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PLANNING THE BEST STRATEGY FOR SLUDGE TREATMENT AND DISPOSAL OPERATIONS

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ABSTRACT

Sludge treatment and disposal operations on a local or regional basis need careful planning to ensure that the strategy undertaken is environmentally acceptable, reliable and cost-effective. A database of information is needed for the area concerned which may include up to 100 wastewater treatment plants of varying size. Sludge quantities and quality have to be assessed now and into the future. Disposal options for sludge have to be analysed by an environmental assessment approach which studies the accessibility of all outlets, environmental legislation and attitudes of collaborating agencies and the public at large. Other wastes which may compete with sludge for disposal outlets must be considered. Outlets which involve recycling and beneficial use of sludge are advantageous but may not be practical. Sludge treatment must be evaluated in relation to the disposal options available. Sludge treatment centres, treating sludge from several surrounding wastewater plants, may be required especially if thermal drying or incineration are likely options. Economic evaluation has to consider capital and operating costs of sludge treatment and transport and other costs associated with disposal. The paper discusses how to evaluate all the information and options and find a suitable sludge treatment and disposal strategy.

KEYWORDS

Disposal; economics; environmental effects; sewage sludge; strategy; treatment

INTRODUCTION

Effective treatment of wastewater is an essential requirement as water usage continues to increase and high standards are set for the quality of surface waters. Treatment and disposal of wastewater sludge accounts for about half the total cost of wastewater treatment and needs careful planning to ensure that the strategy undertaken is environmentally acceptable, reliable and cost-effective. The sludge contains much of the polluting load of raw sewage including inorganic and organic contaminants and pathogens , and is highly putrescible so that the environmental implications of disposal, and especially the need to avoid contamination and odour problems, are of particular importance. Fig. 1. shows the treatment options for primary and secondary sludges

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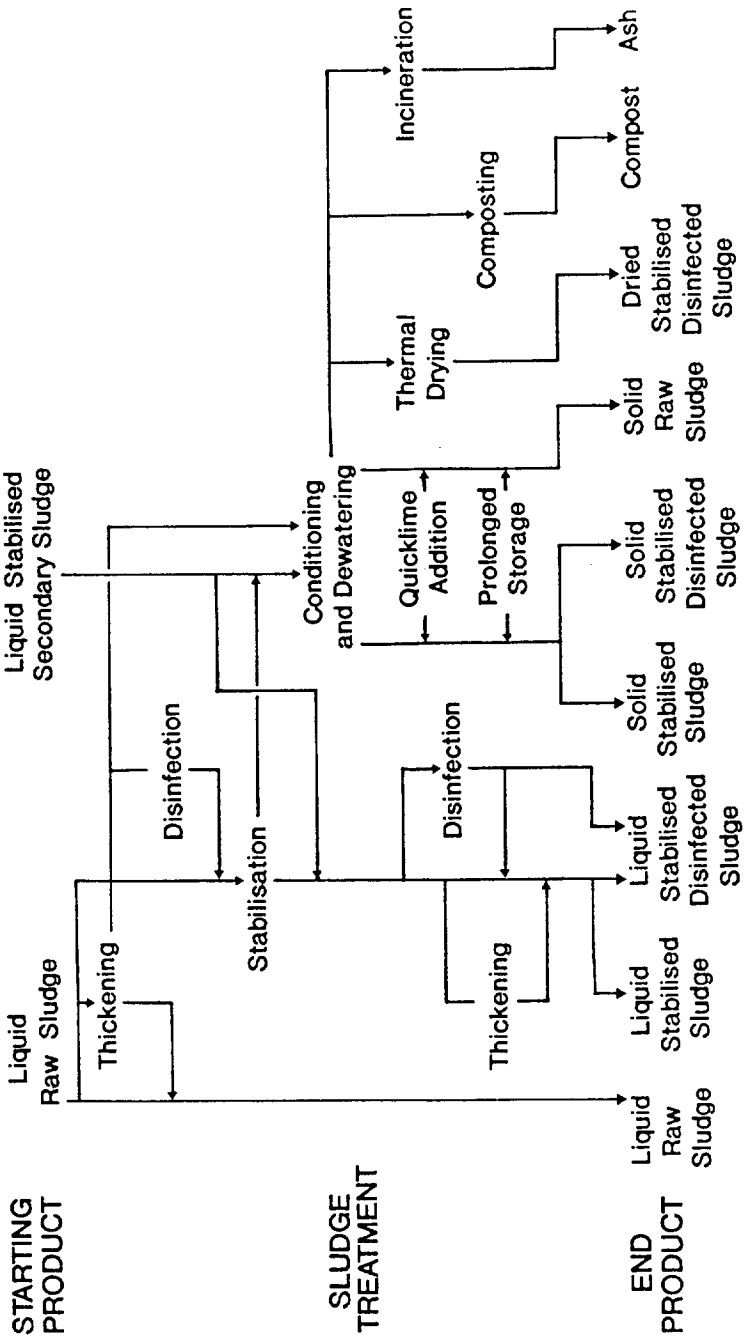

Fig. 1 Flow-chart of sludge processing options for production of suitable end-products for utilisation or disposal

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produced by conventional two-stage wastewater treatment. Treatment must be geared to provide a suitable product for the outlet routes available including recycling to agriculture or other land, and landfill. It is seen that the options for treatment and disposal are complex even for a single treatment works and more so if, as is often the case, a treatment and disposal strategy is required for a number of works on a regional basis. One reason for adopting a regional approach is to include the option of central treatment of sludge at one works where an expensive process, such as incineration, is under consideration.

METHODOLOGY FOR PLANNING TREATMENT AND DISPOSAL STRATEGY

An objective approach to this problem involves finding the 'Best Practicable Environmental Option' (BPEO) as defined in the 12th report of the UK Royal Commission on Environmental Pollution (Royal Commission, 1988). The BPEO approach is applicable to any developmental activity and aims to achieve reductions in environmental pollution and damage, and improvements in the quality of the environment as a whole. Use of the BPEO approach for sludge treatment and disposal is described by Powlesland and Frost (1990), and a recent application in Warsaw, Poland by Hall, Zmyslowska, Stefanicki and Murray (1993). Emphasis is placed on the selection of a route for sludge treatment and disposal which will minimise the overall adverse environmental impacts, on a case-by-case basis, with costs occupying more of a subordinate role. This is in contrast to selection of the least cost route subject to its compliance with legal requirements and constraints, and operational considerations.

A fundamental principle of the BPEO procedure is that impacts on all environmental media or compartments have to be considered and an assessment of the overall impact on the environment is required. Where a purely quantitative basis for comparing the pollutional impact on different environmental media is not possible, then value judgements have to be used for the BPEO procedure. Because of this, in part, it is essential that the procedure for the selection of a BPEO be an open one in which decisions are accountable and which permits the effects of adopting different assumptions and value judgements to be examined and reviewed. So the recording and presentation of information and decisions such that an 'audit trail' can be followed is characteristic of the BPEO selection procedure.

Additional features of the methodology for selecting the BPEO for sludge treatment and disposal are as follows:

- long-term effects should be considered in addition to those which would be evident in the short-term;
- long-range effects should be considered in addition to those which would be apparent at short-range;
- an imaginative search for potential options must be made which seeks to challenge the status quo (the scope of this search to extend from an examination of opportunities to control the quality and quantity of inputs to a sewerage system to the use of novel outlets);

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- local factors of a social and political nature are excluded from consideration (where a decision to implement an option is taken on these grounds and overrides environmental considerations, this fact must be openly and clearly acknowledged);
- a reasonable balance between benefits and costs should be struck and, whilst a BPEO may not be the cheapest option, the financial implications of adopting the identified BPEO should not be disproportionate;
- the financial implications should cover both capital and revenue expenditure and, where appropriate, the costs borne by:
  - the dischargers to a sewerage system (where the BPEO involves the modification of dischargers' existing practices or the introduction of new ones)
  - the water undertaking having operational responsibility (it might be in either the public or private domain)
  - the public sector purse;
- in appropriate circumstances, where their inclusion would help to allay public concern, precautionary measures would be included in the BPEO provided that their cost was not disproportionate;
- the procedure should take into consideration the current stage of knowledge concerning the technology available and the potential impacts of sludge disposal routes on, for example, human health, flora and fauna, buildings and other environmental targets; and
- plans to monitor potential environmental effects should be developed and subsequently implemented, the results reviewed, and any actions arising from the review should be taken at the appropriate stage.

The methodology described here for selecting and implementing a BPEO for sludge treatment and disposal involves nine stages. Central to all of these, however, is the need to maintain an audit trail and this will be the first component of the BPEO procedure to be addressed. The nine stages to be undertaken are illustrated in Fig. 2.

Maintaining an Audit Trail

In order that the BPEO procedure be open and amenable to independent scrutiny, an audit trail is necessary to permit checking of the procedure and its results, and permit an evaluation of alternative assumptions and judgements. This will require keeping records of the following:

- Sources of primary and secondary data and information; basis of assumptions; justification for any criteria adopted to compare environmental impacts and to determine acceptable risks. Also, the flow of information and decision making should be set out on a flow chart.

Step 1 - Statement of Objectives and Constraints

The procedure starts with a statement of what is to be achieved, not to be confused with how it is to be done. For sludge treatment and disposal, this statement of the objectives

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	STEP	COMMENT
1	OBJECTIVE AND CONSTRAINTS	Identify what is to be achieved by the study and the constraints
2	COLLECT DATA ON DISPOSAL OPERATION	Provides background information on current operation. Identify constraints Quantify constraints
3	GENERATE TREATMENT AND DISPOSAL OPTIONS	Generate a number of treatment and disposal options for works in the study area.
4	SCREEN TREATMENT AND DISPOSAL OPTIONS	'Coarse screen' the options generated in step 3 to identify options for further evaluation.
5	EVALUATE TREATMENT AND DISPOSAL OPTIONS	Consider - environmental impact - economic aspects - operational security
6	IDENTIFY PREFERRED OPTION	Select the BPEO.
7	REVIEW THE PREFERRED OPTION	If necessary review the BPEO in more detail to establish its feasibility.
8	PRESENTATION OF EVALUATION	Prepare a succinct report on the data collection methods, generation of options and evaluation procedures.
9	IMPLEMENT AND MONITOR OPTION	Implement BPEO and monitor environmental and economic impact.

Fig. 2 Stages in the development of a sludge BPEO

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will define the treatment works and land area for which the BPEO is to be developed. The objectives should be broad enough to ensure that an open-minded approach to the assessment is adopted. A list and summary of constraints should accompany the objectives and include the following:

- all legislative and regulatory constraints affecting the disposal of sewage sludge;
- policies of the company or authority having operational responsibility for sludge disposal from the works;
- technical constraints which might affect sludge treatment and disposal. For example, the capacity and condition of any existing civil infrastructure and plant; the area of available land at the works for expansion or new capacity; the proximity to the works of housing or other developments; status of knowledge concerning technology and environmental effects of discharges;
- economic and financial constraints; and
- any other constraints, for instance non-cooperation of a second or third party necessary for the implementation of an option.

In practice, the statement will be case-specific and reflect the range of options which are generated and evaluated. It follows that it will not be possible to identify all the relevant constraints until Step 2 has been completed. However, a full and integrated range of constraints should follow the statement of objectives in the documented procedure.

Step 2 - Study Area and Data Collection

Study area. The study area should be of sufficient size to allow disposal to each of the principal alternative outlets: agriculture, landfill and land reclamation. Flexibility should be employed in choosing the boundaries of the study area to ensure that major landfills, for example, are not ignored just because they lie outside a nominal radius from the principal works. The scope of the study should also include all works or other products which are likely to be competing for the same disposal outlets or other resources within the study area.

Data collection. Details of sludge production, sludge quality and costs of existing treatment and disposal operations will be required for each works in the study area, together with information on potential constraints on the operation such as poor access, odour or lack of space for future development.

It is important to ensure that the data relate to the same period and that cost information is considered consistently across different processes or disposal outlets.

The collection of data on the availability of outlets for sludge disposal is a key part of the study. Data should be collected on the capacity of outlets to receive sludge, their location, constraints, and any charges. It is recognised that much of the data will not be readily available and that estimates will need to be made based on the existing information. Consequently, it is particularly important that a careful record of the sources, assumptions and data handling procedures is maintained for this step in the BPEO procedure.

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Step 3 - Generation of Options

This step requires an imaginative and open-minded approach so that the range of feasible options is not restricted to the mundane or routine. Each option will equate to a sludge treatment and disposal route with one or more distinctive features. Factors to consider in the generation of options include:

Exploration of control measures at source. Where sludge disposal from a number of works is involved both integrated works and distributed works options should be considered. Due account must be taken of all the sludge treatment techniques, transfer operations and disposal options which are available and practicable (Frost, Powlesland, Hall, Nixon and Young, 1990). Opportunities for the substitution of sludge, or its derivatives, for other resources used in the economy should be explored as should opportunities for integrating sludge disposal with the disposal of other wastes.

Step 4 - Selection of Treatment and Disposal Options for Evaluation

It is likely that a large number of options will have been generated during the previous phase and these need to be screened to provide a manageable number (probably at least four) for further evaluation. A balance will need to be struck between the complexity of the physical/political situation (which will tend to demand that more options be considered) economy of effort, and the need to offer clearly defined options which are defensible to both decision-makers and the public at large.

Step 5 - Evaluation of Options

A first stage in evaluating an option should be the construction of a simplified diagram - especially, perhaps if the BPEO for sludge disposal from a number of sites is to be selected, or if some routes are relatively complex - which describes the 'system'. The system should extend to embrace the sewerage network or networks supplying the work(s) with raw sewage and/or sludge, the main processes within a works considered within the option, and the final disposal outlet(s) of the sludge and/or its derivatives. Forming the second stage is an assessment of the impacts on the environment in both the short and long term (taking into account both cross-media and long range migration of pollutants) of:
Any construction phase; the proposed operations - routine and accidents/hazards; any decommissioning phase; storage, handling, and use of the sludge and/or its derivatives; the final disposal of sludge and/or its derivatives.

The assessment should be as quantitative as possible. As a third stage the capital and operating costs of each route need to be estimated and expressed as a Net Present Cost. The formulation of these costs needs to be clearly stated to permit checking, alternative analysis and sensitivity studies to be undertaken. This implies that capital and especially operating costs be broken down into their basic cost centres.

Evaluation of the security of the treatment and disposal operation is the fourth stage. It is dependent to a large extent on the number of factors over which the company is able to exert some measure of control. It is difficult to quantify their effects but it may be possible to rank the options in order of increasing security based on a subjective assessment of the risks posed by the different factors.

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WISDOM computer model. Evaluation of options is a key stage of the operation involving effective interpretation of much information on sludge production and quality, economics and outlet availability. A computer model (WISDOM) which simulates sludge treatment and disposal operations was originally developed by WRc and Yorkshire Water for a regional sludge management strategy (Powlesland, 1987) and has been widely used since (Garnett and Carlton-Smith, 1993; Lowe, 1993). WISDOM provides a valuable means of testing the short- and long-term viability of alternative treatment and disposal options so that the most economic and environmentally acceptable strategy can be identified.

Step 6 - Selection of the Preferred Option

Information on the relative environmental impact and economic implications of each of the options will now be available and the treatment and disposal route which offers the Best Practicable Environmental Option for the area being considered can be selected. In selecting the BPEO, subjective assessments may be required as to the relative merits or consequences of different routes. There can be no hard and fast rules for the selection of the preferred option but the approach should take account of the following principles (Royal Commission, 1988):

- the route will represent the option which is best for the environment as a whole but does not incur excessive costs;
- it will observe the imposed standards and limits for emissions to air, discharges to water and in the handling and treatment of wastes for disposal to land;
- it will improve upon the relevant environmental standards, if practicable.
- it will incorporate a safety factor to overcome uncertainty about the environmental impacts or their scale and to reduce the possibility of inadvertent pollution transfer between different environmental media;
- it will envisage the potential for accidental damage to the environment and how it might be mitigated; and
- it will include the specification of control equipment and operating procedures where these provide an effective means of achieving the required environmental objectives.

These criteria mean that the option selected as the BPEO should represent the most environmentally acceptable and economic treatment and disposal route available. However, it is recognised that different decision makers may come to different conclusions based on the same evidence. It is important, therefore, that these conclusions can be well supported by the evidence collected during the study.

Step 7 - Review of the Preferred Option

This can take the form of a more detailed technical appraisal by the company or its consultant, or its main contractor; of an environmental statement prepared by an independent body or a HAZOP study of the proposed project.

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Step 8 - Summary and Presentation of the Evaluation

The evaluation of the various options considered need to be summarised and presented in a fashion which draws out the salient features of each option and facilitates a meaningful comparison. More contentious projects can be the subject of planning enquiries/approval and require an environmental impact assessment statement to be prepared. The BPEO procedures would predate and be a necessary precursor to any environmental statement that might be required, and hence would in all probability be a public document. The main text of any document forming the basis upon which a BPEO would be selected will need, therefore, to be prepared with the intelligent lay-person in mind as the principal reader.

Step 9 - Implementation and Monitoring

Once the requirements of the BPEO have been implemented the performance of the option should be monitored in order to establish that design targets for environmental impact, safety and cost are being achieved. Monitoring should take place as soon as a stable operation has been achieved and preferably within one year of implementation. If required as a result of this exercise, changes are made to the plant, operating procedures, or the outlets utilized then monitoring should be continued until satisfactory conditions are achieved.

CONCLUSIONS

Wherever centralised collection and treatment of wastewater is practised throughout the world, a sustainable sludge disposal operation is required with outlet routes which like wastewater treatment and sludge production, can function continuously. This requirement is shared by many countries (see Agg, Wellstein, Cartwright and Zabel, 1992). The BPEO approach provides for systematic collection and appraisal of all relevant information to find a sludge disposal strategy which is based on open analysis and can be justified on environmental and economic grounds. The environmental case within the BPEO will be particularly important in securing a suitable sludge disposal strategy.

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