COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT

WASTE AND RESOURCES ACTION PROGRAMME (WRAP) REPORT ON ANAEROBIC DIGESTATES.

1. In December 2009 and February 2010 Members discussed two risk assessments carried out under the Waste And Resources Action Programme **(**WRAP) Confidence in Compost Programme (COT 2009/39; 2010/01). These were draft risk assessments on Use of Green Composts in the Scottish Livestock Sector and All composts in all agricultural sectors. Following these discussions Members provided comments on the reports which the Secretariat communicated to WRAP. The Committee wished to see the final versions of the reports before agreeing its conclusions. The Food Standards Agency (FSA) also sought advice on the microbiological aspects of WRAP's peer-reviewed risk assessments from the Advisory Committee on the Microbiological Safety of Food (ACMSF). The ACMSF comments were forwarded to WRAP in Autumn 2010 allowing revision of these reports. The revision of the compost reports was delayed by WRAP's and the contractor's other priorities and commitments. The revised versions are expected to be available later this year.

2. In the meantime WRAP had commissioned work on anaerobic digestion which is an alternative method to composting for processing biodegradable material.

Background

3. WRAP is a not-for-profit private sector company established in 2000 and backed by substantial Government funding from Department for Environment, Food and Rural Affairs (DEFRA), Department of Trade and Industry (DTI) and the devolved administrations in Scotland, Wales and Northern Ireland. WRAP has a major UK programme established to promote sustainable waste management. WRAP works with local authorities, business and households to prevent waste, increase recycling and develop markets for recycled and sustainable products. WRAP works with partners to prevent waste, promote recycling and develop markets for valuable products. WRAP works with the public providing information and tools that support recycling and reduces food waste.

FSA involvement with WRAP and Consideration by Advisory Committees

4. The FSA's position has been that, based on the evidence currently available, the treatment and recovery of waste materials, including animal by-products (ABP) and catering waste, for application on agricultural land should not pose unacceptable risks to food safety providing such application and the composting or biogas treatment is carried out in accordance with regulatory requirements

5. The work commissioned by WRAP has provided an opportunity to re-assess anaerobic digestates in light of the most up to date scientific evidence and FSA officials have provided technical and legislative input on relevant food safety matters. As with the compost work, stakeholders have highlighted a range of concerns relating to the potential risks to food safety and animal health associated with the use of anaerobic digestates. While these concerns relate to the microbiological and chemical risks associated with both digested green and ABP-derived wastes, the application of food-derived wastes containing meat have caused particular concern. It was recognised that in addition to the peer reviews undertaken for WRAP additional scrutiny by independent experts would provide greater reassurance for other stakeholders. During discussions with WRAP and other stakeholders, the FSA has again agreed to provide this additional scrutiny by consulting the ACMSF and the COT on the report.

Legislative and policy context

6. UK targets to recover value from municipal waste, coupled with the legal requirements of the EU Landfill Directive (1999/31/EC) have increased the importance of waste reduction and sustainable methods of waste management such as recycling and composting. The number of composting and anaerobic digestion plants is set to increase as the UK moves away from landfill, and with the costs of fertiliser continuing to rise, there will be benefits associated with the use of anaerobic digestates made from green and ABP-derived wastes in agriculture.

7. In the UK, the production of compost is controlled through the regulation of composting and anaerobic digestion plants (by the Environment Agency (EA) in England and Wales, the Scottish Environment Protection Agency (SEPA) in Scotland and the Northern Ireland Environment Agency (NIEA) in Northern Ireland), as well as a British Standards Institution Publicly Available Specification (BSI PAS 100:2005), which sets a standard for compost quality.

8. In addition, there are further legal controls in place for the composting of ABP and catering waste regulated through the EU Animal By-Products Regulation (EC) 1774/2002. This Regulation permits the treatment of low-risk (category 3) ABP in an approved composting or biogas plant according to the required standard (treatment at 70ºC for 1 hour, with a maximum particle size of 12mm).

9. Regulation (EC) 1774/2002 also allows Member States to set their own national treatment standards for composting plants treating only ABP derived from catering waste containing meat (but not other animal by-products, except for manure, digestive tract content, milk or colostrum), providing the same level of pathogen reduction can be achieved. In the UK, national standards were developed by DEFRA following an independent risk assessment commissioned in 2002, and a public consultation exercise. Based on the findings of this risk assessment, from 1 January 2007, the UK permitted the use of treatment standards that differed from the EU standard. These require minimum time/temperature and particle size standards for treating catering wastes that are based on the type of system used (e.g. closed reactor, biogas, windrow), with additional barriers for wastes that contain meat.

10. The DEFRA risk assessment underpinning the UK national standard was evaluated by the ACMSF in 2003. Overall, the Committee considered the approach adopted as robust in relation to the scenarios covered. However several issues relating to food safety matters were considered not to have been adequately addressed and the Committee's recommendations were communicated to DEFRA for consideration.

Anaerobic digestion.

11. Anaerobic digestion is a naturally occurring process in which microorganisms break down biodegradable matter in the absence of oxygen. The products of anaerobic digestion are a mixture of carbon dioxide [CO_2] and methane [CH_4] (referred to as biogas), and digestate – a nitrogen-rich biofertiliser. Anaerobic digestion is not a new technology, having been widely applied in the UK for the treatment of sewage sludge for over 100 years. However, until quite recently it has not been used here for treating other wastes.

12. The key parameters influencing the anaerobic digestion process are the material inputs, moisture content and temperature within the anaerobic digestion vessel. The digestion vessel comprises either a single- or multi-stage digestion system, in the former all of the biological reactions occur within a single sealed reactor or holding tank whereas the latter utilises different tanks to optimise the different reactions that result in generation of biogas. The digester is typically referred to as 'wet' or 'dry', the choice between technologies depending largely upon feedstock availability. Wet anaerobic digestion may be preferred where low dry-matter materials (such as domestic food waste or livestock slurries) are available, whereas dry anaerobic digestion may be preferred when higher dry-matter materials (such as domestic garden waste) are available. Wet processes are currently the most common in the UK. Both wet and dry anaerobic digestion can be carried out at different operating temperatures; for mesophilic anaerobic digestion [MAD] these range from between 35–40°C whereas for thermophilic anaerobic digestion [TAD] these range from 55–60°C. Although TAD processes require higher energy inputs than MAD, the increased temperature contributes to the more rapid destruction of bacteria and facilitates more rapid biogas production. Operation at higher temperatures also helps to sterilise the digestate, although this may also be achieved with a discreet pasteurisation step.

13. As with compost, WRAP together with environmental regulators, trade associations and other partners developed the baseline PAS110 specification to provide quality assurance for digestate. PAS110:2010 is the UK's specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials (a copy of PAS110:2010 is at Annex 2, PAS110 is broadly analogous to PAS100 for composts as described in the previous papers). This covers input materials, minimum process parameters and minimum output quality so that, when used in line with good agricultural practice, the digestate does not harm human health or the environment. PAS110 does not cover production or quality of biogas. If an AD operation complies with both PAS110:2010 and the Anaerobic Digestion Quality Protocol (ADQP) then the digestate produced is not legally considered a waste in England, Wales or Northern Ireland, and the

Environmental Permitting Regulations (Waste Management Licensing Regulations in Northern Ireland) no longer apply to the spreading of the biofertiliser to land. A similar approach has been adopted in Scotland, but this differs from the ADQP in some details.

14. Development of the ADQP was based on work analysing the complete range of potentially hazardous agents in wastes that might survive an anaerobic treatment process. This considered the extent to which a receptor of concern, i.e. a river, plant species, human, or animal stock could be exposed for every combination of allowable feedstocks, potential pathways and possible end-uses of digestate. In practice, several barriers prevent exposures occurring, notably:

- the initial exclusion of unsuitable wastes from treatment;
- the effective treatment of suitable wastes in the anaerobic digestion plant;
- the appropriate use of the digestate, adopting accepted codes of good practice and guidance; and
- the attenuation of any residual, post-treatment hazards in the environment prior to reaching a receptor of concern, a factor which is not considered within this assessment.

The WRAP report.

15. Two chapters of the report are relevant to the Committee, Chapter IV describes allergens in the food chain and Chapter VII considers microbiological and chemical risks following the anaerobic digestion process. These chapters can be found at Annex 1. In addition the analytical work measuring organic contaminants in digestate is summarised briefly below.

Analyses of organic contaminants in digestates

16. Digestate (from three facilities in England) and livestock manure samples (from twenty sites across Britain, including five in Wales) were taken using standard sampling methods. Triplicate digestate samples (ten sub-samples were taken from the vessel and thoroughly mixed to give a representative composite sample) were taken for analysis from three facilities on two occasions from material that had been treated and subsequently stored, ready for land application. Two sites used food waste based feedstocks and the third site crop residue/livestock manure based feedstocks. The two food-based digestate sites were working towards PAS 110 compliance; the manure-based digestate site was not seeking PAS 110 accreditation.

17. These samples were analysed for a range of organic contaminants such as industrial chemicals, unintentional by-products of industrial processes, incomplete products of combustion, plasticizers, flame retardants, agricultural chemicals and pharmaceuticals and personal care products.

18. The following chemicals were analysed;
    - 18 Polychlorinated biphenyl congeners (PCBs) using a low detection limit analysis high resolution gas chromatography mass spectrometry (GCMS) method

- 17 Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzonfurans (PCDD/Fs) congeners using a high resolution GCMS method
- Perfluorooctane sulfonate (PFOS), PFOS derivatives and substances that degrade to PFOS (nine compounds) using a high resolution GCMS method
- 25 Polycyclic aromatic hydrocarbons (PAHs) congeners using a GCMS method
- 16 Polybrominated diphenyl ethers (PBDEs) congeners using a GCMS method
- 9 Phthalate compounds (butylbenzyl, dinonyl, dioctyl, dibutyl, didecyl, diethylhexylphthalate (DEHP), diethyl, diisobutyl and dimethyl phthalates) using a GCMS method
- Triclosan using a GCMS method
- Tributyl-tin using a GCMS method
- Bisphenol A using a GCMS method
- Clopyralid and aminopyralid using a GCMS method

19. A number of PCB congeners and PCDD/Fs were detected and subsequently risk assessments of these were undertaken and these are discussed below.

20. The mean TEQ in the food-based digestates was 1.89 ng TEQ/kg dm and in the manure-based digestate 1.51 ng TEQ/kg dm. Notably, the most toxic congener 2,3,7,8-TCDD was not detected above the limits of analytical detection in any of the digestate samples

21. PFOS, PFOS derivatives, PBDEs, tributyl-tin, bisphenol A, clopyralid and aminopyralid were not detected above the limits of analytical detection in any of the digestate samples. PBDEs, tributyl-tin and bisphenol A, clopyralid and aminopyralid were not detected above the limits of analytical detection in any of the livestock manures samples taken for this project but the PFOS derivatives (perfluoroheptanoic acid - 24 µg/kg dm; perfluorononanoic acid - 6.32 µg/kg dm) were measured in one of the twenty livestock manures sampled in this project.

22. Low concentrations of DEHP were measured in the food-based digestates (range 1.58-2.42 mg/kg dm; mean 2 mg/kg dm), while concentrations in the manure-based digestate were below the limits of analytical detection (<0.1 mg/kg dm). DEHP concentrations in treated sewage sludge have been reported in the range 0.50-28.3 mg/kg dm biosolids (Chambers et al. 2010) and in livestock manures sampled in this project concentrations ranged from <0.1 to 0.45 mg/kg dm. The EU (2000) proposed a DEHP limit of 100 mg/kg of sewage sludge dry solids. A number of other phthalates were measured at very low concentrations in the digestate samples (butylbenzylphthalate, di-n-nonylphthalate, di-n-octylphthalate, dibutylphthalate, didecylphthalate and diisobutylphthalate) which were not considered to pose a risk to human health or the environment. Triclosan was detected at low concentrations in three of the twelve food-based digestate samples (mean concentration 0.75 mg/kg dm), but not in the manure-based digestate. In livestock manures sampled in this project, Triclosan concentrations were all below the limits of analytical detection. Triclosan concentrations in treated sewage sludge have been reported in the range 0.10-38.0 mg/kg dm biosolids (Chambers et al. 2010).

Allergens.

23. A literature review was undertaken to examine and collate evidence for allergens in the food chain, with an emphasis on the fate of allergens during composting and anaerobic digestion. A summary of the current regulatory controls on allergens in the food chain was also compiled.

24. Current common practices, such as the direct application of manures; blood, fish & bone meal; milk; and shellfish shells to land, have revealed no apparent allergenic risks to susceptible consumers. It seems likely that this is because bacterial populations rapidly break down proteins in soils. Thus, while there are no published studies of the fates of any allergenic agents in manures, crop residues, composts or biofertilisers, the proteinaceous nature of almost all allergenic agents would lend them to breakdown by bacterial proteases and incorporation of the resulting nitrogenous compounds into the bacterial biomass. It is considered likely that susceptible proteins in the feedstock (such as those found in food wastes) will be destroyed during processing or after application to soils.

25. It was considered likely that susceptible proteins in the feedstock (such as those found in food wastes) would be destroyed during processing or after application to soils. If they were applied to soils, protein-allergens are unlikely to be taken up by plants, and even if they were it is considered likely that they would be metabolised within the plant (as a source of nitrogen).

26. Risks perceived as possible are expected to be from ingestion of ready to eat crops that receive minimum processing before consumption. However, based on the limited information available, it is difficult to foresee additional risks from compost or biofertiliser if existing good practice is followed to minimise soil splash onto crops (including thorough incorporation of any organic amendments into the soil before sowing / planting) and if crops are washed before consumption.

27. No evidence was found to inform a specific risk assessment on the potential for food allergens to be transferred through the recycling process and back into the food chain. Likewise, there was no direct evidence that current agricultural practices have caused problems.

Chemical risks.

28. Section 4 of Chapter VII details quantitative risk assessments for toxic chemicals, plant pathogens and plant toxins which are potential concerns when anaerobic digestates are used in agriculture. Currently this describes a source-pathway-receptor scenario which compares loading rates with proposed regulatory limits. However the authors recognise the need to extend this work to a quantitative risk assessment prior to final publication.

29. The source-pathway-receptor approach considers; the initial input concentration, decay or residual concentration emitted from the process and the potential for harm or existing standards and regulatory limits Each assessment

considers the highest plausible hazard concentrations, the most direct route for receptor exposure and the most sensitive receptor categories to evaluate risk. The source material was assumed to be PAS110 compliant and a 1 hour pasteurisation before MAD at 35 to 40 C with 1% of material short circuiting the process. An application rate of 50 m^3/ha dm at a depth of 10cm was assumed, using these assumptions implies that dilution will occur due to leaching from and/or incorporation into soil.

30. Three groups of chemicals were considered: PCBs and PCDD/Fs, PAHs and heavy metals. For the first two groups the pathway was intended to be two stage, 1) contamination of plants by the chemical followed by consumption by livestock and 2) the final receptor was humans consuming the livestock. In contrast for heavy metals a single step uptake into plants pathway was used and the final receptor was crops and livestock.

PCBs and PCDD/Fs.

31. Maximum and mean levels of PCBs and PCDD/Fs were measured in 18 digestate samples obtained plants in England (these plants were using mixed feedstocks which were not necessarily PAS110 compliant). The values for 7 indicator PCBs (28, 52, 101; 118, 138, 153 and 180; maximum 7.90 ug/kg dm (dry matter), mean 2.89 ug/kg dm) resulting from the pathway model were compared against the proposed EU limits in the Biowaste Directive (400 ug/kg dm) and the draft Sewage Sludge Working Document (800 ug/kg dm). The concentrations for dioxin like PCBs in digestate samples were compared to levels in urban and rural herbage and soil obtained from the 2007 EA UK Soil and Herbage Pollutant Survey. The concentrations were summed (but were not corrected for potency using TEFs either in the measured or the survey data), levels were comparable with or below the survey data. Similar results were obtained for PCDD/Fs.

32. The digestates in which PCBs and PCDD/Fs were measured were not derived specifically from PAS110 compliant feedstocks. The scenario was therefore reconsidered using upper bound PCBs and PCDD/Fs values in rural herbage from the 2007 EA UK Soil and Herbage Pollutant Survey as a surrogate for levels in PAS110 compliant feedstock and assuming no degradation during MAD. The values predicted in these scenarios were lower than those obtained when using measured PCBs and PCDD/Fs values in digestate from English plants.

PAHs.

33. The same two approaches using measured levels in digestate from UK plants and levels measured in rural herbage as source materials were used for PAHs. Using the maximum measured levels in digestate, the sum of 9 congeners (acenaphthene, phenanthrene, fluorene, fluoranthene, pyrene, benzo(b+j+k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene) was 3362 ug/kg dm and were just above the proposed EU limits in the Biowaste Directive (3000 ug/kg dm) and the draft Sewage Sludge Working Document (6000 ug/kg dm). However they were lower than the maximum levels in UK urban and rural herbage and soil. This value approximately halved (1757 ug/kg dm) when using UK rural herbage as a surrogate for PAS compliant source material.

34. In neither case (PCBs and PCDD/Fs or PAHs) do the risk assessments currently continue as outlined to ingestion by livestock or the effects of consumption of livestock by humans but conclude on these risks based on limits proposed for other potential soil improvers (biowaste and sewage sludge). Thus in the case of PAHs which are readily metabolised in mammalian species, ingestion by livestock and subsequent metabolism would be expected to reduce levels consumed by humans.

Heavy metals.

35. Two scenarios were modelled, effect on soil levels of heavy metal and risk to humans from uptake by carrots grown on land treated with digestate.

36. For the former scenario heavy metal levels were assumed to be the maximum permitted in PAS110, whereas maximum measured levels from 18 samples of digestate from English plants were much lower than permitted (at least 50% lower). Levels of heavy metals incorporated from sewage sludge, cattle and pig slurries were used for context. The overall conclusion of the scenario was that quantities of heavy metal applied through digestate were low and would have little effect on soil concentrations.

37. In the second scenario the effect on soil concentrations of cadmium, lead and arsenic at maximum levels permitted by PAS110 and at the mean measured concentrations from English plants were estimated. The estimated effect of a single application of digestate on background soil levels were 0.5, 0.9 and 0.05% for cadmium, lead and arsenic respectively. Based on this (and in the case of lead the lack of take up into edible tissues) the report concludes these metals will not present a risk to human health.

Discussion.

38. The report only considers a limited range of chemicals in digestate and the risk assessment of these is incomplete. The comparison to levels in UK soil and herbage suggests that use of anaerobic digestates at the levels used in these scenarios would not significantly modify the amounts present or available for uptake. This implies that there is unlikely to be a significant difference in the risk to humans from consumption of livestock fed on crops fertilised with anaerobic digestate compared to crops grown on untreated land. In the case of PAHs the effect of metabolism by livestock would probably further decrease exposure of humans to any PAHs arising from the digestate.

39. The analysis of the potential risks from allergens are largely based on the anticipated nature of the allergens, the probability that they would not survive the anaerobic digestion process and the absence of evidence of problems from the use of comparable materials. Although the supporting data are limited the argument appears logical and cogent but it may be desirable to generate evidence to support the inferences.

Questions asked of the Committee

40. Members were invited previously in TOX 2009/39 and 2010/01 to comment on the earlier WRAP reports on the risks associated with application of PAS 100 compliant composts to food producing land.

i. Members are invited to comment on whether the approaches employed are appropriate and sufficiently rigorous to fully assess the chemical risks associated with application of PAS 110 compliant anaerobic digestates to food producing land.

ii. Members are asked whether they agree with the conclusions derived with regard to chemical and allergen risks to the food chain.

iii. Members are asked whether they consider that possible risks to the food chain have been adequately considered in this programme of work and whether any additional chemical food safety scenarios should be brought to the attention of WRAP.

iv. Members are asked whether, in relation to chemical food safety, they agree with the overall conclusion that the risks associated with the use of PAS 110 compliant anaerobic digestates in agriculture are similar to other materials used for these purposes.

v. Members are asked whether there are any particular data gaps that should be prioritised in future research programmes in order to allow additional potential chemical food safety risks associated with anaerobic digestates use to be more fully quantified.

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Reference cited in WRAP report.

Chambers, B., Comber, S., Gardner, M., Smith, S., Sutherland, J., and Taylor, M. (2010). Investigation of Organic Chemicals in Sludge. UKWIR report 10/RG/07/19

Glossary.

ABP animal by-products

ACMSF Advisory Committee On The Microbiological Safety Of Food

ADQP Anaerobic Digestion Quality Protocol

BSI PAS British Standards Institution Publicly Available Specification

DEFRA Department for Environment, Food and Rural Affairs

DEHP diethylhexylphthalate

DTI Department of Trade and Industry

EA Environment Agency

EU European Union

FSA Food Standards Agency

GCMS gas chromatography mass spectrometry

MAD mesophilic anaerobic digestion

NIEA Northern Ireland Environment Agency

PCBs Polychlorinated biphenyl congeners

PCDD/Fs Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzonfurans

PFOS Perfluorooctane sulfonate

PAHs Polycyclic aromatic hydrocarbons

PBDEs Polybrominated diphenyl ethers

SEPA Scottish Environment Protection Agency

TAD thermophilic anaerobic digestion

WRAP Waste And Resources Action Programme

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Chapters 4 and 7 of the Draft Final Report: Quality, Safety and use of Digestate in UK Agriculture.

Note: The unpublished chapters of the draft report in this Annex are not included in the published version. WRAP will publish the final report at a future date.

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PAS 110:2010 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials.

Note: For copyright reasons the contents of this Annex are not included in the published version.

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