BIOLOGIZATION AS AN OPPORTUNITY FOR A SUSTAINABLE DEVELOPMENT OF AGRICULTURE

Sławomir Gacka, Roman Izdebski, Stanisław Kolbusz

EkoysteEM Association, Poland

Abstract

The unprecedented economic growth has improved the living standards of many people, but at the same time contributed to the degradation of the natural environment of our planet. This article contains a review of scientific research on the current state of the ecosystems, conclusions following the scientific assessment, including those related to land degradation, transposition of research into political decisions at the global, European and Polish levels and a proposal to introduce biologization to ensure a sustainable development of agriculture. In support of the introduction of the idea of biologization, its tools such as probiotechnology are presented and the authors refer to the need of changing the current dominant paradigm of treating only the symptoms and accepting the paradigm of tackling the underlying causes. It gives examples of probiotechnology applications in the revitalization of agroecosystems and its beneficial effects on the fertile power of the soil.

1. Environmental assessment by the scientific community

THE WORLD. Agriculture is a human activity that is directly related to the state of the ecosystems, whose progressive degradation has been unambiguously indicated by scientists. This poses a real threat to humanity's future. In 2005, the results of the Millennium Ecosystem Assessment (a 3,000-page report) were announced.[1] The Assessment was **among the biggest scientific projects in recent years** and counted with the participation of 1,360 experts from 95 countries. **It was carried out for five years** and the results were reviewed by over 80 independent experts. Its findings include information that over the last 50 years, man has changed the ecosystems more than at any previous time in the history of humanity. **The average extinction rate is now at least one thousand times higher than before humanity's appearance on the planet, which causes an irretrievable damage** to the richness of the biodiversity of life on Earth. The reviewers arrive at the conclusion that such factors as nitrogen pollution, climate change and loss of biodiversity that are damaging to the environment are no longer within safe limits. This is particularly true of biodiversity, where safety concerns have been **exceeded tenfold!** In 1985-2000, over 50% of nitrogen contained in fertilizers produced since 1913 has been introduced into the ecosystems. Since 1960, the amount of nitrogen from fertilizers introduced into terrestrial ecosystems has doubled, and the amount of phosphorus has tripled. **The amount of nitrogen introduced into the environment by humans is now equal to the amount of nitrogen fixed by bacteria in natural environments**. The Millennium Assessment concerns changes which are taking place in all ecosystems as well as functions that they serve, including regulatory functions (the impact on the climate, floods, diseases, desertification, water quality) and supporting functions, such as **soil formation**, photosynthesis and nutrient cycling. In many areas, agricultural **pest control normally carried out by the pest's natural enemies has been replaced with pesticides, which reduced the ability of the agroecosystems to combat them**. Human-induced changes to the ecosystems largely contributed to increasing losses caused by floods and fires. It is estimated that only in 2003, **damages caused by floods and fires around the world amounted to about $70 billion**.

The report commissioned by the United Nations and the World Bank from the International Assessment of Agricultural Knowledge, Science and Technology for Development, on the preparation of which participated more than 400 scientists from around the world, found that **the current agricultural model is not able to meet the food needs of a growing human population**[2].

Statistics presented at this year's Dublin conference dedicated to food security and natural resources showed a dramatic loss of biodiversity—about 900 plant species and 22% of more than 8,000 animal

[1] Millennium Ecosystem Assessment 2005. http://www.millenniumassessment.org

[2] IAASTD, 2009. Agriculture at a crossroads. IAASTD Synthesis report.

species are at risk of extinction. The importance of **biodiversity** in providing food and the key role that microorganisms play in maintaining it was stressed during the conference[3]. Disturbing data, assessments and warnings come from other studies as well. The use of pesticides not only degrades the environment, but is also a direct threat to human life and health. It is estimated that pesticides cause more than **26 million cases of poisoning**, including about **220,000 deaths** and approximately 750,000 cases of chronic illness[4].

At the same time, they do not deliver the expected economic benefits. In 1945-2000 in the United States, despite more than a tenfold increase in the use of pesticides, **crop losses due to insects almost doubled, i.e. increased from 7% to 13%**. The current average of additional **costs of using pesticides in the United States amounts to 42 USD / ha** (research from 32 U.S. states, 56 plants and 325 pesticides), and by 2100 will rise to 72 USD / ha. Every dollar invested in pesticide control generates savings of approximately $4 / ha, which in face of the **$42 for additional costs generated from 1 ha of land reveals that pesticides only seem to be cost-effective**[5].

These and other losses brought about by environmental degradation or related to the depletion of natural resources **are not included in the methods used to calculate economic growth**. Thus, the role of agriculture, especially that based on natural technologies is, harshly speaking, tendentiously underestimated[6].

In 1976, for the first time, the total demand placed on nature by world economy reached the equivalent of what the Earth can sustainably provide in a year. **As of 2007, we are using the equivalent of 1,5 Earths-exceeding what nature can provide by half**! To a large extent, this applies to the soil, which is the **foundation of our civilization**. Some scientists warn that if soil erosion on arable land is greater than the formation of new soil, then the phenomenon of land abandonment will take place, and when the state loses the soil, it forever loses the possibility to feed its citizens[7].

The dramatic situation of the world's soils is confirmed by UNEP,[8] whose data shows that every year we lose up to 50,000 km² due to soil degradation, mainly soil erosion. Every year, our planet loses as much as **24 billion tons of humus**. The loss of productivity only because of desertification costs the world more than **$40 billion per year**!

Available data shows an excessive use of chemicals in agriculture. Among others, it shows a huge increase in the use of chemical fertilizers-fertilizer use went up from 14 million tons in 1950 to 160 million tons in 2008, i.e. 11.4 times more[9]. Today, as many as 3 million tons of pesticides are used every year (Koleva, Nikolinka 2009).

It is mainly these two factors that have led to an increase in food production. The amount in terms of calories consumed per day by an average person increased from 2,200 kcal / day in the early 1960s to more than 2800 kcal / day in 2009.[10] This is a result of an increase in the yield of cereals (which are the most common source of food in the world), which increased threefold during this period. However, the annual rate of yield increase has fallen from 3% in the 1970s to 2.3% today. In the last 50 years, there has been a much lower annual rate of yield increase for some very environmentally useful (nitrogen fixation and improvement of soil structure) crops, which was at less than 1%.

As yields increase, however, there is a decrease in food palatability and its nutritional value. A growing number of consumers opt for a choice, as evidenced by the growing popularity of food purchases from

3 Food Security Futures conference.11-12 April 2013, Dublin, Ireland. Presentation by Place Frank (ICRAF, CGIAR), Meybeck Alexandre FAO) et al. "Food security and sustainable resource use - what are the resource challenges to food security?

4 Pimentel, D., 2005. Environmental and economic costs of the application of pesticides primarily in the United States. Envoronment, Development and Sustainability, 7: 229-252.

5 Koleva, Nikolinka G., Shneider Uwe A., 2009. The impact of climate change on the external cost of pesticide applications in US agriculture." International Journal of Agricultural Sustainability, Vol. 7, issue 3, 2009.

6 Such approach has widespread influence on common opinions, including also those of "prominent" economists, about the very insignificant role of agriculture in the creation of national wealth expressed in Gross Domestic Product (GDP) and following political consequences concerning reduction of expenses on agriculture and agricultural research.

7 Brown, Lester R., 2012. Full Planet. Empty Plates: The New Geopolitics of Food Scarcity.

8 http://www.unep.org/geo/GEO4/report/GEO-4)

9 Brown, Lester R, 2011. World on the Edge by the Numbers – Grain Production Falling as Soil Erosion Continues, Earth Policy Institute.

10 FAO Statistical Yearbook 2013. Rome, 2013.

farms where natural methods of crop cultivation and animal breeding are used.[11] Symptomatic support of this option is received from political VIPs e.g. organic crop cultivation by Prince Charles in the UK or planting a vegetable garden by the First Lady of the United States. The negative effects of an excessive use of chemicals in agriculture is also shown in studies conducted on organic farms. There is well-documented research from the United States.[12] In 2004, Dr. Donald Davies together with his team found that **the levels of vitamins, minerals and proteins decreased in the analyzed 43 fruits and vegetables grown from 1950 to 1999 in the USA**. For example, broccoli in 1950 contained 130 mg of calcium, and now only contains 48 mg. Dr. Davis concludes that it is an effect of the changes introduced in plant cultivation that used to be based on the natural biological rhythm and is now geared toward producing vegetables as quickly as possible. The introduction and consumption of synthetic fertilizers continues to increase and deregulates homeostasis. This, in turn, consistently opens the way to using the substitute i.e. chemical plant protection. On the basis of a 10-year study, Dr. Alyson Mitchell found, however, that when compared with factory farmed, organically grown tomatoes contain 30% more beneficial compounds associated with their color (called phytochemicals). The decreasing nutritional value of food meets with an attempt at compensating for it with an increased industrial production of dietary supplements supported by a multitude of international food standards *of Codex Alimentarius*.[13] This creates a paradoxical situation on a global scale where instead of supporting the natural environmentally friendly technologies, the assistance goes to the development of technologies that cause environmental degradation. At the same time, life is degraded by their unification in monocultures which eliminate biodiversity, the primary mechanism for supporting life on Earth.

The existing mechanisms, including the CAP direct payments system, preserve the defective development of industrial food production while promoting commercial production of the "full-fledged" supplements in the form of pills, capsules, powders or liquids as chemical components supposed to substitute for the lost ingredients of a healthy diet of the local, regional and national cuisines of Europe. Meanwhile, as the specialists in the area of human nutrition and dietetics D. Gajewska, Ph.D. and J. Myszkowska-Ryciak, D.Eng. from the Department of Nutrition of the Warsaw University of Life Sciences conclude, the prehistoric man ate twice as much minerals, four times more dietary fiber, ten times more antioxidants, fifty times more omega 3 fatty acids, two times more protein, four times less saturated fat conducive to the development of atherosclerosis, and ten times less sodium responsible for hypertension.[14] Hippocrates, the father of modern medicine, was the one to urge *"Let food be **your medicine**, and **medicine** be your **food**,"* thus indicating a point of reference, a kind of meter of Sevres on the way to development as we are searching for sustainability in agriculture.

A general conclusion resulting from the above-mentioned studies indicates the need to make significant changes to the current policies implemented especially toward the so-called modernization of agriculture and development of the so-called rural areas, as well as in the functioning of institutions and in practical applications. What we need is systematic and coherent action in the remodeling of existing economic policies at a global, European and national levels. Human activity is putting so much strain on the planet that we can no longer assume that the Earth's ecosystems will be able to ensure proper conditions for life of the future generations.

EUROPEAN UNION. A sustainable management of natural resources applies in a special way to agriculture, which is naturally associated with the environment. The state of the environment in the EU is not optimistic. Detailed status of soil degradation is provided by the European Environment Agency (EAA) on the basis of research carried out by one of the EU's research centers.[15] General data indicates that **about 45% of European soils have a low or very low organic matter content** (0-2% organic carbon), while another 45% of the soils are found to have an average content of organic matter. At the same time, 12% of the total land area of Europe is affected by water erosion (115 million hectares), and 42 million hectares by wind erosion. In addition to the obvious role that a healthy soil plays in supplying raw materials for food production, the study emphasizes its importance

[11] *Inter alia* in Poland increasing popularity of such purchases in specialized grocery stores "Kredens" or "Alma."
[12] Burns, Sarah "Nutritional value of fruits, veggies is dwindling," 7 Sept. 2010.
[13] Latin for *"Book of Food"* is a collection of internationally recognized standards, codes of practice, guidelines and other recommendations relating to foods, food production and food safety and utilized by official duty services, food industry and scientists.
[14] Lectures for the Warsaw University of the Life Sciences within the theme "Diet prophylaxis of diet- conditional diseases."
[15] The European environment – state and outlook 2010. Soil - SOER 2010 thematic assessment. EEA and JRC, 2010.

in terms of climate change (according to evaluations it is the second reservoir of coal as its natural and free sequestrator), thus also pointing out the fundamental role of soil organisms in biodiversity and the soil's fulfillment of multiple functions.

The annual costs of soil degradation only for EU25 are estimated **at 39 billion Euros,**[16] which is almost equal to the cost of the CAP. According to the current agricultural model in Europe, about **60% of the energy needed to produce wheat is used on production of fertilizers.**[17] In 1990-2006, 19 EU Member States lost the fertile power of the soil equal to a total of 6.1 million tons of wheat. In order to compensate for the loss of one hectare of fertile land in Europe cultivation on an area of ten times the size should be started in another region in the world.[18]

POLAND. The quality of the soils in Poland is among the lowest in Europe. The average yield potential of Polish soils corresponds to an average of 0.6 hectares of arable land in European Union countries, and chemical analyses indicate that in the last 30 years the amount of organic carbon content has decreased in Polish soils by 10-20%.[19]

Meanwhile, the use of pesticides in Poland is growing, as evidenced by data from 2005-2011.[20]Thus, we are gradually losing the possibility of maintaining the natural functioning of the agroecosystems, as well as of having access to high-quality foods that support, and not weaken human health. The situation has worsened in recent years, which is clear from the increasing damage caused by floods, heavy rainfall, hurricanes, droughts, frosts, hail, landslides, etc. According to preliminary data, only recent weather events affected more than 100,000 farms in an area of about 600,000 ha of agricultural land, estimated at 150 million PLN.[21]

2. Reactions of politicians - conventions, strategies, declarations, laws

THE WORLD. Scientific warnings have an impact in the world of politics. At the global level we have the United Nations Framework Convention on Climate Change,[22] the Convention on Biodiversity (covers all ecosystems, including soil ecosystems) whose parties are 192 countries, including the EU and Poland[23] and the Kyoto Protocol.[24] The world also has institutional arrangements such as the 1972 United Nations Environment Programme (UNEP), Conference of the Parties (COP) with the Secretariat in Montreal consisting of representatives of the countries that have ratified the Convention on Biodiversity. These institutions coordinate international efforts on the development of environmental policies and their practical implementation. At the global level, since 1945, there is also the United Nations Organization specialized in agriculture, i.e. the Food and Agriculture Organization (FAO). For the purposes of the abovementioned conventions and institutions, the **protection of the soil is only an indirect objective** operating within the context of the protection of biodiversity and combating climate change.

EUROPEAN UNION. The EU law has no separate legal regulation pertaining solely to the problems of soil protection. The solutions in this regard, despite efforts of the European Commission to stop the degradation of the soils, are left to internal policies of the Member States.[25] In its

[16] Land degradation and desertification. EP, March 2009. IP/A/ENVI/ST/2008-23. Study made for the European Parliament on request of the Committee on the Environment, Public Health and Food Safety.

[17] Report of the European Fertilizer Manufacturers' Association.

[18] Gardi C. et al., 2011. Soil Sealing: "Land Take and Food Security: Impact assessment of land take in the production of the agricultural sector in Europe," JRC, 2011.

[19] Skłodowski, P. and Bielska, A. 2009. Właściwości i urodzajność gleb Polski - podstawą kształtowania relacji rolno-środowiskowych (Properties and fertility of soils in Poland – a basis for the formation of agro-environmental relations). IMUZ Woda-Środowisko-Obszary Wiejskie, t. 9, z. 4(28), s. 203-214.

[20] Elaboration of R. Izdebski on the basis of data of the Polish Ministry of Agriculture and Rural Development on "Sale and stock of pesticides – producers and importers data."

[21] Data from the press conference of the Polish Minister of Agriculture and Rural Development on 13 June 2013.

[22] United Nations Framework Convention on Climate Change of 9 May 1992 (http://unfccc.int/) that entered into force on 21 March 1994.

[23] Dz.U. 1996 nr 53 poz. 238 (The Polish Official Journal of Laws 1996 No 53, item, 238).

[24] The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, it was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005.

[25] Soil - a key resource for the EU. European Union, 2010.

Communication to the European Parliament and the Council "Towards a Thematic Strategy for Soil Protection," The European Commission has identified **nine major events** threatening the soils in the EU**, including organic matter decline and the loss of soil biodiversity**.[26] These threats also display **the important relationships between soil protection and climate change**.[27] A minority represented by five countries—France, Germany, United Kingdom, Austria and the Netherlands, whose governments opposed the compromise version prepared by the Presidency of Portugal, blocked the introduction of this strategy and The Soil Thematic Strategy Framework Directive despite the support of 22 EU Member States[28].

EU Member States may, however, voluntarily decide on more or less effective soil protection policies and determine their own policy objectives and manner of achieving such objectives. Soil protection at the EU level derives only indirectly from the Europe 2020 strategy in which the Union diplomatically declared a sustainable and inclusive growth encouraging social inclusion,[29] objectives of the Union (*Article 3, paragraph 3, third subparagraph* of the Treaty on European Union)[30], by far the declarative and not obligatory objectives of the new Common Agricultural Policy[31] and The European Model of Agriculture, whose purpose is sustainable development[32] and is formally binding[33]. Soil protection is also indirectly included in the two pillars of the CAP. These include Pillar 1 of the CAP, compulsory since 2005, so-called cross compliance, and a set of activities in the three axes of Pillar 2 of the CAP, particularly in axis 2 (agri-environment)[34].

Soil quality is also affected by some of the requirements of EU directives encompassed in the EU's environmental policy.[35] The European Parliament (EP) provided a favorable position on soil protection. According to the MEPs, the **objective of all agricultural activity must be to preserve the soil and improve its fertility.** Fertile soil is the first indicator of quality and its loss is one of the main problems that Europe faces as a result of desertification and erosion[36].

Both the Commission and the MEPs encourage the use of technologies that contribute to maintaining and increasing the organic matter content of the soil and prevention of desertification as well as the use of organic fertilizers and compost that enhance the fertility and biological activity of the soil. At the same time, they request the Member States to **decide on their own agricultural policy in respect to the soil,** encouraging them to choose from such cultivation methods or programs that have a positive **impact on the organic matter and soil fertility.** For the Member States, including Poland, that is the opportunity to introduce biologization for a sustainable development of national agriculture and application of probiotechnology methods for the regeneration of soils.

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[26] The European Commission, 2006. The Soil Thematic Strategy, (COM(2006) 231).

[27] Remaining include erosion, contamination, salinization, compaction, sealing, desertification, landsliding and floods.

[28] Final report on the project "Sustainable Agriculture and Soil Conservation (SoCo)." The project "Sustainable Agriculture and Soil Conservation (SoCo)." European Commission, 2009.

[29] Europe 2020 Strategy endorsed by the Council on 17 June 2010.

[30] Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union. OJ C.83, Official Journal of the European Union Volume 53, 30 March 2010.

[31] Viable food production, sustainable management of natural resources and climate action, balanced territorial development.

[32] "The European model of agriculture - challenges ahead." A background paper for the meeting of the Ministers of Agriculture in Oulu 26 Sept. 2006.

[33] The model goals have been endorsed by subsequent declarations of the EU Council, the highest authorities of the Union.

[34] Conditionality of direct payments with fulfillment of some other regulations as Nitrate Directive ((91/676/EEC), Water Framework Directive (2000/60/EC) and good agricultural practices (GAEC)

[35] As Sewage Sludge Directive (86/278/EEC), Plant Protection Products Directive (91/414/EEC), Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC), Birds Directive (2009/147/EC) and Directive establishing a framework for Community action to achieve the sustainable use of pesticides (2009/128/EC).

[36] The report of the European Parliament on the proposal for a directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC (COM(2006)0232– C6-0307/2006 of 24.10.2007.

Yet detailed regulations of the CAP, in particular those concerning financial support for agriculture, are only marginally consistent with the stated objectives of these regulations. Meticulous review of the distribution of financial support in recent years proves that most of the support has been provided to a small group of farmers, which led to the strengthening of an excessive use of chemicals in agriculture and its intensification to the detriment of the environment[37].

Direct benefits of using natural low-input and organic farming methods are supported by the EU, but only as part of research projects co-financed by the European Commission under the Framework Programmes for Research.[38] So far, they have had no chance of becoming widespread within the obligatory duties of the Common Agricultural Policy.

A chance for widespread soil protection can be found in the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP).[39] It envisages support for innovative activities to promote the agricultural sector, which shall be efficient in the use of raw materials, cost-effective and low-emission. EIP objective should be to promote a faster and wider use of the water- and energy-efficient solutions in practice.

POLAND. Polish agriculture, family farms in particular, as well as Polish lakes and forests, which are still filled with the presence of wildlife, are the largest and invaluable resource of biodiversity in the heart of Europe. **Poland is still rich in biodiversity, and therefore even more responsible for its protection**. Nevertheless, it could be more ambitious in making use of the existing, albeit very limited, EU regulations to protect the soil. An example is the inclusion to Polish legislation[40] of the Directive 2009/128/EC on the Community Action for the Sustainable Use of Pesticides. Poland was obliged to implement the Directive on 1 January 2014; the Directive clearly states that **biological, physical and other non-chemical methods must be preferred to chemical methods**. Unfortunately, in Polish law, as well as in the Directive, the non-chemical methods are treated in a fairly marginal way and much more space is devoted to the well-known pesticides and procedures associated with their use. Polish government now stands before the challenge of not only effectively making use of the Directive, but also of the aforementioned European Innovation Partnerships.

3. Biologization and probiotechnology as an opportunity for a sustainable development of agriculture

In terms of protecting the biodiversity of the ecosystems, including the soil, a vast majority of legal proposals concentrate on "improving" the existing tools that are focused on combating the effects of the loss of biodiversity. Even Albert Einstein warned that ***"We can't solve problems by using the same kind of thinking we used when we created them."*** The socio-economic HEALTHY EARTH Movement centered around EcosystEM—Nature's Heritage Association proposes a change in the paradigm to the assumption that it is better to remove (prevent) the causes of a process, instead of treating its effects!

We propose a widespread use of biologization utilizing natural biological tools shaped over the course of millions of years, which revitalize the environment, regenerate the soil and thus create conditions for plant growth, high yields of the highest biological quality while reducing the use of chemicals and other substances that are harmful to the environment, including soil environment. We are confident that this new path well deserves to be included in the development of sustainable agriculture.

The definition of biologization of agriculture was developed by Professor of Soil Science Lesław Zimny from the University of Life Sciences:

37 This opinion is based on the analysis of the subsequent agricultural budget distributions related to environmental measures, distribution of direct payments, agricultural areas utilized by large farms and their commercial production together with the scale of monocultures.

38 European Commission, 2012. A decade of EU-funded, low-input and organic agriculture research (2000-2012). The publication summarizes 49 research projects on low-input and organic agriculture, worth EUR 50 million co-funded by the European Commission under the 5th, 6th and 7th Framework Research Programmes, conducted or started in the period 2000-2012 (worth EUR 50 million).

39 Proposal for a Regulation of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) ('the rural development regulation'). 2011/0282 (COD).

40 Ustawa z dnia 8 marca 2013 r. o środkach ochrony roślin. Dz. U. z 12.04.2013 r. , poz. 455 (Regulation of 8 March 2013 on Plant Protection Products. Poland's Journal of Laws of 12 April 2013, item 455).

BIOLOGIZATION OF AGRICULTURE: *"Using biological yield-enhancing factors in crop cultivation such as compost, manure, bio-preparations, rational crop rotation, phyto-amelioration, high-yielding, pest-resistant varieties, biological nitrogen retention of legumes, in order to produce healthier foods and protect the environment."*

Biologization of agriculture signifies reduced consumption of chemical fertilizers and pesticides. In addition to many other benefits, it brings big savings on water and energy used in agriculture, which has lately been developed to resemble a factory conveyor belt. It fits in with the political objectives of the need for energy-efficient technologies. Most studies suggest that **when applying organic methods, agriculture consumes 20-40% less energy than in conventional production. It is estimated that in order to produce 1 calorie of food in the industrial food production system, 10-15 calories of energy from the outside are needed**[41]**.**

According to FAO, **farmers in industrialized countries consume five times more energy to produce 1 kg of grain than farmers in Africa** (in order to produce 1 kg of corn an American farmer uses 33 times more energy than his counterpart in Mexico, and in order to produce 1 kg of rice he uses 80 times more energy than the traditional farmer in the Philippines). In other studies it is concluded that a simple, rural farmer may produce **about 10 calories of energy per 1 calorie used**, while an American farmer (probably European farmer as well), in order to produce a can of corn **consumes up to 10 calories** per 1 calorie obtained, most of which consists of energy used to power equipment and energy in the artificial fertilizers and pesticides[42].

A rational approach to agricultural production was promoted several years ago already by Professor Ryszard Manteuffel, a Polish agricultural economist. He proved that industrialized agriculture is less efficient when he stated that *"A farm is not a sum of production actions but an organized integrity consisting of separate, yet closely and mutually related production activities."*[43] Cyprian Kamil Nowid, one of the most prominent Polish poets forewarned us against the loss of quality more than hundred years ago: *"multiplicity, number, scale can be the rule and law where there is no quality."*[44]

The above statements show that the idea that modern agriculture is efficient is a myth, and that it is actually very energy-intensive and contributes to the devastation of natural resources. Meanwhile, keeping the existing solutions in place is an expression of a lack of interest in the use of the potential of the natural mechanisms that govern ecosystems.

Caring for fertile soil means also paying attention to lowering emissions of greenhouse gases (GHG) - agriculture is a significant contributor to these emissions[45] - as well as an opportunity to promote new patterns of consumption, including the promotion of food obtained by natural methods. Within the scope of biologization, we suggest using methods of probiotechnology based on the use of probiotics and prebiotics.

Among the wealth of definitions of probiotics (in terms of food products), the shortest one describes them as **"live microorganisms that, when applied in sufficient amounts, deliver a health benefit to the host."**[46] When administered to animals and humans, as well as to the soil, probiotics and prebiotics awaken life in them and restore the biodiversity of life in them. In order to continue, plant and animal life requires constant change in the natural protective systems. Such change, when it occurs in undisturbed nature, leads to the formation of new species, whose abundance and diversity increase the stability of the ecosystems. Natural sexual reproduction makes the shuffling of genomes with each generation

41 "Effects of industrial agriculture on global warming and the potential of small-scale agroecological techniques to reverse those effects." A report to Via Campensina by The New World And Ecology Group. November 20, 2009.

42 Rifkin, J. and Howard, T. Entropy. Into the Greenhouse World. New York, Bantam Books, 1989, p. 154.

43 Radziewicz Joanna. "Ryszard Manteuffel-Szoege". Rolniczy Magazyn Elektroniczny. CBR Maj-Czerwiec nr 55 (Radziewicz Joanna. "Ryszard Manteuffel-Szoege". Agricultural Electroniv Magazine. CBR May-June No 55).

44 Cyprian Kamil Norwid. Asocjacja, Ilość i Jakość. Komu się podoba przypisane (Association, Quantity and Quality. Assigned to whom finds it pleasing).

45 According to different sources, agriculture is responsible for 9-22% of the world CO_2 emissions.

46 "Health and Nutritional Properties of Probiotics in Food including Powder Milk with Live Lactic Acid Bacteria." Report of a Joint FAO/WHO Expert Consultation on Evaluation of Health and Nutritional Properties of Probiotics in Food Including Powder Milk with Live Lactic Acid Bacteria. FAO / WHO. Argentina 1-4 October 2001.

possible, which in turn allows for maintaining of the effectiveness of the protective systems against the invasion of diseases and parasites. Monoculture leads to dwarfism. **Biodiversity, and not uniformity, is therefore the basis of order and harmony of life of each ecosystem**. Its condition is determined by microorganisms, which are the beginning and the end of absolutely all the links in the food chain.

The definition of probiotechnology adopted by EcosystEM - Nature's Heritage Association in the context of its use in agriculture, is as follows:

Probiotechnology (Greek *pro bios* - for life)[47]: *The method of manufacturing and applying natural microbial products branded ProBio Emy, which are probiotic compositions based on SCD Probiotics mother cultures enriched with compositions of minerals and herbal extracts with structured water and natural growing media, whose purpose is to have a beneficial effect in the ecosystems for human health and the health of the environment.*

Pathogenic microflora serves in the chain of life as a natural vaccine. A characteristic feature of microorganisms is their remarkable **biodiversity**, of which they are also a natural and best guardian. **Microorganisms can either support the immunity of the soil, plants, animals, and people or weaken it**. Every environment, every organism is a unique ecosystem which has the same, almost limitless potential for disease as for health. The issue for us is to **want and be able to support by our daily behavior the natural friendly potential of the surrounding forces of Nature**. This goal is well served by probiotechnology.

Seminars organized by the Ministry of Agriculture and Rural Development of Poland which took place in 2010-2011[48] confirmed the innovative way of thinking of the users of probiotechnology, revealing also the need for extension of the previously used methods of biologization of agriculture in order to reduce humus decline in the soil[49] (crop rotations, use of organic fertilizers, elimination of deep plowing, etc.) to include the study of the microbial activity in the soil.[50]Thus was also confirmed the validity of the restrictive measures regarding synthetic fertilizers and chemical pesticides adopted by some farmers, who instead are using bio-preparations that activate beneficial soil microorganisms.

The success of these seminars continued during the International Conference on the problems of decreasing soil organic matter organized in Brussels during the Polish Presidency in the EU.[51] The conference program included eight presentations given by soil scientists from Germany (Prof. Franz Makeschin from Dresden University of Technology, representing also The European Research and Technology Network for Soil and Land Use), the Netherlands (Oene Oenema and Peter Kuikman of Wageningen University) and Poland (Professors Jan Kuś, Tomasz Stuczyński and Wiesław Oleszek from the Institute of Soil Science and Plant Cultivation, State Research Institute, Puławy), a presentation regarding practical applications of microorganisms by Mr. Sławomir Gacka, M. Eng. from EcosystEM - Nature's Heritage Association, and presentations by two representatives of the European Commission - Mr. Luca Marmo of the Environment Directorate-General and Mr. Massimo Burioni of Research and Innovation DG, Biotechnologies, Agriculture and Food. The participants confirmed the ongoing process of degradation of European soils and at the same time the fundamental role of the soil, among others in crop cultivation, collection and treatment of water, as a buffer and in biodiversity conservation. They recommended the following:

- Improved legislation at the EU level, including greater consistency of legislation so as to stimulate the implementation of measures leading to prevention of environmental degradation (current legislation, despite existing legal regulations, is inadequate in the context of the risks),
- Showing the legislative way to the implementation of biologization of agriculture through the

[47] Definition from the „Uzdrowić Ziemię" album. Warsaw 2012.

[48] Seminars "Is Poland at risk of decreasing soil fertility?" held on 8 Dec. 2010 and 9 Feb. 2011 in the Polish Ministry of Agriculture headquarters.

[49] Information from Prof. Wiesław Oleszek, IUNG about the significant decrease of organic matter in the best drained soils – during last 30 years these soils lost 40% of their OM initial content.

[50] Presentation by Kucharski, J. and Wyszkowska, J. "Shaping possibilities of microbiological properties of soils." University of Warmia and Mazury in Olsztyn. Presentation within a/m seminar held on 9 Feb. 2011.

[51] "Soil organic matter – old truth, new challenges." International conference on Soil Organic Matter held on 21 September 2011 in Brussels under the Polish Presidency with cooperation of the European Commission, DG Research and Innovation and Institute of Soil Science and Plant Cultivation, State Research Institute, Puławy – IUNG.

use of preparations of natural origin,
- The urgent need to intensify research on the soil and of scientific cooperation of key institutions and the users, including research on the humus content in the soil and development of verifiable methods of its assessment,
- Revision of the well-known definition of the soil which is currently exposing its physicochemical properties, in order to take into the account its biology, especially the biodiversity of its microflora,
- Increasing the intensity of research on the effects of the different types of agrotechnology on the humus content (including regional differences),
- Reduction of the excessive use of chemicals in agriculture that resulted in a decline of soil productivity,
- Limiting the expansion of monoculture crops without livestock,
- Revision of the existing indicators of assessing soil features that indicate the quality of the biological, physical and chemical processes occurring in it,
- The need to examine the impact of life in the soil on the abundance of nutrients available for plants,
- Introduction of financial support for those who care for the conditions necessary to increase humus content in the soil.

4. The soil is a seed bed - let us protect it like the health of every mother

The soil ecosystem provides important environmental services such as soil formation, decomposition of dead organic matter (impact on soil fertility and plant growth), infiltration of water and its retention, degradation of pollutants, pest control and pollination process (majority of pollinating insects go through a developmental phase in the soil). For centuries, the soil and creatures living in it were not subject of profound interest of humankind, including scientists. Around 1500, Leonardo da Vinci stated, *"We know more about the movement of celestial bodies than about the soil underfoot."*[52] After more than 600 years, despite many advances in technology, this has only slightly improved. The soil is still underestimated. Many started to see it as a tank full of various chemicals, however, like water, the soil is a shared wealth of humankind. It is also a non-renewable resource and a platform for the following environmental, economic, social and cultural functions:[53]

(A) **The soil is the basis for life and biodiversity.**
(B) It stores, acts as a buffer, filters and transforms nutrients, stores groundwater and surface water.
(C) It is the primary source of biomass in agriculture and forestry.
(D) It serves as the physical and cultural environment for humans and human activities, including cities, infrastructure, recreation and other forms of public and economic activity.
(E) It is a source of raw materials for many sectors of the economy.
(F) It acts as a reservoir and natural sequestrator of carbon.
(G) It is an archive of the geological, cultural, geomorphological and archeological heritage.

It is for good reasons that experts say that the **soil is the cradle of our civilization**, and its absence would mean loss of life on Earth. Too often people do not appreciate the many functions that it fulfills. This is particularly evident in the recently observed and ever intensifying floods and huge losses caused by floods, including human casualties. A fully functional soil would certainly limit the losses. Such soil can **store for up to 3,750 tons of water per hectare**.[54] Some studies question such great potential of soils[55].

The core purpose of soil cultivation is to ensure the optimum quality through the protection and proper use of the existing biodiversity in it. In Europe, soil scientists have identified more than 10,000 types of soils. It is estimated that in the area of one hectare of the soil there is more than 5 tons of

[52] Skubała, P. 2004. Colonization and development of oribatid mite communities (*Acari: Oribatida*) on post-industrial dumps. Print. Uniwersytet Śląski, Katowice, pp. 207.
[53] *Inter alia* it is the assessment of the Members of the European Parliament in "The report of the European Parliament on the proposal for a directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC (COM(2006)0232– C6-0307/2006" of 24 Oct. 2007.
[54] Soil Atlas of Europe, European Soil Bureau Network European Commission, 2005.
[55] *Inter alia* Prof. Herman's data from the University of Technology and Life Sciences in Bydgoszcz indicates that 1% of humus can accumulate up to 150 tons of water.

live organisms,[56] which is an invaluable reservoir of genetic variability. However, the knowledge of these organisms, particularly concerning their mutual relations and influence on the yield and quality of crops is still relatively low. It is a paradox that there is a lot more information about the impact of fertilizers and pesticides on the yield (especially volume) in plant production despite knowing about their destructive effects on the ecosystems and human health.

5. Application of probiotechnology benefits crop production and maintains soil functions

Around the globe, interest in making use of the probiotic properties of microorganisms has been growing for a long time. It derives from the increasing knowledge about the degeneration of the ecosystems, its causes and the dramatic consequences of this process as well as the increasing awareness of the disastrous consequences of using chemicals for all life on Earth. The theoretical foundations and practical use of microorganisms are related to the Japanese scholar **Professor Teruo Higa**. He is the author of the concept of Effective Microorganisms (EM) and the concept of the so-called EM technology used by a large number of farmers-ecologists and people involved in environmental protection. Prof. Higa's ideas have already gone beyond the strict confines of science and become a sociological phenomenon around the world. Prof. Higa's concept of human life lived in peace and harmony with one's self as well as with nature in this ever-changing world has a huge group of supporters[57].

The beneficial effects of using the composition of probiotic microorganisms in agriculture have been indicated in a growing number of scientific papers as well as in practical implications of their use by farmers. Studies abroad have been undertaken on a wide range of topics. There are studies devoted to the use of beneficial microorganisms in combination with organic fertilizers,[58] effects on growth, photosynthesis and yield of sweet corn[59] or on the physiological characteristics and yield of peanuts.[60] North Carolina Agricultural And Technical State University in the USA published an important review paper in 2012.[61]

Studies of the impact of microorganisms on crop yield and soil condition are also undertaken, although on a relatively small scale, by Polish research institutes and universities. The study assumed by IUNG[62] revealed that the use of the EM-A preparation **increased yield of spring rapeseed by 4-13%** as well as **increased the amount of biologically available phosphorus in the soil**, both in the soils rich and poor in this element; increased the **enzymatic activity of the soil**, and increased the biomass of microorganisms, both in rich and poor soils.

In the study of the soil under wheat, the cellulolytic bacteria population was seven times greater and the population of cellulolytic fungi doubled. In tests using formulations based on humic acids (a group of biostimulators) it was established that humic acids (HAs) have a direct impact on plant cell membranes, causing increased permeability and thus resulting in more efficient transportation of minerals to metabolically active areas. Finally, treatment of winter rapeseed of Adriana varieties with preparations containing humic and fulvic acids (FAs) increased the germination of seeds[63].

Study conducted at the University of Life Sciences in Lublin asserted that the application of probiotic microorganisms and fermented plant extracts in the protection of hops against pests is ef-

[56] Soil Atlas of Europe, European Soil Bureau Network European Commission, 2005. There are also estimates that indicate existence of 15-20 tons of only microorganisms on such area.

[57] Russel, Stefan, 2003. Biodiversity and its meaning in ecosystems functioning. The 38th International Microbiological Symposium. SGGW Rogów k/Łodzi 2003.

[58] Yamada, K and Xu, H., Properties and Applications of an Organic Fertilizer Inoculated with Effective Microorganisms. Journal of Crop Production. 3(1) June 2001. pp 255–268.

[59] Among others: Xu, Hui-Lian. Effects of a Microbial Inoculant and Organic Fertilizers on the Growth, Photosynthesis and Yield of Sweet Corn. Journal of Crop Production. 3(1). June 2001. pp 183–214.

[60] Yan, P.S. and Xu, H.L. Influence of EM Bokashi on Nodulation, Physiological Characteristics and Yield of Peanuts in Nature Farming Fields. Journal of Sustainable Agriculture. Vol. 19, 2002, pp 105–112.

[61] Song D. et al., 2012. Recent Application of Probiotics in Food and Agricultural Science. In "Probiotics," book edited by Everlon Cid Rigobelo, Published: 3 Oct. 2012 .

[62] "Definition of production and ecological effects of EM-A preparation in cereals and rapeseed cultivation – research report," Puławy, November 2003.

[63] Rutkowska, Agnieszka, 2013. Tajemnice biostymulatorów. http://www.farmer.pl/ (The secrets of biostimulators).

fective in all phases of plant growth[64]. Research conducted at the University of Warmia and Mazury[65] showed beneficial effects of the use of beneficial microorganisms on soil structure parameters, levels of biologically available phosphorus in the soil and colonization of earthworms. At the same time, there was a 12% increase in corn silage yield. Experiments with potatoes done at the University of Natural Sciences and Humanities in Siedlce (randomized block design, with three replications) where UGmax microbial preparation (soil fertilizer) was used, showed an average increase in yield of 30-47,9% and also a positive effect on the yield structure (increased share of large tubers)[66].

Prof. Lidia Sas Paszt from the Institute of Horticulture in Skierniewice leads a specialized study which is important for the development of biologization in agriculture, first in Poland and then in Europe. The research project is called "EkoTechProdukt" and is carried out within the theme "Developing innovative products and technologies for organic cultivation of fruit plants" (www.insad.pl). The project is implemented by a consortium consisting of two partners, the Stefan Pieniążek Institute of Pomology and Floriculture in Skierniewice and the Medical University of Łódź. The project involves a subcontractor, the Institute of Plant Protection in Poznań, as well as Warsaw University, Warsaw University of Life Sciences, and Koszalin University of Technology. Under this project, Europe's first SYMBIOBANK will be created, where strains of beneficial bacteria and symbiotic mycorrhizal fungi will be isolated, identified and characterized. These can later be used in bio-preparations for plant production.

Recently, there have been some **review papers** published in Poland concerning the benefits of applying microorganisms. A review of the Institute of Pomology and Floriculture in Skierniewice includes information about the beneficial use of effective microorganisms (EM - Effective Microorganisms) in the cultivation of agricultural crops, industrial crops, fruits, vegetables, medicinal and ornamental plants[67]. The EM bio-preparations have a broad spectrum of action affecting the plant environment in a comprehensive way. As a result, they can be applied to the seeds, foliarly and to the soil. In many plant species, it has been found that EM bio-preparations have a potential of inducing plant immunity, increasing yields and protecting plants. The positive effects of introducing beneficial microorganisms to the soil, such as humus-forming activity and regulating biotic soil relations have also been indicated in another review paper of that Institute that regarded the application of probiotechnology[68].

The review paper of the University of Natural Sciences and Humanities in Siedlce offers many examples of the beneficial effects of bio-preparations. Their use can bring significant increase in the yields of some vegetables, grasses and cereals as well as improved plant health by increasing the resistance to soil pathogens, thereby increasing the consumer quality of crops.[69]

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64 Solarska, E. Dobre praktyki rolnicze w produkcji integrowanej z zastosowaniem pożytecznych mikroorganizmów w uprawie chmielu. Warszawa 2012. (Good agricultural practices in integrated hop cultivation using beneficial microorganisms. Warsaw 2012).

65 Tyburski, Józef and Łachacz, Andrzej, 2008. "Efektywność środków ulepszających gleby ciężkie w gospodarstwach ekologicznych". Sprawozdanie z prowadzenia w 2008 r. badań podstawowych na rzecz rolnictwa ekologicznego w zakresie upraw polowych metodami ekologicznymi. (Tyburski, Józef and Łachacz, Andrzej, 2008. "Efficiency of heavy soil improvement means in ecological farms." 2008 Report from the implementation of basic research on ecological agriculture using ecological methods in field cultivation).

66 Zarzecka, K. and Gugała, M., 2012. Plonotwórcze działanie użyźniacza glebowego UGmax w uprawie ziemniaka. Inżynieria Ekologiczna Nr 28, 2012. (Zarzecka, K. and Gugała, M., 2012. Crop-yielding effects of soil fertilizer UGmax in the cultivation of potatoes. Inżynieria Ekologiczna Nr 28, 2012).

67 Janas R. 2009. Możliwości wykorzystania efektywnych mikroorganizmów w ekologicznych systemach produkcji roślin uprawnych. Problemy Inżynierii Rolniczej nr 3/2009 (Janas, R., 2009. Possibilities of effective microorganisms application in ecological systems of plant cultivation). Problemy Inżynierii Rolniczej nr 3/2009.

68 Grzesik Mieczysław et al., 2012. „Biologiczne i fizyczne metody stosowane w produkcji i uszlachetnianiu nasion." Journal of Research and Applications in Agricultural Engineering 2012, Vol. 57(3) (Grzesik, Mieczysław et al., 2012. Biological and physical metods of seed production and processing. Journal of Research and Applications in Agricultural Engineering 2012, Vol. 57(3).

69 Truba, M., Jankowski, K., Sosnowski, J., 2012. Reakcja roślin na stosowanie preparatów biologicznych. Ochrona Środowiska i Zasobów naturalnych nr 53, 2012 r. (Truba, M., Jankowski, K., Sosnowski J., 2012. The plants' reaction to biological preparations treatment. Ochrona Środowiska i Zasobów naturalnych nr 53, 2012 r.)

Attention was drawn to bio-preparations in the cultivation of various plants that are diverse and do not always lend themselves easily to evaluations. For this reason, more research is needed. In 2003, Prof. Lesław Badura pointed out that the *Pseudomonas fluorescens* bacterium might have different properties depending on its location and that the *Amanita muscaria* fungus has a varying sensitivity to external factors[70]. Thus, soil microorganisms may be present in different environments and serve different functions.

Papers from the International Microbiology Symposium in 2003 contain numerous reports and studies on beneficial microorganisms and their practical use in agriculture.[71] Also, papers from the latest conferences held in Poland contain similar reports within the broader theme of biologization of agriculture.[72] There are also numerous articles about the use of beneficial microorganisms in agriculture in Polish trade newspapers and magazines.[73]

In light of these studies and reports, probiotechnology should be considered as innovative and worthy of support at EU levels, as well as in Poland.[74]

6. The use of beneficial microorganisms in the HEALTHY EARTH Movement

SCD Probiotics Technology, which was developed by Mr. Matthew Wood, M.Sc., student of Prof. Teruo Higa, author of the pioneering concept of using compositions of beneficial microorganisms in the development of sustainable agriculture—is used in 47 countries,[75] including in Poland, by more than 20,000 participants of the HEALTHY EARTH Movement (Fig. 1). HEATLHY EARTH is a socio-economic movement whose goal is to build lasting relationships with probiotechnology users - including those applying probiotechnology to grow crops—and to promote farming methods based on natural biological tools in order to prevent the degradation of ecosystems. The movement was initiated by EcosystEM - Nature's Heritage Association, which was established in 2005 with the aim of promoting the biologization of agriculture. The Association is guided by the motto "Healthy Earth and its inhabitants". HEALTHY EARTH Movement encompasses several entities, including ProBiotics Polska™ as the exclusive representative in Poland of SCD Probiotics®, LLC, Kansas City, USA. ProBiotics Polska™ promotes, produces and implements probiotic products in Poland, as well as assures quality compliance of the procedures. In Poland, there are already numerous reports from farmers who are pleased with the multiple benefits of the probiotic products they use.

Table 1 presents a general overview of the benefits noted by the participants of the HEALTHY EARTH Movement who are users of bio-preparations based on the composition of probiotic microorganisms. The data does not come from peer-reviewed sources or experiments documented according to the requirements of scientific experiments, but is based on the results observed by farmers. Analyzing causes of these results is a task for Polish agricultural science and at the same time an opportunity to create effective partnerships for innovation proposed in the new CAP.

Inoculation of plants with beneficial fungi is easier, more effective and cheaper than GMOs[76]. As it was discussed before: "*Increasing the plant's productivity through the use of its own microbes can bring better results in many different ways*"[77]. We present detailed data for one of the users of

[70] Badura, Lesław, 2003. Biodiversity and its meaning in ecosystems functioning. The 38th International Microbiological Symposium. SGGW Rogów k/Łodzi 2003.

[71] The 38th International Microbiological Symposium. SGGW Rogów k/Łodzi 2003.

[72] „Biologizacja warunkiem zdrowego środowiska i ekonomicznego rolnictwa". Materiały pokonferencyjne. Toruń 25.03.2013 r. (Conference materials "Biologization as a necessary condition for a healthy environment and cost-effective agriculture." Toruń 2013).

[73] As AGRO-SERWIS, MPS Sad, Tygodnik Poradnik Rolniczy and other.

[74] *Inter alia* it would be helpful to include it in climate and energy policy within The National Programme for Low Emission Economy Development.

[75] Wood, Matthew, 2012. Nie bójmy się zmian. W „Uzdrowić Ziemię". Warszawa 2012 ("Let's not be afraid of change" in "Uzdrowić Ziemię" album. Warsaw 2012).

[76] Opinion of Mary E. Lucero, biologist in the research center Jornada Experimental Range in Las Cruces, New Mexico, USA Agriculture Department.

[77] Tennesen, Michael. Świat Nauki nr 6 (226) 2010 r. **(**Michael Tennesen. Science World No 6 (226) 2.010).

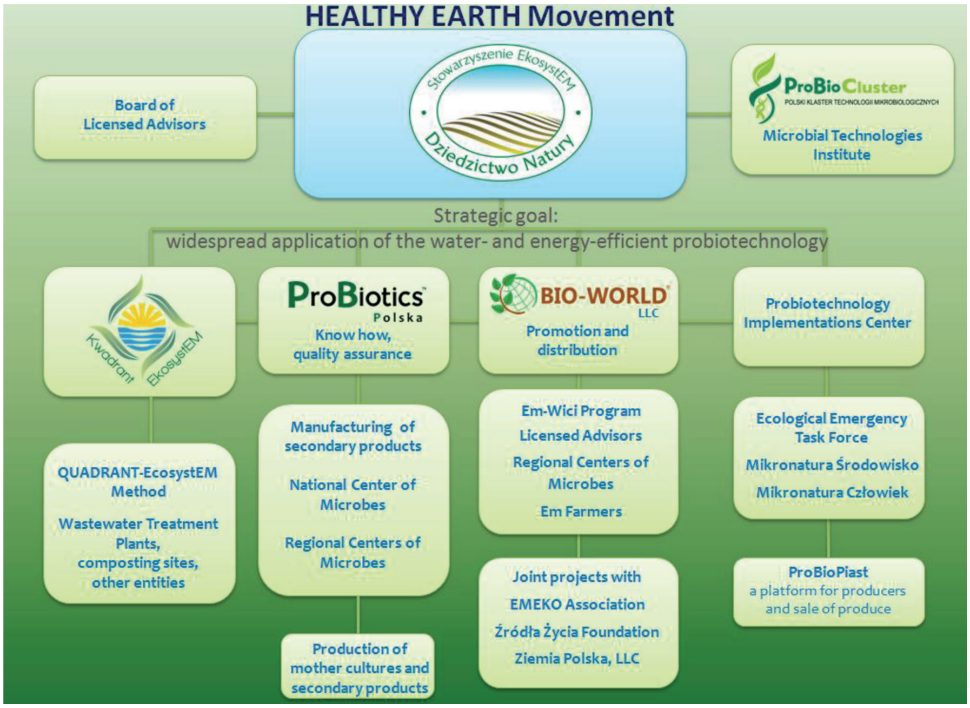

Figure 1. Structure of HEALTHY EARTH Movement

probiotechnology. It shows an increase in the bioavailability of phosphorus and potassium after 5 years of using the composition of beneficial microorganisms (such results were also confirmed by the study conducted by Dr. Gotthard Stielow[78]). This data is interesting in that it shows benefits in a cultivation of crops that heavily exploit the soil of low valuation class (Table 2). This data comes from the Agricultural Experiment Station in Chylice[79] with 10 years of experience in the application of the composition of beneficial microorganisms.

Total cultivated area: 440 ha, including 200-220 ha potatoes for chips and 220-240 ha seed corn, most of the area belongs to the fifth and sixth class of soil valuation, being of the lowest quality in Poland. After a few years of applying beneficial microorganisms (soil and foliar applications), the quality and quantity of yields have improved. Potato yields increased from 7 tons/ ha in 2001 to 35 tons/ ha in 2009. Although main crops grown on the farm are corn and potatoes, both burdening plants for the soil, soil **levels of phosphorus and potassium availability increased (Tab. 2) and the soil's organic matter content increased by 0.3-0.8%**.

Potatoes provided from the farm to a potato chip factory are of very high quality and for this reason for a number of years now Mr. Jan Marczakiewicz has been among the manufacturer's leading suppliers of potatoes. The improvement of soil quality and crop yields was brought about not only by direct application of microorganisms, but also by the use of additional methods of biologization

[78] Żyzna gleba nie wymaga nawożenia Raport Rolny nr 2/2003 (Fertile soil does not need fertilization. Agricultural Report No. 2/2003).

[79] Similar proved effects are available in Brody Experimental Station of Poznań University of Life Sciences, Demonstration Farm of the Agricultural Advisory Center Wielkopolska, Ecological Farm of Grażyna and Mirosław Serafinowicz in Grabina, municipality Dąbie – laureates of 1st place in Ecological Farm Competition, category commercial farms in Wielkopolskie Province, Urszula and Kazimierz Kossakowscy AgroGreen Farm - participant of the project implemented by ProBiotics Polska within measure 1.4. "Preparation and implementation of a bacterial culture prototype for feed to improve broiler well-being and production results" (www.kosakowscy.pl) and many others.

Table 1. Reports on the benefits of using compositions of probiotic microorganisms

Probiotics user	Cultivation	Main benefits and remarks	Source of information
Marek Brunka, farm owner in Pawłów, Kaszuby region, specialization: fruit orchards, cereals and rapeseed cultivation	Rapeseed, fruit orchards	Higher yields of rapeseed and its better quality (in dry periods), possibility of spraying treatment during rainfall. Elimination of chemical plant protection and fertilizers, which gives approximately a 50% reduction of costs. 30% reduction of microelements treatment in the orchard. First year of probiotics use in the orchard is the most expensive (restoration of soil microorganisms).	Article "To one nas znalazły" ("They have found us") in "Uzdrowić Ziemię" album. Warsaw 2012.
Jan Marczakiewicz, manager of a 500 hectare Agricultural Experiment Station RZD Chylice	Potatoes, corn	Improvement of potatoes and corn yields and their quality. Increase of phosphorus and potassium availability, higher content of organic matter in soils.	"10 lat doświadczeń w stosowaniu kompozycji pożytecznych mikro-organizmów w gospodarstwie rolnym RZD SGGW w Chylicach" - pisemna informacja z 09.02.2011 r. ("10 years of experience in beneficial microorganisms compositions at the farm of the Agricultural Experiment Station RZD Chylice," Warsaw 9 Feb. 2011) together with analysis of data concerning soil analysis in 2006 and 2011 - written infomation of 9.02.2011.
Jolanta Myszkowska	Cereals	Faster germination of seeds after probiotic inoculation. Plants are healthier and more resistant to drought, have a brighter color and no color defects. Higher yields of grains and straw. Better soil structure and no stagnant water. Higher cereal production due to elimination of chemical plant protection and reduction of fertilizers use.	Higher yields and healthier plants - information as of June 2013.
Antoni Pieprzyk, owner of the PIEPRZYK Group of Agicultural Companies	Rapeseed, wheat	Comparative experiments on 350 hectares of rapeseed and 500 hectares of wheat to measure the efficiency of probiotics and fungicides in maintaining plant well-being. In wheat cultivation, probiotic inoculation of seeds and soil prevented soil from crusting (it was observed in traditional cultivation with the use of chemical treatment and fertilizers), improvement of soil structure and its fertility, which enables earlier plant vegetation and rich plant growth.	Article "Nowa jakość postępu" ("New quality of Progress") in "Uzdrowić Ziemię" album. Warsaw 2012.
Tomasz Piskier, Koszalin University of Technology, Department of Agricultural Engineering	Spring wheat	Increase in grain and straw yield of spring wheat by approximately 23%, increase in the elements of its structure and biometric characteristics of the crop	"Reakcja pszenicy jarej na stosowanie biostymulatorów i absorbentów glebowych" ("Reaction of spring wheat to the application of bio-stimulators and soil absorbents"). Journal of Research and Applications in Agricultural Engineering 2006, Vol. 51, no 2, pp. 136-138.
Tadeusz Walkowiak, agronomist in the PIEPRZYK Group of Agicultural Companies	Rapeseed, wheat, potatoes, vegetables.	Replacing fungicide protection in rapeseed cultivation with probiotics. Improvement of soil structure in wheat cultivation. Reduction of agrochemicals use and soil structure improvement in potatoes and vegetable cultivation and consequently improvement of tubers and roots quality.	Article "ProBioEmy w wielkoobszarowym gospodarstwie rolnym" ("ProBioEmy in large-scale farming") in "Uzdrowić Ziemię" album. Warsaw 2012.
Kazimierz Zgoła	Plantations of rasberries, strawberries, blackcurrant, redcurrant, chokeberries and rhubarb.	High efficiency in the protection of strawberries, currants, chokeberries, rhubarb and raspberries against grey mold. mprovement of: liquid manure fermentation, soil structure, soil water capacity and its humus content. In rapeseed cultivation: foliar probiotic sprays eliminate pests such as aphids and *Coleoptera* pests. 60-80% reduction in the amount fertilizers and pesticides used (improved production profitability). Additional income due to sale of fermented liquid manure. Lower activity of probiotics at low temperatures.	Article "Rodzą nadzieję" ("They bring hope") in "Uzdrowić Ziemię" album. Warsaw 2012.

Table 2. Increase of nutrient availability after using probiotechnology in the cultivations of the Agricultural Experiment Station in Chylice in 2011 compared to 2006.

Year	Content of nutrient availabilty in w mg/100 g soil (average values)			
	ph in KCl	Phosphorus - P_2O_5	Potassium - K_2O	Magnesium -Mg
2011 (99 analysis)	6,10	**15,9**	**13,2**	5,3
2006 (95 analysis)	6,17	11,7	7,5	5,4
2011/2006 w %	98,8	**136,5**	**177,0**	98,7

Source: Roman Izdebski calculation using data provided by Jan Marczakiewicz, M.Eng. manager of the Agricultural Experiment Station in Chylice

of agriculture. These include the cultivation of cover crops (rye and mustard) and application of fermented potato waste generated in the production of chips. Potato waste is distributed with spreaders and mixed with soil. Both cover crops and crop residues of corn and potato waste, fermented with a special composition of beneficial microorganisms, are the main source of humus increase in the soil.

7. Summary

- Scientists unequivocally prove that the technological progress that has been implemented in agriculture in recent years has brought a significant increase of efficiency per unit, but has also contributed to the massive degradation of the agroecosystems including, among others, loss of biodiversity and a decrease of humus content in the soil.
- Underestimating the ancient good farming practice teaching that the most effective means of plant protection is by a biologically diverse life of the soil, has led to a dynamic development of an excessive use of chemicals in agriculture furthered with ever heavier agricultural equipment. This model of agriculture has contributed not only to the degradation of the soil and diminished its role in combating the adverse weather events, but also proved to be ineffective in protecting against pests. It is reflected in the data from the USA quoted in this article that despite more than a tenfold increase in the use of pesticides, crop losses caused by insects increased from 7% to 13%. At the same time, side effects of pesticide use are more than 10 times greater than "profits" from their use.
- Human-induced changes in the agroecosystems leading to loss of soil sorption, largely contribute to increasing losses caused by floods and fires-solely in 2003, the losses caused by floods and fires in the world amounted to about $70 billion. Therefore, a fertile soil, rich in organic matter and humus can be considered to be the first flood protection.
- The current agricultural model is not able to meet the food needs of a growing human population, as confirmed in an IAAST report commissioned by the United Nations and the World Bank.
- Legal regulations prefer solutions based on the paradigm of treating the effects of the degradation of the agroecosystems with chemical methods. Meanwhile, it is the chemical methods that have contributed to the current state of the soils. The research of Prof. Lidia Sas Paszt of the Institute of Horticulture in Skierniewice, proved that each time the soil is treated with agrochemicals it causes stress to its microbial ecosystem. There is therefore a need to change this paradigm to a paradigm of tackling the causes of this situation on the basis of natural regulatory mechanisms in the soil that have been formed by nature over millions of years.
- The use of these mechanisms can be achieved through probiotechnology as a tool for the biologization of agriculture. Its multiple benefits, both environmental and economic, have been indicated in an increasing number of studies, and in the practical applications of tens of thousands of farmers in Poland. An increasing number of similar experiences is confirmed by studies throughout Europe.
- A popularization of this method requires detailed studies and changes in the distribution of financial support from the new CAP. Opportunities offered by the integrated pest management and the

European Innovation Programme are not substantial enough considering the degradation of the agroecosystems and its impact.

- It is necessary to improve the legislation at the EU level, including greater consistency of the legislation so as to effectively stimulate the implementation of measures to combat environmental degradation, and, above all, help revitalize the soil and water.
- One of the methods for improving existing regulations is to promote and implement biologization in agriculture through probiotechnology as its major tool.
- There is an urgent need to intensify research on the soil coordinated at the EU level. Such research should also include the role of microorganisms in fulfilling the soil's many functions, including the fact that they provide nutrients to plants. There is also a need to review the well-known definition of the soil which currently exposes only its physical and chemical properties, towards a definition that encompasses also the soil's biology.
- It is advisable to develop verifiable methods of assessing the humus content of the soil that would also account for microbial activity. Additionally, it is recommendable to increase the intensity of research on the effects of the different agricultural technologies on the humus content.
- We should strive to reduce the excessive use of chemicals in agriculture which has led to a radical decrease of the natural fertile power of the soils.
- In the context of the decline of the humus content in the soils in the EU it would be desirable to introduce financial support in recognition of maintaining an increased humus content.