ORIGINAL ARTICLE

ENVIRONMENTAL STEWARDSHIP FOR INTERVENTION AND CONTROL OF A BURGEONING TOXICOLOGICAL HAZARD

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ABSTRACT: Increased consumerism and diversity of economic activities have led to an increase in pressure from the increase and diversification in waste. Environmental stewardship has become essential to reduce the toxicological risk by an active involvement in waste disposal like planning of landfills for ensuring impedance at source. The risks from waste disposal practices in Malaysia are examined along with the essential considerations for secure sites to prevent environmental hazards to health. ***(JUMMEC 2002; 2: 122 - 126)***

KEYWORDS: Waste disposal, environmental stewardship, adequacy of disposal sites, collective analysis of considerations.

Introduction

The stresses on the environment from economic development and increasing consumerism in countries like Malaysia is posing new and increased medical risks and amongst these are those from toxicological hazards. This requires a strategic shift in dealing with the sources that are responsible for this burgeoning hazard particularly in changing the practice of intervention and control in dealing with hazards.

Pressure from increase and diversification in waste

Consumption habits and industrialization has caused a proliferation in both domestic and industrial waste which also includes the variety of waste. An indicator of this is the rise in industrial sources and their effect on the environment as evidenced from the complaints lodged with the Department of the Environment, Malaysia (JASM) as far back as 1997. A breakdown of these sources of pollution is given in Fig.1.

The sources in Fig.1 indicate that the industrial sector has grown substantially to show up as a major component as above. An expected outcome of this is an inevitable increase in the use of raw materials and the ensuing production of industrial by-products and wastes adding to the amount variety of wastes. The rise in consumerism is also inferred, as the above industrial activities are market driven. This has led to an increase in commercial and domestic waste as well. Waste release is a pressure factor within the health and environment cause-effect framework as shown in fig. 2.

Action is required to eliminate this pressure that stresses the state of the environment by increasing pollution levels and the toxicological hazard risk. The necessary form of action involves active intervention and control to reduce toxicological releases at the source involving environmental stewardship.

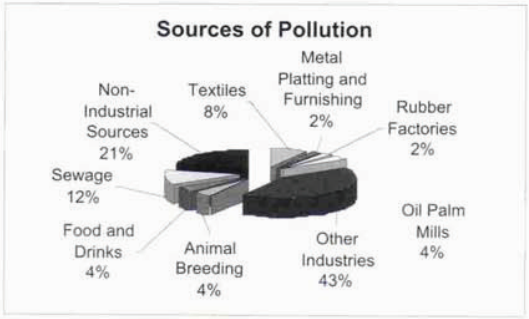

Fig. 1 Sources of water pollution complaints (1)

Intervention and control models

Moeller (3) states that in traditional medical practice physicians deal with patients according to the model

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given in Fig. 3. In this clinical interventional model the intercession comes in the diagnosis and treatment of a disease to cure the patient. This affords intervention but no control over the disease to enable elimination of its source or cause before infection. The environment health stresses, especially, new stresses in newly developing economies like Malaysia need to be tackled to enable a measure of control of diseases arising from environmental factors. Traditionally pre-emptive measures are taken under public health [branch of medicine dealing with safeguarding and improving community health through organized community effort involving prevention of disease, control of communicable disease and health education (Academic Press Dictionary of Science Technology)] including epidemiology [defined by Mausner and Kramer (4) as the study of the distribution and determinants of disease and injuries in human populations]. Moeller (3) describes this practice according to the model given in Fig. 4.

This public health intervention seeks to establish some degree of control over sources risks to human health and well being. However, this does not afford sufficient control as the causes and sources themselves are not addressed. The ability to exercise greater control lies in the field of environmental health which is defined by

Pew Environmental Health Commission (5) as comprising those aspects of human health, including quality of life, that are determined by interactions with physical,

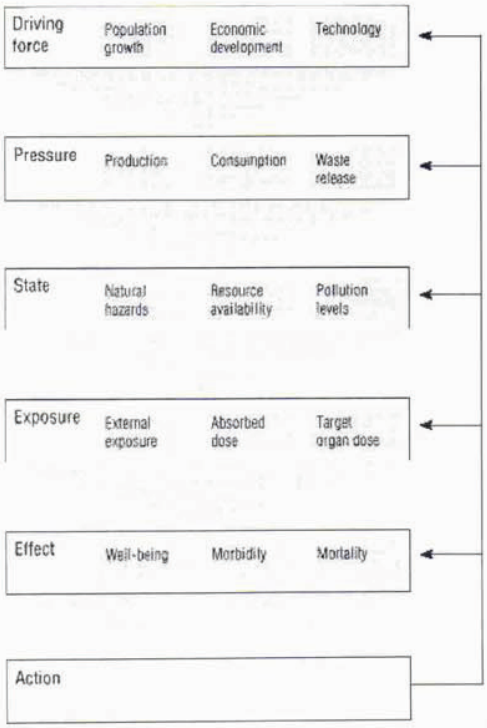

Fig. 2 Health and environment cause-effect framework (2)

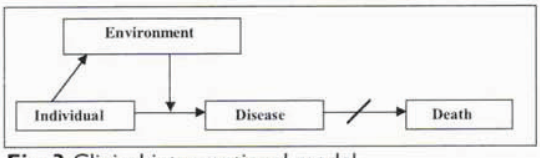

Fig. 3 Clinical interventional model

chemical, biological and social factors in the environ-

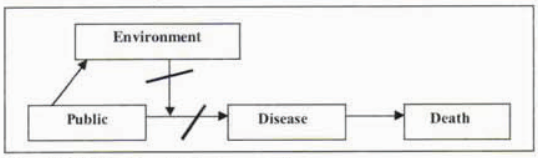

Fig. 4 Public health intervention

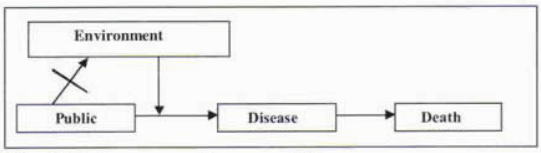

Fig. 5 Environmental stewardship

ment. It also refers to the theory and practice of assessing, correcting, controlling and preventing those factors in the environment that may adversely affect the health of present and future generations. This control according to Moeller (3) is as in Fig. 5.

Environmental stewardship prevents environmental degradation and consequences for human health. The advantages are obvious as it reduces the risk factors in the environment. This control has become essential in developing countries like Malaysia which has undergone stresses on its environment as a result of economic growth, for example, by an increase in waste.

Impedence at source

Waste depositories on land are landfills, surface impoundments, deep well injection, underground disposal and concrete vaults and bunkers (6). Landfilling is still the main method of solid and many hazardous wastes (7). In spite of the use of incinerators the final materials from these still go into landfills (8). This waste disposal practice is a source of pollution and Charbeneau (9) specifies it as being a source of ground water pollution.

The Source-Pathway-Target model in Fig. 6 assesses the toxicological analysis

Optimum intervention and control lies at ensuring that the source does not emanate contaminants. The pathways available are not subject to contamination. Environmental stewardship requires that there is an active involvement in insuring that the source is capped. It does seem paradoxical to have clinical or public health intervention when the source is not controlled. The effective

practice of environmental stewardship for more enhanced intervention and control with erecting impedance between the Source and the Pathway as shown in Fig. 7.

According to Zaman (11) of the 230 official dumping sites in Malaysia the majority are crude landfills with only 10% providing leachate treatment ponds and gas ventilation systems and most have no control mechanisms or supervision. None of the seven landfill sites in the Federal Territory of Kuala Lumpur (FTKL) studied by Md. Mizanur Rahman *et al.* (12) were found to have leachate prevention safeguards.

Impedance involves the proper and safe disposal of waste. Md. Mizanur Rahman *et al.* (12) report that their investigations revealed that the ground waters from three and surface waters along two of the said FTKL were found to be heavily polluted with heavy metals as a result of leachate percolation and surface flow respectively. Therefore, an active involvement in waste disposal like planning of landfills is necessary to ensure that toxicological risks are checked at the point of origin.

Essential impedance measures at source

I) Waste Categorization for Appropriate Disposal

The understanding of the variety of waste is an essential part of the understanding of environmental health and in the establishment of control, for instance, against toxicological repercussions. The refuse that goes into waste are extremely varied. These different types of may be characterized by their hazard potential i.e. the potential to harm life forms and the environment (6). Moeller (3) lists four types of waste as in Table 1.

Three varieties i.e. hazardous, mixed and radioactive above have direct serious implications for the environment and present health risks that requires the question of their proper and safe disposal to be given priority (13). The non-hazardrous waste is also a hazard as it presents an environment for disease vectors to incubate and propagate.

Wastes of different risks need different depositories with different levels of secure environments and suitable localities. For this purpose, the different types of wastes require to be differentiated according to the toxicological risk they present as given in Table 1 above and disposed according to their hazard potential. Locating waste in this way contains health risks spatially preventing the wide dispersal of hazardous material enabling stringently monitoring.

Md. Mizanur Rahman *et al.* (12) state that information on the quantity and type of wastes disposed in almost all the landfills studied in FTKL was not available except

FIG. 6 Source-Pathway-Target Analysis Model [from Holdgate (10)]

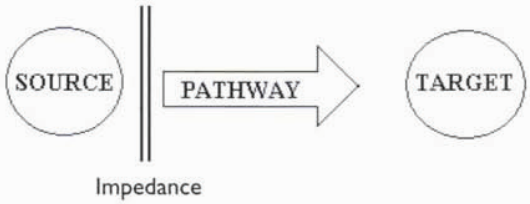

FIG. 7 Source -Pathway Impedance

Table 1. Types of Waste (3)

Type of Waste	Typical Content
Non-hazardous	Refuse, garbage, sludge, municipal trash
Hazardous	Solvents, acids, heavy metals, pesticides, residues, chemical sludges, incineration ash, plating solutions.
Mixed	Radioactive inorganic liquids, Radioactive heavy metals
Radioactive	High and low level radioactive waste and accelerator-produced material.

for the one at Taman Beringin which consisted of mixed waste ranging from household, commercial, building construction and light industries.

II) waste disposal sites

I) selection of suitable physical environment

It needs to be ascertained that waste disposal facilities are sited on secure locations for containment of toxicological effects. The selection of proper disposal sites is very crucial and this involves use of suitable terrain. An awareness of the concerned features of the different varieties subsurface is necessary for those responsible for intervention and control to ensure containment of toxicological effects. The most important factors in the physical environment are the hydrological conductivity and stability of the subsurface. The first is its ability to prevent leakage of contaminants to pollute the groundwater, an important source of water supply. According to rock permeability the subsurface consists of aquifers (capable of transmitting water) ii) aquicludes

(with little or no capacity to do so) and iii) aquitards (that retard water flow) (6). An awareness of the rock permeability is desirable for location of disposal facilities to minimize risk. An example of the lack of consideration of the physical environment is evidenced at the three FTKL landfill site studied whose ground waters were found to be heavily polluted. The regional and local groundwater flow paths in one of them i.e. the Taman Beringin landfill site leach into the Jinjang River (16) which is reported be a pathway for mercury and cadmium (12).

In Peninsular Malaysia, igneous rocks, reportedly suitable repositories due to the lack of permeability (14), constitute almost half the surface area (15) making them ideal for locating waste. The other half of the peninsular is underlain by the two other rock types i.e. sedimentary and metamorphic rocks. Sedimentary rocks are normally aquifers and should be avoided although some like shales may form aquitards and these have reportedly received serious consideration as repositories (14). The suitability of metamorphic rocks was not found reported in literature. Another body of rocks, the Quaternary, basically sedimentary in nature, consisting of unconsolidated to semi-consolidated deposits along the coast and inland valleys (15) in Peninsular Malaysia overlying other rock types are unsuitable due to high porosity. The second factor is the stability of the subsurface. These Quaternary deposits not have the same stability as other rock types as these are unconsolidated. In fact the guidelines for the location of disposal facilities in the United States prohibit disposal facilities on Quaternary rocks like a 100 yr floodplain (6). The same guidelines prohibit disposal within 61 m of an active subsurface structure called a fault (5). It is, therefore, essential for heath authorities to be aware of the physical environment and institute guidelines for locating disposal facilities.

ii) secure waste disposal facilities

The local climatic conditions are a cause of high geochemical activity and potential pollution fluxes due to heavy rainfall placing in a very active geochemical category which results in leaching in the near subsurface. Leachates are a major problem for waste depository sites like landfills (17). The mobilization of contaminants like heavy metals in leachates is potentially hazardous (18). Natural infiltrative process simulations demonstrating the potentiality of leaching (19) would operate on waste depositories producing leachates into surrounding water sources. In addition, biological processes, involving microbiological organisms hazardous to health, decomposing landfill materials turning it into a biochemical reactor (7), find favour in the local climatic conditions.

As mentioned above, none of the landfills in FTKL have been securely engineered by using techniques like lining landfill that impedes seepage. It is, therefore, necessary to ensure that the waste disposal facilities are properly engineered and secured from the environmental conditions that are a natural driving force for health hazards.

iii) evaluation of the cultural environment

Effective environmental stewardship has to investigate the distribution of population centers near proposed disposal sites also. The aforementioned landfill sites in the FTKL are all located in a region with a high population density. A study has shown a raised risk of congenital anomaly in babies whose mothers live close to landfill sites that handle hazardous chemical wastes (20). It is also a common fact that people want their waste to be dealt with but not in their area. This is a strong impediment due to it being a cause of social pressures. These factors may make the sites meeting the physical requirements unavailable.

Another method that has expanded is incineration due to the prohibition of open burning. The other major reasons for the expansion of incineration has been over the concerns over landfills (8) although there is some concern that incineration of waste produces pollutants that may cause more harm to the environment than other forms of waste disposal (21). The combustion of waste materials produces a wide range of pollutants. There is a need to assess the locations of incinerators with respect to population centers.

Collective analysis of the diverse considerations

This location of suitable sites requires a holistic understanding of an area which necessitates the considered of different factors in to form a projection of the impact of selecting a particular site. All these factors will detect the pollution pathways enabling the potential impact assessment through source-pathway-target analysis to be made. In case of an existing problem this could serve as detection tool from the identification of the source of the toxicological risk by reverse analysis taking the target as the starting point.

Therefore, the holistic understanding of an area from a health effect perspective needs a concerted evaluation of the diverse factors. As one form of the vital information is spatial data and the impact analysis also involves spatial analysis the use of spatial information analysis techniques are amenably suitable as their geographic dimension enables the manipulation of spatial data. The geographical information systems (G.I.S.), which incorporate these techniques, also allow data from diverse disciplines to be collected and analyzed. With the use of G.I.S. the spatial data may be conceptualized using one of the approaches mentioned by Quiroga *et al.* (22) i.e. the categorical approach to define specific relationships amongst the different categories each forming a

data layer. This is one solution towards the identification of toxicological sources or selection of secure locations to overcome challenges imposed by, to use a term by Petts (8), 'locally unacceptable land-uses'.

G.I.S. is a very powerful tool that will be invaluable in meeting the serious challenge for locating disposal sites in the future due to the availability of land coupled with a better-informed public which will make the collective analysis of diverse ever more crucial.

It is apparent that waste disposal is a very complex problem involving an array of disciplines like legislation, disposal methods, monitoring, public pressure and risk assessment. Integrated waste management represents the most comprehensive approach to waste management to reduce contamination and pollution of the environmental media.

Environment stewardship needs to be part of the integrated waste management so as to exercise intervention and control to eliminate the hazard at the source. It is imperative that this strategic shift in preventive medicine be made towards an active involvement by leading the planning and regulation of waste disposal management especially to set standards and requirements that satisfy medical requirements as this aspect poses the biggest anxiety from waste.

The importance of impedance measures at source cannot be emphasized enough to prevent portentous environmental hazards. The time is appropriate for the health agencies assume the stewardship by leading the assessment to identify proper and suitable areas for waste disposal for the entire country. The guidelines to assist with different risk level categories of waste would enable preemptive safety and corrective measures to be taken to safeguard the public.

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