SESSION 9C

WASTE DISPOSAL AND MANAGEMENT

Chairman & Session Organiser:	Bill Basford *Mechanisation Consultant, Southwell, UK*
Platform Papers:	9C-1 to 9C-4

The extension of the Waste Framework Directive to waste from agricultural premises in England and Wales

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ABSTRACT

Since the 1970's agricultural waste has been excluded from the waste controls that impinge on other industrial sectors in the England and Wales. However this is in breach of the Waste Framework Directive and the European Commission has "infracted" (prosecuted) the UK Government for this failure. The UK Government's response to this infraction is to introduce Regulations (due in December of this year) applying Waste Framework Directive controls to agricultural waste.

INTRODUCTION

The Waste Framework Directive aims to control against harmful effects caused by the collection, transport, treatment, storage and tipping of waste. In particular in Article 4 it lists the following objectives in relation to the disposal or recovery of waste:

(a) to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment and in particular without -
   (i) risk to water, air, soil, plants or animals; or
   (ii) causing nuisance through noise or odours; or
   (iii) adversely affecting the countryside or places of special interest.

This is the main point of the Directive. To ensure that these objectives are met Article 8 and 9 of the Directive requires that the recovery or disposal of waste by an establishment or undertaking (but not a private individual) must be carried out under a permit.

An important aspect of this requirement to have a permit is the ability for member states to make exceptions to that general rule by virtue of Article 11 of the Directive.

Additionally the Directive requires that an establishment or undertaking carrying out an excepted activity need to register with the competent authority (usually the Environment Agency in England and Wales).

The Directive also requires that the establishments or undertakings transporting waste on a professional basis also need to be registered with the competent authority (usually the Environment Agency in England and Wales).

EU Directives have to be transposed into domestic legislation: that is to say they have to be given effect by each member state writing national laws that replicate the requirements of the Directive.

The UK Government has done this by way of the Environmental Protection Act 1990 (EPA) and its underpinning secondary legislation, or in other words "regulations" (not to be confused with an EU Regulation, which has direct effect in member states).

This Act creates "Waste Management Licensing" which gives effect to the article 8 and 9 requires disposal and recovery activities to have a permit.

The UK Government have also used their power under Article 11 and provided 44 exceptions to the need to have a permit. These exceptions are known as exemptions and are contained within Schedule 3 of the Waste Management Licensing Regulations 1994 (WMLR). The majority of these exemptions have to be registered with the Environment Agency in England and Wales or the Scottish Environmental Protection Agency, where the activity is in Scotland.

By enacting the Control of Pollution (Amendment) Act 1991 ("Registered Carriers") the Government also gave effect to the Directive requirement the transporters of waste needed to be registered.

But the only problem is:

> When the Government gave effect to the Waste Framework Directive (WFD) it created a UK definition of waste (in Section 75 of the EPA) that specifically excluded waste from agricultural premises.

This has the practical effect of dis-applying Waste Framework Directive controls for agricultural waste in England and Wales.

The European Commission noticed this breach of European legislation and "infracted" (basically a prosecution in the European Courts) the UK. The UK offered no defence for this breach and now has an adverse judgement from the European Court against it.

Scotland has been progressively changing its legislation to incorporate agricultural waste but to date no changes have been made south of the border.

This means that the Department for Environment, Food and Rural Affairs (Defra) must give effect to the Directive in England and Wales before the European Court begins imposing fines.

What is agricultural waste?

In excluding agricultural waste from control the Government had to define it. This definition is:

> Waste from premises used for the purposes of agriculture within the meaning of the Agriculture Act 1947.

The 1947 Agriculture Act defines agriculture as being:

"...horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use is ancillary to the farming of land for other agricultural purposes, and 'agriculture' shall be construed accordingly."

It is important to remember that agricultural waste includes both natural (organic wastes) and non-natural waste.

Research shows that agriculture generates about 500,000 tonnes of non-natural waste each year (Environment Agency, 2001). Although this represents only some 0.125 % of all wastes arising in the UK, the impact of the controls will be felt by most farmers as they will have to seek alternatives to on-farm burning and burial (see below). The yearly costs associated with off farm disposal have been calculated to be about £45M, which represents an average cost to farmers of £277 a year (1.8% of the average farmer's income in 2003).

Key non-natural waste streams	
Packaging wastes	Machinery wastes
(plastics and cardboard and paper)	(including oils, batteries and tyres)
Non packaging plastics	Building waste
(silage wrap)	(including asbestos cement roof sheeting)
Animal Health products	

In addition agriculture generates some 9M tonnes of manure and slurry and other organic by-products, the majority of which are used on farm to fertilise the land and are not discarded as waste (see below).

How the waste framework directive will be given effect to with England and Wales

Defra has already consulted on the regulations it intends to make to give effect to the Directive for agricultural waste in England and Wales. The consultation paper included a set of draft regulations, which are due to take effect from 5 December 2005 (at the time of writing). In preparing those draft regulations (The Waste Management (England and Wales) Regulations, 2005) Defra took account of the commitments given by the Prime minister in the **Action plan For Farming**. These commitments were that his Government would:

".....Start from the position that the Directive does not apply to manure and other natural, non-dangerous substances used on farms for agricultural benefit;

• Ensure that, where controls are necessary, they will be proportionate to the environmental and human health risk;

• Make full use of powers to provide licensing exemptions – especially for the re-use and recycling of waste – without charges;

• Ensure that registration schemes for exemptions and waste carriers are as simple as possible; and

• Provide that farmers carrying waste as an incidental part of their businesses are exempt from the requirement to register."

How the waste management (England and Wales) regulations 2005 give effect to the action plan for farming

Taking the components of the Action plan in order.

"..the Directive does not apply to manure and other non-natural ...used on farms for agricultural benefit."

Unfortunately the Directive does apply to such materials used in farming. However Defra has stated its position that:

"(a) Where a farmer is using manure/slurry on the farm on which it is produced as a fertiliser or soil conditioner to meet the requirements of agricultural land (i.e. the use is beneficial to the land), then it is not being discarded as waste and does not fall within the WFD's controls.

(b) Manure/slurry may be waste:-

(i) where a farmer uses it on the farm on which it is produced in quantities which exceed the requirements of agricultural land (i.e. it is not beneficial); or

(ii) it is transferred from the farm on which it is produced for use by someone else. In this case, Defra (Defra, 2005) confirmed its intention to exercise the UK's discretion under Article 11 of the WFD to provide a licence exemption where the use of the manure/slurry provides "benefit to agriculture or ecological improvement.""

We will discuss the exemption referred to by this statement below.

Ensure that, where controls are necessary, they will be proportionate ....;

Make full use of powers to provide licensing exemptions... without charges

Both these commitments are allied. Providing exemptions to the need to have a waste management licence is the means by which Defra is proportionate in its approach.

We consider that 24 of the existing exemptions are of relevance to farming. In addition to these exemptions already existing, the regulations make three new exemptions relating to manure and slurry spreading, milk spreading, and the rotting down of plant tissue at the site of production. Additionally the Regulations amends an existing exemption to ensure that it is applicable to the burning of agricultural plant tissue. Defra intend to conduct a second, supplementary consultation that may suggest further exemptions.

The regulations create an exemption for the spreading of manure and slurry. This exemption must be considered in the light of Defra's and the Environmental Agency's position on when manure and slurry become a waste. This exemption is applicable when the manure and slurry is exported off-farm and used for agricultural benefit or ecological improvement.

There is a clear commitment that these exemptions are available free of charge. The consultation paper makes clear that there will be no charges for any exemption that involves agricultural waste.

Ensure that registration schemes for exemptions and waste carriers are as simple as possible

Provide that farmers carrying waste as an incidental part of their businesses are exempt from the requirement to register

This commitment places an obligation upon the Environment Agency to make our exemption registration systems as simple as possible. Over the coming months we will be putting in place the systems needed to discharge this obligation. Those systems are likely to involve registration through Defra's Whole Farm Appraisal initiative.

However the Regulations go further when implementing registration systems for waste carriers. The regulations dis-apply normal carrier registration, as described above. Instead they have applied a much simpler registration system called:

"Registration by professional collectors and transporters of waste, and by dealers and brokers" (see Paragraph 12 of Schedule 4 of the Waste Management Licensing Regulations 1994).

This registration system differs from normal registration in that:

1. it is one-off (that is the registration does not have to renewed every 3 years;
2. it cannot be refused or revoked;
3. there is no fee for registration.

In applying this lower level of registration control Defra have given effect to the last two Action-plan commitments.

Farm tips /dumps

Some 32% of farmers currently use 'farm tips' for a variety of wastes including asbestos and in some cases the disposal of oils and lead acid batteries (Environment Agency, 2004).

The consultation paper accompanying the draft regulations is very clear on this subject. It advises framers that they should stop using their farm tips/dumps before the regulations come into effect or face the full rigours of the Landfill Regulations.

If a farmer continues to accept waste after the commencement date for the regulations he is supposed to send us a "conditioning plan" if he wishes to continue that farm/tip. Our role is also made clear. We, as the regulator, are meant to close down the existing farm tip including all previous deposits when:

i) the farmer decides he does not want to continue to take waste (operator has taken waste after the commencement date of the regulations but decides that he isn't going to continue taking waste);

ii) we decide, after receiving a conditioning plan, that the farm tip (or any part of it) cannot meet the requirement of the landfill regulations (we are required to set out this decision, and the reasons behind it, to the operator by way of notice); and

iii) the operator fails to submit a conditioning plan.

The big problem for the farmer is that the tip closure has to be in accordance with the Landfill Regulations, which will involve him in significant time and money (over an uncertain timeframe). These closure requirements will also have to take into account all the previous deposits made at the landfill.

Of course the farmer could make an application for a landfill permit but, given that it costs in the order of £16,000 just to make an application and he will have to have planning permission, we do not consider that this will be a viable option for most farmers.

Therefore the advice contained within the consultation is extremely valid and will be one of our key messages to farmers.

Sheep-dip disposal

Disposing of used sheep-dip to land under a groundwater authorisation is potentially a landfilling activity caught under the Landfill Regulations 2002.

This would place a ban on the disposal of sheep-dip to land.

However it is Defra's position that an area of land covered by a groundwater authorisation does not be come a landfill if it is used infrequently to dispose of used sheep-dip.

As such it is our position that the disposal of sheep-dip to land does not become a landfill if the disposal does not take place on the same area more than once a year.

In addition, Regulation 17 of the WMLR provides an exclusion from waste management controls where liquid waste is disposed of under a groundwater authorisation (and the disposal is not landfilling).

Therefore we intend to control the disposal of used sheep-dip to land under groundwater authorisations. This approach does not require any additional controls. We consider that using an authorised area more than once a year is banned by virtue of the Landfill Regulations 2005.

We will also apply this approach to the disposal of pesticide washings under groundwater authorisations.

Burning

Farmers currently burn a variety of waste on farm, including paper and card, plastics, clinical waste and plant material. They principally use two methods to burn: open burning and a drum incinerator (commonly used to burn pesticide containers. Indeed research (Environment Agency, 2004) shows that 70% of farmers burn plastics in the open and the shows that 10% of the UK's annual dioxin loading is attributable to this burning (see ENTEC report 2004).

The only thing that farmers will be able to burn legally will be plant tissue. Therefore farmers will have to phase out their reliance on burning and seek alternatives.

IMPLEMENTATION

Defra intend to put in place various transitional arrangements to give farmers the time to comply with these new controls. This timetable (assuming an implementation date of 5 December 2005 is as follows:

Pre-December 2005	Final Date for farm tips
December 2005-	Duty of care applies and Transitional provision for licensing begins
June 2006	Schedule 12 registration for carriers and brokers
December 2006	Hazardous waste controls have effect (subject to the Hazardous Waste Regulations being amended Waste management licensing and exemptions have effect.

The new controls will be a challenge to both the farming community and the Environment Agency. Our environmental aim when implementing these controls is:

To improve the environmental performance and waste management standards on farms progressively and in a fair and proportionate way so that the environment and human health are better protected.

What we actually want to achieve can be seen in our key objectives:

- *To ensure that the agricultural industry is fully aware of the new controls and how they will affect them*
- *To ensure that the new controls are implemented in a manner that is proportionate to the environmental and health risks posed by the sector*
- *The adoption of a regulatory and enforcement policy that is transparent, fair and fit for purpose*
- *Encourage the adoption of best practice in sustainable farm waste management through research and communication with the farming sector*

- *Establish a baseline against which to measure the benefits of regulation and other measures on the environment and health impacts of farm wastes against farm waste performance indicators*
- *To work with others to educate the farming industry to minimise farm waste, reuse and recycle it as much as possible*
- *To work with others to promote recycling and recovery of farm waste*
- *To promote the adoption of an Environmental Management System for farms and the 'whole farm' approach.*

You can see from these objectives that we understand that our implementation has to be sensitive to the needs of farming. It needs to recognise that other industrial sectors have been evolving with waste controls since the 70's whereas farmers have to comply overnight (well, "over-year"). Therefore our regulatory strategy focuses on guidance and education and measuring the effects of implementation. But farmers have to respond and actually see this change as a real opportunity to save money by minimising and re-using their waste.

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On farm retrieval – logistics options

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ABSTRACT

Total agricultural waste arisings – excluding straws and crop by-products – amount to over 200,000 tonnes each year. The inclusion of agricultural waste as a 'controlled waste' in the context of relevant Environmental Regulations now means that farms will have to address the issue of returning this material for further use in the emergent waste reprocessing sector, covering other industries, commercial and municipal arisings throughout the UK. The question is – what is the most financially and environmentally cost-effective framework within which the return of products ranging from tractor tyres to silage films, can be structured? To do nothing is not an option – this process is driven by broader environmental considerations targeting improved resource efficiency and the reduction of airborne emissions from uncontrolled on farm burning (the most common destination for a significant proportion of the tonnage). At £50 per tonne – the average cost of managing domestic waste at the moment – the financial costs to the sector could amount to as much as £10m annually. In terms of the timetable, draft regulations will be published in December 2005 with the Environment Agency claiming a light touch application for at least 15 months or so. Nevertheless, it is now time to consider the optimal methods by which manufacturers, the agricultural sector, the waste industry, and scrap material processing organisations can develop the necessary infrastructure to meet this challenge.

THE SCALE OF THE PROBLEM

A considerable amount of work has already been undertaken in relation to this area, the most prominent of which are:

- The Biffaward funded Environment Agency Agricultural Waste Survey in 2003 (ISBN 1844321916).
- The Biffaward funded study undertaken by the Resource Recovery Forum entitled "Farm Packaging Waste – Proposals for a UK Collection and Recovery Scheme". (Available from +44 (0) 1756 709808).
- The Biffaward funded agricultural mass balance study entitled "Agricultural Waste Mass Balance: Opportunities for Recycling and Producing Energy from Waste Technologies (produced by C-Tech Innovation Ltd., 2002, +44 (0) 151 339 4181). Figure 1 shows the breakdown of agricultural waste streams.

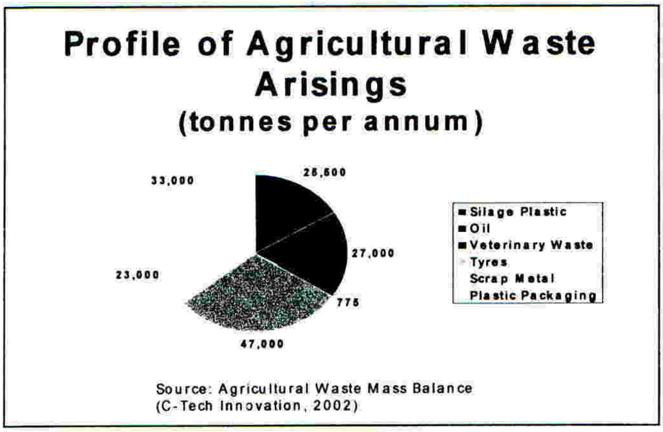


Figure 1. UK Agricultural waste: silage plastic, oil, veterinary waste, tyres, scrap metal and plastic packaging

Further studies in the Environment Agency 2003 work estimate that plastic is, by far and away, the most significant material stream comprising 32,000 tonnes of sacks/packaging and 103,000 tonnes of non-packaging plastics (of which around 75% comprises silage and much film materials). Early Environment Agency enforcement action will also be focused on this plastics element of the stream. Historically, much of this material was subject to distributed on farm burning but the recognition that the combustion of around 80,000 tonnes of such material and the transfer of dioxins plus other particulates into the atmosphere, has now driven a commitment to end this practice. On a positive note, there is also a growing realisation that in the area of biomass utilisation, the agricultural sector offers opportunities for further integration with the waste sector in terms of energy recovery systems for using straws, sugars, and waste carbohydrate products from the direct agricultural stream.

The concept of Producer Responsibility is also a significant force. Producer Responsibility, (the concept whereby manufacturers and/or supply chains take responsibility for end life by-products from their materials and packaging), is growing apace. Initially developed for the packaging sector in industry and consumer markets, the concept is now rolling out to end life vehicles and waste electrical and electronic appliances (including batteries and mercuric lighting devices). Whilst early attempts to develop on farm retrieval systems failed, it is now likely that within 5 years there will be a statutorily enforced Producer Responsibility film relating to the supply of packaging and film materials into agriculture, within which freeloaders will not be able to achieve competitive advantage (as has happened in the past). The central notion of Producer Responsibility is that the end life management costs for a product are transferred from the last user/disposer to the manufacturer and are thereby incorporated into the selling price of the product on an equitable basis linked to volume, tonnage, or value or sales. In theory, such Producer Responsibility mechanisms can also access economies of scale in delivering integrated retrieval systems to maximise collection route densities and costs of disposal through bulking up.

A framework of economic instruments is also emerging in the form of Tradeable Pollution Permits, whereby companies can buy or sell traded certificates which are awarded by a central audit body, depending on whether they over- or under-achieve their targets. In effect they have the option to fund the scheme by purchasing 'get out of jail' certificates, or fund active retrieval systems and be awarded 'credits' which it can sell to competitors (Figure 2).

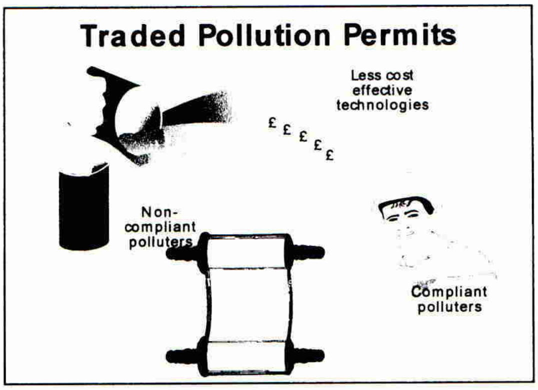
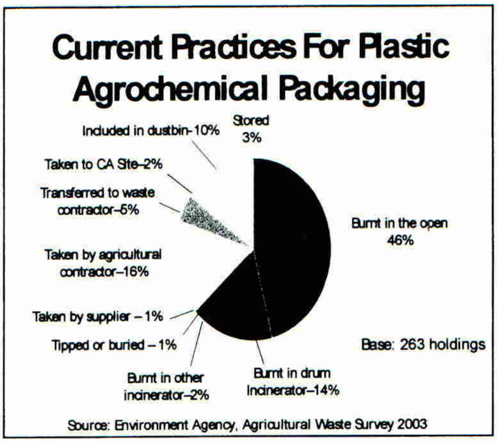


Figure 2. Traded pollution permits

Current practices for disposal of agrochemical packaging, and plastics etc.

The scale of the issues around agrochemical packaging, and plastics specifically, in terms of current disposal systems is borne out by the Environment Agency survey. Figures 3, 4, 5, 6, 7, and 8 all indicate current methodologies for disposal and the scale of open burning is self evident.

The elements of a farm waste packaging strategy comprise a complex mixture of methodologies to trigger behaviour change from sticks and carrots through to a re-examination of the product design itself, to the characteristics of a logistics collection infrastructure and, finally, the development of viable exit routes for the retrieved product, through systems that are themselves environmentally compliant in terms of emissions standards and capability to meet current and future regulations. This complex interaction requires the participation of all players in the entire supply chain, each of which has established prejudices and sunk capital costs in existing methodologies. It is unlikely, for instance, that the filler packers could easily move from disposable to returnable systems (and there are question marks as to whether returnable systems would be environmentally sensible anyway given the distances which pharmaceutical and farm protection chemicals are transported in the first place).



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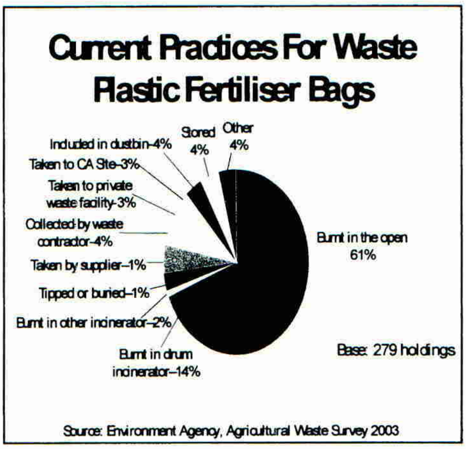

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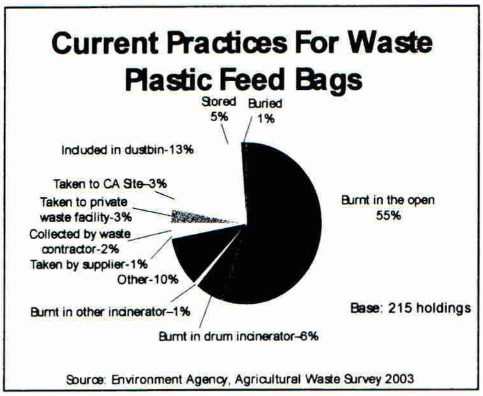

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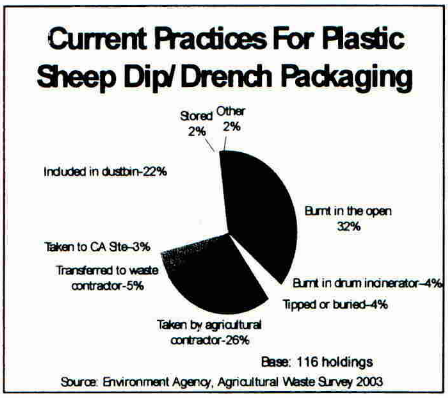

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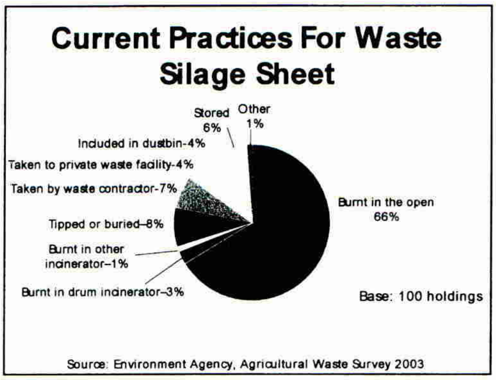

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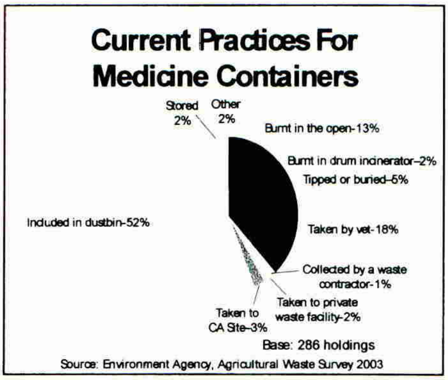

Figure 8.

Logistics

As far as logistics is concerned, commonsense suggests that some form of bulking up is going to be necessary to minimise economic impacts. With over 200,000 separate economic units in the UK the agricultural sector is going to need some form of direction around other farms, co-operatives, or integrate with extant municipal and industrial waste transfer station sites, appropriate to the geography and established infrastructure available in different regions. At those concentration sites, some form of bulking up will be achieved through compaction, shredding or other intermediate treatment, before final dispatch to the recycling or energy conversion sectors (Figure 9).

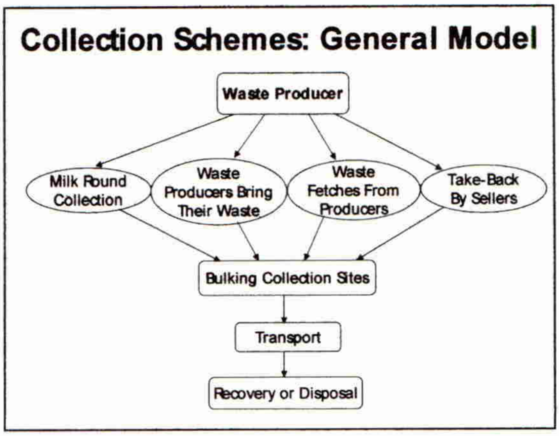

Figure 9. Model for collection schemes

Agricultural on-farm retrieval issues

The detailed mechanism will result from the interplay of 3 basic drivers:

- Producer economics: funding, market 'pull' (recycling, energy)
- Technology options: logistics density,process exits (power, cement)
- Socio political issues : EU experience, market creation (WRAP), planning, definitions

The timing of Producer Responsibility in the different waste product material chains will shape funding. Optimal systems for agricultural films and plastic packaging have yet to be tested. What is clear from experience in the waste electronic and the packaging sectors is that there is a reluctance on the part of competing suppliers to participate in joint programmes when it comes to retrieving their waste material. In the end life vehicles sector, the major car marques made it clear from the start that they were eventually prepared to accept a funding liability for vehicles that they placed on the market themselves (directly or through subsequently acquired companies) but they were resistant to the idea of funding end life management for suppliers

who had either gone out of business or no longer operated in the UK. The nature of that debate for packaging and films suppliers is thus one that needs to be triggered early.
As far as technology is concerned, the biggest cost driver is vehicle collection route density. Existing waste vehicles are unlikely to be cost effective in serving individual farms and they are not designed in such a way that they can co-collect domestic waste and on farm agricultural waste on the same vehicle. It is thus likely that local farmers will form collection cooperatives to bulk concentrate this material, either on one of their own farms or at local farm cooperatives who are supplying the product in the first place. This will then enable the transfer of 10- or 20-tonne loads long distances to energy or recycling plants. There is also the question of intermediate processing technology, insofar as silage films will require some form of washing and shredding facility whether they go to co-firing biomass power plants, cement kilns, dedicated gasification plants or back to the plastics industry for recycling.

In the socio political arena there is also a challenge in relation to extant retrieval programmes that operate in Europe, the relativities of end market values for recovered products (largely a contest between energy value and recyclate value), questions of planning and licensing consent, and the attitude of the Environment Agency to what constitutes a waste operation at on-farm level. If the latter are classified as waste processing centres, they will almost certainly be subject to some form of expensive licensing regime through annual fee structures. The funding models for Producer Responsibility are many and varied – Figure 10 demonstrates the different models that have emerged in packaging, waste electrical equipment and mercuric lamps. Under the auspices of Defra, additional funding has been made available to investigate these options in more detail.

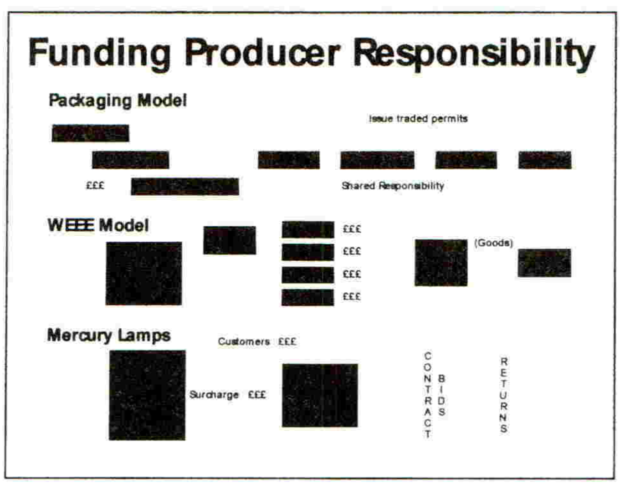

Figure 10. Funding models for Producer Responsibility: packaging, waste electrical equipment and mercuric lamps.

The Business Resource Efficiency & Waste Programme (BREW) has funded further work in this area under the chairmanship of the Chartered Institute of Wastes Management (CIWM). For more information on the aim of this work contact Ivan Good on 01604 844625 or ivan.good@btinternet.com. The BREW Programme's outputs matrix falls into four broad areas – logistics, economics, end market creation, and dissemination.

Current experience with extant and/or aborted schemes is highly variable, but most appear to operate at a cost of around £80-£100 per tonne with limited expectations of contributions from farms. It is likely that the cost per tonne will stabilise at the lower end of this expectation if large-scale Producer Responsibility schemes can be put together on an integrated basis. These figures apply generally to polytunnel, silage and other films, which account for the majority of on farm plastics. The issues for hazardous waste containers that are contaminated with pesticide and other organic chemicals are rather different. Within the RRF report, Ross Dyer undertook a wide range of work positing typical costs per container on an annualised basis as the scheme is rolled out nationally. That assumed a scheme start-up in 2005 – a date likely to be moved back by at least 2 years. It is anticipated that per kilo of plastic, the likely cost will be of the order of 35p with a total scheme cost in the region of £1m by 2010/2011. This is equivalent to around £9,000 per percentage of market share in a producer scheme. Cost per container would be around 10 -15p for a container that could wholesale to the farmer at £85 or more (Figure 11).

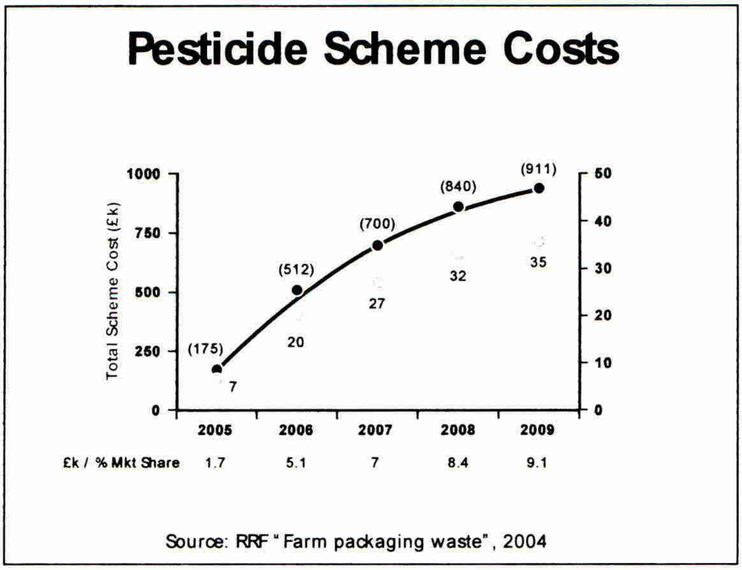

Figure 11. Anticipated costs of the Pesticide scheme: total cost of scheme £k (upper line); per kg of plastic (lower line)

CONCLUSION

The development, introduction and management of a national UK wide on-farm agricultural waste management programme therefore represents substantial challenges. Elements of this process are subject to emergent agreement between manufacturers, farmers' organisations, and the waste industry – work that will require close cooperation, communication and integration by all those participating within it. To do nothing is not an option – the uncontrolled disposal of over 80,000 tonnes of materials annually, through the agricultural sector, in the form of significant air pollution will no longer be tolerated and will exposure farmers to far greater risks in terms of human health and the financial cost of prosecutions. It is therefore in all our interests to move forward to a resolution of this issue, at the earliest opportunity.

Global pesticide packaging waste collection and recovery schemes with particular emphasis on Europe

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ABSTRACT

There are at least 13 crop protection industry schemes around the world which collect and arrange the recovery of pesticide packaging waste. They have been introduced as a result of product stewardship, direct legislative requirements or an economic instrument. Running costs of such schemes vary according to the time that they have been operational but all achieve costs lower than the normal waste disposal route. The full participation of farmers, legislators, economies of scale and efficient logistics are the fundamentals upon which low cost operation is built. Financing of schemes is normally through a levy on crop protection companies and is recovered through the cost of products to farmers. Most schemes achieve over 50% collection within a five-year period with the Belgian scheme achieving 80-90% for almost all of its operation. This paper provides detailed information on these schemes but the main focus is to draw out the common points of all schemes and examples of best practice.

INTRODUCTION

UK agricultural holdings will be subject to industrial waste laws and this will mean that farmers will need to ensure that their waste is disposed of safely or they risk prosecution. This will inevitably lead to an increase in farm costs and this, in turn, may lead to additional unsafe practices. The new law could also mean that more farm waste enters landfill at a time when the Government is trying to discourage this means of disposal and promoting recovery.

Farm packaging waste, which is often contaminated, is a major environmental hazard that can result in air, soil and water pollution, particularly when it is burned or buried. Therefore any new solution to dealing with farm packaging waste needs to immediately and permanently reduce the risk to the environment and should be given a high priority.

Other countries have demonstrated that the collection of pesticide packaging waste is achievable and provides a safe, low cost and sustainable means of dealing with the risk associated with this waste stream. Such schemes, some of which include recycling, also assures the crop protection industry of the safe disposal of the waste and underpins product stewardship.

Clearly farmers would prefer that all their plastic and packaging waste be collected from farms at one go - however this is likely to be impracticable, long term and high cost. The aim of this paper is to provide the reader with information on the pesticide collection and recovery schemes that exist around the world and to present an analysis of them in order to draw out common themes and lessons that could be adopted in the UK.

CURRENT INDUSTRY COLLECTION AND RECOVERY SCHEMES FOR PESTICIDE PACKAGING WASTE

The table below lists the global schemes that have been set up by manufacturers of crop protection products to collect pesticide packaging waste from the marketplace. Visits have been made by the author to the German, Belgium and French schemes to have discussions with their management, obtain information and see them in operation. Information on the other global schemes was either obtained direct from the scheme or from the European Crop Protection Association (ECPA). Croatia, Romania, Slovakia, Turkey, Slovenia, Lithuania are only at the planning stage

Table 1. List of Global schemes set up by manufacturers of crop protection products to collect pesticide packaging waste

Country	Name Web Site	Operating Since	Collects	Sites	Funding Source	I E R	Material Recycling
France	ADIVALOR www.adivalor.fr/en/	2001	PP	3500	Industry Levy	33%	No
Germany	RIGK PAMIRA www.pamira.de/en/index.asp	1990	PP	300	Industry Levy	59%	No
Holland	STORL www.nefyto.nl	1989	PP		Industry Levy		No
Belgium	PHYTOFAR www.phytofar.be	1997	AP	250	Industry Levy	92%	No
Luxemburg	PHYTOFAR www.phytofar.be	2003	AP		Industry Levy		No
Spain	SIGFITO Agroenvases www.sigfito.es/	2002	PP		Industry Levy	16%	No
Portugal	VALORFITO www.anipla.com/	2005	PP		Industry Levy		No
Poland	PSOR System	2005	PP		Industry Levy	4%	No
Hungary	CSEBER www.cseber.hu/	2003	PP		Industry Levy	46%	No
USA	ACRC www.acrecycle.org	1992	PP		Industry Levy		Yes
Canada	CPICM www.croplife.ca	1989	PP		Industry Levy	>70%	Yes
Australia	drumMuster www.drummuster.com.au/	1998	PP		Industry Levy		No
Brazil	inpEV www.inpev.org.br/index.asp		PP		Industry Levy	96%	Yes
Central	America	2002	PP		Industry Levy	24%	
South	America	2002	PP		Levy	6%	
Italy	CONAi www.conai.org	Local Initiatives	PP				
Czech	EKO KOM www.ekokom.cz/	National Scheme	All wastes				
Austria	ARA www.ara.at/ara_engl/	National Scheme	All wastes			70%	

IER; Industry Energy Recovery

PP; Collects primary plastic packaging of various sizes, AP; all primary and secondary packaging

COMMON THEMES

It is clear from both the research and practical scheme experience that for any sustainable waste strategy to be successful in any sector of industry that a number of fundamental building blocks need to be in place. These are:

- Marketplace drivers to bring the scheme about
- An agreement between all the 'core stakeholders' to move forward and which includes the critical success factors
- Prevention of waste at source by product design which includes the introduction of reuse containers where appropriate
- Packaging which is designed so that it can be cleaned
- Characterisation of the waste arising in the sector
- Cleaning of the waste at source
- Achieving a non hazardous classification of the waste
- A collection process which meets the needs of suppliers and customers
- A means of reprocessing the waste collected
- An end-use market
- Cost and a funding mechanism
- Measurement and targets

Marketplace Drivers

The drivers must be clear and understood so that the solution is obvious and supported by all the stakeholders involved. Most industry sector schemes operate best when they have a legal or binding voluntary framework and a number of industry sectors, particularly those that produce products that contain dangerous substances have been driven forward by this means. Many global pesticide schemes have been set up to meet or avoid specific laws or economic instruments. The Belgian, German, Dutch and Brazilian schemes are good examples.

An early ban on farm disposal, coupled with laws that make the producer responsible, has provided a key driver in many European countries.

The cost of legal disposal in comparison with an industry run scheme and the effect on product sales, are equally strong drivers in all countries. Increasingly farmers see waste management, which costs money, as a key element of their buying decisions and the global schemes have provided an industry answer to this problem.

An evaluation of the development of policy within Europe suggests that, within a short period of time, collection of pesticide packaging waste may become a requirement of selling crop protection products.

Stakeholder participation

In all global schemes manufacturers, distributors and farmers have been the core stakeholders who have lead and managed national schemes. The involvement of legislators and the waste industry has also been fundamental to success. Voluntary supply chain initiatives for stewardship reasons have been the means of unifying the sector behind a strategy.

Greatest success has been achieved where the core stakeholder senior management jointly agree to the direction being taken and the consequences of that decision including financial arrangements. Having a written Concordat and a business plan that outlines the options, process, cost and funding has helped stakeholders make a decision to move forward.

In most schemes there are contractual arrangements with a waste company who in many cases provide supporting stakeholder participation.

Prevention of waste at source

All farm packaging should be designed with waste reduction, collection and recycling as part of the design criteria. There are already laws in place in the UK which underpins this requirement. ECPA members have for some time had an agreement to ensure that their packaging meets standards which will facilitate pack cleaning on farms. The need for high standards of pack design needs to be fully extended to the design of formulations and application equipment. In many countries the education of farm operators is not as advanced as it is in the UK.

Characterisation of the waste stream

The physico-chemical characterisation and knowledge of the waste stream particularly the quantities involved is fundamental to the collection process and funding. At the moment almost all global collection schemes concentrate on the removal of primary heavy-duty polyethylene (HDPE) packs from farms.

On farm waste management and cleaning

Farmers need to understand that lowest cost and safe disposal can only be achieved by cleaning packaging waste on farm after use. Reducing the volume by crushing and ensuring that poorly cleaned packs are segregated is vital to cost reduction and recycling. A legal requirement for farmers to rinse packs as part of the pesticide approval process has helped in a number of countries.

In countries where material recycling takes place on farm segregation of different plastics and cardboard assumes an even higher priority.

Most schemes supply farmers, usually through the distribution chain, with heavy-duty sacks in which they can collect their rinsed packs. The bags are then sealed and labelled before being presented for inspection at the collection site.

Waste classification

No global scheme would be able to operate if it had to meet all the legal requirements attached to the disposal of hazardous waste. The logistics of such an operation would be impossible to implement, maintain and finance. Therefore achieving a non-hazardous classification for rinsed clean and drained pesticide packaging waste is fundamental to the operation of global schemes.

The application of the requirements of European legislation to classifying rinsed pesticide packaging shows that almost all of this type of waste is non-hazardous. However, some EU countries still classify the waste as hazardous.

Currently this issue is the number one challenge to the successful continuation of such schemes worldwide.

The collection process

All pesticide collection and recovery schemes operate the same general model:
On farm storage > Transport by farmer > Bulking collection site(s) > Volume reduction > Transport > Recovery with some disposal

Scheme leadership and central management are the most important part of any national scheme. Schemes are involved in all aspects of waste management including on-farm and this has led to a significant reduction in the risk to the environment, particularly water, of pesticide packaging waste. The key to operating any collection system is the effective management of the logistics involved and achieving low recovery costs as a result of competitive tendering.

All schemes operate with the full involvement of the farmer who brings the packaging waste to a collection site. 'Take Back' of packaging waste by the distribution trade, whilst helpful, is not fundamental to the success of collection schemes. Distributor sites are the backbone of most pesticide collection schemes. However, it is possible to collect and recover waste from farming groups using the models used by European Pesticide Schemes. The logistics of the scheme needs to be tailored to suit the activities of the farming group concerned.

Understanding the waste management licensing regulations and taking advantage of exemptions where appropriate reduces cost. A quality control step before waste is accepted at a collection site to stop hazardous waste from contaminating non-hazardous waste at the collection site is an important part of the process.

The majority of schemes are set up as 'not for profit' companies separate from the operation of the local trade association. Crop Protection Companies affect control by being the majority on a stakeholder board of directors.

Costs and funding

The main cost elements of schemes are those associated with the central management team, which are normally fixed, and those associated with the amount of packaging waste collected which are variable. Operational costs decrease as the amount of packaging collected increases and can start as high as an 'all-in' cost of 2000 Euro per tonne recovered. All schemes in Europe tend towards an operational cost of c. 1100 Euro per tonne recovered. There is no clear relationship between the numbers of staff employed in a scheme and the size of the market. A manager and secretarial support being the minimum that exists, but some schemes employ in excess of ten staff. All global schemes are run on a 'not for profit' basis.

Almost all schemes that have been running for some time and have therefore achieved economies of scale realise that recycling is the main means of getting income into the scheme and stabilising the funding required.

Funding can be a bar to setting up such schemes and needs to be addressed early. All global schemes use a levy system and in most, the funding comes from crop protection companies who are members of the country trade association. The annual levy is, except for one case, based on the amount of packaging placed on the marketplace. Funding is recovered from the marketplace through the cost of the product. There are distinct advantages to both the scheme and the industry in levy funding. For the scheme it avoids the need for third party finance and markedly reduces operational costs. For the levy payer it answers a customer need, ensures control and demonstrates producer responsibility.

Free riders, i.e. companies who do not pay the levy but take advantage of the scheme because it is difficult to sort packs at collection sites, are a problem in all types of industry-run schemes and can in some cases threaten the viability of the scheme. In many countries the law has helped in controlling the Free Rider problem.

End use markets

Most schemes are implemented over a period of years and many achieve greater than 50% collection and recovery within a 5-year period. The Belgian scheme, driven by a tax on pesticide packaging, has achieved a recovery level of greater than 80% from very early stages.

Recycling of rinsed, clean, pesticide-packaging waste, which had contained dangerous preparations, is carried out in a number of countries in the Americas but not in Europe. Within Europe the accepted practice has been to incinerate the packs collected with energy recovery, cement kilns being used as a disposal route in at least one country.

In the Americas metal and metal containers are being recycled into metal for the construction industry. Cardboard boxes, if uncontaminated, are being recycled back into paper products. However, many boxes cannot be recycled as farmers used them to retain primary packaging. These are incinerated.

Plastic bottle caps are being recycled into new caps for pesticide bottles and casing for batteries. HDPE bottles are being recycled into pipes for electricity cables, packs for motor oil, corrugated tube, fence posts, pallets and drainpipes. Coex HDPE bottles are being recycled into plastic wood, electric wiring boxes and railway sleepers.

All recycling is carried out under industry control and has to meet high health and environmental safety standards.

CONCLUSIONS

For a UK stand-alone pesticide packaging waste scheme the best option would be to adapt the process that works in other countries. This decision is based on the following:

1. No other alternative being available or shown to be more effective.
2. Farmers in the UK indicating that they would support a pesticide collection scheme and this being confirmed by the experience in other countries.
3. They are not for profit and operate at lower cost than the farmers arranging their own individual disposal with waste companies.
4. They operate safely and have been shown to deliver on farm environmental improvements.
5. Levy funding with recovery through product cost underpins the producer responsibility concept and internalisation of environmental costs.
6. The possibility of the future recycling of the pesticide packaging waste collected.

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Biobeds: the story so far

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ABSTRACT

Pesticides may be released to farmyard surfaces as a result of spillages, leakages and the decontamination of tractors and sprayers. Residues on the yard surface may subsequently be washed off to surface waters. Such 'point source' releases can be minimised by modifying handling practices. However, it is inevitable that some releases will occur. Additional treatment methodologies are therefore required to reduce these releases. One possible approach is to use a biobed to intercept and treat contaminated runoff from the farmyard and/or drips and spillages arising during the filling process. Biobeds are capable of degrading high concentrations of relatively complex mixture of pesticide applied replied repeatedly. Water management is crucial in terms of both performance and construction costs. By manipulating biobed depth and hydraulic inputs, unlined biobeds were able to achieve the required level of performance.

INTRODUCTION

Pesticides may be released to farmyard surfaces as a result of spillages, leakages and the decontamination of tractors and sprayers, (Ramwell *et al.*, 2004). These activities are typically performed at the same site in the farmyard year after year due to location of the farm pesticide store and the convenience of a clean water supply (Helweg, 1994). Recent studies have demonstrated that residues on the yard surface may subsequently be washed off to surface waters and that losses from the farmyard can contribute a significant proportion of the pesticide load being released to surface waters, (Mason *et al.*, 1999; Kreuger, 1998). The design, management and operation of these mixing / handling / washdown areas is therefore considered a primary target in reducing the amount of pesticide leaving the farmyard (Rose *et al.*, 2003). Such 'point source' releases can be minimised by modifying handling practices in order to minimise losses. However, it is inevitable that some releases will occur. Additional treatment methodologies are therefore required to reduce these releases. These treatments would supplement good handling practices that reduce inputs to aquatic systems. These methodologies need to be cheap to use and require low labour and time inputs. One possible approach is to use a biobed to intercept and treat contaminated runoff from the farmyard and/or drips and spillages arising during the filling process.

In its simplest form a biobed is a clay lined hole in the ground filled with a mixture of topsoil, peat and straw in the ratios 25%:25%:50% respectively. A number of researchers in Europe have investigated the use of biological systems which sorb and degrade pesticides (e.g. Henriksen *et al.*, 2003; Rose *et al.*, 2001; Torstensson, 2000). In order to assess the suitability of biobeds to treat releases of pesticides to UK farmyards, a number of studies have been performed. These studies have investigated the persistence and mobility of a range of commonly used pesticides in biobeds and the effects of range of factors (including pesticide concentration, mixtures, repeat applications, soil type, biobed depth and water loading) on biobed performance, (Fogg *et al.*, 2003a, 2003b; Fogg *et al.*, 2004a, 2004b, 2004c). A number of field scale prototype biobeds were subsequently built (Rose *et al.*, 2003).

MATERIALS AND METHODS

Test chemicals

Test pesticides were selected to cover a range of their physico-chemical properties (Table 1). Formulated products were used to make up stock suspensions in tap water.

Table 1. Test substances used and their physico-chemical characteristics

Active substance	Product	Concentration % *wt/wt*	Koc (ml/g)	Mobility class	DT_{50} soil (days)	Solubility water (mg/ litre)
Isoproturon	Alpha Isoproturon 500	43.6	125	Moderately mobile	6-28	65
Pendimethalin	Stomp 400 SC	36.4	5000-17200	Non-mobile	90-120	0.3
Chlorpyrifos	Dursban 4	44.65	6000	Non-mobile	7-15	1.4
Chlorothalonil	Cropgard	41.6	1600-14000	Slightly / non-mobile	5-36	0.6-1.2
Epoxiconazole	Opus	12.1	957-2647	Slightly mobile	60-90	6.63
Dimethoate	Rogor L40	37.4	16–52	Mobile	2-16	23800
Mecoprop	Optica	48	12-25	Very mobile	3-13	860
Metsulfuron-methyl	Jubilee 20 DF	20	4.6-35	Very mobile	7-35	27900

Preparation of biomix

Biomix was prepared by mixing topsoil, peat free compost ('Levington Peat Free Universal') and winter wheat straw in the volumetric proportions of 1:1:2 respectively. The wick series soil was used in all experiments apart from those designed to investigate the impact of different soil types (Table 2). The mixture (o.m. 12.36%, pH 7.5, maximum water holding capacity 75 - 127% *wt/wt*) was composted outside for 71 - 97 days prior to use. Biomix for use in the degradation experiments was then macerated using a food processor, air dried to approximately 25 - 40% *wt/wt* (depending on topsoil texture), and refrigerated at a 0-10°C prior to use.

Table 2. Soil types used in the preparation of the biomix

	Soil Series		
	Wick	Worcester	Blacktoft
% sand (63 µm – 2 mm	65.38	19.63	12.85
% silt (2 µm – 63 µm	18.71	36.05	46.56
% clay < 2 µm	15.39	44.32	40.59
pH (water)	6.15	7.3	7.7
% Organic Carbon	0.9	1.0	3.6
Texture	Sandy loam	Clay	Silty clay
Maximum water holding capacity % *wt/wt*	32.99	55.32	64.63

Laboratory investigations

A number of laboratory scale experiments have been performed. These have focused on the determining whether the biobed matrix was able to treat high concentrations of relatively complex mixtures of pesticide applied repeatedly. Moreover, experiments were made to quantify the effect on biobed performance when different topsoil textures were used in the preparation of the biomix. The detailed methodology for these experiments is reported elsewhere, (Fogg *et al.*, 2003a, 2003b, 2004c).

Semi-field scale experiments

The biobed system relies on maintaining conditions whereby maximum adsorption is achieved while at the same time maintaining the bioavailability of the retained pesticides. A number of semi-field scale lysimeter experiments have been performed. These have focused on pesticide leaching through the biobed. Studies include:

- The relative performance of the biomix in retaining pesticide residues when compared to a sandy loam topsoil.
- Lined vs. unlined biobeds
- The effect of hydraulic loading.
- The effect of biobed depth
- The effect of different topsoils

As with the laboratory experiments detailed methodologies are described elsewhere, (Fogg *et al.*, 2004a, 2004b. 2004c)

RESULTS AND DISCUSSION

The repeated use of the spray filling area is likely to result in the biobed being exposed to high concentrations of more than one pesticide. At concentrations ranging from half to 20 times the maximum recommended application rate for isoproturon and chlorothalonil, the rate of degradation decreased with increasing concentration. Degradation was generally faster in biomix than in topsoil at all concentrations. Studies with a mixture of isoproturon and chlorothalonil showed that interactions between pesticides are possible, however these effects were less apparent in biomix (Figure 1). These results suggest that biobeds are capable of treating high concentrations of more than one pesticide. These initial mixture studies were performed using only a single application of two active substances. Experiments involving a mixture of 6 active substances showed that, in general, degradation was faster in biomix than in topsoil (Figure 2). Also degradation of the compounds applied to the biomix as a mixture was slower than when the compounds were applied individually. However, DT_{50} and DT_{90} values were generally less than 5 months and one year respectively.

Repeated use of certain compounds over a number of seasons can result in enhanced rates of degradation due to adaptation of specific microbial communities, which utilise the compound as an energy source and thus degrade the compound very rapidly (Cox *et al.*, 1986). In the field, such enhanced degradation can result in reduction or loss of efficacy of a pesticide, (Suett *et al.*, 1990) but in a biobed, enhanced degradation could improve performance. The degradability of three applications, made at 30-day intervals, was therefore investigated.

Whilst degradation was quicker in biomix compared to topsoil, the rate of degradation decreased with each additional application. Whilst many agricultural soils possess the necessary ingredients to cause enhanced degradation of a susceptible pesticide, the lack of enhancement in some soils may be due to the absence of responsive microbes or essential cofactors, unsuitable environmental conditions, presence of inhibitory factors or faster reversion to normality, (Roeth, 1986).

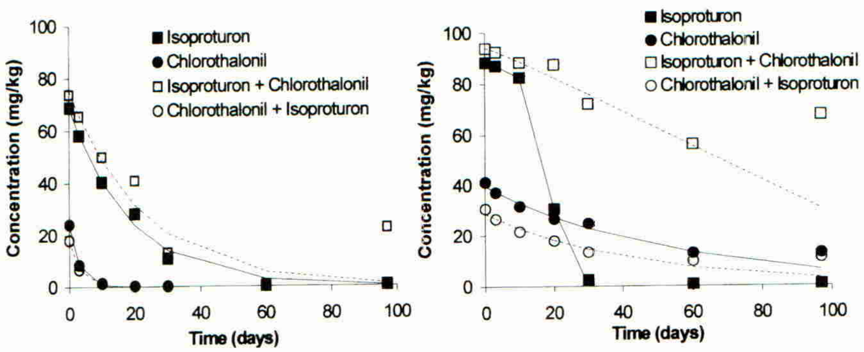

Figure 1. Isoproturon and chlorothalonil degradation in (a) biomix and (b) topsoil when applied individually and as a mixture

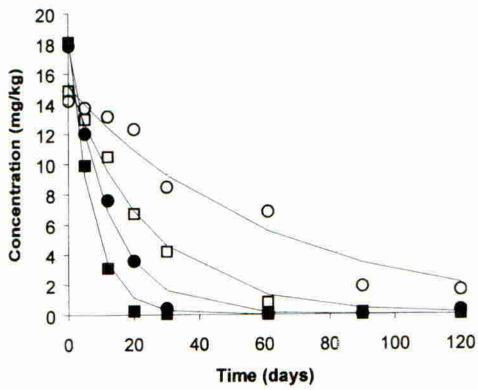

Figure 2. Degradation of dimethoate when applied to biomix as an individual treatment (■), topsoil as an individual treatment (●), biomix applied with isoproturon, pendimethalin, chlorpyrifos, chlorothalonil and epoxiconazole (□) and topsoil with each of the remaining five pesticides (○)

These experiments were performed using a mixture of six active substances applied at concentrations four times higher than the maximum recommended dose. Whilst the timing and number of pesticide treatments can affect the rate of pesticide degradation it is likely that the negative effects of high concentrations and the interaction between the different active substances masked any increase in microbial activity. Whilst no increase in degradation was observed in these studies, repeated exposure of an agricultural soil to a susceptible pesticide increases the chances that adaptation and enhancement will occur (Roeth, 1986). The present experiments used a 30-day interval between treatments. In reality this may not represent real world use conditions. Analysis of pesticide usage data, in particular that for autumn applied herbicides, shows that applications are typically made over continuous 5-10 day periods. Apart from other occasional days, it is likely that the same compounds will not be used again for further 12 months. Experiments performed over this time frame may show results that are different from those reported here.

The degradation of pesticides applied to soil is mainly carried out by soil micro-organisms, (Torstensson, 1986), therefore those factors which effect microbial activity in soil should also influence rates of pesticide loss (Walker, 1984). In the three soils tested (Table 2), measured biomass levels were highest in the silt topsoil and lowest in the sand. Mixing each of the soils with compost and straw resulted in a twofold increase in the measured biomass, indicating a significant increase in the levels of microbial respiration. DT_{50} values for individual compounds applied at 4 times the maximum approved rate were ≤ reported DT_{50} values for soil treated at approved rates. Mixture studies again showed that interactions between pesticide mixtures are possible. However, the DT_{90} values for the individual compounds when applied as part of a mixture, were all < 167 days, indicating a negligible risk of carry over from one season to the next.

Bound residue experiments suggest that degradation was the main process responsible for the reduction pesticide residues and not irreversible binding to the biobed matrix.

In these experiments, two systems were investigated: namely a lined system where the biomix was enclosed in a sealed column and an unlined system where leachate was able to percolate from the bottom of the biomix. The use of a lined system was considered attractive as it minimises the potential for leachate to contaminate groundwater and is hence likely to be more attractive to regulatory authorities. The lined biobed columns had to be covered to exclude clean rainwater from being intercepted by the biobed itself. However, irrigation was applied to each column to simulate runoff from an area of hard standing. A survey of local farms carried out prior to the study concluded that the preferred location of a biobed would be adjacent to the existing pesticide mixing area. Of the farms surveyed the mixing area was generally constructed from concrete and as such would generate runoff in response to both rainfall and cleaning operations. Once covered, the top 10cm dried out to form a cap. Hydrological connectivity was interrupted severely restricting evaporation from the system. Minimal water loss resulted in saturated conditions below 10cm within 12 months, agreeing with observations reported for covered Swedish Biobeds, (Torstensson, 2000). Microbial biomass was used to assess levels of biological activity within the biobed. Over a 12-month period, biomass decreased in the 0-10cm layer. This was probably a function of low moisture content, but there may also have been inhibition by the high levels of retained pesticide. On the basis of the results, it therefore appears that lined biobeds would be unlikely to cope with large volumes of waste associated with tank and sprayer washings as they would become waterlogged and microbial activity would be reduced. Some form of water management might resolve these problems but this would probably result in increased costs and time inputs from the user.

The use of unlined biobeds removed the need to manage water inputs whilst at the same time maintaining near optimum conditions for pesticide degradation because rainwater is able to enter and subsequently drain from the system. The studies demonstrated that the concentrations of pesticide leaching from the biomix filled lysimeters were significantly lower than from soil lysimeters (Figure 3). Only the most mobile compounds (Koc <100) leached to any great extent and even for these compounds the system appeared to retain or degrade more than 99% of the applied dose. Whilst > 99% removal was achieved for the six compounds tested, maximum concentrations of the two most mobile compounds, isoproturon and dimethoate were 127 and 50.4 µg/litre respectively. In order for biobeds to be approved for use it is likely that the performance of the system will have to improve.

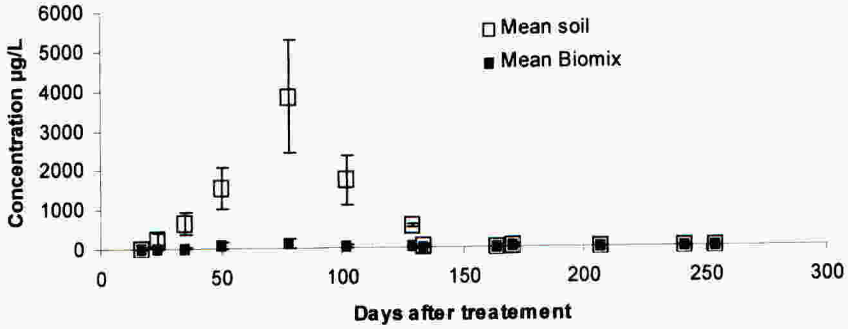

Figure 3. Concentrations (± 1 SE) of (a) isoproturon measured in leachate from soil (□) and biomix (■) filled lysimeters (50cm deep)

A number of factors, including the hydraulic load and the depth of the biobed will control concentrations of pesticide in leachate. Experiments were therefore made to understand the relationship between biobed size, water load and concentration of a range of pesticides in order to provide guidance on the construction and operation of biobeds in the UK. Lysimeters (0.5 m, 1.0 m and 1.5 m) were subject to hydraulic loadings of 1175, 688 and 202 litres/m^2. By controlling water inputs and increasing the retention time within the biobed through increasing depth, studies showed that for mobile (Koc 15 – 74) and moderately mobile (Koc 75 – 499) pesticides, < 1.41% of the applied pesticides leached from 0.5 m deep biobeds receiving the highest water loading, compared with < 0.32% from 1.5 m biobeds. For lysimeters subject to a water loading of 688 litres/m^2< 0.1% of the applied pesticide leached from the 0.5 m deep biobed compared with < 0.06 % from the 1.5 m biobeds, and those receiving only direct inputs of rainfall (202 litre/m^2), < 0.0007% of the applied pesticide leached. At this low water loading average concentrations of both isoproturon and dimethoate from 0.5 m deep biobeds were < 0.03 µg/litre. For the two very mobile (Koc <15) pesticides tested, mecoprop-P and metsulfuron-methyl, amounts of pesticide leaching from the biobed lysimeters were higher. Lines of best fit were fixed to the data generated in these experiments. This enabled the minimum depth of the biobed and the maximum hydraulic loading to be calculated such that the average concentration in leachate did not exceed a given maximum concentration, for example 5 µg/litre. Data for isoproturon (Figure 4) demonstrates the combined effects of hydraulic loading and biobed depth on concentrations of pesticide leaching from the biobed, and data suggests a minimum depth of 1.0 m is required. To establish a maximum water loading for the biobed, average concentrations of isoproturon were correlated against hydraulic loading. Lines of best fit were used to calculate a hydraulic loadings 1161 litres/m^2 for isoproturon such that from a 1.5 m deep biobed concentrations, should not exceed 5 µg/litre. These data can be used to calculate the minimum surface area of a 1.5 m deep biobed in order to treat any given volume of pesticide waste and washings. For example, if the farm had a bunded spray fill area of 40m^2, generated 10,000 litres of tank and equipment washings, and is located in an area where the annual average rainfall is 650 mm, then the total volume of liquid entering the biobed would be 36,000 litres. By dividing this figure by the maximum hydraulic loading (1161 litres/m^2) it can be calculated that the surface area of a 1.5m deep biobed would need to be 31 m^2 in order to achieve a maximum average concentration of 5 μg/litre.

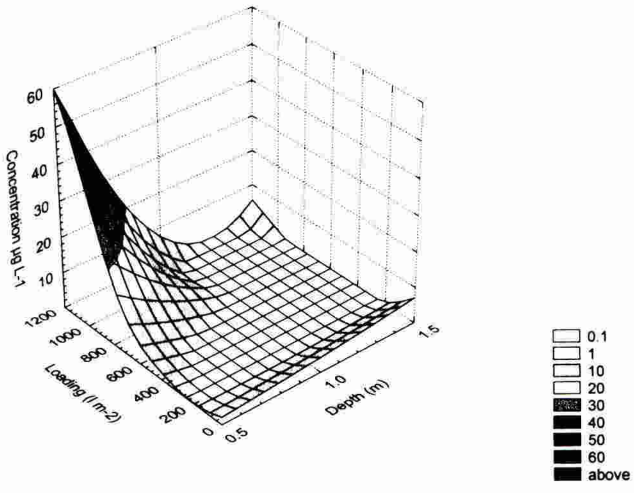

Figure 4. Surface area plot showing the combined effects of biobed depth and hydraulic loading on average concentrations of isoproturon in leachate

The Environment Agency has issued guidance recently both on the approved use of biobeds and also how the Agricultural Waste Regulations, the Waste Management Licensing Regulations and the Landfill Regulations will impact on existing disposal options of pesticide waste and washings as well as biobeds. When the Agricultural Waste Regulations are introduced sprayer washdown or pesticide solution disposal to soil or grass or on hard surfaces that drain to soil or grass will be illegal under the Landfill Regulations if the activity takes place more than once a year. The practice may be allowed to continue, subject to a Groundwater Authorisation, if the practice takes place once a year or less. It may be possible therefore to have a number of individual plots that could be used in rotation to ensure any one plot is only used once in any given 12 month period. An alternative is to mix and wash down directly to a lined biobed or indirectly using an off-set system. Under the Agricultural Waste Regulations biobeds will be regarded as waste recovery systems and as such will need a waste management licence. However, the Environment Agency is recommending that biobeds are exempt. Subject to exemption status being granted (decision being made later this year) biobeds would simply need to be registered free of charge with the Environment Agency. Finally the leachate from the biobed needs to be reused in some way. Current recommended re-use options are for irrigation, equipment wash-down water or for making up spray solution.

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