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THE ATMOSPHERIC IMPACT ASSESSMENT GENERATED BY THE SLAG AND ASH DUMP IN CEPLEA VALLEY

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Abstract: *The study emphasized the pollutants produced by the Ceplea Valley slag and ash deposit, which belong to The Turceni Energy Complex, and was carried out during 2008-2009 period. The fuel used in the combustion process from the thermal power station is the lignite from Oltenia coal field, and black oil and pit gas are used for the maintenance and stabilization of the flame in the boilers. The amount of slag and ash produced by the burning process is of approx. 1 mil m^3/year/ energy group (there are 7 energy groups of 300 MW). The produced slag and ash is formed of sterile granular material, being deposited in accumulations created with the retaining dams, creating a waste dump of slag and ash, which are deposited through the hydraulic method used exclusively in our country. The most important pollutants are the total particles in suspension, $PM_{10,}$ and the gaseous pollutants as NO_2, SO_2, CO determined in the diurnal but also in the seasonal evolution (during summer months). Depending on their concentration, the INPUFF model was used to determine the dispersion areas, and the impact on the environment. The TSP exceeded the maximum permissible concentrations, and the gaseous pollutants had a decreasing trend in comparison with the previous years, as a result of introducing the modern technologies to the filtering system of the post burning emissions.*

Key words: *dispersion of pollutants, air pollution, seasonal evolution, environmental impact, thermal power plants*

INTRODUCTION

The technological process from the Turceni TPP produces ash and slags, which are wastes, formed basically of calcite, pyrite and other minerals which during the coal combustion are divided and decomposed. The clay particles remain in the burning area sufficiently enough to become clear small spheres of molten complex silicates, similar to glass. The

mineralogical analysis of slag and ash resulted from the low coals combustion indicates the presence of spherical solid aggregates, beside other lacy spongy aggregates (Hjartstam et al., 2009). The mineralogical data shows that ashes have a crystalline phase in percentage of 10-16% (quartz, mulit, hemalit, and magnetite) and a vitreous phase in percentage of 50-70%. The global analysis indicates that the ash produced by lignite, from Oltenia coal field, has the following oxidic composition: SiO_2 48%, Al_2O_3 23%, Fe_2O_3 8.1%, CaO 9.2%, MnO 3%, and SO_3 3.7%, the ash being silico-aluminous (Gavrilescu, 2007). The conducted researches on the radioactivity level of ash produced by the Turceni TPP are as follows (Eq/kg): Ra-226 137.4±16.5, Th-232 82.9±14.9, K-40 520.9±52, α-global 554±100, β-global 1070±117. This pointed out a radionuclide content of 2-4 times higher than that of standard materials (Popa, 2008).

The ash also contains PM_{10} which represents aggregates containing hundreds of individual compounds, with different chemical and thermodynamic properties (Gomez et al., 2005). The main compounds that are found in PM_{10} structure are the sulphates, the nitrates, the organic carbon, the elementary carbon, the soot, the ammonium etc. It should not be missed the primary organic fraction (Casper, 2010). The organic compounds represent approx. 21-39% of the material particles (Vallero, 2008).

At the European level there have been conducted many studies regarding the assessment of the level of air pollution, especially the dust pollution (Sharma et al., 2004 ; Brebbia et al., 2002 ; Dobjanschi, 2007). One of these studies is APHEIS (Air Pollution and Health: A European Information System) which tried to assess the levels of dust pollution and their impact on health in 12 European countries. This study showed that Romania is among the most polluted countries in Europe, the annual limits set by the EC being significantly exceeded.

In order to highlight the harmful effects of ash and slag, we took into consideration the dispersion way of pollutants within the Ceplea Valley Landfill, afferent to the Turceni TPP. The study objectives are: i.) The determination of pollutants and their concentration according to accepted standards; ii.) The impact on air, performed using the program INPUFF; iii.) The impact on population health.

MATERIALS AND METHODS

The study was carried out during 2008-2009 period in the area of Ceplea Valley slag and ash Deposit, located at 3.3 km from the Turceni TPP. The

map area covers a surface of 12x12 km, sufficient enough to highlight the impact in populated areas near the waste dump. For the determination of dispersed pollutants, the OLDHAM equipment was used to determine atmospheric pollutants, with which we determined the CO, SO_2, NO_2, TSP, and PM_{10}. For these ones we recorded the daily maximum values and the average values during the warm season. . The device works with sensors interchangeable allowing the operator to change the configuration of time. The device is equipped with LCD alphanumeric display, acoustic alarm (85 dB) and optical (LED) on each measurement channel. There were also calculated the deposits of total dust in suspension, the results being presented as spatial distribution of the concentration field of deposits. The data were processed using the INPUFF program, using the vertical and horizontal variations of wind direction also quoted in the papers of (Ionel 2009; Ferrarini 2009). Climatic data of the area were also used in the study (the topo-climate, the air temperature, the relative humidity, the nebulosity, the precipitations, the evapo-transpiration, the aeolian regime).

RESULTS AND DISCUTIONS

The analyzed area is characterized by a temperate continental climate with southern Mediterranean influences, having the specific character of the hills and valleys of Getic Piedmont, being necessary to highlight also the topoclimates of hills, couloirs, inclusive the ones created as a result of the anthropic activities (Zecchini, 2008).

The air temperatures recorded at the two stations: Tg. Jiu and Strehaia, have values of 10.2°C at Tg. Jiu, and the average multi-annual amplitude is 23.5°C at Tg. Jiu and 24.4°C at Strehaia. The average monthly temperature ranges between –2.3 and –2.90°C in January and between 20.2-21.6^{0}C in June. The ground surface temperature has differential variations, the annual averages decreasing with the increasing of altitude. These can be increased by 1.2^{0}C in the sunny and sheltered areas.

The relative humidity of air in the studied area has annual averages of 68-70%, increasing to the wooded regions on the slopes of the hills and to the Jiu flood plain at over 75%.

The hydrometric station of Rovinari recorded a multi-annual average rainfall of 644.6 mm. The maximum of precipitations in 24 hours was 89-95 mm.

The average annual potential evapo-transpiration for the studied area is of approx. 669 mm, and the average annual real evapo-transpiration of 571 mm, the maximum values being recorded in July, over 122 mm.

Due to the location in the south-west of the country, The Hydrographic Basin of Jiu River is under the influence of the movement of northern, north-eastern and south-eastern air masses, the maximum frequency occurring in the north direction, with over 14%. Along river valleys and sheltered depressions, it prevails the atmospheric doldrums. The highest wind speed is from the northern part, of over 2.3 m/s.

The monitoring of pollutants (Alastuey, 2004) have shown that the resulted dust is from the combustion process of energy coal and from the atmospheric entrainment of ash from the slag and ash deposits, under favorable climatic conditions, of the mineral and clayey dust particles from the lignite mining pit, from the dirt heap or from the conveyor and from the intense road traffic (Cocarta et al., 2008) (Table 1).

Table 1

The gaseous pollutants concentrations determined in 2008

Month of determination	Gaseous pollutants - 30 minutes average samples (mg/m^3)		
	SO_2	NO_2	NH_3
Average concentration I	0.0057	0.0103	0.0525
Average concentration II	0.0048	0.0138	0.0467
Average concentration III	0.0049	0.0070	0.0189
Average concentration IV	0.0050	0.0046	0.0145
Average concentration V	0.0049	0.0044	0.0220
Average concentration VI	0.0037	0.0106	0.0528
Average concentration VII	0.0036	0.0095	0.0779
Average concentration VIII	0.0044	0.0045	0.0904
Average concentration IX	0.0039	0.0082	0.0696
Average concentration X	0.0050	0.0089	0.0466
CMA	0.75	0.30	0.30

According to the above data there have been no exceedings of maximum permissible concentrations.

Regarding the sedimentary dust indicator (Table 2) there were exceedings of the MPC (17 g/m^2/month), in several sampling points.

The maximum concentration of SO_2 in 24 hours recorded at 200 m distance from the Turceni TPP has a maximum of 18 $\mu g/m^2$. As the distance from the source increases, concentration decreases, reaching values up to 2 $\mu g/m^3$, not exceeding the MPC of 125 $\mu g/m^3$.

Table 2

The sedimentary dust content recorded in 2008

Sampling points	Dust quantity (g/m^2/month)									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Turceni V 2000 m	3.76	3.62	7.39	6.73	14.66	6.41	7.89	8.07	10.02	6.17
Turceni V 1300 m	4.40	3.66	5.86	7.57	9.60	6.84	7.20	7.67	7.77	-
Turceni – Ceplea Valley – V 2000 m	5.32	3.31	12.48	11.26	18.08	11.55	22.82	11.99	18.52	6.57
Jilt Village, NE 3000 m	5.45	3.27	6.61	13.18	5.00	4.58	13.84	6.72	9.97	3.70
Cursaru E 1100 m	14.66	2.85	11.33	8.72	13.63	15.12	25.29	5.70	14.15	7.34
CMA 17 g/m^2/l										

The concentrations of total suspended particles TSP do not exceed the maximum permissible concentration (MPC) but exceed the alert threshold up to 1000m distance (north-east and south- west). The 24 hours average concentration exceeds the MPC up to 1000m distances (north-east), and exceeds the alert threshold AT, on distances of 750m south-west (Table 3). The TSP dispersion is shown in fig. 1.

Concomitantly, data were interpreted mathematically also from the long intervals of mediation (warm season) (Querol et al., 1998). A general characteristic of all mediation ranges of maximum concentrations occur within the waste dump and in its vicinity (Yuval et al., 2009). This thing occurs due to the shattering process at ground level, the generated cloud of particles having a low initial emission height (3-4m). Additionally, due to the presence of Ceplea Valley, the wind field will induce a transport of pollutants along the valley. This thing determines the distribution of the concentrations along north-east- south-west directions (Fig. 2).

In table 3 there are synthetically shown the results of mathematical simulation of the concentration fields- concentrations depending on the

Table 3
The total suspended particles concentration at various distances from the source

The distance from the limit of dump waste perimeter and sector (m-sector)	The concentration/ the concentration range ($\mu g/m^3$)	Health alert threshold (AT) ($\mu g/m^3$)	Limit value=Health Intervention threshold (LV/IT) ($\mu g/m^3$)	Vegetation protection threshold value (VTV)/ Ecosystems	Obs.
Mediation time 1h					
0-500 m, NE	430-410	350	500	-	<CMA,>PA
0-1000 m, SV	400-350				<CMA,>PA
500-1000 m, NE	410-380				<CMA,>PA
1000-1500 m, SV	350-320				<CMA,<PA
1000-3000 m, NE	380-280				<CMA,>PA
1500-2500 m, SV	320-260				<CMA,<PA
>3000 m, NE, >2500 m, SV	<280, <260				<CMA,<PA
0-500 m NV, SE	400-350				<CMA,>PA
500-1500 m, NV, SE	350-290				<CMA,< PA
Mediation time 24 h					
0-500 m, NE	210-180	105	150	-	>CMA,>PA
0-750 m, SV	150-105				>CMA,>PA
500-1000 m, NE	180-150				>CMA,>PA
750-1500 m, SV	105-80				<CMA,<PA
1000-2000 m, NE	150-105				<CMA,>PA
> 2000 m, NE >1500 m, SV	<105, <80				<CMA,<PA
0-500 m, NV, SE	190-150				>CMA,>PA
500-1000 m, NV, SE	150-105				<CMA,>PA
1000-1500 m NV, SE	105-80				<CMA,<PA

distance from the ash dump limits, and the comparison between maximum concentrations and limit values at different distances from the source (zoning). It have been taken into consideration besides the limit value (LV) also the margin of tolerance (MT) until 01.01.2010, mediation time 24 hours. It can be observed PM_{10} maximum concentrations reaching values which exceed the limit value and the margin of tolerance (according to Ord.

592/2002), up to 1000 m distance on the north-east direction, and values which exceed only the limit value up to 2500m distances on the same direction. In fig. 3 there are shown the izoconcentration curves in 24 hours, the maximum value being practically required by law, values related to the maximum number of exceedings of the admissible limit values during a year (Fig. 3).

During the warm season, on the long intervals of mediation (Triantafyllou, 2003), the average concentrations of PM_{10} exceed the limit value only in the perimeter of the ash dump or at distances very close to its limit (250-500m) (Fig. 4).

t should be noted that these maximum values of the deposits occur usually in the immediate vicinity or even on the waste dump surface.

The study shows that the limit values (especially the short term ones) imposed by STAS 12574/87 are exceeded for both TSP and PM_{10}.

Due to the fact that the main pollutants generated by the ash dump operations are dust in suspension, there is no possibility of developing synergistic effects caused exclusively by the studied objective. However, taking into consideration the presence in the area of significant concentrations of SO_2 and NO_2 (due to the thermal power plant activity), there is the possibility of developing synergistic effects (Pandey et al., 2010).

The presence of high concentrations of atmospheric dust in suspension and especially of PM_{10} at large enough distances from the objective perimeter can affect population health. The introduction of appropriate mitigation measures significantly reduces cases of disease. At the same time, the population may react negatively due to synergistic effects of TSP + SO_2 or TSP + NO_2 (Gurjar et al., 2010). Regarding the soil pollution, the MPC exceeding of suspended particles in the air do not raise any problem, maybe only through the accumulation of potentially significant quantities of pollutants on the surface of the particles, which by depositing sedimentary particles reach the ground (Pandey et al., 2010).

Concerning the mitigation opportunities of the shattering phenomenon, it is expected to stabilize the dry crust that forms on the surface of active deposit (bitumisation, polymerization, silication) during periods when there are fulfilled the conditions for manifestation of this phenomenon in order to prevent its occurrence (Rădulescu, 2008).

The placement of trees around the deposit is considered sufficient to reduce the amount of slag and ash shattered by wind at a minimum risk level for human health.

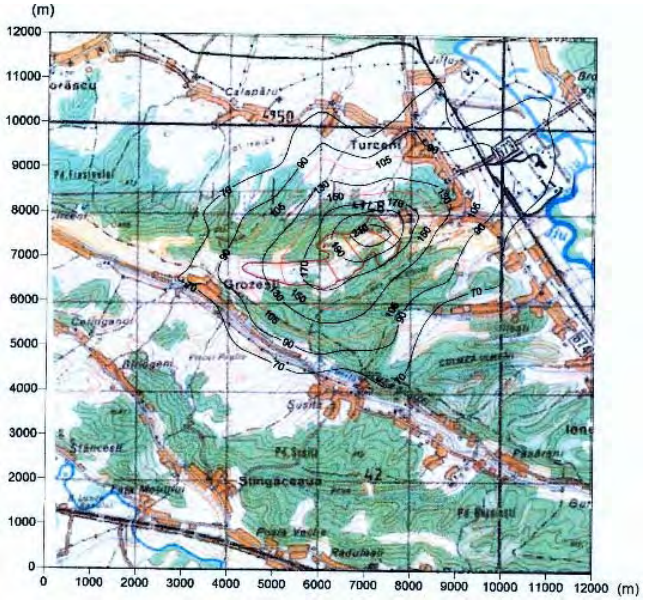

Fig. 1. TSP- the maximum concentration in 24 hours (μg/m^3)
(ISPE S.A. Bucharest)

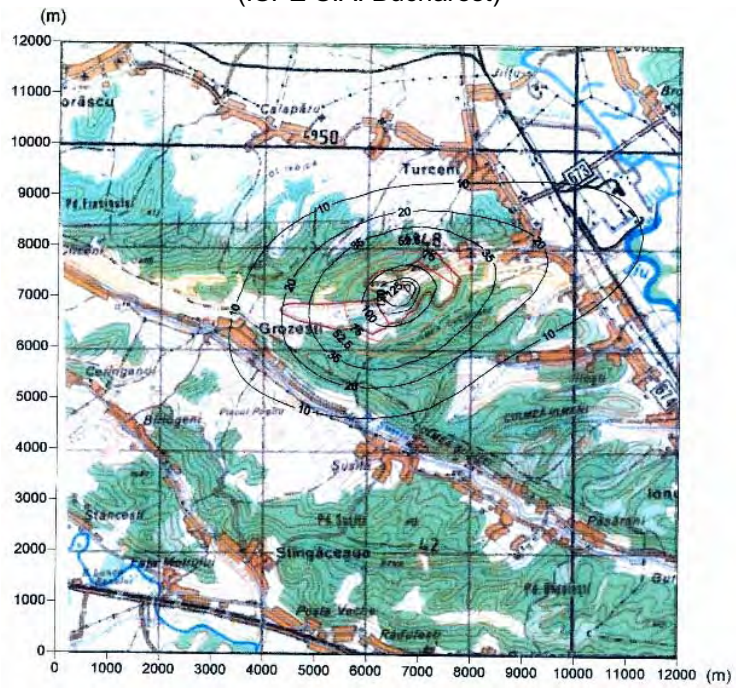

Fig. 2. TSP- the warm season average concentration (μg/m^3)
(ISPE S.A. Bucharest)

Table 3

The PM_{10} concentration at different distances from the source

The distance from the limit of dump waste perimeter and sector (m- sector)	The concentration/ the concentration range ($\mu g/m^3$)	Health alert threshold (PA) ($\mu g/m^3$)	Limit value= Health Intervention threshold (VL/PI) ($\mu g/m^3$)	Vegetation protection threshold value (VLV)/ ecosystems	Obs.
0-500 m, NE	110-95	-	75/50	-	> VL+MT
0-1000 m, SV	75-50				>VL,<VL+MT
500-1000 m, NE	95-75				> VL+MT
1000-1500 m, SV	50-40				<VL
1000-2500 m, NE	75-50				>VL,<VL+MT
>2500m,NE, > 1500 m, SV	<50, <40				<VL
0-1000 m NV, SE	110-75				>VL+MT
1000-1500 m, NV, SE	75-60				>VL,<VL+MT
1500-2000 m, NV, SE	60-40				<VL

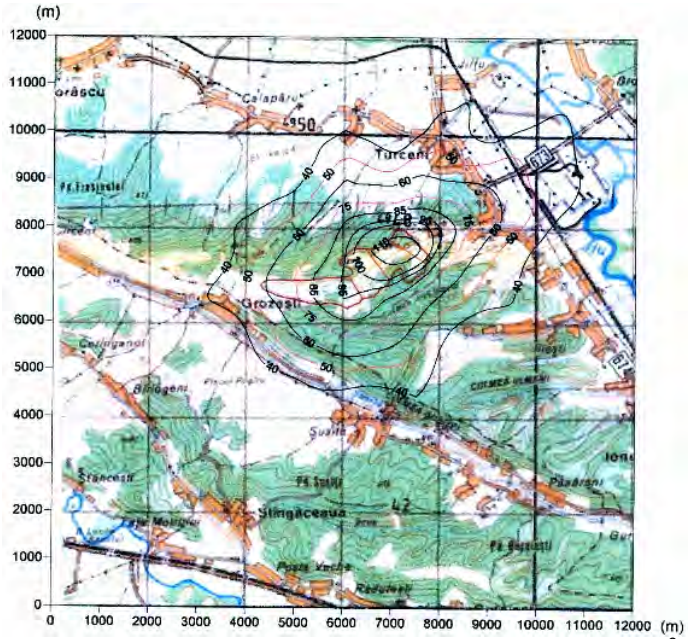

Fig. 3. PM_{10}- the maximum concentration per day ($\mu g/m^3$) (ISPE S.A. Bucharest)

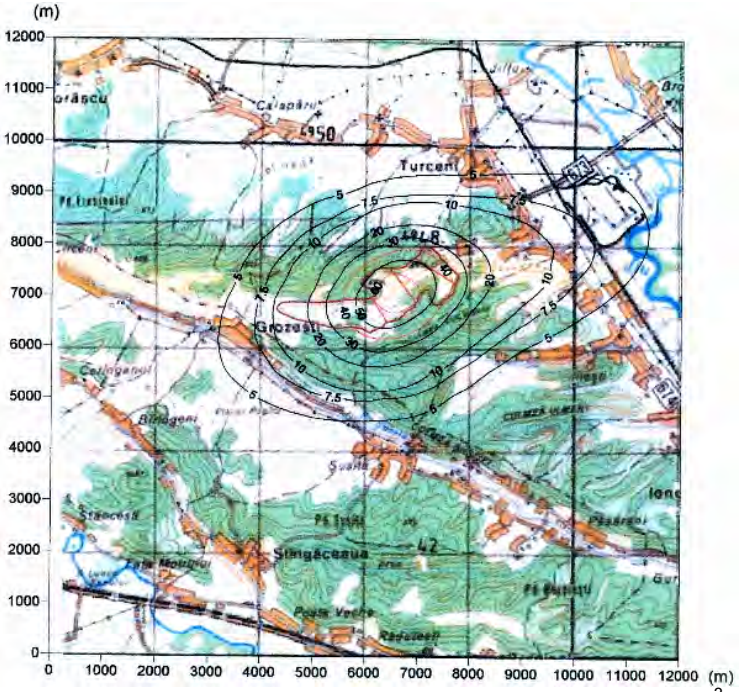

Fig. 4. PM_{10}- the warm season average concentration ($\mu g/m^3$)
(ISPE S.A. Bucharest)

After using the storage capacity, the surface of the deposit will be included in the manufacturing circuit, meaning technical and mining arrangement and the biological recultivation in order to create tree plantation.

CONCLUSIONS

Taking into consideration the shattering potential of ash from the proposed location, it is necessary to monitor monthly the quantity of settled dust in various points of the nearby localities, from the Turceni TPP site. Install an automatic meteorological station in the specified location agreed with the National Meteorological Administration for the data to be used in the national network.

The concentrations of total suspended particles (TSP) do not exceed the maximum permissible concentration, but exceed the alert threshold. The

24- hour average concentration exceeds MPC. The gaseous pollutants are within acceptable limits.

This study is important for determining the impact of slag and ash dump on vegetation, soil and human health.

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