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Environmental education

SCIENCE AND PHILOSOPHY IN THE CORRELATION ECOSYSTEM–BIOSYSTEM–SOCIETY

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Abstract. An ecological perspective on the world is based on a global approach destined to understand how the various parts of nature interact in patterns that tend toward balance and persist over time. In such a perspective the earth can not be treated as something separate from human civilization. Based on the thermodynamics of irreversible processes, the balance of entropy source is applied to explain the complex correlation among ecosystem, biosystem and society. The role of academic research in environmental education as well as in promoting collaborative networks for a clean Europe is also underlined.

Keywords: environmental education, thermodynamics of irreversible processes, balance of entropy source, coupled processes.

AIMS AND BACKGROUND

The anthropic activity performed during this last century of industrial society has produced huge damages on the ecosystem-biosystem equilibrium, thus, being threatened even the existence of mankind in the near future.

The scientific and technological development produced a considerable improvement of the quality of our life (comfort, health care, occupation, recreation, etc.), but at the same time many new risks and damages to the human health and the environment were generated.

In the past, the protection criteria were directed mainly to the human health and very little attention was devoted to other environmental components such as air, water, soil, flora, fauna and ecosystems. The need to give an innovative approach to the protection of the environment came up from the evidence that the environment is not able to restore itself from the damages produced by mankind: air pollution in the cities and in the proximity of industrial plants, pollution of waterbodies due to civil and industrial activities, increase of the gas concentration in the atmosphere able to produce the green-house effect and ozone layer depletion, radioactive pollution, etc.

Two approaches have to be pursued to protect the environment:

- to prevent as much as possible further degradation;
- to remediate the situations already degraded.

287

To accomplish these two goals several tools exist and have to be applied: technological know-how, adequate regulation, political willingness, training of the professionals, information to the population.

These trends are particularly important for industrial activities that have been for a long time the main responsible for the environmental modifications. So, a number of procedures and techniques are now adopted in many countries, particularly in the western world, to reduce at minimum possible levels of the risk associated with industrial production and social services.

Among them is the Environmental Impact Assessment, the Risk Assessment Techniques, the legislation to prevent severe accidents, and the Strategic Environment Assessment. Each of them has a definite role in the field of environmental protection, but all are based on the obvious criterion that - like for the human health – prevention is better than remediation, also from the economical point of view.

A further consideration is that environmental damages, mainly when they are large and widespread, very seldom involve only the country where they are produced. In this respect, they are usually a global problem that must be faced by joined efforts of the international community.

Therefore, an ecological perspective on the world is based on a global approach destined to understand how the various parts of nature interact in patterns that tend towards balance and persist over time. In such a perspective, the earth can not be treated as something separate from human civilization[1].

This paper aims to explain, based on the thermodynamics of irreversible processes, the complex correlation among ecosystem, biosystem and society.

THERMODYNAMIC LAWS – GENERAL PRINCIPLES ALSO VALID FOR THE LIVING WORLD

Apart from the zerouth principle that states the concept of temperature, the three thermodynamic laws postulate different impossibilities for real processes, for instance a thermal engine can not run without supplying fuel, or the heat can not be transferred from a cold to a hot body, or absolute zero of temperature is approachable but unattainable.

In Table 1 are presented the scientific statements of the thermodynamic laws together with their philosophic paraphrase[2,3], which reflect the irreversibility of living process.

Since the time variable represents the driving force that determines the evolution of living things from birth to death, Prigogine and Berthalamphy created the Thermodynamics of Irreversible Processes as a new discipline destined to extend the validity of thermodynamics of systems in equilibrium also for non-equilibrium systems.

288

Table 1. Scientific statement and philosophic paraphrase of thermodynamic laws

No	Science - thermodynamic law	Life - paraphrase
0	T→ Q L E M C B	Life is a game
I	$\Delta U = Q + L$	You can not win! The only thing you can do is break even
II	$\Delta S = Q/T$ $(\Delta S)_{U,V} \geq 0$; $(\Delta G)_{T,P} \leq 0$	You can only break even if you live forever
III	$T \rightarrow 0°C$	You can not live forever!

SOURCE OF ENTROPY IN IRREVERSIBLE PROCESSES

Thermodynamics of Irreversible Processes (TIP) is based on the principle of local equilibrium that states that an elemental volume is completely characterized by the equations of the 1st and 2nd laws not only at equilibrium, but also in non-equilibrium states.

This made possible the fundamental equations of thermodynamics to be extended also for irreversible processes.

There are two main results of TIP: it can explain both the stationary state and the existence of coupled processes, that is processes with decreasing entropy can also be produced provided they are accompanied and sustained by other processes in which the increase in entropy is much greater.

The demonstration is based on the general equations of the balances in which the source of entropy is calculated as a balance of entropy, using the balance of mass and energy.

The final equation for the entropy source created per unit volume[4] is:

$$\sigma_s = J_q \chi_q + \sum_i J_{id} \chi_{id} + \sum_r J_{ch,r} \chi_{ch,r} + J_\eta \chi_\eta \geq 0$$

where the thermodynamic forces (χ_i), excepting χ_η which is a velocity gradient, are thermodynamic functions that determine the appearance of fluxes, while these last functions are kinetic properties: J_q – thermal flux; J_{id} – diffusional flux; $J_{ch,r}$ – chemical flux; J_η – impulse flux (viscosity).

Shortly, the equation of entropy source has a bilinear form, in which the fluxes and forces are conjugated:

$$\sigma_s = \sum_k J_k \chi_k$$

289

During irreversible processes can also be produced some phenomena that are foreseen by the principle of local equilibrium so that the total change in entropy must be positive:

$$d_{irrev}S_{total} > 0$$

In every elemental volume can also exist processes with negative change in entropy (ordered systems in coupled processes) provided that:

$$d_iS_{couplant} > d_iS_{coupled}$$

By generalizing the conclusion resulted from the study of coupled processes, one can state that one flux J_k in a system is dependent not only of its conjugated force χ_k, but also of the other forces existing in the system. For some states not so far from equilibrium, this dependence between fluxes and forces is linear:

$$J_j = \sum_{k=1}^{n} L_{jk}\chi_k, \; j = 1,\dots,n$$

where L_{jk} are phenomenological coefficients.

There are two restrictive principles of TIP:

• the Onsager reciprocity principle that postulates the equality of the crossed phenomenological coefficients; $L_{kj} = L_{jk}$;

• the Curie symmetry principle which states that in any homogeneous system the fluxes and forces having a different tensional character can not couple. In this respect there are the following cases:

– scalar phenomenon, like chemical reactions, molecular kinetic relaxation;

– vectorial processes – diffusion, thermal conductivity, electrical conductivity, etc.;

– tensorial processes – viscous flow.

In nature, there are some deviations from this rule, and the coupling between different classes of phenomena is also possible. For instance, in tribochemistry, chemical reactions or relaxation phenomenon can couple with vectorial processes, diffusion or conductivity, and thus some chemical reactions caused by the dissipation of mechanical energy during irreversible processes can be explained.

Biological systems are obviously non-homogeneous in their structure and, therefore, the coupling processes among phenomena belonging to different tensional character are also possible.

The existence of any biological system exhibits a long series of coupling processes as in the scheme presented in Fig. 1.

The first step is the catchment of solar energy as vegetal biomass by means of photosynthesis, the sun being the only energy source available for living things on our planet. The next step involving the synthesis of biopolymers from small

290

molecules is an organizing process accompanied by much more increasing entropy during excretion process. The other step is referred to the food chain, when the animals take their energy from vegetal biomass during oxidative phosphorilation, and store it also as chemical energy in macroergic compounds - adenosine triphosphate (ATP). The last step is the use of this energy in different forms of biologic work: locomotion, sighting, thinking, speaking, etc.

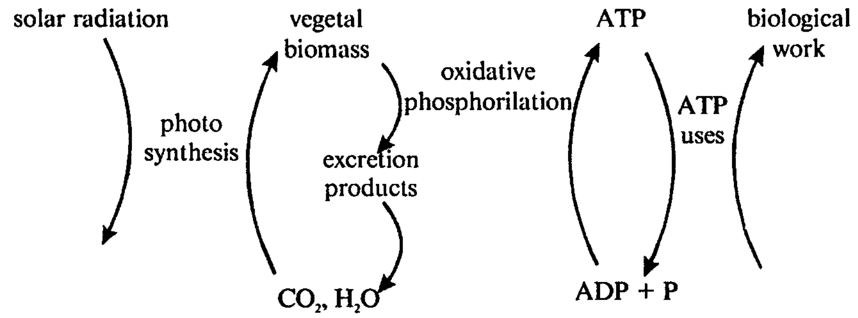

Fig. 1. The coupling between the process producing (↓) and consuming (↑) entropy in biological systems

From this general scheme it can be concluded that the highly ordered biosystems (negative entropy) are possible only because they produce much more disorder in the environment. On the other hand, the existence of such organized living things can not indefinitely postpone the increasing of their entropy, and according to the last paraphrase in Table 1, they can not live forever and the cycle life and death is continuously repeated. The well-known verse from funeral litany "Ashes to ashes and dust to dust" expresses the essence of this science and philosophy of our passing existence on the Earth.

A simple question can arise from all these arguments: "Why is worthwhile to live if finally must dye?"

One possible answer could be that we were endowed with life in order to receive a lesson on the perfection, so we should do our best to merit this priceless gift. Even if we dye we are able to transmit to our followers what was the best in our work, knowledge and feelings.

Unfortunately, the organization of mankind at a social scale assumed once more decreasing in entropy, which can be sustained on an even higher disorder in the environment. That is why, the anthropic activity of our society in the last decades caused so huge damages on the ecosystem – biosystem equilibrium as the stationary state established during 350 million years can not be mantained any longer. The nature will arrive to another stationary state, but this huge change might be a real cataclysm for the living things.

Even if there are many advertisements related to the degradation of environmental factors, major changes in climate of the Earth causing decreasing in the

291

life quality there is no a public awareness yet of how serious is the threat to the global environment.

Much more should be made by scientists and universities in order to facilitate public education and faster a greater understanding of what this new information means within the larger content of rapid global change.

In this respect a special role is accomplished by environmental training centers and technology assessment centers in those areas where major environmental remediation efforts are needed and where major technology transfers from the West are expected, so that most of the citizens will be concerned about the ecological system and thus will urge their leaders to bring the earth back into balance.

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292