LIFE CYCLE CHECK AS A DECISION SUPPORT TOOL FOR MEDICAL WASTE MANAGEMENT IN UNDERDEVELOPED AREAS OF AFRICA

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ABSTRACT

In most developing countries, the emphasis for health care has moved to community preventative services and away from district curative health services, e.g. immunization. Sterilization and reuse is being replaced with single use and disposal to minimize the risk of cross infection. This has lead to larger amounts of infectious waste in underdeveloped areas. The responsible authorities and agencies do not have waste management infrastructure to safely handle and dispose of the waste. Although not recognised as a significant problem before, health care professionals now require allocation of funds that were previously not identified. In Africa where much of the health care currently receives donor funds, these professionals are also obliged to comply with national regulations and international protocols for waste disposal, mostly only known to specialist waste management practitioners.

In order to address these problems a Check List has been developed for planning at District, Regional, and National Managerial levels, using a Streamlined Life Cycle Analysis (SLCA) according to ISO 14040. SLCA can evaluate parameters of the waste life cycle qualitatively and thereby reduce the time and cost of conducting a comprehensive, quantitative life cycle analysis. The SLCA was compiled from data obtained through a case study of an African country and was used to evaluate different management options for health care waste in such a country. The checklist is aimed at providing decision makers and waste management practitioners with a tool to prepare budgets and waste management plans. The planning tool will be discussed using a process assessment and a comparison between waste management options.

PROBLEMS ASSOCIATED WITH HEALTH CARE WASTE MANAGEMENT IN UNDERDEVELOPED AREAS

Developing countries usually lack procedures to develop reasonable waste management plans that can be implemented within practicable time frames. This is further exacerbated through the:

- Low awareness of options, equipment and technologies, possibly not all available in that country.
- Cost of the equipment, facilities and running expenses of the available waste management options.
- Inability to implement options due to poor institutional capacity, absence of training and skills, absence of practicable regulations and coordination in national departments (health, environment).

These factors contribute to the complexities summarised in table 1. The consequence is the slow agreement at national and regional level on the appropriate waste management options that must be selected, and the means to obtain budgets and funds to implement changes in current practices.

Table 1: Problems with health care waste management in developing areas of Africa.

Health care waste problems	Waste management problems
Waste is highly infectious and dangerous	Lack of trained manpower
Quantity of generated waste is increasing at facilities	Lack of practical, working equipment
The number of facilities and locations are increasing	Lack of institutional capacity

The difficulties that health care waste managers and decision makers have are attributable to:

- The larger amounts of infectious waste in underdeveloped areas; the previous practice of sterilization and reuse is increasingly replaced with single use and disposal, to minimize the risk of cross infection. The most hazardous waste is blood contaminated needles, and syringes
- Wider incidence of blood borne infectious disease in the population in Africa. The most recognized diseases are Hepatitis B and C and HIV / AIDS. In Africa relatively larger percentages of the population are infected and this means that the risk of contracting the disease as the result of needle prick is higher than in developed countries which have at least 100 time lower prevalence of infection in the general population (examples given in table 2).
- Poor management of health care waste is widely spread in underdeveloped areas.
- Increased awareness of the hazards associated with health care waste, making the donor and regulatory requirements for safe waste disposal practices increasingly difficult to comply with.
- Competition for scarce funds, e.g. food, medicines and transport, vs. waste disposal facilities capital and operating costs.
- The overall lack of skills at national and regional regulatory and technical support levels.

Table 2: Risks from infectious diseases and needle pricks in Africa (Simonsen, 1999).

Disease	% of population in sub-Saharan Africa infected	Infection risk based on one needle prick
Hepatitis B	10.0 %	20-40 %
Hepatitis C	2.6 %	6.0 %
HIV/AIDS	> 3.5 %	0.3 %

AVAILABLE TOOLS TO ASSIST WITH WASTE MANAGEMENT

The tools designed to assist decision makers with waste management practices and are shown in table 3. Certain tools have been developed for specific applications, e.g. decision trees and Rapid Assessment Tool (RAT), and others under the auspice of formal Environmental Management Systems (EMS), e.g. BPEO, EA and LCA.

Table 3: An overview of waste management tools (continued overleaf).

Environmental Accounting (EA)	**Description**	Procedure to place a monetary value on the environmental consequences of a defined practice; typically includes compliance obligations, civil and/or criminal fines and penalties, remediation costs, compensation and punitive damages and natural resource damages.
	Positive aspects	Identifies benefits and costs avoided as well as actual costs. Attempts to place impacts into known decision metrics, i.e. costs.
	Negative aspects	The fundamental incompatibility of economic and ecological scales. The questionable emphasis placed on data artificially generated with hypotheses instead of making use of empirical observational data, i.e. the lack of important financial information. Often applied at company level and less at government level.

Life Cycle Assessment (LCA)	**Description**	An objective process to quantify the environmental burdens associated with a waste management process. The assessment includes the entire life cycle of waste up to final disposal. Impact categories are identified and quantified and subsequently compared (SABS, 1997).
	Positive aspects	Only EMS tool that attempts to quantify environmental impacts for a numeric comparison. Environmental profile of the waste life cycle created.
	Negative aspects	Subjective basis or usage of subjective data typically gives subjective results for routine analyses or assessments of a waste life cycle. Limitations in the data collection and analysis of the inventory stage. Variations in the temporal scale, spatial scale and locale, and assignment procedure of values to different environmental impacts.
Best Practical Environmental Option (BPEO)	**Description**	The waste management option that provides the most benefit or causes the least damage to the environment as a whole, at a cost that is acceptable to society, in the short and long term (NEMA, 1998).
	Positive aspects	Enables a rational ranking of options at each step in the waste disposal process, including a costing and impact assessment.
	Negative aspects	The ability of uneducated and inexperienced communities to be able to assess and decide on costs and impacts may be low. Requires a lot of information on costs and impacts in order to be able to quantify and rank options.
Decision makers guides (WHO, 2002a)	**Description**	Guideline document for national assessment (of current policies, regulations, economics, and facilities), development of a national plan using key stakeholders, and recommendations for piloting and developing supporting regulations and guidelines.
	Positive aspects	Comprehensive and providing a focus for short and long term goals.
	Negative aspects	Can be a long drawn out process that takes several years to implement. During this period can require a lot of financial resources to support decision-making and change within the national organizations.
Decision trees (WHO, 2001)	**Description**	Three components to decision trees: • A decision procedure in the form of a flowchart of the processes at a typical health care facility, accompanied by a list of parameters that should be assessed before using the decision tree; • An outline of the risks associated with unsafe waste disposal practices; • A report on management options, based on nominal cost and risk rankings.
	Positive aspects	The tool graphically illustrates a wide range of options for the management of health care waste. It also highlights the risks associated with each step of the management process.
	Negative aspects	The tool is not particularly user-friendly at a practical level. Its value as a realistic guide in the day-to-day management of health care waste is therefore limited.
Practical Technical guides (SABS, 1993; WHO, 2002b)	**Description**	Technical documents identifying problems and solutions
	Positive aspects	Practical advise on management involvement and examples of equipment used to segregate, store and transport waste.
	Negative aspects	Limited information on costs, and availability of equipment in developing countries.
Rapid Assessment Tool (RAT) (WHO, 2002c)	**Description**	Questionnaire based quantification and qualification of waste amounts and locations at country level.
	Positive aspects	Standard format that can be used at many locations, and by many types of personnel. Provides data that can be interpreted to gain quantities and categories of waste.
	Negative aspects	Does not provide quantitative data on environmental or health impacts, or budget data on manpower, training and equipment requirements. The data requires expert assessment and interpretation in order to provide environmental and budget costs.

These tools are inherently information and data intensive and lack data on environmental health and safety impacts and costs, technical solutions that are feasible for the country and costs that can be used to assess options. Obtaining the level of data required for these tools is typically impossible for decision makers of health care waste management options in underdeveloped areas, especially where quantitative data is necessary. Rather, by adapting the available approaches, a qualitative tool should be developed that assesses the entire life cycle of health care waste and its associated risk and cost impacts.

Streamlined Life Cycle Assessment (SLCA) approach

If the negative aspects of table 1 are considered, it becomes clear that an extensive Life Cycle Assessment (LCA) is not a suitable tool for comparing waste management options in underdeveloped areas. The limitations of the tool lie in the detailed data requirements and time-consuming procedure with subsequent costs to decision makers. Nevertheless, the benefit of LCA lies in its comprehensive approach.

LCA is increasingly used as a tool for policy development by regulatory authorities (Allen, 1997). Options for possible first world waste management practices have been good examples of using LCA results for policy purposes (Tukker, 1999). These decision-making options are performed by governmental and non-governmental organizations at the following levels: (SABS, 1997)

- Strategic planning.
- Priority setting.
- Process design and redesign.

In this paper procedures are proposed to reduce the detail of LCA whilst maintaining a certain degree of the comprehensiveness. They are collectively termed Streamlined Life Cycle Assessment (SLCA), which is illustrated in figure 1.

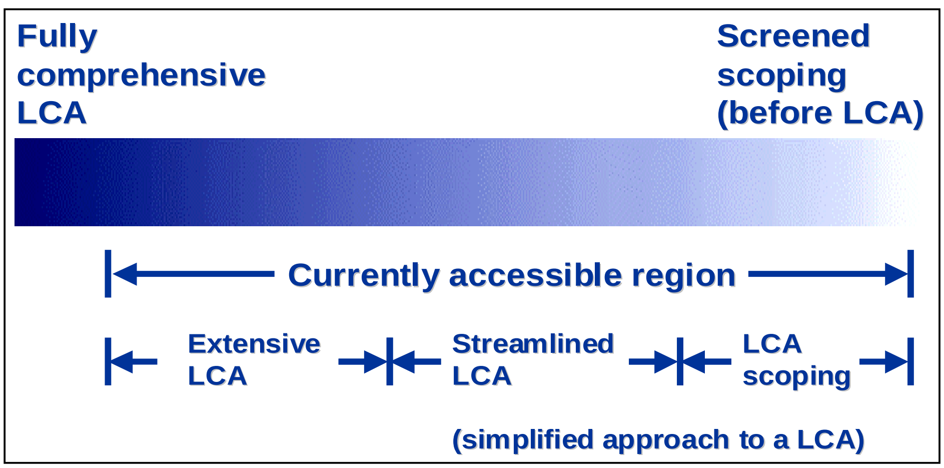

Figure 1: Level of detail – SLCA in relation to extensive LCAs.

SLCAs typically use qualitative rather than quantitative data and the impact analysis procedures are simplified. The main assets and liabilities of SLCAs (Graedel, 1999) are listed in table 4. Although expenditure of time and money is better limited, the liabilities again indicate potential inadequacy of the tool for waste management in underdeveloped areas.

Whereas conventional LCAs are based on international standards and guidelines (Tukker, 1999), no formal framework has been provided for SLCAs. However, where a SLCA is used for an evaluation or for further development of a procedure it must adhere to following principles (SABS, 1997):

- All relevant life-cycle stages should be evaluated in some manner.
- All relevant environmental stressors should be evaluated in some manner.
- The SLCA should include the four stages of conventional LCAs, although not necessarily quantitatively:

- o Definition of goal and scope.
- o Inventory analysis.
- o Impact analysis.
- o Interpretation.

Table 4: Assets and liabilities of Streamlined Life Cycle Assessment (SLCA).

Assets	Liabilities
More efficient. Less costly. Usable in the early stages of decision-making. Routine procedure carried out on a variety of products and industrial activities.	Limited capability to track overall material flows. Minimal capability to compare completely. dissimilar approaches to fulfilling a need. Minimal capability to track improvements over time.

A need therefore arose for the development of an evaluation tool based on these principles of SLCA, not only addressing its liabilities but also including the comprehensive life cycle approach.

DEVELOPMENT OF THE WASTEOPT LIFE CYCLE CHECK TOOL

Goal and scope of the development study

The development of the WasteOpt Life Cycle Check tool is aimed at the adequate evaluation of risk and cost impacts associated with health care waste management options that will be applied in a specific region. WasteOpt is directed towards decision makers at national, regional and district level, typically health care professionals. It will therefore identify the most practical and affordable waste management solution with the least risk to the environment and human health in the context of a specific underdeveloped area.

1. Functional unit

The functional unit of the WasteOpt Life Cycle Check (LCC) tool is defined as “The amount of health care waste (of average composition) generated in an average rural primary health care facility in one day”.

It can therefore be represented as a table or list of constituent materials. The user of the WasteOpt tool can enter and modify the quantity and composition of health care waste in the functional unit.

2. Boundaries of the development work

The assumptions currently used by the WasteOpt tool are as follows (illustrated in figure 2):

- Health care waste is segregated from general (non-hazardous) waste.
- In terms of the spatial dimensions, health care waste begins its life cycle when medical supplies have served their purpose or function and become classified as waste. This corresponds to the “cradle”. Health care waste ends its life cycle at final disposal (“grave”). Emissions to air, water and soil correspond to the final boundary.
- The individual life cycles of the various unit processes (collection, transport, storage, treatment and disposal) are taken into account if they fall within certain cut-off criteria, e.g. the conventional “Relative Mass-Energy-Economic (RMEE) system boundary selection (Raynolds, 2000).
- In terms of the time dimension, the system is bounded by that time at which the health care waste has caused a predetermined percentage (e.g. 98%) of its impact or risk.

3. Allocation assumptions

The assumption (see section 2) that general and non-hazardous waste is always segregated from health care waste may not be realistic. If the two types of waste are collected, handled, stored, treated and/or disposed together, the resulting impacts should be allocated to the two types of waste separately. However, for the purposes of this tool, the risks associated with general waste are regarded as negligible when compared to those associated with health care waste. All impacts are therefore allocated to the health care waste.

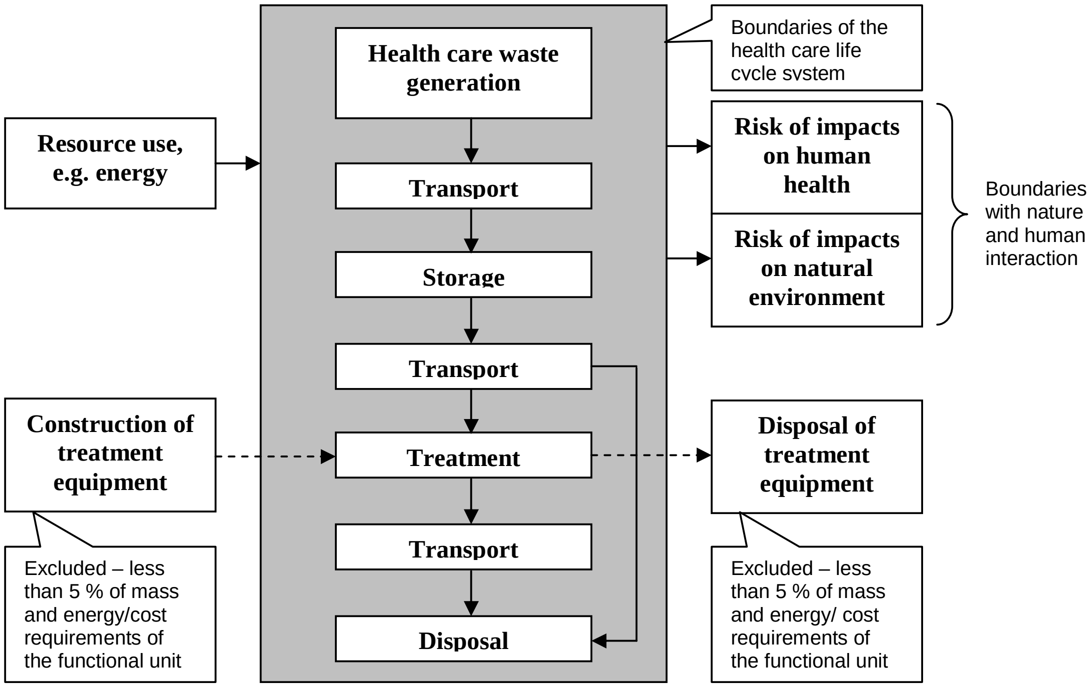

Figure 2: An example of boundary selection of the health care waste life cycle system

Development of an inventory analysis database

The purpose of the inventory analysis is to quantify the relevant inputs and outputs of each unit process in the life cycle of the waste (see figure 2). The WasteOpt tool provides the framework to populate an inventory of the health care life cycle system using all available data. In developing countries data is usually limited due to the lack of resources available for coordination and assessment and the best accuracy is therefore obtained from surveyed data or general knowledge of decision makers. However, if a survey is not practicable, data can be used from other surveys or published performance measurements. Also, with the exception of costs, quantitative data is typically not required for strategic decisions and the evaluation of options and qualitative (non-parametric) data can be used (see figure 3).

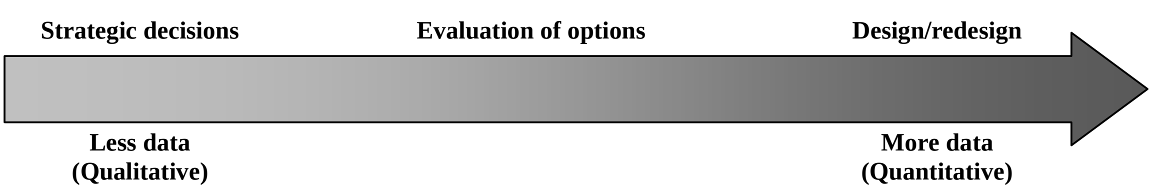

Figure 3: Requirements for qualitative and quantitative data in SLCAs.

Qualitative data can be obtained through answering a series of questions about the practices at the health care facility. An example (for storage of health care waste) is given in table 5. WasteOpt includes similar worksheets for each of the processes in the health care waste life cycle. The tool requires the user to select an option in each block, thereby guiding the decision maker through the required information with relatively simple and practical questions.

Table 5: Example of the WasteOpt questionnaire for the storage step of the life cycle.

Conditions	Options	Selection	Impact value*
Temperature	Refrigeration	√	1
	Insulation only	×	5
	No insulation or refrigeration	×	10
Containers	Secure, covered and spill proof	√	1
	Covered, and spill proof	×	3.25
	Spill-proof	×	5.5
	Open	×	7.75
	None	×	10
Access to storage area	Controlled access, and vermin free	√	1
	Controlled access	×	5
	None	×	10
Training of waste handlers and managers	Formal qualification	√	1
	Course	×	4
	In-house knowledge transfer	×	7
	None	×	10
Availability of protective equipment	Gloves and apron	√	1
	Only gloves or apron	×	5.5
	None	×	10

* Not shown in the user interface of the WasteOpt tool, i.e. background calculations

Development of an impact analysis procedure

The impact analysis identifies potential and actual impacts associated with the inputs and outputs at each stage of the waste life cycle, e.g. fuel usage, and emissions in transport. The impacts are classified as

- Direct: a direct impact on a receptor, e.g. needle prick of a health worker that results in an infection with a hazardous illness. Cause and effect are clearly demonstrable.
- Indirect: an indirect impact on the environment, e.g. formation of dioxin by poorly operated incinerators, impacting residents eating the agricultural produce grown in the vicinity of the incinerator.
- Quantitative: impacts that can be measured directly and an estimate of the measurement's uncertainty be made, e.g. costs associated with a particular unit process in the life cycle.
- Qualitative: non-quantitative, but can be assigned a risk or impact based on expert assessment.

The WasteOpt tool includes an impact rating system (see table 5). When qualitative data is available and a ranking is required, the conventional LCA approach is to attach a numeric value to each option. Based on expert assessment, and on whether a procedure complies with an acceptable practice (WHO, 2000) a numeric value is assigned to each option. An example of possible values is shown in table 5. The rating system is based on a "1 to 10" scale that attaches a value of 1 to the lowest risk and 10 to the highest risk. However, it is not possible for decision makers to interact with these calculations, i.e. the values are used in background calculations to provide a ranking that can be used by the decision maker to select the best available option for a waste management system in a given area or region.

Development of an interpretation procedure

After the user has chosen one option for each question, WasteOpt calculates the total impact of each unit process of the life cycle and tallies these as a single score. The lower the final score, the lower the overall risk of that specific health care waste management option. The different waste management options for health care waste in underdeveloped areas are compared and the results graphically displayed to the decision maker, according to the following three criteria:

- Overall costs for implementing and operating the waste management system.
- Overall risk due to direct exposure of health care facility staff and the general public.
- Overall risk due to indirect exposure of health care facility staff and the general public.

PRELIMINARY EVALUATION OF THE WASTEOPT LIFE CYCLE CHECK TOOL

Overview of health care waste management in developing countries in Africa

By way of example, table 6 summarises conditions that can be expected for a developing country in Africa, i.e. Malawi, in terms of constraints to evaluate waste management options for health care facilities.

Table 6: National statistics for health care waste management in Malawi.

Parameter	Malawi statistics
Average population growth rate	1.7 % (falling due to HIV/AIDS)
Percentage of population under the age of 5	17 %
Percentage of population in rural areas	65 %
Percentage of waste disposal on-site at health care facilities	100 %
Number of health care facilities	503
Average population served by a rural facility	30000
Percentage of facilities with working water supplies	44 %
Percentage of health care facilities vehicles in working order	36 to 100 % (region-specific)
Main mode of transportation for patients	Walking
Average distance between patients and health care facilities	3.5 to 8 km
Formal training for waste disposal	Being developed
Budgetary allocation for waste disposal	Being implemented
Working incinerators	< 40 %
Working landfill sites (burnt and un-burnt waste)	< 10 %
National guidelines for waste management	Under development
National inspection and control	Low

Issues being assessed are:

1. Feasibility of transportation to centralized locations for efficient incineration followed by safe burial of the ash.
2. Feasibility of destruction at the site where the waste is generated.
3. Feasibility of burial in a safety pit without incineration.

Without budgetary provisions, and given the current problems of maintaining vehicles on the road, as well as the competing priorities for transport of medicines, the preference is for treatment and disposal on site, as opposed to transporting the waste for off-site treatment and / or disposal.

Figure 4: Transport available at a typical rural facility: bicycle and ox cart.

Figure 5: Typical incinerator in operation. Due to maintenance problems, most do not work well.

Figure 6: Medical waste disposal pit in a vegetable garden. Problems with training result in poor pit disposal practices

Analysis of the WasteOpt tool in the context of African countries

Depending upon the amount of site-specific data, there is a possibility that the tool will lead to some degree of over-simplification of the actual conditions at health care facilities in African countries. The main requirement is the availability of reliable survey data or practical experience of the current situation by decision makers who will use the tool. However, the main benefits of the WasteOpt tool are:

- It is tailored for the level of information available, and the provision of rapid information on ranking of options.
- It can be used for strategic planning (with default information on the data base) enabling the comparison between actual practice and acceptable practices.

- It can be combined with existing survey assessment tools to provide information suitable for planning and replanning by using acceptable unit operations.
- It can be upgraded to include transportation and cost modelling for cost and feasibility assessments of alternative scenarios.

The primary advantage of the tool lies in the simplified questionnaire, which provides a framework to guide a user through the kind of information required to evaluate waste management options. However, waste management expertise is not required to use the tool but is incorporated in the calculation procedure. It must be noted that the tool is focussed on developing countries where quantifiable data and skilled in-house capabilities are lacking, and can therefore be adapted for regions outside Africa. Similar tools have been developed for the first-world scenario (MacDougall, 2001) and should be applied where state-of-the-art waste management options are evaluated.

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