A knowledge-based decision support tool for selecting Eco wastewater treatment technologies in today's global complexities

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Abstract: There is a clear need for a decision support tool that can address the complexity of selecting wastewater treatment technologies and account for the technical, environmental, economic, and social challenges the water sector is faced with today. The Novedar_EDSS, an environmental decision support system software tool, is now being commercialized for this purpose and is undergoing a rigorous and systematic validation process. Presented herein are results for one validation case study from the U.S. highlighting the comparison of the Novedar_EDSS with the state-of-the-art. In a matter of hours, the Novedar_EDSS produced comparable results to that of the state-of-the-art approach. Also presented are two case studies from Italy and France to demonstrate the application of the tool for different relevant problems in Europe. The results highlight the significant advantage the Novedar_EDSS offers over the state-of-the-art and its high market potential for sustainable / Eco wastewater treatment technology selection.

Keywords: Eco, Environmental decision support systems, technology selection

Introduction

Given the rapid pace of urban development across many parts of the world, specifically China, India, and countries in the Middle East, Africa, and Latin America (City Mayors Foundation, 2013), new wastewater treatment plants are needed to meet the public health and ecological standards that are increasingly being enforced. Where growth is not as fast, like in the U.S. and Europe, new WWTPs are in less demand; however, there is still need to retrofit existing WWTPs to meet more stringent water quality regulations. Moreover, in developed countries, reclaimed wastewater effluent is increasingly accepted as a water resource alternative for several end-uses, e.g. agricultural, industrial and indirect potable use (NRC, 2012). As water scarcity, the growing number of leading edge alternatives to conventional wastewater treatment, and growing pressure on balancing technical, environmental, economic, and social criteria in water projects, add complexity to the fundamental drivers for installing new/retrofitted treatment facilities, decision making inherently becomes highly complex. There is a clear need for a decision support tool that can address the complexity of selecting wastewater treatment technologies and effectively account for all of the technical, environmental, economic, and social challenges the water sector is faced with today. At the moment, one can only use separate tools for each technical, environmental, and economic evaluations, then integrate the various outputs, and then restart the process for each technology being evaluated for making comparisons, which is highly labour-intensive, especially as the number of technologies being evaluated increases. Recognizing this limitation in the industry, the Novedar_EDSS (Molinos-Senante et al., 2012; Garrido-Baserba et al., 2012a; Garrido-Baserba et al., 2012b), an environmental decision support system software tool was developed through the Novedar_Consolider Project (a research consortium of nine Spanish universities, and two Dutch universities), with technical, environmental,

economic, and social capabilities all in one platform. As part of the tool's commercialization, which is currently underway, a rigorous validation process is being conducted. Presented herein, is a validation case study from the U.S. comparing the technology selection results through the state-of-the-art approach versus that of the Novedar_EDSS. Also presented are two case studies from Italy and France to also demonstrate the application of the tool for different relevant problems in Europe.

Methods

The architecture of the EDSS is based on a rule-based hierarchical decision approach and uses quantitative and qualitative information, heuristics and the use of reasoning processes (expert judgment) to produce suitable process flow diagrams for any specific scenario and then ranks them based upon the specific criteria priorities established by the user (Garrido-Baserba et al., 2012a). To test the Novedar_EDSS capabilities in producing results that are comparable to the state-of-the-art, the case study of Steichen et al. (2009) was used as it included a sustainability assessment using the state-of-the-art tools of various wastewater treatment technology alternatives for a planned new wastewater treatment plant. The same influent wastewater characteristics and effluent requirements were input into the Novedar_EDSS, and similar non-economic critieria, such as operational reliability, operational flexibility, aesthetics, and environmental were established for the technology rankings. A similar case study was conducted for a retrofitted wastewater treatment plant in France (results to be included in full paper). For the Italian case study, the tool was used to compare the sustainability of upgrading/retrofitting three decentralized wastewater treatment plants versus the construction of one large centralized plant and decommissioning the existing plants. Each existing plant was evaluated individually using the Novedar_EDSS tool and selecting the configuration best matching the actual planned retrofit. The technical, environmental, and economic results were then aggregated for the three plants and compared to that of the scenario for the one large plant.

Results and Conclusions

Table 1 summarizes a comparison of results for the technology ranking based upon the non-economic factors established for the project. The Novedar_EDSS included the same technologies included in the shortlist of technologies developed by Steichen et al. (2009), and ranked them essentially in the same order as they were scored through the state-of-the-art approach. The economic evaluation also produced similar costs, although reasonable differences are expected as costs will vary from one place to the next, especially in different parts of the world. However, the tool will have the capability of specifying cost indices that appropriate for the location of the project. Table 2 provides a summary of the Italian case study comparing the retrofitting scenario versus the construction of one large centralized plant. When looking at the whole plant level, retrofitting the existing plants is more economical as seen in Table 2, economic and cost benefit results. However, when looking at the secondary treatment line, which is what the EDSS tool scores, the new centralized plant has significant advantages in terms technical, environmental and economic criteria because there is the freedom to select the best theoretical technology, whereas, for the existing plants, you are limited to selecting the configuration that it is the best practical retrofit.

These results demonstrate the significant advantage that Novedar_EDSS offers over the state-of-the-art, as the results were produced in a matter of hours, whereas comparable results were

produced in a matter of weeks through the state-of-the-art approach. Therefore, the Novedar_EDSS will fill a significant gap, in sustainable/Eco wastewater treatment technology selection as urban development and more stringent effluent requirements are met across the globe, once the technology is fully transferred from research to industry.

Table 1 - Summary of U.S. Case Study Results: Comparison of State-of-the Art versus Novedar_EDSS

Technology	SOA Score	Novedar_EDSS Score
MBR	0.81	3.93
MBBR*	0.80	4.25
MLE	0.72	3.81

*MBBR was technology actually selected as best using state-of-the-art approach.

Table 2 – Summary of Italy Case Study Results

Criteria		Scenario			
		Retrofit WWTPs 1 - 3		New Centralized WWTP	
		All Lines	Secondary	All Lines	Secondary
Costs	O&M (M€/yr)	2.96	0.66	5.15	0.47
	investiment (M€)	28.69	17.99	58.59	13.39
	total equivalent costs (M€)	**81.19**	**29.41**	**152.88**	**22.01**
	reactants (M€/yr)	4.93	0	2.79	0
Scores	total		**4.45**		**6.74**
	economic		1.43		1.53
	environmental		1.27		2.58
	operational		1.75		2.62
Cost Benefit Analyis	total equivalent costs (M€)	**81.19**		**152.88**	
	Accumulate benefit (M€)	**0.97**		**22.70**	
	net profit value (M€)	**-83.27**		**-130.18**	

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