Prodigio

Developing Early Warning Systems for improved microalgae PROduction and Anaerobic DIGgestIOn

Grant Agreement Number: 101007006

D7.4 REPORT OF THE FIRST MEETING WITH THE SCIENTIFIC ADVISORY BOARD

The PRODIGIO project consortium

Consejo Superior de Investigaciones Científicas (CSIC), Spain, MINES Paris (ARMINES), France, Alfred Wegener Institute (AWI), Germany, ID-Consortium (IDC), Spain, IMDEA-Energy (IMDEA-E), Spain, National Taiwan University (NTU), Taiwan, Norwegian University of Life Sciences (NMBU), Norway, University of Almería (UAL), Spain.

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Meeting minutes

Meeting Dates: 14th June 2022 (for microalgae)
30th June 2022 (for anaerobic digestion)

Place: Virtual

A copy of the agendas is attached as **Annex I**

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SUMMARY OF THE MEETING

This deliverable reports the information gathered during the first meeting of the PRODIGIO project with the Scientific Advisory Board (SAB). PRODIGIO aims to develop tools for the early detection of process failure throughout the microalgae-to-biogas production chain. Since the microalgae production and biogas conversion work packages are currently in the experimental phase, we decided to split the meeting into two different sessions. This format allowed us to focus on the complexities of each experimental setting and first results rather than having a more holistic meeting.

The first session, dedicated to work packages (WPs) 1 and 3 (microalgae production), was held virtually on June 14, 2022, and the SAB was made up of Prof. Maria Barbosa (Wageningen University, Netherlands) and Prof. Paul Falkowski (Rutgers University, USA), both recognized experts in microalgae ecophysiology and bioprocess engineering. The second session, dedicated to WPs 2 and 4 (anaerobic digestion), was held virtually on June 30, 2022, and the SAB was made up of Prof. Raúl Muñoz (University of Valladolid, Spain) and Prof. Jean Philippe Steyer (INRAE, France), both well-known experts in the conversion of microalgae and biowaste into biogas. WP 5 (Sustainibility assessment) served as a link between sessions, integrating knowledge from microalgae biomass production and biomass-to-biogas conversion.

The SAB members expressed their enthusiasm to be part of the external advisory board and highlighted the innovative nature and potential of the project to advance research in monitoring and control of bioreactor systems. Each session allowed us to review the experimental designs and sample processing schedules, as well as redesign the experimental setups if deemed necessary to meet the objectives of the project and improve its scientific and technological impact.

This report includes the minutes of each of the meeting sessions. The minutes transcribe the presentations of each WP by the lead partner and the general discussions with the external advisors. All the main issues raised in the discussion are summarized at the end of the document in the section 'Conclusions and action plan'.

We all agreed to convene another meeting in the spring of next year, this time bringing all partners and external advisors together in one general session.

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SCIENTIFIC ADVISORY BOARD

Maria BARBOSA is a Professor at Wageningen University and Director of AlgaePARC. AlgaeParc is a large multidisciplinary research program, whose mission is to develop a commercial and sustainable production chain for food, feed, chemicals, and fuels from microalgae. Maria leads the Microalgal Biotechnology group with the goal of connecting fundamental research and business applications to accelerate innovation in the field of microalgal biotechnology. She has more than 100 paper in the field of microalgae and has led many international projects, contributing very substantially to advancing this field of research and raising awareness of the importance of microalgae for future society.

Paul G. FALKOWSKI is Bennett L. Smith Chair in Business and Natural Resources and Board of Governors Professor at Rutgers University in NJ. His main research interests include – the molecular bases of photosynthesis, the origins of life and how organisms transformed the geochemistry of Earth. He is the PI of the NASA astrobiology project ENIGMA, which explores the co-evolution of proteins, life, and rocks as a means to potentially discover whether or not there is life in planets light years away by looking at their mineral composition. Prof. Falkowski has written many influential papers and written or co-edited now classical books such as aquatic photosynthesis, coauthored with Prof. John Raven, or The evolution of aquatic photo-autotrophs co-edited with Prof. Andrew Knoll. Paul is one of the world's leading experts in the field of aquatic photosynthesis and has received numerous international awards and recognition.

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Raúl MUñOZ is Full Professor of Environmental Technology at University of Valladolid and senior researcher at the Institute of Sustainable Processes. His main fields of research are microalgae-based wastewater treatment, biogas upgrading and biological gas treatment. Raúl has more than 260 works published in JCR scientific journals, and has co-authored 30 International Book Chapters. He has been Principal Investigator in 48 R&D projects and contracts, including European Demo Projects (INCOVER, DEEP PURPLE, URBIOFIN, CIRCULAR BIOCARBON and CHEERs)

Jean Philippe STEYER is Deputy Leader of the INRAE Division TRANSFORM: Division of Science for Food, Bioproducts and Waste Engineering of the National Research Institute for Agriculture, Food and Environment (INRAE) in France. He is in charge of the scientific strategy of the division – 27 laboratories, 600+ people. Since 1993, Jean Philippe is Researcher at the Laboratoire de Biotechnologie de l'Environnement (INRAE), Narbonne, France. His research is focused on Environmental biorefinery, waste and water resource recovery, anaerobic digestion, dark fermentation, microalgae, instrumentation, modeling and control of bioprocesses, life cycle analysis.

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PRODIGIO meeting with Scientific Advisory Board (for microalgae)

17:00 – 17:25. Pedro Cermeno, CSIC (Coordinator) introduces the project objectives, work packages and consortium partners to the SAB.

Pedro remembers this project is focused on both the microalgae biomass production and the anaerobic digestion processes. He emphasized the main objective: To develop early warning signals that help us to anticipate when the system is going to fail.

17:35 – 18:00. Prof. Gabriel Acien, UAL (leader of WP 1) presents advances in WP1.

Gabriel describes the raceways, routine measurements, highlighting that the wastewater raceway is nutrient limited, Fv/Fm shows stress only in summer and dissolved oxygen and pH are controlled (details on the photobioreactors, operational conditions, sampling protocols and routine measurements are provided in the deliverable *D1.1. Routine measurements in photobioreactors, PBRs*). The culture kept functioning satisfactorily. At least 3 times exhibited pre-failure conditions and once it had a CRITICAL failure in May 2021. From the pre-failure conditions, the system was able to recover and maintain the productivity afterwards. The stability of the culture in the fertilizer raceway was higher than in the wastewater. He points out that they had some peaks of ammonia in the wastewater raceway. In the fertilizer, they provide nitrogen in excess to avoid limitation, but in the wastewater tank they don't provide, so it's possible that N limitation happened. Regarding phosphate (PO_4), he comments that the peaks of accumulation of PO_4 were correlated to lower performance of microalgae.

Gabriel shows the bacteria and viruses counts performed by the master student Oriol Puig at CSIC. He says that 10^7 concentration of bacteria per liter is quite low and therefore fine. He is puzzled by the greater concentration of viruses in the fertilizer raceway. We should keep in mind that Oriol has two categories: viruses and possible viruses. We will check the robustness of these estimates.

Gabriel states that both reactors, the one fed with wastewater and the one fed with fertilizers are now being sampled to generate another (the 2nd) time series.

In the 2nd part of the presentation, Gabriel highlights that the indoor experiments in PBRs are behind schedule because the cultures die after 2-3 weeks, once steady-state is reached. They do not know the reasons why.

Paul Falkowski, Board of Governors Professor at Rutgers University in USA (member of the SAB/microalgae), says those may be chytrids (fungi) coming from the air. Pedro and Carmen ask about the AC system. Maybe the filters need a deep clean, maybe also the room.

UAL have performed specific experiments, trying 3 different *Scenedesmus* strains (S. *acutus*, S. *obliquus*, S. *rubescens*), which failed again. S. *obliquus* lasted longer than the others, so they

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performed a second experiment using it, but failed once again. They thing maybe there's something (parasite, virus) that is affecting the system. they are thinking of using the natural community from the outdoor raceway or moving the system anywhere else.

It is concluded that perhaps the cleaning of filters and the analysis of the samples taken during the failure could help. Unfortunately, the acquisition of metabarcoding data (outsourced) is too slow. María Barbosa, Professor at Wageningen University in Netherlands (member of the SAB/microalgae) suggests to examine the samples under the microscope. Cintia, researcher at UAL, says that they can see unexpected protists, but that it does not mean they are affecting the crop. Rather, she suggests that their abundance increases just because the microalgae die.

Paul Falkowski says that to verify it through RNA analysis (maybe it's not very feasible that we use money for this). Paul Falkowski asks if the materials used to build the system are the same as those on the outside. Gabriel nods. Pedro asks Paul if the failure could be caused by viruses and Paul says that it is a possibility since they can kill the entire culture in a matter of 2-3 days. Paul Falkowski says that we would need more crashes in order to predict them mathematically. He asks how they measure Fv/Fm and Gabriel says with a Junior Pump in situ.

Paul Falkowski changes subject and goes to the general application of green algae for biofuel production. He is very skeptical. He says that in Israel they have led technology towards this since the 80s and have numerous problems not solved. He suggests to invite Asaff Sukenik from Israel to Almeria since Dr. Sukenik has experience in both indoor and outdoor photobioreactors. He says that green algae are not good for energy production because they contain a high % of proteins. Better to use *Nannochloropsis* for their greater content in lipids. Cristina González, IMDEA-E in Madrid (Spain), leader of WP2 – Failure tests in anaerobic reactors, argues that lipids take longer to be digested.

18:10 – 18:40. Ramiro Logares, CSIC (leader of WP3) presents advances in WP3.

Ramiro presents preliminary results of metabarcoding for 16S and 18S. He goes through the overall taxonomy find for 18S and 16S and comments they need to remove mitochondria and chloroplasts for 16S reads and to remove or not metazoan from de 18S reads. He shows Richness, Shannon index, community composition and nMDS for the different treatments (inflow-outflow, wasterwater-fertilizer & 0.2 and 3 um filters). He stresses the importance of fungi and the great % of reads corresponding to NA. He says that diversity is not correlated with biomass. Pedro stresses that relationships are dynamic and therefore we need to apply EDM to find causal links between microbial interactions and biomass production. In the nMDS, there's a change in the community composition: the inflows are more different and converge on the outflows of both raceways. Moreover, this convergence is stronger in the protists. Pedro says that maybe Bray-Curtis distance gives weight to the common groups and one of them is the one being cultured (*Scenedesmus*). Ramiro says that anyway, it indicates that immigration is generally not successful in staying in the culture. Ramiro proposes to use

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Jaccard. He also shows nMDS with environment superposed but just as an example of what they will do to explore the data before preparing them for EDM.

Ramiro finishes saying that we will select samples for metatranscriptomics and genomics. They will build MAGs and gene catalogues to explore the potential of biomolecules.

6:40 – 7:00. General discussion with SAB.

Paul Falkowski talks about Tod Lane who has been researching about algal bioculture for 30 years. He also suggests to contact Adriana Zingone and Marina Montesori at the Stazione Zoologica de Napoli, who have been working long time to explore molecular cues of culture crash. Carmen knows them and could contact them. Paul suggests to encourage students to go to the library and read about what has been done in the field of green algae cultivation in the past decades (mainly the 80s and 90s). He says that there is potential for ecological engineering now, that is, add genes into cells but that along generations, inserted genes tend to be rejected by the cells (lineages).

María Barbosa comments that she is not sure how time series data will be used to accomplish our main objective. She stresses that we only have one catastrophic event throughout the time series (besides of a series of crash and recovery cycles). She also asks a bit more detail about the purpose of the indoor experiments. Pedro and Carmen respond that pushing the system to collapse is much easier under controlled laboratory conditions, like those of indoor systems. This will allow us to manipulate experiments to cause failure and identify changes in the microbiome. Maria says that she hopes to see the results at the next meeting next year.

Both Paul Falkowski and Maria Barbosa agree that the goals of the project are important, the methodology is truly innovative, and the experimental framework is well designed. Both hope to see more mature results derived from the experiments in course and data processing at next year's meeting.

7:00 – 7:30. Paula Pérez-López, ARMINES (leader of WP4) presents advances in WP4.

Paula explains the main goals and objectives. She explains how to evaluate and compare the environmental, economic and social impacts of energy production from microalgal biogas with and without the early-warning technologies aimed in PRODIGIO. Paula comments that they are using a life cycle assessment (LCA) approach. Also, that microalgae systems are strongly influenced by weather conditions and climate change effects. They have completed one deliverable (D5.1), and two other are ongoing (D5.2, D5.3); for 2022, they plan to start with D5.4 and for 2023 with D5.5, which will be the Life Cycle Sustainability Assessment (LCSA) of PRODIGIO biogas production chain. They want to analyze the positives and negative impacts of PRODIGIO biogas production.

End of the meeting ;)

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PRODIGIO meeting with Scientific Advisory Board (for Anaerobic Digestion)

13:00 – 13:15. Cristina González, IMDEA (leader of WP2) introduces the project objectives, work packages and consortium partners to the SAB.

Cristina states the objectives of the project, focusing on the anaerobic digestion part, to our SAB and the expected impacts. She also introduces the consortium to our SAB and the SAB to the consortium.

13:20 – 13:35. Silvia Greses, IMDEA (postdoctoral researcher, WP2) presents experiments carried out so far and preliminary results.

Silvia describes the experimental setup, made up of six independent anaerobic reactors that operate in parallel and are digitally controlled. Two reactors for control purposes, the other 4 for specific treatments (i.e., increase/decrease of the organic load rate). All the variables analyzed are described, including the methods used and the frequencies of the analyses. Silvia also mentions that part of the samples are stored for later analysis by other project partners (genomic data --> NMBU, chemical fingerprinting data --> AWI). Silvia presents some preliminary results of the first set of experiments, carried out from April to October 2021. A second set of experiments was performed from February to June 2022 designed to perturb the systems more gradually. Silvia states that the comparison of these two approaches (perturbation desgins), sudden perturbances and gradual disturbances, will advance our understanding of the mechanisms underlying system failure. The results hold very promising and will provide relevant information concerning how the different microorganisms respond, fail and/or adapt to these sort of perturbations so common in industrial-scale digesters.

13:40 - 13:55. Juline Walter, NMBU (postdoc, WP2 & 4) and Magnus Arntzen, NMBU (leader of WP4) present molecular analyses and preliminary data of amplicons, metagenomics and metaproteomics related to the disturbance experiments carried out during 2021.

Juline first explains the methodological framework designed for sample analysis and raw data processing. Amplicons (16s): clustered at the Phylum level, are dominated by specific taxa, showing striking fluctuations around points of disturbance. Further analysis of the amplicons (at higher taxonomic resolution) shows that there are significant fluctuations over the time course of the experiments and that these fluctuations appear to be associated with perturbations. Some "populations" decrease in abundance, others increase or remain stable, pointing to temporal succession associated with changes in environmental conditions.

The analysis of metagenomes and metaproteomes is also presented for the 2021 experiments. MAGs have been generated and related to fucntional activity of genes as derived from the repertory of proteins sequenced. MAGs have been recovered for bacteria and archaea.

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Magnus describes the tasks that will be carried out during the second part of the project, from June 2022 to December 2023, related to WP4-Modeling of Anaerobic Digestion Failure. During WP4, the team will i) integrate 16s, metagenomics, proteomics, and chemical data generated during the experimental phase (WP2) (leaded by NMBU), ii) use models to explore flows and budgets (leaded by IMDEA), and iii) apply empirical dynamical modelling (EDM) to reconstruct network interactions and identify the system failure triggers (leaded by NTU).

14:00 - 14:20. Chung-Wei (Clark) Chang, NTU (senior researcher, WP3 & 4) present the current state-of-the-art in empirical dynamic modeling (EDM) and future advances, and their application to time series data generated in PRODIGIO, both for microalgae and for anaerobic digestion.

Clark presents the fundamentals of EDM and its applicability to time series data generated in PRODIGIO.

Pedro says that the application of EDM to time series data of chemical and biological variables from microalgae photobioreactors and anaerobic reactors represents the most innovative aspect of the project. "It will allow us, for the first time, to reconstruct the interactomes (causal interaction networks) that are prevalent in these bioreactor systems and their temporal dynamics. Furthermore, it will also allow us to quantify the strength of the interactions and the dynamic stability of the bioreactor systems. This is primarily prospective research that can result in high-impact research outputs and publications."

14:20 - 14:40. Paula Pérez-López, ARMINES (leader of WP4) presents advances in WP4.

[Same presentation as SAB meeting for microalgae]

Paula explains the main goals and objectives. She explains how to evaluate and compare the environmental, economic and social impacts of energy production from microalgal biogas with and without the early-warning technologies aimed in PRODIGIO. Paula comments that they are using a life cycle assessment (LCA) approach. Also, that microalgae systems are strongly influenced by weather conditions and climate change effects. They have completed one deliverable (D5.1), and two other are ongoing (D5.2, D5.3); for 2022, they plan to start with D5.4 and for 2023 with D5.5, which will be the Life Cycle Sustainability Assessment (LCSA) of PRODIGIO biogas production chain. They want to analyze the positives and negative impacts of PRODIGIO biogas production.

14:40-15:30. General discussion with SAB

Raúl Muñoz, University of Valladolid, (member of the SAB/anaerobic digestion), asks about possible delays associated with the coronavirus pandemic situation. Pedro Cermeño (CSIC, project coordinator) responds that there have been some delays in the setting up of the

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bioreactors, mainly due to the delay in the supply of materials. Currently, we are only 2-3 months behind schedule. All teams have worked hard to keep plans and tasks on time.

Jean-Phillippe, INRAE, (member of the SAB/anaerobic digestion), comments that the idea of the project is fascinating and very innovative. He is particularly interested in the application of models, not only EDM but also mechanistic models to address the objectives set out in the project.

Pedro asks Clark (from NTU) how to use the data generated in the second set of experiments, in which a few deterministic factors seem to lead the reactor to collapse.

Jean-Philippe offers the possibility of using some previous models developed by members of his lab to explore biogas production from microalgae biomass [This would be really interesting, I (Pedro Cermeno) thinks]. He also asks Clark what type of variable will be used to conduct the EDM analyses. Clark responds that, in addition to biological data, other chemical data can be used provided that they are part of, for instance, signalling mechanisms within the biotic interaction networks. The main advantage of EDM is that can cope with many many variables, that is, it can manage with and resolve highly complex systems. These systems are, however, hardly tractable using mechanistic models.

Jean-Philippe asks how to manage with the different time horizons of perturbations (i.e., short and long microbiological responses) – moving the time window of the analysis for instance. Jean-Philippe suggests the possibility of using wavelet analysis to decompose the time series signals. Finally, he warns about the many potential factors involved in the functioning of anaerobic digesters, and so the analysis will be quite challenging (although neccesary).

Raúl Muñoz comments that microalgae biomass production and microalgae biomass digestion are carried out in different locations, the first is carried out in Uual and the second is carried out in IMDEA. This could affect the performance of the microalgae production chain to biogas, its empirical validation and modeling. Would it be possible to test the entire process in a unique installation? Pedro responds that, as the project is designed, there is no possibility of performing the entire experimental phase in a single location. It would imply redesigning the entire project and would be too much workload for a partner. Raúl agree that the requirement of partner specialization in each of the process limits the possibility of carrying out both microalgae production and microalgae-to-biomass conversion together.

Jean-Philippe asks how to deal with the system recovery process. Although the project aims to investigate the failure process, the recovery process is also crucial since it also influences the overall system performance. Silvia Greses (from IMDEA) replies that we can explore the recovery process by analyzing the time series data. She emphasizes that the result will depend on the nature and magnitude of the disturbance. Until now, the results show that the structure of microbial communities and biogas production yields recover faster after sudden disturbance than after a long disturbance. A subsequent analysis of metagenomic data will

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reveal the main reasons behind these patterns. Magnus (from NMBU) also stresses that although we see a recovery in biogas production yield, metagenomic data reveal that some specific genera that did not recover and other emerge after the shock. Thus, methane production increases, but this is due to other microbes producing it. According to Jean-Philippe this is consistent with previous observations in digesters fed with biowaste.

Raúl suggests that, for the next experiments, we could include nitrate in the feedstock since nitrate use to accumulate in microalgal photobioreactors.

Jean-Philippe notes that they have been running microalgal reactors for quite a long time taking samples twice per week for more than one year for molecular sequencing, and so those time series data are available to be exploited in the project.

Raul says that he is very impressed by the dataset and looking forward to seeing the final results and analyses because the overall idea is very innovative and the experiments are quite neat.

Paula (ARMINES) explains the overall idea of WP5 including and excluding strategies for failure prediction and prevention on the sustainability of the microalgae-to-biogas production chain.

Raúl send us a paper on safety and health issues related to the production of carbon sufide (CS_2) emissions in industrial-scale bioreactor systems. This is something to take into account and some measurements are proposed to test the production of this harmful gas in our bioreactors.
https://onlinelibrary.wiley.com/doi/abs/10.1002/ep.670220209

The possibility of nitrous oxide (N_2O) emissions from microalgae bioreactors also arises. Mahefa (from ARMINES) says that there is evidence reported in the literature. However, they have recently been visiting the UAL facilities for the production of microalgae and, according to previous in situ measurements, the emission of this gas was negligible, at least under operating conditions similar to those that prevailed during the PRODIGIO project.

End of the meeting ;)

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Conclusions and action plan

The general conclusion drawn from this first meeting with the SAB is that the project is innovative, the experiments are well designed and, a priori should generate original and highly valuable results. The members of the SAB have expressed their willingness to continue being part of the advisory panel and have shown great interest in seeing the final results combining experimental data and mathematical analyses.

The table below lists the tasks that need to be done to correct the issues raised by the external advisors and project participants during the two meeting sessions. These tips and recommendations will be followed scrupulously to increase the chances of success of the project. The achievement of these tasks will be reviewed before the next meeting with the SAB in the spring of 2023.

Issue	Task	Due date
Indoor photobioreactor (PBR) systems are experiencing problems reaching steady state: microalgae cultures crash repeatedly before reaching steady state or during the first few days of steady state.	Check all possible sources of contamination. We will carry out a scrupulous cleaning of the AC points and of the PBRs themselves.	ASAP
The catastrophic failures that are observed in the time series of the outdoor PBRs are scarce, which could compromise the significance of the statistical analyzes in search of the triggering mechanisms.	We will force catastrophic failures over the course of the second time series. We must be careful to avoid the total collapse of the systems since this could imply restarting the entire system with the consequent loss of time.	ASAP
How to integrate chemical, biological, environmental datasets into empirical dynamic modeling (EDM) analyses?	A series of meetings with NTU researchers will be convened to define how the data should be pre-processed before starting EDM.	Autumn 2022
We are preparing an opinion article to show the importance of developing microalgae crop protection systems and how to advance the field. The draft outlines the methods that are being developed by our colleagues at NTU and will be applied within the framework of the project. However, we do not yet have results that corroborate the success of these methods.	Intertwined with the previous point, we will carry out a set of preliminary analyzes that aim to support the idea of using EDM as a novel way to identify early warning signals in microalgae production systems. This could also be extended to anaerobic reactor systems.	Autumn 2022
Use of mechanistic models to explore the impact of perturbations on the biogas production from microalgae biomass in	We will apply a mechanistic model (ADM1) and the results will be compared with time series data.	Spring 2023

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anaerobic reactors (ARs).		
In both, the shocks applied to the PBR and AR are being gradual. Would it be interesting to apply short-term shocks (hours) to destabilize the systems and evaluate the recovery dynamics (ie, see if we can detect a slowdown in the recovery)?	In the next experiments, we wil apply those short-term perturbations (i.e. a slight increase in dilution rates) at predefined time intervals.	ASAP
The third type of disturbance to be applied to AR systems is the addition of chemicals to the algae feedstock, simulating the effect of pesticides used to protect microalgae. It would also be interesting to increase the nitrate load since it tends to accumulate in PBRs.	Nitrate will be added to the feedstock accordingly	Autumn 2022

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Annex I: Meeting AGENDAS

First PRODIGIO project meeting with SAB (for microalgae)
Date: 14th June, 2022
(17:00-19:10 CET, 11:00-13:10 NJ time)
Meeting link: https://conectaha.csic.es/b/ped-c4i-nl8-z5f

17:00 – Introduction (*SAB, project objectives and consortium*). ***Pedro Cermeno***
17:20 – WP1. Failure tests in photobioreactors. ***Gabriel Acien et al.***
17:40 – WP3. Modelling the failure of microalgae production. ***Ramiro Logares et al.***
18:00 – WP5. Sustainability assessment. ***Paula Perez-Lopez et al.***
18:20 – General discussion with SAB (***Carmen G-Comas & PC as moderators***)
19:00 – Concluding remarks (10 minutes) (***CG-C & Judith Traver***)

– End of meeting –

First PRODIGIO project meeting with SAB (for anaerobic digestion)
Date: 30th June, 2022
(13:00-15:30 CET)
Meeting link: https://conectaha.csic.es/b/ped-c4i-nl8-z5f

13:00 – Introduction (*SAB, project objectives and consortium*). ***Cristina González***
13:20 – WP2. Failure tests in anaerobic reactors. ***Silvia Greses et al.***
13:40 – WP4. Modelling the failure of anaerobic digestion. ***Juline Walter et al.***
14:00 – Empirical dynamic modelling. Concepts & recent advances. ***Chun-Wei Chang et al.***
14:20 – WP5. Sustainability Assessment. ***Paula Perez-Lopez et al.***
14:40 – General discussion with SAB (***Magnus Arntzen as moderator***)
15:20 – Concluding remarks (10 minutes) (***SG & JW***)

– End of meeting –

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