BULLETIN 2020

Department of Remediation and Environmental Projects

dekonta

CONTENT

WHAT 2020 BROUGHT US?

For the majority of us, 2020 was very unusual in many ways, and it brought a number of challenges, both in private and professional life. However, in spite of all the difficulties caused by the world pandemic and consequent government regulations and restrictions, we implemented a number of new projects in 2020, and we can say that we do not slacken in gaining new orders either. We would like to present a selection of the most interesting activities to you in this bulletin that has been created in the course of the whole 2020, and its aim is to outline, in brief, the diversity of activities of the Department of Remediation and Environmental Projects of the company DEKONTA.

As an introduction, we are proud to say that we gained the prestigious SDGs Award in 2020, awarded by the Association of Social Responsibility to the best Czech projects fulfilling, in various ways, the UN Sustainable Development Goals in the Czech Republic and abroad. The company DEKONTA won in the category Foreign Development Cooperation with its project of constructed wetlands improving living conditions in rural areas of developing countries. Specifically, it concerned successful construction of 349 m^2 of new wetland ecosystems in developing areas of Bosnia and Herzegovina, and Cambodia. The SDGs Award was handed over to Karel Petrželka, CEO of DEKONTA, during ceremony in gardens of the Černínský Palace of the Ministry of Foreign Affairs of the Czech Republic on September 17, 2020. The award is a huge impulse for us to continue with further meaningful activities in developing countries.

Almost the whole 2020 was impacted by the COVID-19 pandemic. In DEKONTA, we accepted this big challenge. An important step in the prevention of spread of this disease was supply of ten pieces of DAF2 devices, developed within the framework of our development activities, intended for disinfection of internal and external surfaces. They were supplied to ten medical centres in Bosnia and Herzegovina.

The activity took place within the framework of a humanitarian aid project financed by the Ministry of Foreign Affairs of the Czech Republic and sponsors of CARE Czech Republic.

On the following pages, we would like to acquaint you with further projects in the fields of remediation, research, and foreign projects, that we successfully implemented in this year, in spite of strict coronavirus restrictive measures.

On behalf of editorial staff:
Jan Vaněk, Petra Najmanová

1. TECHNOLOGY OF CO-COMPOSTING OF SOILS CONTAMINATED WITH PAH, AND ITS PRACTICAL APPLICATION

Ondřej Lhotský, Radek Červinka

From the immemorial, the composting process was used for stabilising biological degradable waste and production of an organic fertilizer. In the past decades, interest in this process has been growing in connection with its usability for remediation of soils contaminated with both organic and inorganic pollutants. Recent research proved that degradation of many substances, biological degradation of which is very limited otherwise, takes place during the composting process.

The so-called co-composting technology is based on mixing contaminated materials (soil, sludge, etc.) with a suitable organic substrate, in a suitable ratio. Subsequently, the mixture is composted using a usual machinery, and monitored thoroughly. The detailed technology proposal for specific contaminants and specific matrices must be based on laboratory and pilot tests, and knowledge of the process. In addition, laboratory verification of biologically available fraction of the contaminant in the matrix in question is also important.

In the course of composting, gradual temperature increase takes place, due to growth of various microorganisms (in particular, bacteria and fungi) that non-selectively decompose all the available organic matter, including the present simple organic contaminants (such as, for example, petroleum substances). In the later phase, when a majority of easily decomposable organic compounds have been decomposed, temperature decreases, and microbial consortium able to decompose more complex organic substances, such as, for example, lignin, grows in the compost. For decomposing the complex substances, the present organisms often use extracellular enzymes, that are very non-selective. In addition to lignin and similar organic substrates, these enzymes are able to decompose also a number of complex organic contaminants (such as polycyclic aromatic hydrocarbons PAHs, explosives, certain pesticides, pharmaceuticals, and personal care products) that

are not biodegradable via conventional methods and, because of that, are considered persistent.

The co-composting technology has been used, for example, by the US Army, utilising this technology for decontamination of soils polluted with explosives since the beginning of 1990s. The US Environmental Protection Agency has recognized it as a remediation method in 1998.

In the Czech Republic, the co-composting technology was investigated, in particular, by scientists of the Institute of Microbiology of the Czech Academy of Sciences. At first, they succeeded in proving that the technology is usable for PAH degradation during composting of railway sleepers. Later, they started to study the possibility of utilisation of the technology for PAH removal from contaminated soil. Within the framework of the research and development competency centre NANOBIOWAT, supported by the Technology Agency of the Czech Republic (TE01020218), the Institute of Microbiology started cooperation with commercial partners (DEKONTA, a.s., and AECOM CZ), and together they were developing the technology of co-composting of soil contaminated with PAHs further, towards its optimisation and practical application. The carried out tests unambiguously confirmed large scale usability of the method for decontamination of soil contaminated with PAHs.

Developed co-composting technology was later used within the framework of the project for remediation of an area contaminated by historical operation of a wood impregnation plant in the territory of the water source Česká Lípa – south, supported from the Operational Programme Environment 2014 - 2020.

The remediation itself consists of construction of an area with water runoff collection, with stabilised surface and foil seal, for carrying out co-composting, having an area of 5,600 m^2. In the area of the former impregnation plant, contaminated soil will be excavated gradually in three successive years, and it will be treated in the secured area subsequently. Ca 7,000 m^3 of contaminated soil should be excavated and treated annually. After a year of co-composting and reaching of remediation limits, the soil will be returned to the excavated place. In total, 21,000 m^3 of soil should be excavated and treated.

The area with water runoff collection was constructed in 2019, and, in 2020, excavation and co-composting of the first part of the area to be excavated during the remediation has taken place. The excavated material was divided into two parts. The first one was composted actively in the period from May to August, composting of the second one started in September, and it will end in spring 2021.

During active composting, mixture of the soil with an organic substrate is deposited in the area in the form of long heaps, so-called fillings, that have to be dug through and moistened at intervals, because of intensive microbial processes and quick oxygen consumption taking place there. Gradually, a majority of organic substrate is consumed, and the process slows down significantly. Since that point of time, the materials need not to be dug actively anymore.

Till September 2020, the active part of co-composting was successfully finished in the case of the first part of sand having the total volume of ca 3,500 m^3. In May 2020, this sand was mixed with organic substrate supplied from the local composting plant in the volume ratio of 1 : 1. Considering the density of the organic substrate ca 350 kg/m^3, and of sand ca 1,700 kg/m^3, this represents the weight ratio ca 1 : 5, in relation to fresh weight, and ca 1 : 10, in relation to dry weight. Thus, the influence of PAH dilution by the organic substrate is approximately 10 % only.

Within the above-mentioned period, co-composting resulted in removal of ca 81 % of the sum of 12 PAHs (decrease from the average concentration of 1.15 g/kg to ca 0.31 g/kg), and of 70 to 88 % of the individual heavy representatives of PAHs. The heavy PAH present in the highest amounts was benz[a]anthracene, average concentration of which in the input soil was about 240 mg/kg, and it decreased to ca 20 mg/kg in less than 120 days of composting. The remediation goals of the individual heavy representatives of PAHs is 60 mg/kg. Thus, remediation goals were reached in the soil after 120 days of active co-composting.

In September 2020, this soil was transferred from long heaps to one big deposition that will not be dug through anymore, but PAH degradation will still proceed there more slowly. PAH degradation will continue even after the soil return into the excavated place, till the time when no biologically available PAHs will be present in the material.

Thus, the co-composting technology represents a suitable solution for decontamination of materials contaminated with PAHs, verified by the company DEKONTA, a.s., in remediation practice

2. REMEDIATION OF EUROŠARM PREMISES BY THE STEAM TREATMENT METHOD

Jana Kolářová, Jan Maštalka

Since 2018, we have carried out a part of remediation works in the former premises of the company EUROŠARM – store Plzeň south (OQEMA at present). The remediation works have been implemented as a part of the public procurement „Remediation of a contaminated area in the premises of the company EUROŠARM – store Plzeň south", the general supplier of which is the company G-servis Praha.

Within the framework of this activity, there is carried out remediation of the unsaturated zone of the geological environment and groundwater under the store of chemicals No. 1207/8, and in its vicinity, including the existing area for pumping of chemicals transported by train, and the railway siding. The main contaminants in soil, as well as groundwater, are chlorinated hydrocarbons, and petroleum hydrocarbons.

The company DEKONTA has implemented a part of remediation of the unsaturated zone under the building of the store, and in the adjoining pumping area, using the technology of steam treatment of the geological environment. The main advantage of the method is its high speed and efficiency, approximately an order of magnitude higher than in the case of other remediation methods. On the other hand, this method is not used very often in the Czech Republic, due to its high technological and investment demands in comparison with the conventional methods.

The principle of the method is as follows:

1. Steam from the installed steam generator is pumped into the geological environment through special injection wells, the contaminated area is heated, and volatile organic substances (petroleum hydrocarbons and chlorinated hydrocarbons) are released (by desorption, volatilization). In our case, the injection steam treatment wells were constructed as horizontal wells in the depth of ca 5.5 m under the store of chemicals, and vertical wells in the area for pumping of chemicals.
2. From the properly located extraction wells, hot soil air with the desorbed contaminants is exhausted, it is cooled and purified in the remediation technology unit, using activated carbon filters. Venting horizontal wells in the depth of ca 3 m under the store of chemicals, and vertical wells around the store, are used as the extraction wells. Subsequently, the separated contaminants are disposed off in an incinerator, in accordance with the valid legislation.

116 temperature sensors are installed at the site, measuring temperature in the geological environment automatically. On the basis of the temperature monitoring evaluation, time of steam generator operation is determined, that is needed for heating the geological environment to 80 ° to 90 °C, necessary for volatilization of the contaminants. The overall projected remediation time using this technology is 24 months.

The steam treatment technology was put into operation in May 2019. In the course of 2020, the remediation implementation focused on sufficient heating of the whole space to be remediated, in order to remove the maximum possible amount of contamination. By the end of 2020, 2.9 t of chlorinated hydrocarbons were removed from the geological environment.

3. FOREIGN PROJECTS CONTINUE...

Ondřej Urban

In spite of the fact that the Covid pandemic reduced implementations of foreign projects significantly, and made them more difficult, we succeeded in finishing one investigation in Bosnia and Herzegovina, and in starting two new projects in Moldova.

Investigation of the Biggest PCB Hotspot in Republika Srpska in Bosnia and Herzegovina

In May, DEKONTA won the international tender announced by the UNDP office in Sarajevo. As soon as the first Covid wave passed, a group of 7 Dekonta empoyees moved to the town Banja Luka, to carry out investigation works in the premises of the industrial complex INCEL, with the historical leaks of PCB substances from transformers. In a relatively short time of 3 weeks, 30 probes were drilled, and ca 200 samples of various matrices were taken.

Subsequently, contamination assessment report, risk analysis, and a proposal of the strategy for remediation of the site, were drawn up for the UNDP.

Luckily, there were not confirmed the worst scenarios and information from previous investigations, indicating pollution at the levels exceeding 1000 ppm PCB was not confirmed. The maximum PCB contents were in the order of units of ppm, i.e., they were comparable with similar hotspots in the Czech Republic.

After preparation of the reports, and presentation in the town Banja Luka, on-line conferences took place with representative of the local Ministry of Environment, in order to discuss the strategy and purpose of the risk analysis, determination of site remediation limits, etc. As the interest of the local Ministry focuses on this issue, it was agreed with the UNDP that it would be beneficial to organize a follow up seminar for representatives of the state administration in Bosnia and Herzegovina.

Investigation and Development of the Strategic Solution for the Transformer Station Premises in Vulcănești, Moldova

In October, extensive investigation was started festively in the transformer station premises in the town Vulcănești in Moldavia. The purpose of the project is to find a strategic solution (remediation) in the case of a contamination caused by an explosion of ca 1000 condensers in 1979. The project is financed by the Czech Development Agency within the framework of foreign development cooperation.

The project outputs include detailed investigation of the soil and groundwater. In its course, ca 400 probes were drilled, and over 1400 samples of soil and groundwater were taken.

On the basis of results of laboratory analyses, the human health and environmental risks of the site will be evaluated, and the best method for its reduction will be proposed (so-called feasibility study). Further, documents forming basis for implementation of corrective measures will be prepared.

The project is a continuation of previous considerable interventions and projects of the Czech Development Agency in 2006 - 2017, focusing on elimination of the risks of environmental contamination, such as, for example: „Remediation of Areas Contaminated with Pesticides in Moldavia I and II", „Technical and Institutional Support in the Field of Solid Waste Management in Southern Moldavia", „Remediation of Sites Polluted with Petroleum Substances in the Municipalities Lunga and Mărculeşti" and „Reduction of Risks Related to Hazardous Waste Landfill in Cişmichioi".

4. WE BUILD CONSTRUCTED WETLANDS

Tereza Hnátková, Michal Šereš

Constructed wetlands (hereinafter CW) have been used abroad for wastewater treatment since 1950s already, and, gradually, their popularity is growing also in the Czech Republic, where many activities of the company DEKONTA contribute to their spreading, too. Practical experience of operators of up-to-date, so-called hybrid CWs, show that their operation and maintenance are simple and cheap, and output quality of the treated wastewater (WW) is very stable throughout the year, and often better than in the case of standard activated sludge wastewater treatment plants (WWTPs).

Constructed wetland for the municipality Nečichy, Louny

Numerous Czech and foreign studies confirm the fact that complex purification processes in CW may remove a number of diverse organic micropollutants from wastewater, such as, for example, pesticides, residues of pharmaceuticals, and perfluorinated compounds. Because of this fact, CWs represent also a suitable method for final tertiary treatment of wastewater from bigger WWTPs.

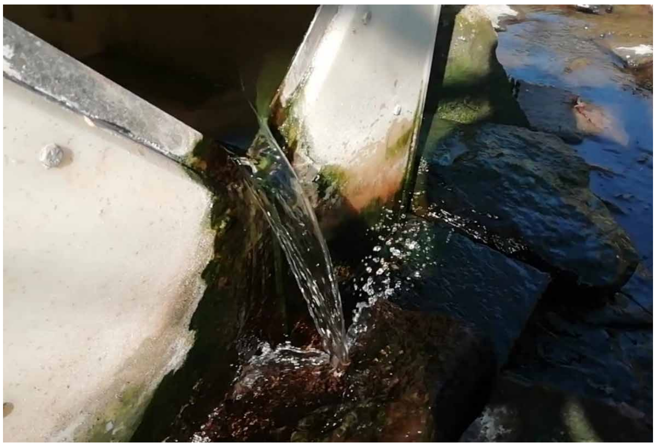
In September 2020, one of the biggest passive wastewater treatment plants was put into operation in the tourist centre Białka in the municipality Dębowa Kłoda in the Lublin Province. The capacity of the facility is 180 m^3 daily, and it is able to treat wastewater produced both by the 250 permanent inhabitants, and by thousands of tourists visiting the place annually. The WWTP in Białka was planned by scientists from the University of Life Sciences in Lublin, and the Gdańsk University of Technology, and it was constructed by the company Dekonta in consortium with the Polish spin-off company RDLS. In practice, it is one of the biggest constructed wetlands in Poland, having the capacity of up to 1800 inhabitants. Thanks to its natural look, the passive technology blends with the landscape, and discharges virtually clean water into the local ecosystem. The facility meets all to environmental standards, and functions all year round.

Constructed wetland for the municipality Dębowa Kłoda, Poland

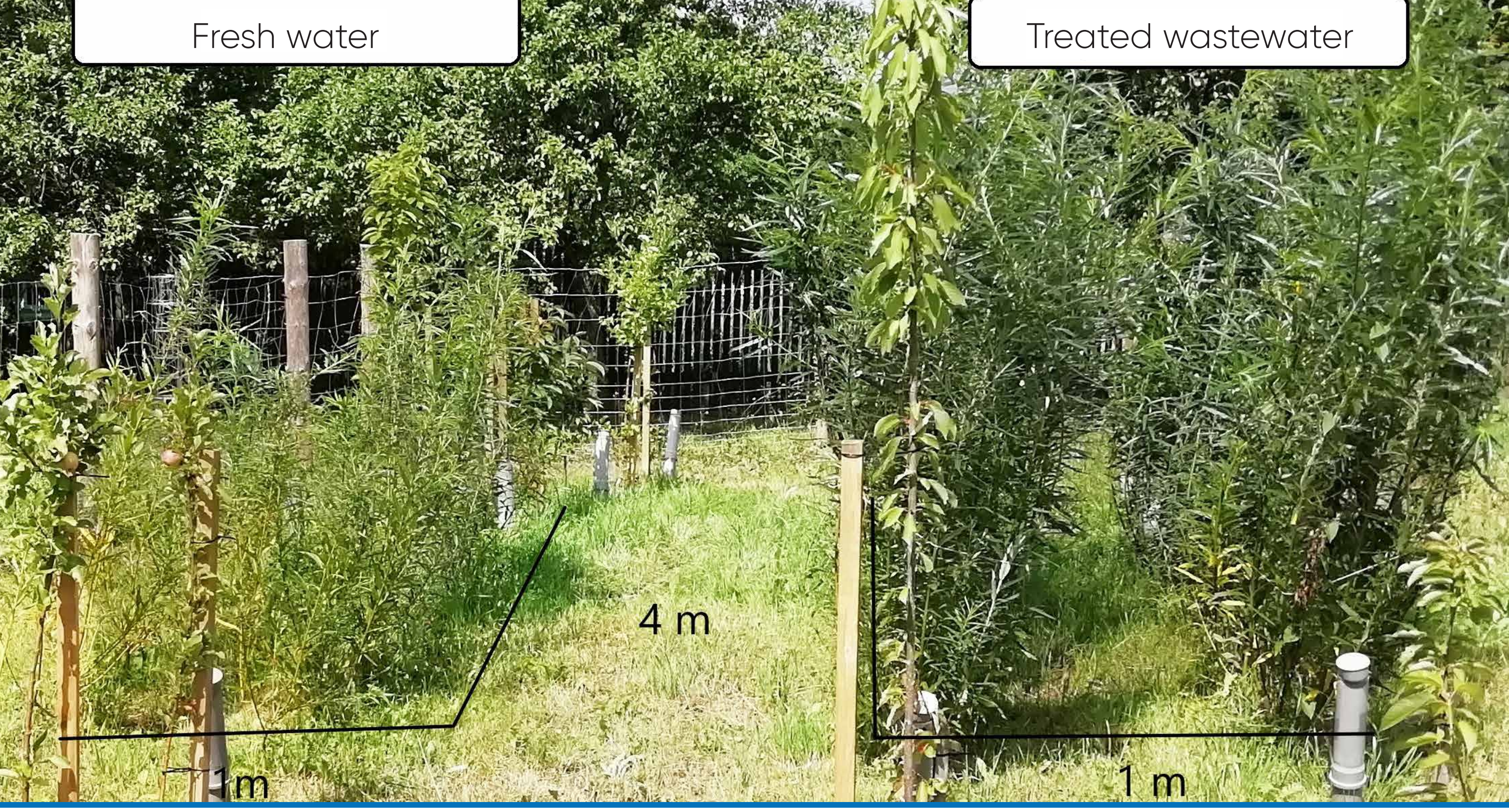

Constructed wetland and Experimental Irrigation in Kostelec nad Ohří

Wastewater Recycling

Change of climate and distribution of precipitations in the course of the year will cause increase of demand for systems of artificial irrigation of agricultural crops and ornamental plants, and altogether more efficient and economical water use. In view of decreasing amount of high quality water sources, increased demand for utilisation of treated wastewater is also expected. However, there exist concerns regarding the inherent wastewater nature, containing a complex mixture of organic and inorganic substances. The basic precondition for wastewater reuse is proper wastewater treatment and disinfection before use in activities concerning plant production, in order to avoid contamination of plant products with pathogenic microorganisms, and other pollutants. In spite of the contamination risk, such water retains very interesting residual contents of nutrients (N, P, K) that may serve as an alternative fertilizer, reducing the amounts of applied mineral fertilizers. It is also proved that its use results in increase of organic matter content in soil, and in stimulation of activity of soil microorganisms, resulting in further releases of nutrients into the soil solution, and, indirectly, fertilizing of plants.



Naturally, risks connected with wastewater reuse must not be underestimated. In addition to the above-mentioned spread of micropollutants and pathogenic microorganisms, there exist threats of gradual soil salinization, changes of physical and chemical properties of soil, etc.



Irrigation Systems

Since 2018, we have carried out a number of tests in experimental irrigated areas connected to CWs in the town Kostelec nad Ohří and in the municipality Hostětín, in cooperation with the Water Research Institute, within the framework of the IRMA project (No. TH02030583). In the spring of 2020, we started continuation of this project by the project AIRA (No. TJ04000322), in cooperation with the Water Research Institute and Institute of Microbiology of the Czech Academy of Sciences. At the both sites, treated wastewater is distributed by drip irrigation over the experimental fields, where agricultural crops are grown, such as, for example, lettuce, tomatoes, and potatoes. Further, fruit trees and fast-growing tree species, namely willows, are irrigated.

For two growing seasons, we observed a markedly higher biomass production of fast growing tree species irrigated by wastewater, namely up to 31.26 t/ha, in comparison with 1.77 t/ha when clean water was used. In the case of potatoes, double number of tubers was harvested; in the case of tomatoes, the number of harvested fruits was by 59 % higher. Microbiological analyses of the harvested vegetable proved that hygienic quality of the crops was approximately identical when using wastewater and water from a well for irrigation. In wastewater from Kostelec nad Ohří, 17 pharmaceutical substances were detected out of 19 monitored ones. Passage through the CW, and, further, through the soil layer, ensured sufficient removal of the monitored micropollutants to minimal level (concentration in the drainage in units of ng/L). Moreover, none of the monitored substances got into the crops grown. Further, the hypothesis was confirmed that, in the Czech climatic conditions, treated wastewater would not represent a significant risk for the soil from the point of view of degradation and changes of structural properties. Simultaneously, it was proved that residual concentrations of nutrients in wastewater do not cause significant increase of concentrations of these substances in groundwater.

Our studies confirm hypotheses that wastewater treated in a constructed wetland may be reused in agricultural production. If human health were directly endangered in any way, then it may be used in plantations of fast-growing tree species, with the aim to produce biomass and, thus, to utilize their fertilizing potential efficiently. Further, wastewater recycling may play an important role not only as a means for drinking water savings and removal of substances causing eutrophication, but it may also serve as a tertiary stage for final treatment of water containing newly occurring pollutants.

5. SOLUTION OF FINAL TREATMENT OF SEWAGE SLUDGE

Michal Šereš, Tereza Hnátková, Petra Innemanová

In view of the fact that legislative limits are tightening, sewage sludge management is becoming ever more urgent issue for their producers and processors. According to the Czech Decree No. 437/2016 Coll. on the conditions for use of treated sludge on agricultural soil, requirements on microbiological quality of sludge for application on soil will be increased from January 1, 2023. The Decree also defines processes related to it. In an ideal case, new BAT technologies, solving hygienic aspects of human health protection in accordance with the Decree, should not have a negative impact on the current costs for wastewater treatment. This is one of the reasons why new technologies are being developed, and new procedures for waste management tested constantly, in order to make their processing and final disposal cheaper, simpler, and, ideally, with an added value. In the recent years, we have studied this issue intensely within the framework of several research projects. Since 2016, we have solved a research project entitled „Production of Fuels from Sewage Sludge by the Biodrying Method" (financially supported by the Technology Agency of the Czech Republic (TACR), No. TF2000027), in cooperation with the Faculty of Science of the Charles University. The purpose of the project was to develop and test technological equipment and method for sewage sludge processing by the biodrying method, resulting in minimisation of costs for reprocessing of this hazardous material. The technology offers the possibility of relatively cheap

Sludge Dewatering Reed Bed

and simple sewage sludge processing in a biological way, resulting in decrease of total moisture content, due to which the final product may be used, e.g., as a fertilizer or a fuel.

Biodrying in a Greenhouse in Slaný


Tests of Sludge Stabilisation by Mixing with Quicklime

Since 2017, we have solved, together with the Water Research Institute of T.G.M., and the Research Institute for Soil and Water Conservation, a project entitled „New Procedures for Treatment and Stabilisation of Sewage Sludge from Small Municipality Sources" (financially supported by TACR, No. TH02030532). The project focused, in particular, on verification of extensive procedures for processing of sewage sludge from small WWTPs by the method of composting and dewatering in the so-called sludge dewatering reed beds. The last technology is related to the constructed wetlands described above, and we can often meet these two technologies next to each other in foreign countries.

The last one of the three „sludge" projects, entitled „Sustainable Methods for Sewage Sludge Recycling in the Ústí and Labem Region" (financially supported by TACR, No. SS01020167), started this year, in cooperation with scientists from the Czech University of Agriculture, further, with the Research Institute for Soil and Water Conservation, and a partner from the industry sector, the company JUROS, s.r.o. Within the framework of the project, we test applicability of three approaches to sewage sludge processing – composting, stabilisation/solidification, and biodrying, on a bigger scale, using sludge produced by three big WWTPs in the Ústí and Labem Region. The purpose of the project is to optimise these methods for specific sludge types, in order to enable their subsequent use, for example, for landscape restoration after brown coal mining in the northern Bohemia.

Reduction of the total volume and hazardousness of sewage sludge is an essential task to be solved by its producers. In view of the produced amounts of sludge, reaching up to 170,000 tons in the Czech Republic annually, processes enabling further utilisation of this hazardous waste should be preferred over other management methods that do not use the additional potential of the material. Thus, the methods described above may represent the key procedures for sludge reprocessing to i) a fertilizer, if contents of heavy metals and other hazardous substances meet the criteria of the Decree No. 437/2016 Coll., and the used process results in reaching sufficient properties of the material from the hygienic point of view; ii) a starting material for thermal processes, such as pyrolysis and torrefaction, if the heavy metal content does not exceed the limits, but the material is not acceptable from the hygienic point of view; or iii) a fuel to be used in cement kilns, if the sludge cannot be used in agriculture due to the contents of hazardous substances.

6. NEW POSSIBILITIES FOR EVALUATION OF TECHNICAL CONDITION OF HYDROGEOLOGICAL WELLS

Jan Kukačka

Evaluation of technical condition of hydrogeological wells may be carried out by a number of hydraulic and geophysical methods. An advantage of the hydraulic ones resides in their directness, and, as a rule, also their lower demands on equipment and costs. They are based on hydrodynamic tests that may be supplemented by hydrometric measurements of the vertical component of flow, however, in any case, these methods provide only minimal information on the possible variability of the determined parameters along the vertical profile of the object. Geophysical methods – when used in hydrogeological wells, they are usually designated as (hydro)logging ones – are indirect, they require complex equipment, and, in contrast with the above-mentioned methods, they provide solely information on the vertical profile of the measured parameters for the evaluation. Their advantages are potentially high resolution, and possibility of interpretation of the operation properties of the objects in question from the point of view of physicochemical properties of the relevant groundwater reservoir. In this case, the basic procedure is resistivimetry, in its various variants. The list of the used methods includes measurements of the real diameter of the well, acoustic logging, density logging, gamma logging, gamma-gamma logging, and neutron-neutron logging, as well as camera inspection of the well.

In practice, technical condition and, thus, also service life, of hydrogeological wells are limited, in particular, by the impacts of the colmatage process, i.e., clogging of the porous area of the well filter, or, optionally, the part of the geological environment in the closest surrounding of the filter parts of the well casing. The cause is, as a rule, a combination of a mechanical factor (suffosion) – i.e., transport of movable sedimentary particles due to transport abilities of flowing water – and a chemical-biological one – i.e., oxidative processes resulting in precipitation of ions dissolved in groundwater. Usually, a number of chemolithotrophic microorganisms participates in this phenomenon, and, at the macroscopic level, the process results in formation of incrustations (precipitates) inside the well screen, as well as in the inner area of the well filter.

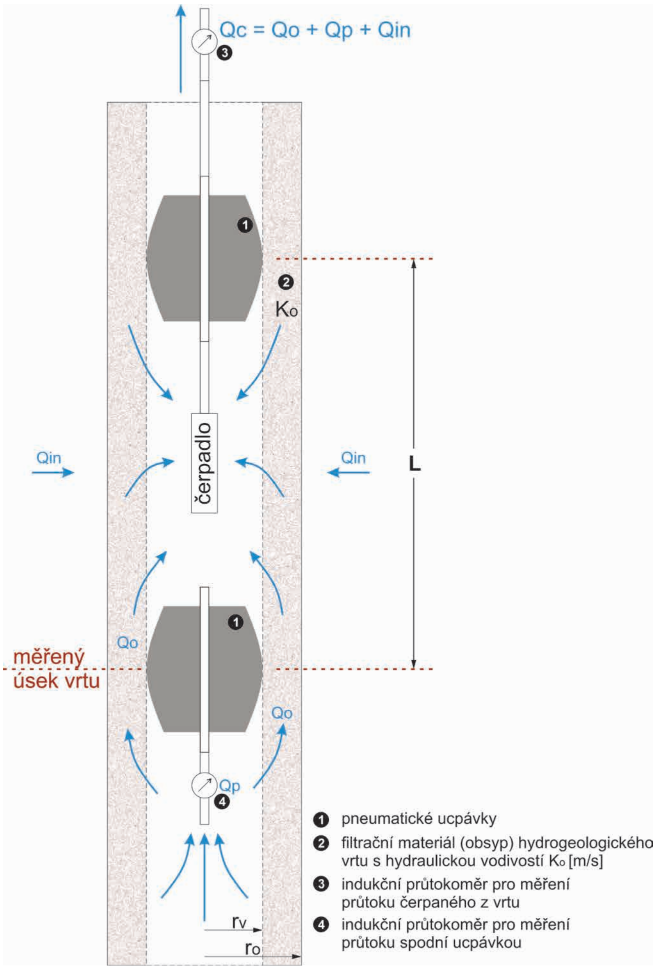
New Method for Evaluation of Filtration Function of a Hydrogeological Well

Within the framework of the INV-FLOW project, a new apparatus was developed, enabling direct evaluation of the technical condition of the filtration part of a hydrogeological well. Thus, the part of the well that participates in the correct function of each hydrogeological well. The INV-FLOW apparatus is designed as a portable one, and it consists of the following parts (Figure on the right):

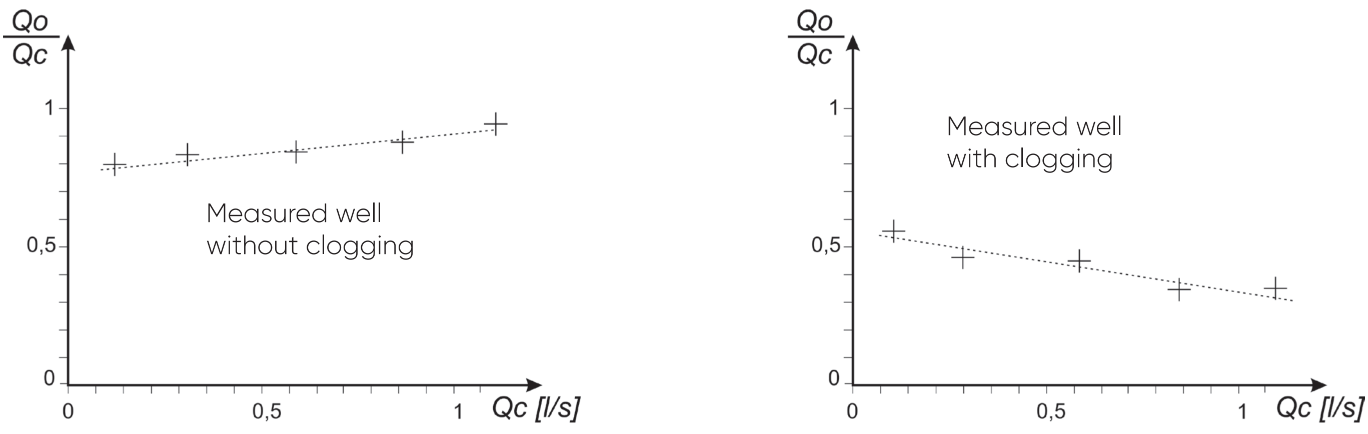
- 2 x through-flow pneumatic packer for sealing the part of the hydrogeological well to be measured;
- Pump located in the area between the packers, enabling smooth regulation of the output;
- Electromagnetic flow meter located on the surface of the ground, for measuring flow of water pumped by the pump from the hydrogeological well;
- Electromagnetic flow meter located under the lower seal in the well, for measuring flow of water pumped through the lower packer.

The function of the INV-FLOW apparatus is illustrated by figures on this page. The apparatus is inserted into the well to be measured into the corresponding depth level where the filtration function of the well is to be evaluated, wherein the measured part of the well corresponds to the centre of the lower pneumatic packer (Figure on the right).

General scheme of the INV-FLOW apparatus



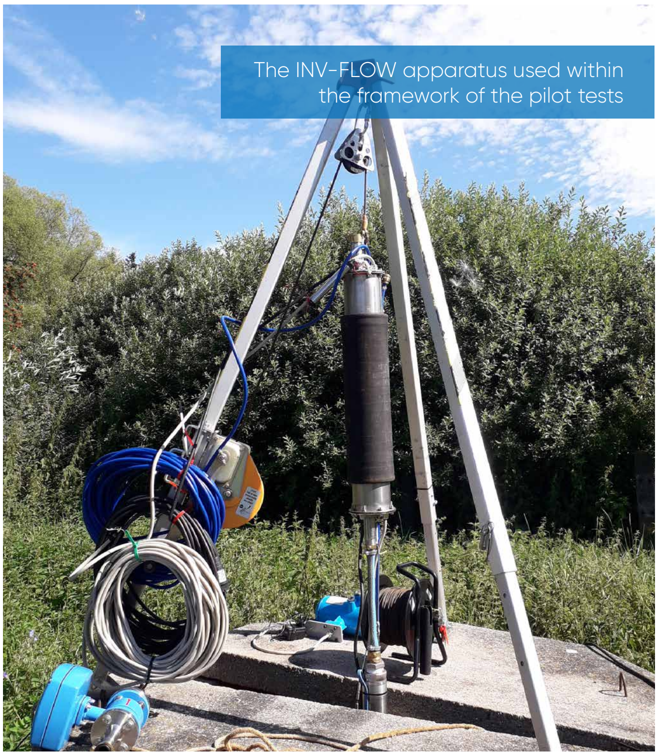
Results of measurements by the INV-FLOW apparatus in a functional well, and in a well with a limited filtration function



Laboratory and Pilot Testing of the INV-FLOW Apparatus

In the first stage, the measurement principle was tested on a laboratory scale. For this purpose, a physical model was constructed, simulating induced vertical flow of groundwater in a hydraulically incomplete well, with simultaneous maintenance of constant piezometric water level in order that the problem be reduced to the one-dimensional component without significant external impacts. In principle, this was a model of an „ideal" flow during investigation or operation pumping of groundwater bodies enabling balance comparison of the individual components of vertical flow.

Subsequently, within the framework of pilot testing of a functional INV-FLOW apparatus (Figure below), vertical profile of a well was measured by the INV-FLOW apparatus at the site Výrov near the municipality Hadačka, in an old catchment well HJ-3 (Figure on the right) with reduced function due to colmatage (originally, the well was constructed for supplying agricultural cooperative Kralovická zemědělská, a.s.). Figure on the next page shows results of measurements in various depth levels and with various pump power. From the graph, it may be deduced that in the depth 11 to 15 m below ground level, the water flow through the filtration material decreases gradually from the value of ca 50 % to



The INV-FLOW apparatus used within the framework of the pilot tests

ca 20 %. Thus, in this depth, filtration ability decreases with the growing depth, and the well colmatage increases. In the portion 15 – 20 m below ground level, the water flow through the filtration material is continually under the level of 30 %. In this depth, filtration function of the well is reduced significantly by colmatage, and, optionally, incrusting.

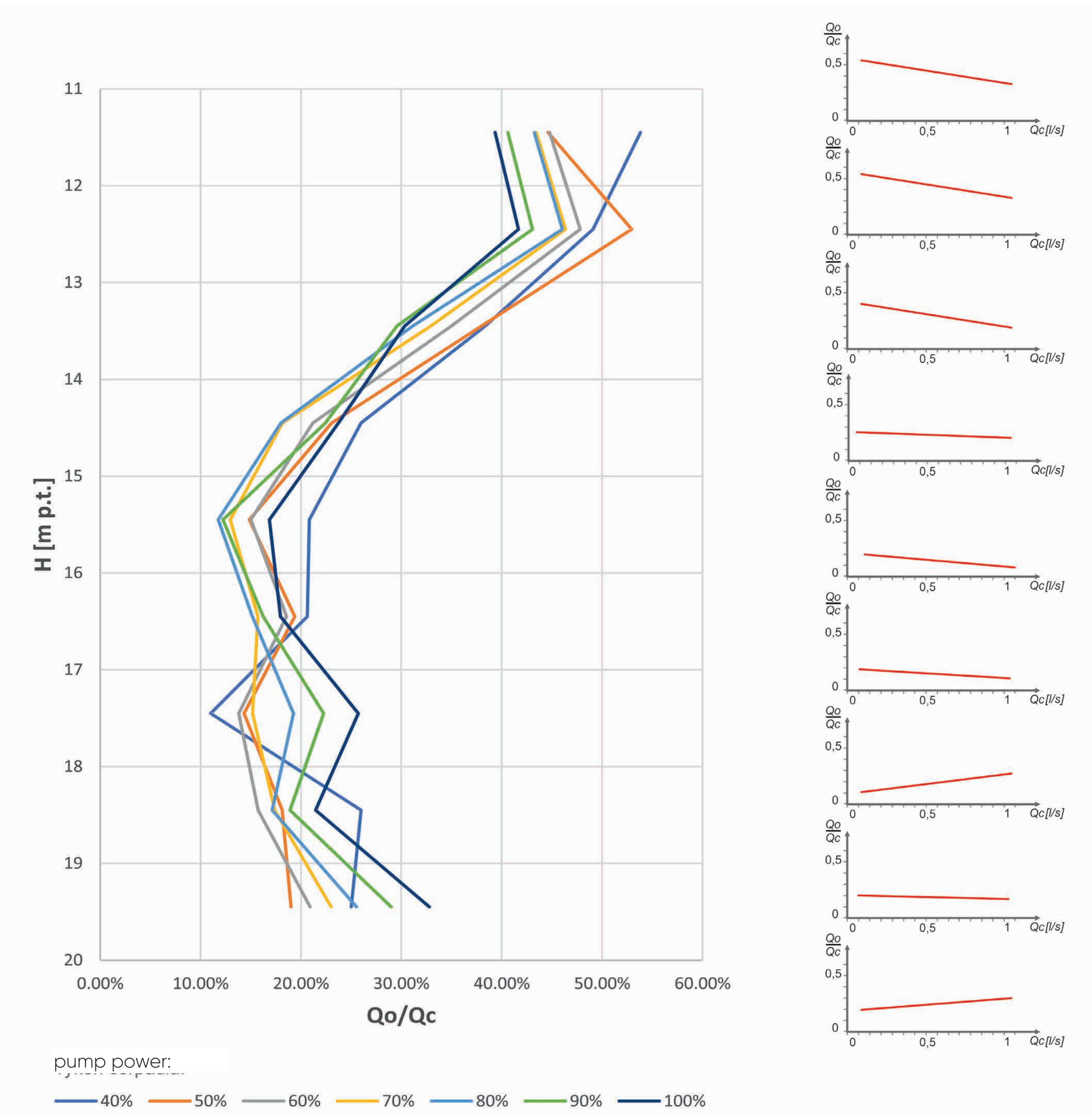
Possibilities of INV-FLOW Application

The newly developed INV-FLOW apparatus, evaluating filtration function of hydrogeological wells by means of measurements of vertical water flow in the wells, is primarily designed for use by water supply companies operating catchment hydrogeological wells, and, optionally, by environmental-geological companies operating remediation wells. On the basis of direct measurement by the INV-FLOW apparatus, the hydrogeological well operator is able to evaluate the level of colmatage and incrustation of the hydrogeological well, and, thus, to decide on the need to regenerate the well in question, or, optionally, to end its operation.

The INV-FLOW apparatus during installation into the measured well HJ-3 at the pilot site

The INV-FLOW apparatus is designed as a modular system that enables changing the overall parameters of the apparatus, and, thus, also its application parameters, by changing parameters of some of its parts. By changing the diameter of the pneumatic seals, it is possible to adapt the use of the apparatus for higher, or, alternatively, lower diameters of hydrogeological wells, and by changing the measurement parameters of the flow meters and the pump power, it is possible to modify the apparatus to measure in a very permeable environment with high groundwater yields.

Results of the pilot testing of the INV-FLOW apparatus in a well with reduced filtration function

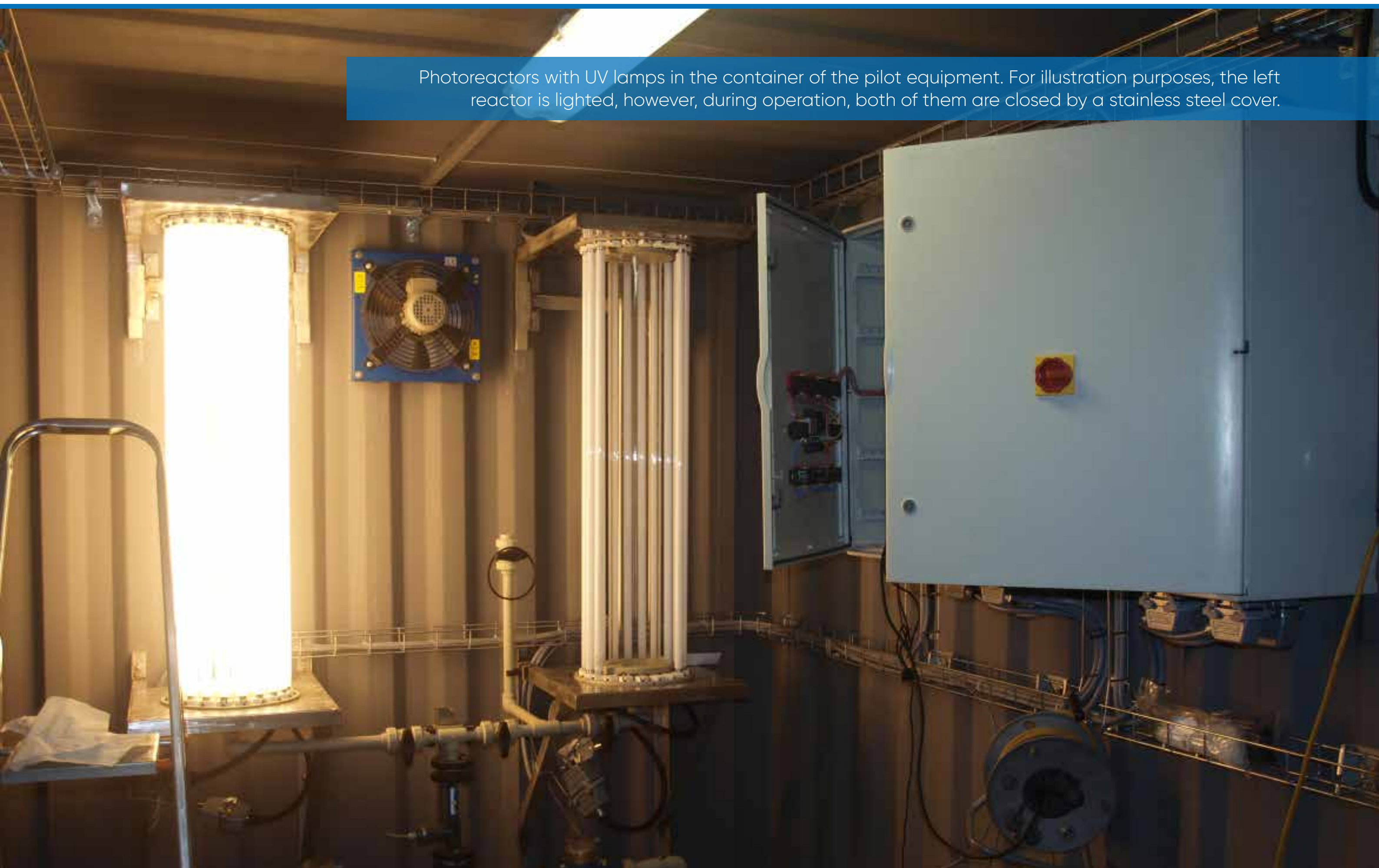


The project INV-FLOW – Technology for direct measurement of vertical groundwater flow and zonal quantification of well inflows based on electromagnetic flow induction, No. TH04030492, was implemented with financial support of the Technology Agency of the Czech Republic.

7. UTILISATION OF PHOTOCHEMICAL OXIDATION FOR ELIMINATION OF MICROPOLLUTANTS FROM WASTEWATER

Vladislav Knytl, Pavel Mašín

Pharmaceuticals are present in water in low concetrations in the orders of µg or ng/L. Because of that, their determination was not possible at all until recently. In the last few years, thanks to quick development of highly sensitive analytical methods, it was proved that these substances are often present, especially in surface water. Pharmaceutical enter surface water usually secondarily from municipal wastewater that, in spite of the fact that it meets all the legislative requirements for discharge into a recipient after passing through a mechanical-biological WWTP, usually contains a great diversity of these micropollutants. The hazards of the above-mentioned substances for vertebrates lie, in particular, in that even very low concentrations, just in the order of µg/L, or even ng/L only, are sufficient for triggering the broad spectrum of their biological and endocrine activities. This fact may have serious impacts on health, especially in the case of long-term exposure.



Photoreactors with UV lamps in the container of the pilot equipment. For illustration purposes, the left reactor is lighted, however, during operation, both of them are closed by a stainless steel cover.

Project Aims

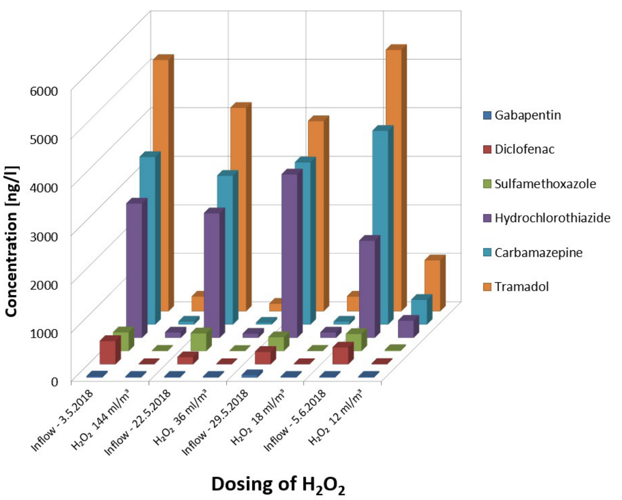
The subject-matter of the project No. CZ.01.1.02/0.0/0.0/15_019/0004571 has been development of technologies for removing the above-mentioned group of pollutants from wastewater. For this purpose, two methods have been tested in parallel, namely sorption on activated carbon, and photochemical oxidation.

The method for removal of pharmaceutical residues that has been developed is intended as a tertiary stage for wastewater treatment plants, especially for hospitals and medical centres. It represents a direct photochemical destruction of the compounds in question by hydroxyl radicals generated by activating hydrogen peroxide (H_2O_2) under UV irradiation. Subsequently, the residual H_2O_2, and optionally, any intermediates formed by degradation of the pharmaceuticals, may be removed by sorption on activated carbon, but, ideally, the resulting products should be CO_2 and H_2O, and, in the case of decomposition of substituted hydrocarbons, also the corresponding mineral acids and salts.

Pilot Testing of the Technology

Technology of photochemical oxidation was installed in WWTP in northern Bohemia for final treatment of water with residual contents of pharmaceutical substances.

The pilot photochemical unit consists of two photochemical reactors located in a mobile container. Each of the reactors is formed by a quartz tube having the diameter of 150 mm and length of 1200 mm, surrounded by 20 low-pressure germicidal lamps having the total output of 720 W (UV radiation output being 300 W). Water flows continuously through the both photochemical reactors, connected in parallel. Before the photoreactors, 35% H_2O_2 is dosed into wastewater (10 - 150 ml/m^3). A special mixing element ensures turbulent flow and uniform distribution of H_2O_2 in water to be treated. The treated water leaving the photoreactor subsequently flows through an activated carbon filter for removing the residual H_2O_2 (the maxium H_2O_2 concentration in the treated water was 3 mg/L). Flow of water to be treated is 300 – 500 L/hour. The method of photochemical oxidation effectively degrades persistent pharmaceutical substances gabapentin, diclofenac, sulfamethoxazole, hydrochlorothiazide, carbamazepine, and tramadol, as shown by the graph. The minimum efficiency of removal of these substances was 85 %.



8. REACTIVATION OF SPENT ACTIVATED CARBON FOR WATER TREATMENT PURPOSES

Marek Šváb, Barbora Štěpánová

Why to Reactivate Spent Activated Carbon?

Water sources, both surface water and groundwater ones, are currently burdened by dozens of various chemical substances xenobiotics present in very low concentrations (in the order of hundreds of ng/L), as proved, inter alia, by a long-term monitoring carried out by the Czech Hydrometeorological Institute. These substances are especially pesticides, but also residues of pharmaceuticals, and, optionally, substances known as personal care products (PCPs).

For the above-mentioned reasons, some big, as well as small, waterworks in the Czech Republic already invested into installation of further, supplementary stage of water treatment before the stage ensuring hygienic safety and distribution. The added final water treatment is filtration through granular activated carbon (AC) in sorption filters able to effectively remove trace amounts of xenobiotics from water. In this case, AC service life in the filter is ca 2 – 4 years. After that, the AC has to be replaced, or AC reactivation has to be carried out, what is advantageous from the economical point of view. The sorption stages are under construction in further water treatment plants, including the biggest one in the Czech Republic (Želivka, ca 1400 tons of AC; investment costs ca 1 billion CZK, costs for the AC in the filters ca 130 million CZK). Thus, the amounts of spent activated carbon to be reactivated will be growing in the Czech Republic.

This is a completely different field, activated carbon types, and technology, than in the case of waste air treatment. However, the necessary technology is able to reactivate even the spent AC from waste air treatment, it means to restore function of even such kinds of AC that cannot be regenerated by usual regeneration procedures for spent AC from waste air treatment anymore.

In the Czech Republic, no company offers the service of AC reactivation. Its offer may be found on internet pages of some companies, but, in all the cases, the service is provided in the form of a subcontract carried out abroad (for example in the company Donauchem Pischelsdorf near Wien).

Principle of the Process

EXHAUSTED AC REACTIVATED AC

The principle of the AC reactivation lies in carrying out the process of gasification of carbonaceous compounds to gaseous products. As a gasification medium, water steam may be used, that, at high temperatures (ca 650 to 900 °C) reacts with the compounds, and the main products are carbon dioxide, carbon monoxide, any hydrogen (depending on the temperature). The gasification methods remove carbonaceous deposits from the AC matrix, formed by pyrolysis of the adsorbed organic substances. The pyrolysis proceeds at medium temperatures (always during AC heating to the reactivation temperatures). However, also the AC crystalline carbon matrix is gasified, what is very undesirable from the practical point of view – the desired material is lost. Nevertheless, decomposition of the matrix may be suppressed by careful control of the optimal process temperature, that is, however, different in the individual kinds of the activated carbon, and may be determined by testing only.

In addition to the AC reactivation, it is possible to carry out also the so-called regeneration at medium temperatures that uses inert atmosphere and heating to temperatures of ca 450 to 550 °C only, however, the optimal temperature is different for various ACs and its application. At these temperatures, thermal (pyrolytic) decomposition takes place of the adsorbed organic substances with low volatility. The products of pyrolysis are desorbed, however, some amorphous carbonaceous residues remain in the AC pores, too. Thus, the AC sorption capacity is slightly decreased in comparison with reactivation, or new AC, but at the expense of minimum loss of the carbon, and lower total costs. It may be suitable to combine cycles of regeneration at medium temperatures and reactivation.

Foreign reactivation companies operate their technologies without changing the setting, and carbon loss at the level of ca 15 - 20 % is expected. This means considerable costs for the client (replenishing with a new activated carbon). Regeneration at medium temperatures is not routinely offered and carried out.

Pilot Tests of the Technology

Since 2018, tests of regeneration/reactivation of various real AC samples from drinking water production, as well as other facilities, have been carried out in Slaný, with the aim to verify the presumptions described above. The purpose is to verify whether it is possible to find the optimum process parameters (temperatures) for various AC samples. The tests are carried out in the facility shown in Figure 1. It is a batch rotary furnace (capacity up to 20 kg of AC – see Figure 2) with an inerting system, possibility to add steam, on-line analysis of the off-gases, operation temperature up to 900 °C, and possibility of microwave heating. The result of the individual tests is information on changes of composition of the gases in time, losses of carbon dry weight, and further parameters necessary for evaluation.

It was proved that AC behaviour is very individual, and proper regeneration/reactivation conditions should be adapted to the specific kind of AC. In a number of cases, this enables to attain only small AC losses. An exemplary result is given in Table 1. It is obvious that increase of temperature causes considerable increase of AC loss, but only insignificant increase of AC surface.

Selected exemplary results of an activated carbon sample (surface of activate carbon used for the testing: 660 m2/g)

Temperature (°C)	550 (no steam)	700	870
Dry matter loss (%)	1,4	10,4	15,6
Specific surface (m^2/g)	891	908	984

Commercial Use – Process Implementation and Expert Services

Possibilities of large-scale implementation of the process in the conditions of the Czech Republic were assessed in detail, including the proposal of the technical solution, calculation of investment and operating costs, as well as expected final price of the service. The total expected investment is estimated to be ca 60 million CZK. If the production capacity of the facility is set properly, conservative calculations indicate that economically acceptable final price of the AC regeneration service will be ca 25 – 27 CZK/kg. In the case of reactivation, the estimated final price, including replenishing AC losses with new activated carbon, is ca 32 – 34 CZK/kg. The calculated price includes all the items, including transport, disposal of waste, and off-gas treatment. These numbers are qualified estimates, however, it seems that the price for regeneration/reactivation of the AC from the sorption filters is ca 50 % in comparison with purchase of new activated carbon, not including costs for disposal of the spent AC as a waste. At the same time, the price is fully competitive with foreign suppliers of similar services.

However, the investment plan is not without risks. The biggest identified risk is connected with ensuring sufficient amounts of materials for regeneration/reactivation, and logistics (i.e., continuous delivery and dispatch) for continuous operation of the facility.

The existing know-how in the field of conditions for AC regeneration/reactivation may be commercially used also by providing independent expert services to AC users. The testing equipment is at our disposal, and its commercial use does not require any significant investments.

The offered services will include:

1. Independent assessment and monitoring of AC properties in a sorption filter;
2. Independent experimental verification of the possibilities of AC regeneration/reactivation;
3. Recommendation of suitable regeneration/reactivation conditions.

As follows from our communication with operators of waterworks, they are interested in the „impartial" services described above. Their benefit is efficient use of activated carbon, and, consequently, cost savings for the operator.

9. ON-SITE THERMAL DESORPTION – A MORE EASILY AVAILABLE VERSION OF A UNIVERSALLY EFFICIENT REMEDIATION METHOD

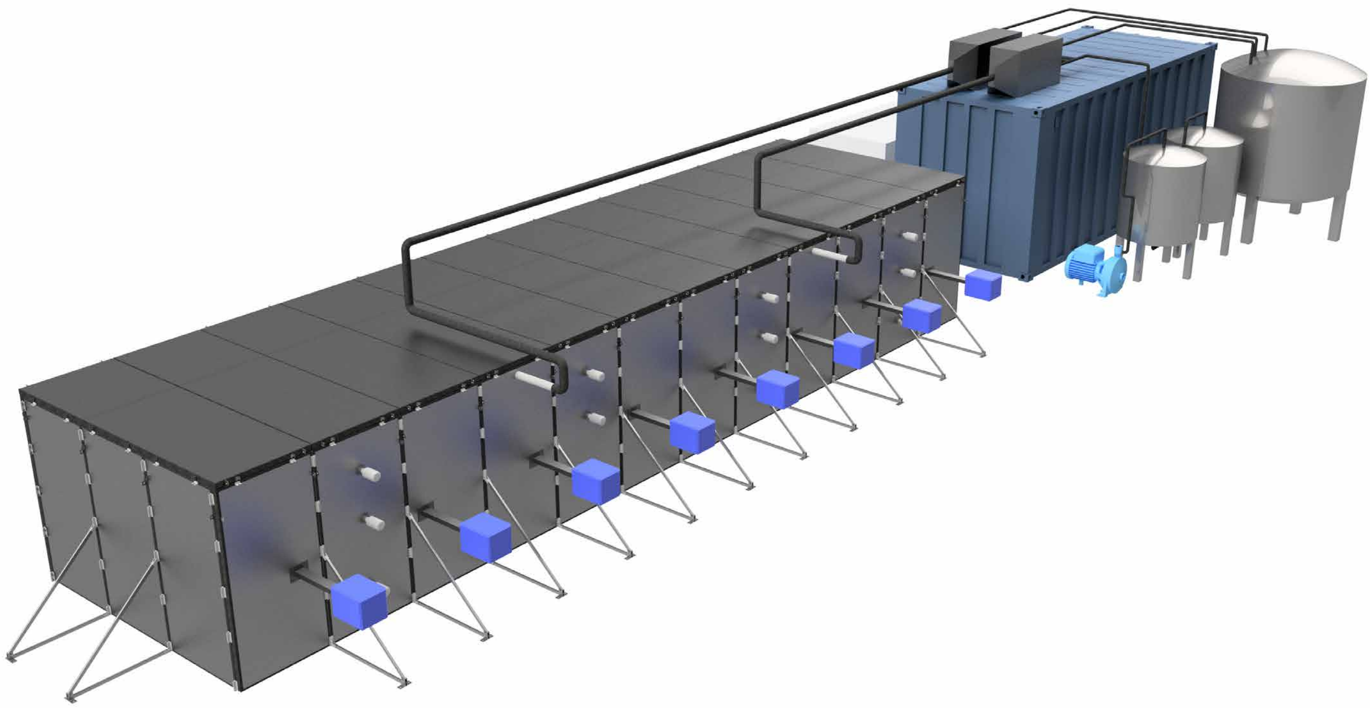
Jiří Kroužek, Pavel Mašín

On-site Thermal Desorption

The thermal desorption (TD) technology ranks among established remediation procedures. It is based on heating the polluted material in order to evaporate contaminants with low volatility. It shows a broad applicability from the point of view of the pollution type, and enables quick and efficient decontamination of soil and debris. However, in practice, these indisputable advantages of the technology are always achieved at the expense of high costs connected with energy consumption for heating, operation safety, and investment requirements. Thus, it is not sufficiently utilised for removal of such kinds of substances as PAHs, PCBs, and pesticides, etc., in the Czech Republic, as well as abroad. In the majority of cases, the pragmatic solution prevails, namely transport of the material to a hazardous waste landfill. On the contrary, TD ranks among recycling processes.

Dekonta has worked at development of the TD technology for a number of years already, especially with the aim to widen the possibilities of its utilisation. This was also the purpose of the last project MOST, solved in cooperation with the University of Chemistry and Technology in Prague, with support of the Technology Agency of the Czech Republic. The aim of the project was to develop a method for application of the TD process that would be technically simpler concerning the technology installation and operation, fully mobile, and adaptable to the conditions of the specific decontamination case. The standard application of the continuous ex-site TD with high capacity and efficiency requires machinery that is very complicated from the technical and economic points of view. In contrast with that, in-situ TD, simplicity of which enables significantly cheaper utilisation, suffers from limited possibilities of the process control,

Design of thermal desorption facility with microwave heating



and, thus, reduced efficiency. The newly developed technology, on-site TD, is a compromise technical solution, maintaining the higher efficiency of the ex-situ decontamination, but having reduced technical requirements. Moreover, it is fully modular, mobile, and quick installation of the equipment at the site needs, in addition to the necessary space, only some skilfulness, usual tools, and a small excavator with a lift truck. This technological application of TD may find use even in the case of smaller remediation projects, and helps to solve the complex issue of contamination with persistent substances meaningfully.

Principle of the New Technology

The new TD application is based on assembling a modular sealed box, consisting of thermally insulated panels, having the dimensions of 1 x 2 m (walls), or 1 x 3 m (roof). Thus, the assembled box has a shape of a rectangular parallelepiped, that is always 2 m high and 3 m wide, and its length depends on the number of the wall panels. It may have any length, depending on the specific remediation conditions. After quick assembly, the box may be gradually filled with the material to be treated by a loader, wherein a heating system is placed into the material, in accordance with the selected design. In practice, the material is applied in layers, and elements of the heating system together with thermocouples are placed between them. The heating system is connected, through openings in the walls, to heat sources located outside the box. The box is filled to the height of 1.8 m, wherein the inner sides of the walls, and surface of the material, are provided with a venting system enabling uniform exhaustion of contaminant vapours from the material into the system for treatment of gases. It is based on a condenser, demister, and adsorber. After installation, the material is heated for 4 - 6 weeks, everyday checks are necessary only during the system operation, and, optionally, adjustment of the setting. Subsequently, the material as allowed to cool down for 1 - 2 weeks, it is carefully removed from the box, together with the heating system, and the process may be repeated. Any number of the boxes may be present at the site, and, thus, they may be operated alternately.

Pilot Tests of the MOST Technology

At first, several small-scale pilot tests of the technology were carried out within the framework of the project in 2018, with various heating methods, using an assembled box having the ground plan of 3 x 3 m, and the batch volume of 9 m^3. The purpose of the tests was evaluation of efficiency of the selected heating methods.

Use of burners and heating pipes, that distribute heat by simple transmission across the walls of pipes through which hot flue gases pass, enables to achieve homogenous heating of the material. However, the heating slows down gradually, and at the temperatures above 200 °C its efficiency worsens. Microwave heating is based on use of a microwave generator connected to a waveguide located in the material inside piping made of fireclay. Range of microwave penetration in the material is limited, thus, especially the surroundings of the waveguide are heated intensely, but to temperatures exceeding even 400 °C. However, a considerable temperature gradient forms in the material, and especially the surface layers remain cold. Steam application into the soil was excluded from further development for the reasons of enormous energy consumption, fact that low temperatures only may be reached, and non-homogenous distribution of steam and complicated catchment of the contaminants. Thus, further development focused on the version using burners (BOST) and the microwave version (MOST). The burners are a cheaper variant, but microwave heating is more efficient for reaching higher temperatures. Combination of the both heating procedures (COMBO-OST) seems to be promising, too.

In 2019, pilot tests of the technology were carried out in Slaný, either with microwave heating or with heating by burners. This time, the box size was 5 x 3 m, volume of the batch 25 – 28 m^3, and weight of the contaminated soil batch 40 – 50 t.

This time, the pilot test of the on-site TD with microwave heating (MOST) was carried out using two 6 kW generators located next to each other. Microwaves were applied by a waveguide in piping made of fireclay, step by step into various positions in the material. Soil from excavation of contaminated areas in the premises Praga Vysočany was used for the test. It contained petroleum substances in the amounts of thousands mg/kg, and PAHs in the

amounts of units mg/kg. A distinctive feature of the material was a relatively high contents of stones having the size up to 20 cm, however, this was not an obstacle for application of the technology. The heating was carried out for the period of 5 weeks.

The test proved a high efficiency of the process. In virtually all the batch, the material was dried. Samples taken in central parts of the material showed concentrations below the limit of quantification. Residual contamination was found near the walls and roof of the box, what corresponded to the fact that lower temperatures, <150 °C, were reached in these parts of the material. These lower temperatures were reached, in particular, in the surface layer of the material having the thickness of 20 cm. On the contrary, continuous temperature measurements made in the course of the process in various points showed that temperatures in the surroundings of the piping made of fireclay were 200 °C to 635 °C, according to the position of the sensor. At least in 80 % of the soil volume, decontamination was successful. Electricity consumption for the heating reached 12.5 MWh.

Characteristics of the technology having the capacity of 100 t/month:

MOST version	
Microwave input	60 – 70 kW
Purchase costs	5 million CZK
Electrical supply	125 A

BOST version:	
Light fuel oil consumption	60 – 90 l/t
Daily consumption	250 l
Purchase costs	2.5 million CZK
Light fuel oil supply	By a tank truck + storage

Box	
Volume	60 – 80 m^3
Width	3 m
Height	2 m
Length	12 – 15 m
Price	600 – 700 t. Kč
Temperature	150 – 300 °C
Cycle	4 – 6 weeks
Cooling	20 kW

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