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CIRCULAR ECONOMY IN THE NATURAL AND ANTHROPOCENTRIC APPROACH

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ABSTRACT: The aim of this article is to present and analyze differences in the interpretation of the closed circulation of matter in the natural environment and in the economy. Circulation of matter in the biosphere shaped in a very long period of development of life on Earth creates the impression of a very stable and durable mechanism. It is a mechanism that, thanks to the constant inflow of solar energy, sustained and evolutionally multiplied forms of life on Earth. Observing nature and assessing the damage done as a result of its economic exploitation prompts scientists and entrepreneurs to seek solutions that rely on the imitation of this circulation phenomenon that seems to ensure the existence of safe and sustainable nature. Repeatable use of the same matter in the biosphere has become an incentive for political and economic actions aimed at re-using the matter contained in goods produced by man. The analysis of natural cycles and those programmed by man leads in this article to the conclusion that we can not expect miracles from the concept of circular economy. Obvious limitations are built into laws governing nature and functioning of the economy itself. Moreover, we should carefully and rather suspiciously analyze the interdependencies of recently designed closed cycles with all these rules and hopes which are combined with the idea of sustainable development.

KEY WORDS: circular economy, circulation of matter, energy, sustainable development

Introduction

Circular economy – it is a fashionable term nowadays that occurs in the statements of environmental protection activists, in politicians' speeches, appears among the tasks of a Corporate Social Responsibility strategy (Instytut Innowacyjna Gospodarka, 2018), and above all appears in documents setting new strategies and directions for development of individual countries and the entire European Union (EU, 2018). The prevailing belief is that sustainable development will easily absorb the idea of a closed circulation of matter and its specific recommendations, and that circular economy in any case will be fully in line with the paradigms of sustainable development (Geissdörfer et al., 2017).

The first part of this paper describes the functioning of the biosphere, i.e. the largest ecosystem we know and at the same time the living environment of all living organisms including us humans. The circulation of matter and the flow of energy are two phenomena whose interpretation in the biosphere, with particular emphasis on biogeochemical cycles and laws of thermodynamics, allows us to understand the indispensable role of energy and the way in which the circulation of matter takes place in the natural system.

In the second part of this paper, by analogy, the management of matter and energy in systems created by man will be characterized. Particular attention will be paid to the differences stemming from the fact that only in the natural environment recycling is occurring automatically within the ecological systems and imposed energy limits. The comparison of two approaches leads to conclusions which tend to strengthen the thesis that closed circulation created by man will not be a panacea for the problems of the disturbingly unstable anthropocentric world.

The closed circulation in the natural environment

Biosphere and all its ecosystems derive energy from solar energy. This addiction is natural in the sense that it formed from the very beginning the evolution and sustainability in the living environment of our planet. We have enough evidence to say that million of years ago the supply of solar energy to the Earth was interrupted several times and combined with ecological cataclysms. They were caused by impacts of meteorites or asteroids on the surface of the Earth and, with the passage of time to a lesser extent, with the volcanic activity of our planet. Each such a break in the supply of solar energy was accompanied by a high concentration of CO_2 in the atmosphere and followed up by a massive extinction.

More then 3 billion years of life on Earth are years of innumerable and diverse adaptation processes that have made the known forms of life directly and indirectly dependent on the flows of solar energy. The sun is the external source of energy that has been supporting the circulation of matter for billion of years. More scientific observation of the circulation of matter in the natural environment has to begin with three groups of living organisms which due to their biological properties participate in the circulation of matter in a very different way. We distinguish between autotrophic organisms, heterotrophic organisms and reducers also known as microorganisms decomposing matter.

Autotrophic organisms are unique in many aspects but for the circulation of matter it is fundamental that they are able to carry out the process of photosynthesis. The chemical reaction created by the inflow of external energy allows an autotrophic organism to produce living matter from inanimate matter. Autotrophic organisms are primarily chlorophyll containing plants, for example green algae and plants such as grasses, flowers, shrubs, trees. Autotrophic organisms absorb available particles – chemical elements and chemical compounds – and with a help of energy generate the Gross Primary Production, which is usually expressed in either energy units or mass units per area and time period. After deduction from the Primary Gross Production the energy consumed for breathing (sustaining life processes of the organism) remains the Net Primary Production. Net Primary Production is an energy-saturated potential food whose presence conditioned in the past and continues to condition today the development of other life forms that do not have the photosynthetic properties of autotrophic plants.

The next step in the development of the world of living organisms could only take place after the lush development of the vegetable green world. There was a chance of living for heterotrophic organisms for which the only source of food, i.e. energy, were exactly the plants. We divide the heterotrophic organisms into first, second and third order consumers. These from the second level are predators and hunt for herbivores eating plants, and those from the third row are omnivorous animals. The latter group includes these organisms that, like humans, adapt relatively well to any diet.

Reducers are heterotrophic organisms difficult to see with the naked eye and living primarily in the soil dealing with reducing dead matter to the basic components. Thanks to them elementary "blocks" made of chemical elements and compounds can be incorporated again and again into new structures and into circulation, as long as they can be absorbed by plants. Reducers are primarily bacteria and fungi, as well as a variety of microorganisms. It is difficult to overestimate the role of reducers in the circulation of matter in nature.

Food chains fill and create the biosphere in accordance with the general rules that allow us to present the ecosystem in the form of a pyramid, the necessary basis of which are autotrophic organisms, and its higher levels are consumers, ending with third-grade consumers. The size or biomass of each population in a given ecosystem is a convenient way of presenting how a single pyramid corresponding to the circulation of matter in nature looks like. For example, in the savannah, a huge biomass of grasses, bushes and trees keeps alive a herd of antelope and other herbivores which are exposed on hunt for much less numerous lions and other predators.

The low number of predators gives us the conclusion that there are apparently food reasons for which they can not be numerous there, but only the energy pyramid explains and proves that the transition from one trophic level to the next takes place with significant energy losses. Simplified rule, but not devoid of reasons in many ecosystems, tells us that the transition to a higher trophic level is associated with the loss of 90% of available energy. Thus, only 10% of the energy accumulated at the lower level can feed organisms from a higher trophic level. This is the most advanced answer to the question posed by any ecology adept: why are there so few large predators? (Colinvaux, 1985). The trophic chain in the average ecosystem usually ends at the 4th to 5th link, and the higher the trophic level the predators and omnivores suffer the most from the energy shortages.

Analysis of the pyramid of abundance or biomass for a specific food chain does not show the essence of the circulation of matter, because this problem can only be explained by the analysis of energy flow throughout the entire ecosystem. The energy pyramid shows then that the energy coming from the Sun is at most half-absorbed by the surface of Earth's lands and oceans. In turn, a small part of the absorbed energy can be used in photosynthesis processes, and finally a small fraction of it becomes a Net Primary Production, which is a food for heterotrophic organisms. Regardless of how beautiful nature seems to us, we simply have to say that the efficiency of energy transfer in the biosphere is not perfect and from the point of view of heterotrophic organisms and our needs this efficiency is disappointingly low.

What's more, the thesis has been justified that the history of life on Earth seen from the perspective of the circulation of matter supported by the inflow of external solar energy can not be presented as the history of increasing absorption of energy and simultaneously unlimited increase in material outlays. On the contrary, the emergence of new forms of life compensated rather for the losses caused by natural disasters. The development of life and its expansion into land obviously increased the biomass and population size of different species, but the barrier of energy was always an irresistible barrier to their further expansion. Therefore, the biomass of any population can be

described by the equation of population growth illustrated graphically by a logistic curve limited from the top by the asymptote. The asymptote limiting further population growth has been set by the number of ecological factors, but in the final instance the growth is limited by available energy.

Critically important in this point is that the occurrence of energy in the natural environment has to be subordinated to the laws of thermodynamics. The first of them, the law of conservation of energy, says that energy does not arise from anything and does not disappear. Energy undergoes transformations and hence its various forms of occurrence: chemical energy, kinetic energy, mechanical energy, electric energy, nuclear energy etc. The second law of thermodynamics indicates that as a result of subsequent transformations part of the energy is dissipated in the form of heat that can neither be "collected" nor re-used. In this way, the entropy increases, i.e. the degree of energetic disorder of a given system increases (Georgescu-Roegen, 1971).

The fundamental difference must be clearly emphasized: matter circulates in the biosphere, while energy flows through the biosphere (Ayres, 1999). A portion of matter can be used repeatedly. A specific portion of energy is available only once for all, because flows through successive parts of the biosphere, undergoes multiple transformations, performs a specific "work", but finally dissolves in space in the form of useless heat.

The closed circulation in the anthropocentric world

In the man-made environment, there are no such mechanisms that could even resemble a producers-consumers-reducers triad and the circulation of matter in the natural environment. The linear model of the economy, which was uncritically used until the second half of the 20th century, was also called the linear or "cowboy" model, following the primitive and rugged methods of acquiring the Wild West in the North America. Under this model, simple and optimistic rules were in force: resources are unlimited, production produces useful goods without harming anything and anybody, consumption does not affect the environment. In such a picture of the world there are no threats and no warning signals. For a long time there was no reason to think about the closed circulation of matter. However, such a reflection must gradually arise when resources are shrinking, and production and consumption are damaging the environment to the degree that threatens the producers and consumers themselves.

Publications on the circular economy bring many optimistic reports that focus on individual technologies and man-made systems of exploitation and utilization (Frosch, Gallopoulos, 1989) or offer prophecy of transformation of

the global economy (Ghisellini, Cialani, Ulgiati, 2016). A long time ago in the literature appeared already an eloquent comparison of our planet to a space-ship, whose crew must deal with all obvious material limits (Boulding, 1966). But can we change the management on Earth in the equivalent of a self-sufficient cosmic capsule? The requirements are very ambitious, because inside such a space-ship each flow is both an input and an output, and a free energy can be drawn in sufficient quantities only from the Sun.

In my opinion, the answer is negative for two reasons. First, the boldest and most modern technical ideas will not replace the 3 billion years of creative experiments that have shaped the relationships between producers, consumers and reducers in the biosphere; all three terms are used here in their biological meaning, not in economic terms. Secondly, there is a problem about the scale of the phenomenon. If the problem concerned only a small section of human activity, it would be possible to point out solutions in which biological and chemical knowledge was able to grow microorganisms decomposing seemingly irreplaceable synthetic substances or to project chemical reactions that provide resources that have been regarded so far as being beyond our technical or economic capability. If we talk about the circular economy, we raise the bar to the level of global economy, and this includes many difficult areas of management. In particular, we have to take into account developing countries as well as countries at a very low development level or even in the stagnation phase. Basically, in poor countries circular economy can not be afforded yet. In rich countries waste paper, glass, packaging and electro waste have been collected and processed for many years. However, the scale of such processes is still around few percent of the material throughput recorded for economies of developed countries. Would we proudly call this small range of factual and international involvement in closing the cycles the new and modern circular economy on a global scale?

The development of human civilization is closely related to the common use of energy. The human population was a marginal and insignificant component of the biosphere as long as the ingenuity and inventiveness of a human being did not turn to obtaining energy in quantities greater than those that are enjoyed by the higher-order consumer in the ecosystem. In the ecological nomenclature, we are a third-order consumer, biologically speaking omnivorous organism. However, we do consume gigantic quantities of energy today.

The agricultural economy in its initial and traditional form did not absorb too much extra energy beyond the strength of human muscles and work of domesticated animals, and in relation to matter and energy requirements it showed a surprisingly high self-sufficiency. Traditional agriculture in a limited degree needed such cultural expressions as waste. In the autarkic farm "competitors" were removed from sown fields before harvest (i.e. weeds,

insects and rodents), however almost everything that was taken from the environment then had its practical usefulness. Natural fertilizers were used and composting has been known for centuries. Increasing knowledge and primary agro-technical treatments prompted the use of crop rotation and fallowing arable land to avoid accelerated soil erosion.

Changes characteristic for agricultural revolution turn out to be of a little importance when compared with the consequences of industrial revolution. Acquisition of additional energy sources has become a sine qua non development condition which was focused on mass sourcing of raw materials, ubiquitous transport, mass and industrial production in order to meet mass demand. Industrial development was based on discoveries and inventions that human hands, oxen and windmills could no longer set in motion. New machines and devices were invented very quickly and all of them required energy in huge quantities. At this epoch, people reached for peat and wood first, then for lignite and hard coal, and later for oil and nuclear fuel. In this way, the civilization dependence on energy subsidies in the form of fossil fuels emerged and consolidated.

What I call here energetic subsidy is energy obtained mainly from the fossil fuels and it is called subsidy, because it exceeds the amount of energy available to people due to their location in the food chain. Today it is the indispensable part of energy consumption in our industrial civilization. It is easy to check how small the number of people on the globe was in the period before and after the agricultural revolution. It is estimated that about 70,000 years ago, the number of people did not exceed 10,000. This first number would say how many people could survive using the energy available for a smart and intelligent predator. Around the year 1500, the population was 500 million. The second number would already take into account a small energetic subsidy obtained mostly in a renewable way – wind, water, domestic animals, etc. However, in 1820 (i.e. after 320 years) the population has reached around 1 billion. There are currently over 7 billion people on Earth, and the only positive signal is the extension to over 12 years of the period needed to increase the population by another billion. These figures clearly show that the industrial revolution with a big help of fossil fuels subsidy has created conditions for a dynamic population growth. Certainly, the number of people translates immediately into production and consumption volume.

The first and small energetic subsidy did not have a destructive impact on the environment. On the other hand, the energetic subsidy obtained from fossil fuels has a significant impact on the environment – it has changed and continues to change the biogeochemical cycles of such elements as coal, sulfur, phosphorus, nitrogen. It creates problems that involve environmental pollution, in the broad sense of this word, and also violates the persistence of

the biosphere as a result of excessive amounts of harmful and synthetic compounds that do not undergo biological decomposition. Many changes caused by anthropogenic pressure are in effect irreversible changes that will cause damages our science and civilization will not be able to repair (Śleszyński, 2016a).

Here we come to a problem that is difficult to solve, and impossible to solve in the short term. A civilization built on an economy highly dependent on fossil fuels will always be exposed to the following combination of events: an increase in the number of people entails an increase in production and consumption and a permanent threat of impending depletion of non-renewable resources. The threat will grow very soon if the applied corrective solutions are not economically sufficient in their use of matter and energy. In the long-term, the energetic sustainability can be provided only by renewable energy sources, which in the modern world are still not taken seriously, as if they were only a temporary and fashionable but defective solution.

It can not be ruled out that any well-organized collection of packaging or electronic rubbish and their thought-out reuse will bypass the trap of an excess of energy consumption. But then the second trap is waiting for the optimists, which has already been well recognized in environmental policy context, especially in the policy of removing pollution resulting from the consumption-oriented lifestyle. High and expensive emission standards will prove ineffective if the demand for the good that causes the emission is not limited for any reason (i.e. the so-called rebound effect). The low emissivity of cars will not improve the quality of air in the city center if people will buy cars more and more eagerly and drive them everywhere. What's more, even an electric car will not appear a symbol of sustainable development, if the demand for such vehicles will force the increase of electricity production, which in turn will be generated as a result of burning fossil fuels.

Creating technological, financial and administrative conditions for the production of packaging from old packaging material or the production of something completely different from materials picked from the old electronic equipment – it could be a huge effort. However, this effect will be wasted if the combined demand for purchased goods increases at the same time. It is worth noting that most programs created for the environment receive financial subsidy, so it is very likely that recycled packaging or a product made from a dismantled computer will be relatively cheap, which will obviously contribute to the growth of their competitiveness and increase in demand for these goods, which in turn will lead to increased material and energy inputs. In this way, closing cycles instead of being a panacea and an innovative tool for sustainable development can become a fig leaf, which in fact covers the

continuation of the material-consuming and energy-intensive growth (Schütz et al., 2002).

Sustainable development focuses on all important spheres of human activity, paying equal attention to economic activity, impact on the environment and social relations. Therefore, analysis of sustainability requires a comprehensive and, if possible, objective assessment using indicators. An example of such an approach may be a team-project from King's College London led by Paul Ekins (Ekins et al., 2008). The subject of analysis and evaluation at the regional level are four types of capital: man-made, natural, human, social. Examples of the application of this approach leave no doubt that the creation of closed circulation is just one of the mechanisms of a proper use of possessed capitals. Moreover, specific solutions closing circulation may not have a positive impact on all four types of capital (Śleszyński, 2016b).

The philosophical analysis of the cyclical problem indicates that the consciousness change enabling the departure from the consumer society model fails because of an extreme individualization which is deeply rooted in European and American civilization (Safranski, 2017). A self-centered person is not inclined to self-restraint, let alone sacrifice. Homo economicus likes rationality based on utility and does not accept the image of itself as a small part of a larger whole, which is carried out as a result of the circulation of matter, which also means the birth and the end of infinitely many individual beings (regardless of the degree of their organization and intelligence). The philosopher explaining why we deal badly with development and its sustainability recalls from antiquity the synthetic thought of the Greek physician Alkmaion: "People must die because they have not learned to tie the end with the beginning" (Safranski, 2017, p. 206).

Conclusions

The conclusion from the paper's comparison and consideration is not optimistic. A closed circulation of matter is a peculiar feature of the biosphere shaped during over 3 billion years of life on Earth, years of uninterrupted change and adaptation of a systematic character. What is more, the circulation of matter is disturbed by the economy, and the perceived and dangerous changes concern even the world's biggest biogeochemical cycles. The energy needed for the circulation of matter is drawn from the Sun, but it is an obvious fact that in this area we are appropriating more than we should because of human position in the world of living organisms. This problem is addressed by a specific indicator defined as the Human Appropriation of Net Primary Production (e.g. Haberl et al., 2010; Krausmann et al., 2013). In addition, our

huge population is critically dependent on energy subsidy, which durability is undermined by the intensive exploitation of fossil fuels, which are of course exhaustible.

The anthropocentric paradigm of today's economy is still so deeply rooted in the ideas and theories of the industrial revolution era that ad hoc created closed cycles will be exposed to a relative isolation from the natural environment and will require the constant supply of energy produced by man. Isolation means here that even thanks to the unprecedented progress of microbiology and revelations from GMO laboratories, we will not be able to create and add to the biosphere such segments that would effectively and adequately imitate the role of producers and reducers in the ecosystem. The second best solution (e.g. consisting of collecting, managing, processing and discovering the economic value in a matter considered so far subeconomic or waste) may have a fragmentary or local meaning but it will never reach such a scale that would allow anthropogenic circulation of matter to be interpreted in terms of closed circulation in the biosphere.

The problem of closed circulation is even worse when considering its relation to energy. Just like in the natural environment the energy input will be necessary at every stage of the matter processing in the anthropogenic environment. This means that the energy demand may not only decrease but may even increase. Thus, there is no easy way out of the basic entanglement in the sphere of energy: critical dependence on energy subsidies in the form of fossil fuels. In addition, not all ideas of closed circulation can be well combined and used with the most favorable scenario involving the use of renewable energy sources.

The basic differences between natural and man-made closed cycles result from the fact that human inventions are lacking systemic ecological dependencies and natural connections between autotrophic organisms, heterotrophic organisms and reducers. The differences are strongly connected with the non-renewable energy sources commonly used in the economy and also with the very selfish way the energy is absorbed in the anthropocentric world. Thus, circular economy is not a miraculous solution. A standard warning is also applicable to the circular economy trying harmonize our actions with the environment: usually, the most questionable and misleading are the solutions that aspire to the role of a panacea (Scruton, 2012).

Another and complex problem is the relationship of closed circulation with sustainable development. There is no automaticity here and no guarantee of change for the better, so every concrete analysis should examine whether the proposed closed cycle solution really contributes to sustainable development, which must take into account simultaneously and with the same attention the environmental, economic and social aspects of the prob-

lem. Will the introduction of closed circulation in practice correspond with the principles of sustainable development positively? Certainly, there will be a number of solutions that will give net economic benefits from the social point of view. However, there are many doubt whether the overall impact of man-made cycles on the environment can always be accurately and objectively estimated. The assessment of a closed cycle, like the life cycle analysis, can give different results if we change the assessment optics by setting the boundaries of the object, as well as by setting the spatial and temporal scope of the analysis. Thus, we will meet difficulty of making a reliable assessment of a multidimensional phenomenon, whose only one apparent advantage is the re-use of certain materials.

Recently, we observe a massive business commitment in Corporate Social Responsibility including elements of the circular economy. However, a company may pretend to appear to be more environmentally friendly than it really is. Negative action which is called "greenwashing" is the practice of making an unsubstantiated or misleading claim about the environmental benefits of a product, service, technology or company practice. The Greenwashing Index assessment and other measurements are needed in order to avoid manipulation.

Finally, it would be good to remember Kuhn's warning (Kuhn, 2011) that science is reluctant to accept really new paradigms and most often tries to save the old by introducing corrections and corrections that do not change the essence of the problem. Indeed, any proposal to create a closed circulation, especially due to the discretionary and wishful character of such ventures on the international stage, will require an individual and in-depth analysis that will allow to determine whether the projects are actually advocating lower consumption of matter and energy (Korhonen et al., 2018). Lack of changes in production models and consumption patterns suggests that there will be a risk of creating incentives causing an increase in demand for goods, and thus a greater demand for raw materials and energetic subsidy.

Conclusions regarding circular economy are summarized in the following paragraphs:

1. Economic activity, so far, to a greater extent violates the natural circulation of matter than it contributes to closing the circulation of matter.
2. The creation of closed cycles is implemented fragmentarily and on a local scale incomparably smaller than natural processes in the biosphere.
3. Artificially created closed circulation will always require additional energy input.
4. The civilization is still dependent on energy subsidy and the resources of fossil fuels are shrinking more and more.

5. Technological and organizational success of the closed circulation may be frustrated by the rebound effect of returning to the original state of pressure on the environment as a result of increased demand for goods made of "retrieved" material.
6. Closed circulation may encourage individuals to save natural resources but circular economy do not induce to change the consumer model of society.
7. The creation of closed circulation may not be an activity consistent simultaneously with economic, environmental and social principles of sustainable development.

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