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Comparison of methods for calculation of sustainability indices for alternative sewerage systems—Theoretical and practical considerations

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Abstract

City planners need practical methods to assess and compare the sustainability of different alternatives for urban infrastructure. This article presents the consequences of selecting different methods to normalize the values of sustainability indicators, and the influence of selecting different indicators and different weighting techniques. Chosen indicators represent use of resources, environment, health and safety, psycho/sociological situation. Infrastructure costs are not included in the indicators, since it is more convenient to weigh them against the sustainability indices of the different systems. All indicators are aggregated into one system index. A nature-based sewerage system is compared to a conventional system. The article demonstrates that the method used to normalize the indicators, the choice of relevant indicators and the weighting technique have considerable influence on which system is found to be the more sustainable.

Keywords: Sustainability index; Sewerage systems; Normalization; Weighting; Calculation; Comparison of methods

1. Introduction

It is widely acknowledged that an acceptable quality of life can only be maintained in the future if mankind's activities and resource use become more sustainable. Such thinking is gaining acceptance in the field of sanitary engineering. However, difficulties arise when claims are made, on the basis of a few indicators, about the sustainability of one system over another. Such claims may have been invalid if all the relevant indicators had been used. Also, the assessment of sustainability is frequently limited by the failure to apply a quantitative approach.

The indicators must reflect the three main dimensions of sustainability:

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- ecological sustainability;
- social sustainability;
- economic sustainability.

The system borders are important for the assessment. A wider or narrower definition of the system studied may give rise to differing results.

It is possible to propose a list of hundreds of indicators (Balkema, 1998; Balkema et al., 1998). However, if the sustainability analysis follows objective and pragmatic criteria, then the selection of 10–20 indicators represents an acceptable compromise between time and accuracy (Lindholm and Nordeide, 2000).

Since the indicators selected for evaluation may be quite different in their characters, it is necessary to weight them to enable comparisons to be made. Weighting can be made on data from the individual indicators, or on data that has been aggregated in various ways (Buckland et al., 2005; Niemeijer, 2002).

Aggregation may be carried out on three levels (Fig. 1):

Level 1: The unaggregated level will do if one is satisfied with having all the indicators separately and doing no weighting.

Level 2: Another solution might be to group natural belonging indicators together. One might, for instance, group together the ecological indicators in one group, the economic indicators in another group and the social indicators in a third group. Or one could sort water pollution parameters in one group, several types of gas emissions for local problems in another group and one for global problems. For each of these groups a group index might be calculated.

Level 3: On level 3, all indicators are weighted into one index, either from level 2 or directly from level 1.

In this paper, we have chosen to aggregate all indicators directly, i.e. level 3.

The most informative method will be to work with all levels and consult with all of them, when the best system is to be chosen. If one puts the calculation into a spreadsheet it will be very easy to perform sensitivity analyses on critical parameters, and see how an increase or decrease in a certain weight, parameter or coefficient alters the indices or results (Gupta et al., 2003).

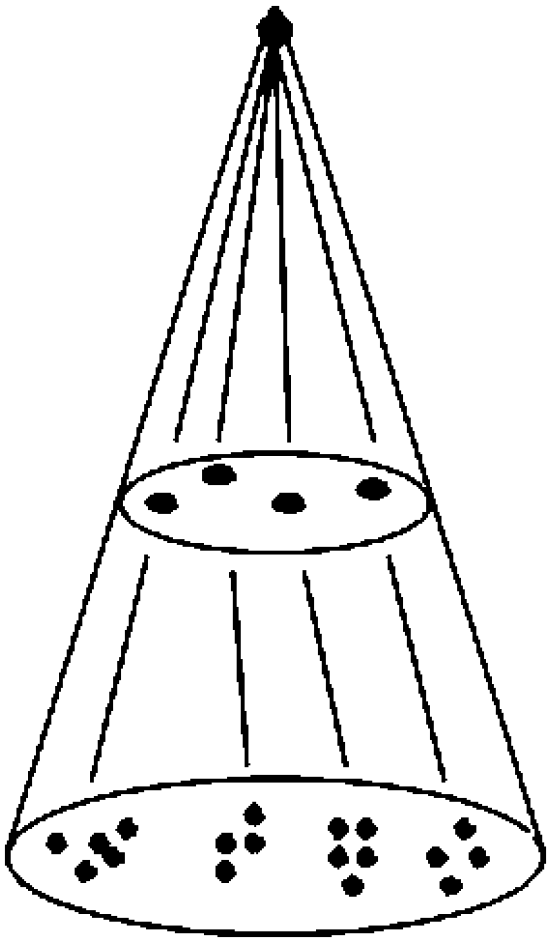

Fig. 1. Different levels of aggregation of sustainability indicators.

The purpose of this study was to compare the sustainability of a conventional and a nature-based system for treating wastewater and to test the outcomes of the study when different weighting techniques or different indicators were chosen.

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2. Methods

In order to obtain representative and balanced data for the nature-based and the conventional systems, calculations were made on hypothetical systems. The data and assumptions used were in line with