Targeting Water Flows and Screening Waste Treatment Technologies Trough Integrated Transhipment Models

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Abstract

The growing scarcity of water resources and the increasingly stringent legislative framework on discharge limits force the chemical industry to adopt water management practices with ever increasing costs. The minimization of fresh water consumption and waste treatment costs must be synchronized since the effluent flowrates are directly related to the fresh water consumption. Treatment costs depend on the effluent flowrates and the selected treatment processes. Prior to detailed designs it is useful to quantify the target for minimum water consumption and the maximum potential of a wastewater treatment configuration in terms of the selected processes to integrate and minimum wastewater treatment flowrates (Kuo and Smith, Chem. Eng. Sci. 52 (23), 4273-4290, 1997). Graphical targeting methods (Wang and Smith, Chem. Eng. Sci. 49 (18), 3127 - 3.145, 1994) are unable to screen treatment technologies and target flowrates for multiple treatment units, while shortcut models for the selection of treatment processes are absent from literature (Bagajewicz, Comput. Chem. Eng. 24 (9-10), 2093-2113, 2000 and Foo, Ind. Eng. Chem. Res. 48 (11), 5125 – 5159, 2009 and Nikolakopoulos et al., Comput. Aid. Chem. Eng., 30, (7-10), 2012). The method proposed in this work extends and integrates two transshipment models. The first model (Nikolakopoulos et al., 381-386 Comput. Aid. Chem. Eng. 30, (7-10) 2012), which was originally used in targeting the flowrate of fresh water, is extended in identifying the flowrates and concentrations of the effluent water mains. The second model (Nikolakopoulos et al. Comp. Aid. Chem. Eng., 34, 381-386, 2014) that initially targeted treatment flowrates, is extended in screening treatment technologies. The two models are connected by identifying the flowrates and concentrations of the wastewater mains, which are allocated at the *pinch points* of the concentration interval diagram of the residual cascade (Argaez et al. Comp. and Chem. Eng., 23, 1439–1453, 1999) which in turn correspond to the *pinch points* of the *limiting composite curve* (Wang and Smith, Chem. Eng. Sci. 49 (18), 3127 - 3.145, 1994). These flowrates and concentrations are subsequently fed to the second model as input. Thus, the mathematical programming tool consists of the integrated transshipment models and synchronizes targeting of fresh water flowrate, screening of wastewater treatment technologies and targeting of treatment flowrates. The method is illustrated by a set of examples featuring the different aspects of the problem and characteristics of the solution. The method offers the additional advantage of detecting the critical parameters of the system and specific process features, where retrofitting changes improve on total cost and reduce water consumption. There is scope to expand the models for multiple water sources, multiple contaminants and treatment processes with removal ratio. Finally, future integration of the two models will offer the possibility to assess the option of regeneration and recycle.

Keywords: Wastewater treatment, Targeting, Water Integration.