

TREATMENT OF ORGANIC POLLUTANTS BASED ON PCB IN THE RIVER SEDIMENT BY ELECTRON BEAM

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Polychlorinated biphenyls (PCBs)

Production: Chemko Ltd. Strážske, Eastern Slovakia up to 1986 all over the world in specific congener mixtures e.g. Aroclor, Delor, Delotherm, Hydeler, etc.

Usage: capacitors, transformer oils, hydraulic oils

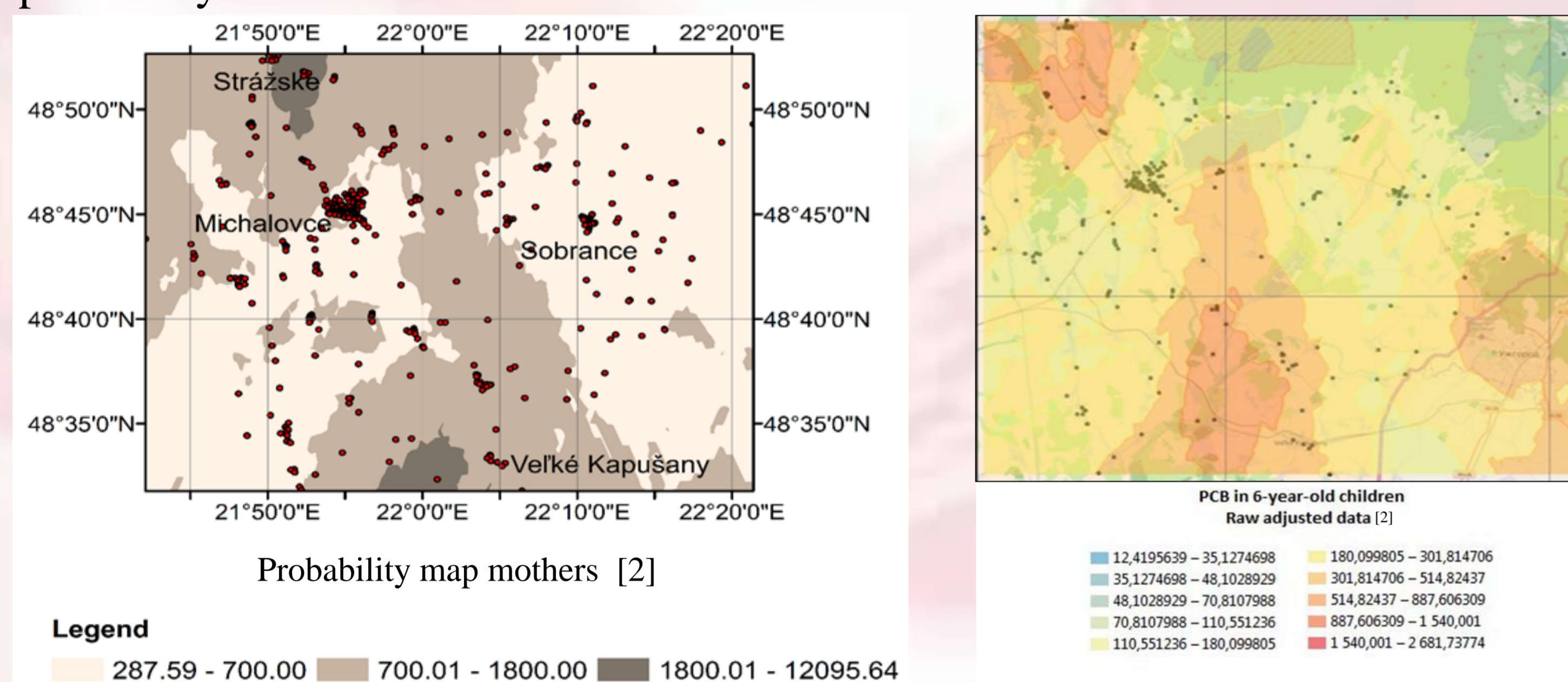
Advantages: high molecular weights and boiling points, viscous

Disadvantages: low flammability, hydrophobicity, bioaccumulation, a long half life time (at about 30 years) in the environment

Motivation: Strážske channel with PCB concentration in sediments of more than 15 000 µg·kg⁻¹ belongs among the most contaminated regions in Central Europe [1]. This PCB concentration is by factor 3 000 above the limit.

Introduction

In eastern Slovakia (Michalovce District) there is an area of 40×80 km² (with 200 000 inhabitants) where the environmental contamination by PCBs exceeds the limit in many places [1]. The most significant source of contamination by PCBs in the region is the Strážsky channel by which a highly contaminated sediments are deposited along to the river Laborec and into the water reservoir Zemplínska Šírava. Contaminated sediments from shorelines of Strážsky channel and Laborec river are distributed by winds to the wide surroundings. PCB substances have caused serious health problems, especially in the pediatric population. At the Slovak Medical University (SMU) there are the experts in mapping of PCBs in the different components of the natural environment. Investigations of the PCB levels in the blood of the population provide estimation of the spatial distribution of human exposure to PCBs [2]. The following figure on the left is the spatial distribution of maternal exposure to PCBs and on the right the distribution of their 6-year old children, which is practically the same as of their mothers.



Electron beam degradation of PCBs

- High energy electrons loose energy through collisions with bound electrons of water providing hydrated electrons.
- Hydrated electrons should react with PCB to cause its dechlorination.
- Radiolysis of water providing free radicals and hydrated electron:



Experiment

Sample preparation:

- Sediments from Strážsky channel were used.
- Weight 20 g of wet sediment + 10 % (w/v) of K₂CO₃ + 5 % (w/v) CuSO₄·5 H₂O powder .

Irradiation:

- Linear electron accelerator with scanning beam UELR-5-1S at the University Centre of Electron Accelerators of the SMU in Trenčín.
- Applied doses were: 0, 100, 326, 500 and 700 kGy.
- Electron energy: 5 MeV.

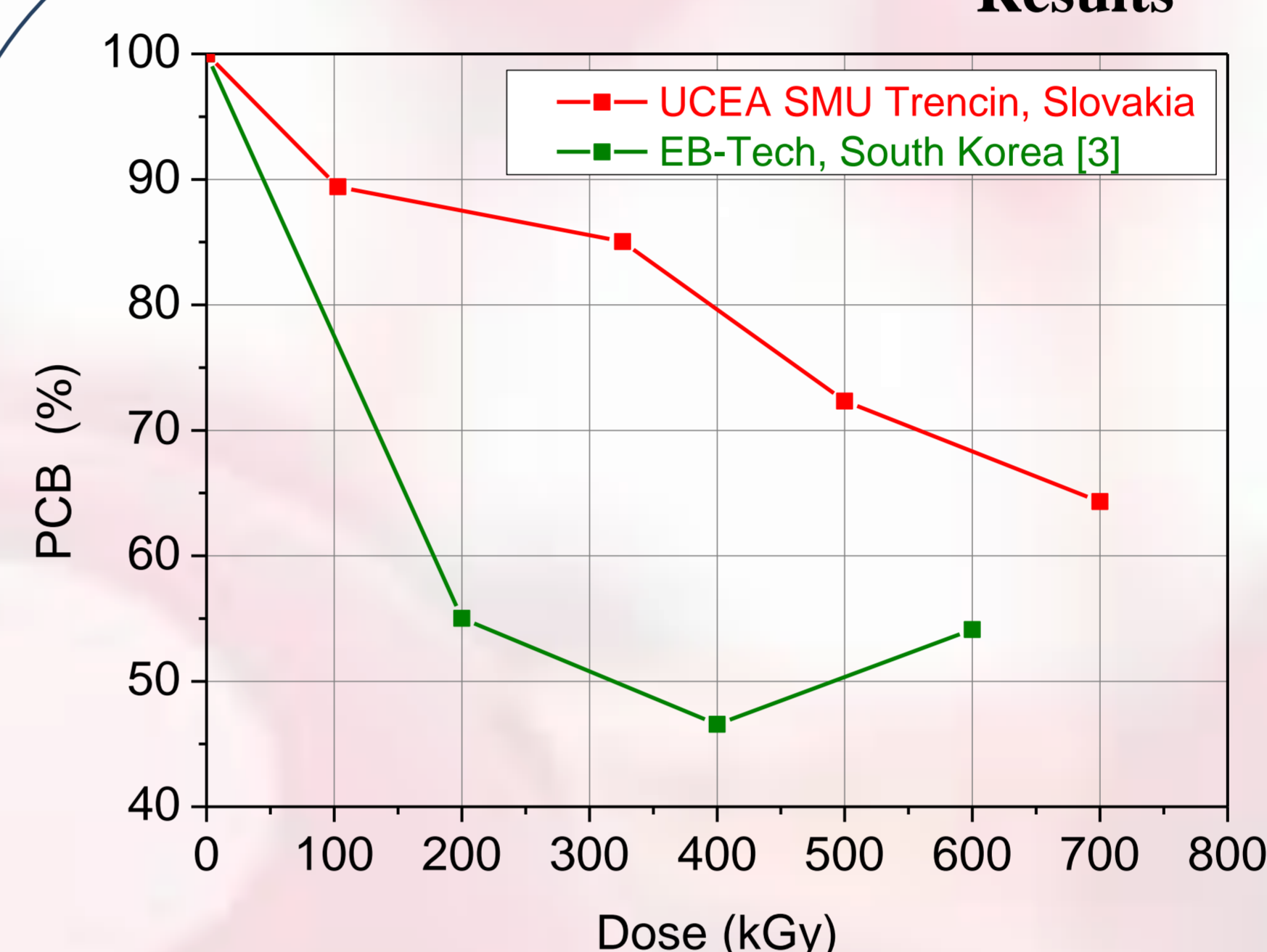
Analysis of PCB:

- At the Department of Toxic Organic Pollutant of the SMU in Bratislava.
- Analysis with high-resolution mass spectrometry (HRMS).
- The total content of PCB (congeners 28, 52, 101, 105, 118, 138, 153, 156, 180) determined in non-irradiated sample was 1842.69 ng·g⁻¹

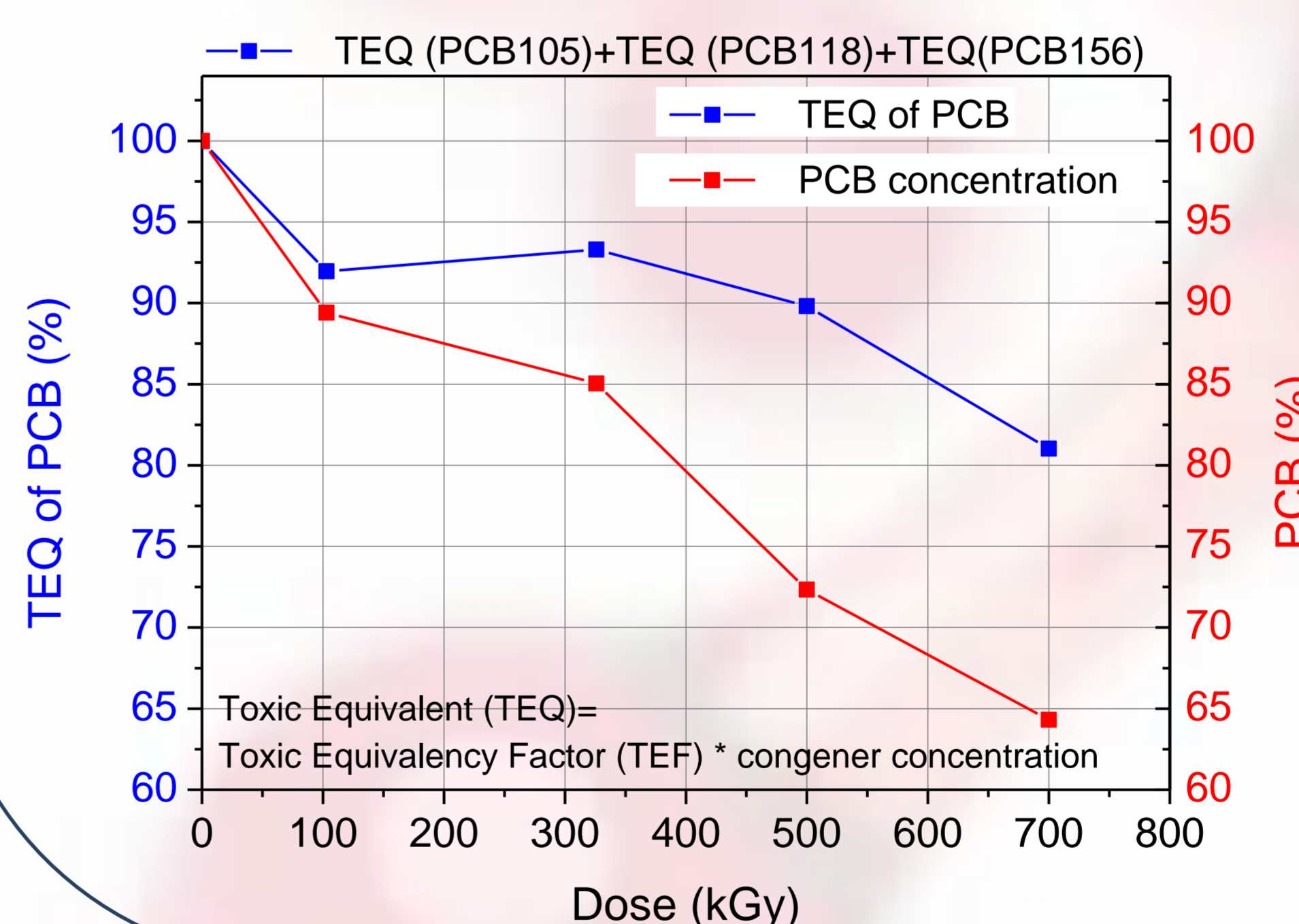
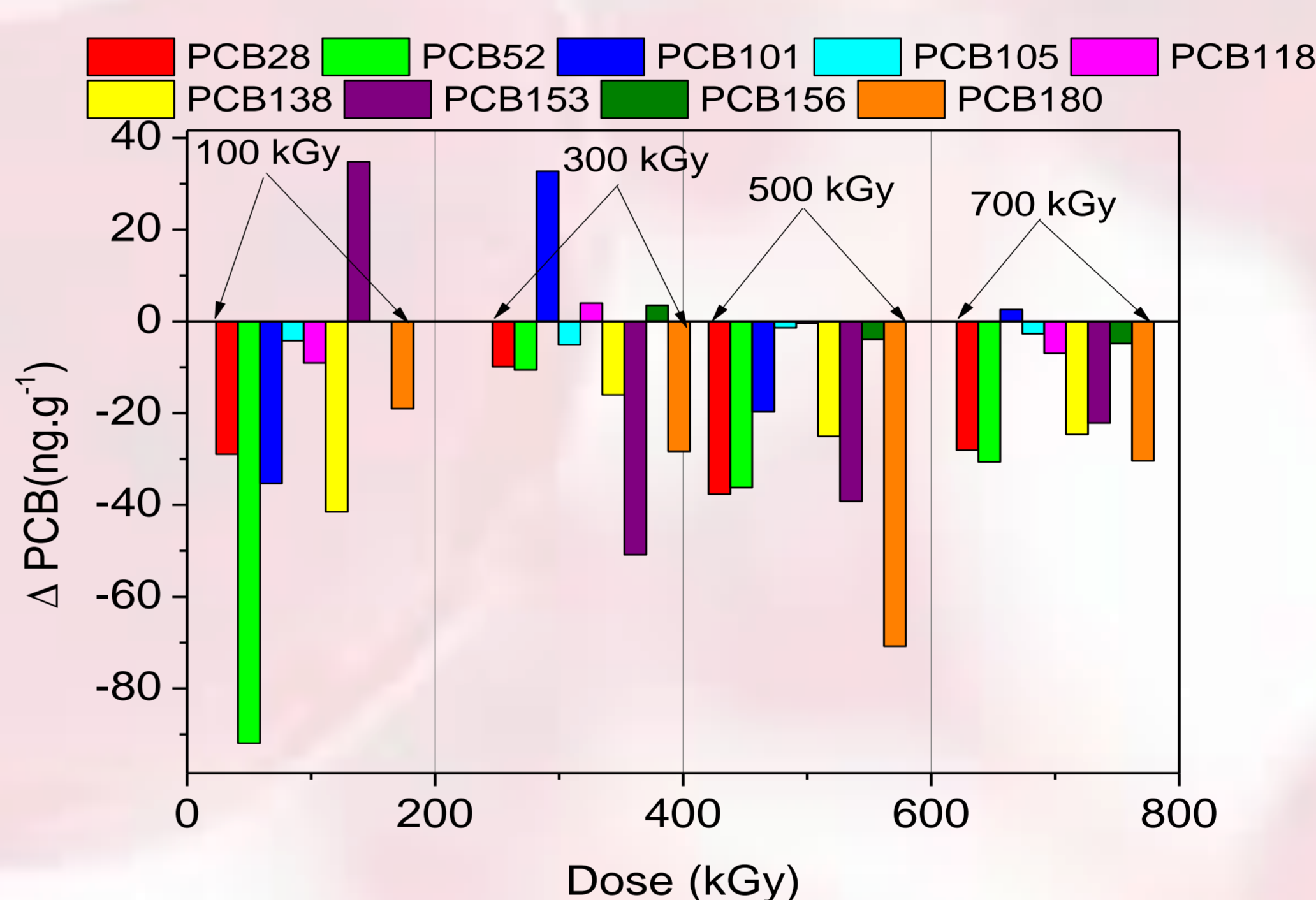
Acknowledgement

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Results



PCB concentration in soil sample as a function of dose irradiated by EB-Tech vs. UCEA Trenčín. Colleagues from South Korea chemically pretreated and irradiated the samples of soil contaminated by PCB from Slovakia. They used lower energy of electrons, 2.5 MeV.



Conclusions

The price of radiation degradation depends on the type and power of the accelerator and the pre-treatment of sediments. When using the accelerator of DC Transformer type (2.5MeV / 100 kW) the operating costs (including capital costs) are estimated at 50 euro per 1000 kg of sediments [3] to reduce the PCB concentration to 50%. The more effective conversion of PCBs can be reached by optimization of chemical pre-treatment of sediments. Due to the fact that PCBs are hydrophobic compounds, it is required to use a co-solvent. Very often the isopropanol is used as a co-solvent, which assists the dechlorination process of PCBs .

Literature

- [1] Igor Danielovič et al., 2014, Soil contamination by PCBs on a regional scale: the case of Strážske, Slovakia, *Pol.J.Environ.Stud.Vol.23.No.5, 1547-1554*
- [2] Soňa Wimmerova et al., 2015, The spatial distribution of human exposure to PCBs around a former production site in Slovakia, *Environ Sci Pollut Res.Vol.22, 14405-14415*
- [3] Lubica Darážová, Andrea Šagátová, Marko Fülöp, Bumsoo Han, Radiation degradation of PCBs in sediments: comparison between two methods, *Česko-slovenská konference jaderného inženýrství ČVUT v Praze.*