2.04 DISPERSION MODELLING IN SERBIAN PRACTICE

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INTRODUCTION

Recent Serbian experience with environmental pollution in some free expressive has two dimensions: peaceful and wartime.

Through the years in the past in Serbia, medical doctors were leaders in area of environmental control. Tacit argument is that environmental pollution is in direct relation to population health, so they were forced to go in for environmental monitoring. In the past ten years of the previous century, when special Ministry of environmental protection of Serbia was formed for the first time and when idea of environmental protection as a good business started to act, doctors recognized it as their chance for business. Such access to the problem resulted mostly in tremendous number of useless environmental analysis (more than 20000 in 7 years). These analyses partly were supported with government documents, but in the same time this documents were not unique recommendations how to do them. Mostly environmental analyses were simple sum of administrative papers which were quite well paid. Hourly meteorological measurements, minimum array of one year data, two years recommended due to seasonal changing or five years array with hourly data were used may be only three to four times among 20000 analysis. In the same time no one hot spot in Serbia was equipped with appropriate air quality monitoring network.

In the period of March-June 1999, during NATO air strikes against Yugoslavia, a numerous of industrial facilities were bombed. Bombing caused explosions and fires, as well as a release of huge quantities of hazardous substances in the surrounding area and emissions of toxic gases in the air. The toxic clouds created by the bombing were consisted of the mixture of toxic gases and particles produced in combustion and in the uncontrolled chemical and photochemical reactions in the atmosphere. Movement of these dangerous clouds was followed mainly by eyes and in the better situations by photo and video cameras.

Due to experiences with frequently chemical accidents during bombing and with several recent accidents in peaceful time, we are oriented to the problem of fast danger assessment at short distance in accidental situations. In designing solution of the problem, our starting point was requirement of making decisions in few minutes in accidental situations. Application of atmospheric dispersion models and appropriate meteorological measurements in real time, at the representative location of some industrial air pollution source, is used in solving mentioned problem.

CONCEPT OF REAL TIME AIR QUALITY MONITORING SYSTEM REALIZED ON THREE LOCATIONS IN SERBIA

Institute of Nuclear Sciences “Vinca”, near Belgrade, Industrial zone of Pancevo and cement factory Lafarge-BFC in Beocin are only three examples of using atmospheric dispersion modeling for analysis its influence to the air quality due to routine or accidental emission of air pollutants to the atmosphere.
Starting points in planning these systems were:

1. Appropriate automated meteorological measurements at a representative location of controlled industrial air pollution source.
2. Meteorological program outlined so to satisfy models requirements for input parameters.
3. Atmospheric dispersion models as constitutive parts of automated meteorological station.
4. Simple operator communication with the system using graphical interface.

The accident at the research reactor in the Institute “Vinca” in 1958, has initiated forming the meteorological service in the Institute, which has started with operating in 1959. This service has defined its aims in accordance with regulatory guides of International Atomic Agency, U.S. Nuclear Regulatory Commission and the other sources from literature. The Gaussian atmospheric diffusion models, Pasquill-Giford stability category schemes and classical meteorological measurements at the location of the institute were elected for the purposes of environmental protection.

Since April 97’, an automated meteorological station is in use in the Institute of Nuclear Science “Vinca“. New meteorological measurement program was outlined in accordance with instruction “…no meteorological measurement program without reference to one or more dispersion models (Sven -Erik Gryning, 1980.)”. At meteorological tower 40 meters tall, (40 meters is the height of four stacks of nuclear installations) are placed sensors for the wind direction and speed, temperature at 40 and 2 meters, relative humidity, short and long wave radiation at 2 meters, and precipitation sensor and Geiger counter at 1 meter above surface. Meteorological tower is located in the institute fence.

Information about air pollution at the territory of the municipal Pancevo (~30×30 km), recently was attainable only from two air monitoring stations located in the city, in spite of suburbs of the city are in touch with faces of the industrial plants which routinely emit more than million tons of air pollutants in the atmosphere yearly.

In the period of March-June 1999, during NATO air strikes against Yugoslavia, industrial area of Pancevo was bombed for the several times. The Petrochemical Complex, The Oil Refinery, Fertilizer factory, and other facilities in the industrial zone were for the several times target. Environmental protection was useless mainly because of lack of appropriate environmental monitoring around industrial plants. Few days after bombing start, one semiautomatic meteorological station was installed in Pancevo. Skyscraper of the municipal Pancevo, in the center of the city was promoted in meteorological tower. Wind speed and direction sensors were mounted on tenth floor. Air temperature and humidity sensors were mounted on some the other floors.

After bombing this station was supplemented with new set of meteorological sensors and station was fully automated. Central part of the system is PC located in control room in the City Hall to which are connected with telephone cables, automated meteorological station, three PCs in factories (Petrochemical Complex, The Oil Refinery, Fertilizer factory) and one PC placed in a room of ecological department of municipal Pancevo. This system in Pancevo is realized only on the experiences during bombing and it is not supported with current environmental regulatory materials of Serbia.

Local administrative authority of Beocin participated in realization of a project of establishing automated air quality monitoring control near cement factory. In this project are included experiences with mentioned systems in Vinca and Pancevo. Meteorological sensors are placed at the top of 40 meters tall cement silo (wind speed, wind direction and air temperature) and at 2 meters tall mast placed close to the silo (air temperature, humidity, air pressure and precipitation). These two levels provide vertical gradients of meteorological parameters necessary for automated determining atmospheric stabilities. PC with appropriate software is placed in a room in the city hall of Beocin about 500 meters away from meteorological station. Meteorological data are transferred to the PC using radio transmitter.

Meteorological stack 40 m tall

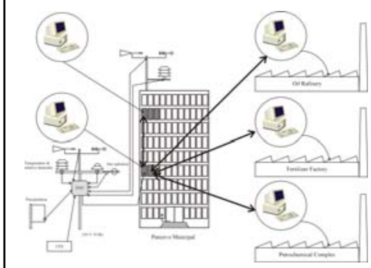

Fig.1. Vinca Pancevo Beocin

ATMOSPHERIC DISPERSION SOFTWARE

Constitutive part of presented systems is software of atmospheric dispersion modeling based on the straight line Guassian dispersion model for routine air pollutants release and puff dispersion model of the Gaussian type for instantaneous releases.

Diffusion equation for routine releases:

$$C(x,y,z)=\frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{1}{2}\frac{y^2}{\sigma_y^2}\right)\left\{\exp\left[-\frac{1}{2}\frac{(z-H)^2}{\sigma_z^2}\right]+\exp\left[-\frac{1}{2}\frac{(z+H)^2}{\sigma_z^2}\right]\right\} \quad (1)$$

Where:

$C(x,y,z)$	Concentration at x, y, z
Q	Uniform emission rate of pollutants
H	Effective emission height
σ_y,σ_z	Standard deviations of plume concentration distribution in the horizontal and vertical
u	Mean wind speed affecting the plume

Diffusion equation for instantaneous releases:

$$C(x,y,z,t)=\frac{q}{\sqrt{(2\pi)^3}\sigma_x\sigma_y\sigma_z}\exp\left\{-\left[\frac{(x-ut)^2}{2\sigma_x^2}+\frac{y^2}{2\sigma_y^2}\right]\right\}\times\left\{\exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right]+\exp\left[\frac{(z+H)^2}{2\sigma_z^2}\right]\right\} \quad (2)$$

Where ut is the downwind travel distance covered by the cloud through the time t, standard deviations σ_i are functions of ut and H is the effective point source height, or height of the cloud center. Other variables in the formula have usual meanings with exception that q represents the total mass released into individual puff.

From wind speed data, solar radiation-day and net radiation-night or temperature vertical gradients stability is derived, which lead to the standard deviations of concentration distribution in accordance with some empirical set of σ curves.
Both models are constitutive part of the automated meteorological station that supplies them with appropriate meteorological data. Input source parameters are: time of integration, coordinates and height of the sources, its diameters, source strength (Q, q), temperature of pollutants and level above ground for concentration calculation, effective source/puff heights and appropriate physical dimensions of the sources. They can operate in the prognostic mode or in the diagnostic mode. Further, plume/puff rise and effective stack height are calculated using the Briggs model and wind power low, respectively. Models take into consideration topography, dry and wet deposition.

REVIEW OF THE RESULTS
Operators need as simple as possible tool for fast receiving information about air quality at the controlled territory. An graphical user interface has to prepare such information. This software is user friendly with next communicating options:

- basic window with minute's and ten minute's meteorological data in graphical and digital form(wind speed and direction, atmospheric pressure; relative humidity; global and balance radiation; air temperature at two levels; precipitation
- chemicals database
- sources database
- daily report of historical meteorological data for any day
- report of historical average hourly air pollution concentration in routine releases for any period
- review of all realized accidents
- simulation of hypothetical accidents
- system working regime
- filling archive with missing data
- instant alarm of current accident

Main result, continual fields of air pollution are presented at the domain 30×30 km on appropriate geographical map. Screen is refreshing every 10 minutes in the case of routine air pollution emission and every one minute during accidental situations. Fields are presented in color scale which operators in control rooms easy understand. During an accident all functions are blocked while authorized operator does not send information that accident is ended.

All communications with the system an operator realizes using dialog boxes. Design of all screens and dialog boxes is realized under operator recommendations and through cooperation with representatives from all factories.

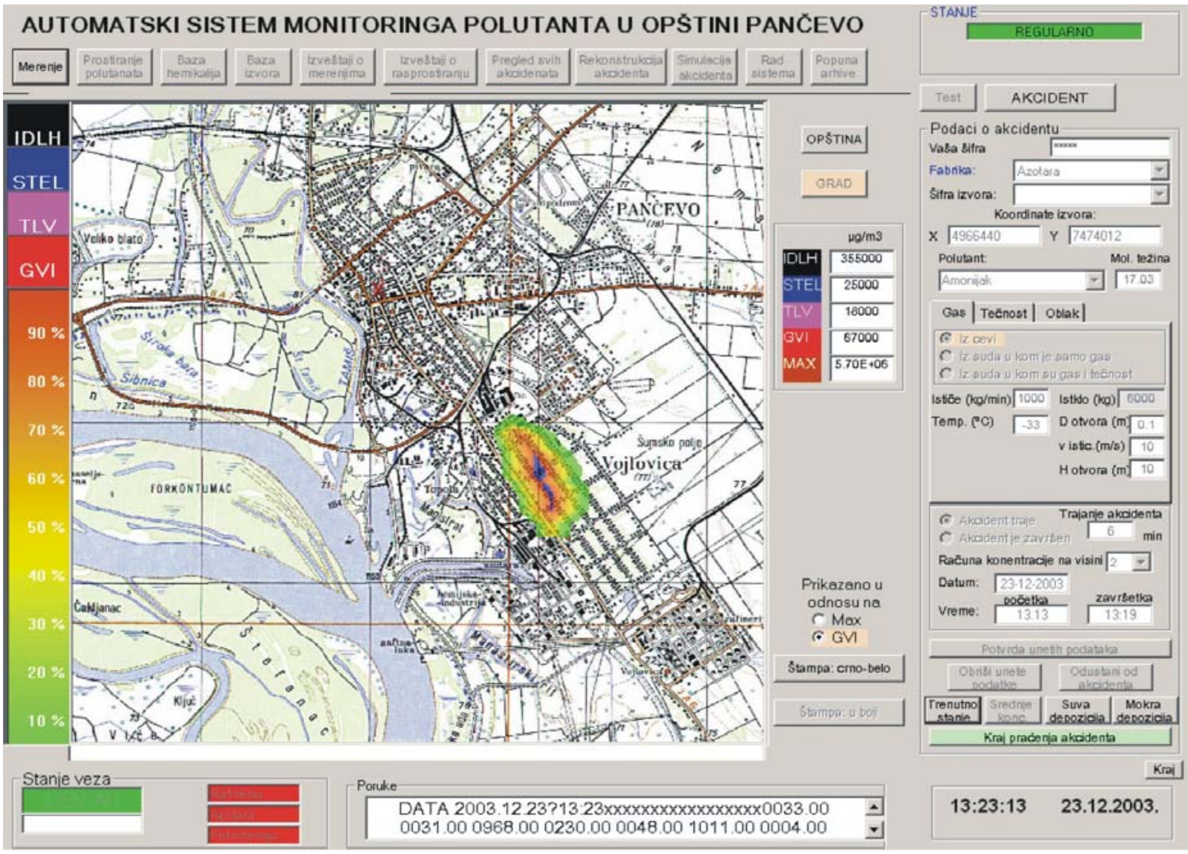

Fig. 2. Review of ammonia concentration field during a hypothetical accident in Pancevo industrial zone.

CONCLUSIONS

Experiences with atmospheric dispersion modeling in Serbian practice are limited on only three locations and on only few previous years. Two automated systems with atmospheric dispersion software are realized in the past few years after bombing, but they are not initiated with regulatory materials because they do not exist. At the conference on harmonization within atmospheric dispersion modeling for regulatory purposes we plan to check concept applied in realization three only real time air quality systems which include atmospheric dispersion models presented in this paper. The other idea is to point to unacceptable situation that one part of Europe has not compatible regulatory materials related to atmospheric dispersion modeling.

REFERENCES

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