CEST 2023

18th International Conference on Environmental Science and Technology

Athens, Greece, 30 August to 2 September 2023

The AquaSPICE Industrial Symbiosis Enabling Platform

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Abstract. The role of the AquaSPICE Symbiosis Enabling platform is to facilitate the development of one-to-one waste reuse value chains, through the collaboration of an industrial waste source and a potential waste user. This can be achieved by adopting a three-step process in order to: (i) map and characterize the potential sources and sinks of waste in a region; (ii) match them based on technical criteria; and (iii) identify and assess potential business models for opportunity exploitation.
Keywords: Industrial Symbiosis, AquaSPICE Project, Online Platform

1. Introduction

Industrial Symbiosis (IS) can be defined as the development of mutually beneficial schemes between two or more industries, through sharing resources and infrastructure and by exchanging by-products, waste or energy cascading (Grant, et al. 2010). Such schemes can lead both to an economic profit and to a reduction of the envrionmental impact of all involved stakeholders.

Industrial symbiosis tools have been developed over the past two decades following the wider implementation and use of Information and Communication Technology (ICT) in industry. In the early 2000s, there were already 17 systems identified by Grant et al. (2010), though over half of them were not in use by the time the paper was published. More recently, Akrivou et al. (2021) have updated the review and reported 32 relevant papers/tools, while excluding more than 100 from the final list.

One of the tools presented in the latest review was the SWAN platform, which has been developed as part of the SWAN ("A digital Solid Waste reuse plAtform for BalkaN") project, a research project which was co-financed by the European Regional Development Fund (ERDF) under the umbrella of the European Union programme Interreg V-B "Balkan-Mediterranean 2014-2020. The functionalities of the SWAN platform and its characteristics have been described extensively in Angelis-Dimakis et al. (2021).

As part of the AquaSPICE project, the AquaSPICE Symbiosis Enabling Platform (Figure 1) is currently being developed, enhancing the functionalities of the SWAN platform and providing further capabilities to the user.

The objective of this paper is to present the main novelties introduced by the AquaSPICE Symbiosis Enabling Platform, highlight some of them with indicative examples and illustrate the future plans for its development

2. AquaSPICE Symbiosis Enabling Platform

The AquaSPICE project (Advancing Sustainability of Process Industries through Digital and Circular Water Use Innovations) has as an overall goal to develop and validate water efficiency management and optimization methodologies, technologies and tools that will carry process industries forward towards a near-zero water footprint target with minimum freshwater consumption and waterborne emissions.

One of the objectives of the project is the development of an Industrial Symbiosis Enabling Platform, that will facilitate the identification and evaluation of one-to-one waste reuse value chains, through the collaboration of an industrial waste source and a potential waste user, focusing on, but without limiting to, water/wastewater-based schemes.

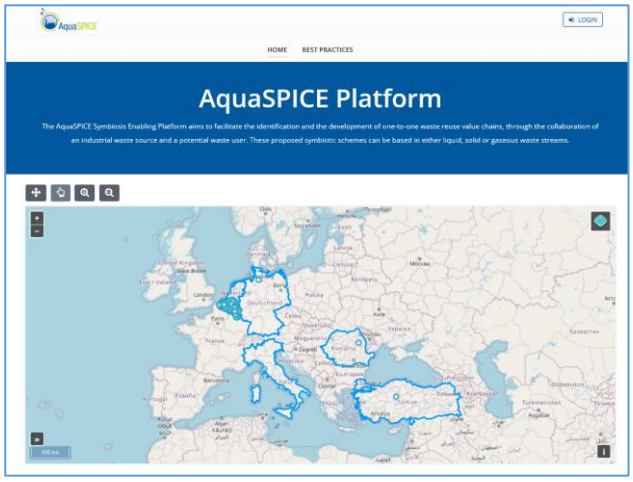

Figure 1. AquaSPICE Symbiosis Enabling Platform Landing Page (available at http://aquaspice.hud.ac.uk)

The platform guides the user through a three-step process to perform the necessary tasks, in order to identify symbiotic schemes for a given region:

- Industry mapping and characterization, by collecting data related to the type, location and size of the industry, as well as data for the input and waste streams.
- Symbiotic scheme identification by matching industries, based on the waste stream properties and the characteristics of the input streams needed.
- Economic evaluation of the identified schemes (provided that the required economic data have been also specified).

Based on the classification reported by van Capelleveen et al. (2018), the algorithm of the AquaSPICE Symbiosis Enabling Platform can be categorised as an Industrial Symbiosis Knowledge Repository, whereas based on Grant et al. (2010), it utilizes a facilitator user interaction model. For the matching between industries, a preliminary screening is performed using a knowledge repository, based on the data reported by Benedetti et al. (2017) and Angelis-Dimakis et al. (2021).

For a further screening and selection of the most appropriate symbiotic schemes, a similarity index, based on a predefined set of waste stream properties has been developed (which can be implemented when relevant data are available), guided by the examples illustrated by Cecelja, et al. (2015). The industry classification follows the Statistical classification of economic activities in the European Community (NACE code) and the waste stream classification follows the European Waste Catalogue (EWC) code.

The main novelty of the AquaSPICE Symbiosis Enabling Platform, compared to the previously developed platform, is that it supports the development of symbiotic schemes based on all possible states of waste and input streams (gas, liquid, solid).

More specifically, liquid and gaseous waste streams are defined using a predetermined set of characteristics. A gaseous waste stream is defined based on its composition. The industrial manager can specify the concentration of each pollutant, using a predefined list of substances, and determines the upper and/or lower limits for the respective components of a potential input stream (Figure 2). Similary, a liquid stream is characterised by a predefined list of quality parameters (Table 1). The user can select the relevant parameters for a waste stream and specify their value and the upper and/or lower limit for a stream to be accepted as a potential input stream (Figure 3).

Table 1. Selected set of quality parameters for liquid waste stream

Flowrate (m^3/day)	TOC (mg/L)
Temp (°C)	COD (mg O_2/L)
pH	Total nitrogen (mg/L)
Conductivity (μS/cm)	Chlorides (mg/L)
Alkalinity (mg/L)	Iron (mg/L)
Nickel (mg/L)	Lead (mg/L)

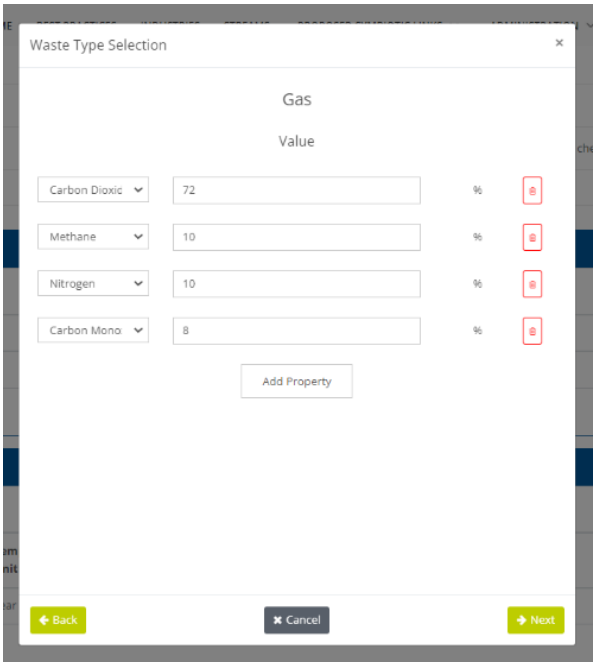

Figure 2. Adding/editing a gaseous waste stream

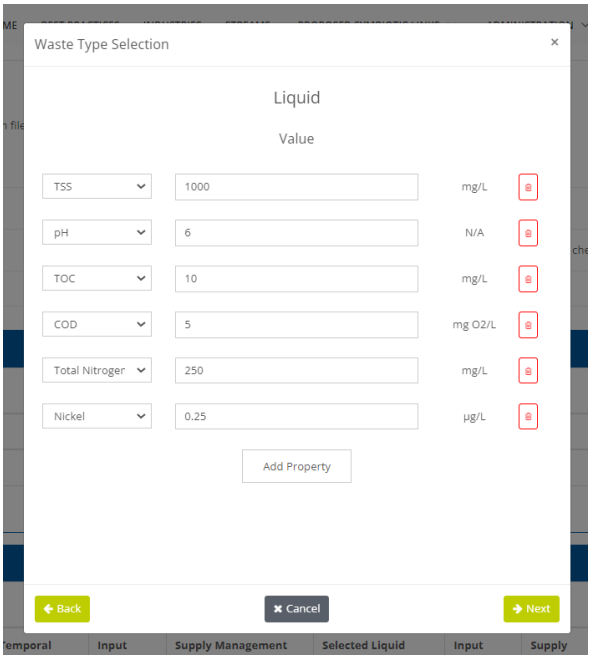

Figure 3. Adding/editing a liquid waste stream

Furthermore, a similarity index has been introduced for the technical matching of the industries, instead of a boolean (Yes/No) option. This similarity index is estimated using the numerical values of either the quality parameters (for liquid waste and potential input streams) or the composition of the gaseous waste streams and potential input streams. The symbiotic schemes that are characterized by a similarity index greater than 70% are added to the list of potentially technically feasible symbiotic schemes.

The economic matching aspect of the algorithm assesses the financial viability for each techincally feasible symbiotic scheme. Compared to the analysis presented in Angelis-Dimakis et al. (2021), the cost analysis has been extended to support liquid and gaseous waste streams. A pipeline option has been added to support the transportation of gases (and in some cases liquids) for short

distances (Pieri, 2021). Moreover, case specific cost functions for the collection and purification of gaseous waste streams have been introduced, based on the analysis presented by Pieri and Angelis-Dimakis (2021).

In order to validate the platform, open-access data, available in public repositories, from more than 300 industries from one of the AquaSPICE regions have been added to the database. However, financial data were not available and thus the analysis was limited to the mapping and the technical matching steps.

3. Conclusions and Future Plans

The AquaSPICE Symbiosis Enabling Platform is currently hosted by the University of Huddersfield and is publicly available at http://aquaspice.hud.ac.uk. As part of the platform's future development, beyond the scope and the duration of the AquaSPICE project, selected artificial intelligence and machine learning algorithms will be introduced to the platform to facilitate other functionalities.

More specifically, it is intended to incorporate a waste prediction model for selected industrial types, which will be trained using publicly available emissions data. The matching method between waste sources and receivers will be upgraded using an artificial intelligence-trained approach. Finally, a data mining process will be utilized to further enhance the best practices database.

Aknowlendgements

The platform presented in the paper arises from "AquaSPICE - Advancing Sustainability of Process Industries through Digital and Circular Water Use Innovations", a collaborative research project that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 958396.

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