Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 22 (2016) 440 – 444

Procedia Technology

9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania

A Performant State-of-Art Tool to Assess Cross-Border Impact of Industrial Activities. A Transboundary Air Pollution Case Study.

Francisc Popescu[a,b]*

[a]University Politehnica Timisoara, Faculty of Mechanical Engineering, Bv. Mihai Viteazu no.1, Timisoara 300222, Romania
[b]EcoAge Engineering SRL, Piata Romanilor nr.15, Timisoara 300100, Romania

Abstract

The paper focus is on the air pollution episode generated by a closed mining tailings dump located on Danube banks in historical Banat region, between Romania and Serbia. In this paper a new generation Gaussian plume air dispersion model was used, based on the hypothesis that the atmospheric boundary layer properties are characterized by the boundary layer depth and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class. The case-study focuses on a sensible case of Romania-Serbia cross-border case generated by the lack of maintenance of a closed mining tailings dump and the evaluation of an area type pollution source on the surrounding environment.

Peer-review under responsibility of the “Petru Maior” University of Tirgu Mures, Faculty of Engineering

Keywords: Air pollution; ADMS 5; Monin-Obukhov length; cross-border air pollution; air quality modeling.

1. Introduction

Models have become a primary tool for air quality analysis in most air quality assessments mainly for the several reasons, mainly because an assessment of the air quality in a large area can be obtained, while the air quality measurements are restricted to limited spatial coverage. The impact of emissions on air quality can be revealed by modelling, a very important aspect for supporting air quality management. Models and model applications can be distinguished on the basis of many criteria, such as the temporal and spatial scale, type of source, type of component,

* Corresponding author. Tel.: +4-0256-403-666; fax: +4-0358-819-404.
E-mail address: francisc.popescu@upt.ro , office@ecoage.ro

Peer-review under responsibility of the “Petru Maior” University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2016.01.082

a.o. The most relevant are the macro-, micro- and mesoscale models, describing the dispersion and transport of air pollutants mainly on a spatial scale, but also temporal, transport equation, chemistry, a.o. sub-model are included.
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. In 2006, the flotation tailing sterile material exceeded in Romania 5 million tones and the volume of polluted water discharged in receiving rivers, at national level, exceeded 50 million m^3. [1] The copper mining in Moldova-Noua was one of the oldest in Romania, with an historical sources dating before Roman Empire. However, the intensive industrialization of the copper mining in Moldova-Noua started in 1970 – 1980, being the largest copper exploitation, at its time, in Romania. The Moldomin, Moldova-Noua flotation tailing dumps covers 130 hectares in 3 tailing dumps with an average heights of 22 meters and a total content of sterile sands of approximately 30 million m^3. 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.

Fig. 1. (a) A view of closed Moldomin mining company flotation tailing dump no.3, in windy conditions.

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. [2]

The environmental impact of the copper mining wastes tailing ponds in Moldova-Noua are of significant concern as it affect not only the Romanian city of Moldova-Noua and nearby villages, but also the touristic city of Veliko Gradiste, in Serbia, giving the pollution phenomena an cross-border character.

2. Research problem and applied method

When it comes to PM10 (airborne particles with an equivalent diameter under 10 µg) worldwide, three techniques are mainly used to establish a PM10 emission factor for a specific site:

- A division of source activity in specific source components (e.g. wind erosion, included industrial roads) and then the available emission factors for each component are combined into a single emission factor for the entire source;
- The development of a new emission factor from applicable related factors and specific data;

- Field testing and direct measurements are used to calculate a source specific PM10 emission factor.

There are several methods to calculate the PM10 emission factor for a tailing pond, the more significant being the US-EPA AP-42 guidance and EU guidance. However, in both cases emission factors are referring to the wind erosion of coarse, dry tailing ponds with stable large rock dumping and not fine sands resulted from copper/zinc wet flotation processes. It is assume that flotation tailing ponds are maintained properly and so no emissions are anticipated, as the fine flotation sterile sands will be discharged as slurry with high water content and not considered to be a potential source of fugitive dust.

$$E_{10} = \frac{73.8 + 25.6\ mg/m^2/\min of\ erosion\, time}{2} = 49.7\ mg/m^2/\min \tag{1}$$

Equation 1 is the US-EPA recommended method to calculate emission factor for PM10 for coarse, dry tailing ponds, for an average threshold velocity of 19 m/s. This emission factor should be multiplied by the number of minutes with wind velocities exceeding 19 m/s during time period of interest. [3]

Another equation recommended by US-EPA, thru AP-42 guidance, is given in relation 2. However, this relation is based on the assumption the erodible surface is well characterized.

$$E_{10} = k \sum_{i=1}^{N} P_i \tag{2}$$

Where 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 erosion potential function for a dry, exposed surface is given by equation 3, where $u*$ is the friction velocity in m/s and u_t the threshold friction velocity in m/s. [4]

$$P = 58(u* - u_t)^2 + 25(u* - u_t) \tag{3}$$

However, the equations 2 and 3 are difficult to implement because of the nonlinear form of the erosion potential function. So, each erosion event should be threated separately. Also, the AP-42 guidance specifically emphases that equations 2 and 3 should be used for dry material with limited erosion potential. [4]

Another significant input, specific for Moldova-Noua flotation tailing pond is the wind character. In Moldova-Noua region the main wind, named “Cosava” is at its highest activity in spring, autumn and winter periods. Cosava is a very intense wind, with speeds over 25 m/s, a foehn character and blows, generally, from south-east. Cosava is a warm and dry wind which causes the melt of snow in a few days, and maintain, nights after nights minimum temperatures higher than in other regions. The Cosava is an intense winds installed in a short time, increasing temperature, decreasing moisture and total disappearance of the clouds. [5] This causes an intense dry out of the tailing pond and massive wind caused erosion and transportation of fine dust in large quantities at long distances (see figure 1).

For the scenario assumed, the fugitive PM10 emissions due to wind erosion from the Moldomin Moldova-Noua flotation tailing pond were represented by a single area source. Based on the aria of tailing, the area source has the eastern length of 1065 meters and the northern length of 950 meters. The elevation above ground was set at 10 meters. The coordinates for the center of the area are 44°423450 North and 21°391991 Est.

3. Results and discussions

Based on the emission factors discussed above the relation 1, based on US-EPA AP-42 guidance was used to obtain the emission factor for PM10 particles, emitted from the surface area by erosion phenomena. The resulted emission factor is EPM10 = 2.982 g/m^2/s, the time of emission was setup at 14 hours and the release elevation at 10 meters. Release area was defined as 1065 m by 950 m, approximatively 101 hectares. For the erosion wind, an average wind speed of 19.8 m/s was chosen, with a blow direction over 24 hours from East, South-East and North-East. This is considered a worst case scenario for wind speed and direction, based on local Cosava wind characteristics. [5]

The impact area was considered square, at 30 km by 30 km, covering the main cities, Moldova-Noua in Romania and Veliko Gradiste in Serbia. The software used was ADMS5.1, developed by Cambridge Environmental Research Consultants, UK. The simulation results are presented in figure 2.

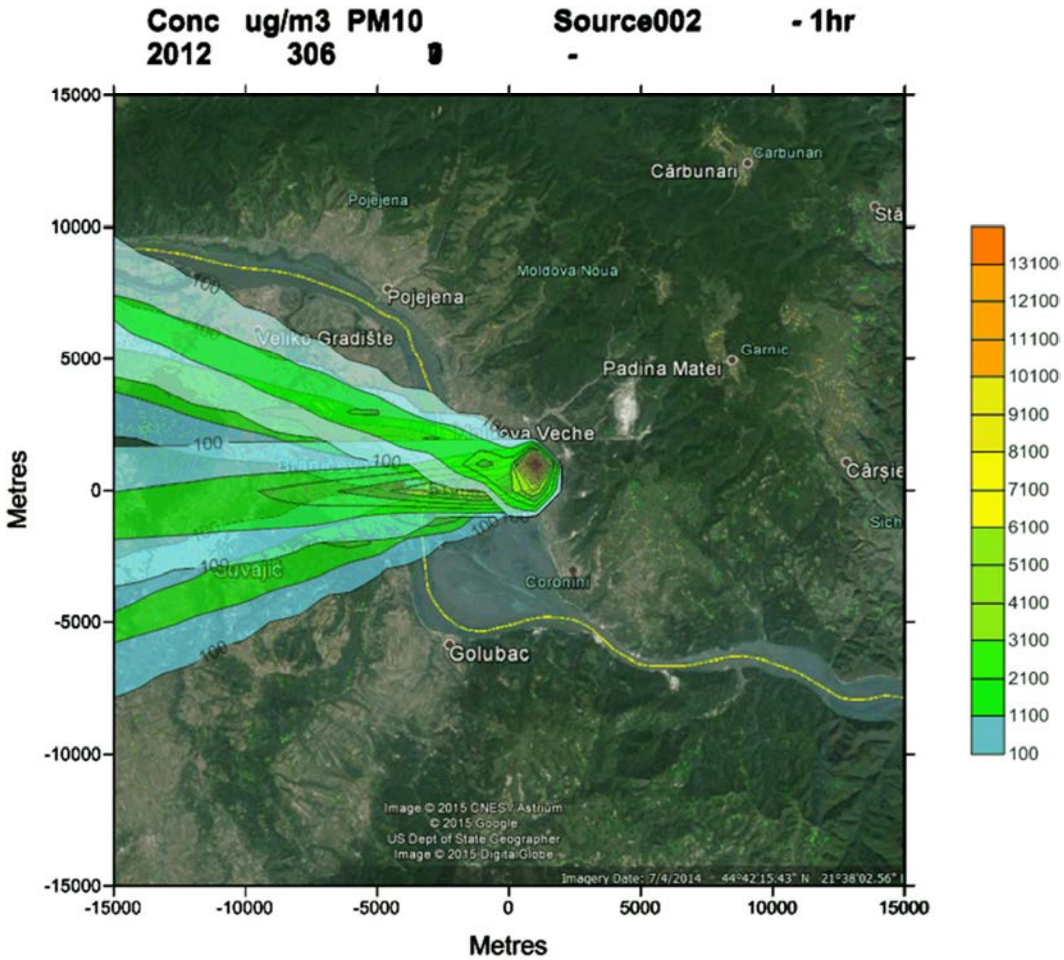

Fig. 2. Simulation result: overlapped one hour mean values for PM10 [μg/m^3] for hours 0, 3 and 9 of day 306 for 2012.

Analyzing the isoconcentration curves in figure 2, obtained from a case scenario presented above with an emission factor according to AP-42, one may observe that:

- The maximum PM10 concentration occur on and in the near vicinity of the tailing pond – in consistency with figure 1 observations – and the maximum concentrations are over 13000 μg/m^3;
- For this scenario the PM10 concentrations in city of Moldova-Noua are from 2000 up to 6000 μg/m^3;
- High concentrations of PM10 are transported over the border, in the Veliko Gradiste region, ranging from 100 μg/m^3 up to 2000 μg/m^3.

However, one should have in mind that the case scenario presented below is based on an emission factor defined in AP-42 as “coarse, dry tailing ponds”, a tailing ponds filled with solid and large scale rocks. In the Moldomin tailing pond, formed by the sedimentation of fine dusts resulted from copper ore flotation process is much smaller in size and the AP-42 emission factor is not relevant for this case.

A view of the fine sands that forms the tailing ponds is presented in figure 3.

Fig. 3. View of the dried tailing pond No.3 of copper mining Moldomin, Moldova-Noua.

The tailing pond, figure 3, should be covered by a layer of water, constantly added to avoid evaporations caused by sun radiation in summer and Cosava wind (hot wind) in spring, autumn and winter. Due to the economic difficulties from the past years, the Moldomin activities seized and the maintenance of the tailing ponds was stopped causing fast dry out and exposure of the fine sands.

4. Conclusions

Analyzing the case scenario results in conjunction with the fact that the size fractions of the sands are significantly smaller than the one used for AP-42 calculation of the PM10 emission factor one can conclude that the case scenario presented is actually much worst in reality.

In the Moldomin, Moldova-Noua tailing pond the only applicable solutions to reduce environmental impact is either the proper maintenance with a covering layer of water (in abundance in the area) either the pond surface to be covered with a layer of soil to stabilize the sands.

The lesson that should be learned from the Moldomin case is that the use of pollutants dispersion models to evaluate the worst case scenarios should be mandatory for any new industrial planed objectives.

Acknowledgements

This work was possible thanks to the successful implementation of “*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”* project, acronym ENVIROBANAT; (envirobanat.ro), Romania – Republic of Serbia IPA Cross-border Cooperation Programme, priority axis 1, measure 1.4, MIS ETC code 1425.

References

[1] Fodor D. Mining industry influence on the environment. AGIR Magazine 2006; 3:2-13
[2] European Commission, Press release IP/14/1149, http://europa.eu/rapid/press-release_IP-14-1149_en.htm
[3] US-EPA. Gap filling PM10 Emission Factors for selected open area dust sources, Midwest Research Institute, EOA contract 68-02-3891, 1988
[4] US-EPA. AP-42, Chapter 13.2.5 Industrial Wind erosion, emission factors, 2006; 13.2.5-14
[5] Barbu S, Moisa C, Mircov VD. Cosava – a Banatean wind. Research Journal of Agricultural Science 2009; 41(1):365-371