Newsletter
2/2019

CzechGlobe
Global Change Research Institute CAS

CZECHGLOBE COLLECTS AWARDS

In the spring, climatologists were still afraid of another extremely dry summer, but fortunately their forecasts were not entirely fulfilled. At least from the perspective of the Czech Republic. Those who regularly monitor the current drought conditions using the INTERSUCHO portal may even have witnessed something they had not seen in the summer months since the launch of the application some 6-7 years ago. After a cooler and damp May, most of the map of the Czech Republic glowed white, at least briefly, indicating sufficient saturation of the soil surface level with water. The same was true in August, when rainfall - so common for this month in the past - came and the July drought began to subside significantly. According to hydrologists in terms of replenishment of groundwater reserves, summer rains did not help as much, but as the saying goes, a bird in the hand is worth two in the bush. Although this summer was the hottest summer in terms of the duration of the measurement period, we could enjoy it as we used to it in the old days - without long, exceptionally hot and dry spells. With this, however, the account of optimistic reports on climate change ends. Within the measurement history, this summer was the hottest July ever recorded worldwide. Temperature records, together with the ever increasing CO_2 concentration in the atmosphere, resulted in the fact that a number of global capitals and, more recently, also the European Parliament have declared a state of climate emergency. This was also supported by a statement of a team of scientists at the University of Oregon stating that the planet Earth is in a state of climate emergency. This was accompanied by a signature of another 11,000 scientists from around the world. This happened shortly before the beginning of the 25th United Nations Climate Change Conference (COP25) in Madrid. The ongoing environmental issue with a global reach were the extremely large fires of the Amazon rainforest and boreal forests in Siberia. These ecosystems are relevant not only in terms of climate but they are also a place of vast species diversity. High above the Amazonia, NASA has captured a large cloud of carbon monoxide, which spreads to surrounding areas and, under intense air circulation, can penetrate into the lower atmosphere where it has an adverse effect on air quality. What is alarming is that up to 90% of fires do not start naturally, but are deliberately set by farmers and miners because of economic interests.

After the rainy May this year, it was assumed that crop yields could be quite satisfactory, but then the problem with voles arose. Farmers decided to eliminate them across the board using Stutox II poison, but it caused a massive surge of displeasure from nature conservationists, scientists and the public. In the end, the Ministry of the Environment took the environmentalists' side and banned the massive liquidation. Among other things, it was due to imminent poisoning of birds and wildlife, and thus further disruption of biodiversity.

The fact that we have not been affected by the drought this year as much as in previous years certainly does not mean that this topic can be abandoned. On the contrary, drought is still the biggest nightmare in our latitudes in terms of GC impacts. Also for this reason, in the summer, CzechGlobe, together with the Association of Water Supply and Wastewater Systems of Towns and Municipalities and the Association of Regions in the Czech Republic founded the SUWAC association, which is the promoter of a program of the same name. It aims to achieve a state of sustainable water availability, and therefore life, in the Dyje River Basin region, which is the most threatened region by the ongoing climate change.

Every year at the end of August, the international exhibition Země živitelka (Earth the breadwinner) is held in České Budějovice. It is not only an important agro-show, but it also presents innovations in the field of applied research. Minister Toman presented the awards for the results of research and experimental development, and CzechGlobe was not forgotten. The team of prof. Trnka won second place in the category "Award of the Minister of Agriculture for the best implemented result in 2019", namely for the certified methodology entitled „System for monitoring and forecast of impacts of agricultural drought".

Next year, the new HORIZON EUROPE Framework Programme will be announced. It will finance international science and research projects in the upcoming years 2021–2027. Although the announcement of the first calls is still expected, we can already celebrate the first partial success in the diplomatic field at least. Doc. Emil Cienciala of CzechGlobe became the first representative of the Czech Republic to become a member of the Mission Board for Soil Health and Food.

Another optimistic piece of news from the EC is from October, when CzechGlobe - as the twentieth institution in the Czech Republic and the fifth institute of the Academy of Sciences - was awarded the HR Award. This is an award for excellence in the care of human resources in the scientific environment and at the same time it entitles the institution to promote its stimulating and favorable working environment.

The account of our accomplishments can also include the fact that Christian Kersebaum, who also works for CzechGlobe, appeared in the list of the most cited scientists within the WoS database, specifically for the field of agriculture. This makes him a member of the elite club of about 0.1% of scientists. -mš-

Introducing the Department Experimental High-performance Photobioreactor

OUR ALGAL BIOFILM SYSTEM CAN REMOVE UP TO NINETY PERCENT OF PHOSPHORUS FROM WASTEWATER,

says RNDr. Kateřina Sukačová, Ph.D, Head of the Department of Experimental high-performance photobioreactor. She majored in limnology at the Faculty of Science, University of South Bohemia in České Budějovice. She passed her Advanced exam in Hydrobiology at the Faculty of Science of Masaryk University in Brno and received her PhD degree in the field of Waste Technology at the Faculty of Agronomy of Mendel University. Kateřina is married and has a daughter Tereza and son Ondřej. After completing her studies, she was professionally engaged in practical applications of algology in water management, where she focused on research into the utilization of algal communities as bioindicators during the evaluation of the quality of surface waters. In her dissertation, she investigated the possibility of using microscopic algae to reduce eutrophication of surface waters and reduce the concentration of phosphorus and nitrogen in wastewater. She is currently focusing on the use of cyanobacteria and algae in environmental biotechnologies.

The title of your department includes the term high-performance photobioreactor. What does it mean exactly?

Although our department is called High-performance photobioreactor, it does not mean that we only use one single device for the cultivation of algae. On the contrary, we have several photobioreactors, which differ in how they are constructed. This allows us to investigate the cultivation of algae under various operating conditions. We have the so-called flat-panel photobioreactors with a minimum volume of 25 liters, where we have the possibility to precisely adjust the cultivation conditions inside. Further, we have tubular photobioreactors, which consist of a series of vertically placed transparent tubes, and also bioreactors formed by helically coiled tubes, where the algal suspension is mixed by pumps. Overall, we can cultivate more than a thousand liters of algae at different operating conditions - hence the term high-performance photobioreactor - and monitor the effect of different construction elements of photobioreactors on the production of valuable algae substances or biomass. All photobioreactors are equipped with a unique monitoring system, which also allows us to monitor algae growth and physiological parameters of cultivated algae cultures in real time. In terms of monitoring cultivation conditions inside photobioreactors, our infrastructure is absolutely unique.

Photobioreactors were mentioned also earlier when we introduced the Department of Adaptive Biotechnologies. In what way does your work differ from theirs and how do you cooperate within the domain?

At first sight, the difference between our departments lies primarily in the volume of bioreactors that are used. The Department of Adaptive Biotechnologies uses exclusively laboratory bioreactors, while our department operates in a wider range of volumes and cultivation conditions. This means that we first work under laboratory conditions and then we apply suitable laboratory conditions to larger cultivation volumes and conditions that are closer to the real use. When cultivating under laboratory conditions, we use the photobioreactor platform of our colleagues from the Department of Adaptive Biotechnologies as well as the associated know-how. We, on the other hand, contribute to the expansion of the knowledge base concerning laboratory cultivations, the cultivation conditions of various algae species, because, for example, we work with different species of algae. We like to share our knowledge with our colleagues, and, as a matter of fact, existing joint publications demonstrate our intensive cooperation.

So what is the next step in the process of cultivating algae? Either in terms of their further utilization or to obtain valuable algae produced substances?

After the phase of laboratory cultivation, we proceed with the selected species to larger volumes and evaluate the production of biomass and the target substance that the algae produce. Our bioreactors are located in a greenhouse, allowing us to use also solar radiation in algae cultivation and compare cultivation processes from different perspectives, such as energy, economics or technology perspectives.

An example, where we worked on a scale from laboratory optimization up to the cultivation in experimental high-performance bioreactors, is the optimization of lipid production using algae *Chlorella pyrenoidosa Chick* (IPPAS C2). We first characterized and optimized algae growth in one-half liter volume laboratory bioreactors. This means that we tested various cultivation conditions, such as light intensity, temperature, or various concentrations of carbon dioxide in the air mixture that was used to mix the algal suspension. Subsequently, we evaluated under which conditions the cultivated algae reached the highest growth rates, and we continued to use these conditions and considered them optimal for algae growth. Similarly, we also optimized lipid production. The result of our research was the proposal of a two-phase cultivation process with a targeted change of cultivation conditions between the growth phase and the lipid accumulation phase. We then tested the process in a 25 liter flat-panel bioreactor. The obtained biomass with high lipid content was analyzed not only in terms of lipid content, but also in terms of energy content and the possibility of using this biomass for biogas production. Our results of lipid production optimization in relation to bioenergy potential evaluation were published in Algal Research Journal, which is a significant journal in the field of algal biotechnologies. I am also going to talk about these results in early December in Paris at the AlgaEurope 2019 conference, which is Europe's largest conference on algae biotechnologies.

What led you to research the potential use of algae for biogas production?
Although some people may find it illogical to test algae for biogas production, in Spain there is already a pilot operation covering an area of several hectares where algae is used for waste water treatment and subsequently used for biogas production. In the summer, I had the opportunity to visit this facility on the occasion of the celebration of „Freedom from Fossil Fuels“, which symbolically took place on July 6, on Independence Day, in a small town of Chiclana de la Frontera in Spain. The celebration of “Freedom from Fossil Fuels” i.e. “day of freedom from fossil fuels” was organized by the Aqualia company, which is the main driving force of the development of algae wastewater treatment technology combined with the subsequent gasification of algal biomass. In addition to the entire technology, Aqualia introduced their algae-powered passenger cars, which are being developed in cooperation with the Seat company. The “Freedom Day” was a follow-up to the conference called “Algal Technologies for Wastewater Treatment and Resource Recovery”, where I had the opportunity to speak upon the use of algal biofilms for the removal of phosphorus from wastewater, i.e. a technology being developed in our department - Department of an Experimental high-performance photobioreactor.

Well, the other subject-matter of your department is the use of wastewater, isn't it?
This is another specific characteristic of our department – i.e. focus on the use of waste sources in the cultivation of algae. For several years, within my work at CzechGlobe, I have been researching the possible use of algae communities in secondary treatment of wastewater. My work was primarily focused on phosphorus removal. The issue of phosphorus is very important because phosphorus and eutrophication is a double-edged sword. On the one hand, high phosphorus concentrations in surface waters cause a deterioration of living conditions for other aquatic organisms. For example, the growth of large quantities of cyanobacteria and algae in the water and the subsequent death of biomass will result in depletion of oxygen, which subsequently threatens fish. On the other hand, phosphorus is a non-renewable natural resource and it is therefore necessary to address the possibility of recycling it in the future. And the technologies using algae are those that are considered very promising in terms of possible recycling of phosphorus. Our department has developed a unique algal biofilm system that is greatly effective in the very process of phosphorus removal. The basis of the technology is an algal biofilm, consisting of algae species that were isolated from specific locations, transferred to laboratory cultures and subsequently used to create an algal biofilm. Algae retain nutrients from water which flows through this algal biofilm. In this way we can remove up to ninety percent of phosphorus from the wastewater. In our technology, we were able to utilize the great ability of algae in terms of using nutrients from wastewater, and what's more, the main advantage of algae biofilm is that algae is concentrated on the surface and not dispersed in the suspension. Algal biofilm is therefore easy to collect, and under certain conditions it could be used as fertilizer.

Apart from your colleagues from CzechGlobe, do you also cooperate with other institutions, and if so, on what projects?
We are involved in the “Strategic Partnership for Environmental Technologies and Energy Production” project, which also focuses on the use of waste sources and aims to research the possible use of algae for after-treatment of flue gases. In this project we are cooperating with the Faculty of Mechanical Engineering of the Brno University of Technology, specifically with the Institute of Process Engineering. The work includes not only the selection of suitable microscopic algae that could be suitable for the demanding operating conditions in the after-treatment of flue gas, but also the proposal of a draft of a suitable cultivation device, i.e. a bioreactor, in which the selected algae would be cultivated while using carbon dioxide from the flue gas. Our colleagues of the Brno University of Technology have become important partners in terms of the technical and technological development of our bioreactors. Together we are working on a design of a new innovative bioreactor with original design features that would be able to offer new opportunities for the efficient use of solar radiation in the cultivation of algae.

DEPARTMENT EXPERIMENTAL HIGH-PERFORMANCE PHOTOBIOREACTOR

It is one of the departments included in the Domain of Adaptive and Innovative Techniques. The department's activities are focused on research into the possible use of photosynthetic microorganisms, especially cyanobacteria and algae, for the production of valuable substances while utilizing waste sources such as flue gases with high carbon dioxide content or various types of waste waters. The work of the department is closely related and builds on the activities of the Department of Adaptive Biotechnologies and it aims to transfer the knowledge gained during the basic research of photosynthetic microorganisms into the level of practical applications.
The department employs one researcher, one research specialist and a laboratory technician.

OPENING MEETING OF CEE CSA HUB

On 3rd December 2019, an opening meeting of the platform of representatives of scientific institutions and stakeholders in the field of climate-smart agriculture in Central and Eastern Europe, the so called CEE CSA Hub, was held in the South Moravian Innovation Center in Brno. The platform, whose leader is CzechGlobe, was created within the Climate Innovation Community of the European Institute of Innovation and Technology EIT Climate-KIC, which we became a member of this year.
Climate-KIC and the CSA concept were in general terms presented at the meeting and the program was divided into three segments. The first segment focused on the identification of existing problems in the field of agriculture, namely from social, legislative, through education up to technological and biological problems. It also focused on the subsequent determination of areas that the Hub should address in the future. The second segment focused on creating a list of all potential stakeholders from individual countries, and subsequently identifying the key stakeholders. The third segment was dedicated to the scheme and objectives that the CEE CSA Hub is supposed to achieve in the next five years.
The event was attended by representatives of all six CEE CSA Hub countries (V4 countries, Romania and Bulgaria), namely representatives from academic institutions, universities, non-profit organizations, private companies, the Ministry of Agriculture, and Climate-KIC. Representatives of already existing Hubs (Nordic Hub, Dutch Hub and Italian Hub) remotely attended the conference as well.

CLIMATE TIPPING POINTS – TOO RISKY TO BET AGAINST

GOT OUR ATTENTION

An international team of climatologists led by Timothy Lenton of the Global Systems Institute in British Exeter, has published a new study summarizing current knowledge on the consequences of climate change. 11 years ago, scientists identified key stabilizing elements in the biosphere. These elements help maintain the dynamic balance of global climate. In the latest issue of Nature, the authors state that signs of disruption are already visible in a total of nine systems. Since we are talking about a description of processes in complex dynamic systems, which exhibit a non-linear type of behavior, scientists are not yet able to determine how close we have got to the "tipping points" in specific cases. When such a critical threshold is reached, the system will be directed towards irreversible damage and loss of its function, or even its existence, and this process may take even centuries. However, it will not be possible to stop it even if the global temperature subsequently stabilizes. It is also possible that in many cases we will find out that this threshold has been exceeded only after it will have already happened.
The conclusions of the publication are of twofold nature. The destabilization of important elements of the biosphere – i.e. the Arctic sea ice, permafrost, Greenland, parts of Antarctica, boreal forest, Amazon rainforest, corals and marine circulation in the Atlantic - occurred in many cases earlier than scientists thought still in the last decade. The perception of the extent of global warming, which would most likely trigger far-reaching and irreversible changes, has also decreased significantly (Figure 1). Perhaps the most important message is that the tipping points do not have to occur separately, but are interdependent. For example, the disappearance of Arctic sea ice will trigger the irreversible melting of Greenland and the release of large amounts of CO_2 or methane from permafrost, etc. We may no longer be in control of climate change, even if we succeed in limiting our contribution of greenhouse gases to zero. Therefore, the authors' claim of a „state of planetary emergency" and their urge to maximize the efforts to reduce greenhouse gas emissions as soon as possible is entirely appropriate. -aa-

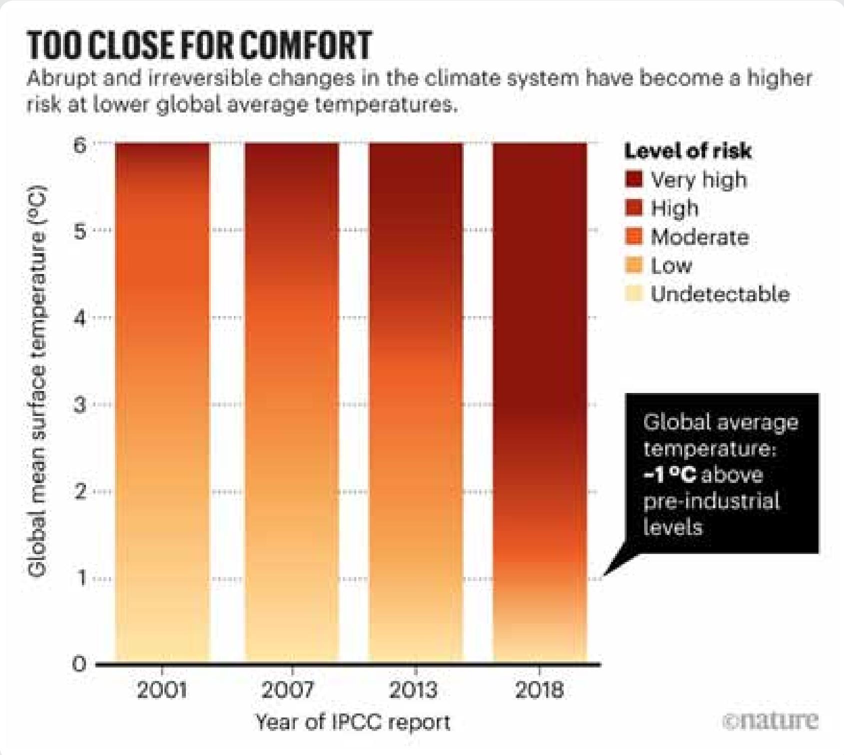

Fig. 1: *Representation of the level of risk (probability) of irreversible changes in the climate system at a given level of global temperature increase. (Source: Nature, Lenton et al., 2019)*

Reference:
Lenton et al. 2019, Nature. https://www.nature.com/articles/d41586-019-03595-0

WHAT´S NEW

RINGO project workshop

From 16th till 20th September 2019, GCRI organized an international summer school of the RINGO project in Brno. It was coordinated by the ICOS-ERIC European Research Infrastructure Consortium. The workshop for participants from Hungary, Poland, Estonia and Slovakia focused on gaining knowledge about the development and operation of ICOS infrastructure as well as on data acquisition and processing. The summer school also included field excursions, where participants could learn about the hands-on operation at the ICOS network stations.

Researchers' Night at Bílý Kříž

On 27th September 2019, the Researcher's Night was held all over the Czech Republic. It is an event organized on the occasion of the European Researcher's Night. This year, CzechGlobe joined the event, whose motto was „Considerately to the Planet", by preparing a commented tour of the Experimental Ecological Station Bílý Kříž and a segment of lectures. The lectures covered the subject of global climate change as an environmental challenge of the 21st century, and also the subject of how forests still manage to „serve" our voracious society. Despite the cold weather, more than 50 visitors of all ages visited the station in the depths of the Beskid Mountains.

Science and Technology Week in CzechGlobe

From 11th till 17th November 2019, the 19th year of the Science and Technology Week CAS was held. This year it was with the subtitle „Science, Freedom, Responsibility". The central theme of the STW were global threats. One of the ambassadors of the event for the area of climate change was the director of GCRI, prof. Marek. In addition to presenting the lecture at the headquarters of the Czech Academy of Sciences in Prague, he moderated the panel discussion *Global Climate Change - Threat or Challenge for Czech Society.* Within this STW event, GCRI in Brno held a Doors Open Day, which offered tours of Brno laboratories as well as virtual tours of detached workplaces and a series of lectures on climate change.

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As usually, the winter issue of the Newsletter (2/2019) includes an appendix dedicated to selected interesting articles published by our colleagues in 2019.

Kahiluoto, H., Kaseva, J., **Balek, J.**, Olesen, J.E., Ruiz-Ramos, M. , Gobin, A., Kersebaum, K.C.,Takáč, J., Ruget, F., Ferrise, R., Bezak, P., Capellades, G., Dibari, C., Mäkinen, H., Nendel, C., Ventrella, D., Rodríguez, A., Bindi, M., **Trnka, M.** Decline in climate resilience of European wheat. *PNAS* January 2, 2019, 116 (1): 123-128; first published December 24, 2018 https://doi.org/10.1073/pnas.1804387115

Due to ongoing climate change, the weather is not only gradually warming, but it is becoming more and more variable and extreme. Unpredictable weather can impair global food security if major crops, such as wheat, are not resistant enough.
The authors of the study found that current breeding programs and selection procedures for wheat cultivars do not provide the necessary resistance to climate change and in addition to that, in most European countries, its reaction diversity has decreased over the last five to fifteen years due to the reduced diversity of cultivated cultivars. Scientists predict that greater variability and extreme weather conditions will lead to an increased imbalance in wheat yields as well as an overall reduction in wheat yields. Lower yields do not directly cause food shortages, but can lead to speculation and price fluctuations in the market for this strategic commodity. This may jeopardize the continued access to food for the poor, which subsequently will lead to political instability and migration.
Scientists based their claims on the evaluation of many observations (amounting to thousands) of the yields of wheat cultivars in nine European countries. These observations allowed them to find out how different cultivars react to weather. They found different responses to weather in field wheat and demonstrated their relationship to climate resistance. The changes in the yields of all wheat cultivars exposed to different weather conditions were relatively similar in Northern and Central Europe, and within Southern European countries this was particularly true for durum wheat. Low resistance of wheat to heavy rains, which negatively influences yields, has proved to be a serious problem across Europe. In general, however, wheat yields can be seriously damaged by rain, drought, heat or cold in the vulnerable phases of its growing season. Wheat yield is susceptible even to a few days long exposure to particular weather conditions and humid weather that promotes occurrence of diseases. In addition, heat stress, even more than drought, seems to be the limiting factor of wheat's adaptation to climate change in Europe. The authors emphasize that the prevailing approach to crop adaptation to climate change through adapting genotypes to the most likely long-term change is probably insufficient.

Kubelka, V., Šálek, M., Tomkovich, P., Végvári, Z., Freckleton, R.P., Székely, T. Response to Comment on "Global pattern of nest predation is disrupted by climate change in shorebirds". *Science* 14 Jun 2019, 364: 6445, eaaw9893. DOI: 10.1126/science.aaw9893

The article in Science is a response of the authors of the original article „Global pattern of nest predation is disrupted by climate change in shorebirds", also published in Science, to the Technical commentary written by several scientists who sought to contradict the surprising findings about the deteriorating success rates of nesting in shorebirds.
The original study brings up-to-date findings about a sharp increase in nest predation in shorebirds, especially in the Arctic, and about a complex change in the historical latitudinal gradient with the highest rates of nest predation in the tropics. Higher nest predation rates in the Arctic are closely linked to greater global warming and climate instability. The fall of lemming populations caused by climate change in many parts of the Arctic before 2000 is also an important and likely contributor to this current situation. Thus, with fewer lemming populations, Arctic predators often hunt alternative prey, such as nesting shorebirds. The sad, but important, finding is that from the perspective of nest predation, the Arctic today represents a large ecological trap for migrating shorebirds.

These findings were extremely unexpected for the scientific community. It was assumed that the shorebirds' populations were mainly limited by the increased mortality of adult individuals during migration, but another potentially very influential factor in bird population dynamics has now been discovered – i.e. lower nesting success rate due to higher predation rate in the Arctic breeding places, which seemed, at first sight, untouched.
The authors of the original article conducted a thorough review of their data and analyses, but found no cause for the objections raised in the Technical Commentary.

Machacova, K., Vainio, E., **Urban, O.**, Pihlatie, M. Seasonal dynamics of stem N_2O exchange follow the physiological activity of boreal trees. *Nature Communications* 2019, 10: 4989, DOI: 10.1038/s41467-019-12976-y.

Nitrous oxide, contributing to global climate change, is naturally produced in soils and exchanged with the atmosphere at the soil surface. This gas can be transported into the atmosphere also via vegetation. Even though trees are known to emit N_2O into the atmosphere, they have so far been overlooked in N_2O inventories of forest ecosystems. The authors studied natural fluxes of N_2O from soil and stems of main tree representatives of boreal forests in Southern Finland (pine, spruce, birch). Whole-year measurements revealed clear seasonality in stem N_2O flux following tree physiological activity. Stem N_2O emissions peak during the vegetation season and remain low but significant to the annual totals during winter dormancy. At an annual scale, all studied boreal trees are net N_2O sources, with spruce being the strongest emitter. The authors underline the role of trees in the seasonal dynamics of ecosystem N_2O exchange and highlight the urgent need to include the exchange potential of trees in the forest ecosystem greenhouse gas inventories.

Večeřová, K., Večeřa, Z., Mikuška, P., Coufalík, P., **Oravec, M.**, Dočekal, B., **Novotná, K.**, **Veselá, B.**, Pompeiano, A., **Urban, O.** Temperature alters susceptibility of Picea abies seedlings to airborne pollutants: The case of CdO nanoparticles. *Environmental Pollution* October 2019, 253: 646-654. ISSN 0269-7491.

Nanoparticles (NPs) are a wide class of materials, which have one dimension less than 100 nm at least. NPs can be engineered or occur naturally, for example in ash clouds from volcanoes, sea breeze and in the smoke from a fire. Especially application of engineered nanomaterials in industry and agriculture led to an accumulation of NPs in the biosphere. However, information about the influence of these NPs on plants is still insufficient and particularly the interactions between atmospheric NPs and higher vascular plants have received only a limited attention. In a previous study, we demonstrated that aerial CdO NPs have a potential to induce significant changes in total content of amino acids and saccharides as well as in the composition of fatty acids in both the roots and leaves of barley plants. Such changes in plant metabolome may result in altered protection of plants against oxidative stresses including temperature, and/or drought. In this work we report, for the first time, the sequential effects of high temperature and atmospheric CdO NPs treatment on higher plants. This study supports our hypothesis that atmospheric CdO NPs penetrate into leaves but high temperature and vapor pressure deficit reduce such penetration due to stomatal closure. The hypothesis that atmospheric CdO NPs influences physiological and metabolic processes in plants was also confirmed. This impact strengthens with increasing time of exposure. Finally, we found evidence that plants acclimated to stress condition have different sensitivity to CdO NPs compared to plants not so acclimated. These findings have important consequences for understanding the impacts of global warming on plants and indicate that although the effects of elevated temperatures can be deleterious, this may limit other forms of plant stress.

Weinzettel, J. Vačkářů, D., Medková, H. Potential net primary production footprint of agriculture: A global trade analysis. *Journal of Industrial Ecology* 2019, 23 (5): 1133-1142. ISSN 1088-1980.

International trade has an increasing impact on natural ecosystems. As a growing number of studies show, more and more natural resources are embodied in food production and traded beyond their borders or imported into rich countries. International trade drives an increasing share of biodiversity loss in tropical areas and has significant effect on ecosystem services. Agricultural land is expanding at the expense of natural ecosystems, and these changes are driven by increasing consumption in rich countries. The aim of the study was to quantify the human footprint on the potential net primary production of natural ecosystems. Primary photosynthetic production is the amount of biomass that will grow in ecosystems over a period of time. We used the data layer of potential natural productivity (i.e. the productivity of natural ecosystems without human influence) and calculated the amount of potential production embodied in agricultural crops and pastures in individual countries of the world, which is appropriated by agricultural production in individual countries. Subsequently, we analyzed the amount of primary productivity embodied in international trade using multiregional models. We have found that globally, humanity appropriates 20% of the available potential ecosystem productivity solely by agricultural production, with 23% of this appropriation being due to international trade. Wealthy countries import more agricultural products from abroad and are net importers embodied footprint of potential net primary production.

Zavřel, T., Faizi, M., Loureiro, C., Poschmann, G., Stuehler, K., Sinětova, M. A., Zorina, A., Steuer, R., **Červený, J.** Quantitative insights into the cyanobacterial cell economy. *eLife* February 2019, 8: e42508. ISSN 2050-084X.

Phototrophic microorganisms referred to as „microalgae“ are promising resources for green biotechnology. However, compared to heterotrophic microorganisms such as bacteria or yeasts, the cellular economy of phototrophic growth is still insufficiently understood. The authors present a quantitative analysis of resource allocation strategies in the model cyanobacterium *Synechocystis sp.* PCC 6803 at the level of physiological, morphological and proteomic changes under various growth conditions.
The results show that with increasing light availability, cells achieve higher growth rates due to increased production of translation proteins at the expense of photosynthetic proteins. On the contrary, too high light intensities lead to a growth rate decrease (photoinhibition), which is partially compensated by further increase in translational protein production again at the expense of the light-harvesting and photosynthetic proteins. The resulting growth laws and insights into quantitative aspects of cyanobacterial acclimations to different growth rates have implications to understand and optimize photosynthetic productivity.