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# The influence of products and technological processes of raw materials and energy management on the environment

Key words

Raw materials, energy management, technology process, environment

Abstract

Author presents basic kinds of influence of products and technological processes on the adequate elements of geogenic and antropogenic environment. The different influences on the environment are classified under various criteria. There are presented several kinds of wastes and different techniques of reduction of environmental damage of waste.

For many years Poland conducted the policy of centrally controlled economy, whose one of the main aims was dynamic industrial development. This led to environmental destruction on a massive scale, primarily in highly industrialised areas.

Raw materials and energy management, dominated by the technology of coal extraction and burning, exerted a particularly unfavourable influence on the environment. There occurred many environmental problems, the most serious of which have been presented below:

— space occupation by mining enterprises, both of hard coal and brown coal (the sector of hard coal extraction alone possessed 15 700 ha in the year 1997),

— pollution of areas with waste resulting from coal extraction, processing and combustion (the sector of hard coal extraction produced 55 mln tons of waste in the year 1996),

— mining damage in areas of coal extraction, mainly hard coal,

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— pollution of rivers with mining water (mainly the Vistula and the Oder — salt water discharge into rivers amounted to 4 570 tons/a day — $Cl+SO_4$, in the year 1995),

— air pollution ($SO_2$, $CO_2$, $NO_X$, dust),

— soil and water acidification, acid rain,

— geosphere destruction (forest devastation, dying out of animals),

— anthroposphere destruction (heavy metals in soil, destruction of buildings).

About two thirds of the pollution of the environment in Poland is brought about by the processes of raw materials extraction and processing, mainly coal, for power industry purposes. About 60% of waste in Poland comes from fuel-power industry, at present it constitutes about 50% of all deposited waste.

In domestic prognoses made for power industry one anticipates an increase in demand for energy after the year 2000 at a level of 3% per year. By the year 2020 a demand for energy will have grown from 35% to 65% as compared with the present level, depending on the economic development scenario which is realized.

The discussed increase in demand for energy can lead to further worsening of the state of the environment in the case of a lack of a proper strategy limiting the impact of the raw materials and power sector on the environment.

TABLE 1

The present structure of air pollution sources in Poland

TABELA 1

Obecna struktura źródeł zanieczyszczenia powietrza w Polsce

| The kind of pollution | Source | Percentage [%] |
|---|---|---|
| Sulphur dioxide | heating industry | 49.0 |
| | power industry | 22.5 |
| | industry | 26.0 |
| | motorization | 2.5 |
| Carbon dioxide | electrical energy production | 57.5 |
| | heating industry | 23.5 |
| | industry | 11.0 |
| | transport | 8.0 |
| Nitric oxides | heating industry | 32.0 |
| | industry | 30.0 |
| | motorization | 29.0 |
| | power industry | 9.0 |
| Methane | coalmining | 37.0 |
| | agriculture | 36.0 |
| | rubbish dumps | 13.0 |
| | swamps | 9.0 |
| | oil mining | 5.0 |

The presently pursued policy of mineral raw materials resources management, including fossil fuels, aims at reducing as well as optimising the impact of the raw materials and energy sectors on the environment.

The hitherto applied management methods do not make it possible to manage the discussed system optimally. There is no cohesive methodology that would describe the phenomena connected with the influence of processes on the environment. The complexity of the system under research requires the application of mathematical modelling methods, which would afford possibilities for its optimal management.

While modelling natural resources management processes one encounters a series of formal difficulties (Stirling 1995). It is necessary to define many notions and phenomena. The issue concerning the influence of the resources management processes on the environment seems to be of utmost importance.

As far as waste is concerned, it is a product of unknown appropriation. The criterion defining if an analysed object is a product (non-final or final) or waste, depends on our knowledge, available technology and the state of social needs in a given period of time. The function of waste harmfulness can be univocally ascribed to the waste that has been introduced into the environment irretrievably, such as volatile waste, or liquid waste dissipated in the environment.

In the future, stored waste can be utilised directly, or after processing. Its harmfulness may be then foreseen with a certain level of probability. It is not possible to define precisely the amount and the harmfulness of waste coming from technological processes, or the harmfulness of the product in a long period of time.

Waste utilisation can reduce the harmfulness, typical of the discussed technological phases and the product itself. Once waste has been utilised, it becomes a product. As an example may serve gas from dumping grounds that can constitute waste introduced into the atmosphere (greenhouse gas), or a product, once it has been used in heating installations. Similarly, slag, which is produced as a result of coal combustion, may serve as material for production of airbricks.

It is also the dynamic state of knowledge, in particular of processes taking place in the environment, which influences the assessment of the level of harmfulness. The discovery of so far unknown mechanisms of degradation of different elements of the environment may augment the results of assessment concerning the level of harmfulness of processes without a change of parameters of the processes themselves.

There may occur a periodic change of classification as to the kind of influence of waste on the environment, and its cyclic inclusion in the scope of waste and products. The above condition is fulfilled by heat produced in the process of electrical energy generation. In the heating period heat constitutes a product sent to the heating net, in the summer it is introduced to the atmosphere, a tank, or watercourse. The influence of heat on the environment is periodically looked upon as harmful; in such a case it is classified as waste.

## 1. The problem of vagueness of the influence of waste on the environment

In the analyses concerning the influence on the environment and its elements, there are a number of events and states that according to the criterion of the function of vagueness can be divided into:

— certain,

— of a definite level of probability,

— unpredictable — of a rationally undefined level of probability (potential events such as flood, war, diversion).

The kind of vagueness of events and states determines the choice of a model describing the influence of waste on the environment. In order to describe certain events and states, one makes use of deterministic models. Phenomena whose occurrence can be predicted only with some degree of probability are presented by means of stochastic models. For the purposes of description of unpredictable events stochastic models are not applied, since it is difficult to define rationally the probability of such events as an explosion of a power station, or a catastrophe of a tanker.

The phenomenon of unpredictability of the influence of waste on the environment constitutes a consequence of random events, which fall into two basic groups: geogenic and anthropogenic. Geogenic events encompass the effects of catastrophic weather conditions, such as flood, earthquake, tornado, typhoon. The other group includes the effects of catastrophes brought about by human activity, which can be either unintentional (fire, explosion of a power station, engulfment of an oil tanker, explosion of an oil shaft) or intentional (war, diversion, destruction of a dam on an artificial lake, dumping nuclear waste into the sea).

As it has been observed, catastrophes of a different scale may imply enormous damage to the environment (Stirling 1995). Catastrophes cause introduction into the environment of additional waste which has not been taken into account by traditional analyses concerning the influence of technologies and products on the environment. It may lead to additional degradation of the elements of the environment, much bigger than the total estimated according to the traditional methodology.

Analyses of the effects of catastrophes are exceptionally useful in the process of decision making concerning building or exploitation of objects of potentially high harmfulness to the environment. It is advisable to examine scenarios of such events and their effects. It may turn out that degradation of the environment as a result of a catastrophe is so extensive that, despite slight probability of its occurrence, one should consider alternative, safer technologies. As an example may serve the explosion of the nuclear power station in Czernobyl in 1986. The degradation of the environment as a result of the explosion was so huge that a number of countries, including Poland, gave up this technology, in spite of its relatively small harmfulness to the environment in the conditions of normal exploitation.

The function of the influence of waste on the elements of the environment is characterised by the relation of vagueness, which refers to the stream of produced waste, the function of waste translocation, objects on which waste exerts an influence, and the function of the influence of the conditions of the environment on the course of reactions of the discussed influence.

The presented analyses usually require the application of mathematical models. The choice of the appropriate model affects the manner of description of the phenomena under consi-

deration, defines the range of the analysed space, time, the kind of mechanism, and the function of intensity. The choice of a model defines the level of accuracy of the research results, or the level of their vagueness.

The vagueness of the source/sources/ of the waste stream refers to:

— the location of the source (or dissipated sources) of emission in space,
— the range and the structure of the waste stream in the function of time,
— total emission of waste in time,
— chemical composition,
— physical form,
— the kind of mechanism of influence on different elements of the environment.

The vagueness of the object/objects/ of the influence of waste refers to:

— the kind and the structure of spatial location (e.g. a dissipated object);
— features of objects such as build, dimension, the kind of objects:

- geogenic — the elements of abiotic nature and biotic nature (plants, animals),
- anthropogenic — cultivation, animal breeding, man, buildings, products;

— systems of different kind of scale: region, globe (e.g. temperature);
— the function of degradation — the characteristics of the influence of different elements of waste on the object, sensitivity (resistance) to the influence of waste.

The function of translocation of waste:

— the function of translocation of particular elements/components/ of waste in space,
— transformation of waste during translocation (self-degradation, reaction with the translocation medium of the environment).

The influence of the conditions of the environment on the course of particular reactions (direct influence, or a series of influences):

— changeability of external geogenic conditions (temperature, wind, rainfall, moisture, the intensity of insolation, etc.),
— changeability of external anthropogenic conditions (temperature, lighting, the presence of different kinds of waste and pollution of the environment, direct degrading influence, protective measures, safeguard, repairs, etc.).

## 2. The product and the technological process

The product is an object of a twofold influence on the environment: direct and indirect, i.e. the influence of different technological processes that the product undergoes in each life cycle phase. It entails that the influence on the environment can be directly exerted by the product, both material and immaterial, in the form of service (e.g. heating of a house), or by technology (technological process). The product itself as well as each technology is characterized by a definite life cycle. The life cycle of the product is not identical with the life cycle of technology.

Within the scope of technological processes are included processes that are indispensable for the product in each phase of its life cycle: generation, utilization and elimination. The phase of product generation encompasses resources acquisition, resources transformation and product manufacture. Technological processes are connected with different phases of the life cycle of

technology: investment phase, exploitation and liquidation of technology. Investment phase can be defined as building a technological process, e.g. a factory. At this stage the technological process connected with the product is not put in motion yet but merely prepared. The phase of technology exploitation refers to different phases of the life cycle of the product: product generation, consumption (+ regeneration of the used product) or its elimination. Liquidation of technology concerns dismantlement of appliances, demolition of buildings and land reculti-vation.

### 3. The kind and level of the influence of products and technological processes on the environment

Both the product itself and each technological phase are characterized by a different kind and level of the influence on the environment. This can be classified under several headings to demonstrate the scope of the problem.

1. Consumption of non-renewable resources of the environment — means utilization of geogenic resources: non-renewable matter (mineral raw materials, non-renewable elements of nature) and non-renewable energy resources comprised in matter, consisting in gaining the energetic state of matter (the energy of chemical bonds or atomic nuclei).

2. Utilization of renewable resources of the environment — refers to geogenic renewable resources of matter and the energy of biotic nature as well as gaining renewable energy in a direct mode (e.g. direct sun heating) and in an indirect mode (by making use of technical appliances).

3. Utilization of renewable resources that are not self-renewing — it is connected with too intensive or improper utilization of renewable resources, in particular resources of animated nature, e.g.: deforestation. Also space occupation is included in the scope of this kind of resources utilization.

4. Introduction of material and immaterial waste into the environment — means introduction of waste which is produced during the life cycles of the product and technology.

5. Utilization of used up elements of the environment — refers both to material and immaterial (energy) waste as well as to utilized (used) resources of space.

6. Degradation of the elements of nature — consists in irreversible damage or unfavourable transformation of elements of the geogenic environment, like the original sculpture of the earth's surface, the composition of matter in nature and the dynamics of its spatial circulation, changes of micro-climate, degradation of animated nature. In relation to the anthropogenic environment, degradation concerns the products of man's economy, like buildings, industrial structures, infrastructure elements, means of transport and other products.

7. Creation of anthropogenic resources of the environment — consists in production and introduction to the environment of resources of matter and energy which are not classified as waste, as well as transformation of space (e.g. a lake next to a water power station or underground spaces left after mineral exploitation).

8. Influence on man.

Each phase of the life cycles of the product and technology can simultaneously display different kinds of influence. If one defines a time function for each kind of influence in which this

influence occurs, one creates the dynamic model. If one does not define such a function, one ends up with the static model.

The entire influence on the environment of both the product and the phases of technological processes, which are necessary for the product at different stages of its life cycle, can be precisely defined by a synthetic calculus. This function is a superposition of the elements representing each phase of the cycle of the two above — mentioned categories of objects in accordance with the scope of influence. Different kinds of the influence of the product and technology on the environment can be aggregated in each phase.

Each kind of influence of products and technologies is characterized by a certain function of harmfulness or noxiousness (and/or benefit). In modern economies material waste can be regarded as the most harmful to the environment. It is characterized by waste emission and other features which will be discussed later.

## 4. Classification of the influence of waste on the environment

In order to classify different kinds of influence of waste on the environment one can take into account various factors. Classification includes the following aspects:

1. Existence in the natural environment.

In accordance with this criterion one differentiates two types of waste: existent and non-existent in the natural environment.

2. The kind of environment and the scope of influence.

Waste is divided into the one influencing the geogenic environment, that is abiotic and biotic nature (plants, animals), and the one influencing the anthropogenic environment, that is industrial and agricultural products, like buildings, infrastructure, transport, cultivated plants, animals of breeding, as well as the human organism.

3. The quality of the influence on the environment.

Here the distinction is drawn between beneficial, neutral and harmful influence.

4. The rate of self-degradation.

One differentiates waste with fast rate of self-degradation (decomposition time is short or zero), with slow rate of self-degradation (decomposition time is defined) and the one that does not undergo self-degradation (decomposition time is infinite).

5. The degree of activity (chemical/biological/radioactive).

Waste can be of low, medium and high activity.

6. The change of concentration state in the environment.

Waste either dissipates, retains its original concentration, or accumulates in the environment. There exists a peculiar type of waste which accumulates in living organisms.

7. The distance of translocation in nature.

Waste falls into: the one that does not translocate, the one that translocates locally, regionally and globally.

8. The materiality of waste.

One can differentiate material waste characterized by a different state of concentration: solid, liquid, volatile and immaterial waste of different nature.

9. Homogeneity (physical, chemical, biological, radioactive).

Waste falls into two categories: homogenous and heterogeneous.

10. The kind of mechanism of the influence process.

One, or, simultaneously, several kinds of influence characterize waste: physical, chemical, biological, thermal influence, the influence of electrostatic field, magnetic field, electromagnetic field (luminous, thermal), roentgen field, noise, aesthetics, scent and others.

11. The way of measurement of the influence on the environment.

The influence can be measured in natural units (physical) and in economic units (money). There are some kinds of influence which it is very difficult to measure and the ones which cannot be objectively measured (e.g. aesthetics).

12. The kind of uncertainty function.

The uncertainty function of influence concerns the function of waste location in space, size, structure, features of the influence of waste, the mechanism and the intensity of influence, as well as ignorance of the elements of the environment, like the function of objects location in space, size, build, structure and other features of objects.

As it has been shown in the above classification, waste is characterized by many features which decide about its influence on the environment. The kind of waste, its harmfulness, available technologies and economic conditions affect the methods of waste management.

## 5. Techniques of material waste elemination

An essential element of waste management constitute techniques of material waste elimination. One differentiates a few methods by the use of which it is possible to get rid of material waste:

1. Waste storage.

There are two basic types of waste storage period: temporary and perpetual. Temporary storage concerns self-degrading (self-neutralising) waste; in the case of waste which can potentially be processed, it is connected with anticipation of new technologies of detoxication, or processing. Waste that cannot be processed is meant for perpetual storage. As far as localisation of storage is concerned, it can be found in the place of waste production (waste storage in factories), in the environment (waste-heaps, piles, tanks) or in isolation from the environment.

Waste of high harmfulness is stored in special conditions in isolation from the environment, usually by the use of concrete or steel containers or tanks protecting the environment from the influence of waste. In order to store waste of high level of harmfulness and a very long period of self-degradation, closed down mines are adopted (e.g. Vattenfal in Sweden). Other technologies consist in injection of liquid waste into big depths (Vattenfall in Sweden). In Russia waste is sunk in the sea (nuclear waste). One of the main reasons for waste storage is expectation of new processing or neutralising technologies.

2. Dumping of waste in its original form and concentration directly in the environment.

This method is the most harmful to the environment because waste directly affects the environment. Solid waste is directed to dumping grounds, excavations and mine dumps. Liquid waste is introduced into surface tanks and underground floodwaters. Volatile waste is directed to

the atmosphere. Direct waste dumping in the environment is usually applied in the case of waste of limited quantity and zero or low degree of harmfulness to the environment.

3. Waste dissipation in the environment.

The method of waste dissipation consists in scattering it on a big area, which leads to a relatively low level of its concentration. Dissipation of solid waste means scattering it on a bigger area; liquid waste is directed to water, it can be also spilt or forced into boreholes. Dissipation of volatile waste is carried into effect by the use of chimneys. Two types of transport are applied: anthropogenic transport making use of means of transport like a pipeline, a car, etc. or geogenic transport, in which natural circulation of matter in nature (the air, water) is made use of.

4. Waste processing into waste of different form and harmfulness.

This method is applied in order to limit harmfulness to the environment. Solid waste is processed in chemical processes (deflagration etc.), in physical processes (crumbling, drying, etc.) or it is mixed with other substances, like fillers and neutralisers. Liquid waste is processed by the use of vaporization and mixing technologies, as well as chemical processes. Volatile waste undergoes physical processes (filtering), chemical reactions (e.g. desulphurisation).

In this case the product of waste processing is also waste, however it has different properties. In many waste-processing technologies there occurs a change of physical concentration state of the whole or a part of the waste mass. The aim of processing is a decrease in waste harmfulness to the environment or/and a decrease in waste mass or volume.

One of the popular methods is waste burning, causing release of carbon from waste matter in a volatile form, usually in the form of carbon dioxide, which is characterized by relatively low harmfulness. It is worth noting that burning some kind of waste is an exothermic process, i.e. it is possible to obtain in this process useful products, such as thermal or electrical energy. One of the examples of waste having a relatively high caloric value is not thoroughly burnt ash of a coal-fired power station (Schachermayer and others 1995). As research shows, even in modern heat and power generating plants such ash contains minimum 2% of energy comprised in carbon. Paper, plastic, rubber, caoutchouc, timber waste or straw constitute high-calorie and inflammable waste.

5. Processing of waste into products waste recirculation.

This method consists in directing waste once again to different phases of technological processes. Waste is directed to the production process either directly or after processing.

The role of waste in the production process resolves itself into substitution of active raw materials indispensable in the production process, or passive raw materials as fillers. Depending on the kind of waste and available technologies, the influence on the product utility is different; substitution of raw materials by waste may constitute a neutral factor, it may worsen, or improve the quality of the product. One of the consequences of such substitution is the influence of waste on the harmfulness of the product: either in the period of usage or/and after the period of usage (the so called deferred harmfulness). Applying this criterion one might divide waste into the kind which increases the harmfulness of the product after usage (slag in air bricks) and the kind which does not increase the harmfulness of the product after usage.

6. Sending waste into outer space.

The technology based on waste transportation into space is still in its infancy. One considers sending into outer space waste (Zubrin 1994) of high degree of harmfulness and a very long time of self-degradation, e.g. nuclear waste.

## 6. The function of harmfulness

Each kind of waste which is introduced into the environment can be ascribed a certain function representing a set of different mechanisms of influence on particular elements of the environment, constituting the objects of influence and the intensity of influence.

A chosen type of waste influences a chosen object, either through one mechanism or a definite set of mechanisms, which can be presented in the form of a value vector. The vector can include logical or numerical values.

Logical values of the type 'yes' and 'no' inform us if a given mechanism of influence exists or not. The numerical values of the vector present the intensity of the influence of particular types of mechanisms. In the case of one kind of waste, one object and one mechanism of influence, the value of a one-element vector 'yes' means that a given kind of waste influences a given object, 'no' entails that there is no such influence. The numerical value of a one-element vector s means that the waste influences the object with intensity s.

The influence of waste on the environment is regarded as beneficial or harmful, which is conveyed by a positive or negative symbol of the intensity of the influence of waste on the discussed object. Usually a positive value of the intensity of the influence s describes the degree of harmfulness of waste to an object belonging to the environment.

One differentiates many mechanisms of waste influence on the environment, consequently the discussed elements of a vector of the intensity of influence can describe different processes in terms of quality. The presentation of the influence in the form of a value vector constitutes an analytical approach. There is a possibility of making use of a synthetic approach to the discussed phenomena, which usually takes into account monetary values but this requires an assessment of numerous phenomena and cause-effect relations.

In the research concerning the harmfulness of waste to the elements of the environment it is important to apply measures in natural units, in the form of quantity relations. On the basis of these relations it is possible to create measures synthesising quite a few analysed phenomena.

An example of the intensity of the harmful influence of waste is the rate of reaction of sulphur dioxide on the stone covering of a building. The level of sulphur dioxide emission defines its concentration in the air, the rate of formation and deposit formation of sulphuric acid on the stone covering. The concentration of the acid enables us to define the loss of mass or the thickness of the covering. The concentration of the acid enables us to define the loss of mass or the thickness of the covering.

The amount of $SO_2$ emission $\Rightarrow$ concentration in the air $\Rightarrow$ sulphuric acid formation $\Rightarrow$ reaction with the covering $\Rightarrow$ a loss of the covering thickness.

As a result of the above analysis it is possible to obtain the intensity function of the influence of sulphur dioxide on the loss of mass or thickness of covering, which can be presented by a monetary measure.

## 7. The features of the function of waste harmfulness

As far as the features of the function of waste harmfulness are concerned, it is worth remembering the following (Boden 1989):

1. One kind of waste can influence an object of the environment simultaneously with a number of mechanisms of influence.

2. One kind of waste can simultaneously influence a number of objects of the environment.

3. The relation between the amount of waste and the intensity (harmfulness) of its influence on the environment can be proportional, or it does not fulfil assumptions of proportion.

The research shows (Boden 1989) that in the case of both the geogenic and the anthropogenic environments, the discussed condition of proportion usually does not occur. As an example may serve the formulae of material degradation intensity, which are presented by the use of non-linear functions (usually power functions). A similar non-linear relation occurs in the case of degradation functions of the elements of the geogenic environment, especially in reference to living organisms.

4. There exist threshold values, after exceeding which one observes a dynamic increase in the function of harmfulness, e.g. extinction of some plant and animal species.

5. If the assumption of superposition of different types of influence is not fulfilled, it means that the harmfulness of the simultaneous effect of various influences is usually different from the sum of the harmfulness of these influences defined separately.

6. The intensity of waste influence on the elements of the environment is a dynamic function of the time, the dynamics and the place of waste occurrence as well as a number of factors of the environment.

7. There exists subjectivity in the methodology of research and subjectivity of assessment (values).

The period of waste influence / occurrence decides about the intensity of waste influence on different kinds of elements of the environment. To give an example, emission of carbon dioxide in winter causes an increase in its concentration in the air, at the time when plants do not assimilate this compound. Consequently, the diminished level of oxygen in the air exerts a harmful effect on living organisms, bigger than in the months of plant activity. Another example is a positive effect of temperature on the rate of metal degradation under the influence of sulphur dioxide. Emission of this compound in colder periods reduces harmfulness of the influence of the discussed emission on objects made of metal.

The place of waste occurrence determines a possibility of the effect on the elements of the environment situated in the area of waste influence. The practice of research which is done proves that the same kind of waste found in different types of areas is characterised by a different level of harmfulness, e.g. in areas where there are no forests the function of their damage does not appear, similarly, a lack of cultivation and stock-farms does not allow us to define directly the loss in these spheres.

Different elements of the natural environment are characterised by a different level of resistance to the influence of waste, which depends on the conditions of geographical location, the climate, the type of soil and also the kind of anthroposphere and geosphere. Therefore, the intensity of waste influence, and the resulting from it level of critical loads, is a function of the discussed conditions (Jonsson 1993).

One has noticed a phenomenon of high sensitivity to waste influence on areas characterised so far by clean environment. There exists a logical interpretation of this phenomenon, namely on such areas are found rare plant and animal species, which usually have a weak resistance to

pollution. It entails that these species will die out. As a result of self-operating processes in nature, the original ecosphere is substituted by an ecosphere with stronger resistance to pollution with succeeding doses of waste introduced into the environment.

Moreover, man introduces resistant plant species into the geosphere, changes the directions of cultivation and animal breeding. There takes place a gradual process of adaptation of infrastructure elements and products, additional protection and substitution of objects and products, so as to increase resistance to pollution. Long-lasting pollution of the environment and its excessive exploitation cause a phenomenon of irreversible transformation of the geo- and anthroposphere.

Long-lasting pollution of the environment and its excessive exploitation lead to methodical understatement concerning harmfulness of the influence of pollution on the environment, while applying measures in both natural and monetary units. Research concerning losses caused by the atmospheric pollution in some regions of Poland shows that the total losses in particular elements of the environment in polluted regions in some cases do not differ so much from the losses in regions where there is no air pollution (Gawrońska 1997).

High market prices of real estate in habitable areas are often connected with the quality of the environment, cleanness of the air, soil and water, as well as natural variety. Degradation of high quality environment brings about a dynamic decrease in real estate value. A fall in prices will not be registered, however, as a result of subsequent activities damaging the environment, since it will reach a certain fixed level of value, which is a function of house shortage in countries with a relatively low or mediocre standard of living, e.g. in Poland.

Subjectivity in the methodology of research constitutes an inseparable feature of assessment of the industrial influence on the environment. The basic difficulty is assignation of the state of reference. Drożdż proposes that analyses should be carried out in the following conditions: existing, potential and historical.

The notion of existing conditions, as the state of reference, assumes the existence of the present state of geosphere and anthroposphere, which constitute objects of influence. The dimensions of influence are defined by the difference between the influence of an unpolluted environment on the discussed elements of the system and the influence in the conditions of pollution. As an example may be given the difference between the rate of steel corrosion in the conditions of unpolluted air, and the rate of this process in the conditions of real pollution of the atmosphere in the area under research.

Potential conditions analysis may be applied in regions characterised by high intensity of harmful influence on the environment in a long period of time. One should assume that as a result of this influence a number of elements of the environment have been transformed, partly due to self-operating processes taking place in the environment, and partly as an effect of intentional human activity. Dying out of plant and animal species as a result of the pollution of the environment and anthropogenic changes of the conditions of nature, such as felling trees, drainage, building infrastructure on big areas, can be included in the first group.

Elimination of the elements of the environment that are sensitive to harmful waste, or their substitution by elements having bigger resistance, can be looked upon as intentional human activity. An example of elimination is building a net of waterworks in regions characterised by big contents of toxins in surface water, or streams which once served as a source of drinking and

usable water in households. It is similar in the case of disappearing surface water as a result of draining areas that constitute the surrounding of a coalmine.

Another example of elimination is substitution of indigenous plant species on polluted areas by plant species of high resistance to pollution. In the anthroposphere, on the other hand, one makes use of building materials of very high resistance and protects objects with special means (gutters made of artificial materials, high resistance paint). All this is an example of limiting the influence of waste on the elements of the anthropogenic environment.

In regions characterised by big pollution of the environment one limits the range of agricultural and breeding activities owing to low quality of products and, consequently, meagre profitability. The conditions of the environment make it possible to cultivate only some plant species, e.g. flowers.

In the transformed environment the harmful influence of waste causes relatively smaller degradation than the same kind of influence in regions with a clean environment. To give an example, water contamination does not lead to fish impingement if sensitive species, like trout or salmon, died out many years ago.

As a consequence of the transformation, the changed environment is less sensitive to harmful effects; due to this fact the statement of losses in such an environment does not reflect the factual changes in the environment in a longer period of time.

Drożdż suggests making use of a potential account of the pollution of the environment, which assumes standard conditions of the geo- and anthropogenic environments. The same author postulates assuming in the account that standard building materials, standard paint, etc. are used in regions with an unpolluted environment. In plant cultivation and animal breeding one defines losses resulting from renunciation or necessary changes in these spheres of activity in reference to typical soil and climatic conditions of the region, but in an unpolluted environment.

In reference to geogenic conditions one should assume that nature is characterised by the variety that it originally had, e.g. the number of tree species in a forest would be the same as before its degradation. It entails that one should define the level of degradation of nature in the form already nonexistent.

The influence of pollution and degradation of the environment in the regions of high intensity of harmful influence in a long period of time brings about a durable loss of market value of real estate: buildings and areas. Drożdż postulates taking into account the loss of value of the discussed objects while preparing statements of losses. This should be done in the following way: first one estimates the value of buildings and areas found in a region characterised by the same values of the natural environment and a lack of pollution. Then one estimates the value of the discussed objects in the conditions of existing pollution. The difference between the calculated values constitutes the value of losses brought about owing to a durable loss of value in the discussed elements of the environment.

One also differentiates the phenomenon of a temporary loss of market value of real estate resulting from degradation of the environment. This is estimated as follows: one forecasts a value increase of the discussed objects in a long period of time, assuming total elimination of the analysed pollution. Then one defines the value of the objects in the conditions of pollution. The difference between the calculated values constitutes the value of losses incurred due to temporary loss of value in the discussed elements of the environment.

A very important issue is incompatibility of various methods of economic account and the influence of the assumed methods on the results of the account, in particular, while making decisions about exploitation of the elements of the natural environment, such as industrial exploitation of forests, or drainage of marshy land and its conversion into cultivated areas. It is similar with economic analysis of decisions about conversion of regions of the natural environment into industrial zones, or for municipal purposes.

It often happens that the comparison refers to the land value which is not estimated, and which society makes use of, being its factual user, since it has a gratuitous access to the resources of the environment. Such a value does not reflect the market value, which is a function of low utility for the owner. The possibility of exploitation of environmental resources gives the owner a chance to gain income. Appropriation of the discussed areas for development, raises the utility of land for the owner and, consequently, leads to an incomparable increase in value.

In both cases, keeping a traditional profit-and-loss account consists in applying a monetary measure to different objects in terms of quality. One compares the elements of the natural environment, which usually have insignificant market value, with the function of their productivity or the value of limited areas meant for development.

A correct assessment of the elements of the natural environment is a difficult and complex issue because of the fact that the natural environment performs many different functions, and due to subjectivity of assessment and incompatibility of the applied methods.

Subjectivity of assessment leads to ambiguity of assessment concerning the influence of the pollution of the anthropogenic environment. Economic evaluation of the results of the pollution requires evaluation of additional costs which are caused by it, e.g. additional window cleaning, additional building painting, discoloration of paint, etc. It should be noticed that during the assessment process are applied aesthetical criteria, this means that the results of such analyses depend on the sense of aesthetics of those who assess.

The analysis concerning the influence of technologies and products on the environment is a demanding task, which is characterised by the occurrence of numerous feedback mechanisms, both positive and negative. The feedback is connected with processes going on in the systems of the geosphere and the anthroposphere, as well as the relations between those systems.

A relatively short period of time of a non-cumulative harmful influence of waste on organisms usually causes functioning of mechanisms of negative feedback, reducing its effects due to the existence of self-acting mechanisms in nature. As an example may serve elimination of intensive transitory emission of volatile substances affecting trees in forests — it will lead to growth of new trees.

The initiation of positive feedback in the environment can be caused as a result of surpassing critical loads of self-regulating mechanisms, which may lead to the domino effect. The principle of this effect consists in the initiation of a given process, which causes subsequent processes; elimination of the cause does not lead to a set-back to the effects of the subsequent phases of the initiated reaction. Unlike in positive feedback, subsequent processes are characterised by different phenomena in terms of quality.

The pollution of the atmosphere at the peaks of the Karkonosze is an example of the domino effect which brought about a massive process of dying of trees. As a consequence, the structure and the hydrological proprieties of the soil changed. This, in turn, led to an intensive process of

washing the soil away from the higher parts during rainfall. The result of the final influence, which was brought about by the pollution of the environment, turned out to be much more harmful than the direct influence on the forest stand.

The occurrence of feedback mechanisms can also be noticed in the anthroposphere. The problem of reducing high temperature in big cities of California has been described by professor Rosenfeld. He argues that painting the roofs of the houses in the cities of California on a massive scale, may reduce temperature by a few degrees Celsius. The reflection of some part of radiation by a white roof will cause a small decrease in temperature, but the use of power by air-conditioning devices will also decrease, which will cause a decrease in heat emitted by these devices into the surroundings of the buildings and, consequently, in external temperature. The presented phenomenon is a typical positive feedback.

## REFERENCES


Bilans gospodarki surowcami mineralnymi Polski i świata 1993—1997. PAN Instytut Gospodarki Surowcami Mineralnymi i Energią, Zakład Polityki Surowcowej i Energetycznej, Kraków 1999.

Boden H., 1989 — Approaches in modeling the impact of air pollution-induced material degradation. IIASA, Laxenburg.

Gawrońska G., 1997 — Metoda szacowania strat w rolnictwie i leśnictwie spowodowanych. Wyd. IGSMiE PAN, Kraków.

Hohmeyer O., Ottinger R. (eds), 1990 — External Environmental Costs of Electric Power Production and Utility Acquisition Analysis and Internalization: Proceedings of a German-American Workshop, Fraunhofer ISI.

Jonsson C., Schopp W., Warfvinge P., Sverdrup H., 1993 — Modeling long term impact on soil acidification for three sites in Northern Europe, Lund University, Department of Chemical Engineering, Report.

Kibert C.J., 2000 — Sustainable Community Development in Poland, Sędzimir Foundation, Workshop: Mogilany, 3—21st July.

Schachermayer E., Rechberger H., Brunner P.H., Maderner W., 1995 — Systemanalyse und Stoffbilanz eines kalorischen Kraftwerkes — SYSTOK, Monographien Band 67, Wien.

Stirling A., 1995 — Some Practical and Theoretical Difficulties with Attempts to Place Monetary Values on the Environmental Effects of Electricity Generating Technologies, The European Network for Energy Economics Research, No. 17, Milan.

Zubrin R., Wagner R., 1984 — The case for Mars, Uniwelt, San Diego.


MAREK DROŻDŻ

**ODDZIAŁYWANIE TECHNOLOGII I PRODUKTÓW GOSPODAROWANIA SUROWCAMI MINERALNYMI I ENERGIĄ NA ŚRODOWISKO**


Słowa kluczowe

Surowce, gospodarka energetyczna, technologia, proces, środowisko



Streszczenie

Autor przedstawia podstawowe rodzaje oddziaływania surowcami mineralnymi i energią na poszczególne elementy środowiska geogenicznego i antropogenicznego. W artykule dokonano podziału oddziaływań produktów i technologii na środowisko według różnych kryteriów. Przedstawiono różne rodzaje odpadów procesów oraz stosowane metody redukcji ich uciążliwości dla środowiska.