WASTE AND THE ENVIRONMENT

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Summary

The amount of waste generated by society has increased as human society has developed, and the character of the waste has changed. There are various types of waste, ranging from domestic waste, through industrial, mining, and commercial wastes to radioactive waste. Waste can also be categorized as non-hazardous or hazardous. Different types of waste must be disposed of in different ways. If waste is to be disposed of on or in the ground then the geological conditions—especially the hydrogeological conditions—must be suitable. This is because waste may contain contaminants that are injurious to human health or to the environment, and reactions within waste material lead to the production of leachate and gases. Leachate is produced when water reacts with waste material.

Domestic waste and non-hazardous industrial and commercial wastes may be disposed of in a sanitary landfill. Ideally, the ground at a landfill site should be impermeable so that the waste and any leachate produced is contained, and so does not pollute the groundwater. Where this is not the case, various types of liners may be installed over the site before waste is disposed of. In a well-designed landfill the waste is enclosed within cells formed of clay, and is compacted. When the landfill is completed it is sealed with a clay cover to minimize infiltration by rainfall or surface water. Hazardous waste may require some form of pre-treatment prior to disposal. If disposed of in a landfill, then construction needs to incorporate suitable liners, which may include impermeable geomembranes, and drainage systems. Again, the site has to be suitably covered when the operation comes to an end. The waste containment system needs to be monitored during its operation and after closure to see that any leakage of leachate does not present a problem. Radioactive waste may be of low to high grade, the latter presenting the most serious problems posed by waste disposal. High-grade radioactive

waste may take thousands of years to break down and no longer represent a hazard. Consequently, it must be isolated away from humans and the environment. Probably the most suitable way of doing this is to seal it in containers that are stored in chambers excavated deep within the ground. These chambers should not interfere with the groundwater system, and so should be constructed in stable areas in large granitic masses or thick deposits of basalt, shale, or rock salt.

Indiscriminate disposal of waste, in the past in particular, have meant that land and groundwater have been contaminated by materials that pose a threat to humans and the environment. Ideally, contaminated areas should be cleaned up so that they are restored to their original condition, but this would normally involve large or prohibitive cost. Consequently, contaminated sites are usually reclaimed in such a way as to make them suitable for subsequent use. Liquid and gas contaminants, because of their mobility, are usually more difficult to deal with than solid contaminants. A contaminated site must undergo a site investigation before it can be developed. As such an investigation may prove hazardous, operatives may have to wear special clothing, and certain facilities may have to be available on site. The type of remediation undertaken will depend upon the characterization of the site. Various treatment methods are available and their use depends upon the type, extent, and concentration of contamination.

1. Introduction

With increasing industrialization, technical development, and economic growth, the quantity of waste generated by humans has increased immensely. Many types of waste material are produced by human society, of which domestic waste, commercial waste, industrial waste, mining waste, and radioactive waste are probably the most notable. Over and above this, waste can be regarded as either non-hazardous or hazardous, the latter posing health risks and environmental problems if it is not managed properly. Waste may take the form of solids, sludges, liquids, gases, or any combination thereof. A further problem is the fact that deposited waste can undergo changes through chemical reactions, resulting in dangerous substances being developed over time. Solving the waste problem is one of the fundamental tasks of environmental protection.

As waste products differ considerably from one another, the storage facilities they require also differ; in particular, special wastes must be disposed of in special ways. Wastes that do not decompose within a reasonable timespan—mainly organic and hazardous wastes, and liquids that cannot otherwise be disposed of—ideally should be burnt. Solid, unreactive, immobile inorganic wastes can be disposed of at above-ground disposal sites. It is sometimes necessary to treat these wastes prior to disposal. To provide long-term isolation from the environment, high-toxicity, non-degradable wastes should be disposed of underground if they cannot be burnt.

The best method of disposal is determined on the basis of the type and amount of waste, on one hand, and geological conditions at the waste disposal site, on the other. When locating a new site, a desk study is undertaken initially. The primary task of the site exploration that follows is to determine the geological and hydrogeological conditions. Chemical analysis of groundwater, together with mineralogical analysis of rocks, may help yield information about the future development of a site. At the same time the

leaching capacity of the water is determined, allowing prediction of the possible reactions between wastes and soil or rock. If groundwater must be protected, or if highly mobile toxic or very slowly degradable substances are present in wastes, then impermeable liners may be used to inhibit infiltration of leachate into the surrounding ground.

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* More advanced text.

Biographical Sketch

Fred Bell graduated B.Sc., M.Sc. from the University of Durham and received his Ph.D. from the University of Sheffield, United Kingdom in 1974. More recently, he received a D.Sc. from the University of Natal. He is a Fellow of the Royal Society of South Africa, a Fellow of the Institution of Civil Engineers and the Institution of Mining and Metallurgy, and a Fellow of the Geological Society, being both a chartered engineer and a chartered geologist. He is the recipient of several awards.

Professor Bell now is a Visiting Research Associate at the British Geological Survey. Previously, he was Professor and Head of the Department of Geology and Applied Geology, University of Natal, Durban, South Africa, during which time he also was a Distinguished Visiting Professor, Department of Geological Engineering, University of Missouri-Rolla, USA.

Professor Bell's research subjects have included ground stability, subsidence, ground treatment, engineering behavior of soils (clays, expansive clays, saprolites, tills, laminated clays, dispersive and collapsible soils, sands), engineering behavior of rocks (sandstones, carbonates, evaporites, shales, basalts, dolerites, granites), cement, lime and PFA stabilization of clay soils, acid mine drainage, mining impacts, landfills, derelict and contaminated ground, rock durability in relation to tunneling, slope stability, aggregates, building stone, and geohazards.

In his professional capacity Professor Bell has been involved in a variety of work in the United Kingdom, southern Africa, and Malaysia concerning site investigations; foundations; settlement problems on clays, fills and sands; old mine workings and subsidence; longwall mining and subsidence; ground treatment; groundwater resource assessment; slope stability; use of mudrocks for brickmaking; assessment of various rock types for aggregates; contaminated ground; acid mine drainage; landfills; and dam sites.

Professor Bell is author/editor of 17 books: several reprinted, one in its fourth edition, one translated into French, two into Italian and yet another into Malay, and an Indian edition (in English). He is also author of over 200 papers on geotechnical subjects. He has served on the editorial boards of five international journals and has been a series editor for three publishers.