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USE OF AIR DISPERSION MODEL FOR SUSTAINABLE MANAGEMENT AND PLANNING OF TRANSBOUNDARY INDUSTRIAL ACTIVITIES. OBSERVATIONS ON A CLOSED MINING TAILING POND

Abstract: *For the case study presented in the paper an air dispersion model based on boundary layer depth, Monin-Obukhov length and Gausssian pplume dispersion – ADMS5 – was used. An area source, situated on the Danube banks on Romanian and Serbia border, is investigated with emphasis on fine particle emissions releases caused by erosion of an open tailing pond.*

Keywords: *ADMS5, cross-border air pollution, air quality modeling, air pollutant dispersion*

1. INTRODUCTION

Mining industry is a major atmospheric, soil and water polluter due to its specific effects: massive landscape modifications, large areas of land occupied by mining facilities, ground and underground waters chemical pollution, soil pollution, negative impact on local flora and fauna, a.m. Today we assist at a different and more dangerous new environmental risks caused by an increasing volumes of sterile dumps and, more dramatically, closed mining tailings dumps left unattended after closing of mining companies due to mineral deposits depletions. [1]

The total areas occupied by mining tailing dumps in Romania reached 6900 ha, in a total of 799 tailing dumps, as a result of ferrous and nonferrous mining industry, coal power plants, steel and industry. From this, about 2140 ha are occupied by the wastes resulted from ferrous and nonferrous processing industry (in 109 sterile tailing ponds). The tailing dumps from Moldova-Noua are wet flotation sterile tailing ponds resulted from intense coper mining, covering about 130 ha, build in a pyramidal body shape with a height ranging from 20 to 23 meters. The Moldova-Noua sterile tailing ponds contain about 30 million cubic meters of fine grade sandy copper flotation sterile wastes. [2]

The technology used to fix the flotation sterile sands in the tailing dumps was a simple one, just a coverage of tailing dumps with a layer of water, constantly supplied on the dump surface. Starting with 2009, when the Moldomin Mining Company has been declared insolvent and its production stopped, the water supply to cover the flotation tailing dumps was also stopped. In this conditions, the main flotation tailing dump, no.3 with a surface of 86 hectares, dry out completely exposing the sterile sands to environmental elements. A view of the effect of closing and drying the Moldomin tailing pond (also named Bosneag) is presented in figure 1.

The environmental situation caused by the Moldova-Noua tailing pond drying and lack of maintenance is well known and in October 2012 the European Commission opened the infringement proceedings against Romania. Romanian government agreed that the tailing pond is a source of pollution during windy periods and recognized the need for actions to solve the environmental problem. However, as the tailing pond remained in a state of almost complete abandonment, in 2014 the European Commission take Romania to Court for a failure to comply with EU legislation on mining wastes. [3]

Today the mining company is closed and according to national laws the owner, Romanian government, should address and solve all arising environmental issues. However, after the closing the company no longer maintained its systems to suplly water to the tailing ponds and as the ponds dryed out significant environmental issues arise with severe fine particle pollution of its main neigbouring cities, Moldova-Noua in Romania and Veliko Gradiste in Serbia.

A view of the Moldova-Noua tailing ponds under windy conditions is given in figure 1.

***Figure 1** – A view of closed Moldomin mining company flotation tailing dump no.3, in windy conditions.*

2. THE CASE STUDY

Particles generation and their dispersion has always been a major concern in large mining projects, however, usually the main concern is on limiting the particles emissions from direct mining activities (opencast, blasting, haulage, a.o.) and not from wet tailing ponds. In this case, the concern is on tailing ponds, that on normal operation should be covered with a layer of water, or, in case on closure by a layer of fertile soil. As one can see from figure 1, the flotation tailing ponds from Moldova-Noua are completely exposed to wind erosion. Also, due to its characteristics, the content of tailing pond is formed by powder type dusts and one can assume that out of the total particles generated PM10 constitute up to half. [4]

The method applied to calculate PM10 emission factors for Moldova Noua dry tailing pond is the US-EPA method, described in the AP-42 guide. The reference equation is:

$$E_{10} = k\sum_{i=1}^{N} P_i \tag{1}$$

In equation 1, k is particle size multiplier, N the number of disturbances per year and P_i is the erosion potential corresponding to the probable fastest wind for disturbance period, in g/m^2. The particle size multiplier (k) varies with particle diameter, as shown in table 1.

Table 1 - Aerodynamic particle size multipliers for equation 1

30 µm	< 15 µm	< 10 µm	< 2.5 µm
1.0	0.6	0.5	0.075

In equation 2, u^* is the friction velocity in m/s and u_t the threshold friction velocity in m/s.

The cross-border area with its majos cities Moldova-Noua and Veliko Gradiste is meteorologicaly characterized by its specific (regonal) wind, call Cosava. Except summer Cosava wind is active with intense bursts of up to 25 m/s, with a foehn character and blows mostly from south-east. Cosava wind is usualy installed rapidly, disperse the clouds and raises temperature concomitant with air humidity decrease. [5] This wind and its high speeds at ground level is the main cause of tailing pond dryout and fast erosion. Also is responsible for transportation of fine particles in large amount over long distances.

In the simulation performed the tailing pond was assumed as a single area source with a area of 1064 m x 950 m, resulting an area source of about 101 ha, at an elevation of 10 meters (assuming that other 10 to 15 meters are under ground level). The coordinates for the center of the area are 44°423450 North and 21°391991 Est.

In a previous study, the emission factor resulted was EPM10 = 2.982 g/m^2/s. [1] However, due to further analysis of US-EPA AP-42 guidance and the erosion phenomena, other hypothesis were used in the current particle dispersion scenario:

- The average wind speed considered is 19.8 m/s (typical Cosava wind characteristic)
- Wind blow predominant direction is from East (and minor South-East, North-East)
- Fugitive emission time set at 14 hours
- Analyzed impact area set at 900 km^2
- In the absence of field data for estimating the threshold friction velocity, a value of 0.54 m/s is obtained from Table 13.2.5-2 [6]
- The PM10 emissions generated by the erosion event are calculated as the product of the PM10 multiplier (k = 0.5), the erosion potential (P) and the source area (A).
- The resulted erosion potential, applying equation 2 is P = 21.4 g/m2
- Thus, the PM10 emission for the considered episode is EPM10 = 4.184 g/m^2/s
- The model used was ADMS 5 and the boundary layer was characterized by the height h and the Monin-Obukhov length

LMO (not by Pasquill-Gifford stability category), governed by the following equation:

$$L_{MO} = \frac{-u_*^3}{\left(\frac{k \cdot g \cdot F_{\theta 0}}{\rho \cdot c_p \cdot T_0}\right)} \tag{3}$$

where: $u*$ - friction velocity at the Earth surface; k – von Karman constant (0.4); g is gravitational acceleration; $F_{\theta 0}$ – surface sensible heat flux; ρ - density of air; c_p – specific heat capacity of air; T_0 – near surface temperature

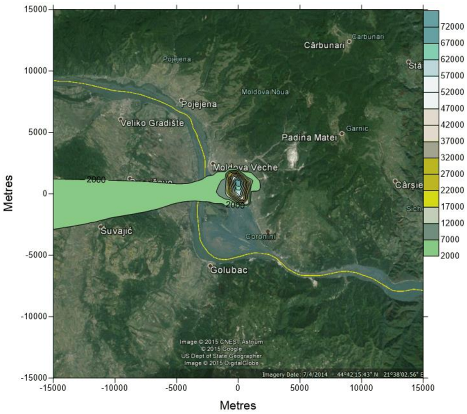

Fig.2.a. *Wind direction: East, 45°*

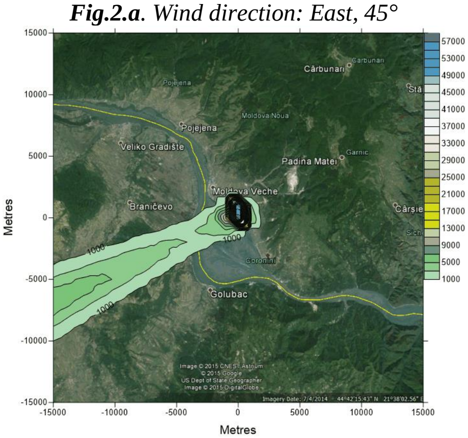

Fig.2.b. *Wind direction: North/East, 65°*

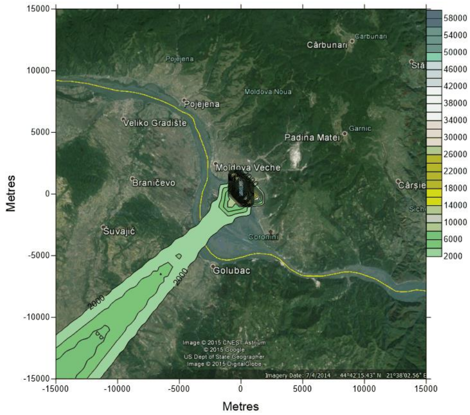

Fig.2.c. *Wind direction: North/East, 45°*

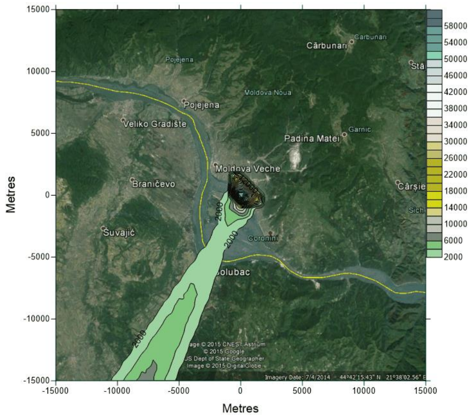

Fig.2.d. *Wind direction: North/East, 28°*

Figure 2. *Simulation result: one hour mean values for PM10 [μg/m³] for typical Cosava wind direction.*

3. CONCLUSION

One should note that the AP-42 guidance emission factor for PM10 refers specifically to coarse and dry tailing ponds, defined as filled with solid rocks and exposed to wind erosion. In the Moldova Noua tailing pond the content of the pond is formed by sedimentation of ultra-fine particles resulted from copper flotation process, much smaller and already eroded, so that the AP-42 methodology for PM10 emission factor estimation may be significantly underestimated.

From the results presented in figure 2, one may note that:

- The high concentrations of PM10 (excepting those wright on top of the tailing pond) are exceeding 6000 µg/m^3 in the vicinity of Moldova Noua city
- The cross border impact is also significant, the PM10 concentrations generated by the dry tailing pond are in the range of 2000 – 4000 µg/m^3 in the Golubac / Veliko Gradiste area, în Serbia

In the Moldova-Noua tailing pond the only applicable solutions to reduce environmental impact could be:

- The proper maintenance with a covering layer of water (in abundance in the area)
- The pond surface should be covered with a layer of soil to stabilize the sands. Analysis of the tailing pond soil shown that the chemical composition consists mainly on SiO_2 (32%) and CaO (13%). Attempts to cultivate have been performed in the past decade, with minimum results and only on the tailing pond banks.
- A possible and feasible solution would be to cultivate the tailing pond with acacia, willow, and miscanthus or phalaris vegetation, as energy plants, a solution already tested for coal power plant ass ponds. [2]
- Another possible solution would be to use the tailing pons as a base to develop biogas facilities, to benefit from the local existing farming manure (unused). This could be an effective solution, especially as know how already exists in the western Romania [7], including already patented tailored biogas installation for agricultural substrates.

Figure 3. *View of the dried tailing pond No.3 of copper mining in Moldova-Noua*

The mining industry in area dates back to Roman Empire and the development and increase of coper mining in industrialized area is normal, however, in the future this case shows how important would be to evaluate any projected industrial activy by running (amoung others) pollutant dispersion models with the worst case scenario, to avoid any potential impacts.

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Acknowledgment: This work was supported by the IPA Romania-Serbia Cross Border Cooperation Programm, project *Sustainable development of an research center in Banat region and Danube flow area through scientific research and environmental simulation tools to asses and evaluate potential threats*, acronym *ENVIROBANAT*, MIS-ETC 1425, www.envirobanat.ro and also partialy supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-1043.