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ASSESSMENT OF THE SUSTAINABILITY OF ALTERNATIVES FOR THE DISPOSAL OF DOMESTIC SANITARY WASTE

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ABSTRACT

When attempting to assess the relative sustainability of a process or practice, it is important to be able to use measures which are appropriate. Sustainability can be viewed at different levels. At one level for any given process, the closing of cycles in terms of resource use and outputs (products and waste) may be an aspiration, and make that process in itself sustainable. However, the process may be intrinsically unsustainable when considered within a broader context accounting for all of the economic, ecological and socio-political implications. Traditionally sustainable indicators have been used as a measure to assess increasing or decreasing sustainability, following detailed analyses to define what the appropriate indicators should be. A current UK project investigating the options for the most sustainable means of disposal of domestic sanitary wastes requires measures to assist in the evaluation of the options. This paper reviews the use of indicators in the context of the current project and municipal water systems, and illustrates how an integrated approach may be envisaged incorporating economics, life cycle analysis and risk assessment as part of a framework to assist decision makers when deciding whether changes to systems or practices are likely to be more or less sustainable. A major conclusion is that any moves to introduce sustainable systems can only be made in conjunction with the system users - the public, who must be involved in the formulation of any new practices which require a change in lifestyle.

KEYWORDS

Cost benefit; indicators; life cycle analysis; multi-criteria; public attitudes; sanitary; sustainability; wastewater.

INTRODUCTION

There is much debate as to what sustainability means in terms of environmental systems and anthropogenic activity. As yet however, the UK government is remiss in not fully incorporating issues of sustainable development into all of its activities and thinking (DoE, 1997). In part, this reflects the current limited state of knowledge about how sustainability may be measured and achieved (*'The solution to transforming unsustainable development to sustainable forms ...remains elusive ..'*, Moffatt, 1996). In Scotland, the prospect of a Parliament has necessitated a separate look at sustainable development issues (SOAEFD, 1997). Various reports relating to 'sustainability' have demonstrated the complexity and the broad range of issues involved. Hence any research into 'sustainable systems' requires inter or multi-disciplinary teams. The paper describes a current UK Engineering and Physical Sciences Research Council (EPSRC) funded project, which is focusing on the disposal of sanitary solids via the WC and the relative sustainability or otherwise of using this or the solid waste route (Souter *et al.*, 1996), within the context of the broader picture of defining 'sustainable systems'. The particular aims of the project are to: assess the total (social, economic and technical) benefit-cost of implementing and adopting alternative means of gross sanitary solid disposal; assess public responsiveness to encouragement to limit sanitary refuse input into sewers, and appraise the effectiveness of public campaigns to reduce water-borne disposal, and the consequential effects on the wastewater, solid waste and other systems; hence to propose a strategy for the disposal of sanitary refuse for Dundee as a 'sustainable city' and relate this to the broader picture of UK-wide sanitary waste disposal. The paper briefly reviews the current knowledge about sustainable systems and the use of indicators, describes the importance of the public in the process, and outlines a development of the project which is now starting to utilise a range of established analytical tools to develop decision support systems such as multi-criteria analysis, to aid the UK water industry in effecting changes which are *more* sustainable.

SUSTAINABILITY MEASUREMENT AND INDICATORS

The definition of sustainability is complex and applies to all aspects of human endeavour, together with the maintenance of natural systems, and also depends upon the perspective of the questioner. Sustainability and 'sustainable development' are often confused and mean different things (Van Dieren, 1995). The use of the word 'sustainable' to promote developments based on sound engineering principles (with today's knowledge) is now virtually endemic, and frequently coupled with the other misused word 'optimum' to justify what is really a traditional solution. This has devalued the use of the term 'sustainable' (e.g. Carroll & Turpin, 1997). Others state that 'sustainable development' is an oxymoron (Torgersen, 1995) largely because of the anthropogenic perspective. As far as this paper is concerned, perhaps the most useful definition relates to people: '*...the critical requirement for sustainable development ..is to build capacity in the* ***ability*** *of people and their representative organisations to* ***sustain*** *lifestyles which are compatible with continued environmental integrity*' (Selman, 1996). In a number of countries, the awareness by planners and engineers that there are essential 'human factors' in (integrated) water management is apparent (e.g. Leentvar, 1997). In others, however, the system 'users' are often excluded from decisions for institutional or economic reasons when moves toward more sustainable systems are made.

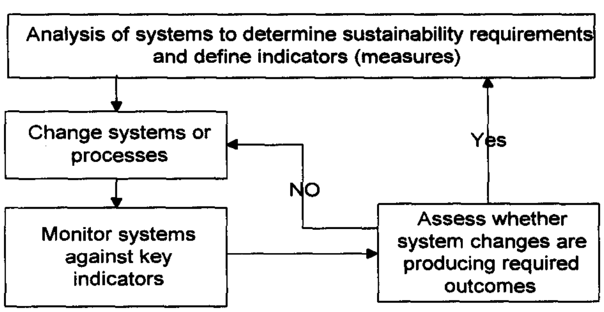

Figure 1. Illustration of the process used to define and monitor sustainability.

Various approaches are in use to 'quantify' sustainability, usually based on some form of indicators: ecological; economic; socio-political (Hatcher, 1996; Moffatt, 1996; Serageldin, 1993). Figure 1 shows the process used to firstly define sustainability for a 'system' and the context of indicators following from the determination of the critical aspects of the system and its interactions. It is clear from the figure that the role of indicators must be dynamic, i.e. continually reviewed within the context of the understanding of the system processes and interactions. The important aspects of indicators are given in Table 1. These approaches are linked to audits of the environment known as 'State of the Environment Reports' (SoER) (e.g. the Dobriš assessment, Stanners & Bourdeau, 1995). Indicators generally fall into 3 categories (the categories, or measures are *not* in themselves indicators) defined by the 'pressure-state-response' feedback loop. A number of approaches have been taken to applying the concept to wastewater systems, as summarised in Lundin *et al.* 1997. For example, Parkinson and Butler (1997) consider five main indicators relevant to sustainable wastewater systems, assigning numeric values to the components. A major recognised problem with the 'reductionist' indicator approach (e.g. Hatcher, 1996) is that of integration. The integration of the three measurement categories in Table 1 is a difficult task, and complicated by the usage of different types of quantification systems for each. Note that whilst 'equity' is shown under the 'economic' category, it should in fact cover all three areas of measurement. Whilst many economists believe that all measures can be 'converted' to money equivalencies, often however, critical factors carry no price. Ideally indicators should be composite and relate to all three categories.

Table 1. Tripartite elements of sustainability and alternative measures of sustainable development

Sustainability Measurement category	Important aspects	Measurement Method	Measure
Economic	Growth	Green Gross National Product	Money
	Equity	Theoretical	Money
	Efficiency	Resource accounting	Energy/money
		Weak*/ Strong** sustainability	Money
Ecological	Ecosystem integrity	Net primary production	Energy/capita
	Biodiversity	Carrying capacity	ha/capita
	Global issues		
Socio-political	Empowerment	Composite	Index/capita
	Participation		
	Social mobility/cohesion		
	Cultural identity		
	Institutional development		

* the measure for this is that the economy should save at least the same as the depreciation in its man made and natural 'capital'.
** a strong measure is a key critical natural 'capital' item, and where this depreciates this indicates non-sustainability.

The other problem with indicators is the perception that they are static and not dynamic. There is a danger that the indicators are seen as fixed aspirations, which as knowledge advances may no longer hold true. Indicators can only be developed once an assessment has been made to determine whether one system is more sustainable than another. To do this, systems analysis techniques are required, necessitating integrated Life-Cycle and Cost Benefit Analyses (LCA and CBA) which in an anthropogenic context, must be carried out in parallel with an assessment of public attitudes, the implications for health, lifestyle and consequent risk. Decisions about changes to systems must then be considered in the light of this range of *multi-criteria* together with a second level of risk assessment in terms of robustness. This robustness must include the resilience of the systems, which in turn should include the adaptability to future changes (Jeffrey *et al.*, 1997). It is probable that in the area of water, key elements in these perspectives will include diversity of types of provision, which may not *a priori* be economically or culturally viable, but essential to support future (currently not envisaged) social and or economic (sustainable) development.

AN INTEGRATED APPROACH

The integrated approach is expected to provide a more rational means of 'measuring' sustainability in the water/wastewater industry and hence defining changes which are *more* sustainable. This usually necessitates the use of technical models to simulate the processes, although the value of these is now questioned (Beck, 1997; Reichart, 1997). Early in the sanitary waste project it was concluded that parallel CBA and LCA were essential for the objective definition of the relative sustainability of the two disposal routes (Johnston, 1997; Ashley *et al.*, 1997). Figure 2 illustrates the framework for the 3 stage study based on the disposal options for sanitary waste, and how this will produce a more generic framework applicable to other wastewater issues. The four key elements involved in the proposed multi-criteria decision model are: multi-criteria analysis; life cycle analysis; economics; risk assessment. The interaction between these components is being investigated prior to the development of a detailed specification for the decision support model.

The model is based on the multi-criteria analysis approach as the shell pulling together the 'core' analyses of LCA, economics and risk assessment. Clearly the technology route adopted (for user convenience) could be such as to allow unrestricted discharge via the WC and require full screening facilities for the waterborne waste. It is probable however, that in sustainability terms the cost of such a system would be unacceptable to current users. The next best system as far as users are concerned needs to be appraised and this requires a cost-benefit study of the solid and waterborne waste disposal routes.

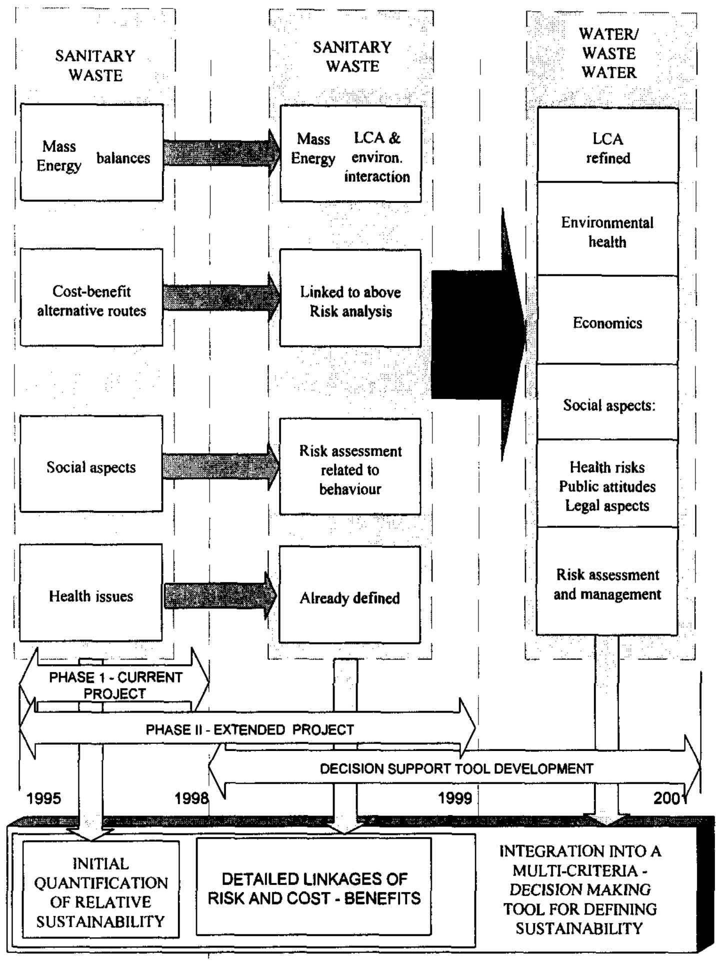

Figure 2. Three-stage project to develop sustainability assessment tool.

To the actual resources which are priced by the market, it is essential to also consider the resources which carry no price, and consider which of these are critical in the alternative disposal systems. This requires LCA or some equivalent approach to provide the information for the comparative decision model. The social barriers and resistance to change must also be included in the evaluation. In developing a multi-criteria decision model involving valuation, in non-monetary terms, of intangible benefits, the uncertain nature of the input data must be acknowledged and robustness of its prediction must be evaluated using risk analysis approaches.

Life cycle analysis.

LCA is a developing management tool which attempts to attribute all environmental impacts of the life cycle of a marketable product or system, with a view to assessing and ideally reducing, the associated impacts. Successful applications have been made of LCA to wastewater systems, both for treatment systems (Emmerson et al, 1995) and for sewerage (Bengtsson et al, 1997). Although there are known problems with

LCA (e.g. Tukker, 1997). By conducting an LCA the following information may be obtained (SETAC 1993):

- as complete a picture as possible of the interactions of an activity with the environment;
- the understanding of the overall and interdependent nature of the environmental consequences of human activities;
- information which defines the environmental effects of these activities and identifies opportunities for environmental improvements.

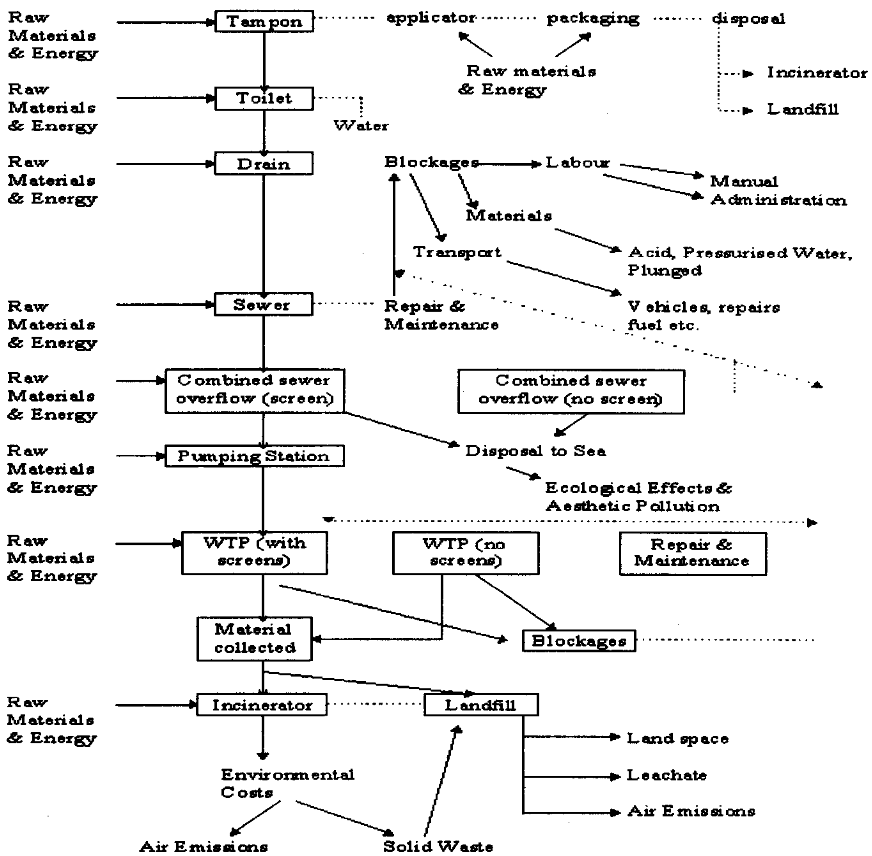

Figure 3. Pathways for a tampon in the waterborne system.

The development of a methodology for an LCA for the project is following SETAC'S Code of Practice, and initially is being conducted for the waterborne system, focusing on the disposal of one sanitary waste item: a tampon (Figure 3) - the most ubiquitous flushed in the UK; 2.5 million per day (Souter, 1997). Once the methodology has been established, additional items will be included, particularly those with plastic components, and the LCA completed using the SIMAPRO software.

Multi-criteria analysis

Whilst LCA can deal with the energy and mass flow systems, and LCIA, environmental impacts, benefit-costs with the economics, multi-criteria analysis can be used to also include social and health factors in the decision making process (Holmberg, 1995; Rogers and Bruen, 1996). Examples of the use of multi criteria analysis to environmental problems demonstrate the applicability (e.g. Weber and Borcherding, 1992; Snell, 1994; Chicken 1994). Whilst these applications demonstrate the value of the analysis in terms of transparency and ease of understanding they are limited because of their use of subjective derivations of scores and weightings (Ashley *et al.*, 1997a). More rigorous mathematical approaches to the analysis have been suggested by others (Keeney and Raffia, 1976) and Bayesian and fuzzy data analysis are also to be investigated (Chicken, 1994). In conclusion, the principles of multi-criteria analysis are well understood, but what is being developed in the study are robust scales and measures, particularly for the intangible aspects of sustainability. The stages in carrying out the work are:

- establish the fundamental concept and axiomatics of the model for sustainable water systems;
- define the criteria and attributes, establish procedures and algorithms;
- model the criteria defining the scale, thresholds and relative importance of the attributes;
- identify imprecision and the consequences of a bad decision by performing risk analysis;
- identify acceptable limits of the above;
- carry out the multi-criteria analysis using appropriate software.

The proposed criteria used to carry out the multi-criteria analysis are shown in Figure 2. As part of the move to more sustainable systems, risks must be minimised and seen to be so. Hence an important part of the project involves risk assessment and management (e.g. Shuval *et al.*, 1997).

The social dimension.

Any attempts to devise systems which are 'more sustainable' without consideration of the social and cultural background and acceptability by users (stakeholders) are doomed to failure. It is clear that any conclusion about changes toward greater sustainability requiring habit change will only be practicable where public culture and mores are understood (Harremoes, 1996). Key aspects also include the institutional structure - and its ability or otherwise to accommodate innovation.

In the anthropogenic domain, it is vital to apply qualitative social research methodologies in order to explore the public notions about the appropriate usage of waste disposal routes, particularly in relation to family concerns, social taboos, and health perceptions, such as those related to WC usage. A key aspect, identified in the current project has been the need to examine how people justify their utilisation of water/wastewater systems and how they deal with the issue of environmental responsibility. Public participation and willingness to get involved in the 'debates' and commitment required relevant to sustainable development depend upon public: perception; awareness; knowledge; 'ownership' - stakeholding (i.e. what has this got to do with me?).

A 'Think Before You Flush' campaign was run in four test areas in Scotland for a six month period (May-October 1997) to persuade the inhabitants to stop flushing and to bin sanitary items instead. These areas were selected to represent different types of wastewater system and different socio-income groups. The range included inland areas served by local WTPs, coastal tourist communities, and a city area with high unemployment. The population sizes ranged from just below 1000 to nearly 2000. Prior to the onset of the campaign both qualitative (focus groups) and quantitative (door to door questionnaire) surveys were undertaken to assess current sanitary waste disposal practices. Currently an 'after' questionnaire survey is being utilised to measure the effectiveness of the 'Think Before You Flush' campaign and to identify the most effective measures that could be used in subsequent initiatives, to both raise public awareness to the problems associated with the WC disposal route and to change public attitudes.

Findings from the 'before' survey suggest that there is a substantial potential for change among the general Scottish public with respect to sanitary waste disposal practices. This potential fluctuates dependent upon both the item concerned and the test area. In areas where there is greater awareness among the public with respect to the environmental impact of WC disposed items, there is a greater use of the solid waste system for disposal and greater willingness to change disposal route.

This can be exemplified by referring to the survey of sanitary towels in two of the test areas: the island tourist community and that with the lowest socio-income group. Aesthetic pollution of local beaches by sanitary waste items is an emotive issue on the island and 39% of women in this area currently use sanitary towels, 26% of whom indicated they flushed this item, 63% binned and 19% burned. 70% of the 26% flushing stated they would be prepared to change to the solid waste route. The remainder were uncertain;

none indicated that they would definitely continue to flush this item. These results are in sharp contrast to the situation in the other area, where the nearest beach is approximately four miles away. 48% of women in this area currently use sanitary towels, 52% of whom indicated they flushed this item, the remainder binned. 38% of the 52% flushing, stated they would be prepared to change to the solid waste route ('soft' flushers). 38% stated however, that they would continue to flush ('hard' flushers), with the remainder being uncertain as to whether they would change.

Analysis of the campaign has demonstrated that in general, by raising public awareness to the problems of sanitary waste items in the environment (via a number of different approaches: public relations exercises, educational presentations, etc.) this will be sufficient to promote change in most areas. Any intervention strategy must be tailored at a local level, with concerns relative to individual areas used to heighten awareness. In this study the campaign was based in part, on public participation at the design stage for the intervention strategy, via focus groups. The 'after' survey and subsequent focus groups will help to determine to what extent such an initiative should be 'localised'.

CONCLUSIONS

Sustainability is hard to define and harder to achieve. Even where there are measures of understanding, changes which require public acceptance often take generations, not just for basic education, but to become inculcated. It is clear that structural changes, integrated into long-term planning objectives are needed at the earliest stage. Unfortunately many individuals are notoriously unwilling to assume responsibility for environmental goods (e.g. Harding, 1968), as exemplified by the 'hard flushers' identified in this study. Water is perhaps one of the best examples of an environmental 'good' which is perceived as 'free' and hence something to be taken for granted, with the UN for example, concluding that in the developed world, the direct cost to the consumer of water is in fact only about one third on average of the true economic cost (UN, 1998) . Complementary to this view is that public 'ownership' of water is often perceived as being too remote (or non-existent) and hence the responsibility of others. In some cases it may be that the only way to change public attitudes and behaviour is by fiscal, legal or technical compulsion. Perhaps moves toward the definition of water as an 'economic good' (Briscoe, 1997) and private enterprise ownership of water will introduce the compulsion required to make people more responsible. Knowledge has been identified as a key element in the move to make the public more responsible. Public views are often based on indicators, however, these are often perceived as 'single-issue' static items, and as a consequence may be misleading. It is essential that indicators are integrated across the various perspectives and acknowledged to be changing continuously as part of the dynamic process as knowledge advances.

In order to make the case for changes toward greater sustainability, it is essential that tools are developed which can be seen to assist with the decision making processes as to what is the most sustainable approach in any given policy or behavioural area. However, if decision makers wait until sustainability (and its' measurement) are defined unequivocally, in a way which enables goals and objectives to be set clearly from overarching principles, society runs the risk of making no progress at all, and given that there may be limited time, this may be tragic. Fully sustainable systems can be developed in terms of technical solutions, but it is doubtful whether there is an effective demand for such systems. In the case of sanitary wastes, the consumer would not be willing to pay (in the broadest sense) for the implementation of full screening. A multi-disciplinary and multi-criteria decision based approach can take this into account and may be able to offer suggestions for a 'more sustainable' alternative which the current generation would be willing to fund to maintain resources for future generations.

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