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Air quality modelling as a tool used in selecting technological alternatives for developing a new abrasive facility

[1]Radu Mihăiescu, [2]Tania Mihăiescu, [1]Nicolae Ajtai, [1]Zoltán Török, and [1]Alexandru Ozunu

[1]Babeş-Bolyai University, Research Center for Disaster Management, Cluj-Napoca, Romania. [2]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania. Corresponding author: R. Mihăiescu, radu.mihaiescu@ubbcj.ro

Abstract. Production of abrasive compounds employs the use of various organic materials as adhesives or as conditioners. During the baking process, a significant amount of air pollutant substances, including various forms of organic compounds are emitted in the atmosphere. Selecting the most suitable technological process is a procedure that involves a cost benefit analysis as well as procedures for complying with BAT requirements (best available techniques). Assessing the resulting environment quality in the vicinity of a new facility is also important, IPPC Directive clearly specifies that a new facility must not induce changes of the quality of the environment. This is highly dependent on local meteorological and topographical conditions. The ISCST3 model was applied to assess the atmospheric dispersions associated with several potential technological designs, and compare their impacts on the environment.

Key Words: air quality modelling, BAT, abrasive production, IPPC Directive, ISCST3 model.

Rezumat. Fabricarea materialelor abrazive necesită utilizarea de compuşi organici diferiţi ca adezivi sau ca şi materiale de condiţionare. În timpul procesului de coacere se elimină în aer cantităţi semnificative de compuşi organici. Selectarea cel mai adecvat proces tehnologic este o procedură care implică o analiză cost-beneficiu în condiţiile respectării condiţiilor BAT (cele mai bune tehnici disponibile). Evaluarea impactelor asupra mediului în vecinătatea unei noi unităţi productive reprezintă de asemenea o cerinţă BAT şi este foarte importantă, Directiva IPPC specificând faptul că noile facilităţi nu trebuie să inducă modificări ale stării de calitate a mediului.. Dat fiind faptul că majoritatea poluanţilor sunt emişi în aer, în vederea evaluării impactelor este necesară modelarea dispersiilor poluanţilor emişi ţinând cont de condiţiile locale specifice, topografice şi meteorologice. Modelul ISCST 3 a fost aplicat pentru evaluarea dispersiilor atmosferice asociate deferitelor variante tehnologice în vederea comparării impactelor asupra mediului.

Cuvinte cheie: modelarea calităţii aerului, BAT, producerea abrazivilor, directiva IPPC, modelul ISCST3.

Introduction. Abrasive production, despite all technological improvements can constitute a serious pollution source, requiring a special approach in order to minimize environmental impacts. The activity is listed in Annex1 of the IPPC Directive (the Council Directive 2008/1/EC on integrated pollution prevention and control). The purpose of the IPPC Directive is to achieve integrated prevention and control of pollution arising from the selected activities, leading to a high level of protection of the environment as a whole, and provides for a permitting system for certain categories of industrial installations requiring both operators and regulators to take an integrated, overall look at the polluting and consuming potential of the installation. The overall aim of such an integrated approach must be to improve the management and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle given in Article 3 that operators should take all appropriate preventative measures against pollution, in particular through the application of best available techniques (BAT) enabling them to improve their environmental performance.

IPPC permits must include emission limit values (ELVs) for pollutants likely to be emitted in significant quantities. According to Art. 9(4) these ELVs, equivalent parameters and technical measures must be based on the BAT, without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. In all circumstances, the conditions of the permit must include provisions on the minimization of long-distance or transboundary pollution and must ensure a high level of protection for the environment as a whole.
Inorganic/organic bonded ceramic abrasives consist of abrasive grains, binding agents and several additives, which are mixed, shaped, dried and fired. The main phases in inorganic/organic bonded abrasives are:

- Preparation of raw materials
- Shaping
- Drying
- Firing
- Subsequent treatment.

Important input and output flows of inorganic bonded abrasives manufacturing processes are presented in the Figure 1.

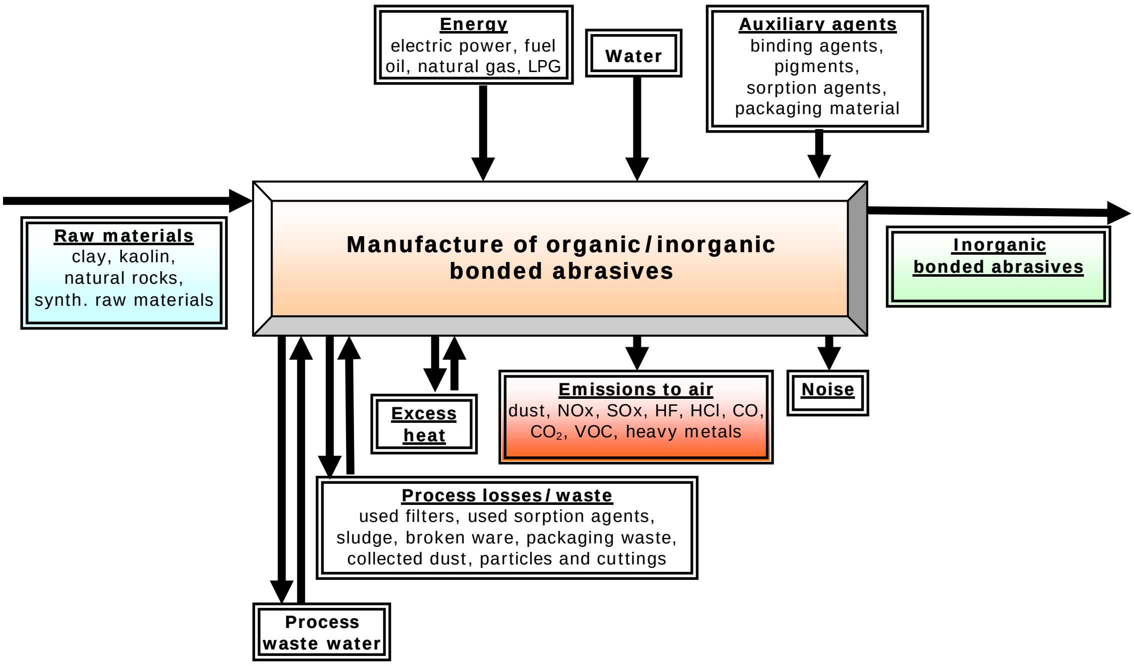

Figure 1. Input and output flows in the manufacture of inorganic/organic bonded abrasives (adapted from Reference Document on Best Available Techniques in the Ceramic Manufacturing Industry, 2007)

The majority of gaseous pollutants are generated in the phases of Drying and Firing. In order to assess the quantity of air pollutant emissions for a projected facility several emissions inventory techniques can be applied:

- direct measurements
- surrogate parameters
- mass balances
- calculations
- emission factors.

In case of realizing a new facility with characteristics more or less similar with other existing facilities a combination of all techniques can be useful. Air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Based on inputs of meteorological data and source information like emission rates and stack height, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere.

AERMOD View is a complete and powerful air dispersion modeling package which seamlessly incorporates the following popular U.S. EPA air dispersion models into one integrated interface:

- AERMOD
- ISCST3
- ISC-PRIME

These US EPA air dispersion models are used extensively to assess pollution concentration and deposition from a wide variety of sources. The AMS/EPA Regulatory Model (AERMOD) is the next generation air dispersion model based on planetary boundary layer theory. AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations. Pollutants dispersions were run in a single ISCST3 configuration. The Industrial Source Complex Short Term (ISCST3) model is the US EPA's current regulatory model for many New Source Review (NSR) and other air permitting applications. ISCST model is a gaussian plume dispersion model that predicts air concentrations around point or area sources using emission rates (flux) and meteorological conditions as model inputs. ISCST3 is applicable for estimating ambient impacts from point, area, and volume sources out to a distance of about 50 kilometers (http://www.weblakes.com/products/air_dispersion.html).

Material and Method

Study area. The study area is an industrial town, where industrial and residential areas coexist. The possible plant location is situated 4 km outside the residential area which is also surrounded by a belt of industrial zone.

Modeling procedure. The model framework to predict nominal gaseous concentrations is shown in Figure 2.

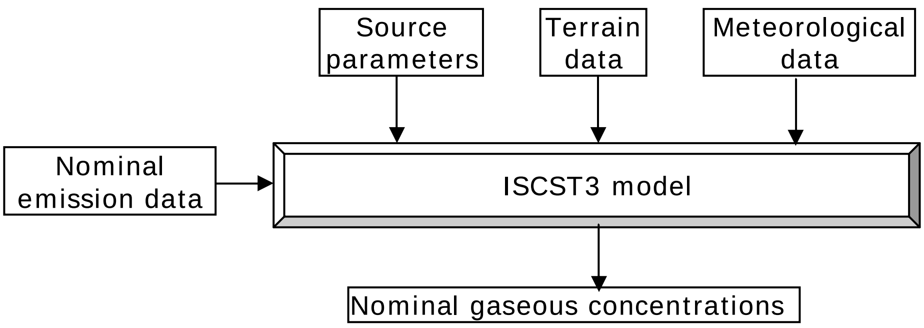

Figure 2. Model framework to predict nominal gaseous concentrations (adapted from Xu et al 2008).

Data pertaining to source characteristics, meteorological parameters, terrain receptor network and nominal emission were used as input to the ISCST3 model to estimate the nominal gaseous concentrations (NOx, PM10 and Naphthalene).

Source characterization. An inventory of all emissions sources was performed using the planning data. Data related to emission characteristics such as stack height, diameter, exit gas temperature, and exit gas velocity of the abrasive plant were taken from a similarly plant which was subjected to extensive monitoring during operation.

Meteorological data. Sequential hourly surface meteorological data were obtained from the Romanian National Meteorological Administration from year 2003-2006 inclusive. Meteorological data processing was performed with Rammet View program, part of the ISC AERMOD View package.

Topographical data. Topographic data was obtained from the website, http://www.webgis.com/, supplied in the GTOPO30 DEM Format and was processed by the USEPA terrain processor AERMAP. Terrain elevation (between 9 m and 13 m) and land use within a 19,8 km-radius of the plant indicated that the ISCST3 "rural" modeling algorithms were suitable.

Results and Discussion. Various simulations were performed using different scenarios (see figures 3-5) on a 392.04 km^2 area (19.8 x 19.8 km) with a grid of 200 m which totals 10000 virtual receptors (points were emission concentrations were calculated). Maximum alowded concentration (according to Romanian legislation) were compared with calculated values and represented as indexes on maps according to the following scheme.

1	2	3	4	5	6
EXCELLENT	VERY GOOD	GOOD	MEDIUM	BAD	VERY BAD

In the case of organic bonded abrasive production the most suitable technological, economical and environmental alternative proved to be the use of a thermal oxidizer coupled with heat recovery in the purpose of controlling VOC emissions which allowed an 80% reduction. Other controlled measures used included carefully recovery of the dust generated by employing exhausters coupled with bag filters, controlling the burning processes in the continuous and discontinuous ovens.

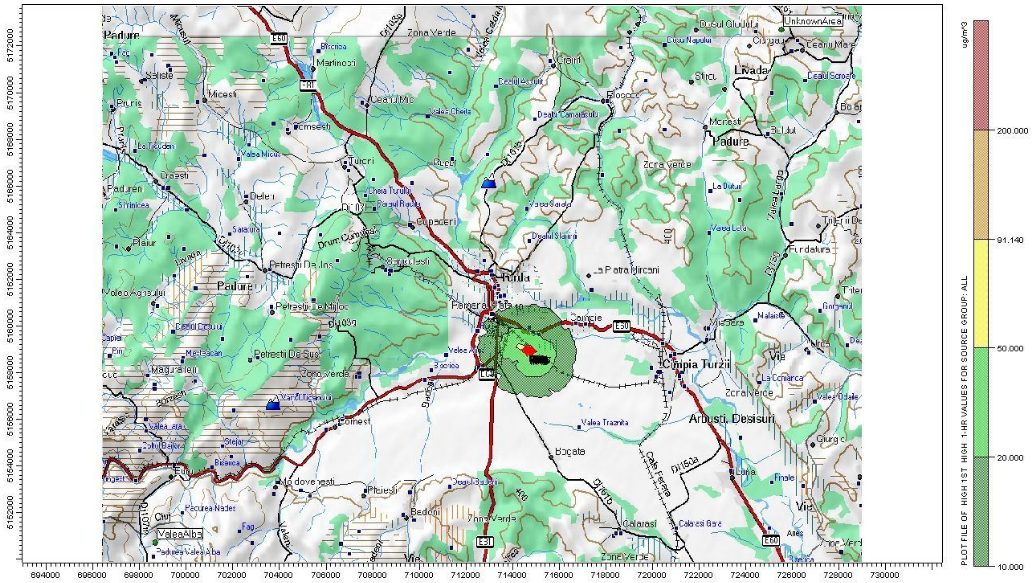

Figure 2. NOx (1 hour) modeling using ISCST3 model.

Comparing the maxim modeled concentrations for various time intervals with the limits values of the specific index shows that all estimated values are situated in the quality index 2 - VERY GOOD.

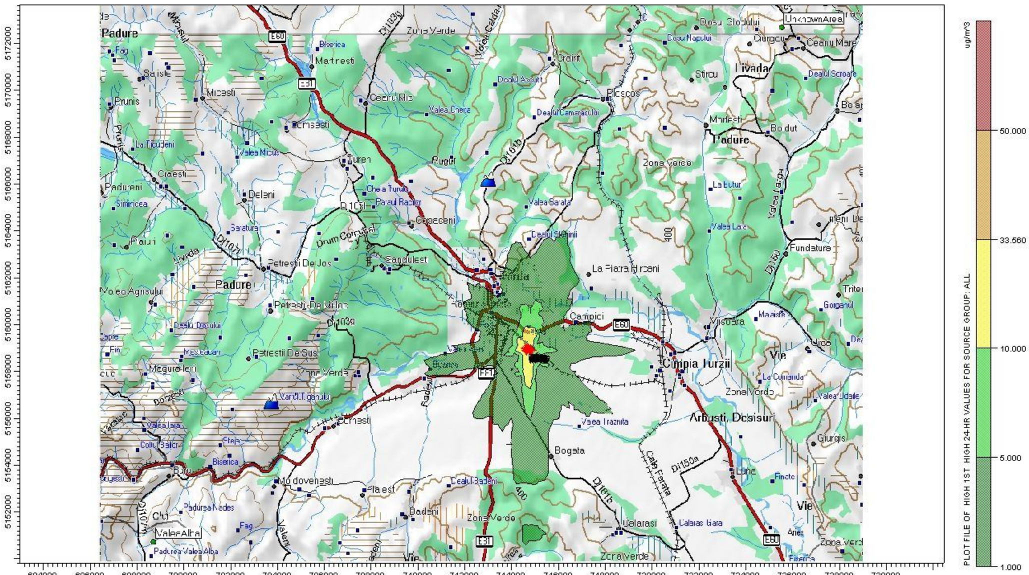

Figure 3. PM10 (24 hours) modeling using ISCST3 model.

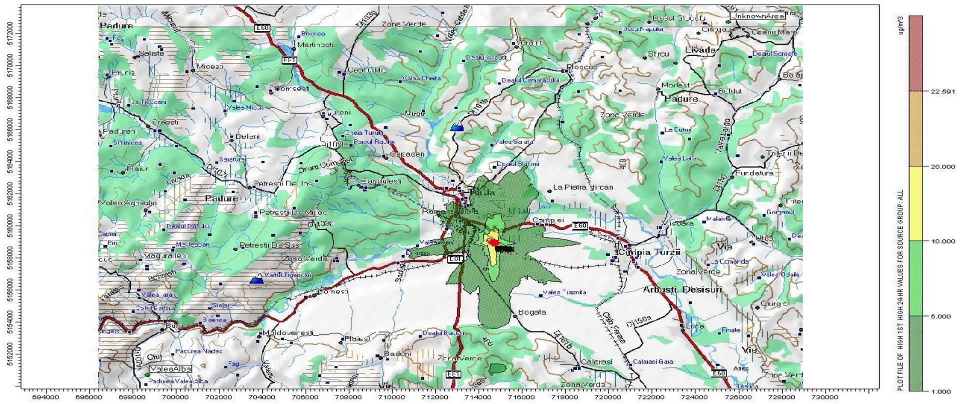

Figure 4. Naphthalene (1 hour) modeling using ISCST3 model.

Conclusions. Applying air quality modeling in calculating the resulting air quality allowed the testing of various technological solutions and their related impacts on environment. The study showed that respecting the emission quality standards recommended by BAT result in complying also with the environmental quality standards in the particular meteorological conditions of the area.

During the EIA statement realization several improvements were identified with effects on both efficient use of resources and environmental quality.

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*** http://www.weblakes.com/products/air_dispersion.html

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Authors:
Radu Mihăiescu, Babeş-Bolyai University, Faculty of Environmental Sciences and Engineering, Research Center for Disaster Management, Romania, Cluj-Napoca, 30 Fantanele, 400294, e-mail: radu.mihaiescu@ubbcluj.ro
Tania Mihăiescu, University of Agriculture Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăştur, 400372, e-mail: tmihaiescu@yahoo.com
Nicolae Ajtai, Babeş-Bolyai University, Faculty of Environmental Sciences and Engineering, Research Center for Disaster Management, Romania, Cluj-Napoca, 30 Fantanele, 400294, e-mail: nicolae.ajtai@ubbcluj.ro
Zoltán Török, Babeş-Bolyai University, Faculty of Environmental Sciences and Engineering, Research Center for Disaster Management, Romania, Cluj-Napoca, 30 Fantanele, 400294, e-mail: zoltan.torok@ubbcluj.ro
Alexandru Ozunu, Babeş-Bolyai University, Faculty of Environmental Sciences and Engineering, Research Center for Disaster Management, Romania, Cluj-Napoca, 30 Fantanele, 400294, e-mail: aozunu@ubbcluj.ro
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