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SYSTEMIC APPROACH TO THE INTEGRATED ENVIRONMENTAL MANAGEMENT

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Apelând la aspectele teoretice şi generale, inserate în standardele internaţionale din seria ISO 14000, în lucrare se evidenţiază elementele specifice unui operator de apă-canal şi se indică ceea ce trebuie făcut de către managementul organizaţiei pentru aplicarea prevederilor respective. Se calculează indicii de siguranţă cu un program scris în limbajul de programare Visual Pascal. Astfel, se obţin diagrame de tip radar, deosebit de sugestive şi ilustrative pentru scopul urmărit. Se permit, printre altele:

- *inventarierea aspectelor de mediu şi stabilirea celor semnificative;*
- *analiza punctelor slabe şi punctelor tari ale organizaţiei;*
- *evaluarea acţiunilor întreprinse în urma investigării disfuncţionalităţilor anterioare .*

In this work, theoretical and general aspects comprised in the international series of standards ISO 14000 are used in order to highlight the specific elements of a water and sewerage operator and to indicate what should be done by the management of the organization in order to apply those provisions. The safety index is calculated with a computer program written in Visual Pascal. In this way, radar diagrams are obtained, which are highly suggestive and illustrative for our purpose. Among others, the following are made possible:

- *the inventory of the environmental aspects and the establishment of the significant ones;*
- *the analysis of the weak and strong points of the organization;*
- *the evaluation of the actions taken after investigating the former dysfunction.*

Key words: systemic approach, environmental management systems

1. Introduction

In the context of the negotiations with the European Union, transposing and implementing environment related legislation are central and extremely difficult subjects, taking into consideration the effects on every sector of the economy, including the ones of public services of general interest (water, sewerage, transportation, etc.). The extremely severe requirements of the environment legislation of the European Union forces the economic sectors in Romania to

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reconsider the fundamental structural elements, once the environmental dimension is introduced in the development strategy of one sector or another, and a new and improved type of management is implemented.

Related to this matter, we analyze in this paper the problems that appear in certain sectors of activity, especially in the field of water and sewerage operators. We approach the relation of that activity with the environment. We also present solutions to introduce this relation into the environment legislation in Romania, by implementing the Environment Integrated Management System, defined by international standards ISO 14000.

We insist on the identification of significant environmental aspects using a multiple criteria method. This method should be in the attention of everyone who manages any activity with impact on the environment. By using this instrument:

- the impact of the analyzed activities on the environment can be estimated;
- polluted areas can be identified;
- required activities for minimizing the impact can be hierarchized.

2. The environment issue as a component of the environment policy

The appearance of ecological risks that put the planet in danger – massive deforestation, green house effect, ozone layer alteration, the danger of nuclear accidents – makes us think that our growth model is not very “sustainable” and a new one should be implemented urgently for all of us.

Sustainable development – a relatively new concept of human society development – was proposed in the 70’s and in the 80’s and officials promoted it in the 90’s.

ISO 14001 Standard refers to this concept in the introduction, stating that “organization of all kinds are increasingly concerned with achieving and demonstrating sound environmental performance by controlling the impacts of their activities, products and services on the environment, consistent with their environmental policy and objectives. they do so in the context of increasingly stringent legislation, the development of economic policies and other measures that foster environmental protection, and increased concern expressed by interested parties about environmental matters and sustainable development”[1].

The point of view generally accepted is that of sustainable development, which tries to achieve the interaction and the compatibility of four systems: economical, social, environmental or ecological and technological.

In a short history of these attempts to interact and make the four systems compatible, can be stated that during the initial phases, there has been a horizontal development tendency in elaborating the indicators, consisting in the identification of various indicators, from different fields and sectors of activity, which should show the sectorial or global sustainable development. The orientation in the same direction tends to be less and less useful, especially for an integrated vision. We notice a filtration of the indicators, in order to retain the significant ones, for the vertical aggregation and finalization through a unique indicator (the ideal case) or a minimum set which reflects the level of sustainable development.

Certain researchers have established the principles of an integrated eco-economical dynamic model, by incorporating five essential aspects of the sustainable development:

- the requirement to assure the equity between generations;
- the approval of the issue on a regional scale;
- the assurance of the optimization of different kind of resources;
- the consideration of possible problems that may appear on long term;
- eco-economical evaluations of the priorities on each temporal and special horizon.

The general policy of a company consists of economical, technical, social, scientific research, financing and environmental objectives. In the context of environment-economy requirements “the objectives regroup around them all the human, material and informative resources of the company focusing them on the achievement of the targets set by the managerial team, to obtain competitive and efficient economic results” [2].

An essential premise of the development action should be the establishment of the priorities in the field of environmental protection.

The eco-economical decision should become the working model for any manager, as well as for administrative and executive boards. Their decisions have the content of a decision with multiple effects [3].

The information is used and interpreted with models adequate to each domain. Economical, ecological, and social information should be analyzed following also the financial implications that should be part of an eco-economical decision.

3. Environmental management as an integrated system

The approach of environmental management becomes a necessity for any organization in order to increase the general efficiency.

The replacement of analytical methods in a series of sciences – in which the increase of knowledge requires the splitting of the whole in its component parts – with systemic methods offers an adequate environment for the important theoretical and practical aspects of systemic approach in studying the phenomena, the processes and the objects from nature, technology and society.

The theory of systems did not manage to offer a generally recognized definition of the concept of system. In general, a system can be defined in various ways:

- a collection of objects of any nature, connected one to another by interaction and interdependence forms, like: biological, technical, geographical, cosmic, economical and social systems;
- an organized data base of knowledge, concepts, sizes;
- a planned way of action, organization and classification.

Today we are talking more about complex systems: those systems that actively interconnect with the environment and that have a structure that allows them to adapt to unpredicted situations and have the capacity to use the experience gained previously.

In the present stage, the environmental management uses a large number of methods and procedures with scientific character. Their diversity is generated by two major factors:

- the inventive spirit of the human beings;
- the necessity of searching for solutions as close as possible to certainty and efficiency, which will assure useful managerial decisions.

The field of environmental management involves the concept of system, because the universal character of the theory of systems offers a new perspective approach to companies. The analysis of the environmental management system is able to get to the essence of the entire ecological issue.

On this basis, guide lines can be established; a list of all the ecological-managerial strategy problems, in order to give the environmental management an improved efficiency. Also, considering the company as an open system, receptive to numerous and dynamic internal and external transformations, we need to take into consideration all the functional combinations and modifications that might take place.

Environmental management, taken as a coherent ensemble of subsystems that interfere and combine, proves its utility in environmental management systems in that it offers answers, quantitatively and qualitatively speaking, to the economical-social command [4].

4. Systemic Approach of Integrated Environmental Management Model (SAIEM Model)

In order to develop the systemic approach of integrated environmental management it is considered helpful to present the definitions of some notions that will be used throughout the elaboration of the model.

Systemic approach: way to think and analyze, which is based, on one hand, on the time-space relation between elements, and, on the other hand, on the analysis of the elements [5]).

Management: exercising the planning, organization, direct leading, control and supervising function of each industrial or business project or activity, assuming the responsibility for the results [6].
Integrated: included, part of a whole.
SAIEM: identification, understanding and leading the correlated processes as a system; it contributes to the efficiency of an organization in reaching its environmental objectives.
SAIEM Model is a methodological instrument, which offers an integrated approach to managing and monitoring the environmental impact, while respecting the environmental enforcements.
The logical scheme of the SAIEM model is presented in Figure 1. This describes the steps required from the moment when the decision of implementing the model is taken up to the moment of certification, maintenance and improvement of the environmental management system.

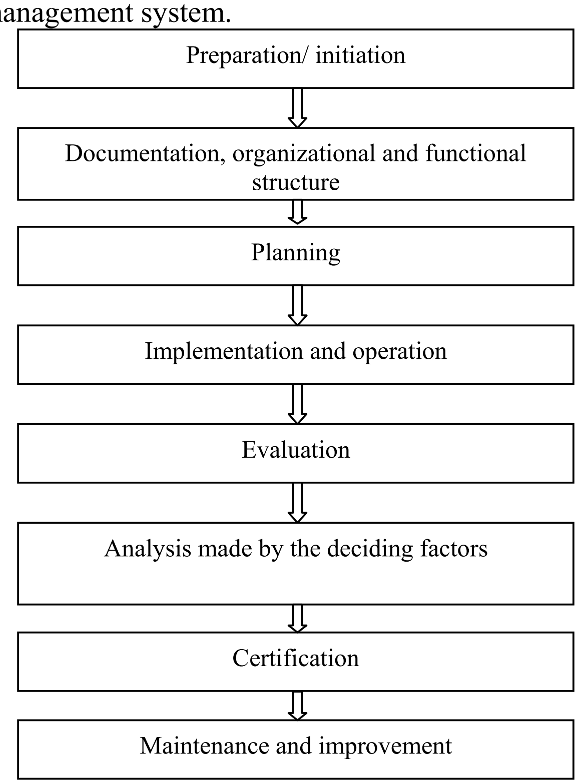

Fig. 1. Steps of the systemic approach of the integrated environmental management model (SAIEM Model)

All the stages and ways of approaching the issues are applied at the level of a water-sewerage operator and are schematically presented in Figure 2. In this figure the following successive transition can be observed:

- the analysis of the determining factors for the systemic approach of the integrated environmental management (SAIEM);
- the objectives pursued in this type of analysis;
- the description and elaboration of the model as an exemplification of the approach as process and integrated system;
- the application of the SAIEM concept.

5. The implementation of the SAIEM model to a water-sewerage company

In order to fulfill the requirements of identifying the fields in which the locations and the analyzed installations may have a significant impact on the environment, a whole set of information is necessary.

The information can be obtained from sources such as:

- the examination of the relevant documents and registrations, which may include: process data, data regarding pollutants, waste, consumption of energy, water, fuel, etc;
- interviews with the personnel of the company (both at management level, and at execution-operation level);
- discussions with members of the local community;
- the inspection and the direct observation of the places and of the installations on the site by the interdisciplinary team involved in the analysis;
- own analysis and measurements.

The process of collecting information requires, certainly, time and effort.

It is important to remember that the received and interpreted information must be:

- from a safe and objective source;
- confirmed and validated;
- significant.

Based on the information obtained by the implementation team, 61 environmental aspects have been identified within the water-sewerage company.

The matrix for the establishment of the environmental aspects with significant impact is filled in by means of relating the environmental aspects to a series of evaluation elements.

As a result of the evaluation, the environmental aspects receive the grades: 0 – unimportant, 1 – important (Table 1).

Table 1

Classification criteria

Reference levels	Definition	Grade
Important	- is relevant for the problem - has measurable effects - must be taken into consideration	1
Unimportant	- without priority - does not have measurable effects - without relevance	0

These grades are gathered in a data file.

In order to calculate the probabilities of these environmental aspects, the method of multi criteria analysis of a characteristics system, based on the environmental aspects of the company, was used.

In this case, the matrix has in the rows the characteristics of the system (environmental aspects - EA), and in the columns the evaluation fields.

The calculation of the safety index (I_{SG})

The following steps will be followed:

– the array *A* of the probability system attached to each characteristic is built up. These probabilities are calculated in the usage of the assessment by weight;

– the reduced weights $p_{s1}, p_{s2}, \ldots, p_{sn}$, which are obtained by summing up the relative weights, are calculated; hence, the sum of all elements from the columns will be calculated;

– the informational energies of the characteristics AM_1, AM_2, …, AM_m are calculated. For the calculation of the energy, the squares of the elements from the first line are added, E_2 being the sum of the squares of the elements from the second line etc.;

– the data file with the 0 and 1 grades is processed using a computer program written in Visual Pascal; by processing we generate text files which will be imported into Access in order to obtain data tables. These data tables are then converted in Excel format for the elaboration of graphs;

The following will be written down, according to Table no. 2:

- E_j (j = 1, m) the informational energy of the environmental aspect *AMj,* for example E_1 is the informational energy of the environmental aspect (AM_1)-waste/paper/carton wrappers,

- p_{ji} *the* probability of the environmental aspect *j* in the evaluation area *i*.

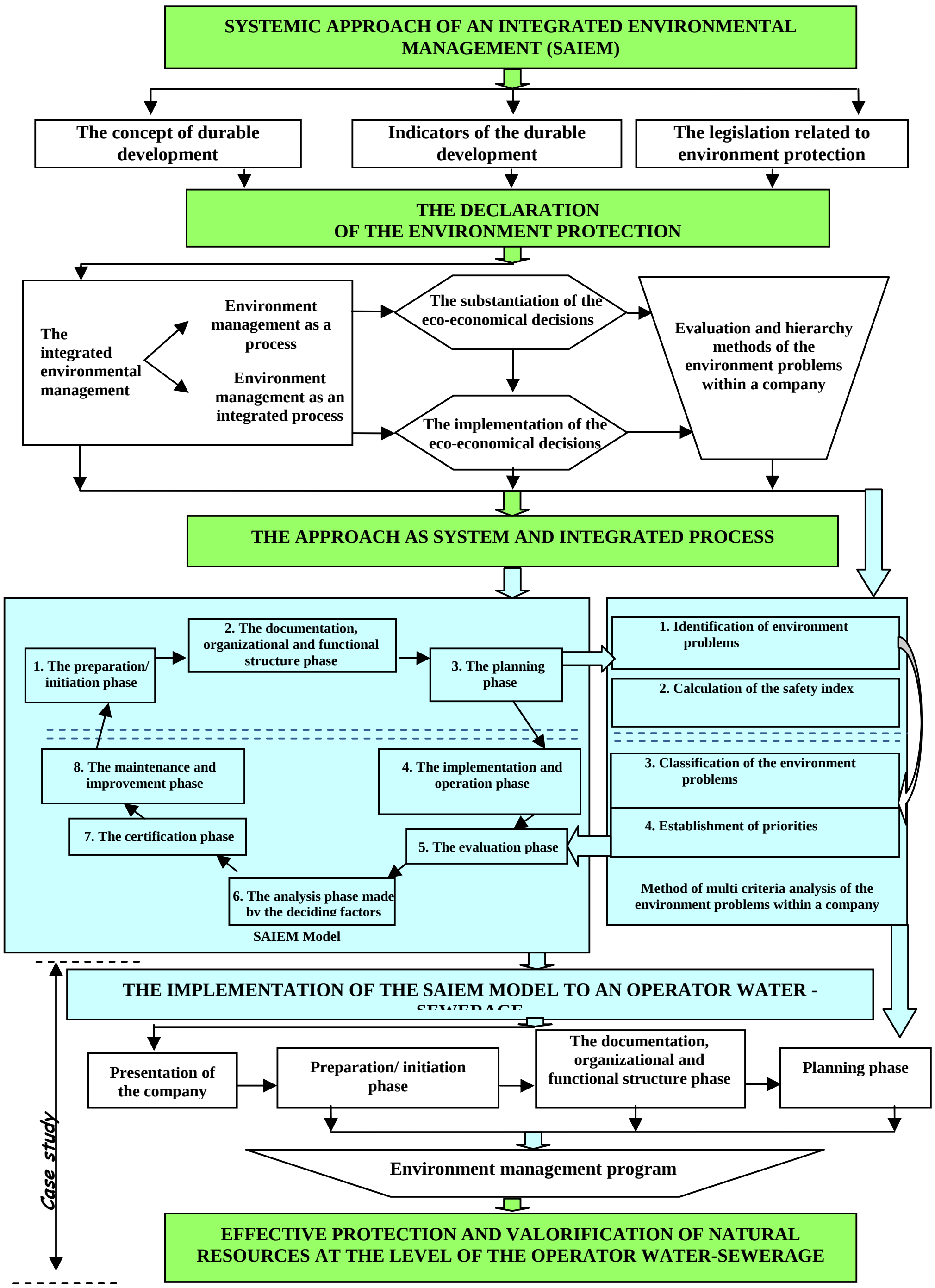

Fig. 2. Definition of SAIEM concept

Table 2

Evaluation matrix of the environmental aspects

PROCES	Activity, product, service	Environment aspect (AM) COD aspect	Influenced environment factor	Elements of beginning the evaluation										TOTAL	I_{SG}
				Legal frame			Periodical inspections	Emissions/ exhaustions	Level of consumption of raw materials and materials	Environment risk					
				Conditions	Restrictions	Compulsory rapports				Toxicity	Volume and mass	Frequency	Gravity		
				(EV1)	(EV2)	(EV3)	(EV4)	(EV5)	(EV6)	(EV7)	(EV8)	(EV9)	(EV10)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
OB-2	Waste-water purification	AM11 Water release in the natural receptor	Surface water pollution	1	1	1	1	1	0	1	1	1	1	9	0.0513
. . .															
P_n															

Note:
15 – Sum of points resulted from evaluation
16 – Safety index resulted from equation (6)

Octav Onicescu noticed [8], for purely statistical purposes, that it is possible to keep the probability itself as information (which is multiplicative for independent conditions) and, therefore, the following average idiom could be considered as information:

$$E = \sum_j p_j^2 \,, \tag{1}$$

which he called *informational energy*, also multiplicative, for independent systems.
According to the definition, E is the information average p_j compared to the respectively individual condition [7].

We define the term of impact on the environment, concerning (the indicators values) the value distribution of the statistical indicators. In the case that the characteristics have equal probability $\frac{1}{n}$ where ***n*** is the observed values number for the reference theoretical system.

The informational energy of the m characteristic with the equal probability values $p^2 = \frac{1}{n}$ is:

$$E^* = \sum_{i=1}^{n} \frac{1}{n^2} = n \times \frac{1}{n^2} = \frac{1}{n} \tag{2}$$

For $n = 10$ it is obtained:

$$E^* = \frac{1}{10}\,.$$

The *informational correlation* notion for distance evaluation between a real measured characteristic and a (theoretical) characteristic whose values allotment corresponds to a major impact upon environment has been introduced in the project.

If a correlation equal to 1 is found between the evaluated (real) statistical characteristic AM_i and the theoretical characteristic AM^*, which expresses the impact upon environment, then the studied characteristic poses the highest risk for the presented eco-economical system.

If that characteristic is 0, it is obvious that the measured values do not represent any risk for the eco-economical system.

$$R(j,*) = \frac{COV(j,*)}{\sqrt{E_j \times E^*}} \tag{3}$$

$$COV(j,*) = \sum_{i=1}^{n} p_{ji} \times p^* = \sum_{i=1}^{n} p_{ji} \times \frac{1}{n} = \frac{1}{n} \sum_{i=1}^{n} p_{ji} = \frac{1}{n} \tag{4}$$

It is obtained: $R_{(j,*)} = \frac{1}{\sqrt{n \times E_j}}$ (5)

The safety index *(I_{SG})* of the characteristic *AMj* is:

$$I_{SG} = 1 - R_{(j,*)},$$ (6)

where:

- $R_{(j,*)}$ – is the informational correlation multiplier between a real measured characteristic and a (theoretical) characteristic;
- E_j – is the *j*-th characteristic informational energy;
- *n* **–** is the number of recorded values (10).

Case study

For establishing the significance of the eco-economical system characteristics depending on the real, on site, measured condition and the theoretical condition, the following steps were followed for wastewater treatment plant "X":

Step 1. The plain file containing the data was created with Notepad;

Step 2. The ***informational correlation multipliers*** were calculated with the program written in Visual Pascal as follows:

2.1. The data was written with a procedure in a **m[61, 10]** matrix.

2.2. The weights of each characteristic were calculated as follows:

2.2.1 The sum of the elements on a line, i.e. sum of (k), with k being the line, was calculated with a function of the program.

2.2.2. The function described above was used in a procedure **s_l (vli)** to calculate the sums on each line. The procedure returned the **vli** (vecl line type).

2.2.3. The matrix of probabilities was calculated with the **matprob procedure**. The procedure returned the matrix **mp[j,i]**, where **j** is the line index and **i** is the column index.

2.2.4. The sum of the squares of the probabilities was computed with the function **sumsquareprob(k),** where **k** represents a line.

2.2.5. The square sum of the probabilities for each individual line by the way of **energ(sqm)** is calculated, where **sqm** represents the matrix of the probabilities (entrance data)**. e[j]** is the vector of the informational energies characteristics on each line and it represents the result offered by the subprogram (exit data).

Step 3. The theoretical correlation was calculated using the procedure **correlation_t(R).** The correlation reflects the case when all original matrix elements are 1-significant. The procedure sends as result the vector type variable

R[j], where **j** is the line index, a variable which holds all the correlations from each line;

Step 4. The safety indexes held in vector type variable **isg[j],** where j is the line index, were calculated.

Step 5. First, the simple sum (S_{G1}) held in variable d was calculated using the program. The value S_{G1}=11,5454 was obtained. Secondly, the sum of the safety indexes' squares (S_{G2}) held in the variable **d1** of the respectively characteristics obtaining the value S_{G2}= 2,7908.

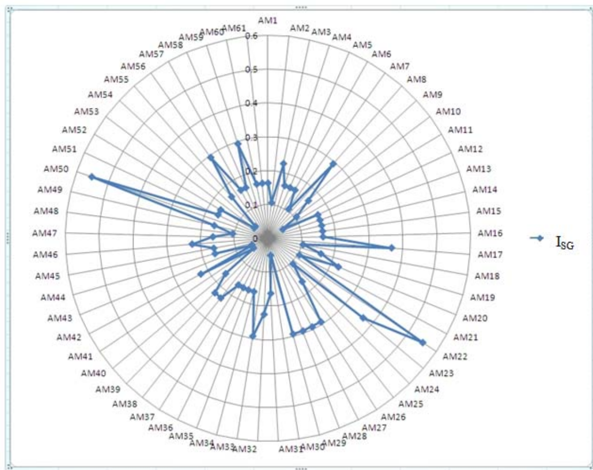

Fig. 3. SAFETY Indexes (I_{SG})

Step 6. With the values obtained previously, the average of the safety indexes, held in variable **med** was calculated. The following value resulted:

$$M_{c1} = \frac{S_{G1}}{61} = 0{,}1893 .$$

The square average of the safety indexes, held in variable **med1**, was also calculated. The value obtained was

$$M_{P1} = \frac{S_{G2}}{61} = 0{,}0458 .$$

Step 7. The dispersion of the safety indexes was calculated and saved in variable **disp**. The following value was obtained:

$$\sigma = M_{p1} - M_{C1}{}^{2} = 0{,}0099 .$$

To estimate the safety indexes, the correlation calculation program was used for the 61 characteristics investigated, and has been calculated an average of value of M_{c1} = 0,1893.

To understand this average value, a confidence interval was built, corresponding to the confidence coefficient α = 0,95.

From the calculations of the selected data, the squared average deviation of the safety indexes σ = 0,0099 resulted (see the calculation program).
Because n > 30, we used a selection function with a normal repartition independent on the parameter that we were evaluating. Choosing a confidence coefficient α very close to unity (which offers a probability close to 1) we can determine the size of z. From the relationship

$$P(-z_\alpha \le M \le z_\alpha) = \alpha$$

it results that: $2\phi(z_\alpha) = \alpha$.
For α=0,95 the equation $2\phi(z) = 0{,}95$ gives for z, from the Laplace normal repartition tables z =1,96, and the confidence interval for the theoretical average of the safety indexes is:

$$M_{c1} - z \times \frac{\sigma}{\sqrt{n}} < M < M_{c1} + z \times \frac{\sigma}{\sqrt{n}}$$

In our case, the confidence interval is: $0{,}1868 < M < 0{,}2143$
Taking into account the values for the limits of the confidence interval, it is required to consider as significant for the eco-economical system those indexes which are lower than the upper limit of the confidence interval.
The situation is reflected by Figure 4, in which the limits of the confidence interval are marked using colored lines.
The precision given to the error probability have a sizable influence over the economical calculations, when considering the characteristics of the eco-economical system.
The environment aspect with the lowest value of the safety index generates the greater impact and, consequently, has the maximum priority.
The environment aspects are sorted ascending based on the resulted safety index (table 3).

Table 3

The hierarchy of environment issues

No.	Process	Activity, product, service,	Hierarchical environment aspects			
			Environment aspect	Code	Environmental Impact	**I_{SG}**
1.	OB-2	Waste water purification	Water release in the natural receptor	AM11	Surface water pollution	0.0513
…	……	……	……	……	……	……
…	……	……	……	……	……	……
61.	S3, S4	Heating (thermal central)	Methane gas consumption	AM50	Waste of the natural resources	0.5528

The environment issue with the lowest value for the safety index generates the greater impact and, consequently, has the maximum priority.

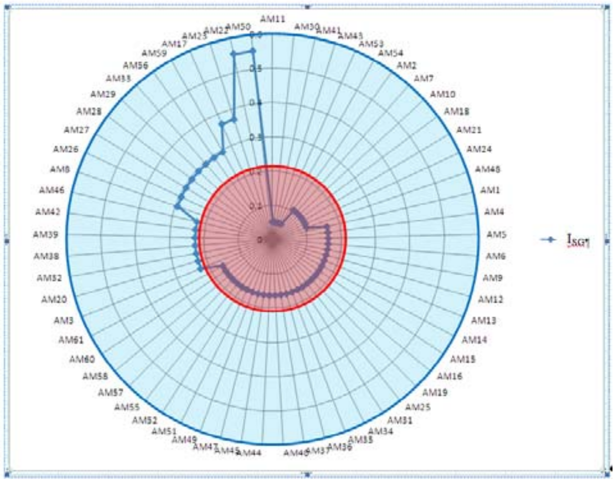

Fig. 4. Hierarchy of the safety indexes
- Significant safety indexes - Non-significant safety indexes

The significant environment issues are communicated to the process owner (table 4).

Table 4

Listing of significant environment issues

Process	Activity, product, service	Significant environment issue
Raw water collecting (OB1-1)	Collecting	Flooding of collection areas
		Underground water exploitation
Raw water treatment (OB1-2)	Water disinfection	Chlorine leaks
	Use of dangerous material	Possibility of an accidental leak
	Transport, storage, usage of containers with chlorine gas	Chlorine leaks
.....	.....	.....

The list of significant environment issues is signed by the owner of the involved process and by the environment responsible, is endorsed by the Management Representative for the environment management system, and is approved by the leader of the organization. After approval, the documents should be posted at the workplaces and should be presented to the personnel, as well as to the personnel designed to work in the area.

The revision and/or updating of the list of environment issues/significant environment issues and the associated impacts should be done at least once per year and are mandatory every time the activities, processes, products, and services made by the organization are changed.

The significant environment issues are taken into account when creating:

- the environment management programs;
- the waste management plan;
- the monitoring of the environment agents;
- the plans for emergency situations and response capacity.

The elaboration of the environment management program is an important stage of the first quarter of the PIVA cycle.
This program includes the establishment of the responsibilities for every relevant position and level inside the organization, as well as the means and deadlines for the established objectives and targets.

6. Conclusions

It is obvious the interest of the companies, including those based on general public services area, as well as on water and wastewater services, for certification according to ISO 14000 „Environment Management Systems”.
In those circumstances, using the results of the systemic approach of integrated environment management can be done on multiple directions:

- the improvement of the image for the organizations;
- the raise of environment performance for the organizations;
- the development of the communications lines inside the organization;
- the development of partnership relations between the organizations and the central and local environment authorities in charge with the environment protection laws enforcement.

At a glance, it can be said that:

- the approach of environment indicators represents the current direction of the organizations, for a systematical measuring and improvement of the environment performance inside the organization;
- at the organization level, the fundament of the hierarchy methods for environment aspects is the principle that the maximum priority environment aspect is the one causing the greater impact;
- an improvement of the environment conditions can be done through the engagement of the high level management, integrated processes and teams which are focused on environment protection ;
- at present, the environment management system represents a strategic instrument of the global management of the organizations, and a deterministic element for their competitiveness;
- the design of a guide represents the most recent tendency in the activities of design, implementation and improvement of the environment management systems;
- the generation of a guide could offer the following advantages:

- the possibility to gather information regarding significant environmental aspects, specific for the activities/products/services inside an organization;
- the possibility of using the obtained information for the improvement of environment performance;
- support in decision making;
- the knowledge and application of the instruments of the environment management are elements without which no organization can resist on the market.

It is considered that the integrated approach model may be extended to the level of an economical organization for certification in accordance with the management of quality – environment – health and occupational security.

Through the implementation of the environment management system and its framing in the global system of the organization, the creation of a balance between the quality of the offered products and services and the environment protection was started at the level of the water-sewerage operator.

Among the main current concerns are:

- *THE QUALITY* of the products and services in order to increase the trust in them and the satisfaction offered by them;

- *THE HUMAN BEING,* who has the right to a healthy life in a proper environment;

- *THE ENVIRONMENT* with its natural resources, which must be protected and exploited as efficient as possible.

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