An optimization based framework for design and retrofit of municipal wastewater treatment plants: Case study on side-stream nitrogen removal technologies

Existing WWTPs need retrofitting due to several different reasons such as: change in the wastewater flow and composition, change in the effluent limitations, as well as changes in the wastewater treatment trends. Specifically, increased nitrogen limitations in the regulations for the WWTP effluents gave rise to development of innovative nitrogen removal technologies mostly used for water streams resulting from sludge treatment. In this study we propose a superstructure optimization concept based on mathematical programming to manage the multi-criteria WWTP design/retrofit problem and generate novel and optimal network designs for domestic WWTPs. Alternative treatment technologies are represented in a superstructure; each of which is described by a generic model in terms of input-output mass balance. The superstructure is coupled with a database containing data for both performance and economics of the alternative technologies. The superstructure optimization problem is formulated as a Mixed Integer (Non)Linear Programming problem and solved in GAMS for different scenarios represented by different objective functions and constraint definitions. Finally, a case study is formulated to perform a retrofit study addressing the nitrogen removal problem in order to highlight the use of the framework.

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