Pesticide run off into English rivers – a big problem for farmers

Recent work has shown that pesticides applied to land are almost certain to run off into water courses. This is set to have a major impact on British farming as requirements on the UK government to comply with EU drinking water guidelines will pressure farmers to reduce use or lead to further pesticide bans. ***Bob Evans*** *reports.*

It has been known for many years that pesticides sprayed on land reach water courses[1]. But for a long time it was thought that the amounts would only be harmful under exceptional conditions such as heavy rainfall immediately after application[2].

In the late 1980s and early 1990s sampling of English rivers showed that pesticides were frequently found in England such as in the River Cam[3], the small Rosemaund catchment in Herefordshire[4,5,6,7,8], the Newlyn River in Cornwall[9,10] and the River Ouse in Bedfordfordshire[11]. And by 1995 the National Rivers Authority[12] after sampling about 3,500 sites in 1992-93 (almost 450,000 analyses), had become seriously concerned about the issue. Its successor, the Environment Agency, continued the monitoring programme[13] and set up the Pesticides in the Environment Working Group to oversee monitoring activities[14].

Pesticide transport to water

Pesticides can reach water courses in a number of ways

- *direct* - directly during spraying
- *surface run off (or wash)* - dissolved in water or attached to soil particles in water flowing across the soil surface
- *sub-surface flow* - dissolved in water or attached to soil particles in water flowing through the top few centimetres of soil
- *bypass flow* - dissolved in water or attached to soil particles in water flowing down cracks which form when the soil dries, or via large pores such as worm holes, and so rapidly reaching field drains. Field drains fill and overflow into water courses when soils are saturated or when bypass flow occurs
- *drainflow* - dissolved in water or attached to soil particles and slowly percolating through the soil to field drains and then to the water course
- *groundwater flow* - dissolved in water and slowly percolating through the soil to the groundwater table and then to the water course

Importance of surface run off underestimated

For a long time it was thought that the main way pesticides reached water was via field drains. Although it was known that aldrin and dieldrin were carried in surface run off from the land[15], and that run off and soil erosion were widespread in some parts of England[16], often during small rainfall events[17], and likely carrying pesticides[18], this route to water courses was not considered important.

For example, in a plot experiment, in the Midlands, near Birmingham, in one season highest concentrations of alachlor were found in surface run off. But it was considered that this run off did not reach the field boundary ditches and so was not considered important[19]. In another season high concentrations in the stream were attributed to spillage at tank-filling.

In another plot study on clay soils in Northumberland, north east England[20], both drainflow and surface flow were studied over two seasons. Four pesticides were monitored (fonofos, trifluralin, IPU and mecoprop) and in both seasons their concentrations were higher in surface flow than in drainflow. Despite this the study considered bypass flow down soil cracks to field drains and leading to drainflow was an important route by which pesticide was lost from the site.

In addition to the apparently blinkered conclusions of these plot studies it is also hard to extrapolate from them to the larger scale of the field[21,22].

In a conference paper presented to the pesticides industry the importance of run off as a route to transport pesticides to water courses was pointed out[23]. But the view that pesticides rapidly reached streams either via bypass flow to field drains[24] or from spillages still held sway.

However, by the late 1990s the importance of surface flow was becoming more apparent. Water in the River Thames at Walton was shown to exceed the 0.1µg/l threshold set by the EC Drinking Water Directive. This was the case even when field drains were not flowing[25], implying that surface flow was an important route.

Costs

Questions in Parliament asked by Anne Campbell, then MP for Cambridge, showed that over the three year period 1992-1994 the cost of treating water to remove pesticides totalled £499 million. Such costs, non-compliance with EU regulations, and the concern of the Environment Agency[26], led the Government in 1997 to consider imposing a tax on pesticides[27]. However, the government also indicated that it would consider a package of voluntary measures in place of the tax and expected the farming industry to adopt a 'partnership approach'[28]. The British Agrochemicals Association (BAA), later the Crop Protection Association (CPA), responded by proposing 'A partnership approach to minimising the environmental impacts of crop protection chemicals'[29] and a later revised proposal 'Minimising the environmental impacts of crop protection chemicals'[30]. The essence of these proposals were that the CPA and associated industries should work in partnership with water companies and environmental agencies to protect plants, animals and water from the harmful effects of crop protection products. The package included proposals for training and raising awareness among farmers, the introduction of crop protection management plans, providing better information on the environmental impacts of pesticides, encouraging the uptake of integrated farm management, surveying current application practices and equipment, and providing additional support for Environment Agency research on pesticide handling and sprayer wash-down areas. The Cherwell project (below) was part of that research programme.

Cherwell catchment studies

As part of their proposal, a small 100 ha catchment in the headwaters of the River Cherwell was monitored to determine the relative contribution of point and diffuse sources of water contamination by the cereal herbicide IPU[31]. The Cherwell was chosen as concentrations of IPU in the water abstracted from the river at Grimsbury reservoir to supply drinking water to the citizens of Banbury frequently exceeded the threshold of 0.1µg/l and abstraction had to stop.

Flows from the one farmyard in the catchment, culverts into and out of the yard, and the River Cherwell were monitored and sampled over the winters of 1998/99 and 1999/2000. Contamination of surface waters from the concrete farmyard was found to be more significant than had been previously recognised. This formed the basis of the Voluntary Initiative project to reduce farmyard spillage (below). However, as Friends of the Earth note[32] a high proportion of the IPU found was not explained by run off from the farmyard.

Surface run off is visible on these saturated fields near the River Cherwell *Photo: Bob Evans*

The amount of IPU found in the Cherwell was related to time of spraying and when the rain fell and was much greater in the second season when rainfall rapidly followed application suggesting that a large proportion of the pesticide ending up in the Cherwell was coming from the sprayed field in surface run off. The FoE report highlights a number of shortcomings in the Cherwell study but itself did not take account of surface run off as a source of contamination. It agreed that water flowing through field drains was the primary route from the field.

The Voluntary Initiative

The Voluntary Initiative was set up in 2001 with the primary aim of improving training of spray operators and has succeeded in this both locally and nationally. In the Cherwell catchment IPU concentrations were less in the first two seasons of the Initiative (2002/3 and 2003/4) than before. At first this was put down to greater diligence by spray operators, especially when filling and emptying spray tanks. However, in the third season (2004/5) IPU concentrations were greater than before. It became apparent that the reduced concentrations in the first two years were due to low rainfall and the increased concentration in year three was due to greater rainfall. This realisation led the Initiative to revise the advise they were giving farmers. Whereas the original advice focused on reducing spills from farmyards the new advice emphasised reducing the movement of pesticides sprayed onto fields into water. It took account of soil type, the shape and gradient of the land, whether field drains were flowing, and the likelihood of heavy rain.

In early 2007 a meeting was held in the upper Cherwell catchment to explore what more could be done to stop pesticides reaching the abstraction point for Grimsbury reservoir near Banbury. Present at the meeting were farmers, agronomists, soil scientists and the Environment Agency's catchment coordinator for the Cherwell. A number of fields were visited which showed signs of soil erosion and run off. When the topsoils were examined some were compacted and waterlogged in areas where the fields had been drilled when wet. Water was 'ponding' on the surface of the soil in many areas. A quick survey of the upper Cherwell showed that soil erosion was occurring; after rainfall, water could be seen flowing down tractor wheelings into ditches and streams. Surface run off seemed to be the main way in which pesticides were reaching water courses.

The Environment Agency made available its data on pesticide concentrations in the Cherwell at Banbury for a number of years, and daily rainfall data for a station in the catchment. To determine if high pesticide concentrations in the Cherwell correlated with high rainfall the highest daily rainfall prior to an exceedance (of the 0.1µg/l limit) was noted and compared with pesticide concentrations in the river. This showed that pesticides were frequently transported from land when rainfall was less than 15 mm (Figure 1), on average four or more times per year. In the case of IPU (not shown), almost every time 5 mm or more of rain fell in winter when topsoils were saturated.

Some pesticides can be found in the Cherwell (Table 1) for large parts of the year (mecoprop), some mainly over winter (IPU, chlorotoluron, propyzamide) and others during spring and summer (simazine, clopyralid). Data from the autumn and winter of 2006 (Table 2) showed that their presence in the Cherwell relates well to rainfall incidence. Some seem to be transported mainly via run off (chlorotoluron, mecoprop), some via run off and field drains (IPU, propyzamide) and some mostly via drainflow (carbetamide, simazine), although in the latter instances the herbicides may have been applied later in the season and so run off may have had a greater role. These findings confirm the supposition[33] that pollutants are more easily transported from the land by surface and near surface flow when there is insufficient vegetation cover to impede flow. Research is now being carried out as part of the Voluntary Initiative to assess if run off is the main way that pesticides reach rivers.

Implications of findings

These findings have serious implications for British agriculture. Although pesticides have been found in rivers for many years, the full range of pesticides used by farmers has not been monitored. As detection techniques are refined it is likely that more pesticides will be found. Thus, one of the conclusions that can be drawn is that a pesticide sprayed onto land or crops, especially in winter when topsoils are saturated, will almost certainly be transported to a water course by run off. Recently metaldehyde (from slug pellets) has been found at high concentrations in rivers in England and is linked to heavy rain and run off[34]. This winter and summer glyphosate has been found in rivers at levels above 0.1µg/l.

If the threshold of 0.1µg/l, set at what was then the detectable level in water, is maintained under the EU's Water Framework Directive[35] as a 'blanket' threshold that should not be exceeded, there is a danger that many more pesticides other than those already banned (aldrin 1989, IPU and trifluralin this year) will be proscribed. The headline in a recent Farmers Weekly says it all: 'Follow advice or lose vital herbicides'[36]. The Home Grown Cereal Authority has published two information sheets[37,38] to try to bring the message home to farmers. The National Sprayer Testing Scheme, part of the Voluntary Initiative, has set up a new scheme – the Metaldehyde Stewardship Group[39].

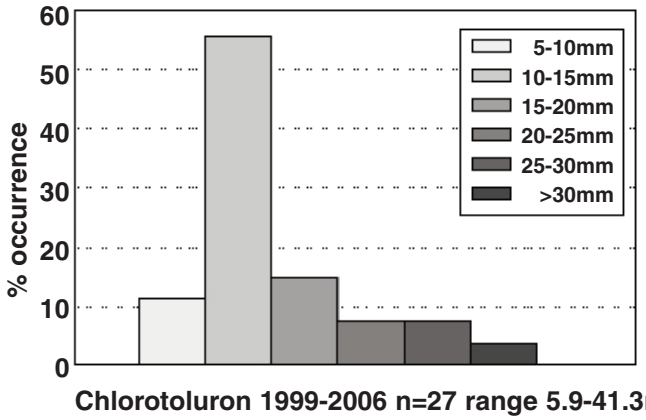
However, even if farmers do all they are asked under the Voluntary Initiative

Table 1. Timing of pesticide contamination in the upper River Cherwell*

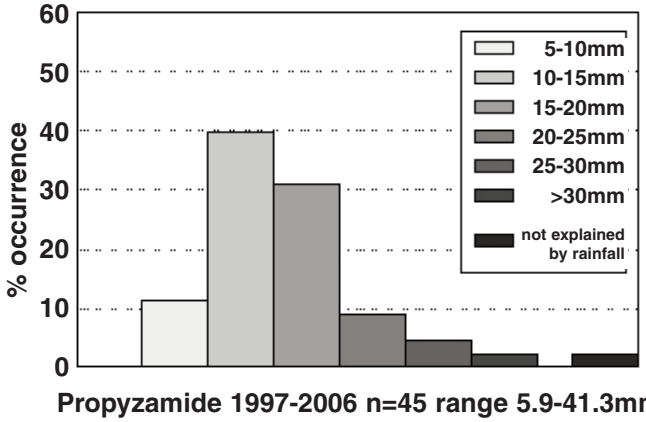
- Isoproturon – October to March, can be later in season
- Chlorotoluron – October to December, can be January to March
- Mecoprop – All months except January, August, September
- Propyzamide – September to February, once in July
- Simazine – April to May, can be winter months, June and July
- Clopyralid – April, but also February, March, May and June

** periods when the pesticides are present above the threshold level of 0.1µg/l, late 1990s to present*

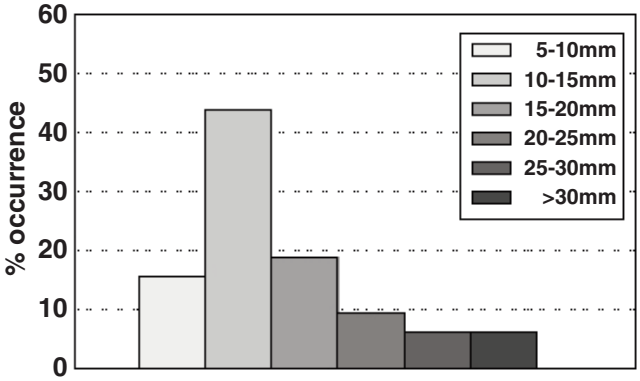
Figure 1. Maximum daily rainfall at Byfield in the upper Cherwell catchment prior to the occurrence in the River Cherwell of herbicides above the threshold level of 0.1µg/l at Grimsbury Water Treatment Works, Banbury.



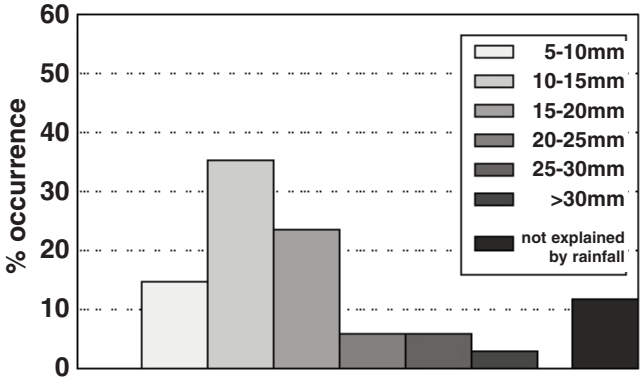
Chlorotoluron 1999-2006 n=27 range 5.9-41.3mm



Propyzamide 1997-2006 n=45 range 5.9-41.3mm



Mecoprop-p* 1999-2006 n=32 range 7.1-41.3mm



Simazine 1997-2006 n=34 range 7.4-60.7mm

** mecoprop contains two isomers present in roughly equal concentrations, one of which is mecoprop-p*

scheme (www.voluntaryinitiative.org.uk), the precautionary approach outlined in these strategies is unlikely to solve the problem. The idea that 'heavy rain' causes run off needs to be questioned. When topsoils are saturated, run off occurs during light rain (5-10 mm rainfall) which happens fairly frequently.

The implication of retaining this blanket threshold of 0.1 µg/l is no use of pesticides. While this may be appropriate in the long-term (and indeed groups like PAN *UK* are lobbying to retain this protective limit), in the short-term it has severe implications for agriculture and farmers in the UK who have been encouraged down a route of pesticide dependency by the UK government and agrichemical industry. Perhaps over the short term, thresholds should be set for individual pesticides, depending on their ecotoxicity and persistence.

Table 2. Observations on pesticides in the upper River Cherwell (with special reference to September–December 2006)

- Isoproturon – In river for long periods, increase in concentration every time rainfall >5 mm; transported to rivers before field drains flow but also transported via drains.
- Chlorotoluron – Transport to rivers correlates well with rainfall events and run off; in 2006 exceeded threshold levels in rivers earlier than IPU and originally at higher concentrations; less soluble than IPU, more carried attached to soil particles, but probably also a drainflow component of transport.
- Mecoprop – Transport closely related to rainfall and run off; in 2006 found in river before IPU and chlorotoluron.
- Propyzamide – Better correlation with rainfall and run off than IPU; probably more attached to soil particles, but as with IPU probably a field drain component of transport; transported to river in storms of late September.
- Carbetamide – Did not reach threshold levels in river until mid November, suggests that transported mostly via drainflow – although later application likely.
- Simazine – Transport probably closely related to run off, but no rise in concentration levels in river until late November when soils saturated; probably a drainflow component – although later application likely.

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Endosulfan accident in Uruguay kills livestock

On 9th April 2009, hundreds of cattle were poisoned when a crop spraying plane suffered a mechanical failure in its spray tank hoses, causing the contents of a 20 litre container of Bayer's Phaser 350EC endosulfan product to spill onto grazing land. The incident took place 100km east of Guichón city in the Uruguayan Department of Paysandú where the plane was spraying the insecticide on soya fields. More than 50 calves died in the following 24 hours from eating contaminated pasture, with a further 700 cattle affected, displaying symptoms of neurological disruption. Local farmers who witnessed the aftermath described how the cattle collapsed very suddenly or ran towards the watercourses but were unable to be saved. Thousands of fish in the Horno Cañada gorge were also killed, plus snakes, doves and other birds. The scale of the water contamination led to concerns that Guichón city's water supplies would be affected too. The aircraft pilot failed to inform either the local authorities or workers on the cattle ranches of the spillage and was therefore arrested the following day when the cause of the mass poisoning became clear. Criminal proceedings have been initiated. **(SW)**