

Out of site, out of mind?

Setting the scene

You will be working as a member of a team of new research students in a university chemistry department. The department has been asked to provide advice to a waste disposal company about the most suitable material to use to line a landfill site to stop toxic chemicals getting into the environment. You will carry out investigations to help you write your report to the company.

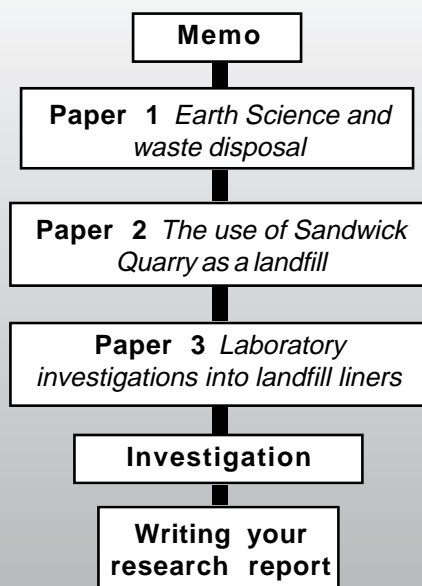
Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- humans reduce the amount of land available for animals and plants by dumping waste
- human activities may pollute land with toxic chemicals which may be washed from land into water
- human activities may pollute water with toxic chemicals
- unless waste is properly handled more pollution will be caused

Route through the Brief



Outcome Checklist

You will produce a report to the waste disposal company outlining your recommendations about the landfill liner. A fax and a memo guide you through the Brief. You should make sure you produce the following items as you work through the Brief.

Paper 1, 2 or 3

- answers to questions and points raised by the notes written on the papers
- summary of your paper to report back to the group

Group discussion

- plan for investigation(s) into landfill liner material

Report to HWD plc

- report on investigation
- summary of advantages and disadvantages of types of liners
- recommendations as to the most suitable liner
- list of other factors the company could investigate to minimise pollution and noise

Fax Transmission

To: Dr. J. Brown, Research Team Leader
Department: Environmental Chemistry Unit, Broomhill Campus

Number of pages (including cover sheet): 2

From: Prof. A. Thompson, Head of Chemistry Division
Department: Chemistry Division, City Campus
Fax: 0192 532299
Telephone: 0192 532209 ext. 2205

Message

Re: Hamside Waste Disposal plc (HWD): Sandwich Quarry landfill site liner contract

HWD has now finished a report on the use of the old Sandwich Quarry as a landfill site. They want to obtain a licence to allow them to put household waste into the site. Before they can obtain this licence from the County Council they must provide information about how the site will be lined to stop polluted water from running out of the site. This polluted water is called leachate. We have been awarded a contract from HWD to investigate three possible liners and make recommendations on which will be the most suitable. We have samples of the lining materials which we can mix into various combinations.

The time scale for the project is very tight. I suggest you involve your new research students but as they have no experience of the technical problems linked to landfill sites we will have to get their knowledge up to a suitable level quickly.

I've enclosed 3 papers which may be helpful. These are listed below. The research team members should work through these before starting the research investigation. I've also written a few comments on the papers which should stimulate some thought and help their understanding. It would be a good idea if the research students made notes based on their answers to my hand written questions and comments.

1. Thompson, A. (1994) "Earth Science and waste disposal" in *Environmental Matters* Vol 3, pp224-5
2. Roberts, R. and Wilks, F. (1996) *The Use of Sandwich Quarry as a landfill site*. HWD Site Investigation Report
3. Thornton, S.F., Bright M.I., Lerner D.N. and Tellam J.H. (1995) "Laboratory investigations into landfill liners" *Journal of Waste Science and Technology* Vol 81, pp74-5

..continued on next page

I've copied the relevant section from the HWD research contract below.

The contractor is required to carry out the necessary research to determine the most appropriate liner for the Sandwich Quarry landfill site. The following factors must be taken into account in making recommendations:

- *rock samples from the quarry must be used in order to find out if they react with the leachate;*
- *the liner must be produced from one or more of the natural materials provided and be able to protect local water supplies, especially the River Aron;*
- *the recommended solution must be based on evidence from investigations and supported by information from the research literature;*
- *a written report of the work with conclusions and recommendations is required. The contractor may also be requested to present a summary of the report to the HWD Management Committee. The report must include:*
 - a) *a summary of the advantages and disadvantages of natural and synthetic liners;*
 - b) *a description of any reaction between the leachate samples with rock from the quarry;*
 - c) *a description of the liner investigations, including all data collected;*
 - d) *a clear recommendation as to the most suitable liner;*
 - e) *a list of other aspects of landfill which our company could investigate to minimise pollution and nuisance.*

I suggest you arrange a meeting of your research team as soon as possible. Please let me know if there are any problems and keep me informed of progress.

A. Thompson

Memo

To: Research students newly appointed to the Environmental Chemistry Unit Research Team

From: J. Brown

Subject: HWD Sandwick Quarry landfill site liner contract: planning meeting

Planning meeting agenda (Chair: J. Brown)

- 1 Background information: presentation and discussion of Prof. Thompson's fax and papers
(Copy of fax and papers enclosed) *(10 mins.)*

Issues for discussion

- a) What do we need to investigate? (J. Brown to outline) *(5 mins.)*
- b) Getting to grips with the technical problems associated with landfill sites. (J. Brown to allocate background reading tasks identified below) *(20 mins.)*

Paper 1: Earth Science and waste disposal article
(Thompson, 1994)

Paper 2: HWD Site investigation report (Roberts and Wilkes, 1996)

Paper 3: Laboratory investigations into landfill liners
(Thornton et al, 1995)

- 2 Brief report back from team members on their reading tasks, followed by discussion *(20 mins.)*
- 3 Planning the research investigation and allocating group tasks (refer again to papers and fax, and the action plan below) *(30 mins.)*

An action plan

What are the tasks?

What order must they be done in?

Who will do each task?

How long will they take and what do we need?

How will we check on progress?

How do we report back?

Earth Science and waste disposal

Anne Thompson discusses some of the issues linked to handling the mountain of waste produced today.

Every year the amount of waste material that we produce increases. Up to 90% of this waste will end up in landfill sites. Usually these sites are old quarries or mines. It seems to make sense to put materials we do not want back in! Unfortunately, it is not that simple. Just burying the waste does not bury the problem. The waste can be broken down by microorganisms once it is underground, just like material in a compost heap, and this can produce harmful gases and liquids. If these gases and liquids escape they can cause problems.

Landfill gas is mostly methane and carbon dioxide. Methane is flammable when mixed with air. Rainwater, and liquid products from the waste, will produce a toxic liquid called leachate. The leachate can pollute both rivers and ground water close to the landfill. If this happens it can have serious effects on the surrounding area. Effective management of landfill sites is essential to stop this from happening.

Where should landfill sites be placed?

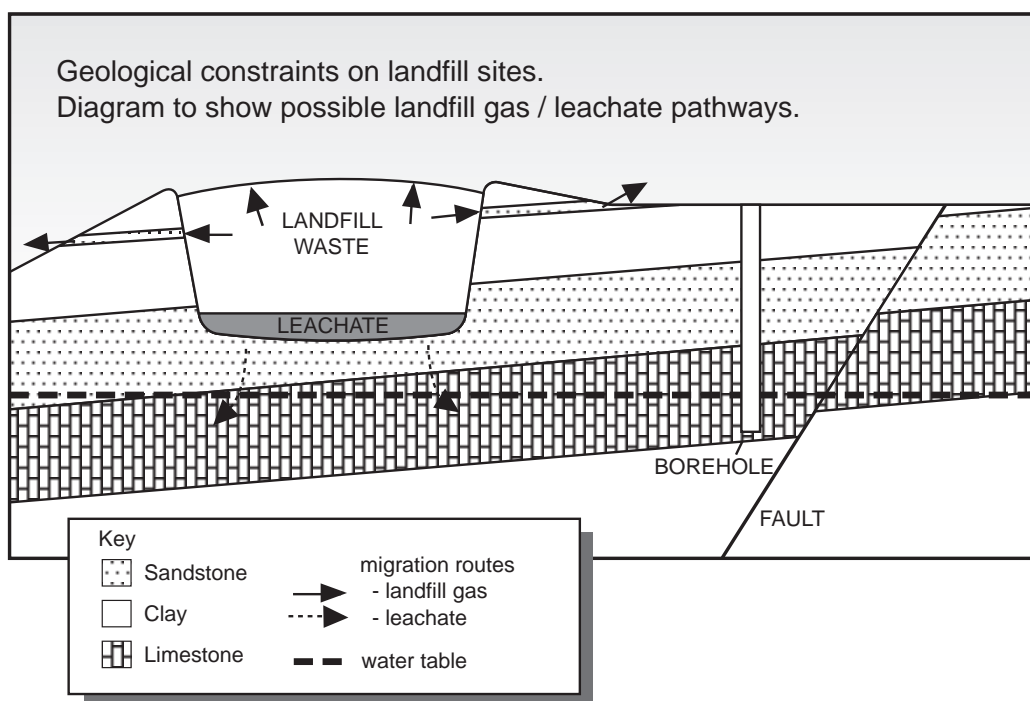
The types of rocks at a landfill site determine whether gas or leachate will escape. If a rock will let liquids and gases pass through it easily, the rock is called permeable. Permeable rocks are not suitable for a landfill site base. The leachate and gas can either move through tiny holes in the rock or may move through cracks or faults.

Why are permeable rocks unsuitable and what problems would arise?

The most permeable materials are sands and gravels. Many older landfills were established in pits where sand and gravel have been extracted for use in the building industry. Other highly permeable rocks include limestone and some types of volcanic rocks with well developed cracks. Landfill gas has been recorded hundreds of metres away from such landfill sites.

make sure we know what this is

Figure 1
Geological constraints on landfill sites.



what does this mean?

how will this happen?

In the past, landfill sites relied on the leachate being 'treated' by the rocks it passed through. For example, alkaline rocks would help to neutralise acids in leachate. Low permeability rocks such as clay are best suited to this approach. High permeability rocks are not considered suitable as the movement of the leachate is too fast. Unmodified sites of this type were used in the past for industrial chemical waste and for biodegradable waste but this often had serious effects on surrounding water resources. Now the main methods of controlling pollution from landfill involves lining them so materials cannot escape. It is now standard practice at sites on permeable rocks to include some kind of impermeable barrier, known as a liner, to prevent the movement of both leachate and gas.

Lining materials can be divided into natural and synthetic. The most commonly used natural liners are clay, bentonite (a special type of clay), colliery shale and pulverised fuel ash (PFA).

Synthetic liners include butyl rubber, polyethylene, neoprene and polyvinyl chloride (PVC). Although synthetic liners are made from totally impermeable materials they can be less than perfect. There may be damage during laying, poor joins between sheets and damage caused by plants and chemicals.

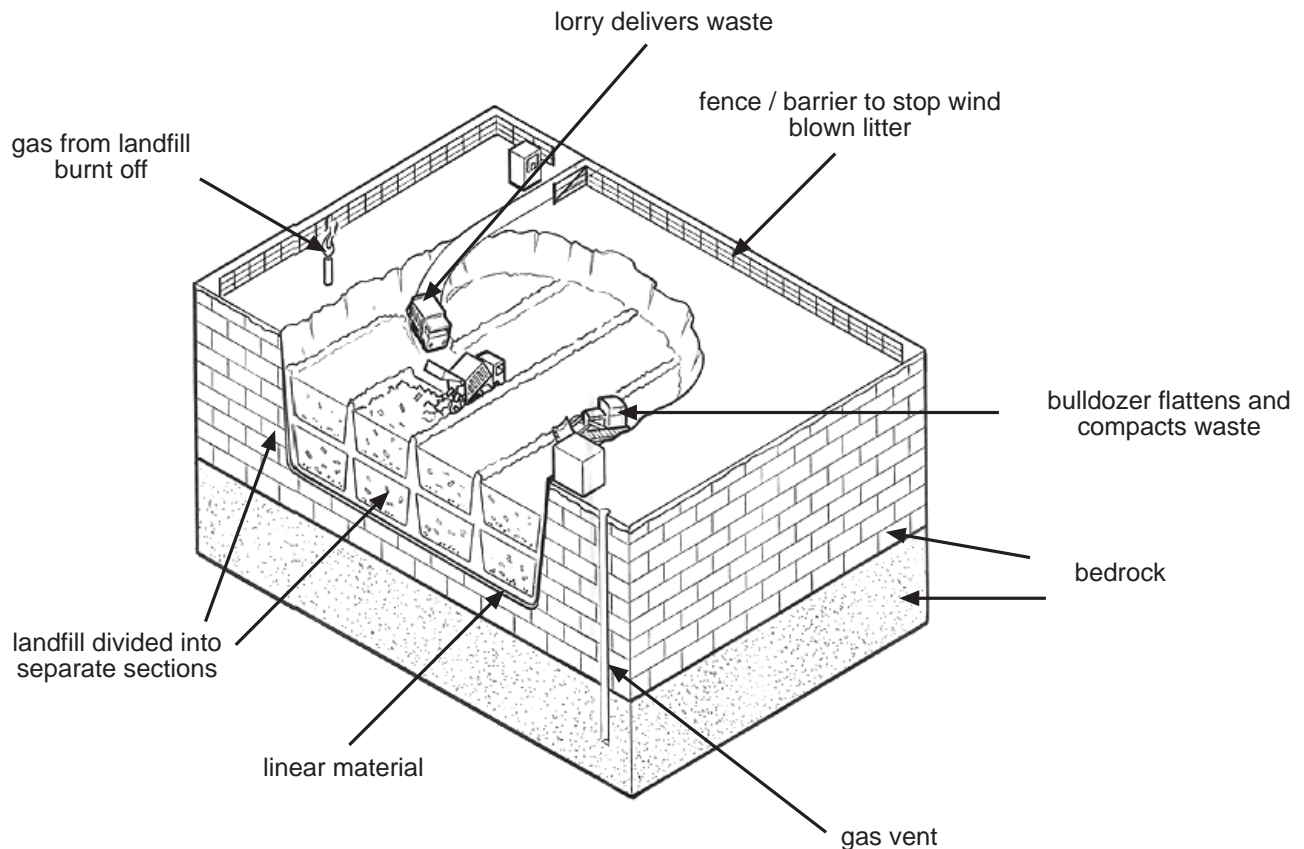
The design of a typical landfill site is shown in Figure 2 below. Note that the site is covered whenever possible because stopping rain from washing down through the waste reduces leachate. Also note that fences surround the site to stop wind-blown litter scattering beyond the site.

Other inconveniences to the public which must be considered are increases in traffic, noise pollution, extra road building, vibrations, smells and removal of footpaths and rights of way. However, a well managed site should minimise pollution, environmental impact and problems for the public.

Why doesn't the gas and leachate just build up?

How can smell and noise be minimised?

Figure 2
The design of a typical landfill site



The use of Sandwich Quarry as a landfill site

Roberts, R. and Wilks, F.

March 1996

Background

Sandwich Quarry has reached the end of its life for the extraction of sand and gravel deposits for use in the building industry. HWD is applying for a licence to allow them to use the quarry as a landfill site for the disposal of general household refuse. The quarry is situated close to a village (see fig.1) and within a short distance of the river. The villagers and the River Inspection Authority are concerned that liquids leaking from the site (leachate) could affect the ground water and river. Villagers are also concerned about potential problems from landfill gas.

The site

What might these problems be? - and what other problems might the landfill cause the villagers?

Fig.1 Location map - Sandwich Quarry

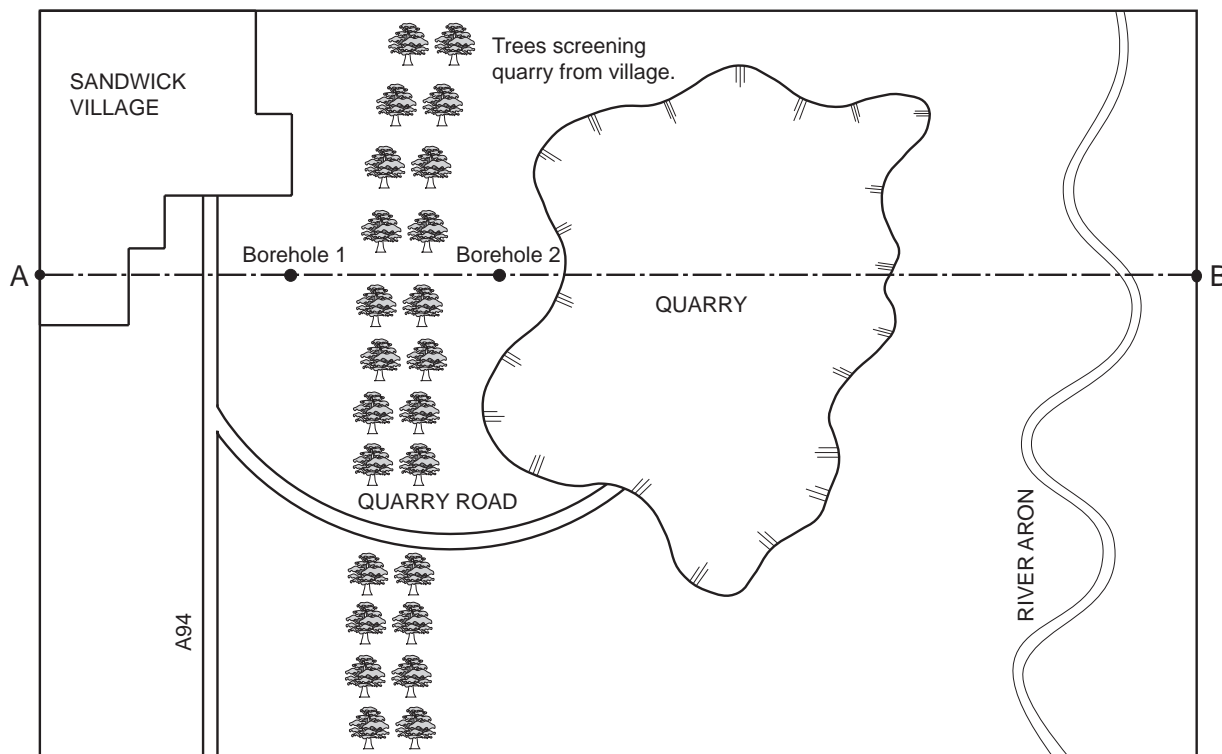
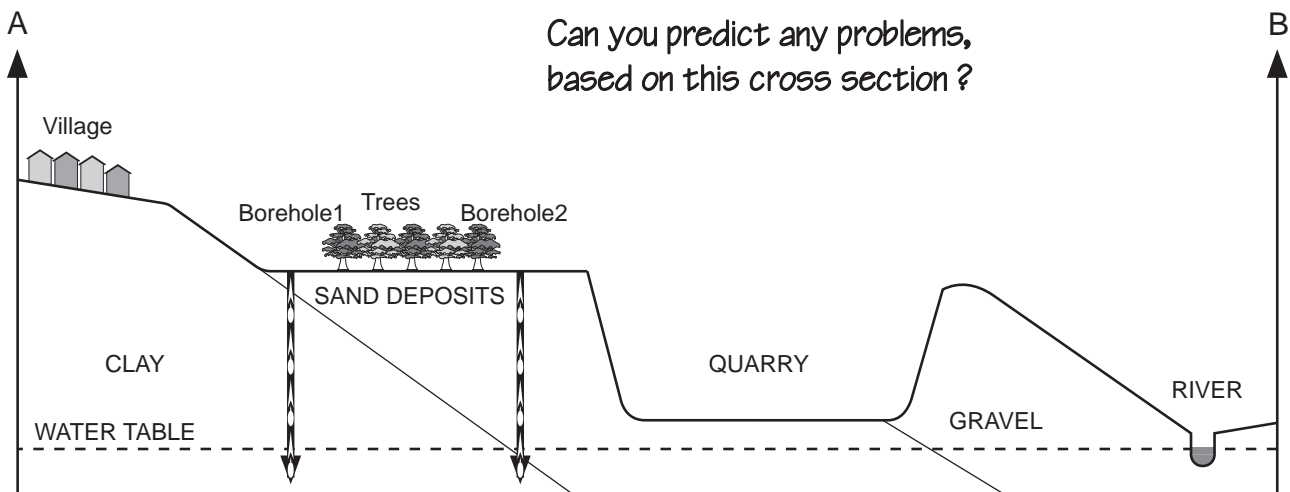


Fig. 2 Cross section of site



Risk of leachate pollution

The sands and gravels of the quarry may pose a risk of leachate pollution. These rocks are permeable and the base of the quarry is within a few metres of the ground water.

Recommendations: Could leachate reach the ground water and river?
Explain how and what problems would result.

Suitable materials should be found to line the sides and base of the quarry. The liner must prevent the movement of leachate out of the quarry. If possible the liner should also react with any leachate to reduce any pollution risk.

How?

Risk to Sandwick village from landfill gas and other nuisance

The clay deposits beneath the village form an impermeable barrier to the movement of gas. There is no risk to the village. However, no further building should be allowed on this side of the village to prevent development beyond the clay/sand boundary.

Recommendations:

The hole should be covered whenever and wherever possible with the impermeable material to deal with wind-blown litter, to prevent rainwater washing down through the waste and to reduce gas and smells escaping. The gas should be removed and if possible used. The site should not be used for construction following its use as a landfill site. A litter fence should be built around the site and working hours should be Monday to Friday, 09:00 to 18:00 only. No additional access roads should be constructed.

Why might rainwater be such a problem?

Explain why each of the recommendations in the above paragraph should be implemented.

Laboratory investigations into landfill liners

Thornton, S.F., Bright, M.I., Lerner, D.N. and Tellam, J.H.

Abstract

The design of liners from natural materials that could prevent the leakage of polluted waters from landfill sites is discussed. Laboratory experiments are currently under way to test the performance of natural liners made by combining a range of widely available materials.

There are a number of processes capable of making leachate less harmful during its movement through natural materials. These are a combination of physical, chemical and biological processes e.g. dilution, precipitation of metals, and the action of bacteria in breaking down organic compounds. These processes are maximised by a high clay content, organic carbon content and carbonate content. The carbonate will help to neutralise acids and help the growth of bacteria. Few natural materials contain all of these substances so the liner has to be constructed from locally available materials modified by adding clay, carbonate or organic-rich materials. To test this approach, laboratory experiments are currently being carried out as detailed below.

Experimental design

A set of columns was packed with example liner recipes. Leachate was fed through the columns and the effluent analysed. Three natural materials were selected to form the basis for the recipes. At one end of the spectrum was sandstone which would make a very unsuitable liner without modification. In contrast, Oxford Clay appears to possess the best properties as a liner. Coal Measures clay represents a material of intermediate properties. See Table 1 below.

Introduction

what does this mean?

In recent years waste liquids or leachates have been prevented from polluting the environment by using impermeable liners such as heavy plastic sheeting materials. However, the liner and leachate collection systems cannot be guaranteed not to leak and so it is vital to consider back-up measures, such as using a liner composed of a mixture of natural materials known to reduce the harmful effects of leachate.

why is Oxford Clay likely to be a good liner material?

	sandstone	Coal Measures clay	Oxford Clay
organic carbon %	0.0023	2.6	3.9
carbonates %	<1	<1	14.8
pH	4.8	2.5	7.7

do you know what this means?

Table 1 Typical properties of materials used in the investigation

Based on the properties shown in Table 1, recipes were designed and designated "poor", "improved" or "good" according to the extent to which each is predicted to reduce the harmful effects of the leachate.

Column experiments

Twenty plastic columns were packed with the various test recipes and fitted with collection systems. The columns are fed at a rate of 140ml/day from supply tanks of leachate. Column effluents are sampled twice a week via sampling valves located at the top of the columns and then analysed.

What do you think of the predictions? Do you agree with them?

explain

Material	Materials added	Prediction
Inert sand	-	Control
Sandstone	-	Poor
Oxford Clay	Inert sand*	Good
Sandstone	Oxford Clay (20%)	Improved
Coal Measures clay	Inert sand* + CaCO ₃	Improved

* Added simply to increase flow rates for laboratory experimentation

Table 2 Predicted properties of test materials

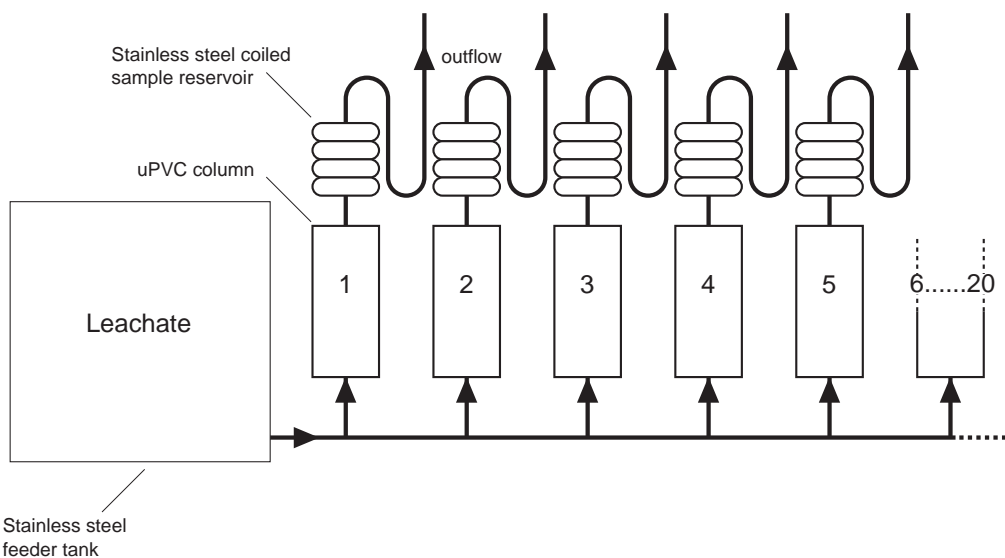


Figure 1 Column Apparatus

how can we learn from the methods used in this paper?

Preliminary results and conclusion

Initial evidence suggests that the test recipes are behaving as predicted in Table 2. The extent to which the results are permanent will be studied at the end of the experiment. The approach, if successful, should permit the engineering of low cost back-up liners for landfill sites from widely available materials.