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Perspectives of the Application of Innovative Environmental Biotechnology for Sustainable Development of Co-Operating Regions**

The concept of sustainable development assumes sustainable management of natural resources and energy, together with the improvement of the quality of human environment and the quality of life for the whole society. The pioneer of this concept on a European scale was the former rector of the AGH University of Science and Technology – Prof. Walery Goetel (1889–1972). For this concept he created scientific premises – by proposing the **integration of natural, technical and socio-economic sciences** in the framework of so-called **sozology**, and technical premises – by the integration of different technologies within so-called **sozotechnics**. The foundation of this concept was care for human right to live in healthy conditions. This kind of concept was contradict to wasteful exploitation, because assumed that exploitation of natural resources by the people living now must not reduce these resources or diminish the quality of life for generations.

Prof. Goetel actively participated in the development of **international co-operation**. A symbolic sign of approval for his concept was the acceptance by the General Assembly of the International Union for the Conservation of Nature (**IUCN**) Edinburgh in 1956, the change of the name of this organization into the International Union for the Conservation of Nature and Natural Resources.

At present the concept of sustainable development is recommended by the General Assembly of the United Nations, as well as in present programs of the European Union. Two years ago **UNESCO announced the Decade of Education for Sustainable Development in a global scale**. It should be reminded that over 50 years ago Prof. Goetel initiated **the Open Seminar on** the Protection of Nature and **Securing Sus-**

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** This paper was financially supported by grant Badania Statutowe at Faculty of Mining Surveying and Environmental Engineering AGH in 2008.

tainable Use of Natural Resources. The seminar had interdisciplinary character and the information on subsequent sessions was systematically presented to mass media. This was a democratic form of informing the local society by experts on the most important environmental problems and – at the same time - the opportunity to discuss the limitations of harmful impact of mining and industrial pollution to environment.

To modernize traditional and narrow-oriented model of environmental education at universities, following Prof. Goetel's ideas, I initiated **the training of students in solving concrete environmental problems in a system way**. The training was carried out in all the study areas such as technology, natural sciences, socio-economic sciences and other sciences. The problems included **human environment of selected regions and solving them in a co-operation with local community**. With the participation of leading experts I organized an introductory seminar that combined the training referring to complementary aspects of the biosphere protection with the application of the newest achievements of technology and care about the protection of endangered species of animals and plants being European symbols (such as the European bison *Bison bonasus* or edelweiss *Leontopodium alpinum*) with the promotion of sustainable development and eco-tourism for more effective protection of the regions of greatest natural values such as national parks.

Prof. Goetel, referring to the Summer Schools „Man and Environment" (organized since **1968**), said: „The academic youth are leading in the conservation of environment both for the benefit of people living at present and for future generations". I presented methodical experience from these schools at the 1st International Seminar in the Palace of Nations in Geneva in the end of 1971. The seminar was on the participation of university students in the preparation for the First UN Conference „Man and Environment" in Stockholm. In 1972, in Poland, I started a series of International Summer Schools on Sustainable Development.

In 1975 at the 1st International Congress on the Human Environment (HESC) in Kyoto I presented the talk on the actions combining new achievements of science and technology with more efficient prevention of environmental threat (risk factors) for the society. At the same time the Science Council of Japan started the activities leading to the present Kyoto Protocol and **world-wide co-operation to prevent global warming**. The sign of international solidarity was, among others, my participation in the scientist's aid to the victims of Minamata disease in Japan and Bhopal disaster in India.

In 1980, in the framework of NGO – the Polish Ecological Club (PKE) I proposed the modernization of the education on human environment at all the universities in Poland and also **the integration of formal and informal training within the whole education system – from kindergarten to postgraduate studies**. The goal of such education was to include knowledge-based society in the democratisation of the decision process and solving the problems of human environment on local scale. Also in the framework of the Polish Ecological Club, Prof. Andrzej Manecki and other

scientists of AGH-UST organized a series of discussion meetings of experts with the society. The result was a significant limitation of environmental pollution and risk for the residents of Krakow and the World Culture Heritage monuments in this city. At that time the pollution was connected with the use of outdated technologies by the largest industry enterprises in Poland.

After the end of the marshal law and with the beginning of system transformations in Poland (1989) the Rector and Senate of AGH-UST accepted my proposal to start the **Technical Open University of the AGH University of Science and Technology (TUO AGH). For over 18 years this University has been contributing to the implementation of the idea of open knowledge-based society and has been helping people of different age to use the progress of different scientific and technological areas for the improvement of the quality of life**. It was not accidental that the series of lectures started with the lecture by Prof. Anna Jankowska-Kłapkowska and me dealing with the Brundtland Report „Our Common Future". The aspect of sustainable development has been systematically developed by specialists of different Polish universities and research centres. In this transmissiotion of knowledge to the society we also collaborate with school teachers and mass media.

The meeting of experts and decision-makers in the framework of the International Workshops: "Environmental Science, Technology and Politics – Experience and Perspectives" was very important in the exchange of useful experience for the promotion of sustainable development. This meeting was held 4th and 5th May 2004 in Gdansk, shortly after the acceptance of 10 new members to the European Union. Many officials on ministerial level attended the meeting. My presentation was a review of the AGH-UST experience in complex research for **the promotion of sustainable development in mining and industrial regions** of Silesia and Krakow. The research had interdisciplinary scientific and didactic character and was combined with the implementation and training. The Director and Vice-Director of the Environmental Directorate in EU – Pierre Valette and Andrea Tilche considered this work **a good model for the European Union**.

Our team carried out **interdisciplinary studies** e.g. in the areas of the biggest steelworks and mines, on the sources of air, water and soil contamination and their direct and indirect effects for natural environment and health of the employees and residents. Not only did we apply different methods of classical environmental monitoring, but also new sensitive methods of early detection of environmental threat with the application of biological monitoring (among others, the application of computer image analysis by one of my former Ph.D. student – Dr. Piotr Lewicki and Ph.D. student Robert Mazur based on higher sensitivity of early development of different elements of aquatic ecosystems).

I have also initiated permanent co-operation with medical doctors and specialists in the management of industrial areas (including agriculture and farming) to

carry out complex studies in human ecology and eco-toxicology. The purpose of this interdisciplinary co-operation was **more efficient prevention of health hazard caused by the pollution** of air (in the place of residence), drinking water and (in particular) food chain. The results of the studies and concrete practical proposals were always sent to end-users (e.g. industry, medical teams, administration, etc.). The information on the existing threat to human health and the ways to prevent them was also sent to the residents. Preventive measures not only referred to the modernization of production technology, but also land reclamation and changes in the structure of land use in some areas (e.g. replacing vegetable cultivation or meadows with industrial plantations). The goal was the improvement of the state of environment and quality of life for local communities, as well as the development of knowledge and research techniques. These are also priorities of the present European programmes, in particular **the 7. Framework Programme of the European Commission (in particular 7.6 on Environment)**.

The meeting in the framework of consultancy with the scientists and experts of NGO, referring to the National Plan of the Development in Poland up to 2013 was held in Lodz in 2005. At this meeting I proposed as the main purpose of this plan the application of the good practices of Polish teams and teams from other countries in sustainable development and primary prevention of environmental threat to human health and objects of great natural or cultural values. We hope that good Polish tradition in this field will be duly represented and consistently implemented in this programme, regarding sustainable development a priority of the policy of the European Union.

We have good experience in different European projects. **An example can be the interdisciplinary project based on the co-operation of 19 universities situated in river regions of the EU (inhabited by about 1.5 million people), including the Vistula region in Poland, represented by AGH-UST. The goal of the project was the model implementation of sustainable development (including the flood protection and the promotion of eco-tourism). This co-operation, combined with the exchange and dissemination of experience useful in similar regions and in different EU countries. The project was based on the INTERREG III C funds, within the Union des Terre de Rivičres.**

Another project called Smart History was connected with the programme CULTURA 2000 and its task was make a model of the co-operation of experts of different disciplines with the stakeholders from the areas of particular natural and cultural values for the promotion of their sustainable development. The example was the Cinque Terre National Park in Italy. Our experience in the interdisciplinary co-operation of professors, junior academic staff, Ph.D. and undergraduate students from different countries with local community was very useful in the carrying out of this project. The experience in environmental

education both for the residents of the protected regions and tourists was also important.

Also three International Workshops on sustainable development in historic cities, organized in Florence and the 11th International Conference on European Co-operation for Sustainable Development and Eco-tourism Euro-Eco 2006 in Krakow are worth continuation. The next International Conference in this field is expected to be held in Florence in cooperation with the Del Bianco Foundation in 1st half of July 2008.

Another field where we have a very good experience are post-diploma studies promoting sustainable development (including the co-operation of decision-makers, engineers, medical doctors, teachers etc.). New perspectives can be seen in the use of electronic information sources (including our international e-book on sustainable development). A particularly valuable contribution is the book of the former rector of AGH-UST Prof. Ryszard Tadeusiewicz on **the Internet and knowledge-based society**. Very useful for the promotion of sustainable development were the experiences and materials from **eleven International Conferences on Sustainable Development organized by our team in 1989–2006** [6] and novel concepts of the Chairman of the Polish Engineers in Germany Prof. Anton Stasch. The lead to the application of modern technologies for the improvement of the state of environment in particularly degraded areas and the reduction of unemployment in Poland by the creation of new jobs (especially for the graduates of universities). Prof. Stasch runs training on practical in practical aspects of the European projects (e.g. in the Leonardo da Vinci programme), with a particular attention to the Internet use. I think that it is one of more perspective directions of co-operation in modern training of experts.

These trainings should refer to the implementation of innovative laser biotechnology for the increase of the production of biomass and bioenergy, as well as economic analysis of alternative energy sources in the aspect of ecological and technological actions for the improvement of the state of environment and sustainable development in industrial regions e.g. Silesia [3, 10, 11, 14]**.**

These problems should be seen in the context of present priorities in the **European Union** and **energy policy in Poland until 2025. The basic document is the Resolution of the Polish Council of Ministers of 4th January 2005.**

Basic objectives of this policy include:

- energy safety of the country,
- the increase of competitiveness of economy, in particular by the increase in energy efficiency,
- effective protection of environment against negative side effects of producing, transferring and using electric energy and fuel distribution.

Polish energy policy is also stated in the Enactment by the Minister of Economy and Labour of 1st July 2005 (Monitor Polski 22.07.2005). It recommends the ad-

justment of Polish energy industry to the conditions of the functioning in EU, in particular producing inexpensive and high quality energy. The energy structure in Poland should be adjusted to the arising in the European Union uniform market for the market of electric energy and gas. Apart from the diversification of energy supply (e.g. recently the government of Poland bought a gas field in Norway), environmental safety becomes more and more important.

The limitation of negative impact of energy industry is also crucial for the improvement of the environment in Europe and all over the world. The progress of knowledge obtained during years-lasting large international research programmes provides new scientific proofs that the life span of residents living in polluted areas is shorter and health status is worse. This also refers to energy industry and traffic making threat to biological diversity and landscape. These factors, together with wrong decisions in the localization of some roads, make it more difficult to fulfil the obligations of EU member states in the reali- zation of the NATURA 2000 Programme. The deposition of wastes becomes greater and greater problem on a regional scale. A pro-environmental energy policy assumes the reduction of the amount of wastes and the demand for water. According to the report of the Main Statistical Office on the Protection of Environment and Water Management, hot water from thermal power plants make the highest volume of sewage, negatively affecting the functioning of fresh water ecosystems.

Another problem is the release of large quantities of salt waters from coal mines and ore mines in the rivers of Silesia. In the limitation of the process of soil and water acidification on international scale it is important to reduce the emission of acid anhydrides (SO_2 in particular) in energy sector.

In the context of growing participation of the European Union countries in global co-operation for the protection from climate changes, it is more and more important to limit the emission of green house gases. The greatest meaning has the diminishing of CO_2 concentration in atmosphere, regarded main factor of global warming. The increase of the participation of oil in the structure of energy sources is diminishing CO_2 emissions. However, according to present expertises by the International Energy Agency, there is a tendency to make European and world economy more and more dependent on insecure supplies from several politically unstable countries. Similar situation refers to natural gas, where the half of world resources are situated in Russia and Iran. This expertise predicts the doubling of the demand on electricity and fuel sooner than by 2030. The growth of demand for oil and gas would be relatively lower if the measures leading to energy and fuel saving are implemented in industry, heating, lighting and transport. Both in Central Europe and many other world regions, electric energy is mainly produced from hard coal and lignite. In this context, for the prevention of global warming, the importance of the integration of ecological criteria with technologic and economic criteria is growing.

International consensus is necessary for effective prevention of global catastrophe. This should refer to such macroeconomic market mechanisms and legal regulations that would promote the principle of sustainable development. A good example of the promotion of renewable energy sources and technologies diminishing the use of energy are annual international meetings of experts in Wals. In my opinion also a good example of comprehensive activities for the improvement of the state of environment is the related to this issue consensus of all the political parties in the Austrian Parliament. This effects in the stability of the promotion of sustainable development, regardless changes in ruling powers. The co-operation is also important on local and inter-regional level. This includes cutting down the emissions of hydrocarbons, CO, VOC and suspended particles as well as CO_2 in energy and transport.

The fulfilment of international treaty obligations by Poland requires the co-operation of central and local administration. This particularly refers to the **promotion of market mechanisms stimulating the development of renewable energy sources (RES). Worth approval are political decisions made in 2006 at the highest level of the European Union, assuming the co-operation of all the member countries so that the participation of renewables by 2020 is 20 per cent in the EU scale. The increase in the participation of renewable energy sources will diminish negative impact of energy sector on natural environment.** Thus their promotion should get adequate financial scientific and technical support. Restructuring of energy sector to minimize negative impact on environment requires consistent and economically justifiable strategy. The co-operation between the Ministry of Environment and Ministry of Economics. Polish membership in EU, according to the Directive 2001/80/EC, requires energy policy reducing the emission of CO_2, SO_2, NO_x and suspended particles. The application of clean coal technologies is very promising. It is also recommended by the World Coal Institute in London and European Environmental Agency.

The use of local sources of renewable energy increases energy and environment security on regional scale. This requires the integration of planning, organization, coordination and constant supervision and control. In Poland the local administration is responsible for meeting local needs in energy and **using local renewable energy sources. As far as heating systems are concerned, it is recommended to extend the co-operation between administrative units by 2025 (regarding the growing participation of RES).**

A positive phenomenon is the fact that more and more diploma students of environmental engineering are writing their Master's theses on the concept of sustainable development of different communes (Polish: gmina). This includes the application of environmental biotechnology to increase the production of biofuels and bioenergy. The Göteborg Strategy accepted by the European Conference on Human

Ecology recommends changes in the way of thinking. It includes a new model of production and consumption to create sustainable regional communities able to more efficient management of natural resources. It also recommends innovations in technical and social sphere.

There are complementary experiences of a Polish team lead by Prof. Juliusz Kulikowski in the application of system analysis in the environmental protection and of a German team lead by Prof. Hans-Dietrich Haasis in the operation studies for the promotion of sustainable development in regional administration and firms. I think that also useful in the limitation of negative environmental impact from mining and metallurgy can be the results of the research by many experts from the AGH University of Science and Technology in Krakow, including the founder of the Institute of Environmental Management and Protection - Prof. Tadeusz Skawina. Prof. Skawina received the Goethes' European Prize for his achievements in land reclamation of mining areas. It is necessary to make modern scientific and technological infrastructure (including well managed databases) to increase the efficiency of common action.

Based on the mentioned above premises I am convinced that mutual intention of co-operation in three border regions of the Czech Republic, Germany and Poland for sustainable development **can set a good model** for other regions of the **European Union**. **It requires joint good will of local communities and decision makers and better innovative scientific and technical solutions.** In the climate of Central Europe, and these regions in particular, it is important to **increase biomass production**, combined with more efficient prevention of health hazard, air pollution, soil pollution and water pollution. In the conditions of contaminated environment food production (farming or agriculture) should not take place, because this poses threat to the health of consumers. The alternative form of land management should be the development of the cultivation for industrial purposes and so-called energy plantations. According to the requirements of sustainable development, **health-oriented environmental actions combined with the effective management and the implementation of best available technologies are necessary.**

Based on the results of long-lasting research with my Ph.D. students and diploma students, I am convinced that laser biotechnology can be useful in practice. Different species of plants are irradiated with a laser light. Respective algorithms of irradiation can increase the resistance to pollution and speed of growth. This will make these plants more suitable in the management of contaminated areas. A proper way of laser photostimulation of seeds and cuttings of plants can be applied in the co-operation of border regions in Europe.

This method will increase the efficiency of:

– **Reclamation of post-mining areas contaminated with heavy metals or salt, often affected by water deficit based on research of Dobrowolski, Różanowski, Jakubiak** [11, 12]**.**

- **Inexpensive methods of the wastewater treatment of in rural and recreational areas, with the use of hydrobotanical wastewater treatment stations with laser irradiated plants, e.g. reed *Phragmites australis*, duckweed *Lemna minor*, willow *Salix* sp., etc. (studies by Dobrowolski, Śliwka and others) with the application of new sensitive biological methods of wastewater treatment (Dobrowolski, Mazur, Śliwka), and bioremediation of metals and other pollutants from contaminated soils (Dobrowolski, Zielińska-Loek, Klasa, Ślązak, and others)** [4, 12]**.**
- **The acceleration of high green belts (over 2 metres high) alongside main trans-border roads to limit the propagation of harmful traffic output and noise (Dobrowolski and Zielińska-Loek) [12, 18].**
- **The increase of the biomass production on energy plantations as a result of laser photostimulation of plants cultivated in unfavourable environmental conditions e.g. on contaminated soils (Dobrowolski, Różanowski, Zielińska-Loek and others)** [4, 5, 12, 13]**.**

The increase of biomass production in the regions near thermal power plants facilitates the fulfilment of the requirement of the EU that at least 5 per cent of fuel consists of biomass. This will reduce the costs and pollution related to transport.

My team has also made experiments indicating that some photostimulation algorithms to increase biomass production by different species of fast-growing plants such as willow *Salix sp.*, *Miscanthu ssp.*, *Sida hermaphrodita*, reed *Phragmites australis* as well as potatoes *Solanum tuberosum*, maize *Zea mays*, oilseed rape *Brassica napus* and flax *Linum usitatissimum*. **This makes new premises to implement the recommendations of the European Union in the increase of biomass production for thermal power stations and cogeneration plants as well as fuel bio-components (e.g. biodiesel, methane biogas, ethanol) to limit negative effect of the development of traffic on environment and health.**

Another field of the future studies could be application of laser irradiation and electromagnetic field for stimulation of growth of moulds involved in biodegradation of some persisent pollutants of the environment [1, 3, 17].

I propose wide application of this innovative laser biotechnology for the improvement of the state of natural environment and for sustainable development in the regions of EU and contaminated regions in particular. This co-operation can lead to the formation of „European Polygons" to find more effective methods of the limitation of the most harmful for the environment local and global pollution originating from energy sector and transport. **Innovative laser biotechnology would be particularly useful. It would be very prospective to stimulate biomass production on degraded land. This can be European contribution in the help to other parts of the world to prevent global warming. My studies of laser photo-**

stimulation show that photostimulated plants can bind more CO_2 than non-irradiated plants. These methods, together with the studies of other scientific centres are complementary and the area covered by the co-operation are very useful in model application.

I also propose active participation of the representatives of regions and experts in co-operation connected with the creation of the Centre of Sustainable Development and Environmental Biotechnology at the AGH University of Science and Technology in Krakow. Creating such a Centre in the promotion of innovative of know-how), and training. It was postulated by the participants of 11th International Conference on European Co-operation for Sustainable Development „Euro-Eco 2006" [8]**.**

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