The selection criteria for a landfill site should be environmentally sound, economi vehicles. If not, the site should cally viable and technically feahave sufficient tipping capacity sible. Site assessment is an to justify the capital and opessential part of the initial erating costs of a transfer stastages of landfill development tion in the collection area. for the financial, environmen-Hydrological and tal and technical viability of the proposed operations. Site geological considerations assessment can be expanded High polluted leachate can into a detailed site investigation, leading to the formulation of plans for the design and operation of the landfill which forms an essential part of the disposal licencing procedure.

The main aim of disposal licencing, and hence of site assessment, both in the short and long-term, is to safeguard human health, water quality and amenity from adverse effects due to landfill develop-

Such an investigation includes

technical and scientific

assessment of hydrological

hydrogeological features and

sotl conditions, of physical,

chemical and biological factors

relating to the ability of the

site to handle the waters, and

of relating to the potential

impact of the operation on the

environment and the local

#### Site Investigation

Good landfill management starts with a site investigation. The objective of the investigation is to produce accurate information on all ground conditions in the vicinity of a site which may have adverse effects on the environment. Such information is a prerequisite to the design, development, monitoring and restoration of a landfill. Site investigation should proceed in stages. It starts with a reconnaissance study; the aim of which is to establish the need for, and feasibility of, landfill operations in the area, and to identify possible sites. An essential consideration at this stage is the level of investment likely to be needed and the viability of the projected operation. If the reconnaissance study is promising, there will follow a detailed field investigation. The report of this investigation will provide the basis for the landfill design and the formulation of the working plan for the site.

#### Planning and Site Selection

The only sites where land development/improvement will result from the disposal of solid waste should be chosen. Selection of a site should always be made in consultation with the local planning, environment, health and water protection authorities. Ecological factors, such as possible damage to birds and animal habitats, should also be considered. The after-use of the land should be determined if possible, so that an appropriate landfilling plan can be formulated. An architectural model of the completed site, showing contours and proposed features, is useful for public relations purposes. Potential sites include land marred by industrial activity. such as subsidence through under ground working, or land not serving a useful purpose but which could be improved by filling and contouring. Mud flats in some tidal reaches may be suitable for reclamation.

Subject to hydrogeological investigation in relation to the protection of groundwater and surface water proving satisfactory, sand, gravel or clay excavation sites, for example, may be suitable for disposal of solid waste. Waste should not be deposited on fissured strata forming part of an aquifer from which public water supplies are drawn.

#### Road Access

The site should have good road access from the collection area and the approaches should be adequate for the concentration of a large num-

200 meter from the boundary

of the nearest residential area.

tracted to landfill sites and are

a potential hazard to low-flying

aircraft, the appropriate air-

port authority should be con-

sulted where a site near to an

Site in relation to waste

airport is being considered.

Because birds may be at-

ber of vehicles. **Locality Considerations** The proximity of inhabited buildings will be an important factor in deciding on the suitability of a site. No hard and fast rule can be given; much will depend on ground contours, the likely duration of the landfilling activity, the number and type of premises and the prevailing wind direction. However, experience indicates and workshops. that the boundary of a landfill site should, as a rule, be atleast

Reliable site monitoring is dependent on an accurate record of inputs. A weighbridge at the site entrance is the best way of providing such date. Alternatively void-usage may be surveyed on a regular

#### Wheel-Clearing Landfill sites operate in all

collection area If possible, the site should be within economic delivery range of the waste collection

arise from percolation of rainfall through the landfill or from ingress of surface water drainage or springs. Full investigation of the hydrological and geological conditions at and in the neighbourhood of the site must be made in confunction with the relevant water authority to determine if any action is necessary to protect groundwater or watercourses against pollution from leachate. In some cases, it may be necessary for a site to be sealed by lining it with impermeable necessary for a site to be sealed by lining it with impermeable material, such as clay or a synthetic membrane, in order to contain leachate for subsequent treatment and disposal. The containment, treatment and disposal of leachate can be a very costly process, so sites which allow slow migration and natural attenuation of the leachate by physical, chemical and biological processes in the ground will normally be preferred. However, where the use of such sites involves long-distance transport from waste collection areas, the selection of nearer sites requiring ex-

#### Availability of covering material

tensive water protection mea-

sures may be economically jus-

The availability of suitable covering material for the duration of the landfilling operation is essential, and this must be studied for each site. If suitable material is not available at the site, it will have to be im-

Dhaka City Corporation, which is solely responsible for solid waste management within city areas, is presently disposing of solid waste at Jatrabari, one of the major disposal sites in and around Dhaka City.

Development of a landfill may begin only after planning permission has been obtained and the disposal licence has been issued. A working plan for the landfill will have been agreed between the operator and the licensing authority and the disposal licence will normally stipulate that, prior to any waste deposits, the designs, works and procedures specified in the working plan must be implemented. The preparations needed at a site before waste can be deposited may be considered under two headings: the infrastructure, that is, the position of the building, roads and facilities that are necessary to the efficient running of the site; the basic engineering needed to shape the site for the reception of wastes and, generally, to meet the technical requirements of the working'

#### Site infrastructure

The site infrastructure provided at a landfill sets the general framework within which the site will be operated. Its careful planning is essential if the landfill is to operate efficiently and safely throughout its operational

### Site Entrance

A landfill site should have a site entrance of properly surfaced and capable of taking traffic in both directions safely. The appearance should be pleasing as it has a major influence on how a landfill site is perceived by the public.

#### Site Accommodation

The size, type and number of buildings required at a landfill depends on factors such as the level of waste input, the expected life of the site, environmental factors and the availability of other facilities and depots. Buildings will therefore range from single portable cabins/messroom units to purpose built complexes incorporating offices, site control office, messrooms, welfare unit, stores, garages

## Recording Waste Input

weathers. Given the nature of the operation, vehicles could carry mud and debris onto the and livers since 1984. highway. This is a breach of

the Highways Act, is unsightly and likely to cause adverse public reaction.

by Mohammad Nurul Islam

One means of ensuring that mud is not taken onto the highway is to provide site roads constructed to both a high standard and of sufficient length that any mud and debris trapped on vehicles is then likely to be shaken onto these roads where it can be regularly swept away. However, in any cases site limitations will require the provision of mechanical wheel cleaning equipment.

Site Notice Board It is important that adequate information of the operation and regulation of a landfill is displayed at the site. At the site entrance a notice board of considerable size should be provided, located in a position where it can be read, to give the site users another interested the following informa-

the site name: the site operator's name, address and telephone

number: (c) the operator's local agent's telephone number for emergency use;

(d) the name of the waste disposal authority responsible for the disposal licence; and the opening hours of the

Suitable speed restriction, direction and other signs such as "No Smoking" should be po-

sitioned as necessary through-

out the site.

#### Disposal of Bulky **Household Waste**

It may sometimes be desirable, particularly in rural and remote areas, to provide a disposal facility for direct delivery by the public of bulky items of household waste near the entrance to the landfill which should be separately fenced.

#### Security Fencing

Except where a landfill site has a distinctive and effective natural barrier, adequate fencing should be provided to prevent unauthorised access to landfill sites. Unrestricted access presents significant health and safety problems not only for trespassers but also to authorised site uses and occupants of adjacent properties.

Litter fencing is essential for an effective landfill site.

## Statutory Undertaker's

Equipment During the planning of a landfill site, consideration will have been given to the possible effects of the development on equipment (for example, pipeline or cables) owned and operated privately or by public utilities on or adjacent to the

### **Quarry Working**

Many landfill sites are in active or abandoned quarries. It is essential that quarry sides remain safe during landfilling

#### Engineering

Appropriate landfill site engineering is the most important and vital part of a successful sanitary arrangement for solid waste disposal. Defective or improper landfill site engineering is a potential threat to the public health,

community and the surrounding environment. Therefore, landfill site engineering should be technically and economically viable and environmentally sound.

#### Earthworks

The working plan require extensive earthworks to be carried out before deposition of waste can take place; this is particularly so if artificial liners are to be placed. The cell method of operation is being increasingly adopted at modern landfill sites, requires the construction of cell walls which has the advantage that infiltration of rainfall is reduced and leachate generation is thus more readily con-

trolled. At some sites earthworks may be needed to construct earth banks around part or all of the site perimeter to screen the landfill operations from the public. A special form of site engineering is required at some coastal sites where deposition of waste is used as a means of reclaiming land.

#### **Lining Landfill Sites**

The principal aim of lining (and capping) a site is to contain the leachate, thus preventing pollution of surrounding land and waters. Lining may also assist in leachate control by reducing groundwater infiltration into the landfill; particular application include landfilling below the level of water table, or the reclamation of lowlying ground in coastal areas where inflow of groundwater occurs. Lined landfill sites can usually accept a wider range of wastes than would otherwise be possible. Artificial liners are constructed of materials which are to all intents and purposes impermeable. Natural lining materials, such as heavy clay soils, exhibit low permeability (for example, 10 cm/sec.).

#### Provision for Leachate Management

Provision for leachate management is an integral part of an effective and environmentally sound landfill site. The following considerations should be made carefully.

#### Monitoring

Lining landfill sites is primarily aimed at safeguarding groundwater quality. A continued groundwater monitoring programme, to confirm the integrity of the lining, is therefore essential. Such a monitoring programme should begin installation of the liner to provide baseline data for comparison with later results.

#### **Naturally Occurring** Materials

For a natural material to be used as a liner it should ideally have a permeability of less than 1x10 cm /sec. The most commonly used low permeability material is clay, either native to the site or imported.

#### Synthetic Liners

Most commonly used synthetic liners are thermoplastics formed from polyethylene, polypropylene and polyvinyl chloride (PVC). Additives may be incorporated to improve the properties of the materials. The choice of a suitable

liner material is a difficult decision since, not only are a large range materials avail able, but their long-term behaviour is uncertain. No definite recommendations can be given since the decision will inevitably depend on circumstances unique to the site. I is clearly important that the liner material selected must be compatible with the types of wastes to be deposited.

#### Covering Material for a Synthetic Liner

Cover is required to protect a synthetic liner from the effects of weather, from mechanical damage by birds, animals and vandals, and from damage during subsequent placement of refuse. Household refuse usually contains cans and glass and these as well as large items such as old refrigerators and furniture, can easily punture synthetic liner. It is recommended therefore that a minimum thickness of 250-300 mm of cover material is used to safeguard against pun-

#### Permeable Liners

The use of permeable liners to provide a zone of attenuation beneath landfill is a new concept which is currently being explored. The aim is to enhance the attenuation capabilities of materials either occurring at the site or readily available nearby so that leachate movement can be delayed and attenuation mechanisms given a longer time to act before the leachate migrates from the site.

#### Operational Considerations

During the early phase of operation, particular care must be taken to ensure that traffic does not damage the liner. One problem unique to landfill sites lined with polymeric materials is that should leachate have penetrated the liner it may then undergo further degradation and produce landfill gas.

#### Preparation for Leachate and Landfill Gas

Management

Leachate management will have been considered as part of site assessment and suitable measures will have been incorporated in the working plan. Preparation of the site may be required at an early stage of development to divert surface of groundwater inputs and so as to minimise leachate

#### Landfill Gas

production.

Where the nature, quantity and depth of the wastes to be deposited suggests that significant quantities of landfill gas will be produced at an early stage of the development, preparation will be required for its eventual handling and control.

The principal design consideration will have been to prevent the uncontrolled escape of gas and thereby minimise fire, explosion or asphyxiation risks. Necessary measures may involve the provision of gas migration barriers and adequate ventilation and gas collection

The environmental expert.

## Plutonium Cargo to Risk Tip of South America

ship loaded with highly radioactive material is to A pass through the tortuous, windswept Straits of Magellan after being banned from going near South Africa, Australia or the Panama Canal. Ecologists have decried the move, which endangers communities in Tierra del

The ship, the Akatsuki Maru, carrying a ton of plutonium oxide waste from Japanese power stations, equivalent to 120 atomic bombs, is to cross the world's two greatest oceans and the equator twice, on its way to reprocessing plants in France.

The cargo is considered so dangerous that the United States has forbidden the ship passing through the Panama Canal. South Africa has said that the ship will not be allowed to enter its 200 mile maritime territorial limits, and Australia, New Zealand and 12 Pacific island nations have demanded a lifting of secrecy concerning the ship's course.

Argentine and Chilean authorities have given the go ahead for the Akatsuki Maru to pass through the Straits of Magellan near the southern tip of South America.

of dangerous and radioactive substances.

Nonetheless Argentina will ask the Akatsuki Maru to steet as far as possible from Argentine Atlantic waters on its way to Europe after leaving

plutonium, banned from the Panama canal and South Africa, is set to pass through the Straits of Magellan, one of the most dangerous waterways in the world, for reprocessing in France. In Argentina, reports Gemini News Ser-vice, people are asking why Japan's increasingly nuclear-depen-dent power generators must ship their nuclear waste half way across the globe.

the Straits of Magellan. No statement has been made on the Akatsuki Maru by the British authorities on the Falkland/Malvinas Islands.

Japan's heavy reliance on nuclear fuel for its power needs produces considerable

Japan plans to increase its use of nuclear power so as to cut down its dependence on oil from abroad. Already one quarter of Japan's very high electricity consumption is

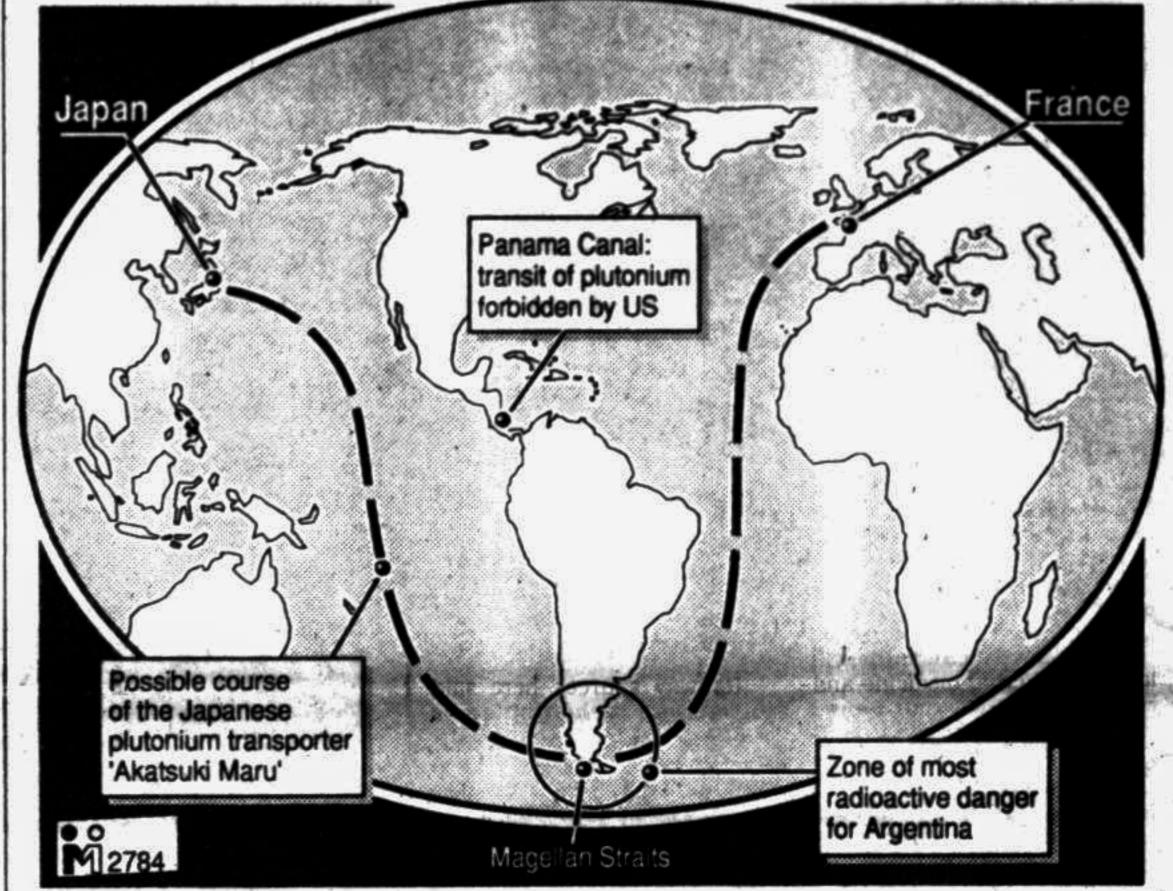
supplied by nuclear plants. Japan's future economic development is based on mas-A shipment of Japanese sive investment in nuclear power. The US in 1987 gave the green light for Japan to accumulate plutonium for

peaceful purposes. The transportation of highly radioactive waste half way round the planet has become the world's problem. Plutonium is difficult to transport: it is highly toxic and has a half-life of tens of thousands

According to the Cousteau Society which monitors ocean traffic in dangerous substances, Japan ships at least five tons of plutonium a year. This is likely to increase, and with it the dangers of accidents during transportation.

One answer would be for Japan to build its own plutonium reprocessing facilities. But this would leave the door open for Japan to hide how much plutonium it has. Fears of Japanese militarism have not yet abated. Processing by

## Deadly cargo



High winds and storms buffet the area and Cape horn is the gravevard of many a ship. Country-size icebergs are an additional hazard.

The southern tip of the South American continent is home to some of the World's most southerly cities: Ushuaia in Argentina and Punta Arenas in Chile. As the ship passes through the Straits it will be a stone's throw from the shore. Local residents are alarmed by the coming of the Akatsuki Mar so close to their homes.

The Argentine Foreign Ministry has dismissed alarm calls as sensational, and stated that waterways such as the Straits of Magellan are open to all shipping according to international law. Both Chile and Argentina have asked the countries involved - Japan the US and France -to comply with United Nations conventions regarding the transportation

quantities of spent fuel which is still useful after processing. The used fuel is abundant in uranium 235 and in various forms of Plutonium (239, 240, 241, and 242). Plutonium does not exist naturally on earth; it is an artificial element created in nuclear power plants. The "waste" can be reused

in other kinds of nuclear installations. Reprocessed material has a high commercial value. Despite its heavy reliance on nuclear power generation Japan does not have reprocessing facilities at home. Instead it transports its radioactive waste half way round the world.

Reprocessing is carried out at a few centres in countries such as Britain and France. Sellafield in northern England is Britain's highest yen earner. After processing, the extracted plutonium is returned to the country of origin.

France, Britain or the US provides some means of control.

Also the Japanese may want to avoid the problems experienced by countries which do reprocess nuclear waste. Lakes of radioactive material into the air, water and land surrounding reprocessing facilities are unavoidable at present.

The government has to shelve plans for building a nuclear waste dump in Patagonia, after the whistle was blown by Greenpeace, and Argentines protested. Everyone knows that without constant vigilance, the dump will be sneakily built and operated.

Meanwhile the Akatsuki Maru is on the way round the most treacherous cape in the world. Ecologists are planning to alert local people who will be exposed to risk. It is doubtful if the ship will be stopped, but one thing has been highlighted: this is not the solution.

# New Commitments for Marine Research

ERMANY'S oldest ma-Trine research station, which was set up on the island of Heligoland, in the North Sea, 100 years ago, can look back on a chequered history. To celebrate its anniversary in summer 1992, the Alexander Konig Zoological Research Institute and Museum in Bonn has staged an exhibition entitled "The Challenge of the Sea" providing information on its work. Since the late 19th century, the programmes and research objectives have completely changed. Originally, the main concern was to find out how many life-forms there were in the sea.

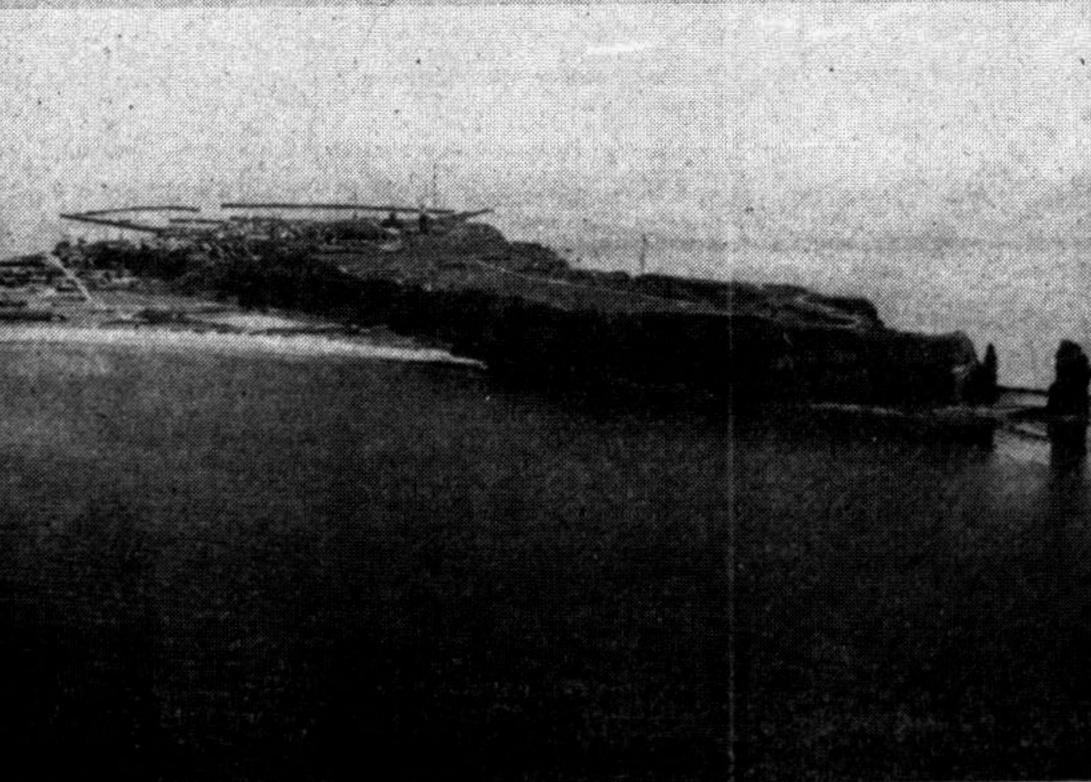
Overfishing and pollution of the sea have caused the fish population to decrease. Herrings, for instance, once a cheap meal, have become almost a delicacy in Europe. Pollution is greatest is the nutritive and shallow coastal waters. Mineral, oils are killing the birds and seals — but are reduced by bacteria time and again. Far worse is the damage caused by heavy metals, dumped warfare agents and chemicals which kill the fish. The Heligoland Biological Institute has also been examining deformities in fish embryos

Just how endangered is the

North Sea? At first glance, the informative exhibition in the Konig Zoological Museum in Bonn - where stuffed animals recall the extinction of count-

less animal species - conveys the impression that the sea is still in order around Germany's one and only deep-sea rescarch station. Quite unex-

pectedly, a colourful collection of maritime fauna from the waters around Heligoland are swimming about in the seawater aquaria : cod and goldfinny,



The German island of Heligoland in the North Sea. The Biological Institute is celebrating its 100th anniversary in 1992. Marine researchers from all over the world met here in September.

plaice and sole, a family of cat sharks, snails and jelly fish, sea daisies, mussels and share crabs. A shimmering blue lobster has been raised at the sta-

The fishermen bring the lobster eggs here before the lobsters end up in the cooking pot. It goes without saying that overfishing and deteriorated living conditions have reduced

reserves: in 1937 87,000 lobsters were caught in the proximity of Heligoland's mottled sandstone rocks: in 1983 the catch amounted to no more than 600. These experiments, however, are not designed - nor adequate enough - to regenerate stocks.

Open to the Atlantic and with strong tides, the North Sea has better self-cleansing properties than the Baltic. All changes are being registered by means of long-term measurements. Water samples, which have been taken daily from the Helgoland roads for the last 30 years, provide the important data for all North Sea conferences. Harmful industrial substances, which make their way into the sea via rivers, are measured and analyzed. It was public indignation at the dumping of waste sulphuric acid into the sea which

brought about its prohibition : the industrial polluter received recycling plant worth millions.

The German Bight has been heavily polluted by agricultural sewage resulting from largescale livestock farming. It is not only endangering the ground water in many places, but also the ecological balance of the mub flats. Phosphate pollution is decreasing quite markedly. Here, one of the main causes of the nitrate concentration was household detergents. Through economic use and phosphate-free detergents, as well as the increased provision of sewage treatment plants, the phosphate level has been reduced. Even far out into the North Sea, it is now possible to establish the fact that the rivers Rhine and Elbe have become cleaner.

The Heligoland Biological Institute has a staff of 170, five research vessels and a budget of some Dm 30 million. The institute, which has its head office in Hamburg, cooperates with research stations throughout the world.

