# Ecological Corporative System Concept in Solving Problems of Ecological Estimation and Ecological Hygienic Normalization

T.V. Kozulia, N.V. Sharonova, M.M. Kozulia

*Abstract* — **Approach of methodical application of concept of ecological corporative system (CES) in the system of ecological monitoring is shown in the article. Appropriateness of corporative approach application was indicated for problem solving of standardization of state parameters of environmental objects. The appropriate algorithms of the assessment of the health risk and of the ecological standardization problems were developed on basis of analysis of existent approaches of determination of system status and appropriateness of introduction of the risk-analysis for problem solving of state identification of CES.**

*Index Terms* — **The ecological corporative system, the risk-analysis, the ecological standardization, the ecological – hygienic assessment.**

## I. Introduction: Relevance of the Work and Relation with Scientific Practical Tasks

ENVIRONMENT is the economics basis, means of subsistence, source, of national wealth. As the world is being industrialized, urbanized and the resource base usage is growing, intellectual resource management is getting necessary. Ecological estimation (EE) is one of the ways attaining the goal.

The EE aim is to provide taking into account environment state and ecosystem durability in the development and approval processes of projects, plans for development, programs, and policies. The EE itself is the planning process. It to use prognosis analysis and interpretation of significant affects upon environment, which will be caused by planned activity, and providing information, which is needed during decision-making management.

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Kozulia T.V. is with the National Technical Univercity "Kharkov Polytechnic Institute", Kharkov, 61142 Ukraine (corresponding author to provide phone: 3-8057-7076474, 3-8057-7135189; e-mail: kozulia@kpi.kharkov.ua).

Sharonova N.V. is with National Technical Univercity "Kharkov Polytechnic Institute", Kharkov, 61142 Ukraine (phone: 3-8057-7076460, 3-8057-3375982; e-mail: sharonova@kpi.kharkov.ua).

Kozulia M.M. is with the Kharkov National Univercity named after V. N.Karazin, Kharkov, 61142 Ukraine (phone: 3-8057-7076474, 3-8057-7135189; e-mail: kozulia@kpi.kharkov.ua).

The EE is used to prevent and minimize unfavourable affect. It also simultaneously estimates real resource potential and maximizes advantages in order to:

- change and improve planned activity project;
- ensure effective resource usage;
- improve social aspects of planned activity;
- determine ways of monitoring and management;
- assist well-grounded decision-making.

The EE process is connected with characteristic and analysis of the whole influence spectrum which includes biophysical (environmental influence), social, in population health affect, economic, risk and uncertainty aspects are taken into account.

Risk always means the result uncertainty. At the same time risk is frequently understood as the loss possibility, although it is described as probability of getting a different result. Risk as a rule combines event probability the event effect and the consequence of the event caused by it. Risk is a progressing contributor of the process that has a negative influence potential upon main process flow according to Rational Unified Process (RUP) point of view [4].

Statistical risk often comes to the possibility of some undesirable event. As a rule such event possibility and its harm estimation are combined into one verisimilar result. Such result combines risk possibilities set, loss and reward into the expected present result value.

So statistical decision-making theory says that risk estimation function $\delta(x)$ for parameter $\theta$ calculated for some observed $x$ is determined as expected loss function $L$ value:

$$R(\theta,\delta(x)) = \int L(\theta,\delta(x)) \times f(x \mid \theta) dx , \qquad (1)$$

where: $\delta(x)$ is estimation, $\theta$ is estimation parameter.

As it is known the harmful factor a effect is determined by the biological response spectrum of the organism to any harmful factor affect. Death, disease, physiological disease symptoms, functional changes of indistinct biological importance, pollutants or their metabolic products accumulation in organs and tissues are possible responses. Three zones are distinguished during harmless pollution levels determination. The first zone (absence of factor affect) is named sub-threshold level. The third zone (toxic influence) is characterized by pathological organism changes caused by the pollutant (disease or its sings). The second zone lies between them. It is the zone of organism changes which are of unclear biological value. Probably such change is connected with protective adjustments. It indicates the environment deviation from the biological optimum.

According to leading hygienists, existing hygienic pollutants normalization principles are widely practically realized. However, theoretical basis of this problem and its methodology are still widely discussed in literature. Concepts of "thresholdlessness", "risk realization inadmissibility", "benefit-harm" and "justified risk" are meant at the moment. All these concepts contradict the main approach established in USSR which substantiated hazardous substances MPC with "harmless" and "medical aspect domination" criterion.

It is necessary to work out a universal approach to solve problems caused by economic activity influence upon environment, by natural and social environment influence upon living organisms and human health.

## II. Aims and Problems of Investigation

Economic, social and natural systems interaction is characterized as versatile. The systems themselves are to be developed and the consequences of this development effect upon living organisms and human health can hardly be predicted. A new concept of solving the above mentioned problem is proposed. It is aimed at harmonizing "economic-social-environment" system. The latter is presented as a corporative system with ecological principles priority and thus it is named the corporative ecological system (CES) [5, 6]. On the basis of the suggested concept and introducing risk theory it is possible to solve the following problems: common developing systems interaction estimation within the in framework of the CES, commonly acceptable managerial decision and healthy human environment conditions determination. To achieve this aim the following tasks touched upon in the present work:

1) to determine main approaches to general system state (CES subsystems) estimation in their present condition their development and external influence;

2) to form methodical approaches to qualitative and quantitative health risk estimation in the sphere of normalization and decision-making concerning secure influence upon human beings.

## III. Research Materials and Scientific Results

Corporative ecological system (CES) concept has been proposed in the ecological monitoring system. This concept considers corporative interconnection between three macrosystem components, their independent progress. This approach gives an opportunity to determine every subsystem state and also the state of the system as a whole. Riskless CES and subsystems state is proposed to estimate on the basis of thermodynamics and synergetic [5, 6]. Ecological risk according to thermodynamic ecosystem structure is conditioned by entropy increasing due to disturbances in it. Equilibrium state is characterized by the minimal entropy level.

Managerial decision is estimated according to the CES general state and depending on every CES subsystem entropy and informative ness. It means that CES state entropy is action result parameter. Current decision realization within some time interval $[t_0 \; T]$ produces incompatible effect series. Incompatibility is conditioned by thermodynamic flow connection between CES subsystems of local level. Thermodynamic equilibrium maintenance is an optimal functionality criterion of such a system. This means $\Delta S \to \min \to 0$ or $S = \max$ state in relation to other states.

Generally the CES state as a macrosystem is determined by its components macro state. Different CES subsystems macrostates are established together with their different microstates. Certain system state is connected with one of the realization of possible $E_n$ energy levels. Each energy level has its own statistical weight $\Omega_n$. If the internal system energy with entropy $S_n$ is close to $E_n$ then:

$$\Omega_n = e^{(E_n - A)/kT},$$

where $A$ is free energy, $k$ is Boltzmann constant, $T$ is temperature.

The $P_{in} = 1/\Omega_n$ value is corporative system macrostate possibility provided that all system macrostates with energy $E_n$ are equally possible. The CES state from the thermodynamics point of view is determined by the following parameters:

$$S_{CES} = S_{EES} + S_{CS} + S_{ES}, \; \Omega = \Omega_{EES} \times \Omega_{CS} \times \Omega_{ES}, \quad (2)$$

where $S_{EES}, S_{CS}, S_{ES}$ are spaces of natural ecological, social and economic systems accordingly; $\Omega_{EES}, \Omega_{CS}, \Omega_{ES}$ statistical weight of CES subsystem macrostate realization.

General CES state realization is characterized by the value:

$$S(t) = \int_V S_{dV}^{(p,e,s)}(x_1(t), x_2(t) \ldots x_n(t)) dV, \quad (3)$$

where $S^{(p,e,s)}$ is entropy of natural (ecological), economic and social system state accordingly; $dV$ is a macrosystem size (volume) characteristic.

Entropy change is determined as $\Delta S_{dV} \geq 0$ and corresponds to entropy intensity production in CES. This takes place in the case of irreversible processes in the corporative system components which are physical chemical systems:

$$\sigma(t) = \frac{dS_{dV}}{dt} \geq 0 \text{ if } t \to 0. \quad (4)$$

This value is connected with new CES state probability realization with changes that happen in time. This means that changes are connected with the macrosystem entropy production:

$$P(t)=\frac{dS_{dV}}{dt}=\int\limits_{V}\sigma(x_1(t),x_2(t)...x_n(t))dV. \quad (5)$$

$P(t)\rightarrow \min$ CES is a condition to be met for the system to stay within stationary process limits and managerial influence not to cause entropy production.

Microscopic state equations are received in synergetic approach to the thermodynamic description (model making) realization of three complex systems inside one corporative system. CES equilibrium loss is determined by small amount of collective modes. These modes are order parameters and describe macroscopic structure. These macroscopic variables represent microscopic system components behaviour according to principle of the subjecting at the same time. Order parameters allow the system to turn into structure which has a stable state.

Information about order parameters changes near instability points and subordinate modes information does not change:

$$P(\xi_u,\xi_s)=\prod_s P_s(\xi_s \mid \xi_u)f(\xi_u), \quad (6)$$

where $\xi_u$ is order parameters probability; $\xi_s$ is subordinate modes amplitude probability.

Macrosystem stability state normalization condition looks like this:

$$\sum_{\xi_s} P_s(\xi_s \mid \xi_u)=1. \quad (7)$$

Equilibrium system state break is connected with entropy production $P=\frac{d_i S}{dt}$. Equilibrium state for CES as a quasi-isolated system is determined as P=0. Equilibrium state breaks the condition of $P=\frac{d_i S}{dt}\geq 0$. When disturbance is small inside CES, entropy production is as follows according to Prigozhin I. R. theorem: $dP\leq 0$ is evolution condition; $P=\min,\ dP=0$ is equilibrium or stationary state condition.

It is proposed to characterize infringement risk estimation in the macrosystem by integrated index in case of CES. Integrated index takes into account changes inside each subsystem and ecological risk value for each subsystem – ecological (natural), social and economic ones. Such risk index value represents deviation from normative stable state (risk). It also promotes such managerial decision-making which could keep each systems right to develop with keeping balance inside the system and in CES as a whole (Fig. 1).

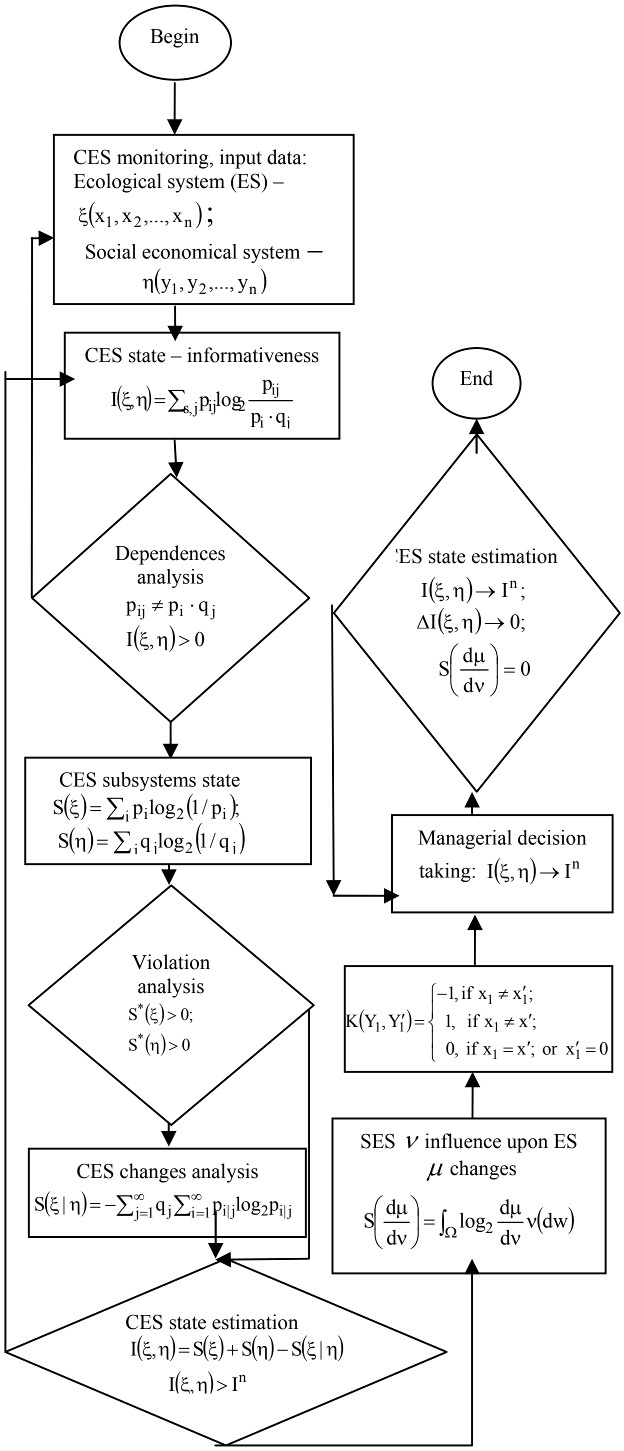


Fig. 1. CES state estimation scheme in the form entropy and comparator K: $\xi$ is probabilistic observation $(x_1,x_2,...,x_n)$ with probability $(p_1,p_2,...,p_n)$; $\eta$ is probabilistic observation $(y_1,y_2,...,y_m)$ with probability $(q_1,q_2,...,q_m)$; $p_{ij}$ is probability of interaction of operation $\xi=x_i;\eta=y_j$; S is entropy of systems state; $\mu$ is ecological changes to man-made $\nu$ argument (in accordance with Radona-Nicodima) ($S_t w=w(t+\tau)$; $I^n$ is unconfigured state, equilibrium position; * is determination S provided that $I^n=0$

Coordination factors of characteristics and parameters interconsistency supply are given priority when determining CES state. These are characteristics of complicated corporative systems along with thermodynamical parameters of identifying corporative system equilibrium, integrity and evolution harmonization. The situation analysis as to ecological risk estimation and people health risk estimation is proposed to consider from a new point of view. Such a position bars further system development with existing violations in environment and negative influence upon components and elements of natural ecosystems. According to CES concept the estimation of considered object is carried out equilibrium besides population health state estimation in the form of positive risk and boundaries normalization of permissible influence upon natural ecosystems and human beings is carried out too.

Existing risk estimation methods are rather tedious and great amount of information is needed to be processed. On the basis of each factor (relevance) from each of the 5 database blocks a characteristic is retrieved which reflects 75–80% of all initial data and provides a practical analysis of output variables structure.

The present approach does not take into account related systems state (economic and natural systems) and doesn't let to estimate risk level in these systems and its influence upon population health risk level.

The aim of approaches main to consider to ecological risk estimation formation for territories and the population health the research is state. Corporative concept advantages were determined regarding corporative ecological system and positive risk estimation.

Analyzed indicator groups are distributed among three factor blocks according to the CES concept of corporative approach. Population health belongs to the 1st block; the way of life, social economic environment belong to the 2nd block; biological, chemical, physical and social environment factors belong to the 3rd block (Fig. 2).

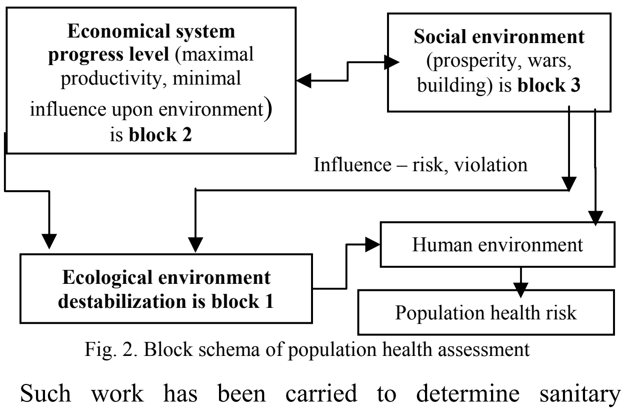


Fig. 2. Block schema of population health assessment

Such work has been carried to determine sanitary epidemiological welfare. Considerable amount of factors are analysed in each block of the multidimensional health risk determination system. There are 33 factors in the 1st block (A), 29 factors in the 2nd (B), 12 factors in the 3rd one. That is why this work provides factors ranking according to their health influence. Bigger factor gets lower rank value if it affects health. Factor value is to be decreased if the direction of the vector is negative. And a bigger factor corresponds a higher rank value in the opposite case.

Rank points are summed for each block for all territories examined. Standardized factor (SF) [10] is calculated for each factor block for each territory. A standardized index is arithmetic mean of the paints sum for each block. It takes into account factors frequencies with positive and negative vectors:

$$SF_i = \sum P_i \cdot (P_{fon})^{-1},\ P_{fon} = \left(\sum P_i^- \cdot f_i^- + \sum P_i^+ \cdot f_i^+\right)\cdot\left(\sum f_i^- + \sum f_i^+\right)^{-1}, \quad (8)$$

where $P_i$ is the sum of points for all indices of each block for each factory (it is calculated by adding factor ranking results with negative ($P_i^-$) and positive ($P_i^+$) direction vectors of influence upon health); $f_i^-$ is relative group index frequency, ranked according to negative and positive ($f_i^+$) vectors influence upon health.

The $SF_i$ values lead to the probabilistic quantities according to the model [9]:

$$P_{risk_i} = 1 - \exp\left[0,5 \cdot \left(-HП_i^2\right)\right], \quad (9)$$

where $P_{risk}$ is probabilistic value, which characterizes isolated influence risk prevention of corresponding blocks factor groups ($n_j$).

It is safe to say two problems appear to an ecological and economic sense within the framework of corporative approach. They concern population health estimation.

1. Research object state, violation probability, destabilizing process risk determination that can be confirmed by entropy value.
2. Forming of standard as estimated values on the influence minimization basis and according to destabilizing factors effect upon living organism (Fig. 3).

This corporative approach realization was considered when solving the problem of ecological security violation detection during Dergachivsky refuse dump and water objects monitoring according to the following scheme:

$$\begin{cases} X = x_i / ÃÄÊ,\ \sigma(X) = \sqrt{\dfrac{\sum_{i=1}^{length(X)-1} (x_i - mean(X))^2}{length(X)-1}}, \\ F(X,i) = \dfrac{1}{\sqrt{2\pi}\sigma(X)} \cdot \exp\left[\dfrac{-1}{2(\sigma(X))^2}(x_i - 1)^2\right]. \end{cases} \quad (10)$$

**Influence risk as informational and influence entropy, if PI doesn't exceeds $x_2$=1:**

$$Risk = S; S(I) = -P(X, x_1, x_2) \cdot \ln[P(X, x_1, x_2)],$$

**where** $P(X, x_1, x_2), PP(X, x_1, x_2)$ **are state, influence possibility:**

$$\begin{cases} P(X,x_1,x_2)=\dfrac{1}{\sqrt{2\pi}\sigma(X)}\cdot\left[\begin{array}{l}\dfrac{-1}{2}\operatorname{erf}\left[\dfrac{1}{2}\sqrt{2}\dfrac{(-x_2+\min(X))}{\sigma(X)}\right]\dfrac{\pi}{2}\sqrt{2}\sigma(X)+\\ +\dfrac{1}{2}\operatorname{erf}\left[\dfrac{1}{2}\sqrt{2}\dfrac{(-x_1+\min(X))}{\sigma(X)}\right]\dfrac{\pi}{2}\sqrt{2}\sigma(X)\end{array}\right], \\ P(X,x_1,x_2)=\dfrac{1}{\sqrt{2\pi}\sigma(X)}\cdot\left[\begin{array}{l}\dfrac{-1}{2}\operatorname{erf}\left[\dfrac{1}{2}\sqrt{2}\dfrac{(-x_2+1)}{\sigma(X)}\right]\dfrac{\pi}{2}\sqrt{2}\sigma(X)+\\ +\dfrac{1}{2}\operatorname{erf}\left[\dfrac{1}{2}\sqrt{2}\dfrac{(-x_1+1)}{\sigma(X)}\right]\dfrac{\pi}{2}\sqrt{2}\sigma(X)\end{array}\right]. \end{cases}$$

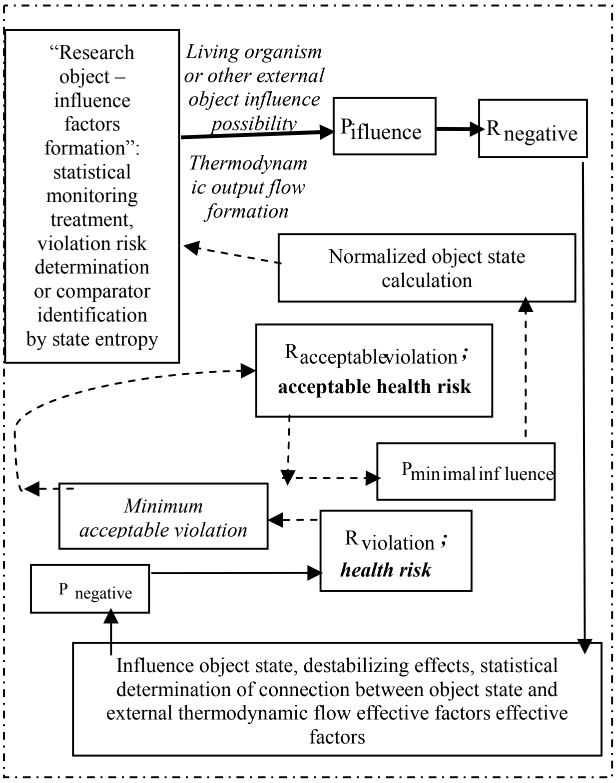


Fig. 3. Risk analysis problems with CES realization: → direction and sequence of the 1st problem solving; - - - -► ranking problem decision concerning influence object

Ecological security parameters were calculated with the help of Mathcad 2001 according to influence objects pollution indices (PI). The objects are refuse dump and surface water according to the system (4).

| Research objects | Determined parameters |
|---|---|
| Microbiological factors-B1 (MK) | $\max(M,K) = 4.3$ $\sigma(MK) = 1.048$<br>$PP(MK,x1,x2) = 0.292$<br>$P(MK,x1,x2) = 0.034$ $S = 0.362$ or *Risk*<br>$SS = 0.36$ or $S(I)$ |
| Organoleptic factors -B2 ($L_1$–$L_6$) | $\max(L1,L2,L3,L4,L5,L6) = 29.75$<br>$Values21 := stack(L1,L2,L3,L4,L5,L6)$<br>$\sigma(Values21) = 4.714$ , $P(Values,x1,x2) = 0.075$<br>$\ln((P(Values,x1,x2))) = -2.596$<br>$PP(Values21,x1,x2) = 0.074$ $SS = 0.193$ |
| Toxicological factors B3 ($N_1$–$N_2$) | $\max(N1,N2) = 25$ $Values31 := stack(N1,N2)$<br>$\sigma(Values31) = 10.002$<br>$P(Values2,x1,x2) = 0.035$<br>$\ln((P(Values2,x1,x2))) = -3.344$<br>$PP(Values21,x1,x2) = 0.074$<br>$SS = 0.193$ |
| Polluting anions ($B_1$), Heavy metals ($B_2$), Organic matter ($B_3$) | $\max(stack(B1,B2,B3)) = 350$<br>$Values3 := stack(B1,B2,B3)$<br>$\sigma(Values3) = 78.022$<br>$P(Values3,x1,x2) = 4.531\times10^{-3}$<br>$\ln((P(Values3,x1,x2))) = -5.397$<br>$PP(Values3,x1,x2) = 4.531\times10^{-3}$<br>$S1 = 0.024$ |

So water indices have the least probability to stay within norm limits. Organic matter and heavy metals will have the most influence in the case of norm excess. This is confirmed by situation analysis at the refuse dump:

$X := Values3$ $\quad x1 = 0$ $\quad x2 := \max(B1,B2,B3)$ $\quad mean(X) = 33.985$ $\quad \sigma(X) = 78.022$ $\quad x2 = 350$

$PP(Values3,x1,x2) = 0.592$ $\quad P(Values3,x1,x2) = 0.445$ $\quad x2 = 350$ $\quad PP(Values3,x1,x2) = 0.592$

$S1 := -PP(Values3,x1,x2)\cdot\ln((PP(Values3,x1,x2)))$ $\quad \ln((PP(Values3,x1,x2))) = -0.524$

$S1 = 0.31$

Each pollutant block on the basis of corporative approach showed the following results. The thermodynamic analysis results were taken into account:

$PP(B1,x1,x2) = 0.438$ $\quad PP(B2,x1,x2) = 4.969\times10^{-3}$

$PP(B3,x1,x2) = 3.673\times10^{-3}$

$SS(B1) := -PP(B1,x1,x2)\cdot\ln((PP(B1,x1,x2)))$ $\quad \ln((PP(B1,x1,x2))) = -0.826$

$SS(B1) = 0.362$

$SS(B2) := -PP(B2,x1,x2)\cdot\ln((PP(B2,x1,x2)))$ $\quad \ln((PP(B2,x1,x2))) = -5.304$

$SS(B2) = 0.026$

$SS(B3) := -PP(B3,x1,x2)\cdot\ln((PP(B3,x1,x2)))$ $\quad \ln((PP(B3,x1,x2))) = -5.607$

$SS(B3) = 0.021$

Heavy metals, dangerous organic matters, anions most probably have an effect within normal PI according to the results above. Transformation processes possibility is foreseen according to their relatively big entropy rates. Statistical processing has shown water properties change dependence on refuse dump ingredients' effect probability. The same dependence was observed between effects in influence system (fig. 4).

| N=4 | Regression Summary for Dependent Variable: microbiol (S<br>R= ,48593048 R?= ,23612844 Adjusted R?= -----<br>F(1,2)=,61824 p<,51407 Std.Error of estimate: ,71622 | | | | |
|---|---|---|---|---|---|
| | Beta | Std.Err. of Beta | B | Std.Err. of B | t(2) |
| Intercept | | | 1,667948 | 0,451186 | 3,696807 |
| BM | 0,485930 | 0,618010 | 0,002539 | 0,003229 | 0,786283 |

| Variable | Correlations (Spreadsheet6sta.sta) | | | |
|---|---|---|---|---|
| | anion | BM | organic | microbiol |
| anion | 1,000000 | 0,611485 | -0,608468 | 0,079973 |
| BM | 0,611485 | 1,000000 | -0,171451 | 0,485930 |
| organic | -0,608468 | -0,171451 | 1,000000 | -0,532610 |
| microbiol | 0,079973 | 0,485930 | -0,532610 | 1,000000 |

| N=4 | Regression Summary for Dependent Variable: toxcolog (Spr<br>R= ,99843848 R?= ,99687940 Adjusted R?= ,99063819<br>F(2,1)=159,73 p<,05586 Std.Error of estimate: ,65584 | | | | |
|---|---|---|---|---|---|
| | Beta | Std.Err. of Beta | B | Std.Err. of B | t(1) |
| Intercept | | | 13,82016 | 0,512073 | 26,9887 |
| organic | -0,799504 | 0,056702 | -0,26831 | 0,019029 | -14,1001 |
| BM | -0,750641 | 0,056702 | -0,03973 | 0,003001 | -13,2384 |

| N=20 | Regression Summary for Dependent Variable: PPı<br>R= ,61181109 R?= ,37431281 Adjusted R?= ,30070255<br>F(2,17)=5,0851 p<,01858 Std.Error of estimate: ,25121 | | | |
|---|---|---|---|---|
| | Beta | Std.Err. of Beta | B | Std.Err. of B |
| Intercept | | | 0,442659 | 0,115734 |
| Ind(mikrobiol) | -0,565826 | 0,193112 | -0,003616 | 0,001234 |
| IdZ(tocsical) | -0,306203 | 0,193112 | -0,008937 | 0,005636 |

Fig. 4. Statistical influence results of certain pollution source upon water quality parameters

## IV. Conclusion

### *A Theoretical And Practical Work Significance*

Main research areas were determined by corporative approach introduction into ecological monitoring system. The aim was to determine CES components definite state estimation and the possibility of making managerial decision. As a result ecological, social and economic optimal system equilibrium and their harmonious progress is obtained. Using risk theory allows conforming CES state determination results obtained with the help of thermodynamical functions and with ecological security risk method. It also allows to give information about population health danger due to the heath risk estimation. Risk analysis gives a new point of view upon ranking in ecology, hygiene and sanitation

### *B Summary*

Corporative approach appropriateness for organoleptic water properties quality risk estimation has been determined. The case of chemical factors influence based on the example of water objects analysis has been considered. This was made by advantages estimation of risk analysis for environment objects quality, “environment—human health” homeostasis disbalance possibility estimation and by health risk estimation application in rate setting. The results of analytical research and water state risk analysis calculation application are as follows:

1. CES state determination algorithm (see fig. 1) has been devised according to the CES and their components thermodynamic (entropic probabilistic) nature (eq.1-7). Ecological hygienic health risk scheme and chemical factor permissible level have provided according to CES realization and minimal health risk estimation conditions (see fig. 2).
2. Complex probability thermodynamic system (see fig.3) for source and influence object ecological state estimation has been determined.

Suggested corporative approach realization appropriateness was shown on the basis of example of ecologically dangerous territory state analysis. The analysis aim is to determine ecological danger points and to work out the most constructive managerial decision. The most probable influence factors and thermodynamically conditioned negative influence processes (eq.10, fig. 3) determination is the analysis possibility condition.

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**Kozulia T. V.** Chemic production engineer in National Technical University “Kharkov Polytechnic Institute”. Candidate of geographical science, Kharkov National University after N. V. Karazin, Ukraine, 1999.
Major field of study: nonorganic substance technology.
Research assistant, Scientific Technical Complex “Monocrystal Institute”, Kharkov, Ukraine. Post-graduate, Kharkov National University after N. V. Karazin, Ukraine. Associate professor, Kharkov National University after N. V. Karazin, Ukraine. Associate professor, Automatic Operating Systems Department, Informatics and Management School, National Technical

University “Kharkov Polytechnic Institute”, Kharkov, Ukraine. Scientific interests: decision making in the system of ecological monitoring, modeling physical chemical processes in natural systems.
**Sharonova N. V.** Applied mathematics in Kharkov National University of Radio Electronics. Candidate of technical science, Kharkov National University of Radio Electronics, Ukraine, 1983. Doctor of technical science, Kharkov National University of Radio Electronics, Ukraine, 1993. Major field of study: applied mathematics. Research assistant, Kharkov National University of Radio Electronics. Pro-rector, Humanitarian Academy. Professor, Automatic Operating Systems Department, Informatics and Management School, National Technical University “Kharkov Polytechnic Institute”, Kharkov, Ukraine. Head of Computer Intellectual System Department, National Technical University “Kharkov Polytechnic Institute”, Kharkov, Ukraine. Scientific interests: applied mathematics, mathematical modeling, computer systems, computer linguistics.
**Kozulia M. M.** Student of the Kharkov National Univercity named after V.N. Karazin, Kharkov, Department of Physics & Technics.