Industry university cooperation regarding integrated water treatment and recycling in a graduate course

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ABSTRACT
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Identification and application of technologies for sustainable, integrated water treatment in the industry requires a holistic approach – a system approach. This includes understanding the environmental situation of the actual industry, the process and the characteristics of and specifications for the quality of the water. This of course must be combined with an understanding of the characteristics and economy of the different treatment options.

Looking at this challenge as a system analysis has proven to be a useful approach to solving such equations. Much information is already available in the industries if you know how to ask and combine the data.

This approach is applied in a 10 ETCS master course called 'Industrial Water Technology' at the Faculty of Engineering at the University of Southern Denmark from 2010 and onwards.

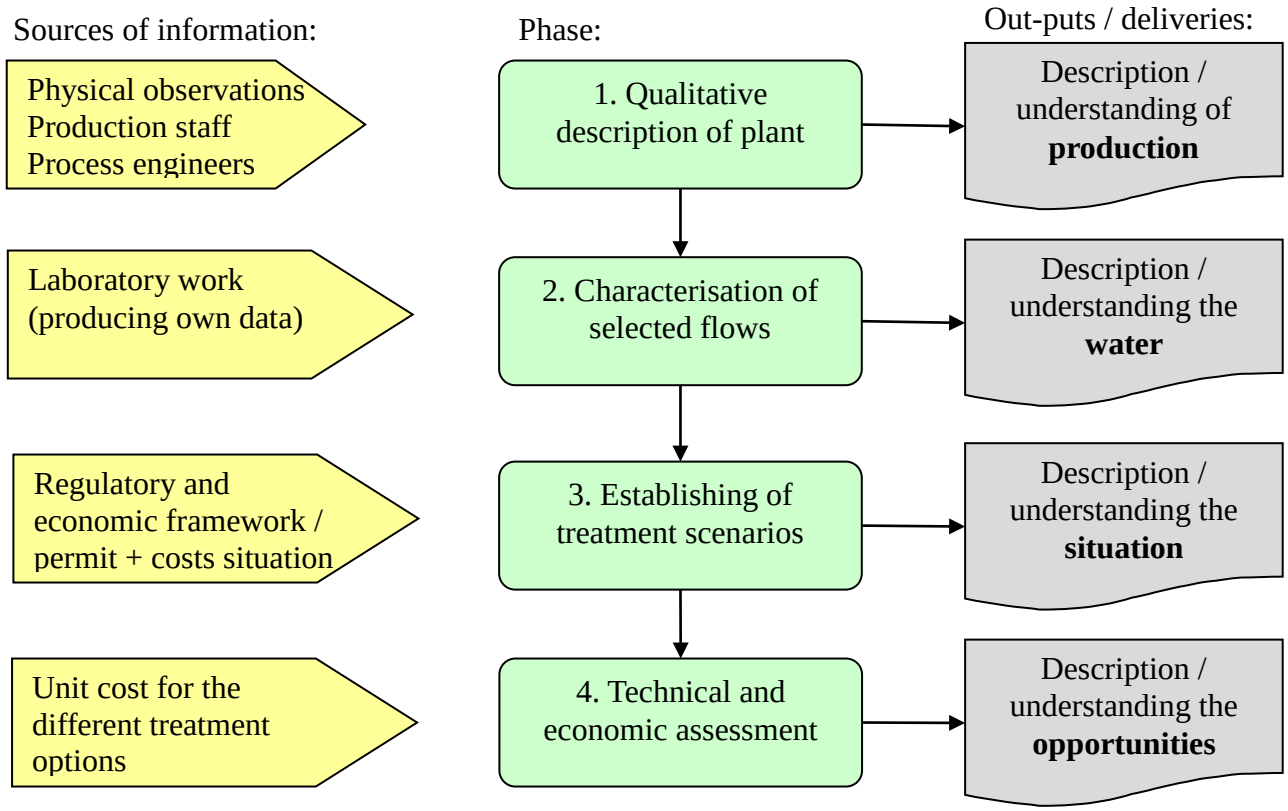
Except for an initial assessment performed along with the initial contact and agreement, the case industries are not studied in details beforehand – the students under the supervision of the course teachers do all data acquisition. This means that the students feel the challenge and responsibility to provide a reliable result, which is typically highly motivation for them. Further, we explain to the students how the project is remarkably similar to a real life job as environmental technology engineer working as a consultant to the industry.

Course design
Overall the course falls into four parts:

1. Mapping the production process – collecting available information
2. Characterisation of the water flows and lab-testing of the treatment options
3. Modelling / creating scenarios
4. Technical and economic assessment

The first challenge is to generate an understanding of the production mainly using existing/available information. This means visiting the case industry studying the production process, interviewing the relevant persons and collecting data regarding the present situation. All groups on the course visit all industries but only one group continue working with the actual industry. The group must present their finding to all the groups, and in this way, we check if they have missed crucial bits of information.

This presentation includes their first attempt to create a production flowsheet with water and mass balance. Joint with an assessment of the nature of the raw materials and auxiliary substances applied, and how it is framed by the legislation on the wastewater discharge and available data regarding the wastewater plus a clear definition of the challenge the industry is facing – equal to the task of the team.



The second phase of the course provides a combination of presentation of theory regarding relevant treatment techniques and testing of the options in the laboratory on water from the case industries.
The treatment options covered are simple filtration, settling, chemical precipitation, membrane filtrations, biological treatment (aerobic and anaerobic) and chemical oxidation. The testing performed is in true lab-scale systems and combined with simple characterisation methods like COD, total and suspended solids, loss of ignition, etc. The purpose is to make the students have a 'feeling' of the actual water with the minimum amount of laboratory work since the aim of the course is not to train laboratory work skills. In a few cases, the case industry pays to have more specialised analyses performed by external laboratories.

Along with the theory/laboratory part the students we encourage to start considering what treatment options they see for their case. Part of this challenge is to try to identify the quality aspects for the water recycled back to the production and considerations on where in the process to apply the water. Both aspects naturally challenge their understanding of the production process and often create a need for new consultations to the case industry or other sources of information regarding the actual industry – like, for example, suppliers of equipment or chemicals. Further, we initiate the assessment of the possible disposal routes for the generated concentrates.

Finally, the students use all the collected and generated information to establish a number of treatment and recycling scenarios, which are technically and economically assessed. During this process, the students often see a need to refresh their understanding of the different treatment options and check part of information regarding the production. The main challenge in this phase is to identify the economic parameters for equipment, installation and running costs in order to calculate the payback period for the

different scenarios. This often creates a need to consult the potential suppliers of treatment plant equipment providing additional understanding of the options.

Experience / outcome

Till now the following industries has been involved; a brewery, a paper mill, a textile finishing plant (a 'dye-house'), a carpet manufacturing plant weaving and dyeing synthetic carpets, a hospital laundry and an industrial mat laundry.

The value of the outcomes for the industries depends on the industries actual status and need for the results of the projects. Mostly some ideas for possible initiatives are unravelled and made available to develop further. Probably the most significant outcome for the industries is the overall assessment that sometimes reveals obvious new ideas they are not aware of.

The design of a course with open cases/problems provides a high degree of focus on the students and creates a high degree of motivation. This is experienced in a high degree of ownership to the cases. In this way, the motivation to work with generic aspects required to perform the holistic assessment is strongly encouraged /Søtoft and Grüttner, 2012/.

The feedback from the students in the form of the standardised course evaluation has been extraordinarily positive and so has the verbal feedback received during the course. A large part of the students are non-Danish, and the course structure makes them learn much on the Danish /EU legislative background of water treatment and Danish industrial practices.

Obviously the course design provides use of all steps in the taxonomy of Bloom /Bloom, 1956/; Acquire knowledge (step 1), understand (step 2), use (step 3), analyse (step 4), generate new solutions (step 5) and assess the developed solutions (step 6) which requires understandings of more complex interactions. Further, it is consistent with the The Engineering Education Model of SDU (EEM/DSMI).

Typically, they experience a period of frustration when they realise the expectations towards them. Later this turn into satisfaction once they realise they are able to perform a proper analysis the industry values. At the individual, oral examination with an external examiner, the students show:

- To be highly skilled in assessing the developed solutions,
- A good understanding of the problem the group has worked with, and
- The ability to identify possible limitations to their conclusions and perspectives on further work needed.

To conclude, the use of real life cases - where the solution is unknown beforehand - gives the students motivation and ownership to the cases and makes them provide excellent results.

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