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Department of Environmental Protection

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INTRODUCTION

Department of Environmental Protection (DEP) is the youngest division of the Faculty of Geology, Geophysics and Environmental Protection. It was established in 1993 by Professor Edeltrauda Helios-Rybicka and a few co-workers. All personnel since the very beginning carried out investigations on environmental geochemistry focused on contaminants of river systems and soils in heavy industrialized and urbanized areas. They continued a freestanding activity till 2006 when the group merged for 6 years with Division of Geology and Geotourism lead by Professor Tadeusz Słomka and then by dr hab. Marek Doktor. DEP re-emerged in 2012 and it was confirmed by decision of the AGH Senate in 2014. The DEP has 12 researchers and one technician, and it is the smallest division in our Faculty.

RESEARCH AREAS

Researchers of the DEP work on geochemistry and mineralogy of contaminants in the environment, their transformation and possible remediation options. Part of these investigations is devoted to pollution of river systems with heavy metals. Investigations, supported also by grants of the National Scientific Centre indicate that in proximity to the former metal mines heavy metals are particularly persistent in small catchments. It is reflected in metal distribution in vertical profiles of sediments in river channels, floodplains and reservoirs. The profiles usually exhibit rather slow decrease of the metal content, which is modified by the sedimentation rate. Such investigations provide a base for reconstruction of catchments pollution over long periods of industrial history. Some discrepancies in metal distributions in profiles and studies of metal mobility indicate the scale of postdepositional changes and potential risk for waters and living organisms.

Similar investigations of heavy metal distribution are carried out also in sediments of some lakes from northern Poland. Their distribution indicates relationships between type of sediment and its chemistry. There are clear differences between gytia, bog lime, postglacial deposits and contemporary, 20th century deposits. The investigations of lake deposits were summarized in set of geochemical maps and stratigraphic profiles explaining genesis of one of the largest lake in Poland – the Wigry Lake.

The role of microbes in transformation of contaminants in the environment is the other part of investigations carried out recently. It has been shown that bacteria play an important role in the transformation of many heavy metal minerals. Fossil bacterial mats are widespread in fluvial sediments of the hyporheic zone. They grow on quartz grains, metal mineral particles or coal particles. Bacterial mats contain authigenic heavy metal sulphides mainly framboidal Fe-Zn oxysulphides, and chalcopyrite-like and bornite-like oxysulphides. In the sediments of rivers heavily polluted by mining industry, bacterially derived sulphides and oxysulphides are main agent controlling abundance of heavy metals. Studies of metal transformations are supplemented by bacteria analyzes in groundwater of the hyporheic zone. Microbiological investigations were summarized in handbook on *Environmental microbiology* (in Polish) designed also as a help for students on lectures in microbiology.

Based on many years of own investigations of heavy metals in sediments and review of international literature, in 2015 the monograph entitled *Pollution of sediments with heavy metals: transport, accumulation and remobilization* has

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been published (in Polish). It describes the state-of-the-art of current knowledge about pollution of sediments both in the fluvial and lacustrine environments, in bogs as well as in the world sea system. Additionally, the book defines problems of management of dredged sediments related to their pollution with metals, PCB's, oils and the other organic compounds. Possible storage, remedy and reuse options are also characterized there.

Besides sediments geochemistry, analysis of natural geochemical background in selected Carpathians flysch rocks is carried out in detail. Analysis of rocks of different Eocene units: Szczawnica, Zarzecze, Magura and Malcow exhibit clear differences in heavy metals content. It is related mainly to grain size and to a composition of fine mineral matter building up coarser clasts. These differences of metal content in given geological formations reflect variable conditions during flysch sediment deposition as well as epigenetic changes.

Ecotoxicological problems are also among the investigated subjects because bioavailable heavy metals can easily transfer from polluted soils to organisms and may became toxic in any part of the food chain. It is particularly well exemplified in snails of *Helix pomatia* and their shells. It has been documented that in living organisms of this snail, even low metal content in the shell can indicate a markedly raised content in the body tissue and an overall pollution of the natural habitat. However, because of long time of metals accumulation and possible release, shells stored for a long time in the soils are not good indicators of environmental pollution.

Sustainable development and risk assessment are particularly important considering large antropopression in industrial areas. The whole spectrum of questions of environmental protection and engineering in intensively industrialized and urbanized regions have been described in a monographic review entitled *Contemporary conditionings of environmental protection and engineering in Poland* (Polish text). The book focuses on waste management in light of requirements of European directives and on problems of their reuse, indicating progressive decrease of costs of permanent waste disposal and diminishing of their impact on the environment.

Waste management and reuse are other important issues in Poland. The research supported, also by a project of National Science Center, focuses on elaborating methods of utilization of spent sulfuric acid and pickling liquor, deposited in settling ponds, in cement production. The applied procedure covers preparation of cement by grinding Portland clinker with the addition of waste gypsum. The obtained product meets standard requirements for Portland cement and can be used for production of construction materials used in buildings. It has been concluded that utilization of the deposited wastes can help to eliminate environmental hazards regarding sulfuric acid pickle liquor waste and can also provide a low-cost resource of waste gypsum which can be widely used in production of construction materials. The results received patent license.

The environmental impact of wastes has been studied also to help in managing the secondary solid waste generated during the incineration process of medical waste. The investigations include leaching tests of ashes and slags as well as air pollution. While pollutant concentrations in the air are generally lower than permissible values, the generated ashes and slags contain usually considerable concentrations of heavy metals, mainly zinc as well as chloride and sulphate anions. Ashes and slags, which constitute 10–15% of the mass of incinerated waste, can be more harmful to the environment than untreated waste. The data obtained prove the necessity of waste solidification and storage in the hazardous waste disposal sites.

Moreover, monitoring of the waste disposal site of the former soda plant in Kraków has been continued for many years. Settling ponds located on the floodplain of the Wilga River have never been properly isolated and land reclamation involved only coverage with 0.5 m thick top soil. The investigations show that, for almost 30 years after plant closure chlorides, sulphates, sodium and calcium are continuously leached to groundwater and to the river. Leaching intensity depends on the weather conditions and river flow rates. Total salinity is the highest during low flows with water conductivity exceeding many times their natural values in the river water.

Another interdisciplinary research is devoted to recognition of relationships between physical

and geochemical features of historical ground strata in medieval city centres. The investigations cover, among many other aspects, explanation of ground pollution with lead, copper or nitrate analyses below pavement of the Central Market, or ruins of St. Stephen Church under the Szczepański Square in the Kraków City Centre. They are correlated to location of medieval smelters, trade centres or former sewage system of the city. Some investigations use geophysical and geotechnical methods to estimate stability of medieval tenement houses and monasteries in the city.

Recent investigations of dust released by car brake discs and pads due to heavy vehicle traffic have started in the framework of an international project of Polish-Norwegian financing mechanism. They aim at extending our knowledge on pollutants related to vehicle exploitation and particularly with environmental threats of dust emission from brake elements. It is particularly important in Poland where the numbers of vehicles have tremendously grown recently, and cars are exploited here much longer than in many other European countries without rigorous check of quality of dust and fumes emission by the vehicles. Our investigations also cover pathways of dusts transport from roads and streets, through sewer system to rivers and streams. Dust is sampled from sediments in manholes, rain-washed suspended matter and from soils in road ditches of the selected heavy-traffic routes in the southern part of Poland. Mineral and geochemical composition of samples is analysed using XRF, FTIR, EPMA and SEM methods. The results will be processed by means of numerical methods in order to construct dynamical model of pollutants migration from road traffic.

COOPERATION

Cooperation with Technical University Hamburg-Harburg (Germany) was initiated by Professor E. Helios-Rybicka and most of researchers of the DEP were research fellows or took part in scholarships in Germany supported by the Deutsche Bundesstiftung Umwelt, Helmholtz Zentrum für Umweltforschung UFZ, The Nowicki Foundation, The Kościuszko Foundation or the Aleksander von Humboldt Foundation. Cooperation with Hamburg University culminated in common International Odra Project devoted to sediment pollution of this largest transboundary river of Poland. Moreover, some persons participated in Partnership for Sustainable Development in Sweden and on internships at Universities in Amsterdam, Utrecht and in Agriculture Institute in Wageningen, and these contacts are still maintained. Some investigations are continued in cooperation with Mining University in Leoben (Austria), Department of Geological Sciences of the University of Melbourne (Australia), Geological Survey of Canada, Bulgarian Academy of Sciences and Czech Academy of Sciences. Together with Sed-Net association the Department co-organized 9th International Conference "Sediments and Society" held at the AGH University of Science and Technology. Moreover, the Department cooperates with scientists from many universities in Poland dealing with geochemistry, environmental protection, geology, archaeology and organizes a set of conferences devoted to investigations of historical grounds from medieval cities in Central Europe and transformation of pollutants in the environment. The DEP, together with Societas Humboldtiana Polonorum, organized the Workshop on "Progress in biomedicine and neuromedicine" with participation of Nobel Prize Winner – Professor Erwin Neher.

FACILITIES

Department of Environmental Protection possess two laboratories. Both are used for student classes and for researchers. One room has standard equipment for soil and water analyses, whereas the biochemical laboratory is newly equipped for biotechnological, biochemical and microbiological studies (Fig. 1). It is designed for 20 students. Each working site has water, gas and electricity. Equipment consists of refrigerators, electric blow-dryer, deionizer, shaker, magnetic stirrer, laminar chamber, incubators, autoclaves, ultrasonic cleaner, centrifugal machine, vortex, bioreactor chamber, spectrophotometer and apparatus for electrophoresis. In another separate room there is an atomic absorption spectrometer with flame, furnace and hydride generator.

EDUCATION AND TEACHING OFFERS

Department of Environmental Protection teaches courses related to environmental protection. It is also possible to do a Master of Science degree led by researchers of the Division in: techniques of environmental protection, informatics in environmental protection and waste management. Annually, up to 60 graduate students receive MSc diplomas and similar number of students gets a BSc degree. Graduated students obtain a general, Earth Science oriented knowledge about the environment protection, acquire biological basis of environmental management and protection as well as foundations of problems on increasing level of xenobiotics. Students also learn the newest analytical techniques and means of soil, water and air improvement and remediation. Besides having a firm theoretical background, our students are provided with knowledge and skills that can be applied in practice, e.g. computer data processing and presenting, background in environmental law or financial and economic measures of small business in environmental management and protection.

DEP's students can obtain positions in the state and local administration, higher education, scientific and departmental institutes and environmental or industrial laboratories. Moreover, there are a vast number of environmental audit companies, individual enterprises and industrial business, which need environmentalists or employ consultants with background in environmental law and economy.

Training begins with an introductory year focused on the foundations in geology, biology, chemistry, mathematics and global environmental problems. The second year is devoted to geological and biological topics such as geochemistry, biochemistry or microbiology and extends the knowledge about methods of environmental protection like technologies in environmental protection, renewable energy sources or pollution and protection of water and aquatic systems. The third year students become acquainted with upper level bachelor courses on pollution control and protection measures as well as more detailed aspects of eco-toxicology. The seventh semester is devoted to elective courses and independent research projects.

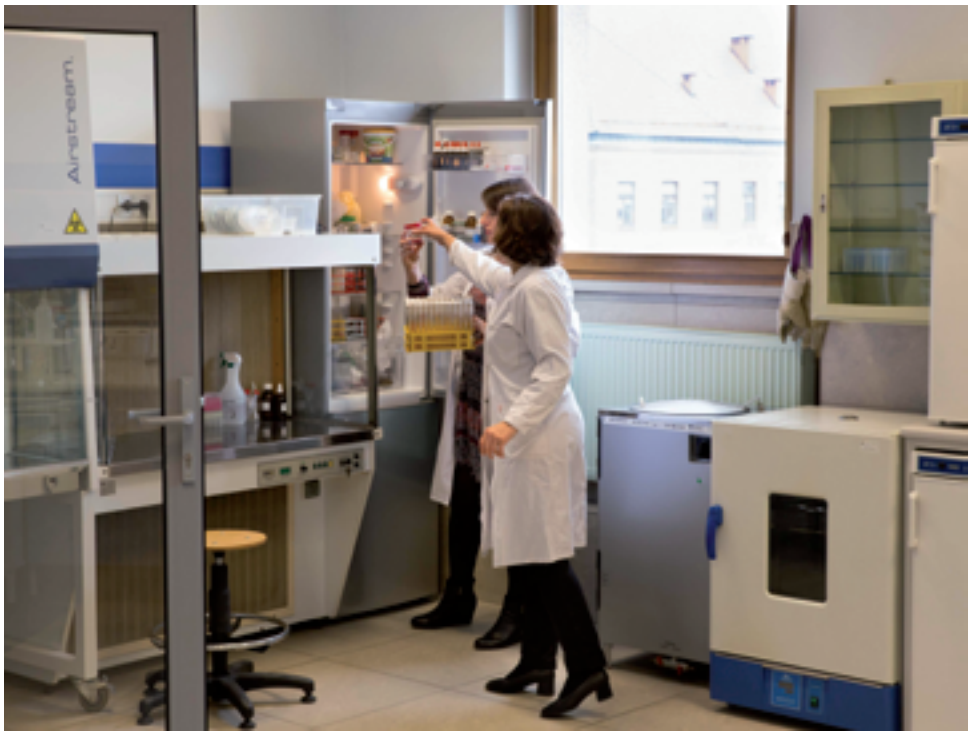

Fig. 1. *Biochemical laboratory of the Department of Environmental Protection*