BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 2/2010	36 - 45	Seria Matematică - Informatică - Fizică

Expert System for Assessing the Effluent's Quality of a Wastewater Treatment Plant

Mădălina Cărbureanu

Petroleum-Gas University, Informatics Department, Ploieşti, Romania
e-mail: mcarbureanu@upg-ploiesti.ro

Abstract

To improve the effluent quality in accordance with the European and Romanian technical normative, in Ploieşti there will be built a new wastewater treatment plant with both the mechanical and biological steps, including the sludge treatment with an improved technology in pollutants' removal. In literature, there are presented expert systems developed for wastewater treatment domain, being outlined fields of interest such as: plant monitoring, plant control and diagnosis, plant designing and decision support. Because of the strict effluent standards used today in wastewater treatment domain, the treatment processes become increasingly complex, so the knowledge of the plant operators is not sufficient for an optimal running of it. Due to the fact that the experts' knowledge in wastewater treatment can be introduced into the plant afferent system through a knowledge base, which may contain knowledge about past events, abnormal events etc., the usage of expert systems with other instruments can be a useful tool for a better plant activity. The quality of the plant effluent has a major impact on the quality of the emissary and generally on the environment, therefore the effluent's periodical assessment is necessary, in order to identify the treatment process problems and to correct them just in time. In this paper, there will be developed a prototype expert system to assess the quality of Ploieşti wastewater treatment plant effluent, using VP-Expert, an expert system shell.

Keywords: *expert systems, wastewater, quality, control*

Introduction

In literature, there are presented some expert systems for wastewater treatment plant monitoring, diagnosis, management, supervising, designing and decision support. Another direction in which expert systems can be developed is that of wastewater treatment plant control, direction which at present is in the research phase.

The scope of the paper is to develop a prototype expert system for the assessment of Ploieşti Wastewater Treatment Plant (WWTP) effluent quality.

The proposed expert system can be used to solve a real world problem, such as the effluent quality assessment for a certain wastewater treatment plant, namely the effluent of Ploieşti plant. To this type of system, there may be added fuzzy logic and neural networks, in order to obtain a neuro-fuzzy expert system to assess the plant effluent. The neuro-fuzzy expert system can be integrated into the plant system (control, monitoring or diagnosis system etc.) for improving its activity.

The structure of the paper is organized as follows:

- *Expert systems in the wastewater treatment domain*, section where there are presented general aspects regarding the usage of expert systems in the domain and several examples from literature of expert systems used in wastewater;
- *The proposed expert system*, section in which it is presented a short description of the wastewater treatment plant from Ploieşti and the development of the proposed expert system for effluent's quality assessment;
- *Conclusions and future work*, where there are emphasized the most important and relevant benefits and contributions of using the developed expert system in wastewater treatment and several future work ideas.

Expert Systems in the Wastewater Treatment Domain

General Aspects

The wastewater treatment process is very complex, consisting in various processes and a certain number of advanced monitoring and control systems. Because in a Wastewater Treatment Plant (WWTP) there are used many complex treatment processes to remove the pollutants, a possible process collapse can produce serious damage to the environment. Thus, the biological and chemical processes used for wastewater treatment need a careful and reliable monitoring and assessment assured by experts.

The Expert Systems (ES) can be a very useful tool for WWTP running, management and also for the plant technological processes designing and control [4]. The usage of ES with other instruments, such as simulation models, fuzzy logic, neural networks, etc, extends the utility of these systems for wastewater treatment plants activity.

Nowadays, there are many attempts to apply ES in the WWTP domain, being outlined three fields of interest, namely [4]:

- WWTP designing, where ES can have many applications because they help the designer in technological decision making or improving the management of the designing process;
- diagnosis and decision support systems for WWTP with the largest number of ES applications;
- WWTP monitoring and control with practical applications of ES.

The wastewater treatment is certainly a domain in which the ES usage can bring significant improvements to processes efficiency, minimization of process failure risk and processes costs. The majority of ES in wastewater treatment are usually associated with supporting decisions that are daily taken by WWTP operators. The ES maintains a knowledge base of plant processes and it usually keeps registrations of the abnormal situations which took place in the past. Using the knowledge and certain inference rules, the ES is capable to suggest to the plant operator the adequate solution for the current problem. The most advanced domain in which there are applied ES-s is that of plant control, using data collected through on-lined sensors. This type of ES application is still in the research phase [4].

Examples of Expert Systems used in the Wastewater Treatment Domain

In literature, there are mentioned many attempts to apply Expert Systems (ES) in wastewater treatment, such as: BIOEXPERT, DEPUR, ISCWAP, expert systems for monitoring and diagnosis of anaerobic WWTPs, advanced integrated expert systems for WWTPs control, etc.

BIOEXPERT is a prototype ES for wastewater treatment process diagnosis. The BIOEXPERT structure is presented in Figure 1.

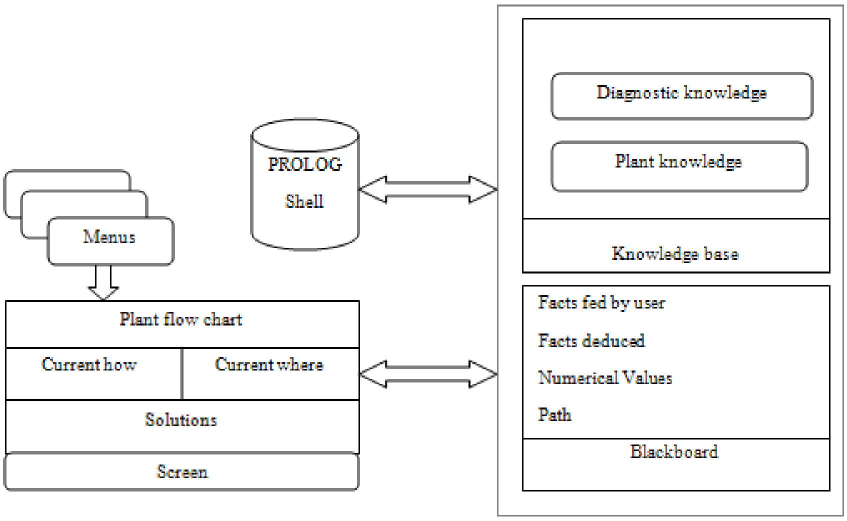

Figure 1: BIOEXPERT structure [3]

As we can observe in Figure 1, this ES has the following components [3]:

- menus necessary to inject input data provided by the operator to the system (data as pH, temperature, wastewater flow, etc. are taken on-line and stored);
- Prolog shell, the expert system shell;
- working memory database under a blackboard form in which there are introduced assertions and attributes;
- expert system knowledge-base which contains knowledge about the plant and knowledge required for diagnosis;
- an interface which allows the user to see the schematic view of the plant, the system solutions and the dialog between the expert system and the user.

According to [8], the expert system DEPUR is a useful tool for WWTPs diagnosis and management, implemented in MILORD, an expert system shell. To build the system knowledge base it was used the LINNEO+ methodology for the automatic process knowledge acquisition. The expert system architecture has a data base to represent the current state of the plant, a knowledge base in which the knowledge is represented through inference rules, two inference engines, a strategies module, a control module whose goal is to control when and how the system knowledge can be used. System modularity and user friendly interface are other characteristics of this expert system [8].

ISCWAP (Intelligent System for Supervision and Control of Wastewater Treatment Plants) is a knowledge-based system (KBS) for on-line supervising of activated sludge processes in wastewater treatment, implemented with G2, a real time expert system shell [9]. The system is capable to deal with unusual situations because it has a set of rules for possible future issues prediction, diagnosis, failures detection and operation rules. The primary goal of this system is to diagnose, using decision tree methodology, if the plant's current situation is normal or not, if the plant works well and if the plant effluent quality is into the required limits. The ISCWAP system architecture has the following components: a number of sensors, the object base, the knowledge base, actuators, reasoning processes, a knowledge based supervisor system, which is the core of the system, an automatic control module and a graphical interface with the user [9].

Also, literature presents an expert system for WWTP control, an efficient and robust system which has a distributed architecture for solving plant's problems [5]. The architecture of this expert system is based on the architecture proposed by Sanchez et al. [10], being composed of a number of subsystems organized on tree levels: data level, supervisory level and distributed knowledge level [5]. Data level receives the information from different plant units through on-line sensors (data such as dissolved oxygen, pH, temperature values, etc.). The supervisory level diagnoses the plant state using the received information (if the effluent values do not surpass the limit values etc.) and makes its own conclusions regarding the measure which must be taken, but the user is the one to decide further action [5]. Distributed knowledge level is composed of a certain number of subsystems, such as the controller, the water line subsystem, the numerical knowledge module, etc [10].

In paper [6], there is presented an expert system for anaerobic wastewater treatment plant monitoring and diagnosis, developed with several standard instruments, such as Visual Basic 5.0, for communication and graphical interface, Access 7.0, for database management and Matlab 5.0, for scientific calculations. The system is composed of a number of modules, such as: data acquisition and filtering modules, diagnosis module, utilities and system configuration and graphic interface modules. In this system, in order to collect the data supplied by the plant there is used a programmable logic controller (PLC). PLC also sends the information to the computer through a RS-232 series port, thus making the interactive information exchange with the system computer possible [6].

The systems presented have in common the usage of an Artificial Intelligence technique, namely expert systems in the wastewater treatment domain used for: plant treatment processes diagnosis, WWTPs monitoring and control, processes evolution prediction and WWTP planning. Because the above-mentioned examples are based on expert systems, they have implemented the main elements of an ES, namely the knowledge database and the inference engines using different methodologies.

As one may notice, there are many applications of expert systems in the WWTP domain, due to their vast area of usage and well-known facilities.

The Proposed Expert System

A short description of a WWTP

The current WWTP from Ploieşti is located in the South-Eastern part of the city. The plant emissary is Dâmbu brook, which joins Teleajen River.

In order to improve the treated wastewater quality so that it should meet the European and Romanian standards, there will be build a new WWTP in Ploieşti. The new plant is designed for wastewater treatment in mechanical and biological steps, including sludge treatment, with an improved technology for biochemical consumption of oxygen (CBO5), chemical consumption of oxygen (CCO), floating materials (MTS), nitrogen (N) and phosphorus (P) removing, nutrients reduction and also sludge thickening, stabilization and dewatering [11].

MTS removal will be achieved within the plant's mechanical step, through rare and thick grids and through a sand trap fats separator. CBO5 and CCO removing will be achieved within the biological step, through organic substances decomposition with the help of anaerobe bacteria.

Nitrogen removing will be achieved in aeration basins using advanced nitrification technologies, while phosphorus will be removed through precipitation with coagulant dosage [11].

For plant monitoring, SCADA (Supervisory Control and Data Acquisition) system will be used. As a principle, a SCADA system consists of a subsystem of units for primary data acquisition and storage, a processing subsystem and a graphical interface with the user [7].

The plant monitoring system has a central dispatcher which allows the automatic supervision of the technological processes in different stages. The instantaneous values of the process parameters are delivered to the dispatcher where they are automatically processed and offered to the user. The system achieves functions such as monitoring, measurement, warning, equipments switch on/switch off, the analysis of system evolution, events history, etc [11].

The goal of the contractor execution project consists in building a new WWTP in Ploieşti, that through modern equipments and advanced technologies to assure the fulfillment of NTPA 001/2002 normative requirements, regarding the quality of the plant effluent [12].

The Expert System Development

In this section, we propose an application of ES in the WWTP domain in order to assess the Ploieşti plant effluent quality. To develop this ES prototype, we used the VP-Expert shell. Familiar with the particularities of the Ploieşti plant and the assurances on the plant final effluent quality parameters, supplied by the plant designer, we considered that it was necessary to build an ES for this particular case. Furthermore, in order to assess the Ploieşti WWTP effluent quality, we need to build specific rules for the discussed problem.

Generally, a WWTP has a mechanical (primary) treatment step, a biological (secondary) and a tertiary treatment step. The primary treatment step is a WWTP component in which there takes place the MTS removal process from wastewater. MTS removal is achieved through a mechanical way (sedimentation and sludge removal) or a mechanical-chemical way (precipitation-flocculation through chemical substances addition and sludge removal).

The secondary treatment step is a plant component in which there is achieved the removal of a considerable part of the biodegradable organic substances. The condition for defining this step is given by the removing efficiency of CBO5 and CCO [13].

The tertiary treatment is the step in which there is achieved the nutrients removal, namely nitrogen (N) and phosphorous (P) [13].

The effluent quality of the WWTP from Ploieşti must fulfill the Romanian wastewater quality standards specified in Table 1 [14, 15]. The concentration values represent the admissible limit values of the pollutants from the wastewater after treatment, at the effluent discharging into the natural receiver, values imposed by NTPA-001/2002 normative [12]. In order that the effluent should observe these values, the designer of the plant from Ploieşti established, in the technical documentation, the necessary treatment level of removing the pollutants from the influent. The minimum reduction percent was established taking into account the influent loading level values with pollutants and the admissible pollutants limit values established by the mentioned legislation [11, 12].

Table 1. Effluent admissible values

Parameter	Concentration (mg/l)	Minimum reduction percent (R)
CBO5	25	83.3%
CCO	125	79.2%
MTS	35	89.1%
P	1	83.5%
N	10	80.9%

The proposed EQA (Effluent Quality Assessment) expert system analyses a number of fourteen variables that were established using the Romanian wastewater standards and the technical documentation for Ploieşti wastewater treatment plant [11, 12]. In Table 2, there are presented the analyzed variables and their values (numerical and symbolic). The treatment step efficiency is given by the reduction percent of a certain substance, so that the effluent may meet the quality conditions imposed by legislation [2]. Knowing the values for the minimum reduction percent, for each treatment efficiency step, there were established the values presented in Table 2.

Table 2. The analysed variables

Variables	Values
Plant_effluent_quality	excellent (under NTPA limits), acceptable (in NTPA limits), poor (over NTPA limits)
Mechanical_step_efficiency	raised (R-MTS>89.1%), minimum(R-MTS=89.1%), inefficient(R-MTS<89.1%)
MTS_reduction_percent	high (>89.1%), minim (=89.1%), low (<89.1%)
MTS_value	under_NTPA_limits (<=33 mg/l), near_NTPA_limits (>33mg/l and <37mg/l), over_NTPA_limits (>=37 mg/l)
Biological_step_efficiency	raised(R-CBO5>83.3% and R-CCO>79.2%), minimum (R-CBO5=83.3% and R-CCO=79.2%),. inefficient(R-CBO5<83.3% and R-CCO<79.2%)
CBO5_reduction_percent	high (>83.3%), minim (=83.3%), low (<83.3%)
CCO_reduction_percent	high (>79.2%), minim (=79.2%), low (<79.2%)
CBO5_value	under_NTPA_limits (<=23 mg/l), near_NTPA_limits (>23 mg/l and <27mg/l), over_NTPA_limits (>=27 mg/l)
CCO_value	under_NTPA_limits(<=123 mg/l), near_NTPA_limits (>123 mg/l and <127mg/l), over_NTPA_limits (>=127 mg/l)
Tertiary_step_efficiency	raised (R-P>83.5% and R-N>80.9%), minimum (R-P=83.5% and R-N=80.9%), inefficient(R-P<83.5% and R-N<80.9%)
P_reduction_percent	high (>83.5%), minim (=83.5%), low (<83.5%)
N_reduction_percent	high (>80.9%), minim (=80.9%), low (<80.9%)
P_value	under_NTPA_limits(<=0.8mg/l), near_NTPA_limits (>0.8mg/l and <1.2mg/l), over_NTPA_limits (>=1.2 mg/l)
N_value	under_NTPA_limits(<=8mg/l), near_NTPA_limits (>8mg/l and <12mg/l), over_NTPA_limits (>=12 mg/l)

Using the technical documentation of the WWTP from Ploieşti and the NTPA 001/2002 normative, we have derived the analysis tree presented in Figure 2.

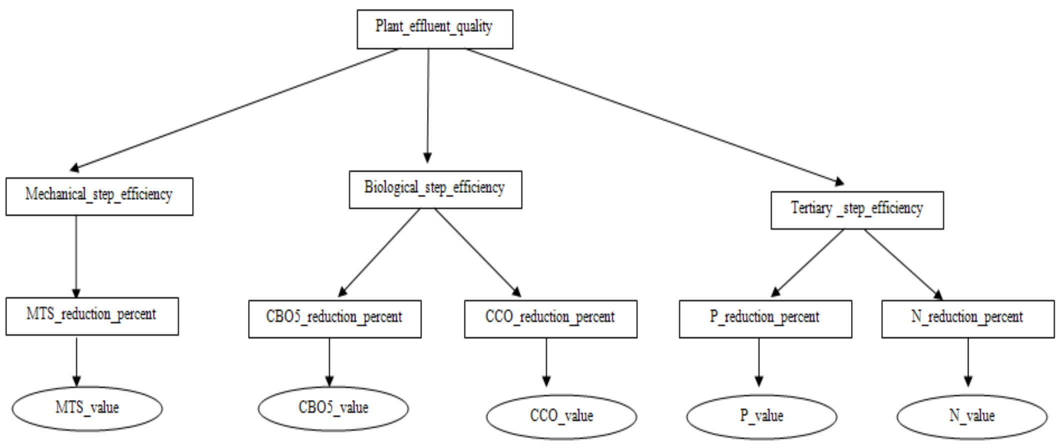

Figure 2: EQA analysis tree

The knowledge base of the EQA prototype expert system developed using VP-Expert, has a number of 78 heuristic rules, established using the values from Table 2. Examples of such rules are given below:

- if CBO5>23 and CBO5<27, then CBO5_value=near_NTPA_limits;
- if CBO5_value=near_NTPA_limits, then CBO5_reduction_percent=minim;
- if CBO5_reduction_percent=high and CCO_reduction_percent=high, then Biological_ step_efficiency=raised;
- if Mechanical_step_efficiency=inefficient and Biological_step_efficiency=inefficient and Tertiary_step_efficiency=inefficient, then Plant_effluent_quality=poor.

The condition of a higher efficiency of the biological step consists in having a high reduction percent of the main parameters measured in this step. When the plant mechanical step proves its inefficiency in removing MTS, this fact has negative influence on the other two steps, because those materials that are not removed during the primary stage can cause malfunctioning of the biological and tertiary steps and even failure and rapid ageing of plant equipments. Finally, all these reflect on the step efficiency level. Using the same reasoning, there were established all the expert system rules. A treatment step was considered inefficient when one of the measured parameters had not been brought at the imposed limits.

The main task of the developed expert system is to assess the Ploieşti WWTP effluent quality, by associating a certain qualitative global indicator with the following symbolic values: *excellent*, *acceptable* and *poor*. In Figures 3 and 4, we show the screenshots with the EQA expert system consultation under VP-Expert environment. The user must introduce the effluent values regarding the loading with MTS, CBO5, CCO, P and N concentrations for establishing the WWTP effluent quality.

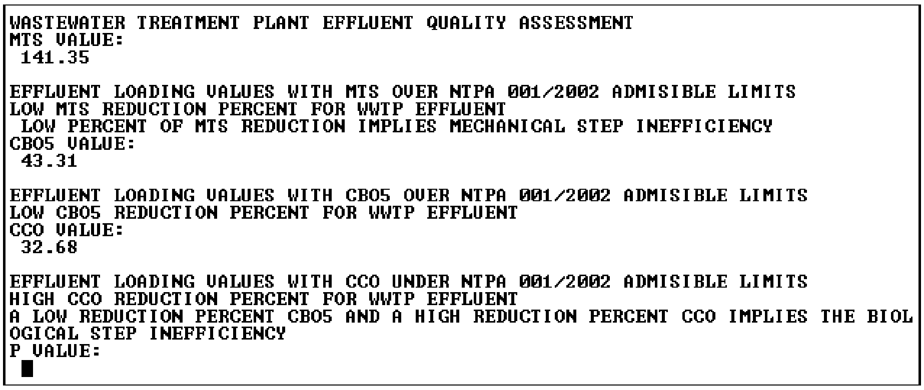

Figure 3: Screenshot of the EQA expert system consultation (part I)

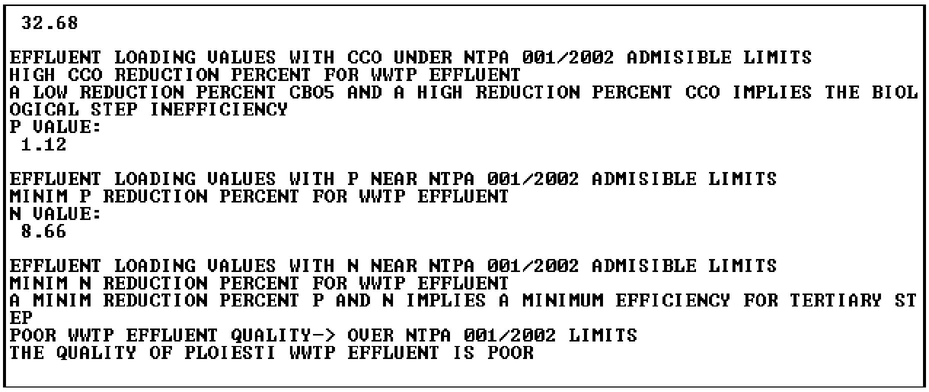

Figure 4: Screenshot of the EQA expert system consultation (part II)

Using real data supplied by the Ploieşti WWTP technical documentation, the results of the EQA expert system consultation are summarized in Table 3.

Table 3. The EQA expert system results

MTS value	CBO5 value	CCO value	P value	N value	WWTP effluent quality
141.35	43.31	32.68	1.12	8.66	poor
141.08	38.85	36.92	1	8.65	poor
130.35	38.09	32.70	0.97	7.17	poor
119.63	37.33	28.53	0.9	5.69	poor
125.26	37.29	31.52	1.15	6.26	poor
125.55	37.31	33.45	1.03	5.67	poor

As we can observe from the results presented in Table 3, the quality of Ploieşti WWTP effluent is poor, which means that the values of the measured parameters are over the NTPA 001/2002 admissible limits. So, plant effluent quality is not an acceptable or excellent one, according to current legislation, with consequences on the emissary quality.

For the relevance of the developed expert system, we shall also test it with theoretical values in order to demonstrate that the system supplies different results (excellent, acceptable and poor effluent quality), as presented in Table 4.

Table 4. The EQA expert system results

MTS value	Mechanical step efficiency	CBO5 value	CCO value	Biological step efficiency	P value	N value	Tertiary step efficiency	WWTP effluent quality
32.65	raised	21.08	105.2	raised	0.7	6.9	raised	excellent
27.4	raised	15.9	73	raised	0.98	11	minimum	acceptable
15.7	raised	24.63	124.5	minimum	1.03	8.23	minimum	acceptable
36.2	minimum	26.01	126.8	minimum	0.86	9.7	minimum	acceptable
33.8	minimum	25.4	123.7	minimum	1.5	15	inefficient	poor
54.3	inefficient	30.1	129	inefficient	2	13.7	inefficient	poor

To obtain at least an acceptable quality for the WWTP effluent, namely the values of the measured parameters to be within NTPA limits, the existent plant must be modernized and automated. At this moment, local administration has as a priority the building of a new and modernized plant that may assure a very good quality of the treated wastewater.

Considering the current state of the Ploieşti plant effluent, there can be taken the necessary measures to improve its quality. In order to prevent the outrun of the admissible limits for the plant effluent, the permanent assessment of the quality parameters is highly necessary, which implies the usage of different types of systems, such as expert systems.

Conclusions and Future Work

The EQA (Effluent Quality Assessment) prototype expert system, developed using an expert system shell, can be a useful software tool for the quality assessment of a wastewater treatment plant effluent. Using this system, the assessment can be done during different steps, such as the mechanical, biological or tertiary step. Also, the system may be extended with new rules in order to make more complex and accurate assessments.

We consider that using expert systems in WWTP domain, from all the artificial intelligence techniques available, is adequate because this type of system includes expert knowledge and it also solves problems at human expert level. Into a WWTP system of a certain type (control, diagnosis or monitoring), there can be supplied new knowledge by means of an ES knowledge base, a very useful fact when the plant operators knowledge are not sufficient.

Such a type of expert system can be incorporated into the wastewater treatment plant system (as control, monitoring, diagnosis, decision support systems etc.), through the usage of different data communication protocols specifications (RS-232/422/485 etc.), in order to improve the plant activity and performance.

The insertion of the expert system knowledge into a monitoring system can be made by means of using the expert system rule base. A monitoring system must supply a reliable plant diagnose based on the measurement of the parameters evolution. An example of an expert system which fulfills this task is presented in the paper of Carrasco et al. [1], in which it is developed an expert system with fuzzy logic for plant monitoring and control.

At the present day, the usage of expert systems for wastewater treatment plant monitoring, control, diagnosis, assessment, etc. is a point of interest for the researchers in domain.

The assessment of a wastewater treatment plant effluent quality is an important task because of the great impact of the plant effluent quality on the emissary quality and because nowadays it is experimented the possibility of using treated wastewater as a potential source of drinking water.

The author contribution consists in developing an expert system to solve a particular problem, namely the effluent quality assessment of Ploieşti wastewater treatment plant, by building a set of rules adapted to Ploieşti plant particularities.

Future work will consist in adding fuzzy logic and neural networks to the developed expert system, in order to obtain a neuro-fuzzy expert system for a wastewater treatment plant effluent assessment. Furthermore, the developed system can be replenished with a control component for wastewater treatment plant effluent quality control.

References

[1] Carrasco, E.F., Rodriquez, J., Punal, A, Roca, E., Lema, J.M., Diagnosis of Acidification States in an Anaerobic Wastewater Treatment Plant using a Fuzzy-Based Expert System, *Control Engineering Practice*, 12 , pp. 59-64, 2004

[2] Ianculescu, O., Ionescu, Ghe., Racoviteanu, R., *Epurarea apelor uzate*, MatrixRom, Bucureşti, 2001

[3] Lapointe, J., Marcos, B., Veillette, M., Laflamme, G., BIOEXPERT – An Expert System for Wastewater Treatment Process Diagnosis, *Computers chem. Engng*, 13(6), pp.619-630, 1989

[4] Mikosz, J., Application of Expert Systems in Wastewater Treatment In:Wastewater Sludge and Solid Waste Management, *Report No.9*, M. Hopkowics, B. Hultman, J. Kurbiel, E. Plaza (Editors), TRITA-AMI REPORT 3088, pp. 137, 2001

[5] Paraskevas, P.A., Pantelakis, I.S., Lekkas, T.D., An Advanced Integrated Expert System for Wastewater Treatment Plants Control, *Knowledge-Based Systems*, 12, pp. 355-361, 1999

[6] Punal A., Roca, E., Lema, J.M., An Expert System for Monitoring and Diagnosis of Anaerobic Wastewater Treatment Plants, *Water Research*, 36, pp. 2656-2666, 2002

[7] Robescu, D., et al., *Controlul automat al proceselor de epurare a apelor uzate,* Editura Tehnică, Bucureşti, 2008

[8] Serra, P., Sanchez, M., Lafuente, J., Cortes, U., Poch, M., DEPUR: a Knowledge-Based Tool for Wastewater Treatment Plants, *Engng Applic. Artif. Intell*, 7(1), pp. 23-30, 1994

[9] Serra, P., Sanchez, M., Lafuente, J., Cortes, U., Poch, M., ISCWAP: A Knowledge –Based System for Supervising Activated Sludge Processes, *Computers chem. Engng* , 21(2), pp. 211-221, 1997

[10] Sanchez, M., et al., DAI-DEPUR: An Integrated and Distributed Architecture for Wastewater Treatment Plants Supervision, *Art. Intell. Engng,* 1, pp. 275–285, 1996

[11] * * * - *The Technical Documentation for the Objective - The Modernization of the Wastewater Collecting and Treatment System from Ploieşti City*, Public Services Autonomous Régie (RASP), Ploieşti, 2009

[12] * * * - *The NTPA-001/2002 Normative for Establishing the Loading Limits with Pollutants for Industrial and City Wastewater at the Evacuation into the Natural Receivers*, published in the Official Journal of Romania, part I, no. 187, 20 March 2002, http://www.aquamundus.ro/pdf/NTPA-001%2028.02.2002.pdf, accessed September 2010

[13] * * * - *INSSE*, https://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=PMI109A, accessed September 2010

Un sistem expert pentru evaluarea calităţii efluentului unei staţii de epurare a apelor uzate

Rezumat

Pentru a îmbunătăţi calitatea efluentului în concordanţă cu normativele tehnice europene şi româneşti, în Ploieşti se va construi o nouă staţie în treaptă mecanică şi biologică, inclusiv tratarea nămolului, cu o tehnologie îmbunătăţită în îndepărtarea poluanţilor. În literatura de specialitate sunt prezentate o serie de sisteme expert pentru domeniul epurării apelor uzate, fiind subliniate domenii de interes precum: monitorizarea staţiei, controlul şi diagnoza staţiei, proiectarea staţiei şi sprijinul în luarea deciziilor. Din cauza standardelor stricte pentru efluent folosite astăzi în domeniul apelor uzate, procesele de epurare au devenit mult mai complexe, astfel că cunoştinţele operatorilor staţiei nu sunt suficiente pentru o funcţionare optimă a acesteia. Întrucât cunoştinţele experţilor în epurarea apelor uzate pot fi introduse în sistemul aferent staţiei prin intermediul unei baze de cunoştinţe, care poate conţine cunoştinţe despre evenimente anterioare, cunoştinţe despre evenimente anormale, etc., utilizarea sistemelor expert alături de alte instrumente poate fi un mijloc folositor pentru o mai bună funcţionare a staţiei. Calitatea efluentului staţiei are un mare impact asupra emisarului staţiei şi în general asupra mediului înconjurător, drept urmare este necesară evaluarea periodică a efluentului, pentru identificarea problemelor aferente procesului de epurare şi pentru corectarea acestora la timp. În cadrul acestei lucrări va fi dezvoltat un sistem expert prototip pentru evaluarea calităţii efluentului staţiei de epurare a apelor uzate din Ploieşti, folosing VP-expert, un generator de sisteme expert.