Journal of Environmental Protection and Ecology 12, No 4, 1948–1953 (2011)

STUDY ON THE ROLE OF NEURAL NETWORKS IN ENVIRONMENTAL POLLUTION FORECASTS

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Abstract. In all the industrialised 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 emphasise that the natural material and resources are not inexhaustible and they should be rationalised 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. The modelling 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 modelling 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 behaviour 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 modelling system depends on the passed inputs and outputs. The present 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 for 2000–2004 period. The values forecasted by the model are compared with the experimental ones.

Keywords: environment pollutions, neural network, forecast.

AIMS AND BACKGROUND

In all the industrialised countries the problem of pollution has become a major issue with important socio-economical connections being considered as an obstacle

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for the socio-economic development. We may emphasise that the natural material and resources are not inexhaustible and they should be rationalised 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[1–4].

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 both with quantitative and qualitative protection for the 3 elements of the environment: the air, water and soil[3–5].

It has also in view the maintaining of a balanced long-term relationship between the nature forces and the civilised 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 were: the air pollution in the Zlatna area, and the theoretical prognosis regarding the quality of the air in the Zlatna area.

The heavy metal pollution represents a problem of major interest due to its negative impact of the heavy metals on the human body both through the impact pollution (directly influenced by man) and the fundamental pollution[1,2].

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 can not 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[6].

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 who bind powerfully those metals in soluble compounds that can not 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[6].

EXPERIMENTAL

Study area. The yearly emissions 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 tropic 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 the Zlatna area[1,2].

Due to the geography of the area (Fig. 1), 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.

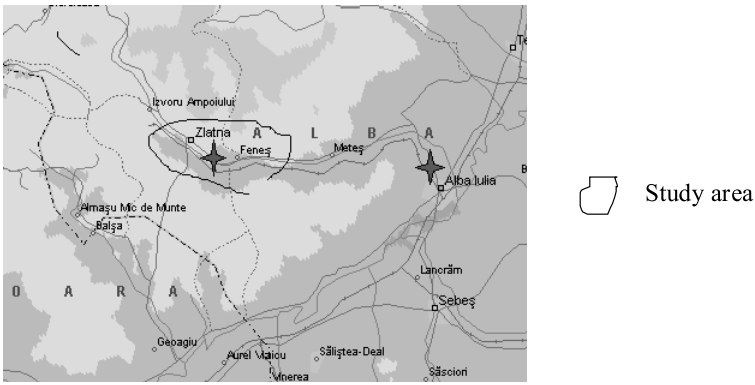

Fig. 1. Study area – the Zlatna depression

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%.

At night and in the cold months of the year there are unfavourable conditions for the dispersion of the polluting agents and that is why the Zlatna area represents a real menace accumulation of pollution. The polluted area lies over an area of approximately 47 000 ha, 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%, water vapours 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 tropic 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, SiO_2 powders and other unidentified substances, acid rains, etc. All these pollutants have combined effects with concentration and accumulation tendencies in all the environmental components.

The measurements have shown the heavy metals concentrations from the suspension powders present in the air and the evolution of the quality of the air during 5 years (2000–2004) (Table 1). We modelled the measured data using neural networks[1,2].

Table 1. Evolution of the air quality in the Zlatna area for 2000–2004

Year	Maximum concentration (mg/m^3)	Average concentration (mg/m^3)	Yearly MAC (mg/m^3)	OVERRUN (number of times)
2000	0.0032	0.0013	0.0007	1.80 times
2001	0.0141	0.0008	0.0007	1.14 times
2002	0.0021	0.0007	0.0007	–
2003	0.0014	0.0005	0.0007	0.71 times
2004	0.0060	0.0002	0.0007	–

RESULTS AND DISCUSSION

The modelling 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[7,8]. This modelling 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 behaviour 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 modelling system depends on the passed inputs and outputs.

When the modelling 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 data in Table 2. The evolution of pollution is displayed

in Fig. 2. We used some of these data to train a feed-forward neural network and then we used the other data to test the network.

Table 2. Input data for network training

Month	January	February	March	April	May	June	July	August	September	October
SO_2 concentration (mg/m^3)	0.89	0.5	0.61	1.79	1.1	1.107	1.162	0.88	1.066	0.742

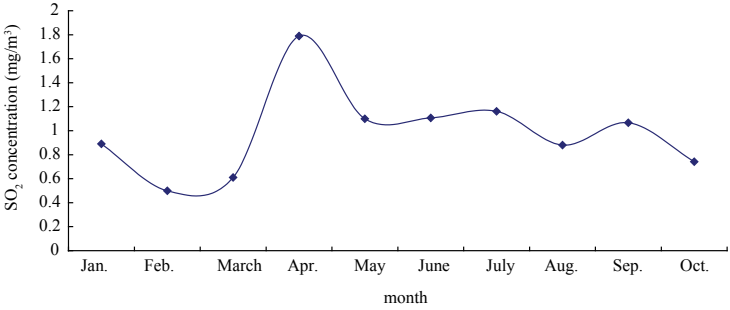

Fig. 2. Evolution of SO_2 concentration

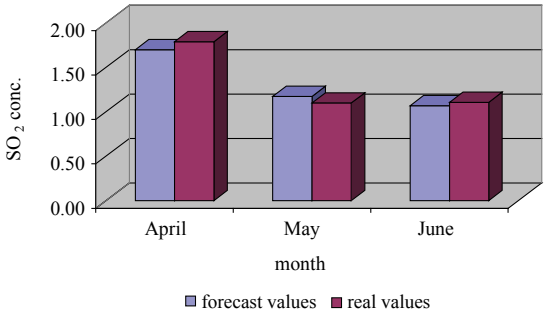

Fig. 3. Results of neural approach

In Fig. 3 we illustrate the results obtained in the prognosis of pollution level, for a neural network with 3 layers. The data show that the network 'learns' the position of Fig. 2. Neural network will know the time variation of SO_2 concentration. Such a network can still be used to forecast such a pollution in the coming months. Note that the forecast accuracy can be drastically affected if the time horizon increases. Note to differences between the measured and predicted values are not significant. Such a trained network was used to forecast pollution in November, with the result shown in Fig. 4.

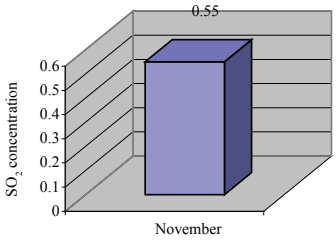

Fig. 4. November prognosis using neural network

CONCLUSIONS

Artificial neural networks offer a way for process modelling and prognosis. They can be used for 'black box' modelling, in processes or systems that can not 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 synthesised for the modelling of some natural phenomena like geomorphic – 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.

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Received 5 October 2011
Revised 25 October 2011