4. MITIGATION MEASURES

4.1 Choice of Mitigation Measures

A major aim of environmental health impact assessment is to allow for the introduction of mitigation measures to minimise any adverse health effects which an urban development project may have. Even when a development has potentially serious environmental health effects, its overall benefits may be sufficient for the project to proceed. In this case the introduction of mitigation measures will be essential to ensure the success of the project.

Mitigation measures can be seen as falling into three main categories. These are listed in Table 4.1(a).

Table 4.1(a)
Mitigation Measures for Urban Development

- Mitigation through control of sources (e.g. pollution standards, safety standards).
- Mitigation through control of exposure (e.g. planning requirements, public health measures).
- Mitigation through health service development (e.g. health education, provision of medical services).

Choice of mitigation measures will depend on a number of factors, and mitigation measures must be designed to fit local circumstances. Factors to consider include:

- the exact nature of the urban development project concerned, mitigation measures may be specific to certain types of project;
- the stage of development of the project, certain measures are only feasible at particular stages (e.g. before final plans are drawn up, or before construction begins);
- local climate and physical conditions (e.g. topography, hydrology);
- the types of environmental health factors identified as important;
- the aims of the project, mitigation measures should allow project aims to be achieved within an acceptable time-period;
- local social, cultural, organisational and political factors; these may greatly affect the feasibility of certain types of mitigation measures.

Below we discuss potential mitigation measures for health effects of urban development projects under the following headings:

- o Mitigation through Control of Sources (4.2);
- o Mitigation through Control of Exposure (1): Planning Measures (4.3);
- o Mitigation through Control of Exposure (2): Public Health Measures (4.4);
- o Mitigation through Health Service Development (4.5).

4.2 Mitigation through Control of Sources

4.2.1 What Measures are Available to Control Sources?

Mitigation measures to control sources act by preventing or limiting introduction into the environment of factors harmful to health. The main way in which such control is achieved is through the use of **environmental health standards.**

Environmental health standards (or quality standards) are acceptable or permissible limits established to protect a defined population from the undesirable effects of exposure to one or several environmental health factors. Such limits may be set for:

- o pollutants taken up by an organism or a population (e.g. acceptable daily intakes (ADI) of toxic substances);
- o pollutants present in specified environmental media (e.g. air, water) or in products (e.g. food);
- o discharges or emissions from pollution sources (e.g. effluent standards, air emission standards, noise standards).

In the past, such standards have often been based on limited knowledge of dose-response relationships. As we noted in Section 3.2, health criteria based on epidemiological and toxicological studies have now been prepared by many different organisations which can be used in the development of environmental health standards. Table 4.2(a) indicates the types of standards which have been developed for different sources giving rise to environmental health factors.

In order to achieve compliance with standards, it may be necessary for developers to take a whole range of measures such as:

- o changing a proposed manufacturing process to produce less pollution;
- o fitting pollutant removal equipment to discharge sources;

Table 4.2(a)

Types of Environmental Health Standards for Control of Sources

1. Air Pollution Control

- **Air quality standards** are based directly on air quality criteria (see 3.2). In addition to the effects of pollution, other considerations have to be taken into account in drawing up standards, such as the existing level of pollution in a region, available technology and other local factors. Thus stricter control of sources may be required in areas where existing air quality is poor.

- **Emission standards** are limits placed on the amount or concentration of pollutants emitted from a source. Standards are most commonly given in terms of the concentration of a substance in a given volume of gas emitted, but may also be given in terms of the opacity of smoke (which may be assessed by subjective means), or a quantity of pollutant emitted per unit of time. Emission standards have been adopted for mobile sources (vehicle exhausts) as well as stationary sources (e.g. industry and domestic stacks).

- **The best practicable means** approach is based on the principle that pollution should be reduced to the greatest extent possible consistent with the methods available in practice, but that the cost of doing so should not be excessive. Application of this approach requires case-by-case consideration of what is practicable for each source, taking into account the effects of pollution and the costs involved. The **best available technology** approach, by contrast, requires that the most efficient methods available should be used to reduce pollution, without regard to their costs.

- **Alert levels** are a particular type of short-term standard. When ambient pollutant concentrations reach these levels, which can be potentially harmful to health, specific action procedures are set in motion. These may include shut-down of factories, restriction of vehicle use, and warnings to people to remain indoors.

- **Fuel standards** are also used in certain countries to control air pollution. They usually take the form of limits on the maximum sulphur and lead contents of fuels to limit the generation of pollutants.

2. Water Pollution Control

- **Water quality standards** have been developed which relate either to different types of water body (e.g. rivers, estuaries, coastal waters) or to the use which is made of the water (e.g. for drinking, bathing, fishing, recreation).

Continued

Table 4.2(a) (Continued)
Types of Environmental Health Standards for Control of Sources

Standards may specify the maximum permissible concentrations of undesirable or harmful substances, and often, some form of classification of the water body. Such classifications indicate the quality of the water body and may be based on a variety of factors including temperature, pH, dissolved oxygen, coliform bacteria content, visual and other characteristics.

- o **Effluent standards** govern the characteristics of effluents discharged into water bodies. These standards depend on the number of pollution sources and on the capacity of a water body to purify itself after introduction of effluent. Generally they must be set separately for each defined water body.

- o **The best practicable means** approach, described above in relation to air pollution, may also be applied to water pollution control.

3. Occupational Exposure

- o **Threshold limit values** are based on the assumption that for each toxic substance there exists a definable and measurable level of human exposure, above zero, below which there is no significant threat to human health. They may be derived either by working downwards from demonstrably harmful levels to a level just below that at which effects cease, or by working up gradually from the assumed 'normal level' using highly sensitive response measures to a level just below that at which effects are first identified.

- o **Biological limit values** are based on the assumption that there are maximum levels of toxic substances within the human body above which harm to health may occur. Medical examinations determine the level of substances in human organs (e.g. blood, urine), and workers with levels above the limit may be removed to other work or given medical treatment.

4. Other Standards

Standards also exist which:

- place limits on the permissible quantities of harmful substances or micro-organisms in food, cosmetics and other consumer goods;

- give safety criteria for machinery and equipment, requiring testing and approval;

- lay down 'Codes of Practice' for safe operation of industry, landfill sites and other activities which are potentially dangerous to health.

- reducing the number of discharge points (e.g. through use of district heat generation rather than individual heating in homes);
- changing fuel types.

As these measures may give rise to major cost and design changes, it is important that any standards relevant to a development are introduced in the appropriate manner and time.

4.2.2 When and How Should Environmental Health Standards be Used?

When standards are adopted the technological feasibility and financial implications of their application must be taken into account. In particular, considerable difficulties may be experienced in applying new standards to existing sources. This may prove technically impossible or prohibitively costly. Applying new standards to new developments is generally easier, as appropriate controls may be "built in" at the design stage.

In general terms, a country will select the standards it can best afford in terms of their costs (direct financial outlay, higher prices of consumer goods, use of skilled manpower, etc.) and their benefits to health. With time, and as the country develops, the balance between costs and benefits changes and stricter standards may be introduced.

The use of environmental health standards is usually not linked to a single urban development project but is part of an on-going governmental policy. Nevertheless, the possibilities for change brought about by major developments may enhance the possibility of introducing new standards.

Environmental health standards may remain advisory or, as noted in Section 3.2, they may be incorporated into local or national law. Even where they do not have legal force, governments may introduce clauses into development contracts or planning controls requiring adherence to certain standards. In either case there will be a need for enforcement of the standards by an appropriate agency. The enforcement of environmental standards may require high levels of skilled manpower to undertake monitoring and inspection, and may therefore prove costly. For this reason certain countries have investigated increased use of self-regulation by polluters.

The different types of standards listed in Table 4.2(a) have different enforcement requirements. The availability of skilled manpower for enforcement should be a decision criterion when the introduction of standards into law is being considered.

4.3 Mitigation through Control of Exposure (1): Planning Measures

4.3.1 What Planning Measures are Available?

A major tool available in urban development for the mitigation of potentially harmful health effects is the restriction of contact between residents and sources of environmental health factors through physical separation.

Many environmental health factors, such as certain types of air and water pollution, and accident sources, are active only over a limited distance. By placing sources further away from people than this distance, or vice versa, health effects can be limited.

By enlarging the scope of urban development planning to cover health effects, and by establishing procedures for consultation between planners and health experts, urban developments can be made intrinsically "more healthy".

In Table 4.3(a) we list health criteria for development planning produced by the World Health Organisation. In addition, the following points may be made:

- as noted in Section 2, both disease transmission and mental health effects have been linked with high-rise buildings;
- however, low density building may also entail penalties in terms of more costly service provision, greater use of private vehicles, longer travel distances, etc.;
- in general terms, "... low rise, high density development in limited areas, providing easy access to open countryside and a high standard of environmental hygiene will obviously give the best possible chances"(1) of improved health.

4.3.2 When and How May Planning Measures be Used?

Obviously, to be effective, planning measures to promote environmental health must be incorporated into the earliest stages of urban development design. This may be facilitated both by specific training programmes in environmental health for planning personnel (see 4.5), or by the introduction of legal minimum standards for development.

Planning measures are also useful in the context of existing urban developments, for example in ensuring that new residential development is located away from existing sources of pollution or hazard. As noted above, failure to carry out these measures has often resulted in enhanced risk levels around existing hazardous plant.

One particular problem which has arisen in practice with the use of planning measures, particularly in developing countries, is the lack of availability and the high cost of land in locations suitable for housing development. This leads to housing being built in close proximity to sources of environmental health hazards. Various methods have been used to overcome this problem, including reallocation of land through land reform measures, and taxation of unused building land to encourage its release.

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(1) MARTIN, A.E. and OFTER, D.; "Environmental Health Aspects of Human Settlements". Copenhagen: WHO Regional Office for Europe, 1978.

Table 4.3(a)

Health Criteria for Development Planning Produced by the World Health Organisation

1. General Allocation of Land

i. Before allocating land for defined uses, consideration should be given to the meteorological, and biological characteristics of the urban area as a whole and to its segments.

ii. Meteorological conditions should be such as to minimise potential problems of air pollution, particularly in residential areas.

iii. The time spent in travelling from residential areas to places of employment and of rest and recreation should be as brief as possible. Distance is not necessarily the only factor, the mode of transportation is also important.

iv. All built-up areas - residential, industrial, commercial and public - should be provided with a continuous supply of potable and palatable water under pressure, without undue expenditure of financial resources.

v. It is essential to provide for the efficient and effective collection, removal and treatment, as necessary, of all liquid wastes, including storm water drainage, and of all solid wastes.

vi. Built-up areas, particularly residential areas, should not be subject to flooding, even at infrequent intervals.

vii. Residential areas should be relatively free from insects and rodents that may be vectors or reservoirs of human disease or that may interfere with the attainment of physical and social well-being.

viii. The arrangement of land use should permit the development and maintenance of meaningful social relationships, free from undesirable isolation or segregation.

2. Residential Areas

i. People should be considered by urban planners not only as residents of large cities, but also as members of communities, neighbourhoods and networks within those urban areas.

ii. Such communities should be planned or maintained as residential units with recognisable spatial limits, so that people can identify themselves with their locality.

iii. The residential clusters - neighbourhoods, districts, sub-communities - should have easy communal contact routes within and between them.

Table 4.3(a) (Continued)

Health Criteria for Development Planning Produced by the World Health Organisation

iv. A range of facilities - schools, stores and buildings for recreational and assembly purposes - should be provided to encourage the development of interacting community units.

v. Through traffic should, as far as possible, be kept from straining or severing community interactions and relationships.

In addition to the above-listed criteria, provision should be made for safe and easily identifiable access to units in a residential neighbourhood and for a balance between the opportunities for privacy and for community interaction of the individual and the family within the residential environment.

3. Industrial Areas

i. Grouping together of compatible enterprises in industrial districts or "industrial parks" for the common use of roads and transport systems, sources of power, heat and water, and treatment of industrial wastes.

ii. Placement of industries that are compatible with residential land use as close as practicable to the housing of workers so as to minimise the length of time spent in travelling to and from work.

iii. Use of buffer strips or "sanitary protection zones" between residential areas and those industries that may discharge or emit into the environment smoke, dust, odour or noise.

iv. Provision of linkages and means of transportation between industrial, commercial and residential areas for the efficient movement of workers to and from work.

The following criteria are considered to have special application to industrial site planning:

i. Industrial sites should be provided with facilities, devices and means, to collect, remove and treat all liquid and solid waste material generated by the industrial operations in a manner that will not adversely affect the health and well-being of the people or cause adverse or undesirable changes in the environment.

ii. The siting of industries that may discharge smoke, dust, odour or other air pollutants into the environment should be based on meteorological and microclimatic considerations to prevent the creation of unhealthy or unaesthetic conditions.

Table 4.3(a) (Continued)

Health Criteria for Development Planning Produced by the World Health Organisation

iii. Industries that emit objectionable noise should be sited in locations where they will not cause undue disturbance.

iv. Industrial sites should be provided with an adequate water supply system, power system and other services and utilities as required by the industrial establishments.

v. Industries that have elements of risk to their operation, e.g. the manufacture of explosives, or utilisation of hazardous, toxic or radioactive materials, should be sited in such places and in such a manner as to minimise the hazards to residents of the urban area and to other industrial enterprises, and to reduce the possibility of causing undesirable environmental changes.

vi. Industrial sites should be provided with an adequate network of roads, transportation facilities, etc., to permit the efficient movement of workers to and from work without undue loss of time.

4. Transportation

i. Urban transportation should be planned to provide safe, easy and efficient routes of travel and convenient means of communication. Consideration should be given to ways and means of reducing the time spent by persons or groups in their daily movements between their homes and their places of work, rest and recreation, the urban centre, and public establishments.

ii. The planning of urban transportation systems and facilities should be comprehensive in scope and include all applicable modes of transport, both public and private.

iii. The transportation system should be planned to serve the urban area and should not impair the basic community structure.

iv. Major highways or roads that carry a large volume of vehicular traffic should not be planned to pass through a residential neighbourhood and should not be located immediately adjacent to a residential area without the provision of a buffer strip or protective zone to reduce the hazards to residents of accident, noise and air pollution.

4.4 Mitigation through Control of Exposure (2): Public Health Measures

4.4.1 What Public Health Measures are Available?

Table 4.4(a) lists basic public health measures which may be taken to improve hygiene and thus reduce exposure to agents of ill-health.

Table 4.4(a)
Basic Public Health Measures

- Clean water supply
- Waste water disposal
- Collection and disposal of household refuse
- Control of vectors and rodents
- Food hygiene requirements

All these factors have a significant bearing on protection against communicable diseases, and also concern fundamental aspects of human life.

Source: World Health Organisation; "Health Aspects of Urban Development". Report on a seminar convened by WHO Regional Office for Europe, Stuttgart, 1973.

Provision of a **safe water supply** and **disposal of waste waters**, especially those which are contaminated with diseases of faecal origin, is a vital goal for all urban development projects. A survey by the World Health Organisation in 1975 indicated that 75% of urban dwellers did not have sewerage systems, while 25% had no system of any kind for excreta disposal.

As part of the International Drinking Water Supply and Sanitation Decade the World Bank have published a series of studies and guidelines on "Appropriate Technology for Water Supply and Sanitation". The guidelines give suggestions concerning:

- water source selection and use allocation;
- water treatment and disinfection;
- water distribution;
- household sanitary installations;
- sewerage and other collection systems;
- sewage treatment and re-use.

The publications in this World Bank Series are listed in the bibliography. Figure 4.4(b) summarises levels of pathogen removal achieved by different sewage treatment processes.

Controlled **collection and disposal of solid wastes** can also play an important role in limiting exposure to environmental health factors. The insanitary collection and disposal of wastes creates hazards both as a direct source of pollution and by encouraging breeding of disease vectors (flies, mosquitos, rodents, etc.). Appropriate control measures are provided by the rapid removal of refuse from premises by an efficient collection system and the proper processing of refuse before final disposal or re-use. The system comprises three aspects:

- waste collection by specially designed or modified vehicles, perhaps incorporating the use of temporary storage receptacles and transfer stations for changing from one method of transport to another;
- facilities for the processing of waste, possibly using segregation of refuse components, composting, pulverisation, compaction, incineration;
- facilities for the sanitary discharge of residues into the environment, for example sanitary landfill, controlled discharge into bodies of water, and discharge into the air of combustion gases and particulate matter.

There are numerous alternatives for the handling and disposal of solid wastes with a wide range of associated cost and other requirements, so that appropriate techniques may be selected based on local conditions. Often the most difficult problem is that of disposal, with the number of potential sites limited and, because of their potential nuisance value, controversial. In view of this, and the loss of resources involved in disposal, recycling and re-use of wastes is receiving increasing consideration.

Vector control under current public health practice is chiefly concerned with insects and rodents. The WHO Expert Committee on Vector Biology and Control has classified environmental mitigation measures into three major groups:

- environmental modification: large-scale alterations to the form of the environment such as clearance of vegetation, drainage and de-watering of land before an urban development project is implemented;
- environmental manipulation: smaller-scale control of the environment during the operational phase using physical, chemical and biological methods;
- modification or manipulation of human behaviour or habitats to reduce man-vector contact.

Where chemical control methods are used (i.e. application of pesticides) care must be taken that the chemicals involved do not in themselves give rise to adverse health effects.

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Table 4.4(b)

Summary of Pathogen Removal by Various Sewage Treatment Processes

Organism	Parameters	Primary Sedimentation	Trickling filter with primary and secondary sedimentation, sludge digestion, and sludge drying	Activated sludge with primary and secondary sedimentation, digestion, and sludge drying	Oxidation ditch with sedimentation and sludge drying	Waste stabilization ponds 3 cells. Minimum total retention time - 25 days	Septic tanks	Effluent discharged to fresh water	Effluent discharged to sea	Unheated anaerobic digestion	Thermophilic digestion or composting	Agricultural application	Composting toilets (three or more months retention)
Enteric viruses	Typical inflow	$10^3 - 10^5$/l	$10^3 - 10^5$/l	$10^3 - 10^5$/l	$10^3 - 10^5$/l	$10^3 - 10^5$/l	$0 - 10^9$/l	May survive for several weeks	May survive for several weeks	May survive for over three months	Killed rapidly at 60°C	May survive up to five months on soil	Probably eliminated
	Typical outflow	$10^3 - 10^5$/l	$10^2 - 10^4$/l	$10 - 10^4$/l	$10 - 10^4$/l	0 - 10/l	$0 - 10^8$/l						
	Percent removal	0 - 30%	90 - 95%	90 - 99%	90 - 99%	99.99 - 100%	50%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated		Contaminated						
Salmonellae	Typical inflow	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$0 - 10^9$/l	May survive for several weeks	May survive for a few weeks	May survive for several weeks	Killed in twenty hours at 60°C	On soil, S. typhi may survive up to three months and other species for up to 1 year	A few non typhoid species may survive
	Typical outflow	$10^2 - 10^3$/l	$10^2 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	0 - 1/l	$0 - 10^8$/l						
	Percent removal	50 - 90%	90 - 95%	90 - 99%	90 - 99%	99.99 - 100%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated		Contaminated						
Shigellae	Typical inflow	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$10^3 - 10^4$/l	$0 - 10^9$/l	May survive for several weeks	Unlikely to survive for more than forty days	Unlikely to survive for more than a few days	Killed in one hour at 55°C or in ten days at 40°C	May survive for up to three months	Probably eliminated
	Typical outflow	$10^2 - 10^3$/l	$10^2 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	0 - 1/l	$0 - 10^8$/l						
	Percent removal	50 - 90%	90 - 95%	90 - 99%	90 - 99%	99.99 - 100%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated		Contaminated						
E. coli	Typical inflow	$10^6 - 10^8$/l	$10^6 - 10^8$/l	$10^6 - 10^8$/l	$10^6 - 10^8$/l	$10^6 - 10^8$/l	$10^7 - 10^9$/l	May survive for several weeks	May survive for a few weeks	May survive for several weeks	Rapidly killed above 60°C	May survive for several months	Probably eliminated
	Typical outflow	$10^5 - 10^7$/l	$10^5 - 10^7$/l	$10^4 - 10^7$/l	$10^4 - 10^7$/l	$10 - 10^4$/l	$10^6 - 10^8$/l						
	Percent removal	50 - 90%	90 - 95%	90 - 99%	90 - 99%	99.99 - 99.9999%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated		Contaminated						
Cholera vibrio	Typical inflow	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$0 - 10^9$/l	May survive for several weeks	Unlikely to survive for more than eleven days	May survive for one or two weeks	Killed rapidly above 55°C	Unlikely to survive more than one week	Probably eliminated
	Typical outflow	$1 - 10^2$/l	$1 - 10^2$/l	$0.1 - 10^2$/l	$0.1 - 10^2$/l	0/l	$0 - 10^8$/l						
	Percent removal	50 - 90%	90 - 95%	90 - 99%	90 - 99%	100%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated		Contaminated						
Leptospires	Typical inflow	Very few	Very few	Very few	Very few	Very few	Very few	May survive for several weeks	Survive for not more than twenty hours	Survive for not more than two days	Killed in ten minutes at 50°C	Survive for up to fifteen days on soil	Eliminated
	Typical outflow	Very few	Very few	Very few	Very few	0/l	0/l ?						
	Percent removal	0%	0%	0% ?	0%	100% ?	100%						
	Final sludge	Safe	Safe	Safe	Safe	—	Safe						
Entamoeba histolytica cysts	Typical inflow	$10 - 10^4$/l	$10 - 10^4$/l	$10 - 10^4$/l	$10 - 10^4$/l	$10 - 10^4$/l	$0 - 10^5$/l	May survive for three weeks	May survive for three weeks	May survive for three weeks	Killed in five minutes at 50°C and in one day at 40°C	May survive for one week if kept damp	Eliminated
	Typical outflow	$5 - 10^4$/l	$5 - 10^3$/l	$5 - 10^3$/l	$5 - 10^3$/l	0/l	$0 - 10^5$/l						
	Percent removal	10 - 50%	50% ?	50% ?	50% ?	100%	0% ?						
	Final sludge	Contaminated	Safe	Safe	Safe	—	Contaminated						
Hookworm ova	Typical inflow	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$0 - 10^4$/l	May survive for several weeks	?	Ova will survive	Killed in five minutes at 50°C and in one hour at 45°C	May survive on soil for twenty weeks under ideal conditions	May survive
	Typical outflow	$10 - 10^2$/l	$10 - 10^2$/l	$10 - 10^2$/l	$10 - 10^2$/l	0/l	$0 - 10^3$/l						
	Percent removal	50%	50 - 90%	50 - 90%	50 - 90%	100%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated	—	Contaminated						
Ascaris ova	Typical inflow	10 - 10/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$10 - 10^3$/l	$0 - 10^4$/l	May survive for many months	May survive for many months	Ova will survive for many months	Killed in two hours at 55°C or twenty hours at 60°C and 20[illegible] hours at 45°C	May survive on soil for several years	Survive well
	Typical outflow	1 - 10/l	$0 - 10^2$/l	$0 - 10^2$/l	$0 - 10^2$/l	0/l	$0 - 10^3$/l						
	Percent removal	30 - 80%	70 - 100%	70 - 100%	70 - 100%	100%	50 - 9%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated	—	Contaminated						
Schistosoma ova	Typical inflow	1 - 100/l	1 - 100/l	1 - 100/l	1 - 100/l	1 - 100/l	1 - 100/l	Ova will hatch and miracidia must find snail	Ova or miracidia will die	Ova may survive up to one month	Killed in one hour at 50°C	May survive up to one month if kept damp	Eliminated
	Typical outflow	1 - 10/l	1 - 10/l	1 - 10/l	1 - 10/l	0/l	1 - 10/l						
	Percent removal	80%	50 - 9%	50 - 90%	50 - 99%	100%	50 - 90%						
	Final sludge	Contaminated	Safe	Safe	Safe	—	Contaminated						
Taenia ova	Typical inflow	1 - 100/l	1 - 100/l	1 - 100/l	1 - 100/l	1 - 100/l	$0 - 10^3$/l	Will survive for several weeks	Will survive for several weeks	Ova will survive for a few months	Killed in ten minutes at 55°C and in over four hours at 45°C	May survive on soil for over a year with sufficient moisture	May survive
	Typical outflow	0.1 - 50/l	0.1 - 50/l	0.1 - 50/l	0.5 - 50/l	0/l	0 - 500/l						
	Percent removal	50 - 90%	60 - 96%	50 - 96%	50% ?	100%	50 - 90%						
	Final sludge	Contaminated	Contaminated	Contaminated	Contaminated	—	Contaminated						

Source: FEACHEM, R.G. [illegible]

Mitigation through **food hygiene** measures may include:

- o protection of food from insects and vermin;
- o employment of food handlers who are clean in their habits and free from infection;
- o storage of food at temperatures inhibiting infection;
- o cleansing and sterilisation of food preparation equipment and utensils;
- o provision of proper sanitary facilities in all locations connected with food preparation;
- o continuous inspection and enforcement of food sanitation regulations and standards.

4.4.2 When and How Can Public Health Measures be Used?

The timing of introduction of different public health measures varies:

- o water supply and waste water disposal infrastructure should be incorporated into the planning phase of any urban development;
- o also at the planning stage consideration should be given to the effect of layout on ease of refuse collection, and to the location of transfer stations, treatment and disposal sites;
- o detailed systems for refuse collection and disposal must be drawn up during implementation of a development;
- o however, both refuse collection/disposal systems and installation of sanitary fittings can be improved during the lifetime of a development;
- o some aspects of food hygiene control, such as design of markets, and slaughterhouse facilities, should be considered during the planning phase; other measures may only be introduced following implementation of the development.

A major consideration in introducing any public health measures is the behavioural characteristics and preferences of the intended inhabitants of a development as well as prevailing institutional factors. In particular, the level of use of personal hygiene facilities (including sanitary fitments and water supplies) will depend upon the demands made on the user and the values and understandings associated with health and sanitation. For example, people may be unwilling to use new latrines for either mundane reasons (inadequate door catches) or profound cultural reasons (inadvertent and inappropriate orientation towards Mecca). Factors important in the introduction of public health measures include:

- o cost; in-house facilities (e.g. dustbins, sanitary facilities) must be affordable to residents;
- o convenience; e.g. location of latrines, refuse collection points, water supplies and their availability at appropriate times of the day;
- o comfort and easy availability of facilities (e.g. provision of personal washing facilities in latrines);
- o administration; the success of public health measures depends largely upon the capacity of responsible authorities to promote, control and service them.

Only by taking such factors into account in designing public health measures is it possible to ensure their widespread and correct use and functioning, without which the measures will not achieve their desired effect.

4.5 Mitigation through Health Service Development

4.5.1 What Health Service Development Measures are Available?

There are a number of ways in which health service development may mitigate the impacts of environmental health factors on human health. Some of these are summarised in Table 4.5(a).

Table 4.5(a)

Health Service Tasks Relating to Mitigation of Environmental Health Effects

- o Development of health education programmes at all levels.
- o Assessment of socio-economic data as a source of indicators of urban health.
- o Identification of special high-risk groups.
- o Promotion, monitoring and evaluation of preventive medical studies.
- o Monitoring of environmental health factors.

A major task of health service development lies in the field of education. The groups requiring education in environmental health measures are wide, and an education programme may incorporate any of the following:

- o basic environmental health training of environment and planning professionals;

- o instruction of operatives (technicians, disposal workers etc.) on the importance of their role in the public health system;
- o basic health education of school children;
- o education of parents on home hygiene measures;
- o general publicity campaigns on the importance and use of sanitary facilities;
- o instruction of workers in the use of safe working methods;
- o training of health care workers in the recognition and treatment of environment-related diseases.

Health services also have a crucial role to play in **monitoring** both the incidence of environment-related disease and the effectiveness of mitigation measures. In this way early warning can be provided of potential health problems and the choice of effective mitigation measures aided.

4.5.2 When and How Can Health Service Measures be Used?

Such health service measures are an on-going requirement, necessitating the development of an effective health service from the earliest stages of an urban development project. Provision of an adequate health service should be included within development plans, and health officials should be able to consult with planners throughout design of the development.

As with other mitigation measures, health service measures should be designed with the local social and organisational conditions in mind. Arrangements for training and education should be geared to the requirements, general state of knowledge and social standards of those at whom it is aimed. (It may, for example, be necessary to hold separate classes for men and women). Monitoring programmes may have to be geared to limited facilities for collection of socio-economic and environmental data.

The World Health Organisation has outlined the following roles for a community health service, geared to improving the health of the whole community rather than simply treating each case of ill-health individually as it arises:

- o to identify the health care needs of the population;
- o to measure the extent to which these needs are being met;
- o to co-ordinate the development of health care objectives and plans to meet them;
- o to co-ordinate the preventive health services and the promotion of health education;

- to provide medical advice to, and liaison with, the responsible medical authorities on all relevant matters, including health education and social work services, communicable diseases and environmental control;

- to co-operate with the bodies responsible for postgraduate medical education;

- to develop relationships with universities and other research and teaching institutions.

5. ORGANISATION AND PRESENTATION OF INFORMATION FOR THE DECISION MAKER

5.1 The Context of EHIA

Environmental Health Impact Assessment may be carried out in a number of different organisational contexts. The original intention of WHO was that it should provide an enhanced form of environmental impact assessment, EIA, by which proposed projects are appraised in terms of their potential impact on man and the natural environment. In EIA, decision-makers (usually government agencies) are faced with a number of options for achieving a particular aim - usually a development of a particular type. In these circumstances an EHIA forms one input into a decision making process in which a choice is made between:

- implementing the project as proposed;
- designing measures into the proposals to prevent or minimise undesirable effects (mitigating measures);
- choosing an alternative development to achieve the same basic objectives with less impact on the environment;
- or abandoning the project altogether.

In practice however, EHIA rarely takes place in such circumstances. For urban development in particular the choice between alternatives is usually less clear cut, the development eventually carried out may be a compromise between a number of options, each with certain advantages and disadvantages. In many circumstances there are no alternatives except to proceed (with or without mitigation measures) or to abandon the project. In the case of urban development projects, abandoning the project in total is unlikely to be acceptable on the basis of environment or health effects alone.

In practice therefore the aim of EHIA is to provide the decision maker with the best possible information on the environmental health effects of the proposed urban development project - and on the possibilities for mitigation of the effects identified. The decision maker will then weigh the beneficial and adverse effects of the project against each other and against the other costs and benefits of development, in taking his final decision on whether to allow the project to proceed and in what form.

A number of guidelines and methodologies have been developed to advise on the decision-making stage in the context of a general Environmental Impact Assessment (EIA). Although most are related to the standard EIA procedure, their general methodologies have a wider relevance. The guidelines recommend a number of more or less complex procedures, but in general the recommended approach requires an EIA study team:

- to present information about all the impacts of different ways of carrying out the development (including the use of mitigation measures);

- to identify those impacts which are crucial to the decision;
- to illustrate how the decision might be affected by different judgements about the relative importance of impacts.

This is therefore a process of organising and presenting the results of the assessment in a way which is most useful to the decision maker.

The aim of this approach is not to identify how the development should proceed, but to enable the decision maker to make the best informed decision taking into account all the relevant issues.

5.2 Presentation of Information on Impacts of Alternatives

Although, as noted above, EHIA's may often be carried out in circumstances where the "alternatives" of EIA's are not available, there is rarely only one way in which an urban development may be carried out. Different phasing of development or the use of mitigation measures may have crucial impacts on health effects, and this should be indicated to the decision-maker.

Information on the impacts associated with alternatives can often be most effectively presented in a matrix format. A simple form covering environmental health effects is shown in Table 5.2(a).

Table 5.2(a)

A Matrix of Impacts vs. Alternatives

Environmental health impacts	Alternatives			
	I	II	III	Comments
Water Pollution				
Air Pollution				
Noise Pollution				
Soil Pollution				
Transport accidents				
Major hazards				
Disease transmission				
Etc.				

The alternatives forming the horizontal axis may relate among other things to:

- o different development approaches, e.g. one large urban area versus several smaller developments;
- o different timing for stages in the development;
- o different development locations;
- o different processes and working methods;
- o different methods of mitigation;

and should always include the alternative of "no action" ie. of not proceeding with the development.

The impact categories forming the vertical axis will include all the potential effects identified in the first stage of the assessment (see Section 2).

The information presented within this first matrix will be the results of the prediction stage (see Section 3), covering the potential health impacts, the number of people affected, whether impacts are short or long term etc. This standard matrix format is a useful one even where only two alternatives (with and without mitigation methods) are being used. It provides a clear format for information presentation and ensures that health effects identified are not overlooked.

In presenting this information several key points should be remembered:

- o the matrix should include as much real information as possible about the nature, size and significance of effects;
- o cross-references should be given to the text of the report for further information about the effects and the methods used to predict them; where experts are asked to advise on prediction of impacts they should be identified and their conclusions explained and justified; where predictive models or other methods are used, the methods should be described and their likely reliability assessed;
- o information on effects should be presented in a way which is understandable to the non-expert reader; technical matters should as far as possible be translated into everyday terms;
- o where there is uncertainty or no information this should be clearly indicated.

A checklist of the items that should be covered in the matrix is given in Table 5.2(b).

Table 5.2(b)
A Checklist for Information on Effects

The Nature and Extent of Effects

- Magnitude
- Frequency and duration - short or long term, continuous or intermittent, increasing or decreasing with time, accidental or hazardous
- Geographical extent - local, regional, national, global
- The groups and interests in the community who are affected (including economic interests, minority groups, recreation, conservation, etc.)
- The reversibility or irreversibility of the affects. Can the effects be mitigated?
- Whether the effect involves committment of non-renewable resources
- Whether the effect involves establishing a precedent for future activities which cumulatively may have a much greater effect in the long term

Significance

- The importance or uniqueness of the affected environment or the people or interests affected
- The controversiality of the effect
- Whether the effect violates any legal standards or policy objectives for environmental protection (e.g. air quality standards, "no deterioration" objectives, etc.)
- Whether the effect threatens endangered or protected species or habitats, or protected sites (historic, cultural, archaeological, scientific)

If there are many different alternatives and impact categories to be presented in the matrix it may be useful at this stage to further summarise the information. This can be done by ranking, scoring or rating (see Table 5.2(c)) but ranking and scoring are not recommended for use at this stage for the reasons given in the table, and in general terms their use in environmental health impact assessment is controversial.

5.3 Identifying Crucial Impacts

The next stage in organisation and presentation of information involves identifying the key impacts which will affect the decision whether and how to proceed with the development.

A "key issues" matrix can be developed which excludes certain development alternatives and impact categories from further consideration:

- firstly any alternatives for action where impacts fail to meet accepted environmental health standards or where the alternatives are considered to be unacceptable for some other reason may be excluded;
- secondly, any impact categories where none of the alternatives have any significant effect may be excluded.

In the rating example shown in Table 5.2(c) it might be possible to exclude Alternative III because of its severe impact in Category C, and to exclude Impact Category D because all alternatives have low or very low impact (see Table 5.2(d)).

Table 5.2(c)
Ranking, Scoring and Rating

Ranking

In ranking the alternatives are ordered in terms of preference with regard to each Effect Category, as shown below:

RANKING OF ALTERNATIVES			
Impacts	Alternatives		
	I	II	III
A	1st	2nd	3rd
B	1st	2nd	3rd
C	2nd	1st	3rd
D	2nd	3rd	1st

As a means of summarising information ranking presents one major problem, that is:

o **loss of information.**

Ranking provides no information about the absolute or relative importance of impacts. The reader has no information about how good or bad the preferred alternative is or about the differences between the first, second and third alternatives. An initial reading of the example above might suggest that Alternative I is best overall; but if all three alternatives have major adverse effects in categories A and B and I is only slightly less bad than II and III, whilst alternative II is much better than I or II in category C, this might lead to II being identified as the preferred alternative.

This conclusion cannot be reached on the basis of the information provided by ranking.

The use of ranking is not therefore recommended.

Scoring

In scoring a numerical scale is set up for each Impact Category (e.g. 1-10, 1-100, ...). Alternatives are then scored according to their relative or absolute impact in each category. An example is shown below:

SCORING OF ALTERNATIVES				
Impacts	Alternatives			
	I	II	III	Scale
A	0		5	0-10
B	1	2	3	0-5
C	8	5	10	0-10
D	17	20	11	0-100

Scoring systems can be used to arrive at the "preferred alternative" by weighting the scores for each Impact Category and adding the weighted scores to give a total for each alternative.

There are four basic problems inherent in this approach:

o like ranking, scoring results in loss of information for the decision maker who is provided with information about the relative effects of alternatives but not about their absolute effects. The decision maker needs real information about the magnitude and significance of effects in order to make judgements about the environmental and other costs and benefits of the proposed activity;

o scoring systems need accurate and detailed information about the effects of alternatives. Often this is not available in EIA because of lack of resources and/or knowledge. Any uncertainties or assumptions involved in providing the data necessary to define scores will be disguised in apparently precise numbers;

o the outcome of scoring and weighting is very dependent on the definition of Impact Categories. If, for example, several different categories were defined for health effects, this might lead to a greater emphasis on health in the final result than if only one health category was defined. This problem of Impact Category definition applies in all attempts to summarise EIA findings, but particularly in approaches involving numerical analysis;

o the selection of appropriate weights to represent the combination of interests in the affected community can be very difficult, particularly as it can involve political judgements about the importance of different interests. If the EIA study team or any other selected group of people are used to define weights, their conclusions and therefore the "preferred alternative" will depend on their particular attitudes and interests.

The use of scoring, and in particular of scoring and weighting to define the "preferred alternative", is therefore not recommended.

Continued.

Table 5.2(c) (Continued)
Ranking, Scoring and Rating

Rating

In rating the alternatives are also placed on a scale for each effect category but the scale is verbal (nominal) rather than numerical. A simple example of a verbal scale is: HIGH, MEDIUM, LOW, as shown in the example below:

VERBAL RATING OF ALTERNATIVES

Impacts	Alternatives I	II	III	Comments
A	NONE	MED.	MED.	
B	V. LOW?	LOW	MED.	
C	HIGH	MED?	*V.HIGH*	
D	LOW	LOW	V.LOW	

To help the reader interpret the summary results:

- the alternative with the lowest impact in each category is shaded;
- areas of uncertainty are highlighted (?);
- and very severe impacts are highlighted (* *).

A more complex rating system is shown below:

RATING ASSIGNMENT SYSTEM FOR EVALUATION MATRIX

+5	Major long term, extensive benefit (highest possible rating)
+4	Major benefit, but characterised as either short term or of limited extent
+3	Significant benefit; either long term covering a limited area, or short term covering an extensive area
+2	Minor benefit, but of a long term or extensive nature
+1	Minor benefit over a limited area
0	No impact
-1	Minor adverse effects over a limited area
-2	Minor adverse effects, but of a long term or extensive nature
-3	Significant adverse effects; either long term covering a limited area, or short term covering an extensive area
-4	Major adverse effects but characterised as either short term or of limited extent
-5	Major long term, extensive adverse effects (lowest possible rating)

In this example numbers are used for convenience, to indicate the different levels of impact. It might be more reasonable to use symbols:

- firstly because they avoid the temptation to add up numbers to give a total for each alternative;
- and secondly because they give a more immediate visual representation.

Experience with the use of these verbal rating approaches, particularly using symbols, suggests that they are an effective mechanism for communication. They provide a basic level of information which can be readily appreciated and which leads the reader to ask the right sort of questions about the trade-offs that need to be made between impacts and alternatives.

The use of verbal rating for summarising effect vs. alternative information is therefore recommended where necessary.

Table 5.2(d)

The Key Issues Matrix

Effects	Alternatives I	Alternatives II	Comments
A Noise Pollution	NO IMPACT	MED.	.....
B Air Pollution	V. LOW	LOW	.....
C Major Hazard	HIGH	MED. I	locates residential area within 500 metres of manufacturing installation with pressurised LPG storage.

The reasons for excluding alternatives or impact categories must be clearly explained.

This process will result in a simplified matrix showing the principal trade-offs that the decision maker must make, for example between the impact of Alternative I on major hazards and the impact of Alternative II on noise pollution.

5.4 Illustrating the Implications of Different Trade-Offs

Finally it may be helpful for the decision maker, to show how his decision would be affected by different judgements on the importance of impacts.

For example, at a very simple level:

- "if impact on major hazards (C) is considered to be of overriding importance then Alternative II would be preferred, while if impact on noise (A) is of overriding importance then Alternative I would be preferred".

In this way the decision maker is shown how his own judgements will affect his final decision.

At this stage it may also be possible to introduce the other factors affecting the decision, such as cost and technical feasibility.

If at this stage the analysis is reduced to a small number of key alternatives and impacts, the important trade-offs can be clearly explained in the text of the report. However in cases where there are still several alternatives and impacts to be considered the trade-offs may not be so clear. In these circumstances it may be justifiable to use scoring and weighting systems to illustrate the implications of different judgements.

This can be done by setting up the analysis with different sets of weighting factors so as to show how different priorities would give rise to different outcomes. This approach should, however, be used with care; in particular tests should be carried out to show how sensitive the outcome is to small changes in weighting. Also the reader should recognise that none of the weighting scenarios developed may actually reflect his real preferences and should therefore treat the results with the necessary caution.

5.5 Conclusion: presenting information to the decison-maker on EHIA.

Whatever the context in which EHIA is being carried out, whether as part of a formal EIA procedure or not, it is important that decision-makers are presented with clear, easy to follow information on the results of the EHIA process. Particularly for urban develpment projects, where a wide range of different impacts may arise, it is important that the most significant health impacts, and mitigation measures to minimise these, are highlighted. A matrix-type format presents a useful method for achieving this.

Nevertheless, EHIA is an area of considerable uncertainty, both about the relationship between environmental change and impacts on health, and about the significance of different health effects. In these circumstances it is essential that decision-makers can see clearly how a particular assessment of health impacts was arrived at: what prediction methods or whose expert judgement were used, what quality criteria were use to assess the significance of effects etc.

The following points should be remembered in presenting information on EHIA to decision makers:

- Information should be presented clearly and concisely, with detailed information on the EHIA procedure used available for reference;
- The report should indicate all the potential health effects that were studied;
- The report should indicate those effects which have been assessed as most significant, and indicate the basis for this assessment; tools such as matrices may be helpful to achieve this;
- The report should note the impact of mitigation measures, phasing etc. on the significant effects identified, and note their impacts on other project factors;
- The report should clearly indicate the choices which must be made between mitigation measures, phasing etc. and importantly, at what stage of the project these must be made.

Finally, although the final report on EHIA should give full information on the study, we have noted above the importance of incorporating the concepts of EHIA at all stages of urban development. This can only be acnieved by full and continued discussions of EHIA findings and problems with all concerned with the urban development.

6. REQUIREMENTS AND RECOMMENDATIONS FOR FURTHER WORK

6.1 Requirements for the Development of EHIA

From the discussion contained in Sections 2 and 3 of this report, it can be seen that our knowledge of how urban development may affect health is limited. In particular, whilst we may know about the impacts of individual environmental factors on health, we know little of how factors combine to affect the overall health of urban dwellers.

At the same time, whilst experience has shown the effectiveness of some mitigation measures (especially public health measures), others have been subject to only limited monitoring. In view of the growing scope and rate of urban development, we believe that further research into its environmental health impacts is urgently required. Recommendations of the form such research might take are given below.

6.2 Recommendations for Further Work

The following subjects are suggested to be amongst the most important areas for further work to increase the scope and coverage of urban environmental health impact assessment:

- o further epidemiological and toxicological studies of the effects of pollutants on human health, particularly the synergistic effects of a number of pollutants acting together;
- o study of the effects of indoor climate on disease transmission and general health, indoor air quality and the movement of indoor air pollutants, particularly in multi-family high-rise buildings;
- o research into the differential effects of environmental health factors on high risk groups, and how such knowledge may be incorporated into EHIA;
- o further development of risk assessment approaches, particularly for the newer industrial developments where practical experience is limited;
- o work on the effects of urban layout (including density) on mental health;
- o study of the impact of more general societal changes arising from urban development on mental and physical health;
- o further development of health indices to measure non-fatal, sub-clinical and mental health levels;
- o development of training programmes in environmental health, particularly for those in the planning and development fields and local health care workers.

In addition to these specific requirements, there is a general need for further work on EHIA methods, techniques and source materials to develop and illustrate the approach, particularly for training purposes. In this context the development of case-studies of EHIA's may be particularly helpful.

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