

Chemical works

pesticides manufacturing works

Industry Profiles, together with the Contaminated Land Research Report series, are financed under the Department of the Environment's contaminated land research programme.

The purpose of these publications is to provide regulators, developers and other interested parties with authoritative and researched advice on how best to identify, assess and tackle the problems associated with land contamination. The publications cannot address the specific circumstances of each site, since every site is unique. Anyone using the information in a publication must, therefore, make appropriate and specific assessments of any particular site or group of sites. Neither the Department or the contractor it employs can accept liabilities resulting from the use or interpretation of the contents of the publications.

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: pesticides manufacturing works

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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: pesticides manufacturing works

1. Background

Pesticides are used to kill or render harmless organisms that may cause damage to agriculture, horticulture, forestry, industry or the home. They may be substances, preparations or organisms themselves.

Pesticides can be divided into the following groups:

- insecticides
- fungicides
- herbicides
- rodenticides and other vertebrate control products
- wood preservatives and remedial treatments
- surface biocides
- antifouling products
- other pesticides (molluscicides, lumbricides, soil sterilants and fumigants).

This profile covers the production of the active ingredients which are contained within pesticides and their formulation into products suitable for use. Ectoparasiticides, such as sheep dips, have been included in this profile although, strictly speaking, they are veterinary medicines.

The formulation of wood preservative and remedial treatment products and the pre-treatment of wood with preservatives before use are covered in a separate profile (see Section 4).

The earliest pesticides were inorganic salt mixtures, principally arsenates, which were used as insecticides. Also, sulphur compounds mixed with bases were found to be an effective fungicide.

In the 1940s, synthetic organic pesticides were developed and this led to considerable growth in the pesticide industry. Organic synthesis now accounts for the vast majority of all pesticides manufactured. There are probably more than 600 active ingredients used in pesticides worldwide and these are incorporated in over 3000 formulations.

A significant factor affecting the evolution of the pesticide industry in the United Kingdom is the growth of regulatory control since the Control of Pesticides Regulations 1986 came into operation. The Regulations detail the pesticides which are subject to control and those which are excluded. They also prescribe the approvals required before any pesticide may be sold, stored, supplied, used or advertised. This control has led to the withdrawal of many pesticides on health, safety and environmental grounds and the frequent introduction of new, safer products. Many compounds withdrawn from use may have caused past contamination at existing or former pesticide manufacturing sites.

Information on pesticides manufacturing works as separate from other chemicals manufacturing works is not available for the period before 1979. Data obtained from the Census of Production indicate that since 1979, the number of sites has fluctuated between 41 and 85. In 1993 there were 82 works, 49 of which employed fewer than 10 people and 9 of which employed more than 200.

2. Processes

The majority of the commonly used pesticides fall within one or more of the following broad groups:

- inorganic
- organochlorine
- organophosphorus
- organonitrogen
- metals
- organometallic
- phenolic or phenoxy-based
- metal carboxylates
- quaternary ammonium
- other organic compounds
- biological pesticides
- pyrethroids.

Common examples of pesticides from within these groups which are potential contaminants are listed in the Annex. The Pesticides Handbook and the Pesticides Manual (see Section 4) should be consulted for further information on these and other pesticides.

Pesticide manufacture can be divided into primary and secondary processing. Primary processing, the production of the active ingredient, is based on synthetic organic chemistry and generally involves several process steps. Secondary processing involves the formulation of the pesticide into a marketable form. Both types of processes are carried out in the United Kingdom.

2.1 Raw materials

The range and diversity of pesticide products means that a wide range of raw materials is required as precursors. It is common for a single plant to produce many separate products, some of which may not be pesticides; for example, some products may be active ingredients for pharmaceuticals.

The principal raw materials are carrier solvents, acids and bases and industrial gases. Other raw materials include metals, other inorganic compounds and a wide range of organic precursors derived from petroleum.

Carrier solvents are used as reaction media in pesticide manufacture and to transfer material mixes in formulation processes. Oils may also be used in some pesticide formulations.

Acids and bases are used as buffers in various reactions, in wet scrubbers (aqueous acid or alkali solutions for removing gaseous reaction products), in wastewater treatment (for pH adjustment) and in de-ionised water production (for regeneration of the ion exchange beds).

Gases, including chlorine and hydrogen chloride, may be used in reactions, while nitrogen may be used to purge gas lines, prevent secondary reactions, dilute reaction gases, or in product drying. Sometimes the noble gases are also used.

2.2 Delivery, transfer and storage of raw materials

Dry active ingredients and additives are most commonly supplied in polyethylene-lined paper sacks or fibreboard kegs. For large scale operations, materials may be delivered in large fibre bags or in bulk, by tanker. Liquid active ingredients, solvents and additives are usually supplied in polypropylene-lined steel drums or delivered in bulk by tanker. Where active ingredients are formulated on site, they may be piped directly to the formulation plant, often via intermediate holding vessels.

Current practices generally include the provision of secondary contained tankage and tanker off-loading stances, and tank overfill protection systems to ensure the safe and secure off-loading of all tankers. In the past less care may have been taken.

Drummed raw materials may be stored inside purpose-built chemical storage warehouses, equipped with fire suppression equipment and secondary containment to receive spills and/or fire fighting water. Historically, raw materials may have been stored in unprotected outdoor compounds without protection against spills or secondary containment.

2.3 Primary processing

Typically, pesticide manufacture is by batch process in which the raw materials are weighed and transferred to reaction vessels; solids may be added manually, whereas liquids are transferred via pipes. Bulk liquors, typically aliphatic, aromatic or chlorinated hydrocarbons, are also added to the reactor (see Annex).

The reactions required to produce specific pesticides depend on the product chemistry but may involve alkylation, chlorination and similar addition or substitution reactions. Normally, the plant is indirectly heated or cooled to maintain reaction temperatures and modern plants are often computer-controlled.

After production, the pesticides must be purified to the standard required for the final product. Solid products are discharged to a filtration unit, where the resulting cake may be washed with water or solvents and then dried, often at high temperatures. Where flammable or volatile liquids are dried, the air in the dryer may be replaced by nitrogen, which is inert. Liquid products are typically distilled to remove solvents, and distilled again to purify the product.

2.4 Secondary processing

Pesticide formulation normally is a batch process involving only physical operations. These may include vessel charging, mixing, milling, warming, cooling, granulation, drying, sieving, product transfer and packaging. In general, no chemical reactions take place.

In addition to the pesticides themselves, formulations may contain additives such as dust carriers, solvents, emulsifiers, wetting and dispersing agents and deodorants or masking agents.

In most cases, multi-purpose plant is used for the formulation of many different products. Formulation may take place at the site where the active ingredients are manufactured, or at a separate site to which the active ingredients are transported.

2.5 Products

The final products from the manufacture of pesticides may be either the active ingredients sold for formulation elsewhere, or ready formulated products for sale on the agricultural, industrial or domestic (home and garden) market. In the former case, the product is usually dispatched in 200 litre drums to formulators.

Formulated final product may be packaged for distribution in containers ranging from 200 litre drums for large-scale agricultural use to small 500 millilitre containers for retail supply. Products may be in the form of powders, pellets, granules or liquids.

Pesticides are prescribed substances for release to land and water under the Environmental Protection Act 1990.

2.6 Wastes

Wastes arising from pesticide manufacture and formulation include both solid wastes and liquid effluents, including contaminated process waters.

Typically, wastewaters will be discharged via on-site treatment facilities to the public sewer as trade effluent. On-site treatment may only involve primary settlement and pH adjustment. More sophisticated treatments such as anaerobic digestion or wet air oxidation may be required for certain processes.

Hazardous liquid effluents, which cannot be discharged to public wastewater treatment systems or dealt with on site, will usually be taken by tanker to appropriate off-site treatment or disposal facilities. These may include co-disposal landfills, hazardous waste treatment plants or high temperature incineration facilities. Used solvents may be collected and recovered on site or sent for off-site recovery (see Section 4).

Solid wastes will usually comprise purification residues, such as spent activated carbon, and will probably be taken to landfill sites for disposal or be incinerated in high temperature incinerators as appropriate. In the past some solid wastes may have been incinerated on site and both solid and liquid wastes may have been disposed of on site in landfills or waste dumps.

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

Sites may have been occupied by the industry over a considerable period of time and the nature of the activities and the physical location of plant buildings and storage areas may have changed.

Soil contamination is most likely in connection with bulk solvent storage and transfer operations, and particularly with underground tanks and tanker off-loading areas. Some spillages and leakages during loading, transfer and charging operations are almost inevitable during the life of a plant. Hazardous waste storage areas, especially outdoor ones, and solvent recovery plants may also cause soil contamination. Surface water soakaways on any site with a long history of industrial use will also be areas of possible contamination, as are on-site landfills used for waste disposal.

In addition, older facilities may have tanks and underground pipework containing residues of pesticides, solvents, process waste and other chemicals.

Fuel oil may have been stored on site for heating and steam-raising, particularly on older sites. Areas around such storage tanks could be contaminated as a result of spillage and leakage.

On sites containing their own electrical equipment such as transformers, polychlorinated biphenyls (PCBs) may be present.

Asbestos may have been used as lagging for boilers and pipework or in roofs and cladding in the form of asbestos cement sheeting. It may have caused local contamination during removal or demolition of plant or buildings.

Contamination may have taken place during decommissioning, demolition or restructuring of plants and spillages may have occurred during removal of tanks, pipework and redundant plant. Old wastes might also have been moved about during plant development phases.

Fire in storage or other areas of the manufacturing or formulation site is a further potential cause of contamination, through spillages of liquids or other potentially fugitive materials, or through runoff of fire fighting water.

3.2 Migration and persistence of contaminants

3.2.1 Metals

Except in areas used for burial of wastes, metal contamination is likely to be found close to the surface.

The movement of metals through the soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals (eg copper, zinc and lead) may increase under acidic conditions. In other cases the relationship is more complex. For example, trivalent chromium is more soluble under acidic conditions, whereas the solubility of hexavalent chromium is increased under both acidic and alkaline conditions and arsenic may become more soluble at higher pHs.

3.2.2 Organic compounds

Many of the organic solvents that may be encountered are volatile with moderate to high vapour pressures. They will readily partition from the liquid phase to the vapour phase, resulting in high concentrations in the soil pore space above the unsaturated zone. Close to the soil surface, some will be lost directly to the atmosphere by evaporation. Some of the other less soluble solvents, eg toluene, may migrate to the water-table. In most cases, such compounds are less dense

than water and will, therefore, float on the water-table surface. However, chlorinated solvents are denser than water and will tend to migrate to the bottom of water bodies. Their migration may not be consistent with the general groundwater flow.

The more soluble organic solvents, including the alcohols (eg methanol) and acetone, will dissolve in water and readily migrate through the soil system and eventually reach groundwater. Organic contaminants with an inherently high mobility include the phenols, particularly phenol itself, which is very soluble and can migrate considerable distances from its source. Phenols can also permeate water supply pipes made of polymeric materials such as polyvinyl chloride (PVC). The occurrence of widespread contamination by solvents may improve the mobility and potential for groundwater contamination by organic compounds which, though of low aqueous solubility, may dissolve readily in such organic solvents.

The transport and fate of both inorganic and organic compounds within soil will be dependent on a combination of physical, chemical and biological factors. The higher the organic matter and clay content within the soil, the greater the degree of adsorption of the organic compounds and the slower their migration. Thus, the greatest degree of migration will occur in coarse-grained sands and gravels with little organic matter. The less soluble compounds which become adsorbed to clay or organic matter will provide on-going sources of water pollution long after the source has been removed, by continuing to desorb into the soil water. Therefore, the risk from buried organic compounds to current and potential water supplies may be considerable. Lateral movement through the soil, either in the dissolved or free phase, may also affect surface water.

Biodegradation processes in soils can be influenced by a number of factors, namely moisture content, oxygen concentration and pH, acting separately or in combination. For example low moisture content reduces microbiological activity, while high moisture content can reduce oxygen penetration and possibly lead to anaerobic soil conditions. Such conditions enhance the biodegradation of some materials, eg chlorinated compounds, while aerobic conditions are needed to biodegrade many oils. Also, low pHs tend to reduce the bacterial population and encourage fungal activity; at pHs lower than 5, microbiological activity is much reduced. The presence of heavy metals also inhibits micro-organisms. Because of these factors, at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

Chlorinated solvents are relatively persistent chemicals and can render groundwater unsuitable for public supply, even at low concentrations.

3.2.3 Other factors

Certain plants can absorb pesticides and metallic compounds; herbicides and fungicides are designed to be taken up by plants but insecticides can also penetrate plant material.

Polychlorinated biphenyls and some of the other halogenated organic compounds are fat soluble and have a propensity to accumulate in food chains.

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

The occurrence of any fires on site may have greatly influenced migration potential of some contaminants.

4. Sources of further information

4.1 Organisations

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

British Agrochemicals Association
4 Lincoln Court
Lincoln Road
Peterborough
PE1 2RP

British Crop Protection Council
49 Downing Street
Farnham
Surrey
GU9 7PH

Pesticide Safety Directorate
Ministry of Agriculture, Fisheries and Food
Ergon House
17 Smith Square
London
SW1P 3JR

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

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

4.2 Sources of further information concerning the activities described in this profile

Austin G T. *Shreve's Chemical Process Industries*. 5th Edition. London, McGraw Hill, 1984.

Dragun J. *The soil chemistry of hazardous materials*. Hazardous Materials Control Research Institute, Silver Spring, MD, USA, 1988.

Hill I R and Wright S J L (Editors). *Pesticide microbiology*. Academic Press, London, 1978.

Ministry of Agriculture, Fisheries and Food/Health and Safety Executive. *Pesticides Handbook (Pesticides approved under The Control of Pesticides Regulations)*. London, HMSO (published annually).

Rochkind-Dubinsky M L, Saylor G S and Blackburn J W. *Microbial decomposition of halogenated aromatic compounds*. Marcel Dekker Inc., New York, 1987.

Wallfer P R and Engelhardt G. *Microbial degradation of pesticides*. In 'Chemistry of Plant Protection Volume 2'. Eds. G Haug and H Hoffman. Springer Verlag KG, Berlin, 1989.

Worthing C R and Walker S B (Editors). *The pesticide manual*. 8th Edition. The British Crop Protection Council, 1987.

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.

Estimates of the size and geographical distribution of the pesticides manufacturing industry can be obtained from the following Central Government statistics, held principally by the Guildhall Library, Aldermanbury, London and the City Business Library, 1 Brewers Hall Garden, London:

Business Monitor Series: Annual Census of Production Reports. Central Statistical Office, HMSO (from 1970 to date).

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: organic chemicals manufacturing works

Timber treatment works

Waste recycling, treatment and disposal sites: solvent recovery 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. *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 organo-metallic compounds.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/7. London, HMSO, 1993.

Her Majesty's Inspectorate of Pollution. *Processes for the manufacture of, or which use or release, halogens, mixed halogen compounds or oxohalo compounds.* 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.

Her Majesty's Inspectorate of Pollution. *Pesticide processes.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/18. 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/groups 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. In particular, the list of pesticide groups contains the main groups and common examples which may be present. A very large number of materials are or have been used as active ingredients of pesticides, either singly or in combination. For more information on pesticides consult the Pesticides Handbook and the Pesticides Manual (see Section 4).

Principal materials related to manufacture

Organic solvents (halogenated)	dichloromethane ethylene dichloride trifluoroacetic acid trifluoroethanol fluorobenzene carbon tetrachloride
Organic solvents (non-halogenated)	acetone methanol dimethyl formamide aromatic hydrocarbons and derivatives eg benzene, toluene, phenols, pyridine
Organic acids	acetic benzoic
Mineral acids	hydrochloric sulphuric
Metals, metalloids and their compounds	arsenic copper eg copper arsenates, cupric acetate, copper sulphate chromium lead eg lead arsenate manganese zinc vanadium (used as a catalyst) thallium (used as a catalyst)
Bases	sodium hydroxide (solid or aqueous solution) calcium hydroxide

Typical pesticide groups, common examples and their uses

Metallic compounds (inorganic)	copper-chromium-arsenates, copper salts, mercuric chloride ¹ mercuric oxide ¹ , mercurous chloride ¹ - used as preservatives, fungicides and antifouling products
Organometallic compounds	
organotin	tributyl tin oxide ¹ - used as a wood preservative and antifouling product
organic arsenicals	cacodylic acid ² - used a as herbicide
Organophosphorus	dichlorvos, bromophos, diazinon, malathion - used as insecticides
Organochlorine	aldrin ¹ , dieldrin ¹ , chlordane ¹ , DDT ¹ - used as insecticides lindane ¹ - used as an insecticide and for vertebrate control
Carbamates	aldicarb - used as a molluscicide and soil sterilant aminocarb ² - used as an insecticide maneb ¹ -used as an insecticide, fungicide and antifouling product
Organonitrogen compounds	
substituted ureas	diuron, linuron - used as herbicides
dinitroanilines	trifluralin, 2,4-dinitroaniline - used as herbicides
other nitrogen derivatives	dinitrocresol ¹ , dinoseb ¹ - used as herbicides and insecticides dinocap - used as a fungicide
triazines	atrazine ¹ , simazine, propazine - used as herbicides
Phenoxyacids	2,4 dichlorophenoxyacetic acid ² , mecoprop, 2,4,5 trichlorophenoxyacetic acid ² - used as herbicides
Phenolics	pentachlorophenol ¹ and other chlorinated phenols - used as wood preservatives
Metal carboxylates	copper naphthenate, zinc naphthenate - used as wood preservatives and antifouling products zinc versatate - used as a wood preservative
Quaternary ammonium (diphyridils) compounds	diquat, paraquat - used as herbicides

Pyrethroids permethrin - used as an insecticide and preservative
resmethrin, bioresmethrin - used as insecticides

Others

herbicides benzoic acids, eg chloramben²
anilides eg alachlor²
chlorinated aliphatic acids, eg sodium salts of
trichloroacetic acid, dalapon (2,2 dichloropropanoic
acid)
amines eg picloram
ammonium sulphamate

rodenticides pyriminil²
warfarin

molluscicide metal dehyde

¹ Use now banned or severely restricted by The Control of Pesticides Regulations but
may have been manufactured in the past

² Not listed in the Pesticides Handbook but may have been manufactured in the past

Other potential contaminants

Dioxins Impurities in, for example, organochloride
compounds, phenoxyacids, chlorinated phenols and
benzenes, and may result from combustion of
chlorinated organic compounds

Chlorates

Coal tar residues

Polychlorinated biphenyls (PCBs)

Asbestos

Fuel oils

Coal and ash

Effluent treatment chemicals sodium bisulphate, hydrochloric acid, phosphoric acid
- used as pH adjusters

'Spent' activated carbon

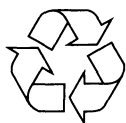
Table 1 Main groups of contaminants and their probable locations**Chemical works: pesticides manufacturing works**

Main groups of contaminants	Location											
	Raw materials delivery/storage/transfer	Process areas			Products storage/transfer	Wastes reject storage	Waste disposal	Process pipework/pumps	Drainage system including soakaways	Fuel storage/pipework	Effluent treatment areas	Electrical transformer areas
		Building fabric	Manufacture/formulation	Solvent recovery								
Mineral acids	Shaded		Shaded			Shaded	Shaded	Shaded		Shaded		
Alkalis	Shaded		Shaded			Shaded	Shaded	Shaded		Shaded		
Asbestos		Shaded				Shaded	Shaded					
Organic solvents	Shaded		Shaded	Shaded		Shaded	Shaded	Shaded		Shaded		
Pesticides ¹	Shaded		Shaded			Shaded	Shaded	Shaded		Shaded		
Tars ²	Shaded		Shaded			Shaded	Shaded					
Polychlorinated biphenyls (PCBs)											Shaded	
Fuel oils	Shaded					Shaded		Shaded	Shaded			
Effluent treatment chemicals	Shaded			Shaded		Shaded		Shaded		Shaded		

¹including all relevant raw materials, formulations and potential impurities (including dioxins)

²still-bottoms

Shaded boxes indicate areas where contamination is most likely to occur.



Recycled paper

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
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Fibreglass and fibreglass resins manufacturing works
Glass manufacturing works
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