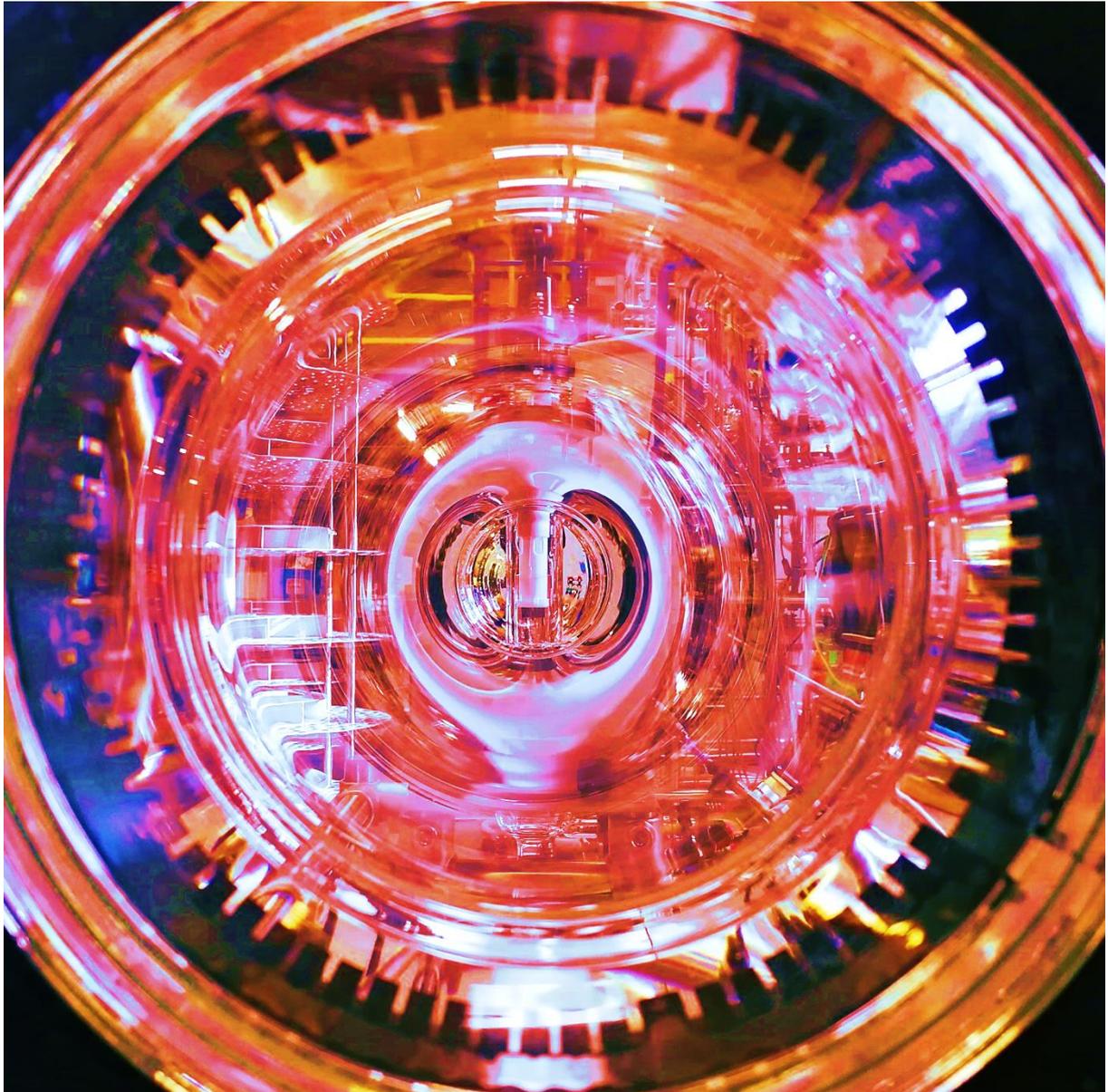


Separation and Purification



2020

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Dear Reader

2020 was determined largely by trying to somehow manage during the corona crisis with all the complications it and the measures to fight the pandemic created. For all of us, that was quite a challenge. We luckily managed without infection with the virus, only quarantine was required for some of us. For a long time, no experiments were possible, even though we were desperate for their results. During the lockdowns and also in between working in home office was recommended anyway. One benefit was that one was forced to work more on the theoretical aspects of each topic, which was indeed beneficial for some projects. But I do not want to complain too much about these effects here. They are described in more detail on the following pages.

Despite all such complications, research progressed. The pilot plant for the PULSE process to recover phosphorous from sewage sludge is built and start-up is almost completed. After that, it will travel to other countries to be tested on-site at several waste-water treatment plants. Also, significant progress has been made in developing a systematic strategy for the optimal design of reactive-extraction processes for the separation and purification of metal components from secondary resources. Another major step is the essentially completed validation of a simulation tool for drop-based modeling of batch settlers.

Another aspect of this year was teaching at a distance. At the beginning of the semester, a typical screen of the Bachelor Project, the schnapps project, looked like shown in Fig. 1. Only after some time, at least the speaker could be convinced to activate his or her camera. Most of the other lectures were recorded on video and supplied as video-podcast. Every second week in each lecture a Q&A session was offered, where interestingly not a single student ever showed up.

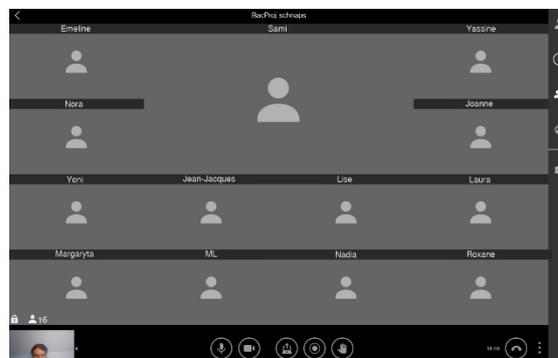


Fig. 1: Typical view of an interactive lecture at the beginning of the semester

Due to working in home office, the time for traveling between home and university could be saved. Nevertheless, there appears not to have been any excess time available. The impression was for example that at least in some online meetings things took longer than usual, possibly because everybody assumed that all participants would have enough time anyway – because they save the travel time.

Summarizing: This year, everything was different. Of course, this is true for everybody. On the following pages, we collect some of the highlights – of research as well as of fighting with the consequences of COVID-19.

So: Enjoy reading!

Andreas Pfennig

PULSE Process Optimization

Zaheer Shariff

The PULSE process for the recovery of phosphorus (P) from sewage sludge has been developed at ULiège within the framework of the [Phos4You project](#). The detailed flowsheet for the PULSE process is shown in Fig. 1. The PULSE process will be tested at different locations at pilot scale. Since the characteristics of sludge differ from one place to another, the process will have to be optimized for each sludge. Therefore, a solid-liquid-liquid equilibrium tool (Shariff et al., 2020) has been developed to aid in the optimization while minimizing the experimental effort.

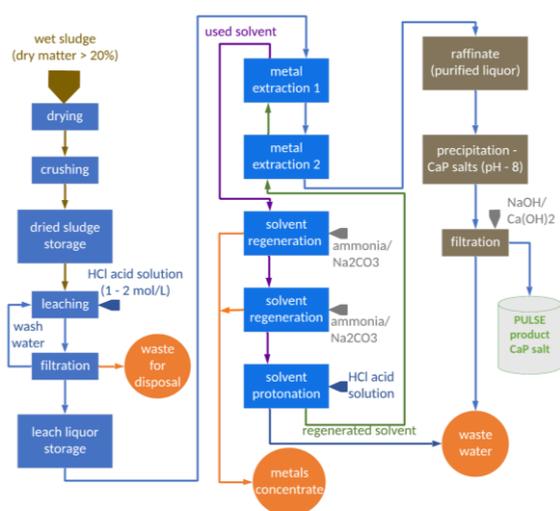


Fig. 1: Detailed flowsheet of PULSE process for calcium phosphate salt precipitation

Drying and Leaching

Dewatered undigested sludge from Oupeye waste-water treatment plant was used in the lab-scale optimization experiments. The dewatered sludge was dried to more than 95 % dry matter content and crushed to particle size of less than 5 mm for experiments with dried sludge. The leaching efficiency with different acids and at different pH was evaluated as shown in Fig. 2. The maximum leaching efficiency of undigested dried sludge that could be obtained around pH 0 was about 70 % and corresponded to the inorganic P content of the sludge. P leaching was independent of the

type of acid used. The P dissolution calculated using the SLLE model follows nicely the behavior found in the experiments. The P-leaching efficiency of dried sludge and dewatered sludge was compared after leaching with hydrochloric acid (HCl) at a pH of about 0.5 and found to be 69.1 % and 72.6 % respectively. Sludge drying doesn't have significant effect on P-leaching efficiency. But due to the rheology of dried sludge, less acid is consumed for leaching. Dried sludge also facilitates easier filtration of the slurry after leaching.

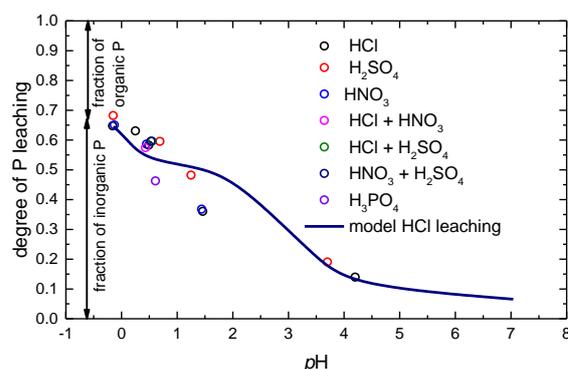


Fig. 2: Degree of P leaching with different aids and pH

Solvent Extraction

The metals that are co-leached with P such as Cd, Cu, Fe, Pb, Zn, etc. are not desired in the final product as they may be detrimental when the recovered P product is used as a fertilizer or they may reduce the P availability to plants. Therefore, reactive extraction is used to remove these metals from the leach liquor. The solvent system Alamine 336 + TBP + Exxal (modifier) dissolved in Ketrul D80 was chosen for the extraction of the metals from the leach liquor based on experiments and the cascaded option trees evaluation (Shariff, 2019). In order to optimize the solvent-extraction step, equilibrium experiments were performed by varying the extractant and chloride (HCl) concentrations. The experimental data were used to fit the stoichiometry and extraction equilibrium constant for the different metals using the

SLLE tool. An example of data fitting for extraction of iron is shown in Fig. 3.

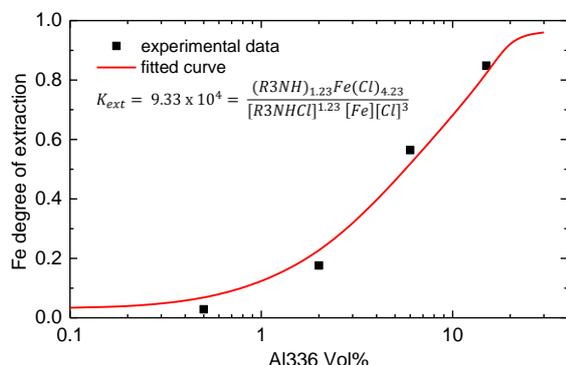


Fig. 3: Fitting of parameters for iron extraction

Experiments were also performed for the regeneration of the solvent system using different alkaline salts as shown in Fig. 4. These re-extraction agents were evaluated against different criteria such as regeneration efficiency, ease of phase separation, environmental impact, and cost using the cascaded option trees (Shariff, 2019). Based on this evaluation Na_2CO_3 was chosen as the best option. The solvent regeneration at different pH using Na_2CO_3 is shown in Fig. 5. The regeneration efficiencies calculated using fitted parameters with the SLLE model follow the same trend as found in experiments.

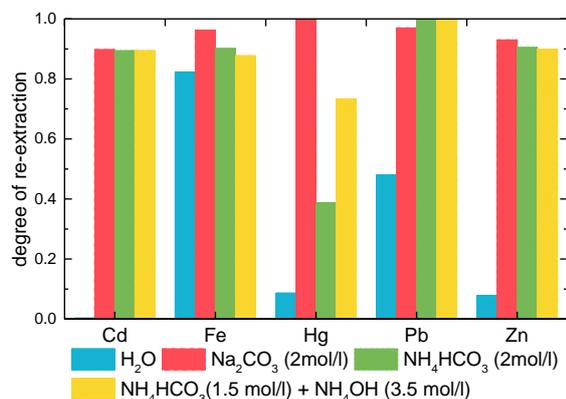


Fig. 4: Stripping of metals from used organic phase 10 % Alamine 336 + 10 %TBP + 3 % Exxal in Ketrul D80

Precipitation of Calcium Phosphate Salts

P precipitation as calcium phosphate was carried out by raising the pH of leach liquor to 7 to 8 with NaOH which resulted in almost complete P precipitation. Further optimization stud-

ies of P precipitation with NaOH and lime as a function of pH are ongoing.

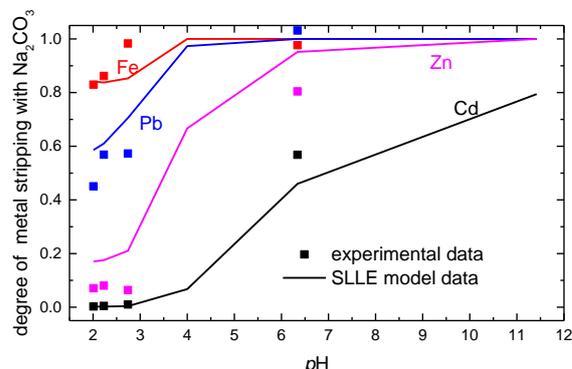


Fig. 5: Solvent regeneration using Na_2CO_3

For the quality-assessment tests within the Phos4You project, 600 grams of PULSE product containing calcium phosphate were produced in large lab-scale set-up from about 8 kg of dried sludge. The Phos4You partners at UGhent responsible for the quality assessment have reported a P_2O_5 content of 25 % in the PULSE product. In the next step, the PULSE process will be demonstrated at pilot scale with input sludge of different compositions.

Acknowledgments

The research work carried out at ULiège under the Phos4You project is jointly funded by Inter-reg North-West Europe and the Walloon Region Alamine 336, Ketrul D80, Exxal 10 were supplied free of cost by BTC Europe GmbH, TOTAL (Belgium) and ExxonMobil Petroleum & Chemical (Belgium) respectively.

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Phos4You: From Lab to Pilot Scale

David Leleu

In the framework of the Phos4You project, the PULSE process for phosphorus (P) recovery from sewage sludge shall be demonstrated at pilot scale. The pilot will be tested at different locations in North-West Europe. This means that the pilot needs to allow to be easily dismantled and transported between the different locations. This creates one of the major challenges behind the design of the plant.

As Zaheer Shariff shows in his contribution, the process combines different unit operations. This leads to a second major challenge, which is the scale-up of all of these different steps, which should be as efficient and robust as possible to be easily operated. The design of the unit operations needs to consider both aspects at the same time: the easy transport of the pilot and the robustness of the different unit operations. Up to now, the leaching and the extraction units have been commissioned.

For leaching, the major challenge for the scale-up is the concentration of sludge in the leach liquor that needs to be pumped for filtration after 1 hour of leaching. The concentration of the particles is too high to run the pump properly without any blockage. To solve this issue, the sludge is contained in a column with a bottom mesh. This column is immersed into the acid and the pump is used to circulate the acid through the column. In the beginning, few particles pass through the mesh of the column. As time proceeds, these particles are captured inside the column. The column thus acts as a filter. An hour later, the pumped liquid is almost free of particles and can be directly used in the liquid-liquid extraction unit. Besides, additional pressurized filtration is still possible if the concentration of fine solids in the liquor is too high to disrupt the downstream processes. Three tanks for leaching are available in order to treat 20 kg of dried sludge per working day. The equipment is shown in Fig. 1.

Concerning liquid-liquid extraction, lab-scale settling experiments were used to design the mixer-settlers. The quantity of leach liquor that needs to be treated per day makes the equipment quite impressive with 8 storage tanks of up to 300 l and 6 settlers of 1 m length. The setup

is shown in Fig. 2. The construction was realized by Normag. The mixer-settlers can be partially dismantled and transported in the containers to the different locations where the pilot plant will be tested.



Fig. 1: Leaching equipment of the pilot plant

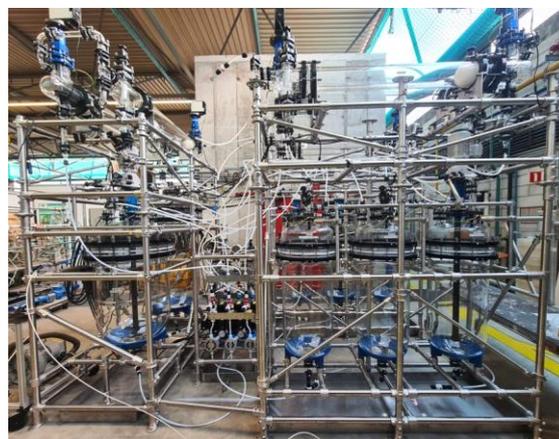


Fig. 2: Extraction unit for the PULSE process

The precipitation unit, which is the last step of the PULSE process, will be constructed during the next weeks. The entire pilot plant should be operational beginning of next year.

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Conference in Berchtesgaden

Zaheer Shariff

Once upon a time, not too long ago, when we could still shake hands, see the smiles on people's faces and travel without limitations, the solvent extraction team at ULiège had the pleasure of participating at the "Jahrestreffen der ProcessNet-Fachgruppen Fluidverfahrenstechnik, Adsorption und Extraktion" in Berchtesgaden, Germany. This was the last conference that we participated in person before the world had to shut down to slow down the spread of the deadly coronavirus.

The ULiège team had two contributions at the conference i.e. presentation on "Influence of Ions on the Coalescence Behavior" by David Leleu and "Development of Solid-Liquid-Liquid Equilibrium Speciation and Data Fitting Tool and Its Application to Phosphorus Recovery Process from Sludge" by myself.

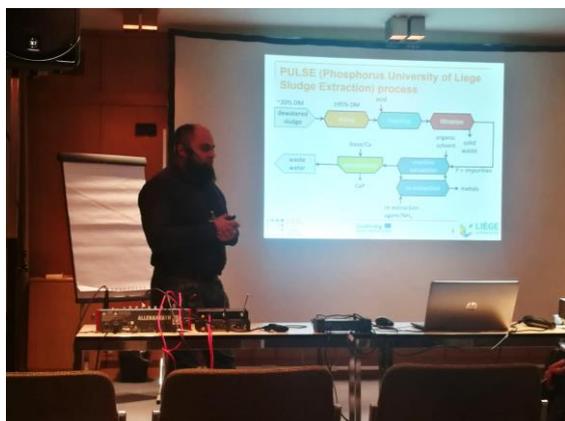


Fig. 1: Zaheer Shariff presenting at the conference

In addition to our contributions, we participated in other talks related to extraction which gave us insights into the latest advancements in the field. It was also a good opportunity to interact with former acquaintances and colleagues from industry and academia.

Usually, conferences are about learning and sharing professional experiences, networking, and building contacts in the area of one's expertise. However, the conference in Berchtesgaden was much more than this.

Berchtesgaden is a small municipality located in the middle of the beautiful German Alps close to the Austrian border. So, it was an official trip to a holiday destination in the Alps. The journey from Liège to Berchtesgaden was close to 6 hours and included different modes of transport: road, rail, air, road in the respective order. On the day of arrival, by the time we reached our B&B, it was already getting dark and so we did not have the opportunity to venture out as we had to prepare for the next day's presentations.

The next morning, we walked to the conference venue which was not far from our B&B. We took a short walk through the quiet lanes early in the morning, to arrive at the conference hall still essentially unaware of nature's beauty surrounding us. As the very first plenary session came to an end, the curtains of the conference room were drawn which greeted us to this awe-inspiring view shown in Fig. 2. At the end of the day, we walked through the small town and clicked a few more pictures of the magnificent views.



Fig. 2: View from the conference venue

As I look upon these pictures, I hope that we can go back to the world that was before the pandemic as soon as possible and once again be able to travel for work as well as for pleasure.

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Pre-treatment Raw-Material Experiments for Phosphorus Recovery

Khang Vu Dinh

Introduction and Objectives

In this research, some potential waste sources are being surveyed and assessed for phosphorus (P) recovery in the south of Vietnam. These include: waste from cattle farming, pig farming, catfish farming, sludge from centralized domestic wastewater-treatment plants, and from rubber-latex processing wastewater-treatment plants (WWTP). Based on assessment of relevant criteria by using the Cascaded Option Tree (COT) method which was established by Bednarz et al. (2014), the results show that the sludge or so-called secondary raw material from rubber-latex processing WWTP in the south of Vietnam has the highest potential for P recovery.

There are two main types of sludge generated from the WWTP. These include sludge from a biological treatment stage, so-called bio-sludge, and sludge from a chemical treatment stage, so-called che-sludge. Some chemicals for the chemical treatment stage are CaO and poly aluminum chloride. Chemical and biological sludge have P contents by dry weight of about 4 and 7 %, respectively. The humidity in bio-sludge and dewatered chemical sludge fluctuates in the range of 80 to 90 % by volume. In addition, the large difference in organic composition also greatly affects the rate of water evaporation during sludge drying. Biological sludge contains mainly microbial cells which are organic components. However, chemical sludge contains mainly precipitation products of inorganic substances in the process of P reduction in wastewater. Both types of sludge are supplemented with polymer during water separation.

P is recovered by leaching, extraction, and precipitation. Therefore, studying the steps of pre-treatment of sludge and types of chemicals for extraction is very important. The sludge pre-treatment solutions are studied and evaluated, including: assessing the effects of drying temperature and drying time, the effects of extraction time, and chemicals used.

Method

Drying equipment Memmert UN30 Plus (Schwabach, Germany) was used in this study. The drying temperature of the device ranges from room temperature to 300 °C. The pre-heated fresh air is fed and mixed by air flap control. An Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) device is used to determine the metals composition in the leach liquor, including P, Fe, Al and heavy metals.

Firstly, for the sludge drying temperature, these experiments were performed in the laboratory with the same amount of initial sludge under the same conditions, except that they were dried at different temperatures. The studied temperature is varied in the range of 100 to 300 °C, additionally the possibility of drying sludge by wind at natural room temperature is also considered.



Fig. 1: a. Bio-sludge and b. Che-sludge pre-treatment

Then, the drying is carried out for 1 to 48 h (see Fig. 1). After being dried, raw materials were ground and classified into fractions with different particle sizes: coarse particle size 2 to 3 mm, particle size 1 to 2 mm, and particle size ≤ 1 mm. These fractions were used to study the effect of particle size on the extraction capaci-

ty. In this report, the smallest particle size studied is less than 0.2 mm (see Fig. 2).



Fig. 2: a. Dried bio-sludge and b. dried che-sludge: different particle size

Results

Fig. 3 shows the effect of drying temperature on the ability to extract P from the sludge by sulfuric-acid solution. At the temperature of 200 °C, extraction efficiency with two types of sludge from the rubber WWTP is highest, in the range of 80 to 90 %. Drying temperatures above 200 °C show that the ability to extract P from the sludge decreases somewhat. The sludge that was dried at high temperatures was burnt and lumped, which was caused by the polymer used in the sludge dewatering process. In contrast, the efficiency of extracting P from the sludge continuously increases when the drying temperature increases for the bio-sludge from domestic WWTP.

The most suitable sludge drying time is 2 hours at 200 °C. The extension of the drying time does not result in higher extraction efficiency. The dry mass of the sludge did not show great variation with increased drying time above 2 h. Particle size affects the efficiency of acid extraction. The larger particles reduce the chances of direct contact of H⁺-ions with the sludge, thus reducing the extraction efficiency. This result is similar to Zaheer's research result on the effect of particle size on extraction efficiency. Fig. 4 shows the degree of P extraction from the sludge with different acids. The efficiency of extraction of P in the bio-sludge is higher than that of chemical sludge in most of the acids investigated. Sulfuric acid showed the highest P extraction efficiency for both chemical sludge and bio-sludge in the range of pH 0.1 to 0.5 during 2 hours of mixing.

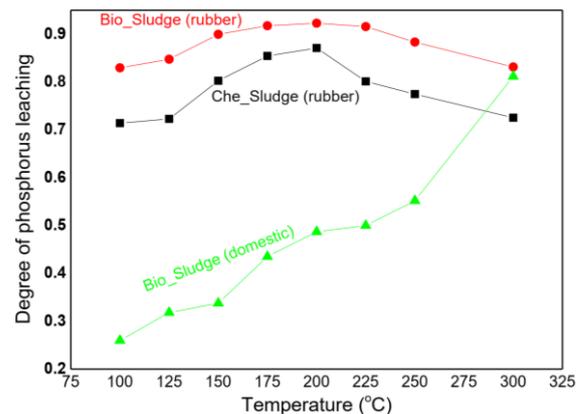


Fig. 3: Effect of drying temperature on phosphorus extraction capacity

The highest P extraction and recovery efficiency can be found when the raw sludge is pre-treated under the drying condition of 200 °C by the Memmert UN30 Plus device for 2 h and the dry sludge particle size should be less than 0.2 mm

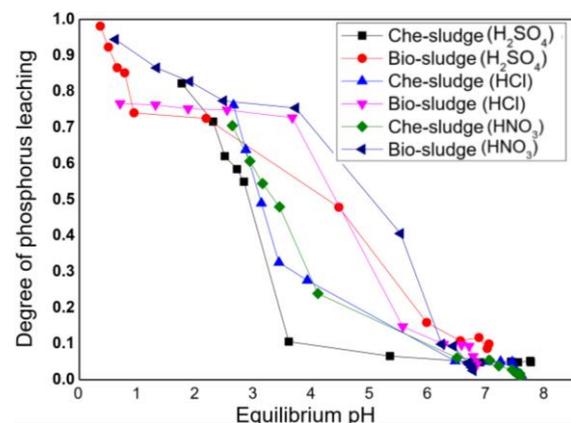


Fig. 4: Degree of P extraction at different pH

Acknowledgments

This work was performed with Linh Nguyen Van's assistance in drying and grinding sludge samples.

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Measurement of Relative Electrostatic-Potential Difference for Coalescence Modeling

David Leleu

Introduction

After finalizing the project initiated at the :Metabolon – Bergischer Abfallwirtschaftsverband (BAV), the results have been published (Leleu and Pfennig, 2021). As a research institute and as a waste recycling center, BAV is always looking to optimize their processes. Integrating a solvent extraction unit to their wastewater-treatment plant can be an option to decrease the contaminant concentration in the effluent. The goal of the secondment was to initialize this research project by modeling the effect of ions on the coalescence.

Indeed, the presence of electrolytes has a strong influence on coalescence behavior. Experiments show a good correlation between the coalescence time of liquid-liquid dispersions and the DLVO theory (Pfennig and Schwerin, 1998). The DLVO theory describes the force resulting from the repulsive electrostatic interaction and the attractive Van-der-Waals force acting between two approaching droplets. DLVO theory should thus in principle be introduced in the coalescence modeling.

A model was developed previously by considering the elementary interactions between two approaching drops (Leleu and Pfennig, 2019a). In settling experiments, the buoyancy as driving force squeezes the drops together and induces the drainage of the film formed between the drops, so that drops approach further over time until they merge. The overall process takes a certain time, which is called the coalescence time. In modeling, coalescence time is evaluated with the force balance between the driving force and the fluid-dynamic force induced by film drainage. The goal of the current research is to increase the level of detail in coalescence modeling by including the DLVO force in the driving-force expression of the coalescence process.

The magnitude of the DLVO force depends on the electrostatic potential existing between the two phases, $\Delta\phi$. This electrostatic potential varies with the ion types and concentrations.

Unfortunately, $\Delta\phi$ cannot be measured experimentally, since it refers to an electrochemical half-cell. The goal of this paper is thus the first step to elucidate the relation between the electrostatic-potential difference and the experimental settling behavior.

The Method

Ions contained in two-phase systems partition between the phases. The corresponding partition coefficient of the electrolytes depends on the affinity of each ion for both solvents in conjunction with the electroneutrality condition that holds for each phase. The partition of the charged species induces an electrostatic-potential difference between the phases. The Albertsson model links these two variables (Pfennig, Schwerin, 1998).

However, as the electrostatic-potential difference cannot be measured directly, an interesting option is to measure the difference of the potential difference relative to that of a reference system, $\Delta\Delta\phi$. Two systems thus have to be compared with different salts added at different concentrations, one of them being taken as the reference, i.e. NaCl.

A dye is then added to the systems, which fully dissociates into ionic species, so that the partition coefficient of the charged dye, K_{dye} , can be used as an indicator for potential differences. The dye is added in so small quantity that it is not affecting the electrostatic-potential difference in the system. The dedicated salt, which is then in excess compared to the dye, thus fixes the $\Delta\Delta\phi$ between the two phases and thus also K_{dye} which is easily measured by UV-vis spectroscopy.

In parallel, settling experiments with the same systems are performed in order to obtain the settling and coalescence curves characteristic for each individual system. The settling experiments are conducted in the settling cell developed by Henschke and further improved in previous research (annual report 2017). The videos taken from the experiments are treated with

MATLAB to obtain a clear overview of the separation. An example is shown in Fig. 1.

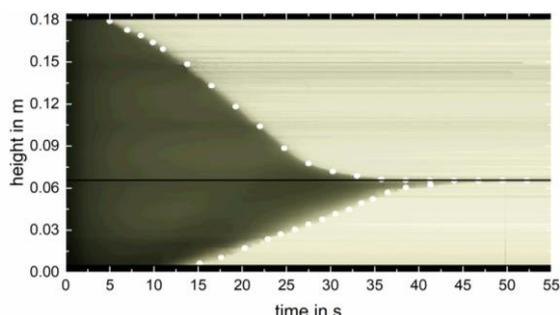


Fig. 1: Settling experiment conducted in the settling cell

Results and Discussion

The results of the partition-coefficient experiments are shown in Fig. 2. With the extended Albertsson model (Pfennig and Schwerin, 1998) a good correlation of the experimental data is achieved. The corresponding relative electrostatic-potential differences are linked to results of settling experiments in Fig. 3.

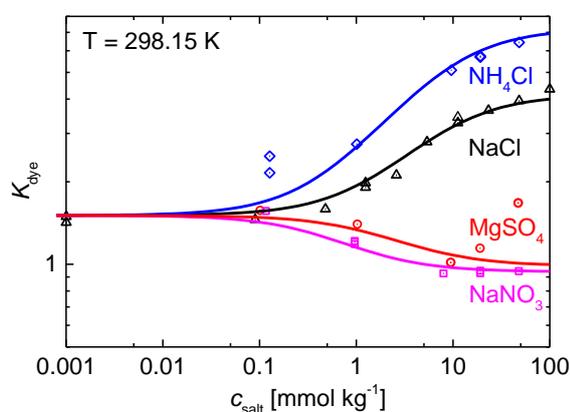


Fig. 2: Partition coefficient of the dye vs. salt concentration. The solid lines are the fitted extended Albertsson model

The systematic and strong variation in settling times nicely demonstrates the strong influence of the electrostatic-potential difference on coalescence. On the other hand, the behavior of sodium nitrate and magnesium sulfate differ significantly, even though they have a similar electrostatic-potential difference. This can in principle be explained by the different charges of the ions which influence the magnitude of the DLVO force as well. This is investigated in further studies.

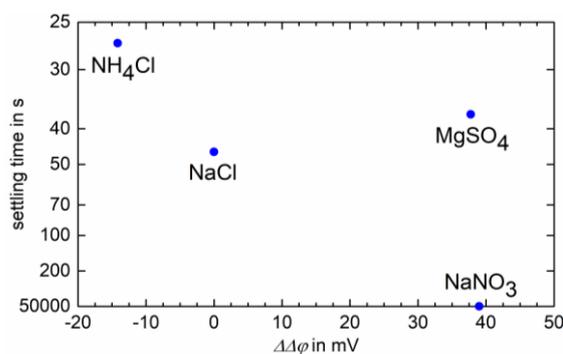


Fig. 3: Settling time as function of $\Delta\Delta\phi$, vertical axis scaled reciprocally, $o/w = 1/2$

Conclusion

Based on these first results, the relative electrostatic-potential difference will thus be included in the detailed coalescence modeling in order to quantify the effect of the electrostatic force on settling. These settling experiments are a good first basis to quantify the implications of the DLVO force on coalescence. In future work, a detailed analysis of the characteristic curves of the settling experiments will be performed with the help of a ReDrop (Representative Drop) (Leleu and Pfennig, 2019b) simulation tool to elucidate this influence and to validate a corresponding model.

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Standardized Workflow for Separation of Co and Ni

Swagatika Satpathy

Introduction

The growing scarcity of critical metals has compelled researchers all over the world to recover them from secondary sources. Metals like Co and Ni are widely used because of their several applications in various sectors (Cui and Zhang, 2008). In recent years, several attempts have been made to separate and extract them from their primary as well as their secondary sources. However, all those methods involve the use of high amount of chemicals to find out the best possible way to separate them. In this report, an alternative is proposed for process design by making use of cascaded option trees (Bednarz et al, 2014). This is realized by taking into account the data already available in literature. A prototype workflow as well as a broad database for the reactive extractants and other components is generated along with the development of the cascaded option trees. Experiments are only performed where no data are available. Here, the methodology involving the use of cascaded option trees for metal separation is described briefly taking an illustrative example of Co and Ni separation. After the detailed evaluation, the most suitable options are chosen for carrying out the separation of Co and Ni.

The Method

The cascaded option-tree method involves graphical visualization and systematic evaluation of options. It enables the evaluation of different alternatives by using a ranked list of criteria. They can be different in structure if different separation processes are considered. The separation of Co/Ni involves steps such as leaching, reactive extraction, precipitation, and purification to obtain pure components. Here, the cascaded option tree for the reactive extraction process is explained in context of the nature of extractant most suitable for Co/Ni separation. The different options available are listed by thorough literature study and evaluated to identify the most suitable option by taking into account certain criteria which the most suited option must satisfy. The option which satisfies most of the criteria is judged as the best one. Individual evaluation is done for each

of the parameters essential in the reactive extraction process based on the different criteria suited for that particular parameter. During the course of the evaluation as shown in Fig. 1, if the option meets the criteria fully, it is assigned a green color and a '+1' symbol. If the option doesn't fully satisfy the criteria but can be optimized to give better results then it is assigned a yellow color and a '0' symbol. However, if the option does not work at all then it is given a red color and a '-1'. Once, a certain option has red color for any criterion, no more evaluation of that option is required with respect to the other criteria. Additionally, if the option is left blank for a certain criterion that clearly indicates that the option has not yet been tried out for the separation process and experiments should be performed taking that option to check whether it is apt or not. The different criteria are evaluated after ranking them as per their priority for that particular parameter. This ranking is done based on the significance of the criteria for the separation process.

		separation possible in principle	easy extraction	stripping efficiently possible
1.000	Cyanex 272	1	1	1
0.667	Cyanex 302	1	1	0
1.000	Versatic 10	-1		
	PC88A			
0.667	DEHPA	0	1	1
1.000	Cyanex 301	-1		
1.000	Cyanex 921	-1		
1.000	TOPO	-1		
1.000	Cyanex 923	-1		
1.000	Cyanex 471x	-1		
	TOA			
	Aliquat 336			

Fig. 1: Cascaded option tree for extractant selection for Co and Ni separation

The cascaded option tree for Co-Ni separation in terms of extraction step has been realized by firstly evaluating the appropriate extractant suitable for the separation process. The chem-

istry knowledge combined with the engineering expertise forms a base for generating the cascaded option trees. The extraction chemistry can be optimized by considering the chemical concept of hardness which is obtained by taking the arithmetic mean of ionization potential and electron affinity, expressed in eV.

The first criterion while forming the cascaded option trees for selecting a suitable extractant is with which extractant the separation is possible in principle. This can be answered by considering the Hard-Soft Acid-Base principle, the HSAB principle. It helps in deciding the most suitable extractant for the separation process. It is well known that metals are hard or soft acids and extractants are hard or soft bases. The HSAB principle states that hard acids bond with hard bases and likewise the soft acids form bonds with soft bases. In general, the extractants having O-, N-, or P-donors are called hard extractants while those having the S-, F-, or Cl-donors are called soft extractants. Tab. 1 gives an idea of the first choice of extractants which can be an option for executing the separation. In Tab. 1, the metals are sorted as per their decreasing hardness values and the different extractants are sorted as per their respective decreasing pK_a values, characterizing the respective equilibrium constant. They are arranged in form of a matrix and the pK values obtained for extraction of the particular metal ion with the extractant are used to determine which extractant is the most suitable one for the extraction process. This is done by choosing the extractants with a high difference in pK values for the metals to be separated. The ones with less difference in pK values for Co and Ni lead to more stages of extraction and separation. Hence, those extractants are chosen which have a significant difference in the values of pK obtained for the two metals to be separated, where here the pK values obtained with the extractant for Co and Ni should be significantly different. This is the first criterion for extractant selection and termed as 'separation possible in principle' as shown in Fig. 1. Likewise, the ease of the extraction process is also considered. The pH range at which extraction and re-extraction are to be performed is taken into account considering that it should be in a technically feasible range. The third important criterion is the possibility of re-extraction using that extractant. The appropriate stripping agent should be available and there should be a minimum difference between the pH necessary for extraction and the pH necessary for re-extraction since a high differ-

ence leads to involvement of high amount of acid and base in the process leading to the discharge of a large amount of salt. Alternatively, T -shifts can also be considered if the equilibrium is temperature dependent, as it lessens the salt production in the overall process.

Conclusion

The extractants Cyanex 272 followed by Cyanex 302 and DEHPA have emerged as the best possible options for extractant selection for Co and Ni separation as evident from Fig. 1. The cascaded option-tree method is easy to use and reduces the need of performing excessive experiments. This is highly beneficial for designing separation processes relevant for any kind of separation done by reactive extraction method.

metal ion	pKa	extractant			
		Cyanex 272	Cyanex 302	Versatic 10	DEHPA
	hardness	6.37	5.63	5.17	3.24
	eV	pK			
Fe ³⁺	15.3		0.9	1.75	0.5
Eu ³⁺	12.028	2.199	3.826		1.449
Sm ³⁺	11.441				2.75
Dy ³⁺	11.141	3.301	3.226		2.52
Nd ³⁺	10.791	>4.697	4.226		2.44
Tb ³⁺	10.696	2.039	3.426		1.199
Y ³⁺	10.1065	2.029	3.026		1.099
Cu ²⁺	9.5	1.75-3.6	<0	4	2.8
Zn ²⁺	9	1.8-2	1.5	5.5	0.75-1.5
Ni ²⁺	8.5	5.75-6.2	6.5	6.4	5
Co ²⁺	8.2	4	3.9	6.6	4
Mn ²⁺	7.82	3.9	5.5	6.8	2
Mg ²⁺	7.517635	5		8.1	3.6
Ca ²⁺	5.923585	5.6		7.4	1.5

Tab. 1: pK values of metal ions with respect to various extractants

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Improvement and Reorganization of ReDrop for Extraction-Column Design

Marc Philippart de Foy

Context

The ReDrop algorithm is a powerful tool that allows modeling the behavior of drops inside physical unit operations such as extraction columns of different configurations. It is based on the study on the scale of drops and the different phenomena that can occur to each drop, which are modeled. These include sedimentation, mass transfer, chemical reactions, coalescence, breakage, swarm effects, axial dispersion, etc. Each of these is influenced by the geometry of the column and internals.

The simulation approach relies on simulating the behavior of a large number of drops in a section of the column. This is not a very commonly followed approach, but it has the advantage to allow the design of large-scale columns of any column type based only on single-drop experiments. The experimental measurements required to determine the model parameters necessary to run the program are those which very generally characterize single-drop behavior as the ReDrop model is based on models that characterize exactly such single drops.

In more classical design paths, the building of pilot-scale plants is required. Moreover, large amounts of solutions are used to run these pilots. Producing such solutions may be difficult before the building of the large-scale plant, and it may be expensive to buy them instead. As single-drop experiments are relatively easy to set up, the single-drop approach followed by ReDrop represents a huge advantage compared to the pilot-plant path.

Another disadvantage of the pilot-scale approach is its lack of flexibility compared to the ReDrop program. For the former, the change of column type would require the costly building of a new pilot plant, if not already available, and the carrying out of the experiments. Using the ReDrop program as design tool avoids that problem as only a few parameters need to be modified to change column type.

ReDrop Algorithm

A graphical representation of the ReDrop algorithm is presented in Fig. 1. Once the initial parameters are entered, the behavior of each drop is simulated, regarding all phenomena that can occur. The drops leaving the studied column section are then considered and several parameters are updated accordingly, such as potential chemical reactions in the continuous phase and resulting concentrations. The behavior of a large number of drops is thus followed over time, which allows modeling the evolution of different variables such as concentration profiles in the column.

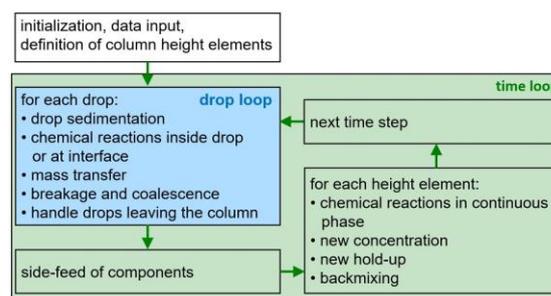


Fig. 1: Graphical representation of the ReDrop algorithm.

Several researchers have developed the ReDrop model over the years. First, Henschke (Henschke, 2004) showed that it was possible to predict the behavior of liquid-liquid extraction columns based on single-drop experiments conducted on lab scale. Several models developed by Henschke are implemented in ReDrop. These models are used – along with other models – to describe drop behavior such as sedimentation velocity, mass transfer, breakage and coalescence, as well as axial dispersion in the continuous phase.

Later, Grömping (Grömping et al., 2004) conducted single-drop experiments with a material system supplied by INEOS Phenol. He used the experimental results to model the behavior of a pilot-scale extraction column. The simulation was then compared to the actual behavior

of a pilot-scale extraction column operated at Bayer Technology Services. The predictions were accurate to within 10%.

Another enhancement of ReDrop was the modeling of the impact of chemical reactions on mass transfer. Altunok (Altunok et al., 2006) first adjusted the coefficients of the model used for non-reactive mass transfer to consider the influence of reactions. Then Kalem (Kalem et al., 2010) studied the problem in more detail and focused on the interplay between reaction, diffusion, and convection. Unfortunately, he did not have time to implement a fully rate-based description of these phenomena in ReDrop.

Buchbender (Buchbender, 2013) then focused on rotating internals, such as in Kühni columns, and extended the ReDrop algorithm to model columns with this type of internals. He described the residence time of drops in the different compartments created by the internals based on the probability that a drop has to pass from one zone to another.

A last major improvement of the ReDrop model was realized by Kalvoda (Kalvoda, 2016). She extended the mass-transfer model to columns in which a concentration gradient is present in the continuous phase. She developed a new experimental cell to conduct single-drop experiments with such a concentration gradient.

Combining all these works lead to building a rather precise tool for the modeling of the performances of an extraction column. Moreover, ReDrop allows predicting the operating limits of a column, such as the flooding point (Altunok et al., 2006). This is a very interesting characteristic of ReDrop as there is no specific correlation in the program to simulate flooding: this event is a consequence of the drops' behavior. This flooding detection gives thus a better idea of the operating limits of the column, which may allow to increase the yield of the process.

Details of the Work

The ReDrop code is currently written in separated blocks, each corresponding to a specific phenomenon. As the different versions have been written by several co-workers over the years, each version has specific features and has been written partly independently from the others. The goal of the current work is thus to approach the code with a more general view, which will lead to a more consistent overall program.

All the blocks will be rewritten and combined in a core program, which will result in a faster program. The drop-population balances will be solved in the core program and systematic variations of operating parameters will become possible. The main program will also detect when a steady-state is reached. The final code should also be highly structured and easier to use. Corresponding flags will be accessible to define all possible options for modeling individual drops and for the effects of the internals.

The current work on the ReDrop program is a great opportunity to improve an already efficient simulation tool. It may be the next step towards the systematic industrial application of ReDrop, which gathered the works of many researchers.

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Feasibility Study of Low-Carbon Ammonia and Steel Production in Europe

Marc Philippart de Foy

Context

This work has been conducted in the scope of the Eureka Student Contest of 2019. The other co-authors of the study are Jean-Luc Hoxha, Mathieu Caspar, Alexis Donceel, Justin Frassel, and Rémi Poncet. The goal was to study the technological and economical feasibilities of two decarbonized processes in Europe, through the modeling of the processes in Aspen Plus and costs calculation. The work shows which assumptions are required to reach this objective until around 2030.

The two studied processes are ammonia production and steelmaking. The decarbonization is realized by replacing the carbon-emitting step of natural gas reforming by water electrolysis for H_2 production. Based on the assumption that the electricity is supplied from renewable sources, this transition allows to decrease drastically the CO_2 emissions of the plants.

Aspen-Plus Simulation

First, the two processes are modeled with Aspen Plus. Classical ammonia and steel production plants are adapted to cope with pure hydrogen as reactant, seen that it is produced by water electrolysis, so with around 100 % purity.

The electrolyzers used are Proton Exchange Membrane (PEM) electrolyzers. This type of electrolyzer allows to operate under high pressure and temperature, and it can operate with fluctuating energy supply. This is important for the decarbonized processes because a peak shaving approach is followed, as explained below. Currently, PEM electrolyzers are not a mature technology, but it can be assumed that it will be the case in 2030, with an efficiency of 85%. The efficiency is defined as the energy stored in the H_2 divided by the amount of electricity required for its production.

For the model of the ammonia production, only a few modifications are required compared to classical plants that use the Haber-Bosh process, which consists in mixing H_2 from natural

gas reforming and N_2 from air in a reactor to produce NH_3 . In the decarbonized process, pure H_2 from water electrolysis is mixed with pure N_2 to form NH_3 . The rest of the process is left nearly unchanged as it consists of recycling unreacted gases and purifying the product through the passage into flash tanks in series.

The steelmaking process requires more adaptations because direct-reduction iron plants, which are the type of plant studied in this work, use the mixture of H_2 and CO produced by natural gas reforming as reducing gas. The model of the decarbonized process needs thus to take into account the change in composition of the reducing agent as pure H_2 is used.

Both Aspen-Plus simulations lead to technologically feasible processes and serve as a basis for their cost estimations.

Cost Analysis

The economic viability of the two decarbonized processes is also studied, regarding the most influential variables. These include the electricity price, the cost related to CO_2 emissions and the product as well as raw-material costs.

The electricity price is the main operating cost of both processes. Indeed, hydrogen being produced by water electrolysis, electricity consumption is huge compared to classical plants. Due to the high consumption, the price decreases, from 70 to 40 €/MWh in the case of ammonia production, but a further decrease is required to obtain an economically viable process. This is achieved by following a peak shaving approach. Peak shaving consists of decreasing its electricity consumption during periods of the day when the demand is high on the market, to allow negotiations with the electricity supplier. Peak shaving leads to an electricity price of 30 €/MWh, and the two processes are modeled such that electricity is only supplied 18 hours per day for the electrolysis. H_2 is thus produced in excess and stored, to be used during the remaining 6 hours to ensure a steady-state production.

The impacts of other factors have also been considered. For the ammonia plant, the cost related to CO₂ emissions has been studied in form of allowances or taxes for instance. This is a cost that only classical plants have to pay, so it increases the interest in decarbonized processes. The sensitivity analysis in Fig. 1 shows the limit of profitability of the process, based on CO₂ emission cost and electricity price. For an electricity price of 30 €/MWh, the required CO₂ emission cost is around 220 €/t. At the end of 2019, CO₂ allowances in Europe were about 25 €/t, but they are expected to increase to between 50 and 100 €/t, and other taxes may be raised in the future such as in the Netherlands, where a tax will be adopted in 2021 and increase up to 150 €/t in 2030.

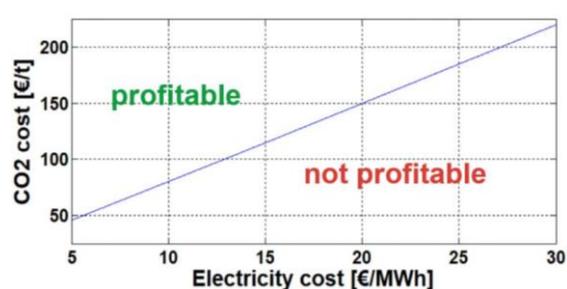


Fig. 1: Limit of profitability of the ammonia plant after 30 years of operation

For the steelmaking process, the price of steel also has an important influence as it varies over years. A similar diagram is drawn and the range of steel price required to reach an economically viable plant is comprised in the actual range of steel price of previous years.

Conclusion

As only few assumptions are required to build the models, the study of the decarbonization of these two processes seems to indicate that the transition is technically conceivable.

From the economical point of view, the main conditions to reach such a transition are that low electricity prices can be negotiated and that political decisions will push the transition towards a decarbonized industry, by introducing new CO₂ taxes or funding industries to make their process less carbon-emitting.

This work is based on the assumption that the electricity used for the electrolysis comes from renewable sources. It would indeed make no sense to switch to electrolysis if the huge electricity consumption was polluting. This assump-

tion may be unrealistic with a time horizon until 2030 and lead to constraints for the choice of the location of the plant, near off-shore wind farms for instance, but the purpose of this work is only to study the feasibility of the decarbonization by switching to water electrolysis.

Acknowledgments

The study has been conducted for the Eurecha Student Contest, where it took the second place. It offered the possibility to present the results at the "CAPE forum" conference. A peer-reviewed paper has also been published for a second event: "ECEEE, industrial efficiency - decarbonise industry".

Unfortunately, the corresponding live events could not take place due to the Covid-19 pandemic and were replaced by digital events. Anyway, it was the possibility for us to bring our touch of originality by recording a video where we presented our results in front of the slides, as shown in Fig. 2.

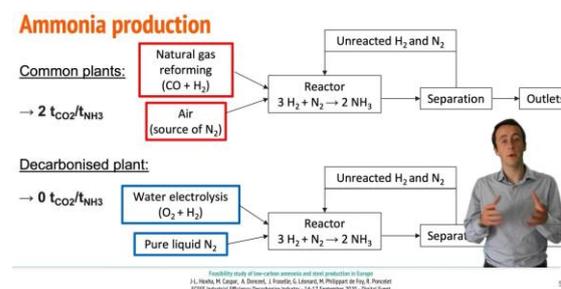


Fig. 2: Adaptation to an online conference, with some special effects

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COVID-19: Math of the Pandemic

Andreas Pfennig

Starting Point

Since the beginning, the author was a bit confused by the discussions among politicians and journalists on the spread of the pandemic and appropriate countermeasures. The impression was that the math of the pandemic had not been understood, to which – unfortunately – also the World Health Organization (WHO) added some confusion. At the same time, the math appears to be actually rather simple (see also [these videos](#)). To explain the impressions and the consequences, first, the simple math of a pandemic needs to be recollected. Then the results are to be discussed relating them to statements by politicians and journalists.

The Reproduction Number

Key to describe if the pandemic spreads or is defeated is the so-called reproduction number R . If someone is infected, R indicates to how many other people that person transfers the infection during the entire time of his infection. If $R > 1$, the pandemic spreads while a value below 1 indicates that the pandemic is defeated, since from generation to generation of infected people, their number decreases. The resulting exponential function is

$$N = \alpha \exp\left(\frac{\ln(R)}{t_{si}} t\right),$$

where t is the time and t_{si} the so-called series interval, the average time required to transmit the virus after infection. The limit $R = 1$ thus discriminates between positive and negative exponent, i.e. growing or decreasing numbers of newly infected people N . R could in principle be determined from the number of newly infected each day, if that number would always be exactly known, i.e. if there were no delay in the outbreak of symptoms and testing. R would then be the ratio of newly infected on one day divided by that same number t_{si} earlier. For SARS-CoV-2 the series interval t_{si} is usually assumed to be 4 days.

Without any countermeasures in a susceptible population, the system behavior is described by the so-called basic reproduction number R_0 . If countermeasures are in place, the corre-

sponding value is called the effective reproduction number R_t .

Obviously, the number of people infected on some given day is not exactly known. Thus, R_t can only be approximated. Unfortunately, the evaluations are quite diverse. The Robert-Koch Institute (RKI) in Germany uses a complex model to estimate the exact number of people infected on a given day, [which they call nowcast](#). In Belgium, the Belgian Institute for Health, the Sciensano, bases its calculation of R_t on the [number of hospitalizations](#).

What makes the evaluation of R_t so difficult is not only that at a given day the exact number of infected people is not known. On top of that, the number of daily infected shows a strong characteristic variation over the week, which is regularly visible in the diagrams shown on TV. This variation is caused e.g. by fewer corona tests during the weekend and tests not being evaluated during that time by some test labs. As a consequence, the respective numbers of two days, which are a series interval apart, cannot directly be compared with each other.

Even the WHO (2020) states about R_t : “while this is a widely used indicator of transmission, it requires familiarity with the various methods for calculation and sufficiently reliable and timely data on incidence”. Such a statement of course does not increase the confidence people have with R_t . Nevertheless, it should be clearly stated: R is here regarded as the single most important parameter to characterize the spread of the pandemic.

Instead doubling times have been used by politicians and journalists to characterize the spread of the pandemic, where some considerations about basic math of the exponential spread directly lead to the insight that this is of course only of limited informative value, since such a value does not exist, if R is less than 1. Then instead a halving time would be relevant. Also, reproduction numbers reported by RKI often showed a different tendency as compared to the weekly trend of the number of newly infected. As a consequence of the approximation via the nowcast, most recent val-

ues of R_t are regularly updated, by which they vary strongly. This is, of course, critical, since it is exactly these data relating to the very last days that are most relevant when trying to estimate the effect of a countermeasure.

To avoid all of these complications and in-transparencies, here a different approach is proposed: The reproduction number is evaluated from the number of positively tested as reported by RKI or Sciensano within one day for a series interval of a week, $R_{t,7}$, which avoids the influence of the systematic variations during a week. Thus, a value e.g. on a Monday is related to that of the previous Monday. Then, the reproduction number for a series interval of 4 days can be obtained from

$$R_{t,4} = R_{t,7}^{4/7} .$$

To avoid too much fluctuation, a three-day average is evaluated. This leads to stable values, which do not require any correction afterward. Also, these values directly correspond to the weekly trend observed in the reported number of newly tested positive.

The major inaccuracy of this approach is the delay of some days between the actual infection and the positive test showing up in the statistics, which corresponds to about 5 days.

For the doubling time the following expression is obtained:

$$\Delta_2 t = 4 \frac{\ln(2)}{\ln(R_{t,4})} .$$

Values for the reproduction number of 1 or less obviously do not allow proper determination of a doubling time, showing the inadequacy of the concept to characterize the spread of the virus.

Understanding Reproduction Number

Before the results shall be shown and discussed, first the spread of the virus needs to be described in some more detail. When considering how a virus spreads, it always reminds me of the local-composition concept in thermodynamic models, where a key property is the number of nearest-neighbor molecules in contact with a regarded molecule. Then counting the probabilities of contact and weighting them with the corresponding energies is the starting point for a thermodynamic model. Modeling the pandemic is quite similar, the number of contacts being a crucial parameter. It is rather obvious that the number of people, to which an average infected person transmits

the disease, can be described as follows, where here the variables are characterized without introducing formal variables:

- number of people to which someone transmits the virus
- = number of people that person meets
- × probability that these persons are susceptible to the infection
- × probability that the infection is transferred.

The latter probability can be expressed as:

- probability that the infection is transferred
- ~ amount of aerosol with virus emitted by the infected person
- × probability that this aerosol reaches the environment
- × probability that the aerosol released to the environment reaches the contact person
- × probability that the aerosol that reached the contact person is entering the body of the susceptible contact person.

The probability of the aerosol reaching the environment and that of the aerosol entering the body are both e.g. affected by people wearing masks. Thus, a mask has two effects in the product of factors. Even the best masks unfortunately do not have a zero probability for the aerosol and the virus passing. While thus wearing mask cannot guarantee 100 % safety for the person wearing the mask, any even small reduction directly affects R , which has an immediate influence on the spread of the pandemic. Thus, it is not understandable, why at the beginning of the pandemic officials have not systematically and in the first place recommended wearing nose and mouth protection. Even, if the efficiency would not have been optimal, it would have reduced R and thus the spread of the pandemic, avoiding thousands of deaths.

A second major influence is the probability that the released aerosol reaches the contact person. This probability is affected by the distance between the emitting and the receiving person. Studies show that during normal speaking aerosols are expelled directly up to roughly a meter in front of the speaker's mouth. Beyond that, the concentration of the aerosol – like anything emitted from a point source – decreases with the square of distance. This applies at least in that case, where no accumulation occurs, i.e. outside of buildings. Additionally, this is influenced by the time until the aerosol evaporates, which will presumably destroy the infectious virus. Ignoring this complication for a conservative 0th approximation, it is clear

that increasing the distance from 1.5 to 2 m the transfer probability is reduced by roughly a factor of 2, to 2.5 m by almost a factor 3, to 3 m by a factor of 4. Thus, if a reduced transfer probability is sought for personal protection, any 0.5 m additional distance significantly reduces the chance to catch the virus.

In closed rooms, the aerosol can accumulate in principle. Also here, ignoring further details for a conservative 0th approximation, the basic math is simple, being that of an ideal stirred-tank reactor. Assuming constant aerosol emission, steady-state concentration of the aerosol in the room is directly proportional to the emission rate divided by the air exchange flowrate. Thus, as expected, for a given spreader in a room the probability of infection is inversely proportional to the ventilation flowrate.

From the dependencies above it is obvious that all individual factors are multiplied to characterize the probability to transmit the virus. Thus, in the following, the influence of these effects needs to be considered as factors.

Consequences of COVID-19 Math

While these considerations apply for any individual person, who seeks protection from the infection, on a larger scale these insights also directly influence the evaluation of appropriate countermeasures against the spread of the virus. For example, extending the distance rule to 2.5 instead of the 1.5 m would directly decrease the infection probability by a factor of 3.

If an entire population is considered, different subgroups may have different probabilities for virus transfer, i.e. subgroup-specific values for R_i . This is especially relevant when considering the influence of corona denial on the virus spread. If such a subgroup of the population ignores protective measures, then the virus will of course spread preferably within that subgroup. Since people from that subgroup also interact with people outside that group, the virus is eventually increasingly spread also to the rest of the population. To characterize the spread of the virus within the entire population, an appropriate average value of R thus has to be considered. In the averaging, the number of contacts of a person within the subgroup and that to people outside that group have to be accounted for. Since corona deniers will presumably not reduce their contacts, it is especially the R within that group that decides on the value of R of the entire population.

This means two things. First of all, the countermeasures have to be chosen such that even in the population group which least applies the countermeasures, the effect is so strong that the average R for the overall population is reduced sufficiently below 1. This in turn means that it may not be required to tighten countermeasures if the reduction of R is not sufficient. It may be fully sufficient to ensure more strictly that the measures in place are followed also by subgroups avoiding the countermeasures. This in turn means that it is especially those people, who do not comply with the countermeasures as strictly as desired, who are finally responsible for the corresponding economic and personal consequences of the pandemic – including additional deaths.

At the same time, such subgroups also has a direct influence on the effect of vaccination. As a worst case, it has to be assumed that those who deny corona are also those, who refuse vaccination. Thus, even if the vast majority of the population is vaccinated, the pandemic will possibly continue to spread at only slightly reduced speed in the denier subgroup. Thus, vaccination primarily protects those vaccinated. Society as a whole will experience an only possibly significantly smaller effect on the spread of the pandemic. Thus, even though the majority of the population is vaccinated, significant countermeasures would need to be maintained to avoid the exponential spread of the pandemic as well as the overload of hospitals. If that is realized, it needs to be reconsidered, if society accepts to shoulder these consequences based on solidarity. Alternatively, costs created by those who refuse vaccination and fall ill with SARS-CoV-2 should possibly be attributed to these deniers personally.

Evaluation of Data

After all of these theoretical considerations, current data for Belgium and Germany can be considered as shown in Figs. 1 and 2. In these diagrams some countermeasures and other relevant information are indicated, where the starting date has been shifted by 5 days since that is roughly the time between infection and positive test result showing up in the statistics.

Some observations can be made in these diagrams, where this is only a small collection:

- In Belgium and Germany, the reproduction number increased to values above 1 already beginning of July. Thus, the countermeasures that have been taken around beginning

of November came much too late. This also shows that the statement of politicians that when the number of daily newly infected falls below a certain number, the countermeasures can be relaxed, is simply not appropriate. If the starting value of an exponential increase is lower, this only means that it takes somewhat longer until very high values are reached. If R is above 1, high values of new infections will be reached sooner or later.

- There is always an upward trend in the reproduction number while the countermeasures remain unchanged. Thus, as time proceeds, people appear to follow the regulations increasingly less.
- In Germany, the reproduction number started to decrease already significantly before the 'lockdown light'. Possibly the curfew that was realized in some hotspots already reduced the spread of the virus significantly.
- The curve of Belgium shows that reducing the permitted number of close contacts even to a single buddy hardly helps to reduce R below 1 permanently.
- A strong difference between sending kids to school and having vacation is not obvious.
- Exceeding the 7-day incidence of 50 indeed appears to increase R , but possibly by less than 10%. Thus, the benefit of reducing incidence below 50 will result only in correspondingly small reduction of virus spread. Being able to track infections is thus beneficial, but not of dramatic influence as is sometimes suggested by politicians and virologists.

From these considerations conclusions for our nearer future can be drawn:

- It is not foreseeable that the countermeasures against the spread of the virus can be significantly reduced even until mid-2021 and beyond. Even vaccination may not significantly reduce the spread of the virus due to the large fraction of people rejecting vaccination and denying corona.
- If shops shall remain open, it appears that to keep R below 1, permitted contacts may need to be reduced to 1 buddy per person over extended periods of time. Possibly additionally a curfew during nighttime is required.
- One major chance to relax this situation and to accelerate our success against the spread of the virus is to better include people reluctant to follow the anti-corona rules in realizing the countermeasures.
- Society possibly needs to negotiate solidarity newly, especially with respect to those, who deny corona and reject vaccination. These are finally driving the spread of SARS-CoV-2.

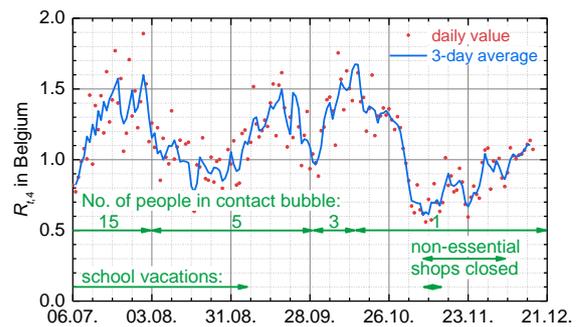


Fig. 1: Reproduction number in Belgium

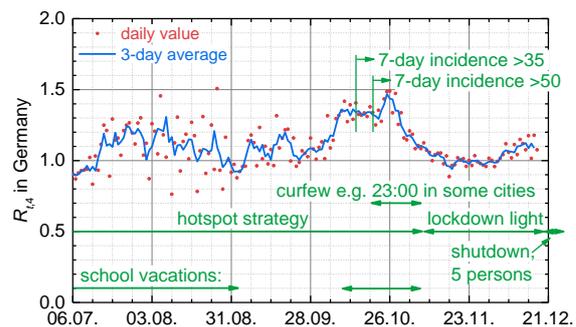


Fig. 2: Reproduction number in Germany

We have to realize that reducing contacts and protecting ourselves against the virus is the new normal, which we simply should accept if we want to successfully fight the virus. E.g. Masks will need to be worn during most of 2021. It is also clear that the personal responsibility called for by politicians and the corresponding personal freedom to decide on following the measures or not as demanded by some, is not just an individual issue. Since at any $R > 0$ also others are affected and society as a whole has to react with countermeasures that affect everyone and finally our economy, every person is individually also responsible for the full societal impact. Thus, such individual decisions are not just a matter of personal responsibility and freedom. Rather an individual responsibility for society is called for.

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COVID-19 Pandemic: The Effects and Adaptation for New Lifestyle

Khang Vu Dinh

Pandemic Outbreak

In December 2019, the world witnessed a serious medical problem: COVID-19 pandemic. Coronavirus disease outbreak was identified first in Wuhan, China. The world first went into a period of surprise, fear, worry, hope, then worry, and hope again. Mid-December 2020, the world recorded more than 75 million cases of infection, of which more than 1.7 million deaths from the Coronavirus (WHO). These numbers continue to increase globally. While we wait and hope for a vaccine that can help prevent the disease, adaptations of our life to disease are essential. As a researcher and working in the education sector, I am clearly aware of the negative effects of the pandemic on my own plans and future.

Impacts and adaptation

Fig. 1 shows the two-sided effects of the COVID pandemic on the global economy, society, and environment. The rare spotlight is noted for positively affecting the environment and climate. Restricted human activities are excellent conditions for environmental and climate restoration. The sources of pollution are significantly reduced.

Effectuated factors	Covid-19 pandemic	
	Possitive	Negative
Economics		
Culture		
Politics		
Agriculture and food systems		
Education		
Environment and climate		
Other health issues		
Xenophobia and racism		

Fig. 1: Impacts of the COVID -19 pandemic

In Vietnam, my home country, where I currently stay, when serious health problems were announced in Wuhan the Vietnamese government soon took drastic measures to prevent

the infiltration and spread of the disease into Vietnam. Schools in Vietnam were forced to close and began to transition to a new learning method: online learning. Social distancing regulations were immediately enforced along with the requirement of wearing masks in public. Vietnam has been actively tracing the sources of infection when new cases are discovered. All positive cases were isolated and treated. Close contact cases (F1, F2) were also isolated for 14 days. In addition, the results of successful anti-SARS in 2003 brought a lot of experience in dealing with epidemics for Vietnam. Fig. 2 shows the total number of positive cases as of November 24, 2020, in my country. The new additional cases were mainly from foreign imports. Currently, Vietnam has moved to a new normal state with dual goals: anti-epidemic and economic development. However, the spirit of disease prevention is still concerned by the whole society.

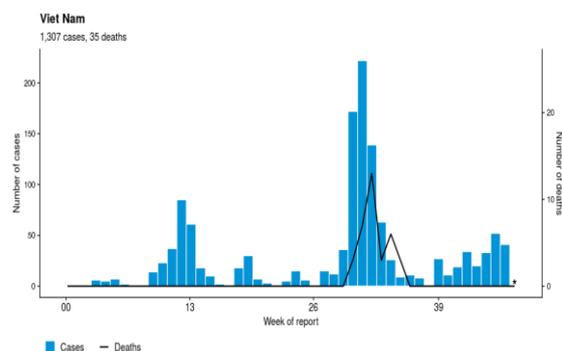


Fig. 2: Situation of COVID19 in Vietnam

Be adaptable and live actively when waiting for good news from vaccine research activities. Let us listen to the exciting and youthful song, with its messages on ways to limit the spread of the COVID19 disease:

www.youtube.com/watch?v=wGoodWEtV8c

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Scientists for Future

Andreas Pfennig

During the last year, my involvement with Scientists for Future (S4F) intensified. After first discussions in the advisory board between the end of 2019 and February 2020 on the future development of S4F, several initiatives were started. For example, cooperation between several members of the advisory board with Gabriele Harrer-Puchner from System Logics T.T. GmbH, St. Gallen, and Georg Wagener-Lohse, Fördergesellschaft Erneuerbare Energien FEE e.V., led to a clearer picture of the structure of interactions within society associated with fighting climate change. The results were presented at the online conference of S4F, June 5&6. In the system's representation shown in Fig. 1, it became clear that reaching the climate goals is mainly influenced by individual behavior, renewable-energy transition, and sustainable production. All these are not directly influenced by S4F. Thus, all scientific expertise available in S4F can only indirectly act, e.g. via informing citizens and politicians, as well as backing up Fridays for Future with the required facts. This in turn means that no short-term effects are to be expected. In turn, we should be patient with seeing any effects of science e.g. on citizen's behavior.

Instead, it would be better to tell a story of how life in a positive future will be feeling like. The goal should thus be to draw a tangible picture of a livable and attractive future. In a series of online meetings, the frames of four such pictures have been defined, which range from a dystopia to three eutopias, in one of which all possible steps to more sustainability are taken. Since it is not to be expected that a majority of citizens can be convinced to change their behavior and way of life so completely, one option is the frame called 'selective', for which I am responsible. The basic idea is that only a few but the truly essential steps are taken. The steps are renewable-energy transition and saving excessive energy utilization mainly to ease that transition, shift to vegan nutrition, and a massive increase in support of development in other nations. By shifting to vegan nutrition, fertile land area will become available for achieving sustainability goals via e.g. organic farming. Also, bioenergy and biomaterials can be utilized, which is much cheaper as compared to the alternative route via CO₂, currently proposed e.g. by the DECHEMA (2017). On the other hand, support of developing countries is essential for limiting population growth. After the corresponding frames of the four pictures of the future have been filled, their content will be scientifically validated and is then used by journalists and artists to produce a tangible representation in stories, performances, and artwork of such a livable future.

Finally, various presentations on the topic have been delivered and two publications have been translated from [English](#) into [German](#), which were regarded essential by the S4F regional group Aachen, [one of them](#) still in the reviewing process.

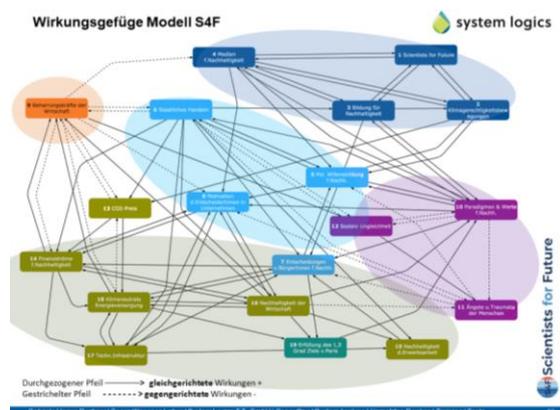


Fig. 1: Systems view of fighting climate change (preliminary version)

A second initiative resulted from interdisciplinary discussions. It was realized that confronting people only with a threatening picture of climate change would not necessarily lead to acceptance of adequate countermeasures, which will influence everyone's personal life.

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Life in India during COVID-19

Swagatika Satpathy

Introduction

COVID-19 has been the most used word for the year 2020 starting from January when it began to spread across the different parts of the world after devastating the Wuhan province of China from where it originated. Here, I will share my experience of the time spend in India during the pandemic. I had just joined the University of Liège as a postdoctoral researcher during November 2019 when I got a call from a university in Odisha to appear for an interview for the position of Assistant Professor for which I had applied back in July 2019. I decided to go to India so as to appear for the interview. I planned a stay of 15 days and went back to India. By then COVID-19 virus had spread to many parts of Europe. The cases kept on rising day by day. A total lockdown was declared in Belgium two days after I went back to India. In India, the situation was not that bad. The number of COVID-19 cases was less, but there was fear in the minds of people with respect to the COVID-19 virus. It even had a huge impact on my interview.

The panel of Jury refused to take my interview after they came to know that I had just returned from Belgium. I tried to convince them that I was not infected but they were adamant. The whole interview was then postponed for an uncertain period of time following this. Till date, no information has been made available regarding the possibility of conducting the interview either through Skype mode or as a personal interview. The next day we saw in the news that those who have returned from foreign countries need to complete a 14 days quarantine period in their respective homes. I followed the guidelines set by the government. Meanwhile, my return flight also got canceled, all other domestic, as well as international commercial flights, were suspended and a total lockdown was imposed over the entire country.

After I had completed my 14 days quarantine period I was hoping to move back to my hometown since I was stuck in the place where I had my interview. However, things did not work out as planned. Some government officials came to my quarantine place and they

informed me of the new regulations where the government had asked all the foreign returnees to complete another 14 days isolation period in the isolation centers arranged by the government. I was not prepared for this but since I was accompanied by my husband, I managed to complete successfully the extended isolation period without being infected by the virus. We were not allowed to cook during this period. They provided us with food and everything required to lead a normal and good life. The concerned officials took good care of each and every person present in the isolation centre taking the necessary precautions required so as to prevent community transmission. I used to spend my quarantine period by reading newspapers and chatting with my husband since we were in a single isolation room. After my isolation period was over, I managed to move back to my hometown and, I started working from home since the government extended the lockdown as the number of cases kept on rising with each passing day. During this period, only the necessary shops such as for food and medical utilities were open to the public for a certain period of time. Apart from teleworking, I learned to cook some new dishes by browsing over the internet (Fig. 1).



Fig. 1: Delicacies prepared by me (a) Chocolate cake, (b) Rasagola, and (c) Cupcakes

We had a small family function during this time where only the immediate family members were allowed to attend. It was the thread ceremony of my nephew. A maximum of 50 guests were permitted to be a part of the entire event and there were officials present who were monitoring whether care was being taken or not in order to avoid the transmission of the virus. Some pictures are attached below which give a glimpse of the event and also of the life during the lockdown period in Bhubaneswar (Figs. 2 to 4).



Fig. 2: My picture while performing a ritual during the family function

Some flights started operating from August and I booked my ticket through Lufthansa and could manage to return back to Belgium after getting permission from Belgian as well as German embassies.

In current times, the situation has not yet improved in India even after all these months. There is no further lockdown in India. The people in India are hopeful of the availability of a COVID-19 vaccine so as to overcome this pandemic. The COVID-19 pandemic taught me that nothing is certain in this universe and we should always be prepared to face the worst. It also gave a message that our families are the most integral part of our life.



Fig. 3: The view from my balcony during the lockdown period



Fig. 4: My family members ready to go shopping during the lockdown period

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COVID-19: Teaching in a New Environment

Andreas Pfennig

It is no news: 2020 was different. Nevertheless, teaching had to be continued under corona conditions. When the lockdown was quickly tightened during spring, colleagues were still debating how to proceed. With a little awareness of the behavior of an exponential function, it was clear that only distance teaching would be possible sooner or later, which was then realized rather sooner.

Of course, the previous experience with recording lecture videos for publication via YouTube in high quality was quite beneficial, because it was directly clear, which setting would be optimal and which equipment would be required. Two strong video lamps were quickly organized – thanks to internet trading. A camcorder was supplied that had previously been used to record the settling behavior in the standardized settling cell. And finally, a Roland R-07 digital audio recorder was already available. Recording the sound with the latter has the advantage that 24-bit recording is possible. The recording level can thus be chosen so low that loudness peaks are safely fully recorded without clipping, while after mixing with the video still full 16-bit quality is ensured, known from 'ordinary' videos and CDs. The overall setting is shown in Fig. 1. It should be stated that after each recording the home-studio atmosphere – of course – has to disappear for the sake of domestic peace.

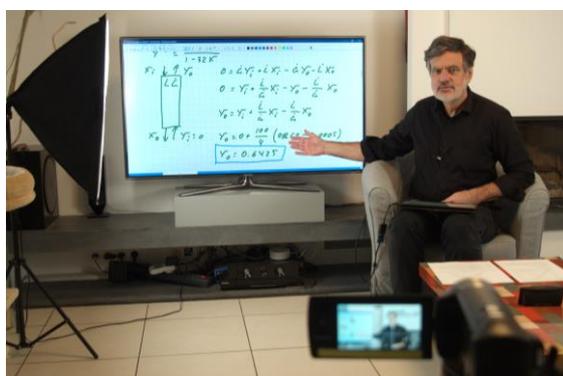


Fig. 1: The home-studio setup realized

The final video result is shown exemplarily in Fig. 2, where it is demonstrated how fast mass transfer is in reactive extraction compared to

that in physical extraction during the course 'Process Intensification and Hybrid Processes'.

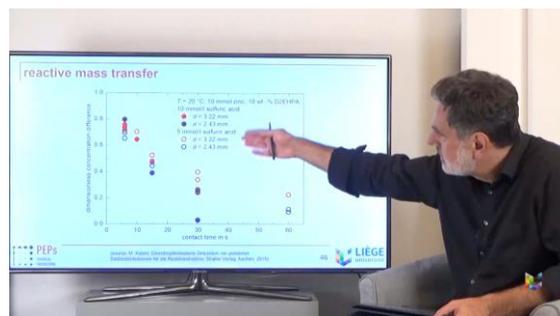


Fig. 2: Discussing mass transfer in reactive extraction

Major challenges were the labs, which could in principle have been realized in our technical hall. Nevertheless, we decided to provide only a short video showing and explaining the equipment and supplying data from previous years for the evaluation. The reports then had to be written based on these data.

The only lab course realized was the schnapps project, with strict regulations applying for safe working in the hall. The number of students present simultaneously was quite limited. With sufficient goodwill, some patience, and the support of department staff, the practical activities of this course could take place. A major last challenge was the organization of the final party, which was realized as an online event. Those who contributed snacks for the party brought them in the morning of the party to a room, where these were then distributed and could be collected by everybody until noon. In the evening the party took place with a joint tasting of the products obtained – this year even with an oak-treated apple schnapps. All participants – including the dean – were enthusiastic about the online event with presentation of the course, tasting of the products, and especially a lively discussion about their quality.

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Sustainability and Culture

Andreas Pfennig

An exceptional experience this year was to be invited for delivering a presentation on sustainability and climate change in cooperation with the [CulturBazar](#). CulturBazar is initiated and coordinated by Yorgos Theodoridis, who originally studied mechanical engineering at RWTH Aachen – like me and almost during the same time period. He later turned to dance, where one of his main objectives is to use dance and performances to allow accessing current challenging topics, which are rather abstract, through alternative routes of perception. The performances are created for school kids, which usually attend as entire classes or groups of classes. In workshops organized around the performance, the thoughts of the young viewers find creative space.

In “Fischers Fritze”, from which a scene is shown in Fig. 1, the starting point of the performance is a foreign animal that arrives at a zoo. This strange animal had to leave its home country because of too much waste and too little food available. In the zoo, it meets saturated and well-fed animals like a lion, an otter, and a flamingo. During the performance, the animals reflect on human behavior of carelessly throwing away a lot of plastics. While in the beginning the zoo animals hardly care, in the end, all animals collect the garbage they can find.



Fig. 1: Fischer Fritze (photo with kind permission: Alexander Müller-Hermes, Artists for Future)

The idea of CulturBazar is to also deliver facts about the topic dealt with in the performance. Supplying these facts was my part. From the continual involvement with the relevant topics,

e.g. through participation in a group of Scientists for Future, who develop basic presentations for schools at different levels, sufficient material was available. Together with own slides, a corresponding relatively short presentation was created, which explains climate change and resource consumption on a level that can be grasped by kids 9 to 13 years of age. Fig. 2 gives an impression of the improvised setting. After the performance and presentation, we discussed the topics with the kids.



Fig. 2: Presentation on sustainability and migration (photo with kind permission: Alexander Müller-Hermes, Artists for Future)

What was a bit surprising as well as disturbing was the depth and level of detail at which some of even the smallest kids were realizing and expressing the challenges of climate change. Essentially in each group, there were some, who could explain the effect of carbon dioxide, where the emissions are coming from, and what can be done to reduce them. Many were well aware on the one hand side of the threatening consequences of global warming and on the other hand of the influence of their individual behavior.

Unfortunately, COVID-19 has hindered further interactions with CulturBazar recently. It is hoped that after corona this cooperation will be resumed.

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An up to date list of publications is available at:
<https://orbi.uliege.be/ph-search?uid=U222548>

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