SESSION 2

GOOD FARM PRACTICE – PREVENTION AND MINIMISATION OF WASTE

Chairman and Session Organiser

A Barnden

The Environment Agency, Peterborough, UK

THE REGULATORY REGIME FOR MANAGING PESTICIDE AND PACKAGING WASTE

J C COOPER
Producer Responsibility Co-ordinator, Environment Agency, London SE1 7TJ

ABSTRACT

This paper outlines the regulatory aspects of pesticides and packaging waste arising on the farm. In the context of the waste hierarchy: minimisation, re-use, recycling and disposal options for waste management will be examined. The implications of the Producer Responsibility Obligations (Packaging Waste) Regulations 1997 will be evaluated. Options for the reduction of packaging waste associated with pesticide usage will be examined. While at present agricultural wastes are largely outside the scope of the "controlled waste" regime there are proposals for the extension of regulations to cover a greater number of categories of agricultural wastes.

INTRODUCTION

During the course of 1998 and 1999 the type of control over solid waste exercised through environmental legislation and regulations common to other businesses will be extended to the agricultural sector. At present, although there are limited controls there is a widespread desire within the agricultural community and its suppliers to see sound policies and practices for the treatment of solid waste.

At the same time there is a trend within the wider community towards enhanced producer responsibility, whereby producers and suppliers of goods take on more of the onus in ensuring that waste is dealt with in an environmentally acceptable manner. Increasingly this means moving waste up the hierarchy away from landfill.

Through the examination of specific case studies, particularly the lessons to be learned from the demise of the farm films collection scheme, and discussion of the current trends in thinking on waste management some conclusions regarding the appropriate strategies for non-natural agricultural wastes for the coming millennium will be drawn out.

THE WASTE HIERARCHY

There is a natural inclination to regard the waste hierarchy as a fixed system of priorities for dealing with resource management. The generation of waste should be avoided or prevented at source but then minimised if that is not possible. Where waste is generated it ought to be re-used and then after that recovered for material recycling, composting or energy recovery. Landfill and the incineration of waste without energy recovery are at the bottom of the hierarchy.

In agriculture there is the opportunity for assessing agricultural practices within the context of the hierarchy and a variety of organisations and systems have been developed to assist the farming community to try to minimise their environmental impacts. For example, LEAF, Linking Environment and Farming, with its emphasis on integrated crop management also tackles issues of waste management.

The hierarchy may be regarded as a first, qualitative approach to sustainable waste management. The diversity and variability of pollutants and impacts means that the waste management hierarchy should be seen as a guide. Waste is best managed through the application of the principle of Best Practicable Environmental Option (BPEO) within this framework.

The principle of BPEO was developed by the Royal Commission on Environmental Pollution, and is enshrined in the Environmental Protection Act 1990 (EPA90). It is an objective to be achieved in the design and management of major industrial processes. It is applicable, in a slightly different form, to sustainable waste management. For a successful BPEO assessment, all the possible outcomes for the environment must be taken into account.

The BPEO approach using life cycle assessment applies sound science to integrated waste management. It thus facilitates decision making in a manner which reconciles cost with impact.

Nevertheless, waste reduction, waste elimination or waste minimisation normally represent the BPEO. The Environment Agency uses a variety of opportunities to ensure that the public and business are aware of the environmental impacts of waste flows. For example, the Agency sponsors or participates in a wide range of waste minimisation projects and initiatives, including one dealing with the food processing industries which is run under the auspices of the University of Hertfordshire.

Agency experience shows that industry consistently makes significant financial savings by implementing waste reduction programmes: good environmental practice is good business.

However, there is sometimes a conflict between a sustainable waste management option and where financial considerations determine an alternative option. The example examined below is the case of agricultural farm plastic films which can at present be disposed of by a variety of methods, including burning and burying. While it is acknowledged that recycling is the BPEO ensuring that a system for maintaining the collection infrastructure can be sustained has proven to be an enormous challenge.

Agricultural plastics films

The agricultural uses of plastics generally, but particularly films, have become greater over the years. This has been in response to two main trends: the possible applications have widened as technical advances in the production of specialised films have increased and as the cost of the films has declined so more agricultural producers have been able to justify expenditure on agricultural films. Table 1 details the range of applications of plastics in the agricultural/horticultural sector, most of which are short-life film applications.

One consequence has been the problem of finding means of disposing of enormous quantities of film when it is no longer fit for use. Unlike most agricultural production residues, plastics film waste takes decades, or longer, to degrade. It imposes severe visual and aesthetic pollution on the countryside and can cause blockages in drainage systems if left in the field, let alone its dangers to livestock and wildlife.

Investigation of the potential for recycling showed that while there were some difficulties in that the material was often very dirty (two thirds of the weight delivered was soil), nevertheless it could be cleaned and recycled at a cost which was worthwhile to the reprocessor. However, the costs associated with the collection from individual farms and its aggregation at central collection points, mainly farms, were so high that financially the total system would run at a loss.

Table 1 Consumption of Plastics in Agricultural and Horticultural Applications

Product	Polymer	1991	1995
Sacks (fertilisers, feedstuffs etc)	LDPE	13,500	15,000
Pots and trays	PP	9,000	9,850
	PS	5,000	5,450
	LDPE	500	550
Containers (drums, tanks etc)	HDPE	8,000	8,775
Tools and equipment	PP +	2,500	2,750
Buildings	PP, LDPE	1,500	1,650
Reservoirs, irrigation & slurry	LDPE, PVC	2,500	2,742
Field Drainage	PVC	9,000	9,850
Screens & nets (tree guards)	LDPE, PP	13,000	14,250
Silage sheets/bags (stretch wrap)	LDPE/LLDPE	21,800	23,900
Mulch & direct covers (non-wovens)	LDPE	4,000	4,362
Twine	PP	9,000	9,850
Greenhouses & low tunnels (inc. bubble film)	LDPE	2,300	2,500
	PC	50	55
Packs for agro-chemicals	LDPE, PET	10,000	10,950
Miscellaneous	Various	1,000	1,100
Total		**112,650**	**123,560**

Source British Plastics Federation 1996 Statistics Handbook table 3.5.2

The proposal for a farm films recovery scheme came about as a result of a combination of circumstances. The British Polythene Industry subsidiary, Anaplast, from the early 1990s had been developing an initiative in Scotland through First Life Plastics for the collection of farm films which was experiencing financial difficulties. The company, and many others in the sector, realised that there were marketing advantages in offering a plastics recovery scheme. Having a system for recovery of the film after use would potentially encourage more farmers to use such films.

Discussions were held with a wide range of interests to determine a system which could harness support. A number of proposals were put forward for funding including an annual levy payable by farmers, as with the Netherlands system.

However, after considerable discussion in response to this dilemma it was decided that the easiest option to generate the necessary funding was through the producers and importers of these plastics films imposing a voluntary levy of £100 per tonne on the agricultural films sold so that the gap between the cost of the recovery system and the value of the recycled plastic product could be bridged. The finances were administered by the accountancy firm, KPMG to ensure full commercial confidentiality for the participating companies.

The Farm Films Recovery Scheme was formed on 1 January 1995 for the collection of as much as possible of the plastics films sold to the agricultural sector each year. The system lasted until 1 January 1997 but had limped along in the last 6 months of its existence when an importer of plastics film refused to pay the voluntary levy. If others had persisted their market share would have declined as any company which had opted out would have had a considerable competitive advantage.

There had been the hope that silage wrap, the most important of the agricultural plastics films in tonnage terms could have been regarded as packaging under the packaging regulations so that its recovery and recycling would have been subject to the same targets as other packaging products (see below). Although some plastics film performs certain packaging functions on the whole it is not performing a packaging function and even in those cases where it is, it is not passed on to another activity or business and hence it does not come within the scope of those regulations.

Nevertheless there is now a strong link with packaging in that the Packaging Unit at the DETR (Department of the Environment, Transport and the Regions) has been assigned the task of proposing a solution to the disposal problem in the context of producer responsibility. A consultation paper will be published in late Spring 1998, following that for the proposed regulatory changes for extending the controlled waste regime to certain agricultural wastes.

Ironically, in Eire one of the first measures under their Waste Management Act 1996 was the introduction of a farm films recovery scheme whereby companies selling these products were required to either set up a recovery scheme or to join an existing scheme. The system works in exactly the same way as the previous UK scheme with even the same level of funding, £100 per tonne of film.

The form in which the system of producer responsibility will be introduced for a new farm film recovery system has yet to be devised but it is expected to be less complex than the packaging waste regulations. Given that farms are the end users of considerable quantities of packaging (see table 1) there is merit in trying to link together the collection of all types of farm films recognising that most of the packaging films will be of greater interest to reprocessors and more easily recyclable than the silage wrap.

PACKAGING WASTE

In many countries increasing environmental and political pressures over the last few years have prompted the development of legislation (or in a limited number of cases comprehensive voluntary agreements) covering packaging waste. Often the responsibility for limiting packaging and packaging waste is shared by different sectors in the community. While most countries take the view that shared producer responsibility for packaging waste will involve at least a partnership between the consumer, local authorities and industry the UK has a very much more specific and narrower definition. Shared producer responsibility for packaging waste in the UK refers only to the industries which produce or use packaging. If and when local authorities and consumers are drawn in it will be to help the packaging producers to fulfil their obligations.

The latest phase in the UK Government's continuing efforts to ensure greater recovery and recycling of packaging waste started in 1993 when John Gummer, the Secretary of State for the Environment, invited 28 chairmen and chief executives of major businesses to prepare a plan to enhance the existing record for recovery and recycling of packaging. Throughout, given the political philosophy of the UK Government, the emphasis was ensuring that industry came up with a voluntary industry-led scheme.

In February 1994 the Producer Responsibility Group produced its report, which showed that the current recovery rate of 32% of packaging waste could be increased to 58% by 2000. There were, however, two main difficulties identified: the need for legislation to ensure all producers would contribute to the recovery of packaging waste and thus avoid freeloading and, secondly, the precise mechanism for ensuring the businesses would provide the necessary financial support for the recycling of packaging waste.

On 15 December 1995 after considerable debate the division of responsibilities was agreed between the four activity sectors: raw material manufacturers, convertors, packer/fillers and sellers.

Nevertheless, it was only on 11 July 1996 that a consultation paper outlining the DoE's proposals for a producer responsibility system under sections 93-95 of the Environment Act 1995 was issued, designed to implement the Packaging and Packaging Waste Directive (94/62/EC) approved on 23 December 1994. This proposed that the shared responsibility should be instituted as shown in table 2.

Table 2 Breakdown for Responsibility by Packaging Activity

Activity	**Share of Responsibility (%age)**
Raw Material Manufacturer	6
Convertor	11
Packer/Filler	36
Seller	47

In addition, in order to determine individual businesses detailed responsibilities the recovery and recycling targets were also important. These were agreed in December 1996, shown in table 3.

Table 3 UK Businesses' Recycling and Recovery Targets 1998-2001

	1998+1999	2000	2001
Recovery	38	43	52
(within which) Recycling	7	11	16

Therefore, taking a very simple example, of a (packer/filer tonnes) company which supplies UK retailers with goods packed in 2,000 tonnes of fibreboard and 2,000 tonnes of plastic bottles from UK suppliers its recovery and recycling obligations for 2001 would be:

recovery 4,000 x 36% x 52% = (748.8) 749 tonnes, of which by

recycling 2,000 x 36% x 16% = (115.2) 115 tonnes each of both fibreboard and plastics.

Businesses can either arrange for the recovery and recycling of packaging waste themselves, in most cases through agents acting on their behalf, or through joining a compliance (collective or exempt) scheme thereby placing responsibility on the scheme to arrange for the recovery and recycling to be undertaken on its behalf.

Agricultural businesses using packaging therefore are subject to the regulations, just as other businesses are. However, one important point appears to have been lost when businesses start to look at how they can deal with the regulations, that if they reduce their packaging their recycling and recovery obligations are also reduced. Indeed the thrust of the Directive is to reinforce the waste management hierarchy. The difficulty is that while targets exist for recovery and recycling there are none for waste prevention, minimisation, reduction or re-use.

However, in future, more re-use systems are going to be introduced for both tertiary (transport) and secondary (in store) packaging so a greater proportion of packaging from the farm sector will be re-usable.

There is also another point which affects the agricultural sector and which is important in the context of the competitive position of agriculture compared to the supermarkets and that is ownership of packaging. The regulations place considerable emphasis on the point of ownership of packaging.

There is a distinction between the position of a farm enterprise which contracts to pack/fill produce for a superstore group where the group supplies the packaging compared to one where the superstore group specifies the type of packaging required, which may include the use of the group's own branding, as well as the product. In the former case the superstore picks up the packer filler and seller obligation, while in the latter case the farm enterprise picks up the packer filler obligation with the superstore then picking up only the seller obligation.

PESTICIDES AND PACKAGING WASTE

Hazardous wastes in the UK are usually referred to as special waste. In 1996 the Special Waste Regulations 1996 (SWR96) implemented the Hazardous Waste Directive (91/689/EEC). The SWR96 replaced the Special Waste Regulations 1980 and introduced a simple system of control based on risk with a complex regime based on the hazardous properties of the waste.

When a waste needs to be assessed under the SWR96 there are some simple questions to be asked. First, is it a controlled waste? If not, it cannot be special waste (with the exception of some radioactive wastes). The definition of controlled waste currently excludes mine and quarry waste and agricultural waste, like used sheep dip and some pesticide containers. These contain hazardous substances which could well make it special when the definition of controlled waste is reviewed and extended to certain wastes subject to the Waste Framework Directive but currently beyond the scope of UK legislation (see below).

Pesticides residues in containers could therefore render that and the container itself special waste. The significance of this is the cost associated with the disposal of containers. As many of the containers are manufactured to high specification using plastics or metals there should be the option of re-use or at least recycling. However, the hazardous nature of the contents will often preclude re-use as munfacturers will be concerned that other materials could have been stored in these containers. Equally operators of recycling facilities will be wary of accepting containers which may contain small amounts of residual pesticide.

Within the agricultural sector and their suppliers, therefore, there have been moves towards reducing the impact of pesticide container waste. Often many of the new policies and practices have been dictated more by the need to address health and safety issues than environmental or solid waste management problems.

In some cases there has been a move to the use of solids, powders and granules, which, provided that the container is emptied, easier to prove than with liquids, can be disposed of with other wastes. This option can be supplemented by the use of soluble PVA film to contain the pesticide until after it has been placed in solution. Another strategy is to provide re-usable/refillable containers which can be kept in a closed circuit between pesticide supplier and user. This may require that there are special couplings between the container and the item of equipment to be filled, partly for safety reasons but also to ensure the integrity of the empty container. The move to provision of pesticides in a more concentrated form, while ameliorating the scale of the problem potentially still leaves residues for disposal.

AGRICULTURAL AND CONTROLLED WASTES

At present agricultural wastes fall outside the definition of controlled wastes, those wastes which were subject to control under the provisions of the Control of Pollution Act 1974, section 30. These included household, commercial and industrial wastes. The definition used in section 30 was largely repeated in section 75 of the Environmental Protection Act 1990 (EPA90). Excluded from the meaning of waste under section 75(7)(c) is "waste from any mine, quarry and waste from premises used for agriculture within the meaning of the Agriculture Act 1947 or, in Scotland the Agriculture (Scotland) Act 1948".

Nevertheless, it was appreciated that with likely changes being proposed to the Waste Framework Directive as the Environmental Protection Bill was going through Parliament that provision would need to be made to change s75(7)(c) at some stage and therefore within the EPA90 under section 63 (1) "The Secretary of State may, after consultation with such bodies as he considers appropriate, make regulations providing that prescribed provisions of this Part (of the Act) shall have effect in a prescribed area....as is mentioned in section 75(7)(c)..with such modifications as may be prescribed.

There are certain types of agricultural wastes which under the terms of the Waste "Framework" Directive 75/442 EEC as amended by 91/156/EEC should be subject to regulation and not fall outside legislative control, such as those dealt with in the paper.

An attempt was made retrospectively through the Waste Management Licensing Regulations 1994 and the accompanying Department of the Environment Circular 11/94, Environmental Protection Act: Part II, Waste Management Licensing and the Framework Directive on Waste to bring in certain wastes which were meant to be subject to control under the Directive under control through existing UK legislation, mainly by extending the meaning of "controlled waste" into "Directive waste". However, that could be regarded more as a measure to avoid infraction proceedings by the Commission. The requirement for consultation, as noted in section 63 of the EPA90, was not sufficient.

There is, therefore, a very longstanding commitment by the DoE, now the DETR, to produce a consultation paper and draft regulations to incorporate the extension of waste management controls to those agricultural wastes which should be brought into the net. The DoE's Annual Report for 1997/98 makes reference to this commitment. However, the prolongation of the BSE crisis, especially the need to make adequate provision for the safe disposal of meat that had become waste, had so stretched the staffing resources of the department that the consultation will be delayed until the Spring of 1998.

CONCLUDING POINTS

The future prospects with greater environmental controls being introduced covering non-animal and non-crop residue wastes, probably in 1999, are considerable for the agricultural sector.

Producer responsibility will require the farming community to participate in ensuring appropriate environmental solutions for a number of difficult waste management issues which today can be important for those seeking to operate to high environmental standards but for many will be regarded as irrelevant in comparison to all the other pressures experienced by the farming community.

The advantage of producer responsibility is that the burden of dealing with these important resource management issues should be shared. Thus there will be others whose own producer responsibility will be harnessed to resolve these waste management problems. Those companies supplying pesticides in packaging which costs least to dispose of, and therefore will probably have the lowest environmental impacts, will be the ones which will boost their sales.

Producer responsibility, in particular, is in vogue with the European Commission and hence will influence UK waste management policy and practice as we enter the new millennium.

GOOD FARM PRACTICE - PREVENTION, MINIMISATION AND TREATMENT OF WASTE THROUGH ADOPTING AN INTEGRATED APPROACH

C J DRUMMOND
LEAF (Linking Environment And Farming), The National Agricultural Centre, Stoneleigh, Warwickshire CV8 2LZ, UK

ABSTRACT

Pollution conjures up no end of negative visions. It is the result of poor management in any business. So how do LEAF Demonstration Farmers and Supporters identify the source of their waste and manage it effectively? What do they see as the best practical environmental options to achieve this? Is Integrated Crop Management (ICM) the right choice? This paper examines these aspects through the adoption of a whole farm approach which focuses in on chemical use, accuracy of application, sprayer filling and washings and waste packaging when planning and setting out strategies for waste management and pesticides. It also raises the questions: Is enough being done throughout the industry, how does the ICM approach apply to pesticide waste issues and how can it be applied throughout the farming industry?

INTRODUCTION

'*....all they which have cast and laid such annoyances, dung, garbage, entrails, and other ordure in ditches, rivers, waters and other places aforesaid, shall cause them utterly to be removed, avoided and carried away betwixt this and the feast of Saint Michael next ensuing after the end of this present Parliament, every one upon pain to lose and to forfeit to our Lord the King twenty pounds.*' Probably the first environmental act and the year was 1388! The moral behind the Act has not changed much today - basically the polluter pays. Now, as in those days, the polluter pays principle relates to two areas in a farm situation; firstly in the form of fines and secondly in the form of a wasted resource. Furthermore, those resources are not only water, soil and air, they are the cost of wasted chemicals and inputs. To get to the bottom of what practical action farmers are taking to tackle the waste problem, we must firstly examine the meaning of the two words - pollution and waste:

Pollution - destroy the purity or sanctity (sacredness) of water, soil, air etc.

Waste - that which is of no value, superfluous, no longer required.

Basically we do not want either.

Our aim as farmers, together with allied industries, is to minimise both pollution and waste. As in 1388 people have a right to clean air, water and soil. However, we must be aware of the concerns associated with modern farming practices and their impact on the environment. Nevertheless, we know that this impact can be, and is being, considerably reduced through the adoption of practical solutions and attention to detail, such as Integrated Crop Management. And for those who do not take heed, there is legislation which over the last few months we have seen being implemented quite readily. The management system of Integrated Crop Management

(ICM) encourages an approach that recognises the real value of the farmers own resources and offers genuine opportunities for farmers now and in the future.

ICM is a system that takes account of the whole farm and any one issue cannot be taken in isolation because of the need to balance all the farmers resources, economics and environmental criteria. However, in order to examine the approach that farmers are taking in managing pesticide waste and packaging this paper will focus in on chemical use, accuracy of application, sprayer filling and washings, waste packaging and the importance of planning and instilling responsibility in a fully integrated approach. LEAF provides a disciplined system for farmers to assist them in adopting ICM through the use of the LEAF Audit, furthermore the LEAF Demonstration Farmers are at the forefront of transferring technology and practical approaches, which again brings real solutions to the forefront for farmers.

THE PROBLEM AREAS

Pollution from pesticide waste and packaging arises from several sources and can have an impact on water, soil, air, food and fibre. It is possible to measure pesticide residues in water, soil, food, and fibre and we can identify the areas of pollution visually in the air through drift or burning of containers.

But how big are the risks?
In 1995 The Drinking Water Inspectorate announced a significant improvement in quality from its analysis of 925 000 tests done for individual pesticides. The figure of 99.2% shows a clear, unequivocal improvement, comparing well with 98.8% in 1994, 97.9% in 1993 and 97% in 1992. 68% of all food samples were free of any pesticide residues in the Working Party on Pesticide Residue's comprehensive monitoring programme. A further 31% were within the internationally recognised Maximum Residue Levels (MRLs) and less than 1% exceeded the MRL (BAA, 1997). But despite the facts and scientific evidence that the risks associated with pesticides are low and that the levels recorded are way below the maximum residue levels public opinion is being distorted by lobby and concern groups. We have seen this clearly illustrated by recent events such as the risk of dying in any one year from contracting CJD by eating beef on the bone - 1 in 600 million, compared to the chance of being struck by lightning (1 in 10 million), homicide (1 in 100 000), being involved in a road accident (1 in 8 000), influenza (1 in 5 000), or the chances of winning the jackpot in the National Lottery (1 in 14 million) (Uhlig, 1997).

Indeed to quote from Graham Harvey (Harvey, 1997): '........ *the chemical pollution of our environment is an integral part of the farming system we have chosen to adopt. It is what we buy with our subsidies and, as with soil erosion the bill is rarely paid by farmers. One estimate has put the investment cost of bringing pesticide polluted water up to EU standards at £800 million. On top of this initial capital outlay the annual cost of regulation and removal of pesticides has been estimated at £121 million. This is what we pay to clean up our drinking water.*'

Agriculture does not contribute to all these clean up costs and where it does in many cases this is attributed to from accidents or misuse. Furthermore these costs do include other factors attributed to the taste of water and clarity of the water - trying to remove the cloudiness.

However it does not mean we should be blasé, the detectable levels of pesticide to meet the requirements of pesticide residues in water of 0.1 parts per billion are the equivalent to *'one drop of water in an Olympic swimming pool.'*

To give a few examples:

- If you spill 10 ml of neat chemical concentrate of 600 grammes per litre, it will contaminate a river for an area of 1 metre wide x 1metre deep x 6km length at 0.1 parts per billion.
- If a spray solution is diluted to 2 litres of concentrate in 200 litres of water, one litre of spray solution will contain 6 grammes of concentrate which will contaminate an area of river 2 metres wide x 2 metres depth x 1.5 kilometres at 0.1 parts per billion.
- And where gloves are washed the contamination levels would be for a water course 1 metre wide x 1 metre deep x 100 metres at 0.1 parts per billion. (Joice, 1997).

It is to counteract these risks that farmers are increasing adopting an informed management approach such as Integrated Crop Management.

SETTING OUT A STRATEGY

Planning is one of the keys in a fully integrated farming system. This means that a farmer must first identify the risks on their farm and take action. The other key is to **instill responsibility**. *'Remember that values are long lasting - they take time to permeate an organisation and, once established, they can be flexed but are difficult to change or eradicate all together* (Harvey-Jones, 1994). Planning and instilling responsibility builds on the background knowledge of the business and leads to adopting prevention and minimisation strategies through a pragmatic approach.

Prevention and Minimisation

As with any situation prevention is better than cure. This is the starting point in the adoption of less risk strategies. It is being prepared and identifying strengths and weaknesses. As an example the LEAF Audit helps farmers take stock of what they have got and encourages targets to be set and priority action to be taken. Since Integrated Crop Management is a whole farm approach it considers: organisation and planning, soil management and crop nutrition, crop protection, energy use, pollution control, wildlife and habitat features and animal husbandry. This provides the starting point for farmers to identify key areas of concern on their farms, so that by taking appropriate action they can, not only enhance business performance, but also reduce the impact of their farming practices on the environment. Strategies for farmers can be established by posing questions such as:

- Do you have a planned and documented crop protection policy?
- Do you use rotational methods to disrupt soil-borne pests and diseases?
- Do you select varieties to ensure you are not over-reliant on one or two?
- Do you use only Approved pesticides?
- Do you use rates of pesticide application below the recommended application rate?
- If yes, is this?
  Routinely
  Only after consideration of growing conditions, infestation level and pesticide type, etc.

This approach 'makes farmers think', 'creates discipline', provides them with a structure to adopt ICM', allows credit to be given for the good things farmers are doing and helps identify priority areas on the farm that perhaps need a bit more fine tuning.

In order to take positive action to reduce risk one has first to identity that risk. One such area on the farm is in the use of pesticides and the management of waste. However, one cannot emphasise enough the fact that with ICM we are dealing with a whole farm scenario and this needs to be put in context. Working on a step by step approach the minimisation of wastes can be achieved by the optimisation of inputs through a planned approach. Identifying the key pollution/risk areas one needs to examine four key areas:

1. **Chemical use**
2. **Accuracy of application**
3. **Sprayer filling and washings**
4. **Waste packaging**

1. **Chemical use**

How?

When adopting ICM for the establishment of a strong, healthy crop one has to consider several options in the defence against weeds, pests and diseases. These include cultural, chemical, mechanical and biological. Where chemicals are used, a step by step approach should be considered to ensure effective management.

- **Rotation** - a diverse crop rotation is probably the most effective indirect means of enhancing and maintaining soil fertility as a basis for optimal plant growth. It also minimises soil erosion, pest, weed and disease incidence. Many pathogens persist in plant debris, but a break of two to five years between the same type of crop in a field allows time or inoculum of many diseases to decline to insignificant levels.
- **Selection of resistant varieties** - part of the varietal selection should include resistance to pest and diseases, paying particular attention to those that are difficult to control by cultural means.
- **Threshold levels of disease, weeds and pests** - there is still much work to be done on this to define threshold levels and also to build up the degree of confidence associated with thresholds (Orson, 1997).
- **Use a BASIS registered agronomist** - it is estimated that over 80% of the UK's farmed area receives advice from an agronomist. Using a BASIS registered agronomist adds credibility and expertise to a highly professional business.
- **Regular crop walking** - if you can't measure it, you can't manage it - knowing what you have is of course a most essential part of the business and only through regular monitoring can truly informed decisions be made throughout the season. Regular crop walking can also improve timeliness and as a consequence reduce rates. The quicker a problem is found the easier it is to control.
- **Biological control** - to date not many products are available, they should be considered only if they are practical and economic. With biological control it is important to remember that these methods work in a highly specific way and require the same care in use as crop protection products.
- **Encouraging natural predators** - aim to enhance natural predators through the use of

selective chemicals and create appropriate habitats eg through the use of field margins and beetle banks.

- **Selection of chemicals** - there is always a need to balance the choice of chemicals between impact on the environment and economics, together with efficacy.
- **Reduced rates** - in many situations such an option can be justified, but beware of the risk of resistance in your farm situation. Firstly ask is there a risk or not? Do I have resistant blackgrass on the farm, in this field? etc. These must be considered as part of the whole farm strategy.
- **Avoidance of prophylactic spraying** - prophylactic spraying should not be carried out unless there is sufficient evidence to suggest that not to spray, at a particular time, could later result in an increased use of active ingredient. For example, depending on the field history, where there would be an economic loss because there is no alternative autumn weed control (in situations such as this one can spray an early low dose of residual eg. IPU and low dose of contact, to kill anything that is growing (Leake, 1996)), or in the absence of a resistant variety a flag leaf application of fungicides.
- **Cultivations** - cultivations have been recognised as a means of controlling pests, diseases and weeds. Choosing the right implement and timing for specific crop/soil combinations are skills of a good farmer.
- **Forecasting for pests and diseases** - weather forecasting is one way of predicting the risk of a particular pest or disease incidence, however there is still work to be done on the interpretation of information from weather forecasting techniques.

2. Accuracy of application

How?

Hitting the target makes sense economically and environmentally. There are many variables in farming so where any risk can be reduced, it makes sense, saves money and time.

- **Training of staff** - this is the key to making it all happen. However experienced an operator, technology and the demands placed on farming have changed so much over recent years that training is both important for motivation and as an indication of responsibility - due diligence, ie it shall ... be a defence for the person charged to prove that he took all reasonable precautions and exercised all due diligence to avoid the commission of an offence.
- **Communication with staff/contractor** - it is so often the case in a busy farm situation that time does not allow for planning and consequently effective communication channels are not established. Such communication channels, with the people carrying out the job, ensures that mistakes are not made. It also means there is more value being given to the experience of the operator - allowing them to contribute to a central decision-making part of the business.
- **Buffer zones** - we will see more of these in coming years, but their value has proven to be worthwhile in the protection of sensitive areas.
- **Avoidance of wildlife/ sensitive areas** - this is in fact the starting point for in field planning. A map should be drawn up that clearly identifies the areas on the farm that are prone to environmental damage or are particularly sensitive, eg soil type, water courses, areas of valuable habitat etc. This map should then be actively incorporated in the daily work routine of farm operations and decision making.
- **Reed bed** - the establishment of a reed bed system acts as an effective filtration system

and in the right place, a useful habitat for wildlife.

- **Calibration of machinery** - this is essential on a regular basis and all machinery should be calibrated according to manufacturers instructions.
- **Maintenance of machinery** - nozzle maintenance and spray pattern, the correct settings for height and pressure, checking for leaks etc, are all essential to ensure attention to detail.
- **Planning** - only using the required amount - this may seem obvious but it is essential to plan the chemical requirement accurately, have a good knowledge of the field size and ensure deductions have been made where no-spray areas have been identified. This means that there is no wasted spray at the end of the day.
- **Improved application techniques** - this area needs to be developed substantially. For many and varied reasons, much chemical does not hit the target. Targeted applications, through the use of precision farming or through the identification of weed/disease areas in the field and patch spraying rather than blanket spraying will continue to develop effectively over coming years, as more technical advances take place. Indeed some farmers are already patch spraying effectively by using their own maps on the farm and spraying only where necessary.

3. Sprayer filling and washings

How?

When all risk has been reduced in the field, it is the management of the spray washings that is most important. High risk times when utilising a sprayer are, when filling, travelling on roads and tracks and when washing out the sprayer, equipment and containers.

- **Planning** - correct planning means no spare spray and, as a consequence, less risk of environmental risk at washing out.
- **Triple rinse** - good rinsing practice of chemical containers is essential, key steps include, using all the product that has been bought and triple rinsing empty pesticide containers (BAA, 1996).
- **Biobeds** - based on some work from Sweden the biobed is designed to work as a biological bed with high microbial activity. Any spillage at filling is quickly broken down by this activity, (Fogg P et al, 1998; Odling I balans, 1995). This work is to be trialed in the UK in the near future.
- **Location of the tank and spray washing area** - the Codes of Good Agricultural Practice highlight the requirements to fulfill the demands of a lower risk strategy. Equipment should be filled and washed in an area chosen for that purpose (MAFF 1996) and that is not located near water courses or areas of high environmental sensitivity and value, where it may be a hazard.
- **New technologies** -for example the laser agitation system developed by Knight sprayers. This system ensures a positive movement through the booms so when starting to spray farmers do not have to purge the lines and wait till the chemical reaches to all the nozzles, (especially important in the use of herbicides). Similarly, when washing out it avoids having to flush out chemicals from the booms. This may require a 24 metre bunded area, which can be difficult to manage and often collects rain water and leaves.

  Most sprayers work on pressure - wash out/push out, the Laser system agitates under suction, and when spray lines are rinsed out at the end of a spraying session, the Laser system returns the rinsing water to the main tank which means it can be washed out in a more controlled fashion. Other advantages of the system mean, if work is rained off half through the day, it stops chemicals settling in the spray lines and provides positive no-drip boom shut off. Further new developments include direct injection sprayers, these sprayers only have a small reservoir for chemicals and this means that there is only ever water in the tank, so it is only the spray boom and mixing area that are contaminated. This is very useful for road travel and when chemicals are changed frequently, since yet again it reduces risk.

4. Waste - packaging

This is the cause of frustration for farmers who are trying to come to a realistic solution.

- **Buying only the required amount** - this illustrates the importance of planning ahead which allows for cost economies when buying in bulk or through using more concentrated chemicals.
- **Correct techniques of disposal** - empty containers should never be used again and should be rinsed (triple rinse), crushed and stored in a secure compound until they are disposed of at a licensed disposal site or buried at a site selected so there is no risk of polluting surface or groundwater, at least 0.8 metres below the surface and below the level of any land drains. Records need to be kept of such sites. If containers are burnt, it should be at very high temperatures taking account of what is being burnt and the location of nearby properties (MAFF, 1996).
- **Recyclable/refillable** - there is still a lot of work to be developed in this area, although we are starting to see co-operation throughout the industry, eg the LinkPak system developed by Novatis. This is a gravity filled system available to all manufacturers and is complementary to the micromatic drum valve system for high dose rate chemicals. However, a concerted effort is required, throughout the whole industry, to ensure this approach and recyclable/refillable containers will become more of a reality.
- **A shared responsibility** - collaboration is essential in order to ensure this is addressed as a matter of urgency. Farmers are certainly feeling that they are shouldering the blame for many of the problems facing the food industry as a whole - however they are only part of the chain and everyone needs to be seen to be playing their part in addressing environmental improvement.

TREATMENT

On farm, the Sentinel system is useful for ensuring risk of contamination from spray washings are minimised through the use of carbon filters, particularly where a wide range of chemicals are being used. However, the system is still being refined and where there are large bunded areas for washing out these have to be managed effectively to ensure that they do not collect leaves or water. It is not a cheap method, and the system is no alternative to good management throughout the spraying operation.

Other methods for treatment are based on the monitoring of the water quality and on some farms a totally managed approach is adopted. This attention to detail is taken to its fullest extent at Shropshires, a horticultural and packing business, where waste water from the packhouse is filtered several times, held in reservoirs and chlorinated before returning to be utilised on the farm. To avoid the spread of soil bacteria, any soil is taken back to the field where it came from and any green wastes are fed to beef cattle. An incinerator burns all waste woods and cardboard and the energy coming off this plant is used for heating the packhouse, student hostels and hand washing water in the packhouse. This approach of using all 'wastes' as a resource is becoming increasingly popular. It certainly saves money and reduces risks.

CONCLUSION

Farmers are genuinely keen to make the most of wastes. Developments in farming are dynamic and we must look for practical and achievable solutions for farmers to reduce risk and raise our game. Integrated Crop Management offers a good guiding philosophy for farmers. It is however a shared responsibility and there is still room for technical advances, such as better plastic disposal, better accuracy of spraying techniques, better forecasting techniques etc. The pragmatic approach adopted by the LEAF in developing a fully integrated system does help identify the main sources of waste of the farm and encourage the positive management as a best environmental option. ICM is a real option for all farmers and the structure of the LEAF Audit creates a discipline to help farmers take these issues to task and act on them, in a meaningful and practical way to save money, time and the environment.

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BIOBEDS: THE DEVELOPMENT AND EVALUATION OF A BIOLOGICAL SYSTEM FOR PESTICIDE WASTE AND WASHINGS

P FOGG AND A D CARTER
Soil Survey and Land Research Centre, Cranfield University, Shardlow Hall, Shardlow, Derby, DE72 2GN, UK

ABSTRACT

Pesticide waste or washings should be disposed of on a suitable area of land or onto a designated soakaway[1], approved by the Environment Agency and in accordance with the Control of Pesticide Regulations (HMSO, 1986). In practice it is known that many users do not comply with this requirement due to the practicalities of the required procedure, refusal of permission for soakaways (on the basis that the site might lead to contamination of vulnerable ground or water sources) or from the lack of awareness of the regulations. A practical but economic method of disposal is therefore required which can be adopted by all potential users of pesticides. Artificial degradation systems known as 'biobeds' have been developed in Sweden and the USA but the technology has not been developed in the UK. A desk study has evaluated available information and a two year research programme has commenced to test the efficacy and sustainability of the biobed system when used under typical UK agricultural conditions.

INTRODUCTION

Water quality monitoring data suggests that the disposal of pesticide waste and washings could be responsible for between 30 and 50% of water contamination incidents. Much of the monitored contamination arises from small spillages and careless handling of approved pesticides during storage, preparation, application or disposal (BAA/NRA, 1995). Barnden (1995) identified a site in the south-west of Britain where the spray tank mixing area was sited directly on a chalk outcrop, all mixing was done on the same site and washings and small spillages of concentrate allowed to drain away into a small ditch, terminating in a swallow hole. Recent research showed that levels of certain pesticides were much higher in ditches draining from the farm yard than in a stream draining from an agricultural catchment comprised of sprayed fields (MAFF,1996). Similarly, monitoring by Thames Water for the 1995/6 season showed two distinct peaks in the concentration of isoproturon detected in the River Thames. Due to the low levels of rainfall in the winter (1995/96) no significant drainflow was observed until late January in the Thames region, but the concentration of isoproturon showed a distinct peak in November / December 1995 (shortly after autumn application) which has been attributed to point source contamination from farms. Helweg (1994) also noticed that the filling of sprayers and the rinsing of spray equipment was often performed on the same site year after year due to the convenience of the water supply. On a site in a Danish orchard where sprayers had been cleaned and filled, simazine, MCPA, mecoprop and dichlorprop residues of 4.1, 0.29, 77 and 390 $\mu g\ l^{-1}$ respectively were detected in ground water 6 - 10 metres below the surface. During the autumn of 1995 the Isoproturon (IPU) UK task force introduced a stewardship programme to protect water quality. An advisory leaflet pointed out that minor spillages and the washing down of equipment probably accounted for more contamination of water than was first thought.

AUTHORISED DISPOSAL ROUTES

In order to minimise the risk of contaminating the environment the statutory Code of Practice for the Safe use of Pesticides on Farms and Holdings (1990) was implemented. The code (which is currently being revised) was issued for the purpose of providing practical guidance to farmers and growers engaged in commercial crop production in Great Britain. The code specifies that all filling and washing operations should be carried out in an area designated and constructed for the purpose and such that spillages cannot escape from the area. It is extremely unlikely that all spraying operations will not produce some liquid waste. It is necessary, therefore, for the user to provide arrangements for its disposal in an environmentally acceptable manner. On completion of spraying, all equipment involved in the operation should be cleaned, washed and rinsed. The washing facilities provided should be designed to ensure that back-siphoning of pesticides in to the water supply cannot occur. Such activities will produce a relatively large volume of water contaminated at low concentration with pesticide. If suitable the contaminated water may be usable for making a further batch of dilute pesticide. Alternatively, its disposal will need to be arranged in an environmentally friendly manner. Possible routes detailed within the code include:

a. storage of the waste in a suitable container pending collection by a reputable specialist waste disposal contractor;

b. use of suitable equipment designed to treat liquid waste containing pesticides, providing the treated effluent can be stored satisfactorily and reused or used for another purpose or disposed of by means acceptable to the Environment Agency, the Scottish Environmental Protection Agency (SEPA) or local Water Services Company (WSC), with agreement in England and Wales from the Environment Agency for Red List substances. An example of such equipment is the Sentinel in which the washings or surplus mix are passed through a carbon filter. This removes the pesticide leaving a contaminated sludge and clean water (Harris *et al*, 1991). This method may be very costly but it is an important solution to a very difficult problem BCPC /ATB (1996);

c. subject to approval of the Environment Agency or SEPA, (and in England and Wales from the Environment Agency for Red List Substances) use of a properly designed and constructed soakaway, which might comprise a widely spread network of perforated or slotted pipes laid over a suitable area of land[1];

d. with the approval from the Environment Agency or SEPA (and in England and Wales from the Environment Agency for Red List substances) spray on to an area of uncropped land, not stubble or fallow, of minimal wildlife value, that is, an area which supports only poor vegetation and without hedges, trees or bushes on it or nearby. If such an area of land is identified, its approval for use will require that it is capable of absorbing the volume of

[1] During the last few years the Environment Agency policy has been not to approve soakaways and they have lobbied to change the code to say that soakaways are not an acceptable means of disposal.

liquid to be discharged on to it without runoff, the leaving of puddles, or risk to wildlife, watercourses, ground water, septic tanks, field drains or sewerage systems. Where necessary it must be signposted and fenced to exclude people and livestock;

e. subject to a consent from the local WSC and the Environment Agency for Red list substances discharging the pesticide contaminated water to a sewer;

f. if within the terms of product approval, applying the contaminated water to the treated crop, recognising that the efficacy of the previous application of the pesticide may be impaired;

g. subject to product approval and in the absence of streams and water courses nearby, application to previously untreated crop areas.

ACTUAL PRACTICE

In 1993 the National Farmers Union (NFU) surveyed current practices undertaken by farmers for the disposal of pesticide containers. As part of this survey the issue of washings and left over spray were also investigated. Wise (1994) reported that with well trained operators the problem of left over pesticide should not occur as only sufficient product should be mixed for the field in question. Nevertheless, "tank washings" caused by washing out the sprayer prior to moving to a new product in a different field are an unavoidable feature of sprayer operation. Wise (1994) noted that the suggestion of using an approved soakaway to dispose of waste was not a real option as no soakaways have been approved by the Environment Agency in the UK.

In the NFU's survey the average volume of rinsate in the washings operation was 200 litres, ranging from 10 to 1000 litres. The average number of rinses was 2.5, ranging from 1 to 5, and the average amount of water used in the washing process as a percentage of tank size was 38%. In-tank nozzles for rinsing were fitted to 1 in 5 of respondents sprayers and the average reduction in washings from such equipment was 64% ranging from 25% to 95%. The BAA (1994) recommend the use of equipment fitted with tank cleaning units. They point out that three rinses with 300 litres of water is 100 times more effective in cleaning a tank than one rinse with 1000 litres. MAFF (1996) also illustrate the risk of contamination from tank washings, if a sprayer tank is filled twice with clean water, the second rinsate could still be 10,000 times more concentrated than the EC drinking water limit of $0.1 \mu g\ l^{-1}$.

A total of 71% of the respondents to the NFU survey disposed of their washings onto the last crop sprayed; 56% sprayed washings out onto waste ground. In many cases respondents said that the first rinses were emptied out onto the crop and the later rinses were emptied on waste ground or in the yard. 16% of respondents said their washings were solely disposed of in the yard and 11% maintained that they had approved soakaways or sumps under their yards. Whilst 8% of respondents disposed of tank washings on low grade wildlife areas, only 1% respondents had Sentinel cleaning apparatus and a further 3% of respondents disposed of washings on set-aside land prior to ploughing or used unmettaled farm roads as a soakaway.

The survey also reported on the frequency of washing the exteriors of sprayers. Only 14% of respondents wash their sprayers down routinely after use or at the very least daily and 21% stated that they washed their sprayers regularly and a further 21% washed their sprayers infrequently on an "as required basis". Some respondents were candid enough to state that they washed their sprayers only at the end of the season and 26% stated that they had no routine cleaning programme. Should contaminated equipment be left in a farm yard over night and a rainfall event occur then any of the residues attached to the sprayer would be washed off and become a contamination risk.

The Soil Survey and Land Research Centre (SSLRC) in conjunction with Rhône-Poulenc and Novartis have recently carried out a sprayer washing study. A mounted 1000 litre sprayer was used to treat 10 hectares with isoproturon and simazine. The equipment had been thoroughly cleaned prior to the application. On completion of spraying the external surface of the spray equipment and tractor were washed and samples collected. Internal tank washings were also sampled. It is anticipated that when the analytical results are available from this study a mass balance of the deposited chemical can be determined.

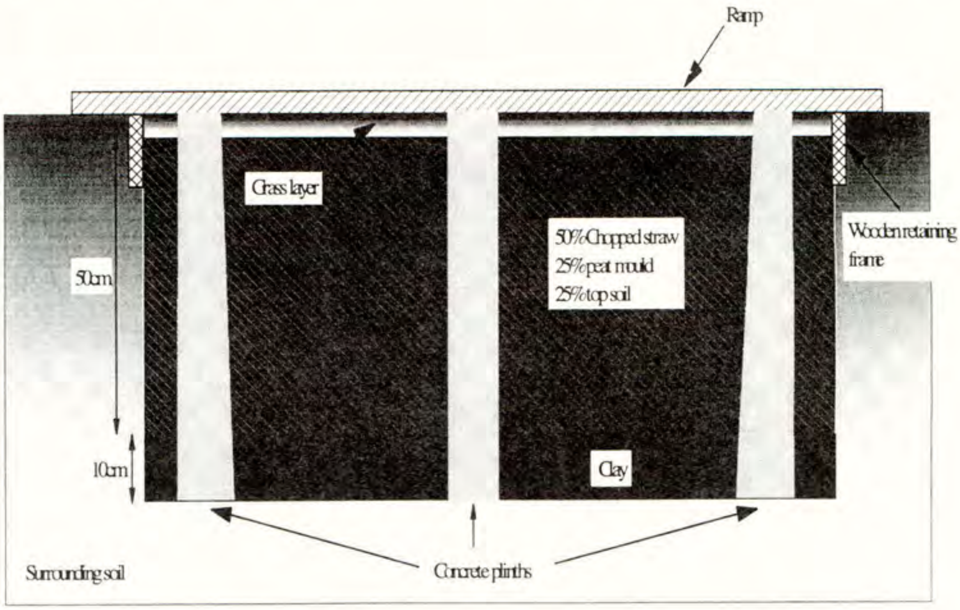
ALTERNATIVE DISPOSAL OPTIONS

The MAFF Code of Practice offers guidance for waste disposal but many of the solutions are either not commercially practical or are expensive. A number of alternative methods of disposal have been identified in the literature which rely on biological degradation and /or evaporation to reduce or remove the pesticide residues from waste tank mix or washings.

Junk *et al* (1984) used mixtures of soil, rock and sand in disposal pits with recirculating effluent. With respect to containing the pesticide waste both pits performed well and it was concluded that soil was an essential part of the disposal system acting as a source of degrading organisms and for adsorption sites. Winterlin *et al* (1984) developed evaporation beds whereby large volumes of dilute pesticide could be concentrated down to more manageable levels. Residues did not tend to accumulate after 6 - 10 years of use but did tend to concentrate in the top 2.5 cm of soil as a result of evaporation from the surface.

Torstensson and Castillo (1996) describe a construction which is intended to retain pesticide spills and decompose the active substance as rapidly as possible (Figure 1). A pit was excavated to a depth of 60cm with concrete plinths set in place to eventually carry the weight of the sprayer. The bottom of the pit was then lined with a 10cm layer of clay and a load bearing frame constructed on top of the concrete plinths with access ramps constructed from one end. The biobed was then filled with the mixture of chopped straw (50%), peat mould (25%) and top soil (25%) with grass either being laid or planted on the surface of the biobed. The actual size of the biobed depends on the spraying intensity and the size of the spray application equipment. Generally the bed should be 0.5m wider on both sides than the sprayer and be of greater length.

Figure 1. Diagrammatic representation of a biobed (after Torstenssen and Castillo 1996)



An environment for disposal was required whereby maximum adsorption was achieved, whilst at the same time still allowing the pesticides to be bioavailable and where optimum conditions for microbial breakdown would occur. The ideal top soil was described as being rich in humus but have a low clay content. This encouraged micro-organisms and provides sites for adsorption. The peat mould also increased the binding capacity of the mix and at the same time acted as a moisture regulator, with the straw also providing a substrate for micro-organisms, especially lignin decomposers (Torstensson *et al,* 1994).

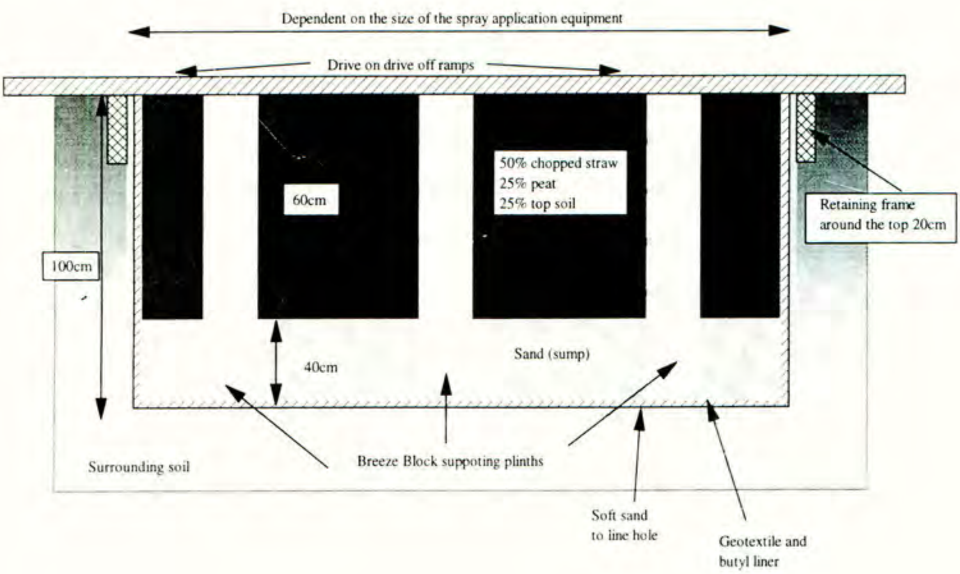
The first three biobeds for practical use on farms were built in 1993, with a total of eight being monitored by 1995. Since being established the biobeds have been routinely inspected and sampled to determine the effects of any spillages and to determine residue levels contained within the bed as well as levels of microbial activity. The rate of respiration and enzyme activity was high within the biobed, supporting the work carried out in the laboratory by Stenberg *et al* (1994).The damage to the grass cover has been concluded to be one of the most useful teaching aids as all of the herbicide spills are clearly indicated by the damage to the grass cover. The observed damage was greatest immediately below the sprayer tank, indicating that pesticides do adhere to the outside of the sprayer tank during the application operation, and are then washed off by spillage of water at the next filling (Torstensson and Castillo 1996).

As expected pesticide residues were detected in the top layer of the biobed as a result of filling and cleaning the spray equipment. Testing of the bottom layers showed no indication of pesticides which demonstrated that the biobed was functioning as expected. Practical operation also showed that the levels of pesticides being spilt or disposed of on the biobed were effectively retained within the bed, with the main part being degraded before the next spraying season.

PROPOSED CONSTRUCTION AND OPERATION IN THE UK

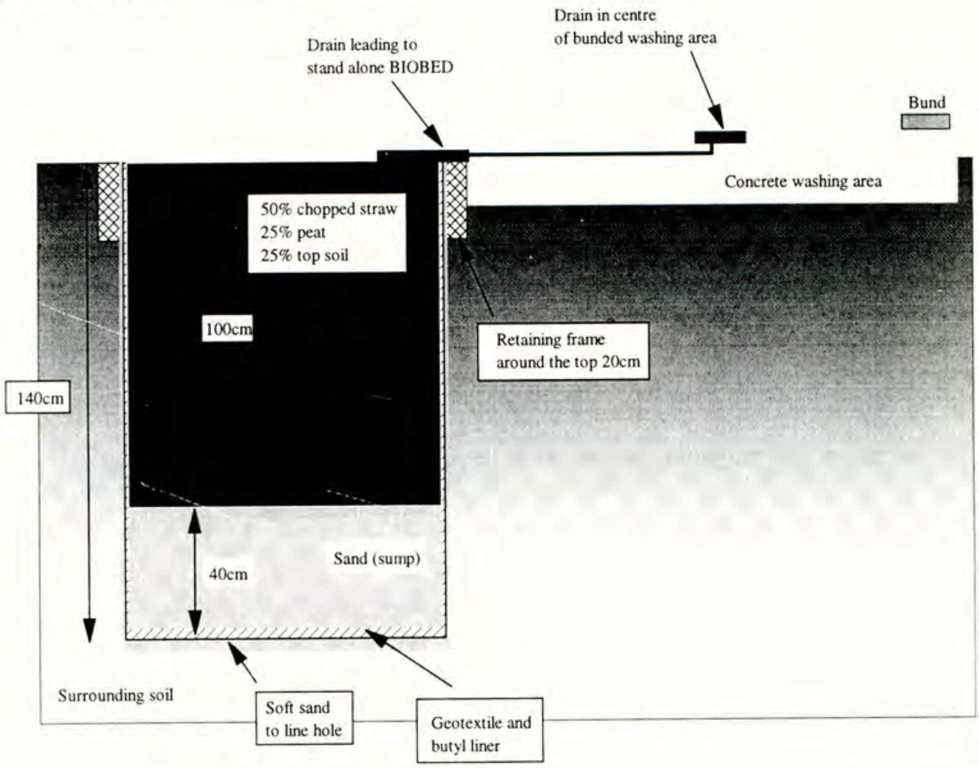
It is proposed to establish three experimental biobeds in the UK as described by Torstenssen and Castillo (1996) with topsoil, peat mould and straw mixed in the volumetric proportions of 25:25:50 respectively. Figure 2 shows a modified SSLRC design for a drive on, drive off facility.

Figure 2. SSLRC drive on drive off biobed design (after Torstenssen and Castillo 1996)



It has however been identified that many UK farms already have concrete bunded areas in place and that the majority of landowners would not be prepared to sacrifice this concrete in favour of a biobed. In order that the disposal technology can still be utilised it is suggested that a biobed is established adjacent to the concrete washing area and that all washings and waste dilute pesticide are directed onto it (Figure 3). The dimensions of a drive on drive off biobed have to be sufficiently large for all spillages, dripping nozzles and washings to be intercepted by the bed and the size of the spray application equipment will therefore determine the size of the bed. The stand alone biobed can have a reduced surface area but the total volume of the bed will have to be similar to the drive on drive off facility. The size of spray application equipment, the area to be treated each season and washing practice will control the volume of waste produced. The minimum depth of a biobed will be 1 metre however this may need to be increased for the stand alone biobed. Each bed will need to be dug to a depth slightly deeper than required to allow for the hole to be lined with fine sand, which prevents stones and any other sharp objects from puncturing the lining material. A geo-textile liner followed by a butyl liner will then be placed into the hole on top of the sand to prevent any liquid from draining out of the bottom of the biobed. The liner will then be covered by 0.4 metres of fine sand. The sand will act as a drainage sump preventing the soil, peat and mixture from becoming saturated and thus anaerobic. When excess liquid is in the bed it will drain into the sand leaving the bed at field capacity. As the bed dries further the effects of evapotranspiration will draw the water from the sand and into the soil, straw, peat mixture thus making pesticide residues bioavailable.

Figure 3. SSLRC stand alone biobed (after Torstenssen and Castillo 1996)



INSTRUMENTATION

The biobed will be instrumented to enable water fluxes and temperature throughout the bed to be recorded, rainfall will also be monitored. Each bed will be fitted with a 20 cm diameter piezometer tube to allow for easy access to the water phase within the biobed and also to allow the bed to be drained should flooding and subsequent overflowing of the biobed become a risk.

Water fluxes will be monitored using equitensiometers. It has been identified that the pesticides are most readily bioavailable when they are in the liquid phase of a system, therefore the matric potential measurement will not only allow the estimate of water content but more importantly how tightly the water is being held. The instrumentation will also identify the direction of dominant water movement, that is, downwards through the biobed into the sand sump or upwards due to the effects of evapotranspiration. The equitensiometer enables matric potentials of between 0 kPa (0.00 bar) through to -1000kPa (-10 bar) to be measured. The data will be logged automatically to enable changes in response to rainfall and waste inputs as well as rainfall to be monitored.

It is anticipated that temperature will have a significant effect on the rate of degradation. Temperature fluctuations will be monitored throughout the biobed at the same depths as the equitentiometers. The environmental data obtained will be used in the laboratory experiments to help simulate the real environment. As the biobed infill materials decompose they are expected to generate their own heat. Careful monitoring of significant temperature gradients are to be looked at as there may be a risk of the bed being sterilised should the temperature rise too high.

MANAGEMENT OF THE BIOBED

Once the biobeds have been constructed it is intended to leave them to equilibrate for 4 to 5 months. Throughout this time the hydrological characteristics of the system will be monitored in detail thus enabling response to rainfall and evaporation to be assessed. It is anticipated that there will be a need for artificial irrigation at times throughout the summer months in order to maintain the efficiency of the bed once it is in operation. A basic hydrological management strategy will be defined throughout this equilibrium period. The biobeds capacity to absorb liquid whilst remaining aerobic will be determined and the theory of the sand sump acting as a water source throughout drier periods will be assessed. The biobeds will be operational for the autumn 1998 spraying season. The chemical inputs to the system will be carefully monitored in conjunction with the users of the biobeds. Following a survey of the agrochemicals likely to be used at each of the three initial biobed locations it is anticipated that the system will be run in an open and uncontrolled manner, that is, the spray operator will deposit waste and washings in line with his normal agricultural practice provided that a detailed record of the inputs is being maintained. The concentrations of pesticide deposited in the biobed from rinsing and washing of a sprayer following its normal use will also be determined from sub samples. Cores of the infill material will be analysed to determine initial residue concentrations as well as levels of microbial activity. Following the last application of the spray season's waste to the biobed, samples will be collected on a monthly basis to monitor degradation and levels of microbial activity. A similar sampling strategy will be adopted for the spring spraying season. The long term efficacy of the biobed may be influenced by the continued disposal of tank mixtures and a wide range of active substances. Should funding permit the programme will extend into the autumn 1999 spraying season to look at the long term viability of the system. It is also anticipated that over time the biobed substrate will decompose and will need to be added to. Complete replacement is at this stage not considered appropriate due to the specialist microbial populations which will develop due to their environment.

LABORATORY WORK

Laboratory work will be carried out in conjunction with Horticulture Research International with experiments designed to determine the choice of the most suitable infill materials and to determine the likely efficacy and longevity of the system. Sorption and degradation processes in a range of construction materials and the effect of mixtures of pesticides on these processes will be investigated. Mini biobeds will be established containing a range of media and will be treated with selected bench mark and environmentally significant pesticides. The cores will be stored out of doors and will be managed to be representative of the on farm biobeds. The total residue content as well as the proportion of bound and bioavailable residues will be examined for the different biobed media being investigated. There is evidence that the persistence of a pesticide may be changed when used in combination with other pesticides. Although most experiments have been conducted under laboratory conditions; there have been few studies to determine the significance of these changes in the field (Hurle and Walker, 1980).

TECHNOLOGY TRANSFER

The three pilot biobeds will be established on high profile farms where training and open days can be organised for interested parties to attend. The farming press will be kept informed of the progress of the project. When the long term viability of the biobed system has been established, a set of guidelines will be published describing the construction and management of a biobed. Venues such as agricultural shows will be used to explain the problems caused by pesticide disposal and the rationale of the biobed project.

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PESTICIDE WASTE - PRACTICAL PREVENTION, MINIMISATION AND HANDLING ON THE FARM

JOHN R McB ALLAN
CropWell Consultancy, Meadow Mist, Radcliffe Road, Cropwell Butler, Nottingham, NG12 3AG

ABSTRACT

For a farmer there is patently no sense in wasting pesticide that has cost him good money. Such waste may be direct - a result of over-ordering, damage or deterioration of pack or product, not emptying and rinsing a pack into the sprayer or any action that means the product does not reach the intended target. On the other hand - financial and human resources may be wasted by the inappropriate use of pesticides when applying them in the absence of apparent need or by misapplication which damages valuable environmental assets or pollutes water.

In addition, incorrect handling of pesticides and their packaging may create unnecessary 'special waste' which has to be dealt with off farm. This is costly to handle and dispose of and in most cases the problem can be avoided or dramatically reduced by training, management, stock control, machinery maintenance and discipline. Laws don't ensure good practice on the farm - training, due diligence and enforcement do!

A check list is given to highlight practical steps that can be taken on a farm to reduce the potential problems of pesticide waste and waste of pesticide.

PESTICIDE WASTE

Pesticide can be wasted in two ways, directly as 'pesticide waste' and directly or indirectly as 'waste of pesticide'. Indirect waste may be by loss of money, wildlife, biodiversity, water quality, human health, time or in a number of other ways.

The manifestation of such waste may be as losses which are:

- **Physical** - from leaking containers, spillage, drift, unwashed packs, cross load contamination, incorrect adjuvant use, surplus spray mix, tank and sprayer washings, inaccuracy of application, effects on wildlife and beneficial predators etc.

- **Human Resource** - for example resulting from insufficient training, lack of discipline and inefficient application, or adverse health effects.

- **Financial** - by definition anything that does not arrive at the required target results in a financial waste, while indirect losses often have financial consequences and at the same time often create negative publicity - which also has a cost.

LEGISLATION AFFECTING PESTICIDE WASTE

UK legislation affecting pesticide waste is outlined in another paper. (Cooper, 1997) Currently, an ever increasing number of EU Directives and UK laws are aimed at overcoming some of the direct and indirect effects of waste pesticide. They are backed up by guidelines and codes of good practice for farmers, managers, advisers and operators.

In addition environmental imperatives are increasingly bringing wasted pesticide into play in drinking, ground water and other controls. While the government recently published a consultation paper which raises the possibility of *Economic Instruments for Water Pollution* - perhaps in the form of taxes. This reinforces the need to avoid any sort of waste, especially at a time of declining farm incomes!

Finalising and introducing a new law often seems an interminable process. But once finalised it will be of little use if management decision and operator training are inadequate. It is people at the sharp end who have to deliver good practice in the field. However, good practice is often only as good as its enforcement!

And what of requirements in other countries? How uneven is the playing field?

An outline survey of agriculturally important world trading EU countries, the USA, Australia and Argentina shows a considerable diversity in the way pesticide use and waste is controlled. This variation may have cost of production implications as we move towards freer world trade.

PREVENTING, MINIMISING AND DISPOSING OF PESTICIDE WASTE ON THE FARM

The following headline lists point to areas that need checking during day to day management on the farm, increasingly backed up by self-audits and verification schemes.

'PESTICIDE WASTE' DOWN ON THE FARM CAN BE CAUSED BY:

- Unnecessary spraying
- Over-ordering product and lack of stock rotation
- Poor storage standards
- Damaged packs and/or labels
- Frosted material
- Out of approval and out-of-date products - details in the annual MAFF 'Blue Book' *Pesticides* and the *Pesticide Register* from the Pesticide Safety Directorate
- Inappropriate pack sizes for the job/area in hand
- Spillage when handling pesticide concentrate
- Unrinsed pesticide packs
- Not using returnable/refillable packs when available
- Inadequate and/or inappropriate storage for used pesticide packs

- Incompatible tank mixes resulting in reject loads
- Weather effects causing drift, crop damage or unused spraymix
- Residual spraymix at end of job
- Sprayer tank washings
- Sprayer washings
- Creation of 'special waste' needing disposal off the farm e.g. unwanted concentrate, unrinsed packs or water contaminated with pesticide

PREVENTION OF PESTICIDE WASTE AND WASTE OF PESTICIDE

Pre-spraying

- Train - Train - Train - before getting on with the job, e.g.,
  - managers and operators in knowledge and skills, legal requirements, decision making and the use of equipment
  - on the need for 'No-spray Zones' and other environmental restrictions
  - on how to find out if an approval is to be withdrawn or a product is outdated
  - on how to minimise pesticide waste
  - on how to deal safely and legally with pesticide waste
- Regularly monitor, calibrate and maintain application equipment
- Pre-plan likely pesticide use and balance orders against use
- Consider any benefits from weed mapping, threshold evaluation, etc. to ensure precise application and that pesticide application is not wasted
- Ensure sound and safe storage with waste containment in case of spillage or fire with sand, brush, shovel, personal protective equipment and impervious container for damaged packs or spillage readily available
- Choose pesticide formulation - soluble packs, water dispersible granules, tablets, etc. to minimise waste
- Never use a non-approved product or parallel import - at worst it could mean a 'crop destruct order'
- Choose most appropriate pack size
- Use returnable-refillable packaging - e.g. LinkPak, Ecomatic, etc.- when available
- Use up old stocks of approved pesticide on approved crop - don't leave it at the back of the store!
- Pre-plan type and use of personal protective equipment to minimise need for safe disposal of contaminated equipment
- Establish an emergency action plan and giving training in its use

When spraying

- Use non-return valves in water supply for sprayer filling
- Use lockable pesticide concentrate storage in the field
- Check sprayer valves, pipes and nozzles to avoid waste and contamination caused by a burst or leak
- Keep sprayer pipework clean - prevent 'arteriosclerosis' and down time resulting from contamination/decontamination and potential waste disposal problem

- Take care with measuring out and charging pesticides to a pesticide applicator:
  - use catch tanks to avoid waste
  - use induction hopper or other semi- or totally-closed filling system
  - use injection systems to avoid excess spraymix and to ease washing out the sprayer
- Avoid drift and misapplication:
  - check weather forecast before spraying
  - select correct setting for nozzles/ pressure rating/ formulation/ adjuvants/ twin fluid/ air assist/ electrostatic, et al.
  - match spray quality to target and environmental requirements
  - check boom suspension, sprayer suspension, tractor/sprayer tyre pressures
  - match spraying speed to ground/product requirements
- Ensure sprayer has a rinse water tank fitted to allow tank rinsing in the field using tank wash additives
- Dispose of tank rinsings to a crop having received less than the maximum permitted dose - do not risk the cost of 'special waste' disposal
- Keep weather delayed spraymix useable - use 'Laser' agitation on the sprayer, or transfer the load to a bowser with agitation to avoid need for disposal
- Use sprayer wash down attachments, if available

MINIMISATION OF PESTICIDE WASTE AND WASTE OF PESTICIDE

- Ensure Training on existing and new legislation and equipment, calibration, product handling, waste minimisation, environmental hazards, etc.
- Give training in how to handle emergency situations involving pesticides
- Ensure Certification or granddad exemption for management and operational staff -
  - Crop Management Certificate (BASIS) for better management decisions
  - BASIS Crop Protection Certificate for advisers and managers making major product choice decisions
  - NPTC Certificate for operator - with up-date courses and modules as needed
- Consider direct injection systems to avoid excess spray-mix and lessen tank washings
- Use sprayer monitors and controls that are readily understood and used by operator
- Ensure accurate sprayer monitors/controls
  - calibrate sprayer and controls
  - and use an annual independent sprayer testing service
- Minimise residual spray-mix left at the end of a job by
  - accurate and regular sprayer and monitor calibration
  - accurate measuring in of water
  - knowing the area of fields and headlands
- COSHH assessment - Is spray needed? - Safety for the operator avoids time wasting
- Use 'appropriate dose' to avoid pesticide waste
- Know accurately - the area to be sprayed, volume needed and how to measure out the pesticide required
- Use in field tank rinsing
- Use sprayer wash down equipment and pads to collect contaminated water
  - or rotate washing down away from ground or water sensitive areas of the farm
  - or perhaps use bio-beds

TREATMENT OR DISPOSAL OF PESTICIDE WASTE/SURPLUS

Do not dispose of -

- Contaminated pesticide packs on farm rubbish heaps, in hedgerows etc., where they can contaminate water or are accessible to the staff, public and children
- Pesticide concentrate by diluting and spraying on waste land
- Surplus spraymix and tank washings on uncropped headlands etc. nor put down the drain or wash into ditch, river or soil

Do -

- Thoroughly wash empty packs by triple rinse/pressure washing and dispose of:
  - on farm, by burning or burial according to the 'Green Code' *The Safe Use of Pesticides on Farms and Holdings'*- never re-use packs for other purposes
  - off farm, to an acceptable and accepting waste disposal site using a specialist, local authority or industry collection scheme
  - according to any changes in the agricultural waste regulations
- Dispose of surplus spraymix by application to an approved crop within the maximum dose and application allowed or, when possible, as a tank mix on an appropriate ensuing crop
- Dispose of tank rinsings in the field to a crop treated with less than the permitted maximum dose, e.g. a reduced rate applied on the headland
- Dispose of contaminated sprayer washings by using a:
  - 'Sentinel' with a disposal route for liquid effluent and contaminated filter material
  - Biobeds
  - Reedbeds
  - in all these cases prior approval of the Environment Agency should be sought
  - otherwise -
- Use Specialist waste contractors to take away all contaminated packaging and/or personal protective equipment, redundant concentrate and contaminated water

RECORDS, CONTROL AND INFORMATION

Farm Records

- Store records for incoming and outgoing stock and stock rotation help to avoid waste
- Application records - application rates and area records will point up any waste that is occurring

Codes of practice:

- 1998 'Green Code' - *Code of Practice for the Safe Use of Pesticides on Farms and Holdings* now incorporating HSE AIS16 - *Guidance on Storing Pesticides for Farmers and Other Professional Users* - MAFF
- *Code of Practice for the Safe Use of Pesticides for Non-Agricultural Purposes* e.g. grain stores and amenity work - HSE

- *Code of Good Agricultural Practice for the Protection of Water - MAFF*
- 1998 Orange Code - *Code of Practice for the Use of Pesticides in Amenity and Industrial Areas* - BAA/NAAC

British Crop Protection Council & CAB International:

- Annual 'Green Book' - *The UK Pesticide Guide*

British Agrochemical Association:

- *Think Water - Keep it Clean'* - campaign and leaflet
- *Rinse, Rinse, Rinse* - leaflet and sprayer sticker
- *Pesticide Disposal* - leaflet
- *Container Rinsing* - leaflet
- *Glove Hygiene* - leaflet
- *Using Pesticides - A Complete Guide to Safe, Effective Spraying* - Ring binder

Self auditing and Verification provided by:

- *LEAF Audit* - Linking the Environment And Farming
- *Assured Combinable Crops Scheme Manual* - UK Food Quality Certification
- *Scottish Quality Cereals - UKFQC*
- *Vegetable Producer Protocols* - National Farmers Union

Other sources:

- Farmers Weekly - *Tank Mix Guide* - helps avoid inappropriate mixes
- Technical, machinery and legislation updates in farming journals - to keep up-to-date with developments that will improve application, increase safety and avoid waste
- The Internet search engine Alta Vista shows 27,451 references giving information on pesticide waste handling in other countries, especially the US.

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