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ECOLOGICAL AND ENVIRONMENTAL CHEMISTRY

Nowadays, our human civilization existing on Earth faces a series of top importance challenges that represent direct impact on its existence and development, both industrial and social. All the natural compartments and their components are subjected to the strong and unprecedented anthropogenic influence, including lithosphere, soil, surface and ocean water, atmosphere, vegetal and animal world. Anthropogenic activities has reached such high proportions that provoke the changes in the energy (heat) balance of certain regions and planet as a whole that can affect the climate, increase of water level in oceans and seas, flooding of large areas.

Almost, all the ecosystems and natural compartments are affected by the anthropogenic pollution. Polluting chemicals and industrial wastes released in the environment, modify the chemical-physical parameters of habitats, chemical composition and structure of biocenosis, interfere into the natural circulation of substances in biosphere, render negatively impacts on biota and natural self-pollution processes. They penetrate in water, foodstuffs, forages, affecting the living organisms and human health.

Therefore, the vital necessity appears in deepening the studies of the commercially produced chemicals and materials, because it became obvious that there are the direct relations between the changes in environment and anthropogenic impacts, extreme events that occur in nature as well as on the industrial enterprises (accidents), the permanent influence of chemicals and their transformation products on people, plants and animals. So, the new viewpoints have to be formulated and new approaches should be identified regarding the processes with involvement of chemicals and their behaviour in the environment.

The main issues that we need to resolve, mitigate or improve, include the rapid decrease and exhaustion of natural resources, first of all the insufficiency of potable water sources, limited soils available for agriculture, food quality and deficiency, to identify the new sustainable and reliable energy sources, to prevent the environmental pollution, to ensure development of industrial and humanitarian aspects of life, to defend against the cosmic threats, *etc*. People have to harmonize their relations with nature, to ensure the long-term and sustainable life of their civilization, under conditions of rapid changes in technology, sciences, social life, natural processes and permanently emerging challenges.

In the previous years of progressively increasing industrial development (XVIII - mid-XX centuries), practically no attention was paid to the danger of deliberated interference of man into the material processes occurring on the planet. Along the decades, the scientists considered the nature possessing the unlimited capacity to compensate the anthropogenic impacts. However, even centuries ago, the facts of irreversible changes in environment as a result of human activity, such as deforestation and subsequent soil erosion, have been known. It appeared that there is no scientific practice capable to elaborate the fundamentals of chemicals classification and to ensure the comprehensive study of the anthropogenic influence on biosphere. In this way, *Ecological Chemistry* was formulated as a separate science, focused on the urgent needs of the economic development and appropriate environmental impacts that had to be addressed. Thus, the *Ecological Chemistry* is one of the relatively new directions in modern chemistry. It appearance was not occasional, being a logical response to the exigent enquiry of the society, which had to settle the numerous environmental problems that had posed serious threats to the social and industrial development. Among the different types, the chemical and radioactive pollution are recognized as the most dangerous. In addition, the combined pollution with various chemicals may be accompanied with the specific forms of their interaction leading to more dangerous toxic effects on living organisms and environment.

The notions of *Ecological Chemistry* and *Environmental Chemistry* emerged in the mid-1950s, at the same time with the formation of these scientific areas, rapidly becoming important perspective directions in chemical research. This area of scientific studies seems to be among the most significant ones, playing a key role in the

modern chemistry, revealing the relations between the living organisms and the surrounding environment. This domain is very comprehensive, as compared to the other fields of chemistry and chemical technology.

The specific feature of *Ecological Chemistry* is much broader spectrum of objectives, tasks, approaches, as well as knowledge from chemistry and other related scientific domains involved, as compared to the other traditional chemistry fields. It involves various approaches, as in case of prediction of chemicals behaviour in the environment, which is impossible to do only based on the study of their physical-chemical properties and structure, as is in traditional chemistry.

For the development of the theoretical bases and experimental methods, it is relevant to estimate the long effect of chemicals on the environment. The reliable methodology of studying the behaviour of chemicals in natural and technological systems can contribute to the elaboration of effective environmental protection strategy and avoid unexpected ecological disasters or irreversible impact on ecosphere.

Ecological and *Environmental Chemistry* join the fundamental and applied research from natural sciences such as chemistry, biology, ecology and engineering, in order to study, design and apply environmental systems and technologies. The global scope of this area of research is to provide explanation of chemical processes that occur in the environment, reveal their future trends and propose measures to mitigate or avoid the negative impacts of human activity on nature [1].

The history of the *Ecological Chemistry* formation as a separate science and establishment of its fundamentals was based on the works of many outstanding scientists, which have brought their specific contributions to the development of each of the compartments of this science. As many researchers and institutions throughout the world have been involved, a great number of various definitions of *Ecological Chemistry* and *Environmental Chemistry* formulated during the last decades, offering different approaches and reflecting various views of their authors.

Thus, by definition given by the prominent German scientists, founders of *Ecological Chemistry*, **Prof. Friedhelm Korte, Prof. Mufit Bahadir** and **Prof. Werner Klein**, this research field "can be regarded as a science of chemical processes and interactions that occur in environment (ecosphere) and their impacts" [2]. According to the more detailed explanation outspoken by **Prof. Müfit Bahadir,** nowadays one of the leading scientists in this field, working at the Technical University of Braunshweig, "*Ecological Chemistry* is the science of the ecologically relevant material changes in the environment. It is an interdisciplinary research field dealing with anthropogenic consequences of human interaction with the ecosystem in a chemical way. Focus is set on *environmental chemicals*, which are substances introduced into the environment by human activities in such amounts that are able to endanger organisms or ecological networks. These can be inorganic and organic substances of synthetic and natural origin. Human impact on the ecosystem can be direct or indirect, intentionally or unintentionally. Anthropogenic alteration of the environment and the ecosystem could be caused consciously and intentionally or unconsciously and unintentionally. Thus, the scope of *Ecological Chemistry* is taking inventory about the current situation of the ecosystem *(Eco-Diagnostics)* and developing methods for solving problems of environmental pollution by means of *Eco-Technology*".

In line with the other definition, proposed by the author of this paper, "*Ecological Chemistry* seeks to study the processes, which determine the composition, structure and chemical properties of environmental objects, adequate to the biological value of habitats, taking into consideration the effects of anthropogenic actions on biotic and abiotic components of the environment" [3]. **Prof. Yury Skurlatov,** one of the founders and promoters of *Ecological Chemistry* in Russian Federation, has mentioned that "this is a science on processes that form chemical composition and biological properties of the environment, subjected to anthropogenic impacts".

The team of authors from Germany led by **Prof. Gerrit Schüürmann** suggest that "one of the scopes of *Ecological Chemistry* is to reveal systematic relationships between the molecular structure of compounds and their fate in environment including biological systems, and to develop methods for predicting their environmental behaviour and risk" [4]. According to Mosby's Medical Dictionary, "*Ecological Chemistry* is the study of chemical compounds synthesized by plants that influence ecological characteristics through chemical communication or toxic effects" [5].

Prof. Wille Peijnenburg (The Netherlands) writes that "*Ecological Chemistry* may be defined as the whole spectrum of physico-chemical and biological processes that jointly

determine the fate of a chemical in the environment and its potential for affecting ecosystems. As such, *Ecological Chemistry* determines the ecological stress posed upon ecosystems by the presence of chemicals in the environment" [6]. International Society of Chemical Ecology has proposed the following phrase: "*Ecological Chemistry* is the study of the interactions between organisms and their environment that are mediated by naturally occurring chemicals".

The authors from Russian Federation, **Prof. Natalia V. Chibisova** and **Prof. Elena K. Dolgani** conclude that "*Ecological Chemistry* is a science on anthropogenic pollutions and mechanisms of their transformations in biosphere. The task of *Ecological Chemistry* is to maximally decrease the level of anthropogenic loads, due to the elaboration of new or modification of the existing technological processes, development of the effective treatment methods of industrial wastes, methods of prognostication and regulation of chemical pollution level in the environmental objects" [7].

According to **Prof. Olga V. Lozhnichenko** and co-authors [8], "*Ecological Chemistry* is a direction of chemistry dealing with the studies of chemical processes in biosphere, migration ways and transformation of chemicals of natural and anthropogenic origin in atmosphere, hydrosphere, lithosphere, characterizing the main chemical pollutants, methods of the pollution level determination, and recommendations of protection methods against the environmental pollution".

Dr. Ketevan Kupatadze (Ilia State University, Tbilisi, Georgia) considers that "*Ecological Chemistry* studies the mechanisms and unity of those chemical processes, which form the Ecology of the Planet Earth. Since we live on this planet, at least, the knowledge of *Ecological Chemistry* fundamentals is necessary".

Prof. Stanley E. Manahan in his works proposes several definitions related to the ***Environmental Chemistry***, a science closely linked to *Ecological Chemistry*, but still having its own specifics: "*Environmental chemistry*-that branch of chemical science that deals with the production, transport, reactions, effects, and fates of chemical species in the water, air, terrestrial, and biological environments and the effects of human activities thereon" [9], as well as "*Environmental Chemistry* is the study of the sources, reactions, transport, effects, and fates of chemical species in water, soil, and air environments, and the effects of technology thereon" [10].

A series of Internet sources contain various formulations, among them:

- "*Environmental Chemistry* is a scientific area that uses methods and results of chemistry to understand the environment. The discipline has arisen due to the recognition that chemical compounds, whether anthropogenic or natural, have important effects on naturally occurring processes and organisms. One of the goals of the discipline is to quantify these effects through controlled experiments and measurements" [11];
- *"Environmental Chemistry* is the discipline, which deals with the environmental impact of pollutants, the reduction of contamination and management of the environment. *Environmental Chemistry* is, thus, the study of the behaviour of pollutants concerning their environmental fate and effects on the environment" [12];
- "*Environmental Chemistry* is the study of chemical processes that occur in water, air, terrestrial and living environments, and the effects of human activity on them. It includes topics, such as astrochemistry, atmospheric chemistry, environmental modeling, geochemistry, marine chemistry, pollution remediation" [13];
- "*Environmental Chemistry* is a compartment of chemistry, which is dealing with the study of chemical transformations occurring in the environment" [14].

Prof. B.K. Sharma adds to these definitions that "*Environmental Chemistry* is the science of chemical phenomena occurring in the environment. It is multi-branched science involving chemistry, physics, life sciences, agriculture, public health, botany and medical sciences *etc.*, and may be defined as the study of the sources, reactions, transport effects and fates of chemical species in the water, soil and air environment" [15].

The scientists from Romania have made a significant contribution, through their theoretical considerations and experimental achievements, both to the development of *Ecological* and *Environmental Chemistry*, and the appropriate definitions.

Prof. Igor Cretescu ("Gheorghe Asachi" Technical University of Iasi, Romania) has

proposed rather original wording, discerning these sciences: "*Ecological Chemistry* and *Environmental Chemistry* are notions which were, probably, meant to be related to the same chemistry, dealing with the environmental studies and technology, in which the environmental protection is obligatory included. Certainly, this similarity is true, although these sciences can have different aspects: whereas the ecology is mainly related to biological aspects, the environment implies all the aspects. Through recognizing of the importance of environment, the importance of the *Ecology* notion has been broadened beyond the narrow sense in biological field, thus becoming a synonym of the *Environmental Protection* idea".

Dr. Marius Mihasan ("Alexandru Ioan Cuza" University, Iasi, Romania) specifies that the „*Environmental Chemistry* is dealing with the study of sources, reactions, transport, effects and transformations of chemical substances in water, soil and air; impacts of technological processes; chemical and biochemical processes occurring in the nature as a result of different human activities". At the same time, Dr. **D. Roscovan** says that „the *Environmental Chemistry* has as a research object the action of chemicals in the environment, origin and registration of substances, their distribution in air, water and soil or ecosystems and chemicals degradation".

A team of the authors from Russian Federation proposed the following notion: "*Environmental Chemistry* is a compartment of chemistry studying the chemical composition and processes running in the environment, as well as the results of these processes" [16]. **Dr. Evgheny A. Zilov** suggests that "the *Environmental Chemistry* is a science involved in study of chemical aspects of the environment. On one hand, it is a part of chemistry, like the organic chemistry, physical chemistry or biochemistry, and from another hand, it studies the environment surrounding the humans" [17]. **Dr. I.V. Wolf** and **Dr. M.A. Syneakova** consider that „the objectives of the *Environmental Chemistry* are the study and description of the condition of geospheres of Earth, first of all atmosphere, hydrosphere and soil, the factors that affect them, both the natural and anthropogenic ones, the pathways and mechanisms of transportation and transformation of various substances in the surrounding natural environment" [18].

Therefore, it can be seen that a great variety of definitions have been proposed by various scientists, which are not contradictory, but complement each other. This made it possible to formulate and outline the modern understanding of *Ecological Chemistry*, as well as *Environmental Chemistry*, in a broad sense.

Until *Ecological Chemistry* emerged, there was no specific scientific field capable to elaborate the bases of the chemicals' classification and to justify the research of the anthropogenic impacts on the biosphere. Nowadays, this field undergoes its rapid, broad and deep development, due to the increased possibilities to explore the relationships between the environment and technological processes, to elaborate and design new approaches towards the harmonious coexistence of these two paramount compartments of humans' ecosphere.

It is quite obviously that *Ecological Chemistry* represents one of the important scientific directions of current epoch, as it seeks to answer the fundamental challenge faced by the environment of what should be the composition of the environment on the Earth to ensure the living conditions for its inhabitants. At the same time, *Ecological Chemistry* can help to resolve many of the climate change-related issues, which are now among the top-ranked problems.

Meantime, the composition of the environment is oscillating permanently. An eloquent example is the buffer capacity of water – a naturally existing phenomenon that ensures the permanent pH value of water within the range 6.5-8.5, even in the presence of other substances. This natural water pH range is unique and is the only favourable for the development and activity of all living organisms including humans. So, this issue is fundamental being specific for the conditions of organic life on our planet. Any changes in the pH value of natural water on the planet caused by technological development and uncontrolled discharges of chemicals can lead to irreversible consequences for organic life forms, destroying our human civilization. It is *Environmental Chemistry* that offers solutions to prevent discharges due to the cleaner technologies, and wastes purification, as well as the natural resources reuse and re-circulation in technical flows.

One of the directions within the *Ecological Chemistry*, which certainly enlarges its domain, is *Ecological Biotechnology*. It focuses on resolving environmental protection tasks, using the living organisms and wastes processing and treatment systems. It also implies a number of specific tasks, all of them having the applicative character, such as the purification of natural compartments from the anthropogenic pollutions, neutralization of polluted fluxes, rehabilitation of soil fertility

withdrawn from the agricultural because of the human activity, substitution of agricultural chemicals with the environmentally friendly agents, production and modification of polymers, surfactants and other materials and non-toxic compounds with useful properties. *Ecological Chemistry* is dealing with the application of both traditional processes, and new ones, in order to purify the gas and air emissions, polluted soils, water bodies, bottom deposits and sludge. *Bioremediation methods* include biotechnological ways of natural compartments purification.

Still, the man and its activity instigate the more and more impressive effects on natural environment, anthropogenic load being increased exponentially in the last decades. In this regard, it is important to know the regularities of these multiple effects, specifically, their chemical aspects: physical-chemical processes occurring in the environment, how they run with time, how they are catalyzed or inhibited, what are their consequences and how they could be managed. One could suppose that it is *Ecology* that is dealing with the study of all the mentioned effects, especially *Chemical Ecology*, being the study of chemicals involved in the interactions of living organisms. Unlike *Ecological Chemistry*, *Chemical Ecology* is limited by the studies of the natural materials, using the materials only in environmental conditions, research of the exchange processes and regulation mechanisms in living organisms. In reality, the main role in these studies along with the biological approaches belongs to the chemical methods, applied, in particular, for the isolation and identification of active principles.

Ecotoxicology is dealing with the studies of the anthropogenic chemicals' impacts on the biological objects of the environment. The task of *Ecotoxicology* is the research of the chemical factors influencing biotic and abiotic components of ecosystems.

The other direction of *Environmental* research is *Ecological Geochemistry*, which dealing with determination of the environment and living organisms' composition under the different conditions. The basic issue is to answer the question – how the composition of natural environment affects the state, composition and activity of living organisms.

With regard to the technological processes, one of the main tasks of *Ecological Chemistry* is to elaborate criteria for the selection of such chemicals, which industrial production, applications and global accumulation would not entail the harmful impacts for the entire ecosphere whose component is the mankind. Thus, mainly the non-toxic and rapidly decomposing chemicals and materials should be considered while implementing the new progressive industrial technologies or flow sheets. Identification of these substances and elaboration of methods capable to predict the behaviour of chemical products in the natural environment makes it possible to take the timely measures. These tasks are related to the *Eco-Technology*, an important research direction of *Ecological Chemistry*.

Nowadays, the annual multi-tonnage chemicals production and appropriate consumption in industry, agriculture, medicine and other areas is responsible for the formation and discharges of huge amounts of wastes including toxic and other dangerous compounds for the environment and human health. According to the published reports [19], production of potentially harmful for the environment chemicals in European Union is fluctuating within 41-44%. Environmental fate and impacts of these wastes are both the matter of public concern and environmental research. It is crucial decrease the industrial production of substances-xenobiotics using environmentally friendly technologies.

As the result of these concerns, the *Green Chemistry* appeared in the early-90s of the last century, aimed at the elaboration of environmentally friendly production technological chains. Within this context, the scopes of the *Green Chemistry* are narrower, compared to the *Ecological Chemistry*, but for the researchers this approach was convenient, as it allowed to present a limited and more definitely focused research.

Similarly to *Ecological* and *Environmental Chemistry*, *Green Chemistry* sometimes called *Sustainable Chemistry*, received a large number of various definitions that testifies on the undoubted interest in this research field from the part of researchers, authorities and broad public.

Thus, according to the US EPA, "*Green Chemistry* is an area of chemistry and chemical engineering focused on the designing of products and processes that minimize the use and generation of hazardous substances. *Green Chemistry* applies across the life cycle of a chemical product, including its design, manufacture, and use. *Green Chemistry* consists of environmentally friendly, sustainable chemicals and processes whose use results in reduced waste, safer outputs, and reduced or eliminated pollution and environmental damage. It encourages innovation and promotes the creation of products that are both environmentally and economically sustainable" [20].

Prof. Paul T. Anastas, sometimes called "the father of *Green Chemistry*" writes in his revolutionary book published in 1998, that the "*Green Chemistry* is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and applications of chemical products" [21]. **Prof. Paul T. Anastas** and **Prof. John Warner** also mentioned that the "*Green Chemistry* implies any improvement of chemical processes that have positive impacts on the environment".

In opinion of other authors, *Green Chemistry* means the chemistry and chemical engineering to design chemical products and processes that reduce or eliminate the use or generation of hazardous substances while producing high quality products through safe and efficient manufacturing processes [22]. In the last years, by the expression of Lancaster, 2002, "*Green Chemistry* was also considered as a means to reach the durability".

American Chemical Society in common with the Green Institute proposed one more definition: "*Green Chemistry* is the design, development, and implementation of chemical products and processes to reduce or eliminate the use and generation of substances hazardous to human health and the environment." According to the IUPAC's wording, "*Green Chemistry* is a discovery, elaboration and using of chemical products and processes which reduce or avoid the using and formation of harmful substances". Another, formal definition: "*Green Chemistry* involves the methods of chemicals production which decrease or avoid the application and production of toxic compounds" [23].

Different and numerous fields of sciences related to the *Ecological Chemistry*, as well as definitions proposed by different authors revealing the aspects of these areas, clearly demonstrate the broad distribution of these studies and their practical significance.

All the above-mentioned *Chemistry* branches are aimed at the environment protection as a principal scope and are strongly connected with each other and cannot be regarded separately from the industrial production. Therefore, all the environmental studies should consider these relations. These research directions cannot be set against each other, because they are designed to address the main challenge – ensure the friendly co-existence of chemistry and environment.

Within the historical context, the research in *Ecological* and *Environmental Chemistry* has arisen as a response towards the progressive industrial development which lead to numerous and growing impacts on the environment and human health. This caused serious concerns in society, and scientists, first of all dealing with chemistry, were among the first ones to respond.

Primarily, the research was aimed studying the changes in nature, including the impact of mankind on the environmental compartments: water, soil, atmosphere and biosphere. Secondly, the types of pollutants, their amounts and their main effects were studied. Further studies included more comprehensive approaches; therefore *Ecological* and *Environmental Chemistry* broadly apply the methods and technologies from other sciences. At this stage, interactions between chemicals and living organisms were studied, processes mechanisms have been revealed, and environmentally-friendly technologies have been proposed, *etc.*

Among the beginners of this area we should mention **Prof. John O'M. Bockris** (USA) [24] who summarized the views on the technological progress development and its effects on surrounding environment and underlined the optimism of possible coexistence of man and nature. He was among the first scientists who clearly expressed this concern and posed a main question: what urgent steps should be taken by chemists to save our planet from pollution and to ensure safe living conditions for humans?

In the following years these views have been further developed in the activities and publications of other scientists and outstanding researchers whose contribution to ecological chemistry is undoubtedly large. They have identified an increasing number of processes caused by introduction in use of various chemical substances, including the hazardous ones for the nature, animals and human life.

A number worldwide-recognized research centres in Europe led by prominent scientists have contributed significantly to further development of *Ecological* and *Environmental Chemistry* and related scientific areas.

The first Department of Ecological Chemistry in the Europe was founded in 1972, at the Technical University of Munich, by **Prof. Dr. Friedhelm Korte** [29]. In his fundamental works [2] he outlined the main objectives of this newly established science. He was among the first scientists to reveal and justify the interrelations and global aspects of chemistry, toxicology, technology as applied to environment, paying significant attention to the issues of environmental quality and safety. According to his ideas, there is an urgent need to compose the list of all the

chemical products released in the environment, to study the pathways of their inflow and the character of their action. To this end, he has classified the chemical pollutants with regard to their toxicity towards the living organisms, and introduced the still usable notion "Korte's index". By his views, the primary task is learning to assess the distribution of toxic chemicals in the environment. His works have initiated and promoted the further development of the key areas in *Ecological Chemistry*.

Prof. Müfit Bahadir (Germany) [1,2] has comprehensively analyzed the environmental problems related to the usage, fate and exposure to chemicals and considered a sustainable approach towards their application and management. The subjects of his research are multiple and include: environmental and waste chemistry and analyses of toxic substances (inorganic and organic) at contaminated sites and in accidental fire residues, chemistry of fires, environmental pollution aspects of recycling processes and products, pesticide chemistry and metabolism in soil and surface water, matter dynamics in agro-ecosystems, with application of radiotracers, ecotoxicology, pollution formation in chemical lab courses, green and sustainable chemistry in education and research, re-growing feed stocks, biodiesel and biolubrificants.

Department of Ecological Chemistry of the Helmholtz Centre for Environmental Research, Leipzig, Germany, led by **Prof. Dr. Gerrit Schüürmann**, pursuits the specific goal to unravel systematic relationships between the molecular structure of compounds and their fate in the environment including biological systems, and developing methods for predicting their environmental behaviour and risk.

We should also mention the Department of Analytical and Ecological Chemistry of the University of Trier, Germany, run by **Prof. Dr. Klaus Fischer**, with the main objectives of research: the development of analytical methods to determine natural and not natural organic substances in the environment and examination of occurrence, behaviour and degradation of organic (harmful) substances in environmental media and systems of environmental technology, in particular wastewater treatment.

Department of Organic and Ecological Chemistry, Institute for Environmental Sciences, University of Koblenz-Landau is run by **Prof. Dr. Katrin Schuhen**. The focus of the research at the Institute for Environmental Sciences concentrates on new anthropogenic stressors in linked ecological systems. Transition zones between ecological systems contribute substantially to the regional biodiversity and are „hotspots" for many ecological and biogeochemical processes. They provide many „ecosystem services", like flood protection, retention and degradation of pollutants as well as the conservation of biodiversity and recreational areas, and are of high socio-economic importance. At the same time, they are considered as particularly sensitive to environmental changes, *e.g.* by changing flooding dynamics as consequence of anthropogenic operations or global climate change.

The very ambitious research and novel original approaches related to *Ecological Chemistry* have been elaborated in the ex-USSR countries within the same period. The Republic of Moldova is among the most active countries in ecological and environmental chemistry research and education activities. It played a pioneering role in promoting the ecological chemistry at the NIS scientific space.

It should be noted that the important research schools activating in Republic of Moldova for several decades, have contributed greatly, through the original approaches and comprehensive studies towards the development of *Ecological Chemistry* and associated fields of research [25,26]. The Department of Ecological and Industrial Chemistry at Moldova State University (one of the oldest and most recognized university in the country) was founded in 1992 by the author of this paper. The studies performed at this Department under my initiative and guidance, have been within the respective worldwide mainstream of the *Ecological* and *Environmental Chemistry*. Among the important subjects of study were the catalytic processes occurring in the environment, with the involvement of the transition metal ions and complexes and polluting chemicals. The mechanisms of reduction oxidation, radical and other types of reactions and environmental impacts of these processes have been broadly studied. Under my supervision, a large pleiad of the experts and highly qualified specialists in *Ecological chemistry* have been educated, which are currently working in industrial and teaching fields in Republic of Moldova and abroad.

The successes have been reached due to the long-term work of the research teams and scientists from the Department of Ecological and Industrial Chemistry of the Moldova State University and Institute of Chemistry of the Academy of Sciences of Moldova: **Acad. Prof. Gheorghe Duca, Prof. Maria Gonta, Corr. Mem. Prof. Tudor Lupascu, Prof. Victor**

Covaliov, Dr. Viorica Gladchi, Dr. Lidia Romanciuc, Prof. Olga Covaliova, Prof. Igor Povar, Prof. Vasile Rusu, Prof. Mihai Ciobanu, Dr. Oleg Bogdevich, Dr. Raisa Nastas, Dr. Aliona Mereuta, Dr. Nina Timbaliuc, Dr. Larisa Postolachi, Dr. Ruslan Borodaev. Due to their efforts, the self-purification and catalytic processes occurring in the natural waters were studied; mechanisms of reduction-oxidation reactions with the involvement of metal complexes, transformations of pollutants and their effects on living organisms were revealed; the technological processes and equipment were proposed for the conditioning of natural waters; physical-chemical and biological treatment of waste waters, systems of liquid and solid wastes management were elaborated; risk assessment approaches were proposed. It should be noted, especially, that the research in *Ecological Chemistry* performed by Moldovan scientists, bear both fundamental and applicative character and are performed in the research laboratories, on the natural sites, as well as the industries.

These scientists are authors of a series of books, textbooks and teaching guides that are effectively used by scientists, specialists and students. A specific feature of these studies is application of local feedstock materials to obtain the sorbents, bioactive substances, catalysts for the treatment of environmental compartments, and the general trend to purify the polluted systems with the obtaining, at the same time, of high validity products that can be further used in technological systems and processes. In this way, a closed-cycle is proposed that is designed for the sustainable use of our planet's resources, avoiding its inevitable pollution.

In particular, **Prof. Maria Gonta** has been studying for many years the red-ox processes occurring in the meat food products with the involvement of nitrogen-containing additives, their transformations and effects on human health. Based on her research, a series of oxidation inhibitors of natural origin have been proposed for sausages. In the last years, **Prof. Maria Gonta** research team elaborates the treatment procedures of industrial waters polluted with dyes of different nature by proposing a several-stage treatment scheme.

Prof. Tudor Lupascu is the founder of a research school dealing with the development, testing and industrial applications of new efficient sorbents obtained from the local vegetal raw materials. Patented research results were used for industrial production of efficient sorbents for various applications. The autochthonous sorbents have been tested and gave positive results, being proposed for field application such as purification/conditioning of potable water, purification of alcoholic beverages, as well as for medical purposes. **Prof. Tudor Lupascu** research team has developed and patented procedure for obtaining of "Enoxil" (from grape seeds), a preparation with pronounced antifungal and antibacterial properties. On the basis of "Enoxil", new pharmaceutical preparations "Enoxil-M" and "Enoxil-A" were developed and tested under clinical and field conditions.

Prof. Victor Covaliov is involved in the long-term studies in the several related domains, including ecologically safe chemical-biochemical-technological processes, elaboration and testing of the advanced methods of purification and treatment of waste and natural waters, management of liquid and solid industrial wastes, modeling and control of these processes. In the last years, he is working on the development and implementation of highly efficient innovation processes and equipment in the field of alternative energy for the production of energy bearers, with neutralization of toxic wastes and obtaining of a series of valuable products, involving bio-methane, bio-hydrogen, soil fertilizers, purified water for irrigation, vitamin B_{12}.

Dr. Viorica Gladchi and **Dr. Ruslan Borodaev** are dealing with the study of photo-catalytic self-purification processes in natural water bodies in Republic of Moldova containing in particular thiolic compounds, copper, manganese and other chemical components. They have elaborated new indicators which reflect the condition of natural waters. Along the years, they are organizing the summer expeditions for monitoring of the chemical condition of rivers and lakes.

Dr. Lidia Romanciuc, in continuation of works initiated by **Prof. Alexei Sychev** at the Moldova State University, has comprehensively studied the red-ox processes in natural and food systems, containing the transition metal ions, and investigated the chemical stability, physical properties and other parameters that determine the life-time and durability of studied compartments.

Prof. Olga Covaliova is involved in the research of heterogeneous, homogeneous and electro-catalytic treatment of natural and waste waters, elaborating the new materials for photo-catalytic purification of waters polluted with the refractory organic matter.

Prof. Igor Povar conducts the research in the modeling, calculations and computational characterization of equilibrium in natural waters, including bottom sediments in the presence of phosphorus, metals, bottom sludge components, thus predicting and revealing the transformations and possible changes in composition of natural water. **Dr. Oleg Bodgevich** conducts a team that has created a systematic cartographic system of occurring pollutants and their distribution in the natural water sources in Republic of Moldova. They provide analyzing of large number of water quality parameters.

Dr. Aliona Mereuta has studied in detail the technological processes of wine-making wastes processing by chemical-physical methods and obtaining of useful products from them, including tartaric acid, dyes, *etc*. In the last years, she is involved in elaboration and application of the waste plastics processing technology preventing the pollution with hard degradable components.

The researchers from the other institutions from Republic of Moldova also contribute to the obtaining of new knowledge in *Ecological Chemistry*.

Thus, **Prof. Elena Zubcov** (Institute of Zoology of A.S.M.) is actively studying the chemical processes in natural water bodies, polluting chemicals interaction with water and bottom sludge components and the toxic effects of these transformation products on water biota, especially fish species.

Prof. Dumitru Ungureanu (Technical University of Moldova) has elaborated and implemented many reactors and adjacent equipment for biochemical treatment of industrial and municipal wastewaters, having educated a number of followers and experts in this field.

In promoting the future development of environmental sciences and research, the key role belongs to the teaching and training system. In this context, important activities have been implemented at the Moldova State University for over the forty decades already. The students from the Department of Ecological and Industrial Chemistry, Faculty of Chemistry and Chemical Technology attend the courses of Environmental Protection, Ecological Safety, Ecological Chemistry and Environmental Protection, Chemical Technology, *etc*. In addition, they are involved into the research, specifically, studying the self-purification processes in natural water bodies, fate and chemical transformation pathways of pollutants entering the environmental compartments, degradation of toxic organics, reduction-oxidation processes involving metal ions and complexes in industrial and environmental systems, wastes management, pollution preventing and other related problems.

The research achievements of world recognized scientists from NIS countries had deep and comprehensive effects on *Ecological Chemistry*. Thus, **Prof. Yury Skurlatov** (Institute of Chemical Physics of Russian Academy of Sciences) being involved for many years in the research of physical-chemical, catalytic and other transformations of pollutants, has proposed multiple reaction mechanisms and has contributed to summarization of the existing relevant knowledge in one of the first books in *Ecological Chemistry* appeared in the Post-Soviet research space, that played a great role in education of younger generations of environmental specialists and scientists [3]. He has outlined the main modern tasks of *Ecological Chemistry*, proceeding from the existing scientific level and possibilities.

The large contribution to popularization and development of educational aspects of *Ecological Chemistry* was made by **Prof. Alma G. Sarmurzina** (Kazakhstan) who has revealed negative impacts of pollutants to environment and its condition, also considering the other issues related to this scientific direction [27]. She has also dedicated many years to the teaching and training in *Ecological Chemistry*.

Prof. Gevorg P. Pyrumyan (Armenia), a well-known scientist in *Ecological Chemistry*, is working for many years in this field, touching also the aspects of hydrochemistry, chemical processes in water objects and resources as well as connected medical problems. He is conducting now the scientific school on *Ecological Chemistry* and *Hydrochemistry* in his country.

The number of related journals and magazines were initiated to reflect the latest achievements, such as **"CLEAN – Soil, Air, Water"** (WILEY-VCH Verlag GmbH & Co, Germany), which covers many aspects of sustainability and environmental safety, **"Chemistry Journal of Moldova"** (Institute of Chemistry A.S.M., Republic of Moldova) that includes many aspects of *Ecological Chemistry*, **"Ecological Chemistry Journal"** (Saint Petersburg, Russian Federation) that is focused practically on all problems in this field.

The **EEC-2017 Conference** is focused on discussions on the various research data, approaches and opinions based on the various expertise and experience. Its meaning is to prevent the antagonism between the *Ecological*

and *Environmental Chemistry* and other related science areas, aiming them to assist each other in resolving the environmental issues.

The EEC-2017 being already the 6th International Conference in the series of scientific events, comprises five interrelated topics: Ecological Chemistry; Environmental Chemistry and Engineering; Green Chemistry; Ecological and Environmental Aspects in Chemical Research and Education; Young Scientists Research in Ecological and Environmental Chemistry. Each topic implies two important scientific areas – *Chemistry* and *Ecology* that historically set down the basis of *Ecological Chemistry*. An important aspect is that EEC-2017 event is a continuation of a series of Conferences on Ecological Chemistry successfully held in Chisinau, Republic of Moldova, starting from the mid-80s of XX-th century. They played a great role in promoting the development of *Ecological Chemistry* and related research directions, establishing the fruitful long-term collaborations in the NIS, EU, USA and other countries.

Still, there are numerous unresolved environmental concerns worldwide that need the attention of researchers. Many of these issues emerged in the last years along with the industrial development, thus, outlining the novel research areas and problems [28]. Today, *Ecological Chemistry* seeks not only to explain the environmental processes with chemicals participation, but to predict their short-term and long-term consequences, to propose efficient and saving solutions to ensure the safe existence of life on our planet. So, the scale and variety of the tasks has greatly increased. The results reached so far with this regard are promising and impressive, however, establishing the further activity ways, avoiding the misunderstanding and overlapping in research is no less important.

The meaning of EEC-2017 Conference is thus to outline the collaborative patterns of further development in research, education, innovation and law related to *Ecological* and *Environmental Chemistry* which is a promising and recognized scientific area, capable to contribute to environmental protection and harmonious living of man with the nature.

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