Department of the Environment
Industry Profile

Chemical works

disinfectants manufacturing works

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Contaminated Land and
Liabilities Division

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The Department's Contaminated Land Research Report series deals with information needed to assess risks; procedures for categorising and assessing risks; and evaluation and selection of remedial measures.

General guidance on assessing contaminated land and developing remedial solutions which is complementary to the Department's publications is provided by the Construction Industry Research and Information Association (CIRIA).

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DOE Industry Profile

Chemical works: disinfectants manufacturing works

This profile is based on work by Dames and Moore International and was prepared for publication by the Building Research Establishment.

Preface

DOE Industry Profiles provide developers, local authorities and anyone else interested in contaminated land, with information on the processes, materials and wastes associated with individual industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination.

Every site is unique. Investigation of a site should begin with documentary research to establish past uses. Information on the site's history helps to focus a more detailed investigation. This knowledge needs to be supplemented by information on the type of contamination that may be present and where on site it may be found. Profiles give information on the contamination which might be associated with specific industries, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on potential contaminants.

The date when industrial practices first commenced on a site and its location are important clues in establishing the types of operations that may have taken place, so each profile provides a summary of the history of the industry and its likely geographical spread within the United Kingdom.

Profiles should be read with the following reservations in mind:

> individual sites will not necessarily have all of the characteristics described in the profile of that industry;
>
> practices can vary between sites and change over time;
>
> as practices change, problems of possible contamination may also change;
>
> the profile may refer to practices which are no longer followed, and may omit current practices which avoid contamination.

The risks presented by contaminated sites depend on the nature of the contaminants, the targets to which they are a potential threat (such as humans or groundwater) and the routes or pathways by which they reach these targets. The current or proposed use of a site and its environmental setting are crucial in deciding whether treatment is necessary and if so, the methods to be used. Some sites may not need treatment.

The information in profiles may help in carrying out Control of Substances Hazardous to Health (COSHH) assessments for work on contaminated land - see Health and Safety Guidance Note HS(G) 66 *Protection of workers and the general public during the development of contaminated land,* Health and Safety Executive, 1991, and *A guide to safe working practices for contaminated sites,* Construction Industry Research and Information Association, 1995.

Note: the chemical names given to substances in this profile are often not the modern chemical nomenclature, but the names used historically for those substances.

Chemical works: disinfectants manufacturing works

1. Background

Disinfectants are substances that kill or inhibit the growth of harmful micro-organisms. They consist of an active ingredient, a biocide, to which other compounds are added to make a marketable product. Depending on the product, they are supplied to customers in solid, liquid or gas form.

Disinfectants are generally understood to be made for application to inanimate objects, whereas antiseptics are medical agents applied to wounds. Examples of the uses of disinfectants are:

- household applications (kitchen/bathroom cleaners)
- industrial plant sanitation
- hospital applications (cleaning and infection control, instrument sterilisation)
- water treatment (water supply, control in air conditioning systems, swimming pools etc)
- sewage treatment.

Heat and radiation are also methods of disinfection but only chemical disinfectants are considered in this profile.

Other biocides (for example herbicides, fungicides and insecticides) are dealt with in the Industry Profile on pesticides manufacturing works (see Section 4).

The disinfectant manufacturing industry emerged on a considerable scale at the beginning of this century. The membership records of the British Disinfectant Manufacturing Association (now the British Association for Chemical Specialities) are probably a good guide to the number of companies manufacturing disinfectants in the United Kingdom, as most companies engaged in this activity are thought to have been members of the Association. The records show that membership increased from 40 in the 1920s to 80 in the 1930s. From 1945 to 1969 membership remained more or less constant, at about 65 companies. There are no figures for the period after 1969, but consultation with industry suggests that there has been little change in the numbers in recent years. The same membership records suggest that about 150 different companies were involved in the manufacture of disinfectants at one time or another between the 1920s and 1969. Some companies may have had more than one manufacturing works.

The manufacture of the active ingredient of disinfectants is normally carried out by an operating division of a large chemical, pharmaceutical or fast moving consumer goods manufacturer. There is no definitive area of disinfectant manufacture in the United Kingdom, but manufacturing sites are to be found in South Wales, Hull, Durham and Teesside in the North East, Warrington and Greater Manchester in the North West, Chesterfield in Derbyshire, and St Albans, Norfolk and Kent in the South East. The development of the industry in these areas can be attributed to good port, rail and road facilities.

The formulation of an active ingredient into a marketable disinfectant was carried out by a number of smaller organisations in various parts of the United Kingdom. This is still the case although the number of sites has decreased.

Some older disinfectants, especially organometallics, have now been reclassified as prescribed substances under the Environmental Protection Regulations (Prescribed Processes and Substances) 1991 (amended).

2. Processes

2.1 Raw materials delivery, storage and transport

The manufacture of the wide variety of disinfectant products commercially available requires a considerable range of raw materials. The typical raw materials include:

- fuel hydrocarbons
- catalysts
- industrial gases, for example oxygen, ethylene, nitrogen, chlorine
- surfactants
- acids and alkalis
- tetrachlorobenzene
- solvents.

For more details on these groups of chemicals, refer to the Annex.

Raw materials are generally delivered to the site by road vehicles or tankers in a variety of containers depending on the physical form in which they are supplied, for example:

- solids in drums, bags or sacks
- liquids in demountable tanks or tankers
- gases in pressurised cylinders, demountable tanks or delivered in bulk by road tankers.

The type of container used to hold the raw materials also depends on whether or not the raw material is corrosive or flammable.

Drums are usually stored inside purpose-built chemical storage warehouses but on older sites they have, in the past, often been kept outside in areas without secondary containment. Bulk liquids are generally stored in bulk storage tanks. Whilst current good practice requires above-ground storage tanks to be equipped with secondary containment bunding, above-ground and underground tanks that have not been contained in this way may be found on older sites.

Drums are normally transferred from storage to the plant, and within the plant, by fork-lift truck or trolleys. Modern good practice requires the use of dedicated drum clamps. Bulk liquids and gases are generally piped into the plant. Within the plant, dry raw materials are frequently manually charged to reactors through ports while barrel pumps are used for liquids.

2.2 Manufacturing processes

There is no single specific process applicable to the production of the active ingredients of disinfectants. As for the production of most chemicals, manufacture is usually carried out in batch processes, chemical reaction being followed by separation and purification steps. The degree of purification depends on the intended use, for example disinfectants used in hospitals need to be very pure. The manufacture of the active ingredients of disinfectants is closely related to that of fine chemicals and pharmaceuticals, which are covered in separate profiles in this series (see Section 4), and may often be carried out on the same sites.

Common production processes are described below, although many other processes may be used, for example hydrolysis of alkenes to form alcohol-based disinfectants.

2.2.1 Sodium hypochlorite

This is widely used in dairies, water and wastewater treatment, and in the home. It is usually produced in batch by diluting sodium hydroxide (note that this contains about 1 ppm mercury) to the necessary starting concentration. This is cooled and chlorine gas is added through a sparger pipe. Although the chlorination reaction is very rapid, some of the side reactions which result in the precipitation of heavy metals and other impurities are substantially slower. It is therefore desirable to allow the finished product to age prior to transferring to tankers for transportation. It is then either decanted or filtered.

2.2.2 Phenolic compounds

Until recently, phenols obtained from coal tar by extraction and distillation constituted the most important disinfectants. Oily waste residues such as phenyl ethers and naphthalenes were often formed in the process.

TCP

The brand name *TCP* used for the medicinal antiseptic, as distinct from a disinfectant, should not be confused with the abbreviation TCP discussed here. The antiseptic *TCP* contains phenol, mono- and di-chlorophenols, which are water-soluble, and iodophenols. It does not contain trichlorophenols which are not water-soluble. The chemical industry uses TCP to denote trichlorophenols.

In the past, chlorinated phenols such as TCPs (2,4,5-trichlorophenol and 2,4,6-trichlorophenol) were used as disinfectants.

2,4,5-TCP was manufactured from 1,2,4,5-tetrachlorobenzene which had been separated from its 1,2,3,4 isomer by continuous crystallisation. The 1,2,4,5-tetrachlorobenzene was hydrolysed in sodium hydroxide, in tubular autoclaves, at a temperature of between 225-300°C over a period of 15-30 minutes (or 160 °C for several hours). If the temperature was not controlled, side reactions may have led to the production of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The resulting sodium 2,4,5-trichlorophenate aqueous solution was neutralised with hydrochloric acid, settled and the organic layer containing the 2,4,5-TCP decanted. The brine layer was discarded after extraction to recover dissolved 2,4,5-TCP, which was further refined by fractional distillation. 2,4,5-TCP cannot be made by conventional chlorination. It is no longer available, owing to the possibility of dioxin formation, but may have been manufactured on old sites.

2,4,6-TCP can be manufactured by direct chlorination of phenol.

OBPCP (Chlorophen)
OBPCP (2-benzyl-4-chlorophenol) is manufactured by the reaction of benzyl chloride with 4-chlorophenol. An appropriate acid catalyst is used, for example sulphonic acids or aluminium chloride (in latter case aluminium hydroxide is a by product). The reaction can also proceed with sodium hydroxide at higher temperatures.

OPP
OPP (o-phenylphenol) is manufactured by dimerising cyclohexanone, followed by the catalytic dehydrogenation of o-cyclohexenylcyclohexanone.

MCOPP
MCOPP (monochloro-2-phenylphenol) is manufactured by chlorination of o-phenylphenol (OPP, see above) with a chlorinating agent such as sulphuryl chloride or elemental chlorine. The process involves direct chlorination of molten OPP, with no solvent being utilised.

PCMC
PCMC (2-chloro-3-methylphenol or 4-chloro-m-cresol) can be manufactured by direct chlorination of m-cresol or by oxidation of chlorotoluene. Direct chlorination with sulphuryl chloride or chlorine results in a crude product which can be purified, to a high level, by distillation and optional crystallisation.

PCMX
PCMX (4-chloro-3,5-dimethylphenol or chloroxylenol) is the active ingredient of the well known disinfectant *Dettol.* It can be manufactured by chlorination of m-xylenol under a range of chlorination conditions, including peroxygen/hydrogen chloride gas, chlorine gas and sulphuryl chloride.

DCMX
DCMX (2,4-dichloro-3,5-dimethylphenol or dichloroxylenol) is produced as a minor co-product with PCMX (above), or as the major product by alteration of the stoichiometry of the chlorination. The material can be isolated by selective crystallisation of the crude mixture.

2.2.3 Hydrogen peroxide

Although hydrogen peroxide has been commercially available since the 1870s, the scale of manufacture and use has rapidly increased since electrolytic processes for manufacture were introduced and industrial bleaching became more important. More recently, lower cost non-electrolytic processes have been used to expand production.

Hydrogen peroxide is handled commercially as aqueous solutions in a wide range of concentrations. It is commonly used as a bleaching agent in paper and textile industries, as an oxidising and reducing agent, and as a supplier of oxygen for other processes or a reagent in organic synthesis. It also has bactericide properties and can be used in the treatment of some toxic wastes. The products of its rapid decomposition are water and oxygen.

Manufacture from barium peroxide
All of the early production of hydrogen peroxide was by the reaction of barium peroxide with sulphuric acid or phosphoric acid. Barium peroxide was formed by the air roasting of barium oxide.

Electrolytic manufacture
From 1908, the barium process for hydrogen peroxide production was gradually superseded by electrolytic processes in which sulphuric acid or ammonium bisulphate was oxidised anodically to perdisulphate, followed by hydrolysis.

Manufacture by autoxidation
The third major industrial route to hydrogen peroxide was first operated on a commercial scale in the mid 1950s and has since almost completely replaced electrolytic manufacture. Known as the autoxidation or AO process, it depends on the reduction of an anthraquinone (dissolved in organic solvents) to anthraquinol using hydrogen, followed by oxidation back to the same anthraquinone with formation of hydrogen peroxide as a co-product. Hydrogen peroxide is removed from the organic compounds by extraction with water and concentrated to produce grades of normal commercial strengths. There is currently only one AO manufacturing facility within the United Kingdom.

2.2.4 Quaternary ammonium compounds
The most common manufacturing process for quaternary ammonium compounds utilises fatty acids as raw material, often coconut fatty acid. Fatty alcohols are also used as raw materials. The process steps are nitrilation with zinc oxide as a catalyst followed by catalytic hydrogenation. Nickel is the most common catalyst while copper and palladium can be used.

Quaternization is often carried out with methyl chloride or benzyl chloride. In older processes alkyl bromides were used, for example in production of *Cetrimide*.

2.2.5 Ethylene oxide
Ethylene oxide is a gas which is a very good bactericide and is therefore widely used as a disinfectant and sterilising agent. A particular application is the sterilization of surgical instruments. A mixture of ethylene, pure oxygen and return gas (in which the ethylene content is 3-5%) is reacted under a pressure of 10-20 atmospheres, in a tubular reactor, with a fixed-bed silver catalyst. The gaseous products are in part returned to this reactor for further reaction, and in part forwarded to a second reactor where the oxidation of ethylene is completed. The gases from both reactors are scrubbed with water to extract ethylene oxide. The aqueous solutions of ethylene oxide from both scrubbing towers are combined and flow to a stripping tower, in which the ethylene oxide is expelled by heating and is fractionated to pure ethylene oxide in other distillation columns. The water is recycled to the scrubbing towers after the expulsion of ethylene oxide.

2.3 Formulation

Disinfectants are formulated by adding various other compounds to the active ingredient, for example solvents, water, soaps and detergents (surfactants) and fragrance, to make a marketable product.

Sodium hypochlorite
Sodium hypochlorite is diluted with water with the addition of detergents or soap

(for thickening) to make bleach or disinfectant as sold to the consumer. Special detergents are used, for example amine oxides or ether sulphates, as the more common ones are broken down by the active ingredient.

Phenolic compounds
Chlorinated phenolics are insoluble in water and, to make an aqueous dilution, they are first dissolved in an oil such as terpinene or a terpineol. Terpineols have inherent germicidal properties. The solution is then emulsified with water by means of a soap. In an antiseptic formulation, alcohol may be added to enhance skin penetration.

Hydrogen peroxide
Hydrogen peroxide is marketed as an aqueous solution, at 3-30% concentration. Owing to its instability, phosphonates are added for stabilisation. A detergent may also be added to the formulation.

Quaternary ammonium compounds
Quaternary ammonium compounds are diluted with water to form a solution of approximately 10% concentration. Non-ionic detergents are added to give the final disinfectant greater cleansing properties.

2.4 Ancillary activities

Some larger manufacturing works may have their own on-site power generating facilities and wastewater treatment plants.

2.5 Waste management

Wastes arising from disinfectant manufacture include solid wastes, liquid effluents and wastewaters.

Waste management policies have advanced significantly in recent years. However, in the past waste materials may have been deposited in on-site landfills and tips, or drained into soakaways.

In modern plants, wastewaters are usually passed through site treatment facilities (for example primary settlement and pH adjustment) and discharged to the sewer as trade effluent. Liquid effluents which cannot be discharged to public wastewater treatment plants are normally tankered to appropriate off-site treatment or disposal facilities, which may comprise landfill co-disposal or incineration. Solid wastes are typically disposed of off-site to landfill or a high temperature incinerator, although some sites may have had on-site incinerators. Spent solvents may be collected and recovered on site or sent for off-site recovery.

3. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials produced there. Potential contaminants are listed in the Annex and the probable locations on site of the main groups of contaminants are shown in Table 1. It is most unlikely that any one site will contain all of the contaminants listed. It is recommended that an appropriate site investigation be carried out to determine the exact nature of the contamination associated with individual sites.

3.1 Factors affecting contamination

It should be noted that on a site where only formulation has taken place, residues can be expected from the formulation additives as well as the active ingredient. On a site where only manufacture of the active ingredient has occurred, potential contaminants are the raw materials and by-products of manufacture, as well as the active ingredient.

Contamination is most likely to have arisen by previous on-site disposal practices, or by spillage and leakage from tanks, pipework and drainage systems.

Bulk solvent storage and transfer operations provide the greatest potential for soil contamination with underground tanks, pipework and tanker off-loading sites being of particular concern. The storage and handling of a wide range of aromatic intermediates, including substituted benzene and phenol compounds, also provide a potential for contamination at certain sites. Hazardous waste storage areas, particularly where these are outside and poorly contained, are also prone to soil contamination, as are solvent recovery plants.

Historical disposal practices were primarily responsible for a legacy of ground and groundwater contamination. Chemical storage was generally less well controlled and it was common practice for any spills or untreated effluents to be washed into surface water drains and localised disposal pits (soakaways). Casual disposal of waste chemicals often took place on site into the soakaways. In addition, dilute and disperse landfills were operated within some large sites. These could be a significant source of contamination, particularly if persistent contaminants such as coal tar distillates were present.

2,3,7,8-TCDD is a potential by-product from the manufacture of chlorinated phenolic disinfectants and should not occur on sites where such processes have not taken place, unless chlorinated organic wastes have been incinerated. Sites where the presence of 2,3,7,8-TCDD is suspected should be investigated with care.

Mercury is a specific contaminant of sodium hydroxide in the sodium hypochlorite manufacturing process. Older hypochlorite-manufacturing sites may contain landfill deposits of mercury.

On sites with power generation facilities, electricity substations may be a source of polychlorinated biphenyl (PCBs) enriched oils.

Asbestos may have been used in pipe lagging or as cladding or roofing on buildings and this may also give rise to contamination. This waste asbestos material may be found in discrete dumps on the site where plant has been dismantled or it may still be associated with existing buildings and plant.

3.2 Migration and persistence of contaminants

The risk to groundwater from contamination depends on the depth of the water-table and the soil structure and properties. Generally, the higher the natural organic matter and clay content within the soil, the greater the adsorption of organic pollutants and the lower the mobility. Consequently, the greatest migration of contaminants occurs in coarse-grained sands and gravels with little natural organic matter. The less soluble compounds which become adsorbed onto clay or organic matter may continue to desorb into the soil-water.

Most of the organic solvents liable to be encountered may be found in liquid or vapour form; close to the soil surface, some vapour will be lost directly to the atmosphere by evaporation.

The most water-soluble organic compounds comprise the alcohols, aldehydes and phenols. These dissolve and readily migrate through the soil system and eventually to the groundwater. Phenols are very mobile, particularly phenol itself, which is very soluble and can migrate considerable distances from its source. Phenol can also permeate water supply pipes of polymeric materials such as polyvinyl chloride (PVC) and can attack the joints of metal pipes which are usually made of (PVC) or plastic sealing compounds.

Other less soluble organics, for example benzene, cresols and hydrocarbons, also tend to migrate to the water-table. Despite their relatively low solubility, their dissolved concentrations may be several orders of magnitude greater than water quality standards permit.

Those compounds that are less dense than water float on the water-table surface. However, chlorinated compounds, for example chlorobenzenes, are denser than water and tend to migrate to the bottom of aquifers. They are also persistent chemicals. Their migration may be opposite to the general groundwater flow.

If contamination by organic solvents is widespread, it may provide the opportunity for groundwater contamination by other organic materials which have low solubilities in water but are readily soluble in such solvents.

Organic contaminants may naturally biodegrade but some of these (for example benzene, chlorobenzenes, polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons) may persist due to unfavourable environmental conditions for degradation, such as aerobic conditions or lack of appropriate micro-organism populations. Natural biodegradation may result in a significant removal of organic compounds but will be less for compounds which have a greater number of chlorine atoms per molecule (significant quantities of which may occur on disinfectant manufacturing sites), have a higher molecular weight, or a lower degree of solubility. Tars are likely to persist because of their insolubility and as a result of unfavourable environmental conditions for degradation. Many biocides are biodegradable, but at high concentrations, biodegradation may be reduced by the high toxicity of the compounds. If oil is present, it may absorb biocides, making them unavailable for chemical and biological degradation processes. Some of the organo-metallic biocides, polychlorinated biphenyls (PCBs) and some of the halogenated organics which are fat-soluble may enter the food chain.

PCBs and dioxins, such as TCDD, are not biodegradable and are extremely persistent. Sodium hydroxide and sodium hypochlorite are soluble and mobile but not biodegradable.

The movement of metals through the soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals may increase under acidic conditions. In other cases the relationship is more complex. Most metals in their metallic form have limited mobility, compared with that in the salt form. However mercury compounds and organometallics can be highly mobile. Metals are not biodegradable.

Acid spillage near buildings may affect the integrity of concrete and cements used in foundations.

Asbestos is neither soluble nor biodegradable . Wind may be a transport mechanism where there is gross surface contamination by some of the less mobile contaminants, particularly metals and asbestos.

4. Sources of further information

4.1 Organisations

For information concerning the disinfectant manufacturing industry in the United Kingdom the following organisations should be consulted:

The British Association for Chemical Specialities Limited
The Gatehouse
White Cross
Lancaster
LA1 4 XQ

The Chemical Industries Association Limited
Kings Buildings
Smith Square
London
SW1P 3JJ

The Society of Chemical Industry
14/15 Belgrave Square
London
SW1X 8PS

4.2 Sources of information concerning the activities described in this profile

Considine D M. *Chemical and process technology encyclopaedia.* McGraw-Hill Book Company, 1978.

Eckroth D, Graber E, Klingsberg A and Siegel P M. *Kirk-Othmer concise encyclopaedia of chemical technology.* John Wiley and Sons, Chichester, 1985.

Sconce J S. *Chlorine, its manufacture, properties and uses.* Reinhold Publishing Corporation, 1967.

Case study including information relevant to this Industry Profile:

Paul V. *Bibliography of case studies on contaminated land: investigation, remediation and redevelopment.* Garston, Building Research Establishment, 1995.

Information on researching the history of sites may be found in:

Department of the Environment. *Documentary research on industrial sites.* DOE, 1994.

4.3 Related DOE Industry Profiles

Chemical works: fine chemicals manufacturing works
Chemical works: pesticides manufacturing works
Chemical works: pharmaceuticals manufacturing works
Chemical works: soap and detergent manfacturing works

4.4 Health, safety and environmental risks

The Notes issued by the Chief Inspector of Her Majesty's Inspectorate of Pollution (HMIP) provide guidance for the processes prescribed for integrated pollution control in Regulations made under the Environmental Protection Act 1990. Of particular relevance are:

Her Majesty's Inspectorate of Pollution. *Processes for the production or use of acetylene, aldehydes etc.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/3. London, HMSO, 1993.

Her Majesty's Inspectorate of Pollution. *Batch manufacture of organic chemicals in multipurpose plant.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/5. London, HMSO, 1993.

Her Majesty's Inspectorate of Pollution. *Processes for the manufacture of, or which use or release halogens, mixed halogen compounds or oxohalocompounds.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/13. London, HMSO, 1993.

Her Majesty's Inspectorate of Pollution. *Processes for the halogenation of organic chemicals.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/15. London, HMSO, 1993.

The Control of Substances Hazardous to Health (COSHH) Regulations 1994 and the Management of Health and Safety at Work Regulations 1992 are available from HMSO. Information on relevant health and safety legislation and approved codes of practice published by HSE publications are available from Health and Safety Executive Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS (telephone 01787 881165), as well as HMSO and other retailers.

Information on the health, safety and environmental hazards associated with individual contaminants mentioned in this profile may be obtained from the following sources:

Howard P H. *Handbook of environmental fate and exposure data for organic chemicals.* Vols I and II. USA, Lewis Publishers, 1990.

Sax N and Lewis R. *Hazardous chemicals desk reference.* New York, Van Nostrand Reinhold Company, 1987.

Verschueren K. *Handbook of environmental data on organic chemicals.* 2nd Edition. New York, Van Nostrand Reinhold Company, 1983.

4.5 Waste disposal and remediation options

Useful information may be obtained from the Department of the Environment series of Waste Management Papers, which contain details of the nature of industrial waste arisings, their treatment and disposal. A current list of titles in this series is available from HMSO Publications Centre, PO Box 276, London, SW8 5DT.

Publications containing information on the treatment options available for the remediation of contaminated land sites, prepared with the support of the Department of the Environment's Research Programme, can be obtained from National Environmental Technology Centre Library, F6, Culham, Abingdon, Oxfordshire, OX14 3DB.

A full list of current titles of Government publications on all aspects of contaminated land can be obtained from CLL Division, Room A323, Department of the Environment, Romney House, 43 Marsham Street, London, SW1P 3PY.

Advice on the assessment and remediation of contaminated land is contained in guidance published by the Construction Industry Research and Information Association (CIRIA), 6 Storey's Gate, Westminster, London, SW1P 3AU.

Annex Potential contaminants

The chemical compounds and other materials listed below generally reflect those associated with the industry and which have the potential to contaminate the ground. The list is not exhaustive; neither does it imply that all these chemicals might be present nor that they have caused contamination.

Organic compounds

Organometallics	organo-mercury compounds eg mercuphenol chloride
Polycyclic aromatic hydrocarbons (PAHs) from coal tar	anthracene and its derivatives eg dibenzanthracene benzo(a)pyrene fluoranthene naphthalene and its derivatives eg methylnaphthalene pyrene
Other components residues of coal tar	cresols eg m-cresol phenols phenyl ethers xylenols
Chlorinated organic compounds	monochlorobenzene dichlorobenzenes tetrachlorobenzenes trichlorobenzenes chlorophenols eg 2,4,5-trichlorophenol, 2,4,6-trichlorophenol 4-chlorophenol 4-chloro-2(phenylmethyl)phenol 4-chloro-m-cresol chlorotoluene chloroxylenol dichloroxylenol 2-benzyl-4-chlorophenol (chlorophen) benzyl chloride monochloro 2-phenylphenol perchloroethylene
Halogenated organics	bromophenolalkyl bromides
Solvents (non-chlorinated)	acetaldehyde benzene cyclohexanone ethanol ethyl dimethyl benzenes isopropanol methyl cyclohexyl acetate trimethyl benzene

	trimethyl benzenes (1,2,4-, 1,3,5- and 1,2,3-) tetramethyl benzenes (1,2,3,5- and 1,2,4,5-) 1-methyl-(2 or 3 or 4)ethylbenzene napthalene toluene other components of multi-hydrocarbon solvents eg *Shellsol AB* *Shellsol A*
Other organic compounds	amines anthraquinones eg ethyl anthraquinone formalin glutaraldehyde nitriles o-phenylphenol
Dioxins	2,3,7,8-tetrachlorodibenzo-p-dioxin
Surfactants	non-ionic eg alcohol ethoxylates linear alkyl benzene sulphonates anionic eg sodium salt of alkyl aryl sulphonate cationic eg benzalkonium chloride

Inorganic compounds

Metals, metalloids and their compounds	aluminium aluminium chloride barium salts copper magnesium chloride manganese chloride mercury and its salts eg mercuric chloride nickel palladium silver zinc chloride zinc oxide
Other inorganic ions	ammonium bisulphate bisulphites bromides chlorides chlorates fluorides iodides hypochlorite sulphates

Acids	hydrochloric nitric phosphoric sulphuric
Alkalis	sodium hydroxide (caustic soda)

General contaminants

Asbestos	
Polychlorinated biphenyls (PCBs)	
Fuels	coke/coal oil

Table 1 Main groups of contaminants and their probable locations

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Main groups of contaminants	Location						
	Raw materials delivery/storage/ transfer	Process buildings manufacture/ formulation	Solvent recovery	Incinerator	Fuel storage/ pipework	Electricity substations/ transformer areas	Waste storage areas and on-site disposal
Metals, metalloids and their compounds	■	■					■
Acids and alkalis	■	■					
Asbestos		■		■			■
Solvents	■	■	■				
Coal tar components including phenols, polycyclic aromatic hydrocarbons (PAHs)	■	■					■
Fuel oils and coal		■		■	■		
Waste organic compounds (can be chlorinated)							■
Polychlorinated biphenyls (PCBs)				■		■	
[1]Dioxins				■			■

[1] Dioxins, which may be produced in incineration processes, are likely to be dispersed over a wide area by stack emissions.

Shaded boxes indicate areas where contamination is most likely to occur

DOE Industry Profiles

Airports
Animal and animal products processing works
Asbestos manufacturing works
Ceramics, cement and asphalt manufacturing works
Chemical works: coatings (paints and printing inks) manufacturing works
Chemical works: cosmetics and toiletries manufacturing works
Chemical works: disinfectants manufacturing works
Chemical works: explosives, propellants and pyrotechnics manufacturing works
Chemical works: fertiliser manufacturing works
Chemical works: fine chemicals manufacturing works
Chemical works: inorganic chemicals manufacturing works
Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works
Chemical works: organic chemicals manufacturing works
Chemical works: pesticides manufacturing works
Chemical works: pharmaceuticals manufacturing works
Chemical works: rubber processing works (including works manufacturing tyres or other rubber products)
Chemical works: soap and detergent manufacturing works
Dockyards and dockland
Engineering works: aircraft manufacturing works
Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)
Engineering works: mechanical engineering and ordnance works
Engineering works: railway engineering works
Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards)
Engineering works: vehicle manufacturing works
Gas works, coke works and other coal carbonisation plants
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works
Metal manufacturing, refining and finishing works: iron and steelworks
Metal manufacturing, refining and finishing works: lead works
Metal manufacturing, refining and finishing works: non-ferrous metal works (excluding lead works)
Metal manufacturing, refining and finishing works: precious metal recovery works
Oil refineries and bulk storage of crude oil and petroleum products
Power stations (excluding nuclear power stations)
Pulp and paper manufacturing works
Railway land
Road vehicle fuelling, service and repair: garages and filling stations
Road vehicle fuelling, service and repair: transport and haulage centres
Sewage works and sewage farms
Textile works and dye works
Timber products manufacturing works
Timber treatment works
Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants
Waste recycling, treatment and disposal sites: hazardous waste treatment plants
Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites
Waste recycling, treatment and disposal sites: metal recycling sites
Waste recycling, treatment and disposal sites: solvent recovery works
Profile of miscellaneous industries incorporating:
- Charcoal works
- Dry-cleaners
- Fibreglass and fibreglass resins manufacturing works
- Glass manufacturing works
- Photographic processing industry
- Printing and bookbinding works

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