Environment pollution, legislative framework and eco - sustainable recycling of industrial wastes in Gorj County

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Abstract: - Power plants represent the main source of air pollution, through combustion processes, both by releasing large amounts of dust, greenhouse gases and acidifying, and large quantities of waste, slag and ash disposed in landfills covering significant areas. SC Turceni S.A. is one of the largest power generating unit from Romania. Their policy is focused on the production and delivery of electricity in order to increase energy efficiency and to reduce the environmental impact. The paper presents environmental impact produced by slag and ash storage, while pointing out that the recovery of this waste significant improves the air quality in the area. An important aspect is the proprieties of the ash and slag evacuated by Turceni power plant in order to use them for building materials manufacturing.

Key-Words: - ash and slag properties, air pollution, building materials industry

1 Introduction

In Gorj county operates the largest energy complex of the country, namely EC Turceni and C.E. Rovinari using lignite as fuel extracted from coal basin of Oltenia open pits.

From coal combustion for electricity generation in the two plants, annually results about 5,000,000 tons of slag and ash which are evacuated in landfills, such as warehouses were built to store huge quantities of this waste. EC Turceni is one of the largest power generation companies in Romania and basic policy of the company is considering production and supply of electricity in terms of high efficiency and low environmental impact. With a total installed capacity of 1980 MW, the plant produces about 7400 m³ of fly-ash per day using lignite as main fuel. The ash is recovered after the 2-nd gas flow (rotary air preheater) and from the electrofilters. Slag and ash from the combustion process are transported hydraulically (1:10 dilution with water), using centrifugal pumps, in deposits designated for this purpose (a natural area with waterproof closure dumps).

EC Turceni has two deposits: 1-st deposit (on 240 ha, 3 compartments and a total capacity of 36 million m³) and 2-nd reserve deposit (on 175 hectares, 5 compartments and a total capacity of 20 million m³). Currently, there is a free capacity of about 4 million m³ (main dump) and about 8 million m³ (reserve dump). The minerals forming slag and ash are silicates, carbonates, sulfates, sulfides, oxides of aluminum, iron, calcium, magnesium, potassium and sodium. Combustion zone minerals that form slag and ashes are dehydrated and lose water of crystallization; carbonate dissociates thermally putting CaO and SO3 in freedom. Due to the high speed of passage through the mineral substances with high temperatures outside dissociation processes of oxidation and other reactions do not occur. In Table 1 are presented the percentages of oxide compounds that are found in slag and ash compared to clay. There is a good correlation between them, so these compositions are called silicate ash.
Table 1. Chemical composition of the average ash and slag, and clay

<table>
<thead>
<tr>
<th>Chemical compounds</th>
<th>Ash and slag (%)</th>
<th>Clayey soil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂ (%)</td>
<td>47.7</td>
<td>50.20</td>
</tr>
<tr>
<td>Al₂O₃ (%)</td>
<td>21.65</td>
<td>17.00</td>
</tr>
<tr>
<td>Fe₂O₃ (%)</td>
<td>11.70</td>
<td>7.60</td>
</tr>
<tr>
<td>CaO (%)</td>
<td>10.97</td>
<td>5.13</td>
</tr>
<tr>
<td>MgO (%)</td>
<td>2.65</td>
<td>7.00</td>
</tr>
<tr>
<td>SO₃ (%)</td>
<td>1.65</td>
<td>0.4</td>
</tr>
</tbody>
</table>

2 Problem Formulation

Always a deposit of slag and ash has a particularly strong impact on the environment. The main factors affected environment and potential effects are listed below [2]:

- leakage from storage affect groundwater and underground
- affecting the quality of Jiu river nearby through water discharges from deposit of ash and slag in case of incidents or damaged.
- wind-blown dust ash affects all environmental factors, water, vegetation, living organisms, soil settlements; fine-grained powders affect the principle bodies of animals and plants leaf system at distances of deposit;
- In terms of radioactivity, it appears that ash deposits in Romania are not polluting objectives, their radioactivity fits in the existing adjacent natural background.

The question is how to manage millions of tons of ash and slag waste already stored.

2.1 The phenomenon of dissipation

Due to smoothness of the ash particles, under wind action, dissipation appears and some of the particles deposited at the surface the deposit are involved and spread in the air and subsequently deposited on the ground.

The phenomenon is thus a major element of air and soil pollution in the area of influence of the landfill where the settlements like villages and town Turceni are. The intensity depends on several factors such as particle size of ash that are involved, weather conditions, climate, temperature, pressure, humidity, precipitation [4]. The dissipation phenomenon occurs especially in summer because of high temperatures and low.

In the case of ash and slag deposit, the pollutant emissions include only particles of entrained ash from the surface and dispersed in air particles are then deposited on the ground.

Estimation of particulate emissions from the landfill is a complex task, depending both on ash properties, but also the state of the atmosphere at the time period considered [5]. It is almost impossible to find a functional relationship which allows for short or long term, estimating particulate emissions from the ash deposit. An alternative that allows the estimation of emissions of particulate matter is the assimilation process of dissipation of wind erosion, a phenomenon for which there are direct calculations of functional relationships. U.S. EPA/ AP-42/ 2003 proposed a methodology for calculating emission estimation relationships through wind erosion, which generally depends on wind speed [7]. The broadcasts hourly total suspended particulate per unit area and per unit time deposit can be estimated by the formula:

\[
E = 1.8 * u (m/s) 
\]

As order of size, an elementary calculation shows, for a 40 ha surface landfills, an average hourly emissions of 144 kg / h. These emissions vary obviously from hour to hour depending on the parameters described above.

To estimate emissions of PM10 (particulate matter with a diameter of ten micrometers) from the surface of the deposit account no relationship similar to the one above, so the only way is to use the account information on particle size components in power plant ash. The determinations on lignite ash from thermal power Turceni revealed the distribution according to particle diameters constituent as shown in Table 2 and figure 1.

The coal combustion waste samples were collected from these landfills, by drilling in different locations at four levels [3].

Based on granulometric curve [6], it can be appreciated that total particulate matter (considered as particles with diameters smaller than 30 m) represents about 30% of the particles emitted from the landfill, while PM10 is a 16%.

Other physical and chemical parameters needed for estimating emissions of different fractions of...
Table 2. Physical characteristics of the average ash samples[3].

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Grain size composition (%)</th>
<th>Bulk density, g/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>4 3 2 1 0.5 0.2 0.09 &lt;0.06</td>
<td>Stamped Charged</td>
</tr>
<tr>
<td>A</td>
<td>25.47</td>
<td>1.84 1.06 2.55 7.19 10.44</td>
<td>24.35 28.35 7.81 16.41</td>
</tr>
<tr>
<td>B</td>
<td>26.78</td>
<td>1.43 0.93 2.43 5.08 8.32</td>
<td>19.24 26.35 8.88 27.34</td>
</tr>
<tr>
<td>C</td>
<td>25.83</td>
<td>2.25 0.86 2.62 7.81 11.89</td>
<td>26.60 27.70 6.36 13.91</td>
</tr>
<tr>
<td>D</td>
<td>25.88</td>
<td>0.51 0.62 2.07 7.72 10.89</td>
<td>22.97 28.38 7.18 19.67</td>
</tr>
<tr>
<td>ABCD</td>
<td>25.99</td>
<td>1.51 0.87 2.42 6.95 10.38</td>
<td>23.29 27.69 7.56 19.33</td>
</tr>
</tbody>
</table>

particulate matter (PM10 for example) and deposition rates and gravitational sedimentation are[3]:
- hygroscopicity coefficient 1.24%
- dimensional weight 0.95 g/cm³

Another important feature of power plant ash is moisture that is stored on the deposit, between 51.7 to 59%. Thus, particulate emissions from the landfill will be particularly intense in summer, when it can easily produce dry ash enhanced by high temperature and solar radiation and the dark color of ashes. In these dry conditions, lignite ash is 23 times lighter compared to the wet weight of particles less encouraging these transport by air currents.

2.2 In situ measurements
The monitoring of air quality is a permanent obligation of EPA Gorj and it is achieved by continuous and indicative measurements.

2.2.1. Monitoring air quality through continuous measurement network (automatic)
According to legislation in force, and as a result of commitments made by Romania in the field of air quality, it was made the National Integrated Assessment and Management of air quality-SNEGICA - by providing local authorities for environmental protection equipment automatic air quality monitoring (automatic stations) and related laboratory equipment. In Gorj county were located, respecting regulations, three automatic stations for monitoring air quality (industrial type) in 2008 in Tg.Jiu area (Gj-1), Rovinari area (Gj-2) and in 2009 in Turceni area (GJ-3)[1].

The measured pollutants are: SO2, NO, NO2, NOx, PM10, Pb, CO, O3 (ozone).

Compared to the Automatic station GJ 3, Turceni warehouse belonging CE Turceni Ceplea Valley is about 3.5 km SSW direction (206.79 ° North) and Thermal Power Turceni approx. 3km ESE direction (115 ° North). Therefore, the influence area of the ash deposit there are continuous and systematic measurements of ambient air quality, the indicators SO2, NO, NO2, NOx, PM10, Pb, CO, O3 (ozone).

Potential sources of pollution with particulate Turceni area:
- deposits of slag and ash - dissipation from the surface deposit
- burning of coal in power plant Turceni in order to produce electricity (emissions)
- residential heating with solid fuel, especially coal.

EPA Gorj does not have the necessary equipment and techniques and does not have competence in quantifying individual contribution of each source to the air pollution in the area. According to statistics, and based on meteorological sensor records from automatic station equipment regarding particularly wind direction and speed, we can say that the first two sources are major [1].

For the indicator PM10 (particulate matter with a diameter of ten micrometers), according to Annex 3 of Law no. 104/2011 on ambient air quality, which came into force on 28 July 2011 (abrogating the MAPM Order no. 592/2002) the averaging time limit of 24 hours for the protection of human health is 50 mg / m (not to be exceeded more than 35 times in a calendar year).

Between 10 November to 31 December 2010 and the first half of 2011, no measurements were performed for gravimetric PM10 indicator, due to technical faults on equipment from the station and laboratory equipment used in the analysis.

The overcoming recorded in the second half of 2011 the indicator PM10 had as main cause extended drought during August-December 2011, fact that determined high demand for energy produced in power plants Turceni and increased activity in mining lignite extraction career. Frequent
statements calm atmosphere for prolonged periods of time, favored the accumulation of pollutants. In winter there are added emissions of pollutants from residential heating sources.

From 01 January 2010 - 31 July 2012, the evolution of indicator PM10 data recorded is shown in Figure 3.

2.2.2. Air quality monitoring by indicative measurements, determinations of sediment particles

Sediment particles are suspensions with diameter exceeding 10 mm, having low stability in the air, which are deposited under the action of gravity, uniformly accelerated speed and low power of diffusion. The solid particles are deposited around pollution sources, depending on the size and density, but precipitation and air currents affect the distances and directions of the spread of pollutants.

The overcomings that were registered had as cause a combined intake from the surface phenomenon of ash and slag dissipation from deposits and emissions resulted from coal combustion process in power plants in order to produce electricity.

In Turceni area, EPA Gorj performed monthly measurements on sediments indicator, in 6 fixed locations. The maximum admitted concentration of this indicator provided by STAS 12574/87 “Air in protected areas – quality conditions” is 17g/mp/month.

From 01 January 2010 - 31 July 2012 the recorded data on indicator evolution of Sediment particles is presented in Figure 4.

3 Problem solution

University “Constantin Brâncuși” from Târgu Jiu is the coordinator of the ECOWASTES LIFE+ project, whose aim is to demonstrate that the recycling of waste from energy industry (coal combustion waste), petroleum extraction (drilling mud) and metallurgy (steelmaking slag) is a technically feasible alternative[8], taking into account that:

- Coal combustion waste (ash and slag) can replace up to 30-50% of natural quartz sand used in the ceramics manufacturing
- Drilling fluids waste (sintered material) can replace about 25% of clay used for classical bricks
- Metallurgical slag can replace about 50% of necessary calcium oxide.

The partners in ECOWASTES LIFE+ project are: University “Constantin Brâncuși” of Târgu Jiu (UCB), Metallurgical Research Institute (ICEM), Energy Complex Turceni (ECT), Environmental Protection Agency Gorj (EPA).

One of the first project’s objectives is selection and fully characterization of the three types of wastes (ashes, drilled solid wastes, metallurgical slag) identified as potential raw materials for the replacement of mainly three natural resources (clay, quartz sand, feldspar) used for building materials. The project aims to establish new ways of recovery of waste generated by the energy industry (power plant ashes), mining (oil drilling sludge) and metals (metallurgical slag) - some not currently use at European and even worldwide.

The project providing for an adjustment of a pilot plant and demonstration of innovative technologies for recycling waste products with high added value - new ceramic composite used primarily for building materials, but also in works such as impermeable layers in road construction.

4 Conclusion

By using the different types of industrial waste mentioned above, the following results are expected: fabrication of new building materials, reducing landfills and preserving important material resources, with significant improvements in air quality in the area.

References:
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Acknowledgements
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Figure 1. Mesh size of sieve(mm)

Figure 2. Location of air quality station
Figure 3. PM 10 automatic measurements

Figure 4. PM 10 - gravimetric measurements

Figure 5. Sediment particles in Turceni area between January 01 2010 – July 31 2012