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Implementing a composite indicator approach for prioritizing activated sludge-based wastewater treatment plants at large spatial scale

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ABSTRACT

Successful implementation of the European Urban Wastewater Treatment Directive requires a deepened and multidisciplinary knowledge of the wastewater systems. The development of ready-to-use tools for decision makers is, in this sense, a challenge. This paper proposes a methodology to efficiently prioritize wastewater treatment plants (WWTPs) on the basis of the relative environmental, social and public health impacts, taking into account the territorial context issues. The proposed methodology has led to the implementation of a composite indicator. The several choices made for its development, from the definition of framework to the final outcomes, have been evaluated in depth and are supported through methodological and statistical techniques. The potential use of the composite indicator with the inherent advantages and limitations are discussed in order to provide a ready-to-use tool for final users for WWTPs prioritization. Moreover, a concise methodology for composite index implementation is described.

1. Introduction

The implementation of the Urban Wastewater Treatment Directive (UWWTD, European Parliament, 1991a,b) among European Member States requires growing expertise as well as reliable and ready-to-use tools able to opportunely support decision makers in defining priority and plan investment actions. The UWWTD establishes a technical and financial program for the construction of sewage collecting systems and wastewater treatment plants addressing European treatment objectives within the established deadlines. The Directive defines systems of prior regulation or authorisation for all discharges of urban and industrial wastewater in order to ensure the environmental protection from adverse effects. Member States are required to ensure that both discharges from wastewater treatment plants and receiving waters are monitored and, at the same time, have to establish reporting procedures and databases to provide information to the Commission and public on the status of wastewater collection and treatment systems and the disposal or re-use of sludge. In order to address all the several directive purposes Member States have to define adequate organization systems involving public (i.e., authorities, administrative institutions) and private companies (i.e., water utilities) which are characterized by a high degree of complexity.

Among the several questions tackled by environmental managers working in such systems the prioritization of municipal wastewater treatment plants (WWTPs) takes special attention. The sectorial normative (D.Lgs. 152/2006 for Italy; European Parliament, 1991a,b) requires the adoption of measures such as the identification of critical facilities (i.e. WWTPs discharging into sensitive areas and not equipped for the nitrogen or phosphorous removal), the definition of appropriate upgrading actions, and finally the planning of interventions for a period of three years. Since resources are to be allocated, these operations are very delicate and should be as unbiased as possible. To date, a national survey in Italy has shown how, in general, each Local Water Authority (in Italian, *Autorità d'Ambito*) adopts its own prioritization methodology within defined boundaries established by the sectorial and local normative (De Gisi et al., 2014a,b). However no reference to reliable tools or unambiguous methodologies (able to facilitate the prioritization of the WWTPs interventions and so, decision making processes) is provided.

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Table 1
Composite indicator construction literature analysis considering several environmental sectors.

N.	Reference	Details of the study				
		Investigation field	Dimension of the investigated environment	Goal	Adopted approach for the index construction[a]	Implementation phase: Size of the case study
1	De Feo and De Gisi (2010)	Solid waste	Economic, environmental and social	Develop an indicator system to select the best site for the siting of a composting plant.	Linear method of aggregation	4 potentially sites for the localization of composting plants were compared.
2	Lozano-Oyolaa et al. (2012)	Tourism	Economic, environmental and social	Develop an indicator system that is easy to implement, measure, and interpret to improve the sustainability of tourism activities in established destinations considering three dimensions (social, economic and environmental) and 85 indicators.	Information aggregated by using a Goal Programming Synthetic Indicator (GPSI)	181 selected cultural tourist destinations (municipalities) in Andalusia (Spain) were compared and strategies to improve sustainability were proposed
3	Golge et al. (2013)	Air, Water	Environmental (Air and water)	Assess the pollution status of the study area (the middle section of the Lower Seyhan River Basin, Tukey) aggregating, into a composite index (indicated with AWQI), the air quality index (AQI) and the water quality index (WQI)	Elaboration of a composite index with the use of a weighted arithmetic mean function (Ratio or percentage differences from the mean)	–
4	Wang et al. (2013)	SEA (Strategic Environmental Assessment)	Economic, environmental and social	Develop an indicator system to foster sustainability in strategic planning in China	Ratio or percentage differences from the mean	–
5	Köne and Büke (2014)	Air	Environmental (Air)	Evaluates the air pollution index in Turkey for the period 1990–2011 by using four different environmental pressure categories, namely global warming potential (GWP), acidification potential (AP), tropospheric ozone forming potential (TOFP) and particulate formation potential (PFP).	Re-scaled values	–
6	Molinos-Senante et al. (2014)	Wastewater	Economic, environmental and social	Assess the sustainability of small wastewater treatment plants systems based on the development of a composite indicator embracing economic, environmental and social issues	Linear method of aggregation	7 wastewater treatment plant technologies for secondary treatment were compared
7	De Gisi et al. (2015)	Wastewater	Economic, environmental and social	Prioritize critical WWTPs by means of a simplified composite indicator approach	Linear method of aggregation	44 WWTPs were considered

[a] Methods for calculating composite indicators (CIs), reported in OECD (2002a,b) and Singh et al. (2012), include: (1) Sum of country rankings; (2) Number of indicators above the mean minus the number below the mean; (3) Ratio or percentage differences from the mean; (4) Percentage of annual differences over consecutive years; (5) Standardized values; (6) Re-scaled values.

Literature shows how several studies have been recently focused on the prioritization of plants operating in the environmental sector. Barjoveanu et al. (2010), adopting a one-dimensional approach, prioritize WWTPs by means of an impact and risk assessment methodology (the EIRA method). Once the impact on the receiving water body due to WWTP discharged effluents is evaluated, a ranking is established of critical facilities according to the increasing value of the environmental risk index as defined