\mathrm{total}}$	< 0,01	< 0,01	0,5
Cu	< 0,01	< 0,01	2
Hg	< 0,001	< 0,001	0,01
Mo	< 0,01	< 0,01	0,5
Ni	0, 2	0,3	0,4
Pb	< 0,01	< 0,01	0,5
Sb	< 0,01	< 0,01	0,06
Se	< 0,01	< 0,01	0,1
Zn	1,3	0,42	4
Chlorides	106,5	213	800
Fluorides	< 0,1	< 0,1	10
Sulfates	910	960	1000
Phenol index	< 0,05	< 0,05	0,5
DOC	4,5	5,9	500
TDS	2370	2490	4000

Note: water/solid = 10 litters/kilogram

Table 9. Leaching properties of dense slurry ash rock w/s =10L/kg [11]

The leaching tests were made according to EN 12457-2003, and were establish specific leaching compounds according to Directive 2003/33/CE. Prof for this are the dense slurry preparation achieved by EGI Budapesta during 04-05.12.2007 for solid residues of FCPP Mintia-Deva [11, 16].

4. Conclusion

Landfilling of the MSWI solids residues still remains and issue to be solved for the future. Integration of these residues into dense slurry technology can be seen as a future possibility came to minimize the leaching of landfill deposits [17].

Dense slurry technology has proven its efficiency as environmental friendly; therefore it was implemented in several fired coal power plants worldwide. Considering that most of FCPP are situated near by big urban settlements, so the quantities of the municipal solid waste are in large quantities. The idea of encapsulations of MSWI solids residues into ash rock can be seen as a real possibility to develop for the future [17].

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References

(1) European Comission, “Integrated Prevention and Control. Reference document on the Best Available Techniques for Waste Incineration”, August 2006. Available: http://ebookbrowse.com

(2) J.Paul Guyer, “Introduction to Solid Waste Incineration”, 2011. Available:https://www.cedengineering.com

(3) Decision Makers’ Guide to “Municipal Solid Waste Incineration”, 1999, The World Bank, Washington. Available: http://siteresources.worldbank.org

(4) Environmental Permitting Guidance “The Directive on the Incineration of Waste”, Octomber 2009, Available: www.defra.gov.uk

(5) R.Lima, R.T. Bachmann, “Pollutant emissions from modern incinerators”, 2002. Available: http://bibliotecadigital.ipb.pt

(6) ICIM, “Metode si tehnologii de gestionare a deseurilor. Metode de tratare termica, Bucuresti,. Available: http://www.deseuri-online.ro

(7) A. Porteous, “Energy from waste incineration – a state of the art emissions review with an emphasis on public acceptability”. April 2001. Available: http://www.aseanenvironment.info

(8) S. Sakai, M. Hiraoka, “Municipal solid waste incinerator residue recycling by thermal process”, October 1999. Available: http://www.hucaribe.gov.co

(9) T. Sabbas, A. Polettini, “Management of municipal solid waste incineration residues, October 2001. Available: http://www.sciencedirect.com

(10) P. Arjunan, M. R. Slisbee, D. M. Roy, “Chemical activation of low calcium fly ash. Part II: Effect of Mineralogical composition on alkali activation”

(11) Sciazko, M., Zuwala, J., Sobolewsky, A., Co-firing of biomass, fossil and recovered fuels methodology of reneable energy fraction determination, Worshop Waste & Biomass thermal treatement. Combustion and Co-combustion, Wrozlaw, Oficyna Wydawnicza, pp. 169-194, (2005).

(12) *** EC, Addressing the constraints for successful replication of demonstrated technologies for co-combustion of biomass/waste, dis/1743/98-nl, Energie Report.

(13) Ionel, I., Oprisa-Stanescu, P.D., Ungureanu, C., Mochizuki M., Cirtog A., Numerical Modelling as a Possible Analysing Tool for Coupling of aWaste Incinerator to an Existing Lignite, Fired Boiler, . J. Trans. Phenomena, Vol. 10, 2008, pp. 63–72

(14) P. Arjunan, M. R. Slisbee, D. M. Roy, “Chemical activation of low calcium fly ash. Part II: Effect of Mineralogical composition on alkali activation”, 2001 International Ash Utilization Symposium, University of Kentucky, Paper #106, Available: www.flyash.info

(15) A. Palomo, A. F. Jimenez, “Alkaline activation, procedure for transforming fly ash into new materials. Part I: Applications”, May 2011, Available: www.flyash.info

(16) M. R. Wächter, “Determinarea parametrilor optimi de transport la distanta prin conducte a slamului dens. Aplicatie CET Sud Timisoara”, Master dissertation, UPT Timisoara, 2008.

(17) M. R. Wächter , Ionel, I., Integration of the solid waste incineration residues into dense slurry technology, Energy (IYCE), 2013 4th International Youth Conference on Energetics, 6-8 June, 2013, Digital Object Identifier: 10.1109/IYCE.2013.6604170, Publisher: IEEE, pp.1-6.