TRANSFER AND UPTAKE OF CONTAMINANTS ARISING FROM THE USE OF RECYCLED MATERIALS IN FOOD PRODUCTION

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Introduction

The green agenda encourages the recycling of waste materials in order to reduce waste sent to landfill or incineration, and increasingly new uses are being found for materials previously considered as waste. This includes the use of recycled materials in food production for purposes such as animal bedding or as fertilisers.

To ensure the safety of food produed using these materials, we have investigated the potential transfer of organic contaminants into food arising from the use of recycled materials. The investigation includes: i) crop transfer studies to investigate the potential uptake of organic contaminants from waste materials spread to agricultural land by plant tissue, including controlled growth chamber studies with barley and carrots and a field experiment with a crop of winter wheat, and ii) dairy cattle ingestion trials to investigate the potential transfer of organic contaminants to milk from waste materials spread to agricultural land or used as animal bedding.

The programme is unique in the range of waste materials and contaminants under investigation and will provide vital information necessary to inform the development of a methodology and quality standards to assess the suitability of new waste materials for recycling in agriculture.

Materials and methods

Recycled / waste materials selected:

The materials under investigation include biosolids (treated sewage sludge), meat and bone meal ash (MBMA), and poultry litter ash (PLA), representative of a range of recycled waste materials currently applied to agricultural land in the UK as sources of plant nutrients, and paper sludge ash (PSA), used as an agricultural liming agent. Additionally, compost like output (CLO) from the mechanical biological treatment (MBT) of municipal solid waste (MSW) is included as it has future potential as a source of plant nutrients in agriculture. A range of recycled materials used as livestock bedding have been selected, and include recycled waste wood (RWW), dried paper sludge (DPS) from paper manufacturing and PSA, which is used as a constituent of livestock bedding and acts as a desiccant.

A high degree of variability in the chemical composition of the materials was expected; hence, at least two examples within each waste category were obtained where possible to increase the probability of finding a material containing the compounds of interest. The waste materials have undergone physicochemical testing, and analysis for a selection of priority organic contaminants. The analysis of the materials enabled one example of each waste type to be selected for inclusion in the trials, which, in most cases, was the waste with the greatest concentrations of organic contaminants; however, a CLO with lower levels of physical (glass and plastic) contamination was selected for animal welfare reasons.

Crop trials

A protocol was developed to check the reproducibility of transfers of organic contaminants from waste-amended soil to vegetative barley shoots. A loamy sand was used in the bioassay, to minimise sorption to the soil complex and to provide a reasonable worst-case scenario of contaminant bioavailability. Barley was grown under controlled light and temperature conditions in a plant growth chamber for a period of 32 days, and the soil

was maintained at a constant water content. A commercial slow release fertiliser incorporated into the soil supplied a balanced nutrient regime.

To provide sufficient plant material sample for analysis, a separate plant growth trial was completed for: (1) unamended control soil, (2) biosolids amendment and (3) CLO amendment. Further controlled environment growth studies will focus on the transfer of contaminants from biosolids, CLO and ash (MBMA, PLA, PSA) – amended soil to carrot roots. Carrot roots have relatively high lipid content in their peel and represent a worst-case for assessing the potential significance of transfers of lipophilic and persistent organic contaminants to food crops and the human food chain via the plant uptake pathway.

A field experiment with winter wheat was established during November 2014 on a loamy sand soil to investigate the transfer of organic contaminants from biosolids, CLO and ash (MBMA) to wheat grain. The crop will be harvested in September 2015, and the grain will be analysed to determine the extent of organic contaminant transfer from waste-amended soil.

Dairy cattle trials
The potential for organic contaminant transfer to dairy products, which is a highly sensitive dietary pathway for human foodchain exposure, was investigated in a series of controlled feeding ingestion studies with lactating cows. There were four replicate animals per treatment, which were housed on straw bedding in pens. Each animal had an electronic tag to operate and access an individual gate which controlled feeding by allowing the specific feeding regime and intake of each animal to be monitored. Waste products were added to a standard feed regime at a rate of 5% total daily dry matter (DM) intake. The treatments included a RWW, PSA, DPS and a control treatment where animals were fed according to normal farm practice. The treatments were given for a period of three weeks, and feed intakes were monitored and milk production was measured. Milk samples were collected prior to feeding and on a weekly basis during the three week feeding period, and during a four week withdrawal period following feeding.

Organic contaminants will be measured in the milk collected prior to feeding, and at selected time points during the feeding period and at the end of the withdrawal period. Two further trials will be conducted to investigate the transfer of organic contaminants from i) biosolids and CLO- amended soil to milk and ii) ash (MBMA, PLA, PSA) - amended soil to milk in order to simulate ingestion by cows of soil from pasture following amendment with these soil conditioners.

Results and discussion:

In general, the consignements of waste materials obtained for this investigation contained relatively low concentrations of organic contaminants. Notably, the concentrations of polyaromatic hydrocarbons (PAHs), polychlorinated dibenzodioxins/furans (PCDDs/Fs) and polychlorinated biphenyls (PCBs) present in biosolids and CLOs were significantly lower than the proposed and implemented limit values for these compounds across Europe for biosolids and composts. Additionally, the toxic equivalency (TEQ) of PCDD/Fs present in PLA samples fell below the maximum limit of 20 ng TEQ kg^{-1} in the UK Quality Protocol for the production and use of Poultry Litter Ash.

Polybrominated dibenzodioxins/furans (PBDD/Fs) were also detected in the biosolids and CLOs, however, the mixed halogenated dibenzodioxins/furans (PXDD/Fs) congeners that were present were found in only ultra-trace concentrations, but only a very limited range of congeners were analysed (due to the limited range of available internal standards) compared with those for PCDD/Fs or PBDD/Fs. For example, for the Penta 1,2,3,7,8- XDDs, there are 26 possible congeners but only 2 were quantified (i.e. 1-Br-2,3,7,8-ClDD and 2-Br-1,3,7,8-ClDD. The situation is similar for other PXDD/F congeners for which only few congeners were actually quantified.

Perfluoroalkyl compounds (PFCs) were detected in the biosolids, CLO and in RWW samples, and are of interest as they have a degree of water solubility, and therefore could potentially be taken up by crops. Brominated flame retardants were detected in the biosolids, CLOs and RWWs in low concentrations, but, as may be expected, were not found in the ash materials, and a similar pattern was observed for polychlorinated

napthalenes (PCNs). The research programme will provide detailed information on the presence and potential transfer of organic contaminants in waste materials recycled in agriculture, to improve the robustness of risk assessments and confidence in the use of these materials in agriculture, and to establish guidelines and advice where necessary to protect the food chain.

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