Possibilities of Gaseous Emissions Neural Modelling Based on Bioreactor Usage

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Introduction

Composting is a process creating a closed ring of circulation of organic substances in the environment. It consists in the microbiological disintegration of organic substances in oxygenic conditions under the influence of thermofilic microorganisms and moulds. The composting process can be carried out in the piles or open containers on a free air, in closed chambers or barrels with controlled oxygen supply (Dach *et al.*, 2003; Raghavarao *et al.*, 2003). The very important condition for the correct execution of this process is a suitable oxygen content in the delivered air (above 8-10%) as well as the proper moisture degree (remaining on a level of 55-75%) for the whole duration period.

Since the beginning of the 90's of the past century the dynamic increase of research advancement on renewed utilization of organic waste materials of agricultural, municipal and industrial origin has been observed (Raghavarao *et al*, 2003; Xiang-hua *et al*, 1999). The problem of sewage sludge composting and application into the agricultural land becomes the subject of many scientific investigations. During the last years different scientific teams carried on the research concerning an estimation of ammonia and greenhouse gases emissions size and the factors influencing on this emission. These activities are focused around national projects and international concerted actions where the different models of gaseous emissions are developed for many countries under different conditions (Jones & Stevens, 2002). In the recent years many authors used artificial neural models in ecologic applications (Pohl 2001). For many applications, the usage of neural modelling makes it easier to find an optimal solution.

The aim of this study is to check the possibility of data collecting from microbiological decomposition of sewage sludge in order to create the ammonia and greenhouse gases emissions prognostic model with an artificial neural network usage. This work is a first part of the project: *Neural Network prognostic model of ammonia emission from composting*.

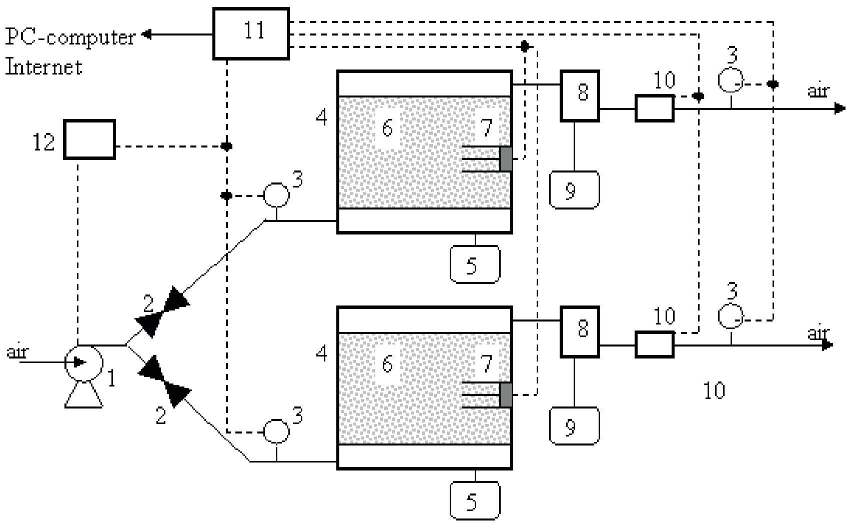
Material

Fieldworks related with composting process of organic materials require an extreme labour and financial input. The weather conditions variability do not ensure the guarantee of repeatability. Moreover during the fieldworks it is difficult or sometimes completely impossible to use so complex measuring apparatus as it is in case of laboratory experiments. Usage of bioreactor eliminates some part of fieldwork, considerably decreases the costs and accelerates the final results. That was the reason of building in 2003 at Institute of Agricultural Engineering the isolated 2-chamber bioreactor to proceed the experiments with decomposition of organic wastes. This bioreactor ensures the run of decomposition comparable with the one in real conditions while composting with usage of tractor aerator (Dach *et* al., 2003). The experimental set-up was extended in 2006 from 2 to 6 chambers.

The capacity of one bioreactor chamber was 125 dm^3. The air pressed by the air pump flows through the biomass placed in the bioreactor chamber (fig. 1). Thermal isolation consists of hermetic 10 cm tight polystyrene layer. It ensures the run of composting process under exact control low heat losses. Laboratory conditions give an opportunity of usage of more developed measuring apparatus in comparison with fieldworks ones.

Applied measurement heads MG-72 of Alter S.A. were designed to measure the gasses concentration and to forward this information to the central measuring unit. Gasses measuring system consists of the following heads: NH_3 (0-100 and 0-1000 ppm), CH_4 (0-5%), O_2 (0-25%), CO_2 (0-100%). The oxygen is continuously measured in order to control the conditions of a proper composting process. Electro-chemical sensor is the main part of this head. Output signal was the most essential information from the recorder point of view. The master part of the measuring system are 2 pararell working microchip recorders of measured signals. The system is constantly connected with a computer (Niżewski *et al.*, 2007).

Fig. 1. Schematic diagram of the bioreactor: 1. pump, 2. flow regulator, 3. flow meter 4. isolated chamber, 5. drained liquids container, 6. composted mass, 7. sensors set, 8. air cooling system, 9. condensates container, 10. column of gases content analysis (NH_3, O_2/CO_2, CH_4), 11. 16-channel recorder, 12. air pomp steering system



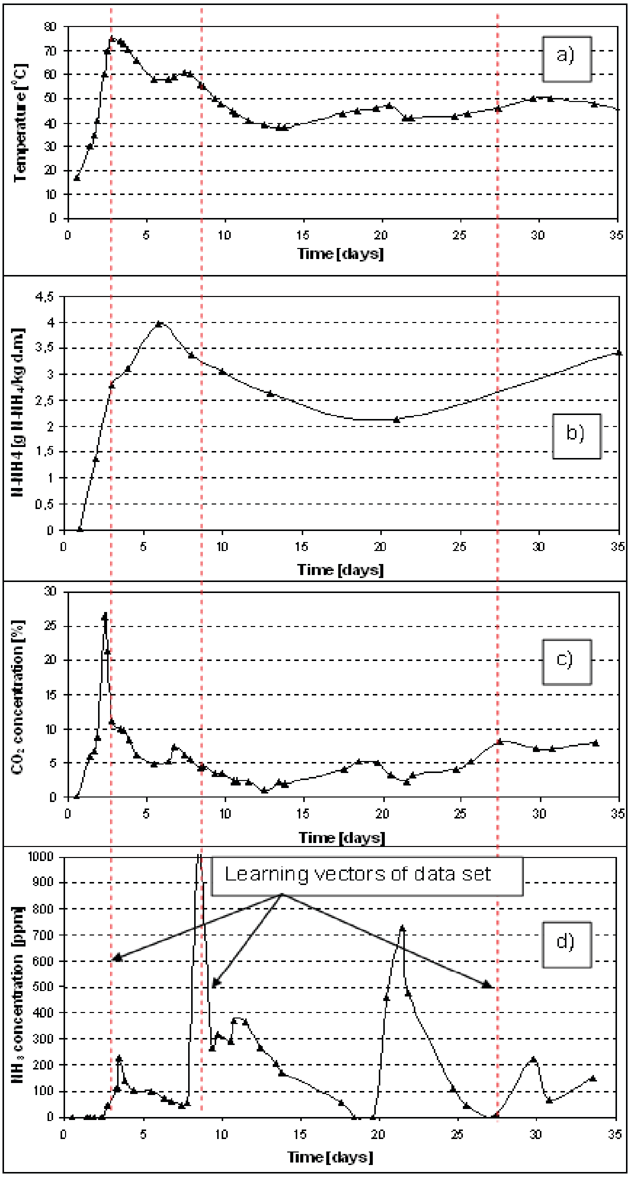
Collecting of physical and chemical data for artificial neural network building

The predictive abilities of artificial neural networks are one of the main reasons of their wide usage. Artificial neural networks can be applied where the user is able to specify the aim and to give an example of the result but is not sure of the methods how to obtain the goal. The basic rule of neural network proper working is gaining the data. Results obtained during the laboratory experiments are collecting and than scaling and divided on the sets: learning, validating and testing. These sets are being used in order to coach the neural models. A tool to create and teach the neural network is Statistica 7.1. Data was collected by two methods: automatic acquisition (temperature, gases concentration, air flow, pH, conductivity) and manual sampling or analysis (C/N ratio, NH_4-N, ash) Automatic measuring systems and signal recorders used in the bioreactor were the source of a large amount of data. This is essential for usage of the bioreactor as a tool for prediction of gaseous emissions during decomposition process with usage of artificial neural network.

Manual results acquisition by the physical or chemical run with the standard procedures described in literature.

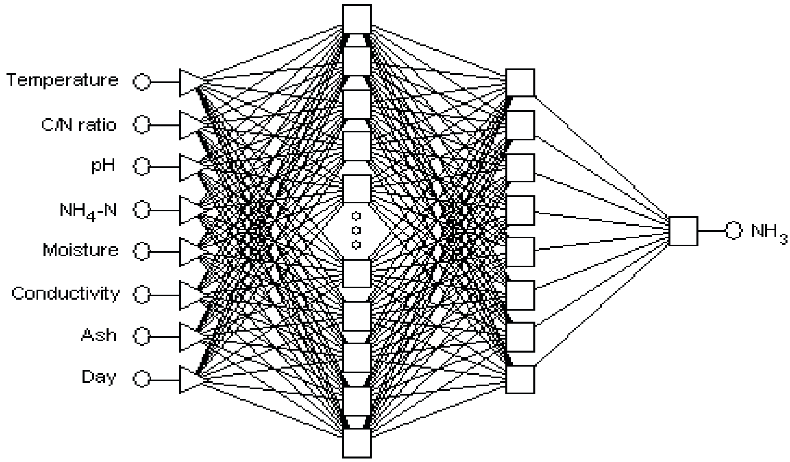
During the experiment, the all the parameters were measured in the same time in order to achieve one learning (or validating) vector of data set. Three exemplary vectors containing the part of data vector (temperature, NH_4-N, CO_2 and NH_3 concentration) while composting in bioreactor are presented on Fig. 2.

Fig. 2. Measurements of selected parameters while sewage sludge composting
a) Temperature changes b) Changes of ammonia nitrogen c) Carbon dioxide concentration
d) Ammonia concentration; Three vertical lines are the examples of learning data vectors



The collected data are used to build the neural prognostic model of ammonia emission. The diagram of an exemplar neural network forecasting the ammonia emission is shown on Fig. 3.

Fig. 3. Diagram of created neural network with the input, hidden and output layers



Conclusions

Usage of bioreactor eliminates some part of fieldwork, considerably decreasing the costs and accelerates the final results. Laboratory conditions give an opportunity of usage of more developed measuring apparatus in comparison with fieldworks ones.

Measuring systems and measuring signals recorders used in a bioreactor are the source of a large amount of data. This is essential for usage of the bioreactor as a tool for neural modelling of gaseous emissions.

Obtained empirical data gave the possibility of effective usage of neural techniques in the modelling of the processes taking place.

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