CONSIDERATIONS ON MODELLING AIR QUALITY IN A VERY POLLUTED AREA, USING ARTIFICIAL NEURAL NETWORKS

by
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Abstract: The paper refers to the problem of pollution in an industrial area. This is a very important problem and two main targets have to be solved: assessment of pollution levels and prognosis of its evolution. Starting with several theoretical considerations and from experimental data series, the authors propose a neural model of time evolution of the air quality in this region. The values forecasted by the model are compared with the experimental ones.

1. THE FEATURES OF HEAVY METAL POLLUTION PHENOMENON

In all the industrialized countries the problem of pollution has become a major issue with important socio-economical connections being considered as an obstacle for the socio-economic development. We may emphasize that the natural material and resources are not inexhaustible and they should be rationalized and efficiently used for the best interest of people, the pollution representing at the same time a great risk with negative impact upon the environment and implicitly upon people and their lives.

Pollution represents at the same time a very strong reason for stimulating and developing non-polluting industries and the establishment of a new environmental policy, a rational environmental policy. The environment protection has in view the compliance with both quantitative and qualitative protection for the three elements of the environment: the air, water and soil.

It has also in view the maintaining of a balanced long term relationship between the nature forces and the civilized world already threatened by the environmental and economical crisis of the industrial society. In this paper we present several results concerning a study on the pollution.

The main objectives of this study are:

- the air pollution in Zlatna area;
- the effects of the pollution upon the human component;
- the theoretical prognosis regarding the quality of the air in Zlatna area.

The heavy metal pollution represents a problem of major interest due to its negative impact of the heavy metals upon the human body both through the impact pollution (directly influenced by man) and the fundamental pollution.

The heavy metal pollution over the environment drawn lately the attention due to the most complex problems risen by this phenomenon, because the majority of the heavy metals cannot be found in soluble form in water, or if they really exist, the chemical form are complexes with organic or inorganic binders, fact that radically

influences the toxicity of those ones.

As natural water polluting agents, the heavy metals lie among the most toxic polluting agents due to their long-term persistence in solutions and the difficulties to be transformed in insoluble compounds in the surface waters.

The risk of heavy metal contamination is increased in the presence of complexant agents that bind powerfully those metals in soluble compounds that cannot be removed in the process of treating the water. Even if the toxicity of the compounds is lower than the one of the free metals, the harmful proprieties of the heavy metals can unhamper manifest through their decomposing during the biological transformations.

As atmosphere pollutants the heavy metals, through the oxides and vapors (which are transformed in oxides in the atmosphere) pollute especially the industrial areas around Baia Mare, Zlatna, Copşa Micã etc. The pollution phenomenon has become specific. Thus in Baia Mare the pollution is determined especially by lead (Pb), in Zlatna by lead, copper, cadmium, zinc, in Copşa Micã by zinc and cadmium. In the last decades the lead concentration in the human organism has grown 200 times from the previous level, even the maximum allowed value being overrun.

2. ZLATNA – SOURCE OF HEAVY METALS POLLUTION

There are industrial areas in which the lead emissions overrun the transportation ones, the problems issued by the impact on the health of the population in the affected areas being truly alarming.

One of these areas is represented by Zlatna depression, situated upon Ampoi Valley (fig.1), including the city of Zlatna, the adjacent hills and valleys.

The yearly emission of thousands of tones of polluting substances over the soil and forests from the industrial area of Zlatna combined with the moist atmosphere form the acid rains and fogs. The accumulation of acids in the soil produces the acidification of the trophic chain, the microbiological activity weakens, the mineral substances reserve diminishes, the clay disappears and the decomposing in primal elements appears, all due to heavy acid rains in July 1995 in Zlatna area.

Due to the geography of the area, the air circulation between the soil and the level of the hills has a local particularity of flowing and balancing along the valley, fact that establishes a horizontal transportation of the polluting agents under the level of the hills, along the valley, on each side of the source with equal frequency.

The spreading of the polluting agents thrown in the atmosphere is weak due to: the low speed of the wind – 0,06 m/s, the high frequency of the calm periods – 51%, the high frequency of stable status – 42,5%.

Fig. 1. The study area

At night and in the cold months of the year there are unfavorable conditions for the dispersion of the polluting agents and that is why Zlatna area represents a real menace accumulation of pollution. The polluted area lies over an area of aprox. 47000 hectares, the balancing distances reaching 10 km. high up and 20 km. down the valley.

The atmosphere is considered to be a collector not only for the organic pollutants but also for the metals, particularly for heavy metals like lead, cadmium etc. The normal composition of the air consists in: nitrogen 78,09%, oxygen 20,95%, argon 0,92%, carbon dioxide 0,03%, other gases (neon, helium, methane, krypton, xenon, ozone, hydrogen, radon) in 0,01 percentage, water vapors 0,2– 0,3%. The metals reach the air like airborne resultants from different technological processors, from melting furnaces etc. The lead pollutes the atmosphere more than all the other metals, the anthropogenic interference of the lead being much higher than the natural one. From the atmosphere the lead reaches the water and the soil thus becoming a potential toxic in the trophic chain (plant – animal – man).

From the studies carried out on this area results that the pollution degree of the atmosphere, the concentration and distribution of the polluting factors indicate a complex pollution with gases (SO_2, CO_2, CO, NO), airborne heavy metals like lead, cadmium, zinc, copper, arsenic, stibine, SiO_2 powders and other unidentified substances, acid rains etc. All this pollutants have combines effects with concentration and accumulation tendencies in all the environmental components.

The measurements performed by the Agency for Environment Protection Alba have shown the heavy metals concentrations from the suspension powders present in the air and the evolution of the quality of the air at the same time (table 1).

Table 1. The evolution of the air quality

YEAR	Maximum concentration (mg/m^3)	Average concentration (mg/m^3)	Yearly MAC (mg/m^3)	OVERRUN (no. of times)
1994	0,0032	0,0013	0,0007	1,80 times
1995	0,0141	0,0008	0,0007	1,14 times
1996	0,0021	0,0007	0,0007	-
1997	0,0014	0,0005	0,0007	0,71 times
1998	0,0060	0,0002	0,0007	-

3.THE LEAD POLLUTION EFFECTS ON THE HUMAN COMPONENT

There are few available data regarding the morbidity in Zlatna that could be useful in evaluating the potential impact of the copper factory on the health of the local population, but from studies of morbidity in 19 places from Transilvania resulted that over the interval 1983 – 1989 tuberculosis increased in Zlatna 50% compared with other subjects. There is also an increased rate of acute respiratory diseases in children of 49%, the rate of chronic respiratory diseases increased with 41% and asthma with 103%. Atmospheric features in Zlatna, especially SO_2 and the sulphuric acid, play an important role in the developing of respiratory diseases. Looking over the consequences on the health consecutively to the heavy metals exposure the studies established that small children are more exposed to lead in their own environment than other children or adults.

Important research have shown that the lead levels in children blood, even 10 – 15 μg/dl blood, are associated with learning difficulties and low IQ levels due to their neurological development phase, and most aggravating, the effects are for the rest of their lives. There are also results over a sample of children with ages from 2 to 12 from Zlatna that state a difference in the measured lead levels (from 18,5μg/dl blood – 110 μg/dl blood) fact that underlines the absolute necessity of identifying the risk factors in order to be able to take all the requested measures (the analysis have been performed by the Public Health Institute from Cluj).

4. MODELING OF THE POLLUTION PROCESS BY THE USE OF ARTIFICIAL NEURAL NETWORKS

The modeling of pollution process is necessary in order to forecast the levels of pollutant substances and for doing this we use the artificial neural network

approach. This modeling involves first the identification of the system. The identification of a system (or process) implies the finding of a class of functions (or models) that could approximate the behavior input-output of the system in the best way possible. In many situations, such as the recognition of the temporal sequences, dynamic systems identification etc., the output of the modeling system depends on the passed inputs and outputs. When the modeling is done by way of neural networks, it is necessary for them to have a memory that takes into consideration these dependencies. Another approach uses feed-forward neural networks (without memory) but "alimented" with delayed outputs and inputs, dependent on the modelled system order. The question is if the system dynamics could be included directly in the network structure, so that dynamic systems could be modelled without knowing much about them. Feed-forward neural networks, equipped with a form of memory by means of an external delaying line, were used successfully for the identification and modelling of some processes or non-linear dynamic systems.

We have investigated the use of neural networks in forecast of SO_2 concentration, starting with the dates in table 2. The evolution of pollution is displayed in figure 2. We used some of these dates to train a feed-forward neural network and then we used the other dates to test the network.

Table 2. Input data for network training

Month	January	February	March	April	May	June	July	August	September	October
SO_2 (mg/m^3)	0,89	0,5	0,61	1,79	1,1	1,107	1,162	0,88	1,066	0,742

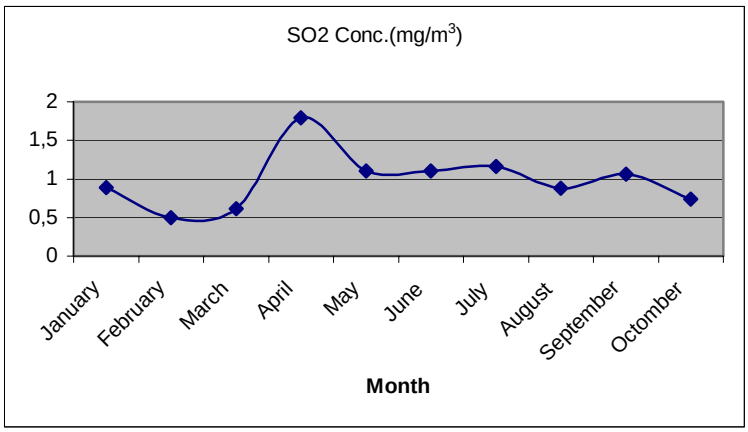

Fig.2. The evolution of SO_2 concentration

In figure 3 we illustrate the results obtained in the prognosis of pollution level, for a neural network with 3 layers.

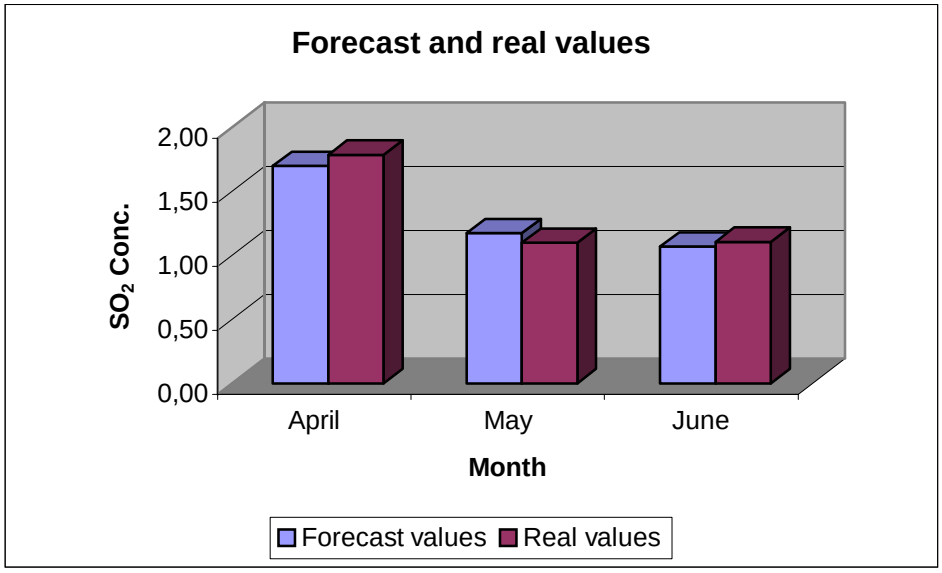

Fig. 3. Results of neural approach

4. CONCLUSIONS

Contemporary man has a 100 times higher lead content in his blood than the primitive man. Regardless of the contamination source (air, plant, water) the toxic effects are equally harmful upon human health and life in generally.

Heavy metals inhibit organism's growth and the activity of the enzymes. The carboxylic and anionic ties from protein are also attacked by these metals which tie themselves on the cellular membranes stopping this way the processes of transport through the cellular walls. They accumulate in the organism and are carried out through the food chain from a species to another. As a result, pollution, through all its actions, must be fight against, its effects must be removed, because the chemical aggression on people is not directed only to the environment, but to themselves.

Artificial neural networks offer a way for process modelling and prognosis. They can be used for "black box" modelling, in processes or systems that cannot be described by an analytical model. In pollution field, the artificial neural networks may be used to forecast the pollution level in order to initiate preventive measures.

The authors studied more variants of neural networks synthesized for the modelling of some natural phenomena like geomorpho-climatical processes, temperature, pollution etc. and, beginning with this modelling, for prognosis. Results obtained are encouraging (the network can "learn" the process) but the quality of forecast depends upon many factors like:

- The amount of available data about the studied phenomena;
- The network structure and the delay order of the process used;
- The training of the network.

REFERENCES

[1]. Clepan, D., **Environmental pollution**, Altip, Alba Iulia, 1999;
[2]. Dumitrescu D., Costin Hariton: **Re⇔ele neuronale, teorie ∏i aplica⇔ii**, Editura Teora, 1996.
[3]. Grecu, I., Neamțu, M., **Biological and medical implications of the inorganic chemistry**, Iaºi, 1982.
[4]. Levente Dimen, Ioan Ileanã, Remus Joldeº, Maria Popa: "*Modelling of some Geomorpho-Climatical Processes Using Artificial Neural Networks*", *microCAD 2002 International Scientific Conference*, Miskolc, Hungary, 7-8 March 2002, Section A, Geoinformatics. Spatial Informatics, pag. 35-42.
[5]. Mureºan, L., **Ecologic chemistry**, Course, Faculty of Chemistry and Chemical Engineering, Cluj – Napoca, 1997;
[6]. Niac, G., Naºcu H., **Ecologic chemistry**, Dacia, Bucureºti, 1998;
[7]. Popa, M., Moise A., *Study regarding the pollution agents. Sources and impact upon the quality of life*, Oradea, 2000;
[8]. Sastry P. S., Santharam G., Unnikrishnan K. P.: *Memory Neural networks for Identification and Control of Dynamics Systems*, I. E. E. E. Transactions on Neural Networks, vol. 5. No. 2, March 1994, pag. 306-317.
[9]. Varduca, A., Hydrochemistry and the chemical pollution of waters, H*G*A*, Bucureºti, 1997.

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