APPENDIX 12
ARCHAEOLOGICAL ASSESSMENT

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Prepared by Christine Kelly , Associate Consultant Archaeologist June 2001 a

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Archaeological Site Assessment
Killycarran,
Emyvale,
Ca. Monaghan

Prepared by

Christine Kelly,
Associate Consultant Archaeologist

1. INTRODUCTION

An archaeological assessment was commissioned by South Western Environmental Services and an assessment was undertaken in June 2001 in order to identify any archaeological constraints associated with the proposed development. Cultural heritage, with respect to man made features on the landscape including archaeological, architectural and historic features were examined. Both a desktop assessment and a detailed field assessment were carried out.

This report outlines the archaeological importance of the land selected for proposed development. The aim is to assess the impact of the development on the receiving archaeological environment and the implications of those impacts.

2. METHODOLOGY

The archaeological assessment was based on a desktop study, which examined the archaeological environment within approximately 2km of the proposed development site and a field inspection of the proposed development site.

Cultural Heritage in the Existing Environment

The proposed development is located in the northwestern part of the townland of Killycarran in the parish of Errigal Truagh. This is the most northerly parish in County Monaghan. Killycarran (Coill Corrain) means wood of the rocky land[1]. The adjoining townland Derrygola (Doire gualainn) was the oak grove of the hill.[2] Such translations would suggest that farming practices changed the landscape from a woodland region to what it is today.

The area is part of the drumlin drift belt, which extends from the Dundalk lowlands to the middle of the Erne valley and as such, the area is represented by a "basket of egg" topography. Traditionally due to topography and poor soils large-scale tillage was never an option in the area and land was used for grazing cattle. A recent trend has in Co. Monaghan has been increased poultry production. Monaghan is at present the foremost broiler producing county in Ireland.

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[1] Joyce, P.W. (1978) *Irish Place Names Vol* 3.

Desktop Survey

The desktop study included the following components:

Sites and Monuments Record (SMR)- This record compiled by the Archaeological Survey of Ireland comprises a list of all known archaeological sites and monuments in the county and their location. The SMR for County Monaghan was published in 1996.

Record of Monuments and Places (RMP)- This record is compiled as a replacement for the SMR by Duchas. It lists all known archaeological monuments and sites in the county. It is an offence to interfere with any of the sites or monuments listed in the record without first giving 2 months notice in writing to the National Monuments Service, Duchas, at the Department of Arts, Heritage, Gaeltacht and the Islands.

Archaeological Inventory of County Monaghan.

Topographical Files of Monaghan County Museum- No finds were recorded from the area.

Cartographic Sources - The first and second editions of the OS 6 inch maps, sheets 3/6 were consulted.

Documentary sources- All available literary references were consulted in Monaghan Library.

Field Survey

The field survey was carried out on Friday 15th June 2001. Weather conditions on the day were damp and misty.

The site of the development was walked and a visual inspection carried out to ascertain if any features of archaeological significance were visible (Map 1)*site map to be scanned.* The ground in general was very wet due to torrential rain the previous evening. For survey purposes the site was divided into five fields F1, F2, F3, F4, and F5. The field pattern has only changed slightly since the 1907 edition of the 6-inch map. F1 and F2 are gently sloping and fairly well drained (Plate 1). F3 and F4 are level and very poorly drained. F5 is a level field and was waterlogged on the day (Plate 2). F4 and F5 contain dense growths of marshy plants. Man made drains have been constructed around the borders of F2, F3 and F4. Small ridges at the northern boundary of F3 along with the associated vegetation change have arisen from material thrown up during drain clearance (Plate 3). The entire site is used for grazing.

Nothing of an archaeological nature was noted during the inspection. However, this does not mean that sub-surface features do not exist.

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[2] IBID

3.Potential Impacts of the Development

Based on this study there is no evidence of clearly defined archaeological activity on the proposed development site or in the immediate vicinity. While the proposed development will not directly affect any known archaeological sites, it is possible it will affect any previously unrecorded archaeological sites, which might still exist undetected below the ground surface during groundworks.

4. Construction Impacts and Mitigation Measures

Although the archaeological study carried out indicates that there are no itesm of significance on the site, nevertheless, where extensive earthmoving is involved archaeological, features are often discovered. The remains of a leveled ringfort or fulacht fiadh may show quite clearly in the subsoil once the topsoil has been removed. Likewise any other archaeological soils, features or deposits may be exposed during topsoil removal.

Earthworks will be associated with site clearing activities during the construction period. It is therefore considered necessary that:

- an archaeologist should monitor all topsoil removal on the site
- in the event of discovering any archaeological features, their investigation and recording by an archaeologist should be facilitated and funded by the developer and the discovery reported to Dúchas, 51 St. Stephen's Green, Dublin 2. Dúchas the Heritage Service and the National Monuments and Historic properties and Planning Authority can advise on what procedures should be adopted for the preservation of such features.
- artefacts discovered should be reported to the Duty Officer of the National Museum of Ireland, Kildare Street, Dublin 2.

These mitigation measures outlined above will prevent any negative impacts on any archaeological finds on the site during construction.

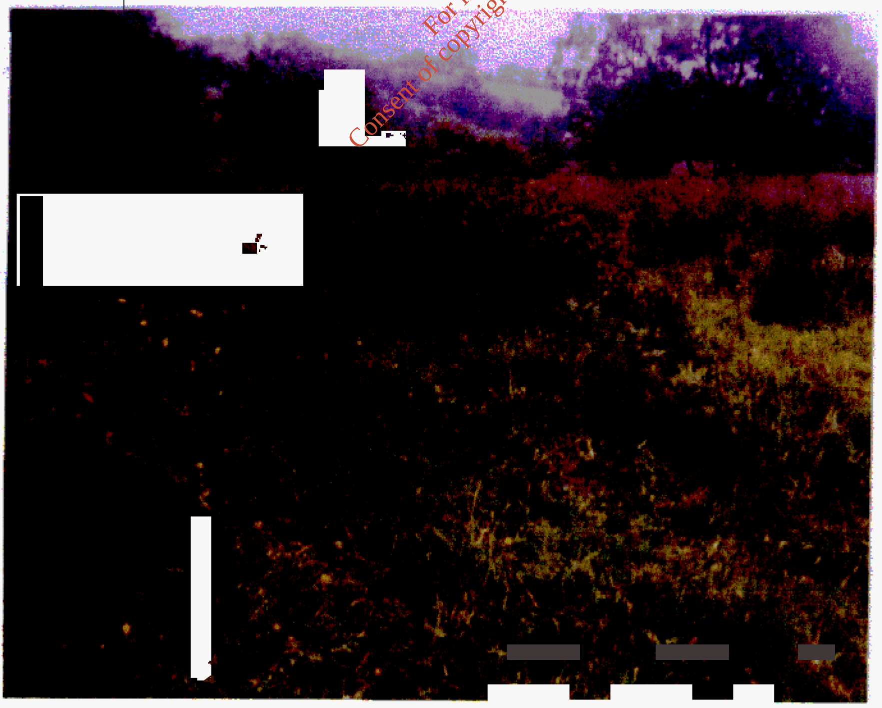
Operational Impacts and Mitigation

No archaeological impacts will be associated with plant operation and therefore no mitigation is considered necessary.

Prepared by *Christine Kelly , Associate Consultant Archaeologist* *June 2001*

Plate 1: Field No 2 facing North;

Plate 2 Field No. F5 Facing East



APPENDIX 13
WASTE RESOURCE STUDY

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13.1 Introduction

RENEWtech Limited commissioned a waste resource study In order to identify the following elements in relation to SMC, PL and WC as potential fuel resources: for a CHP Power Plant.

- Details on current environmental considerations with regard to waste management practices
- Adequacy of a fuel supply taking into account current disposal practices, legislative requirements, recycling options, environmental considerations
- Raw material characteristics to assess fuel suitability in waste-energy
- Waste movement and end uses with respect to a potential site location and siting suitability
- Potential end uses of ash produced as a result of combustion
- Environmental considerations with respect to emissions
- Economic viability with respect to capital costs and revenue generated from electricity.

Aspects of this survey have been reported In the main volume of this EIS. The following is a summary of the environmental considerations with respect to the proposed development of a biomass fired CHP plant utilising SMC, PL and WC as fuel resources.

13.2 Spent Mushroom Compost

13.2.1 Mushroom Production System

There are approximately 580 mushroom growers throughout Ireland based on a satellite grower system. The industry is mainly concentrated in the border counties of Armagh, Tyrone, Cavan and Monaghan and there is a significant amount of cross border trade. In Monaghan alone the industry is worth £20 million and represents 24% of gross national production. Cavan, Roscommon and Donegal represent 11%, 9% and 7% of the industry respectively. The establishment of the mushroom industry in Ireland over the past number of years has lead to a significant increase In the amount of exhausted mushroom growth medium known as spent mushroom compost (SMC) (Total Renewable Energy Resource in Ireland, March 1897, ALTENER Programme). The total tonnage of SMC from thew regions has been estimated at ~145,000t/pa (Teagasc,1989). While studies indicate that the number of individual growers is decreasing, the total production is not expected to fall as the average size of the production units will increase. Therefore, the volume of SMC produced is not expected to decrease.

Fresh mushroom compost comprises about 70% composted straw and 30% chicken litter with about 1% of other additives including gypsum, cotton seed meal and mushroom spawn. The fresh mushroom compost is supplied to the growers in 20kg polythlene bags, with all the ingredients, including mushroom spawn, already added. The bags are laid out on a concrete floor in an insulated polyethene clad tunnel. The growers open these plastic bags and add a layer of peat —— (-)— to the top surface. The mushrooms develop in four weekly flushes and each flush is hand picked and sorted. Spent Mushroom Compost (SMC) is the remains of the compost in which mushrooms are produced. Variability in composition is due mainly to control in production processes of compost manufacture

After the fourth flush all dthe SMC is removed and the growing units are then cleaned and disinfected ready for a new batch of fresh compost. At the end of the production cycle the bales of used compost represent a waste material. Each mushroom tunnel produces on average 20 tomes of mushrooms per year with a corresponding 85 tonnes of waste SMC.

13.2.2 Composition

The following factors will determine potential end uses for SMC:

- ☐ Nutrient Content
- ☐ Salt Content
- ☐ Moisture Content
- ☐ Carbon:Nitrogen Ratio
- ☐ Content of weeds, seeds, pathogens, pesticides, heavy metal content

These parameters were determined through both desk top studies on available literature as well as analysis carried out on behalf of RENEWtech Ltd on raw material and ashed samples. Potential atmospheric emissions associated with the combustion of SMC were based on a study carried out by the Department of Economic Development in Belfast under the EC INTERREG Programme.

Sampling Methodology and Sampling Procedure

In order to determine the fuel characteristics and chemical composition variability of SMC, a series of raw SMC samples were taken from a representative number of farms in the Monaghan region in July 2000 and October 2001. Samples were taken from various locations in the bedding material (top, middle. bottom) and combined to make one homogenous sample. Raw SMC and ashed samples dried at 550°C, 850°C and 1200°C were analysed for a wide range of physico-chemical parameters including organo-P pesticides and chlorinated organic pesticide, volatile organics as well as a suite of heavy metals and dioxins/furans. Physical characteristics including moisture content and sample density were established as well as combustion characteristics. Sampling results are included as Tables 13.2a-13.2d. Results obtained were used to establish predicted emissions for heavy metals from the stack. Pesticides were included in the analytical suite in order to determine whether they are present in the SMC fuel and ashed samples and results are included as Table 13.5.

13.2.3 Chemical Usage in the Mushroom Industry

Chemical usage for insect and disease control occurs at several stages of the mushroom production. There are strict regulations regarding the use of pesticides in food crops and the safe, proper use of crop protection products is an important issue in the industry. Pesticide usage is in accordance with good agricultural practice and therefore should not result in unacceptable levels of pesticide residues in treated produce. The introduction of an Integrated Crop Management (ICM) system by the Irish Mushroom Growers Association, Teagasc, the mushroom marketing companies and An Bord Glas, the horticultural board, has resulted in the application of pesticides only when "without their use, significant economic losses would occur due to a reduction in crop yield or quality". In accordance with EC Regulations (Prohibition of Certain Active Substances in Plant Protection Products) Regulations 81-90, marketing and use of certain pesticides are prohibited because of the risk to human health and the environment. Table 13.4 outlines the list of chemicals which are used in the mushroom industry as per their brand name, chemical used and the active ingredient(s). The quantity of chemicals may vary between farms depending on the variability in the total production bed area and room size as well as operator preference and experience.

The fate of pesticides in the environment is dependant on the properties of the compounds. A composite picture of the physical and chemical properties of a pesticide is essential for the determination of the potential fate and impact of that pesticide on the environment. Detailed analysis of SMC raw material as well as waste ash was therefore carried out on behalf of RENEWtech examining a wide range of physico chemical properties. It is also worth noting that the industry is moving away from pesticide usage, driven by consumer demand. More research into biological control treatments to minimise the use of chemicals in the Industry are being carried out.

At present, the use of pesticides in the industry is being reviewed as per of an EU programme under EU Directive 91/414/EC (Council Directive Concerning the Placing of Plant Protection Products on the Market). This defines target dates for pesticides and ensures that only degradable, non presistent pesticides are utilised (Department of Agriculture, pesticide laboratory, pers comms Nov 2001). Steam steralisation could become an important element in disease control and reduction in chemical use.

13.2.4 Atmospheric Emissions

Atmospheric emissions were evaluated based on combustion trials carried out by the Department for Economic Development in Belfast under the INTERREG Programme whose overall aim was to assess the potential for combusting SMC and energy recovery based on technical, environmental and economic assessment criteria and results of this analysis are included for reference as Table 13.7.

13.2.5 Disposal Methods for SMC

SMC is an inevitable by-product of mushroom production which remains after the mushroom crop has been harvested. The management of SMC is of critical importance to the continued development of the industry (Teagasc, 2000). Correspondence with Monaghan County Council indicates that in this county, approximately 30% of SMC is landspread, 10% is recycled through composting, a small volume is utilised in the manufacture of topsoil and the remainder (60%) is disposed of in an unidentified manner.

As mushroom production can operate independently of a land base and many producers have only a small area of land, land spreading of the SMC is a major concern as the land is becoming saturated with SMC. The average size of a mushroom growing unit is 3-5 houses equating to a required ~250 acres of land for disposal. The average farm size is approximately 40 acres. Approximately 85 tonnes of SMC is produced per mushroom house per year. This equates to 4.25kg waste: 1kg mushroom. The amount currently disposed of to landfill has been quantified as ~60,000 tonnes per year. While some mushroom producers are licensed to landspread the SMC, the majority of the material is landspread illegally. Planning permission is now only given when the land owner can show that they either own 50 acres of land per house or have a recognised disposal route.

Environmental Concerns Associated with Current Disposal Methods

1) Groundwater Pollution

The high phosphorous content of SMC is causing serious river pollution problems. Although the amount of nitrogen and phosphorous generated by fresh SMC is small in comparison to that of animal waste, the fact that this material is concentrated in a small area in combination with heightened concern for phosphorous discharges to water resulting in eutrophication of Irish water systems. In addition, the high phosphate pH and salt levels (N, P, K, Ca) restrict the option of landspreading SMC, in addition to the presence of potential pests (e.g. eggs or larvae of mushroom flies and pathogens) and unbalanced C:N ratio. The ideal solution would be to eliminate the need for landspreading. This has resulted in a recommendation to reduce the quantities of P used in crop production (Teagasc, 2000). Also, as SMC contains organisms that are potentially pathogenic to actively growing mushrooms, handling of SMC which would facilitate dispersal of spores should be carried out at a safe distance (~2km) from mushroom farms.

2) Waste Plastic Produced in the Mushroom Industry

Plastic bags used in mushroom cultivation also present a serious waste problem. At present, disposal of these bags is primarily to landfill. Monaghan County Council estimate that approximately 0.5t of waste plastic from SMC is sent to landfill every week. Under the Waste Management (Farm Plastics) Regulations 1997; producers and importers of these materials have a responsibility to arrange for their collection from the farmer.

At present, trials are being carried out to find a more suitable environmentally friendly and economic alternative to plastic bags and use of biodegradable plastic or "dutch shelving" is being considered but is still at the development stage. The current disposal costs of landfilling waste plastic amount to £46/t but there are plans to increase these costs thereby encouraging increased recycling of the plastic in accordance with the Polluter Pays Principal (pers. comms. Senior Engineer, Scotchcorner landfill, Monaghan; N w 2001). Currently, it is more costly for mushroom producers to recycle plastic (at £80.t) than to landfill.

If planning permission is received for the construction and operation of the proposed biomass development, waste plastic may be a waste stream produced from SMC. In this event, a debagging unit capable of taking the waste plastic from SMC will be incorporated into the plant design and the plastic disposed of in accordance with relevant legislation.

13.2.6 Raw Material and Ashed Samples; Physical and Chemical Results

i) Raw Material Physical Characteristics

The compost often contains the polythene sheet In which the bale was mapped. The material is collected on the farm In a bulk tipper and is delivered to the combustion plant as a friable bulk solid with handling characteristics similar to chicken litter. The SMC is slightly compacted and entangled due to the partly decomposed wet straw, is sticky and has no particular odour. SMC is described as having a relatively low bulk density, high moisture content, high organic matter content, moderate plant nutrient content and "unbalanced" distribution of major plant nutrients (Teagasc, 2000)

The fuel as received had a moisture content of approximately 68% and was not possible to separate in size fractions by sieving. Results are included as Table 13.2a.

ii) Raw Material, Combustion and Chemical Characteristics

SMC has a moisture content of 60-68%, volatile matter of 15-25%, fixed carbon of 4-6% and a calorific value in the range 12-14MJ/t on a dry basis. (Tables 13.2a-13.2d). On a dry ash free basis this is similar to sewage sludge which has successfully been fired for many years. The C-H-O composition of the dry and ash free material is typical for biomass. Results of a study carried out by Teagasc, examining the chemical composition of 13 samples of SMC obtained from a number of producers in 1997 am outlined in Table 13.3 at the end of this report. The results of this study illustrate that the high salt levels associated with raw SMC are a result of the potassium and electrical conductivity.

These parameters, in combination with high ammonia levels are limiting factors when considering potential end uses for SMC. On average, SMC is reported to contain 0.82% N; 0.2% P and 1.3% K and S content at 2.2%. Nitrogen content is approximately half that contained in poultry litter, sulphur at 2.2% is high, but the majority of this mains in the ash.

Composition of Raw SMC

Straw %	60-70
Poultry Litter %	28-34
Gypsum %	24.5

% Weight	Mayner (1993)[1]	B9 Energy (1997)[2]	Aalborg Energy (2000)[3]
Moisture content	65	61.8	67.8 (mean)
Volatiles – dry basis	61	63.1	
Ash – dry basis	39	36.9	30.6 (mean)

2:Assessment of SMC Resource and the potential for processing options for the generation of renewable energy

3:SMC fuel characteristics Report No 1 Jan 2000 Aalborg Energie Technik

Calorific Value

Higher Heating Value kJ/kg dry basis	12,200
LHV	2,408

iii) Moisture Content and Use of SMC as a Fuel

The high level of moisture must be reduced considerably before SMC is suitable for combustion at a suitable adibatic temperature. Drying increases the specific heat value and a reduction to 20% moisture increases the NCV to approximately 10,000kj/kg. An estimated 200,000t/pa of wet SMC corresponds to 25t/phr of wet SMC into a drier and, after drying to 15-20%, would result in 10t/hr fuel leaving the drier. After drying, the SMC flow represents approximately 29MW heat

iv) Pesticides

Organo-phosphate pesticides are not persistent and the amount of initially unreacted pesticide is known to disappear rapidly from the environment (WHO 1996 in Mushroom Waste Management Project Liquid waste Management 1998). Studies indicate that the major health hazard to humans is caused by organo-phosphate insecticides by acute exposure to high dose levels. All organo-phosphate pesticides used in the mushroom industry are subject to degradation yielding water soluble products that are believed to be non-toxic at all recommended applications and doses. Carbamate insecticides are readily detoxified and relatively short lived in aquatic and soil environments. Also, the vast majority of the breakdown products are less toxic than the original pesticides.

Analysis on pesticide residues in mushrooms was carried out by the Department of the Environment and by An Bord Glas in 2000. Pesticides due levels are regulated through the establishment of the Maximum Residue Levels (MRL's). Of 53 samples carried out by An Bord Glas, pesticide residues were found in 8 samples and no samples were found to exceeded MRL levels. As mushrooms will pick up any compounds present in the compost, pesticides are anticipated to be correspondingly low. This was confirmed through the analysis carried out on the raw SMC and ashed samples outlined In Table 13.5. With both the raw material and the ashed samples all results were found to be below the sample detection limit of 20µg/kg (ppb).

v) Dioxin Levels in SMC and Ashed Samples

Three ash samples were analysed for dioxin and furan contamination. Analysis of the samples I-TEQ on a dry weight basis indicated that there were no dioxins detected in the ashed samples at 850°C and 1100°C. The raw samples showed an I-TEQ value of 0.13 ng/kg. The total dioxin/furan content for the raw SMC sample was 26ng/kg, ashed samples at 850°C and 1100°C giving results at 5 and 3.9ng/kg respectively. Sampling results are outlined in Table 13.6a and b.

vi) Heavy Metals in Raw Material and Ashed Samples

Heavy metal results are outlined in Table 13.5. As expected, heavy metal levels are low, reflecting the material eaten by the poultry or growth substrate for mushrooms. Results were used as a basis for calculating potential atmospheric emission in the modelling data outlined in Section 4 of Volume 2 of this report.

vii) Combustion Trials to Assess the Potential for Combusting SMC for Energy Recovery

Combustion of SMC for energy recovery has not to date been found to be commercially viable at any plant in the world. With its high moisture content, the material would require pre-drying or the use of a supplementary fuel for ignition and sustained combustion. To date, the commercial use of SMC as a fuel resource has not been carried out. Research carried out in a project partly funded by the Department of Economic Development, Belfast within the EC INRERREG Programme with University of Ulster was used as a basis to evaluate possible emissions from the combustion of SMC

Initial trials undertaken with SMC at a moisture content of 70-75% and required natural gas as an auxillary fuel and pre heated combustion air. Reducing the moisture content to 60% eliminated the need for auxillary fuel, preheated combustion of 200-300° was required whik reducing the moisture content to below 50% eliminated the need for auxillary fuel and pre heated combustion air.

Atmospheric Emission Trials Results

Trials carried out on fuel at a moisture content of 15% showed a high overall combustion efficiency in excess of 99%. The higher the combustion efficiency, the lower the atmospheric emissions. Atmospheric emissions were low with CO levels (between 70-100mg/Nm^3) indicating a high combustion efficiency greater than 99% and low emission levels of unburned hydrocarbons were recorded in this study thereby validating the fact that SMC can be used as a fuel with respect to environmental considerations. Low CO levels are indicative of low emissions of unburnt hydrocarbons, volatile organic carbon, dioxin and other organic species. Total NO_x emissions ranged from 133 – 260mg/Nm^3. While the total sulphur content of the raw compost was 3% on a dry basis, most of this sulphur was present as inorganic sulphate compounds which do not normally produce SO_2 at temperatures of 850°C.

13.3 Conclusion

Reducing the moisture content of raw SMC from *-70%* - 15% renders the material more viable as a potential fuel. It was ascertained that SMC could be utilised, as a fuel from both economic as well as environmental criteria with no anticipated emissions which could give rise to health concerns.

13.4 Poultry Waste

13.4.1 Production Process

Poultry litter consists of bedding, droppings, feathers and waste food particles. Bedding material, consisting of wood shavings, straw or paper, is spread over the solid floors within the poultry houses where chickens or turkeys are fattened. Turkey litter varies from poultry litter due to the extended rearing periods for turkeys and is not suitable for the manufacture of mushroom compost. Animal wastes, in the form of excrement, fall upon the litter and are absorbed. Fresh litter is placed for each growing crop of birds and is removed when the birds go forward for processing after a period of 6-8 weeks. The litter can be handled as a bulk solid like wood chips and transported in bulker lorries.

13.4.2 Composition

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The material can have a moisture content of around 20-25%, however in some circumstances the moisture content can reach 36% (Turkey litter). In general poultry litter is a consistent quality medium fuel. The litter contains a high proportion of lime, which neutralises the production of acid gases. While its gross calorific value depends on moisture content, for air-dried samples it is typically 13.5GJ/t for both used poultry litter and droppings, respectively. The litter varies from coal having about twice the volatile content, and produces about 50% more ash than coal. Typically on a fresh weight basis it contains approximately 60-65% dry matter; 0.3% N 0.25% P_2O_5 and 0.18% K_2O. Poultry litter has a high concentration of dry matter and nutrients. The combustion characteristics of turkey and poultry litter are similar. Table 13.4 outlines typical chemical composition of broiler, breeder and rearer poultry.

Chemical Composition Poultry Litter

by Weight Dry Basis	itter	er Litter	r	Composite Mixture
Carbon	42.4	35.8	38.45	27.98
Hydrogen	5.7	4.8	5.3	3.78
Nitrogen	4.9	2.5	34.45	2.66
Oxygen	31	34.5	4.05	24.2
Chlorine	0.5	0.35	0.8	0.34
Total sulphur	0.6	0.45	0.7	0.41
Ash	14.9	21.45	16.25	13.28
Moisture range	20-45	25-40	20-30	
Lower Heating value kJ/kg	11,265	9,008	11,500	10,216

13.4.3 Chemical Usage In the Poultry Industry

While there is a move to minimise the use of chemicals in the poultry industry, antibiotics are used when necessary. Additives are usually added to feedstuffs and in some cases through medication. The list of approved poultry feedstuff additives is found in Council Directive Concerning Additives in Feedstuff 70/524/EC Annex B. Council Directive on the Fixing of Maximum Levels for Pesticide Residues in and on Foodstuffs of Animal Origin (86/363/EC)outlines the maximum pesticide residues allowable in foodstuff of animal origin. A report published by An Bord Glas (2000) details results from the analysis of 33 poultry fat samples for a suite of 97 pesticides and metabolites. Of these only one sample contained residues and no samples contained residues in excess of MRL's. As poultry droppings are comprised of material the birds have eaten, any antibiotics are assumed to be correspondingly low and not of any significance wlth regard to fuel characteristics.

13.4.4 Dioxins/ Furans

To alleviate possible fears of dioxin/furan contamination within the food chain resulting from the combustion of Pt, preliminary and post commissioning milk sampling for analysis was done from sites adjacent to Eye Power Plant by MAFF (Ministry of Agriculture, Fisheries and Fad) Food Safety Contaminants Unit. Milk was used as a suitable sampling medium as dioxins am known to bioaccumulate in the environment. Results of this sampling Indicated that results were at background levels with no evidence of increase over the sampling period.

13.4.5 Use as a Fuel

Poultry titter is an excellent fuel for electricity generation with nearly half the calorific value of coal (~13.5Mj/kg at 20-30% moisture. Poultry litter has been established as a commercially viable fuel for the generation of electrical and thermal energy. At present 3 power plank are operating in the UK under the ownership of Fibrowatt Lffl - Eye in Suffolk 12.7mWe; Thetford in Norfolk 38.5Mwe and Glanford in North Lincolnshire 13.5 Mwe), and one plant in Scotland Fife, Westfield (11.5MWe) under the ownership of Energy Power Resources Ltd, all utilising PL as a fuel source. This plant In Scotland receives strong support from the Scottish Environmental Protection Agency (SEPA) recognising it as a renewable energy source.

Table 13.5.1: Poultry Generating Power Plants In the UK

Location	Fuel Usage	Power Generated
Eye Suffolk, UK	130,000	14 MWe
Thetford, Norfolk, UK	430,000	38.5 MWe
Glanford Lincs, UK	127,000	13.5 MWe
Westfield , Fife Scotland	110,000	11.5 MWe

Eye power station in Suffolk has been the focus of extensive environmental monitoring of raw materials, ash analysis and atmospheric emissions. The focus of this sampling carried out by FEC Consultants UK on behalf of the Energy Technology Support Unit (ETSU) on behalf of the Department of Trade and Industry and the EC. Monitoring included atmospheric sampling. an environmental survey of soil metal content, a visual examination of flora and dioxin/furan sampling on milk samples. The environmental monitoring programme carried out over a period of 16 months has shown that them is no evidence of the deposition of harmful substances from the 41.5m high chimney onto the surrounding plants and soil. Results of this sampling are included in Tables 13.8a-g.

13.4.6 Current Disposal Methods and Environmental Implications

Poultry residues contain material that can potentially be used beneficially. However collection, transportation and processing costs often negate against this and disposal of raw poultry litter by direct use as a fertiliser or by landfill can, in some circumstances, have adverse environmental impacts. Over application of waste can result in plant nutrient build up in the soil or leaching to groundwater. With approximately 80% of all poultry farms located in the Blackwater and Finn Catchments. This represents a potential environmental problem with regard to overapplication leading to eutrophication. Often, for dry manures such as poultry litter application rates should be less than 5 tonnes/ha. All poultry installations exceeding 100,000 units must apply for an IPC Licence from the EPA which dictates disposal conditions In a report commissioned by Monaghan County Council volumes of poultry waste landspread were reported as 5% for chicken/broiler waste; 10% breader/rearing ; 60% layer and 40% turkey litter (Agricultural Waste Management in County Monaghan December 2000).

13.4.7 Poultry Ash Disposal

Poultry litter is already a proven biomass fuel and poultry litter ash is recognised as an effective fertiliser (ETSU report B/M3/00388/32/REP) and Is used as a substitute for conventional fertilisers. Burning of broiler l i concentrates the nutrients in the ash, which accounts for 9-13.6% of the original waste. It is dry, sterile and has a concentration of nutrients suitable as a fertiliser *in* agriculture or horticulture being rich in phosphate and potash. The nutrient content of ash analysed from a demonstration plant in Worcestershire showed as nitrogen concentration of 3.5kg/t; phosphate 298 kg/t potash 172 kg/t and pH 11.3. This nutrient content of the ashed litter very closely matches a currently successfully marketed commercial fertiliser which contained nutrients Nitrogen:Phosphate:Potash: 0:30:15 ((ETSU B/FW/00224).

Studies carried out in the UK have shown that phosphorous in poultry litter ash is 90 – 100% as available as that in triple superphosphate within the first growing season after application. At high soil pH it is as effective as basic slag and superior to rock phosphate. Similarly, the potassium content of the ash is very quickly available and it appears to be 90-100% as effective as that in muriate of potash. In comparison, with regard to the organic material, the logistics of applying the large quantities of farmyard manure would limit the amount of nutrients which could be supplied by this method.

i)Atmospheric Emissions

Atmospheric emission data for poultry litter is based on literature available from Eye Power station and is included as Tabb 13.8 (F-K). *Heavy* metals (cadmium, mercury, arsenic, lead, chromium, nickel, copper and manganese, dioxin/furan emissions and NOx; Sox and Co emissions were examined. Soil and foliage samples were taken on 5 sampling occasions at distances of 200m; and 500m north, south, east and west of the plant. Dioxin levels in milk samples were recorded from two points 1km and 2km from the stack in a vector of the prevailing wind on 5 sampling occasions at intervals of 1 sample pre commissioning, 4 post commissioning/ every three months – In all samples, no increases from background concentrations were recorded.

ii)Dioxins/furans: Results with an I-TEQ <0.17ng/m^3 and a >90% TCDD recovery rate which upon correction to 273k, 101.3kPa and 11% O_2 dry gas emission rate is I-TEQ 0.222ng/Nm^3.

iii)Heavy Metals: Cadmium, lead and mercury levels were very low

iv)Gases SO_2, NO_x: Stack emission levels were low with levels of 109.2mg/Nm^3 SO_2; NO: 112.5mg/Nm^3;

v)Chemistry of Poultry Raw Materials and Ashed Samples

Representative samples of bottom and precipitator ash residue were analysed for cadmium, mercury, arsenic, lead, chromium, nickel, copper and manganese, dioxins and furans as part of the ETSU Study. Results are included as Tables 13.8 (c-d). All results were recorded at low concentrations.

13.5 Conclusion

The use of poultry litter as a viable fuel is an already proven technology with associated environmental benefits. The combined waste ash can, and is utilised as an organic fertiliser.

13.6 Wood Waste

136.1 Composition

Introduction

The use of wood waste as a biomass fuel is well established. Interest in modern applications of Wood energy started in the seventies and eighties after the oil shocks, which raised concern about high-energy costs and dependence on imported oil. With decreasing oil prices, these concerns faded out, but because of environmental concerns, such as global warming and CO_2 emissions, the interest in modern wood energy is still increasing

wood waste is considered to be:

i)Forestry residues – unwanted material left behind after forest or woodland management operations have been carried out. This material consists of thin tops, branches and other material, which currently is not marketable and considered to be waste. In Northern Ireland and the Republic of Ireland only shortwood harvesting is carried out and such management practices result in significant leaving forest residues, which can be harvested for energy. Second pass harvesting can therefore be implemented provided appropriate harvesting, collection and utilisation systems are implemented.

ii) Wood industry residues and wood waste – This consists of material which enters the processing industry as saw logs or logs for paper e.g. bark from logs and sawmill residues

The residues are used by sawmills and wood processors as an energy source in the wring of wood. Only untreated wood waste will be considered as a potential fuel resource. The average fuel requirements for wood waste is as follows:

Parameter	Value
Moisture content %	50-60
Ash content %	<5
Particle size mm	25-50

(Irish Biofuel Report 1999)

The califoric value can be calculated as follows:

5.36 − (0.06x moisture content)/ 3600 - giving the califoric value in kJ/kg. The net calorific value of the wood varies inversely with its ash and moisture content but has been calculated as 18-19MJ/kg (Department of Trade and Industry). wood has a low ash content, low sulphur content (90% less than coal), low nitrogen content and its moisture content is the main variable influencing the energy input. Forest residues allowed *to* dry an the forest floor before harvesting will have a moisture content of between 35-40% depending on weather and *site* conditions.

The wood producers require that the fuel be chipped or ground in order to ensure that the particle size is kept to a minimum and to eliminate the possibility of alien matter. The most important fuel quality specifications are moisture content and particle size.

Sulphur, nitrogen and chlorine content In wood waste Is very low, and as a result there are correspondingly low atmospheric emissions as outlined in Table 13.6.2 below.

13.6.2 Environmental Discharges

Load %	100
CO2 %	10.84
SO_2	10.04
N_2	55.74
O_2	2.78
H_2O	30.6
Gas Density	1.99 kg/Nm^3
NO_x	175 mg/MJ
Dust	50mg/NM^3

(Source Integrated Energy Systems 2001)

13.6.3 Fuel Availability – Wood Chip Waste

Studies undertaken on behalf of RENEWtech in 2001 to examine the market for electricity generation from woad fuel indicate that the minimum immediate available resource is 4,800 tonnes per annum. This material available does not include private or commercial forestry residues and, the survey was confined to fuel available within a narrow area. Forest residues from private forests are not currently considered to be economically viable. The plant fuel supply is not dependent on wood chip waste as a potential energy source. This fuel would be natural and unprocessed and unlikely to exceed 20% of the total feed at any given time and less than 10% of the annual fuel throughput.

.7 Ash Composition and the Use of Ash as a Fertiliser – Examining the potentia age of Combined PL WC and SMC Ash

The need for a balanced fertlizer, taking into account land use and soil nutrient status have to be taken into account in considering the use of ash as a potential fertiliser. The requirements of plants for the principal nutrients – Nitrogen (N), Phosphate (P_2O_5) or Potash (K_2O) have to be considered in relation to soil nutrient status, and the need for balanced fertilisers depends on the type of crop. Blending of a combined ash with other organic manures will be considered to assess the likely market for a SMC, WC and PL ash fertiliser.

Poultry litter, wood chips and spent mushroom compost are of consistent quality – with the exception of variability in moisture content. The chemical composition of the fuel is very consistent –and this will be reflected in ash produced.

A possible end use for the ash from the proposed biomass plant is as a fertiliser. However, this fertiliser would have to have a stated nutrient content. In relation to a combined ash (PL;

SMC; WC) of either bottom or fly ash or a combination of both, further ash analysis will be required in order to improve upon the knowledge of ash constituents and the solubility of some of the nutrients. Modern farming is reliant upon high quality uniform and easily handled artificial fertilisers so it will be important to achieve the correct physical and chemical properties and to achieve the right balance of nutrients from these by-products. The blending of the ash from PL, WC and SMC (possibly by mixing with other organic manures) will have to be examined to determine whether a balanced PKN fertiliser can be produced. The product of various mixes of the ash would have to be evaluated as fertilisers for both agricultural and horticultural crops in order to identify performance and any toxicity effects. The ash will not be classified as hazardous under the definition outlined in Section 4(2) of the Waste Management Act 1996 which implements the Hazardous Waste Directive and associated European Waste Catalogue (EWC) and Hazardous Waste List (HWL).

Ash from poultry litter combustion is an already proven valuable fertiliser. Ash from SMC is originally a mixture of PL and straw and the resultant combined waste ash will be a mixture of these components. Waste ash from SMC is high in potassium, calcium and sulphur. Gypsum and lime in the SMC dilute the fertilising value of the combined ash end product. If the wade ash is tu be marketed as a fertiliser it may have to be blended with other components. other potential uses for the ash include use as a liming agent (CaO and MgO are present In the ash as carbonates). Its use in cement industry may be another possible end use but further analysis of the ash would be required. Fly ash from coal combustion has been used successfully in the cement industry and this avenue may represent a possible end we for the ash.

The Bio-Con process (developed by Bio-Con A/S, Denmark) which is still in the development phase may represent another alternative end disposal route for the waste ash. This process involves the chemical treatment of waste ash using sulphuric acid for the recovery of phosphorous and other chemicals. Up to 90% of the phosphorous may be recovered.

Each of them potential markets has the capacity to absorb the 47,000 (dry) tonnes of waste ash which could arise from the combustion of up to 353,000SMC, WC and PL utilised per anum. It is important to note that the 47,000 tonnes represents a significant reduction in the original waste of 353,000 tomes. In determining a final end use of the ash by product a full assessment ofthe ash contents from the development would be undertaken.

13.8 Variations in Feedstock Quality with Season

No significant variations in moisture content or litter quality due to seasonal factors are anticipated due to the uniformity in the production systems of the industries. No impact on the chemistry of the ash or the emissions are therefore expected.

13.9 Fuel Resource Availability

Based on RENEWtech's investigation into the availability of fuel supplies in the border regions the Company is confident that sufficient fuel will be available to supply the 20MW plant. As mushrooms and poultry are produced all year round there is no seasonality associated with fuel supply. Fuel surveys were initially carried out in the Monaghan region where the greatest number of poultry and mushroom farms are congregated. Preliminary assessments of fuel availability in Northern Ireland indicate that there are additional fuel resources available here and a study is currently being commissioned by the North/South Ministerial Council to examine nutrient management planning in agriculture and quantification of cross border movement of slurreys/SMC. This survey is anticipated to be completed by June 2001 and this data will be used to further quantify waste volumes available in Northern Ireland. A conservative estimate for total fuel resources of 353,000 combined SMC and PL was used in the plant specification design comprising of up to 150,000 tonnes of poultry (comprising of turkey, and chicken litter) and 220,000 tonnes of SMC. Only 4800t of wood waste has been confirmed from this fuel resource as being available to the plant. In assessing fuel availability, arrangements with key fuel suppliers have not been finalised at this stage but it is expected that supply areas will be within 100kms of the development with the majority of fuel being sourced within a 50km radius. The high moisture content and associated low calorific value of SMC prohibits long haulage distances and distances of greater than 100km are not currently considered for economic reasons.

On receipt of planning permission it is the intention of RENEWtech to pursue the establishment of waste contracts and exact tonnage available within the 100km-haulage band can be quantified. In addition, there is scope for improved waste and catchment management in a cross border context, taking account of waste policies of the EU, Ireland and the UK.

The fuel survey was based on a field reconnaissance study carried out by Integrated Energy Systems Ltd on behalf of the RENEWtech Ltd., the developers, between January – June 2001 and a desk top study on available literature and information received where available from Local Authorities and landfills (November 2001). In all cases regarding fuel survey results the most conservative data was used with regard to calculations taking into account existing practices for alternative uses of SMC and PL.

Table 13.12 a Fuel Survey - Summary

Fuel Type	Moisture (Ave)	Density (bulk kg/m3)	Disposal Costs (£/t)	Net Mean d.a.f Calorific value mj/kg	Net chemical energy MWch
SMC	65%	400 kg/m3	5	17.6	30
PL	30%	400kg/m3	6/7	20.716	24
TL	37.5%	400kg/m3	6	18.07	15.5

Total chemical energy available: 80.2MWch which will produce 20 MWe

Table 13.1 b Fuel Resource Summary

Report Ref.	SMC	Location	PL	Location	WC
Assessment of SMC Resource and potential processing options for the generation of renewable energy INTERREG II Feb 97	71,000 32,000	Monaghan Tyrone			
RENEWtech Feasability Study - additional fuel identified	17160[1]	Donegal	200,000[2]	Northern Ireland Enniskillen	4800
Managing Spent Mushroom Compost	144455	Monaghan Cavan Roscommon Donegal			
Investigation into the recovery of energy from spent mushroom compost	190,000[3]	Border Counties			
Agricultural Waste Management Options Co Monaghan			63,219	Monaghan	
Additional Resources Identified in RENEWtech Feasability Study – (Inc N Ireland)	40,000[5]		50,000		
Total Volumes Available for Combustion – Conservative Estimate	***198000***		***150,000***		***4800*** [4]

1: Pers comms – Donegal County Council 2001

2: Survey Data received from Queens University Belfast. 15% used in Poultry industry – rest unaccounted for. Assume at least 30% available

3 not all available for combustion – assume 40-50% used for composting

4 Not inc in final design spec for fuel availability but will be utilised when available. Initial survey indicates that additional WC waste is available

5 Preliminary assessment – contracts not yet finalised with producers

Note: Additional fuel resources have been identified in the draft waste sludge management study carried out by Feeily Timony on behalf of Monaghan County Council (Dec 2001)

Conclusions

a Detailed analysis was carried out on SMC samples, as this material has not been previously used as a biomass fuel commercially. All results indicate that there are no environmental concerns in relation to breakdown products or possible atmospheric emissions associated with this material as a fuel source. Abatement technology utilised in the plant will result in emission levels which are with relevant air quality standards and combustion trials carried out by the University of Ulster indicate that this material can be successfully used in a commercial situation as a fuel source.

☐ Concerns raised in the public consultation process regarding potential residual pesticides and dioxins In the SMC and PL raw material, ash and possible atmospheric emissions were investigated. Results Indicate that trace amounts only may be present which are not of environmental concern. The industries are moving away from pesticide use driven by consumer demand. Similar results were found for residual dioxin/furans and heavy metal content In the raw material, ashed samples and potential atmospheric emissions. Untreated wood waste is considered as a third fuel when available and is not considered a source of pesticide residues.

o Both poultry litter and wood residues are proven as successful biomass renewable energy sources. Combustion trials indicate the viability of utilising SMC as a fuel resource

☐ Waste ash associated with the process will be produced and marketed as a fertiliser pending further research on final chemical composition. This will only be possible to achieve once the plant is operational. Other potential options for use of ash include utilisation in the cement industry.

☐ It is considered that sufficient fuel resources are available within 100kms of the development to develop an economically sustainable plant. Additional fuel resources can be obtained from areas in Northern Ireland. On receipt of planning permission. further work will commence with regard to fuel and haulage contracts

13.14: Raw D

Table 13.2a: SMC Raw Material Characteristics

Parameter	Units	Sample 1	Sample 2	Sample 3	Sample4	Mean
Size	g	3.267	913	784	898	
Moisture	%	68.8	68.3	69	64.9	67.8
Ash	%	9.3	10	9.7	10.5	9.9
Chloride	%	0.13	0.038	0.17	0.18	0.13
GCV received	MJ/kg	4.04	4.01	4.1	4.8	4.24
NCV received	MJ/kg	2.11	2.05	2.13	2.89	2.3
NCV dry ash free	MJ/kg	17.26	17.08	17.94	18.16	17.6

Legend: Samples taken from top, middle and bottom to provide a homogenous sample

Sampling carried out by AET July 2000

Table 13.2 b: Combustion Characteristics SMC – Fuel as Received

[Parameter	Mean	Units	Range	Units
Moisture	67.8	%	64 - 69	%
Volatiles	18.8	%	-	%
Fixed Carbon	28	%	-	%
Ash	9.9	%	9.3-10.5	%
NCV	2.3	MJ/kg	2.05 – 2.89	MJ/kg
Fuel on Dry Basis				
Ash	30.6	"	29.8 – 31.8	%
NCV	-	MJ/kg	-	MJ/kg
Fuel Dry and Ash Free				
Volatile Matter	85.4	%	-	%
Fixed Carbon	12.4	%	-	%
Sulphur	2.2	%	-	%
NCV	17.6	MJ/kg	17.1-18.16	MJ/kg

Sampling carried out by AET July 2000

Table 13.2c: Chemical Composition SMC

		As Received	Dry Ash Free
Parameter	Units	Mean	Mean
Carbon	%	11.1	50.4
Hydrogen	%	1.2	5.45
Oxygen	%	8.5	38.62
Nitrogen	%	0.6	2.73
Sulphur	%	0.48	2.2
Chlorine	%	0.13	0.6
Moisture	%	67.8	-
Ash	%	9.9	
Total	%	100.6	100

Table 13.2d: Ash Analysis at 550°C and 29.7% O_2 Dry Basis

Parameter	Units	Mean	Basic/Acidic	Melting Point °C
P_2O_5	%	6.6	A	580
CaO	%	44	B	2614
MgO	%	3.1	B	2852
Na_2O	%	1.1	B	1275
K_2O	%	7.7	B	350
SiO_2	%	16	A	1610
Al_2O_3	%	1.3	B	2072
Fe_2O_3	%	0.92		1565
SO_3	%	16		
TiO_2	%	1.1		
Cl	%	0.091		
Total	%	97.9		

Sampling carried out by AET July 2000

Table 13.3Composition of Irish Spent Mushroom Com——

Constituent	Mean	Minimum	Maximum
Available Nutrients			
pH	6.6	5.9	7.4
EC (mS/cm)	750	580	903
$NO_3 - N$	62	21	87
$NH_4 - N$	49	2	133
P	31	11	73
K	2130	1450	2650
Na	253	160	350
Cl	118	40	157
Total Nutrient content			
N (g/kg DM)	25.5	23.1	28.2
P	12.5	10.3	15.3
K	25	17	32
Ca	72.5	42	99
Mg	6.7	5.2	8.7
S	15.9	9.6	22
Na	2.67	1.7	3.2
Fe (mg/kg DM)	2153	1300	3200
Mn	376	320	460
B	37	32	43
Cu	46	36	65
Zn	273	220	390
Bulk density (g/l)	319	257	395
% Dry Matter (DM)	31.5	24.1	35.1
% Ash	35	30.4	41.5

(Source: Teagasc) units: mg/kg

Table 13.4: Crop Production Products Approved for Use In the Irish Mushroom Industry

Function Product Name		Marketing Company	Active Substance
Disinfectants			
Disolite	91981	Progress Products	Ortho phenol phenol Orthobenzyl chlorophenol
Environ	90559	Sylvan Spawn Ltd	Sodium o-benzyl-p-hlorphenoxide Sodium Ortha Phenyl Phenol Sodium p-t-amylphenoxide
Prophyl	90879	Mckenna (JF) Ireland Ltd	2-Benzyl-4-chlorophenol 4-Chloro-3-methylphenol
Sudol	91349	McKenna (J.F) Ireland Ltd	Tar oils
Vesphene D39	92016	Ceva Animal Health Ltd	+Sodium o-benzyl-p-chlorphenoxide Sodium Ortho Phenyl Phenol Sodium p-l-amylphenoxide
Bladafum	90296	Bayer Ltd	Sulfotep
Bavistin DF	90220	BASF Ireland Ltd	Carbendazim
Bravo 500	00198	Syngenta Ireland Ltd	Chlorothalonil
CT 500	017848	DHM Agrochemicals Ltd	Chlorothalonil
Sporgon	912888	Aventis Crop Science Ireland ltd	Prochloraz
Insecticide			
Apex 5E	91925	Syngenta Ireland Ltd	Methoprene
Birlane 24% EC	90293	BASF Ireland Ltd	Chlorfenvinphos
Dimilin 2L	01283	Interchem Ltd	Diflubenzuron
Dimilin WP-25	91648	Uniroyal chemicals Limited	Diflubenzuron
Nemasys M	92079	Microbio Ltd	Steinernema feltiac
Pynosect 30 WM	90999	National Agrochemical Distributors Ltd	Pyrethrins Resmethrin

(Source: Bord Glas)

Table 13.5: Heavy Metal Content Pesticide Residue Levels and Volatile Organics in Raw Spent Mushroom Compost and Ashed Samples

Parameter	Units	Raw Received	Ashed Samples 1100°C
Metal Analysis			
Arsenic	mg/Kg	<8.0	48
Cadmium	mg/Kg	<0.6	<0.6
Chromium	mg/Kg	5	27
Copper	mg/Kg	35	160
Lead	mg/Kg	4.3	3
Nickle	mg/Kg	<6.0	17
Mercury	mg/Kg	0.03	<0.10
Antimony	mg/Kg	0.2	2.6
Manganese	mg/Kg	210	1000
Tin	mg/Kg	<10	23
Vanadium	mg/Kg	11	61
Pesticides			
Azinphos-Methyl	µg/Kg	<20	<20
Chlorfenvinphos	µg/Kg	<20	<20
Diazinon	µg/Kg	<20	<20
Dichlorvos	µg/Kg	<20	<20
Fenrtioithion	µg/Kg	<20	<20
Malathion	µg/Kg	<20	<20
OPP Total	µg/Kg	<20	<20
Propetamphos	µg/Kg	<20	<20
Aldrin	µg/Kg	<20	<20
BHC-Alpha	µg/Kg	<20	<20
BHC-Beta	µg/Kg	<20	<20
BHC-Gamma	µg/Kg	<20	<20
Dieldrin	µg/Kg	<20	<20
Endosulphan-Alpha	µg/Kg	<20	<20
Endosulphan-Beta	µg/Kg	<20	<20
Endrin	µg/Kg	<20	<20
HCB	µg/Kg	<20	<20
Isodrin	µg/Kg	<20	<20

OCP Total	µg/Kg	<20	<20
op-TDE	µg/Kg	<20	<20
PCB Congener 118	µg/Kg	<20	<20
PCB Congener 138	µg/Kg	<20	<20
PCB Congener 153	µg/Kg	<20	<20
PCB Congener 180	µg/Kg	<20	<20
PCB Congener 28	µg/Kg	<20	<20
PCB Congener 52	µg/Kg	<20	<20
PCB Total	µg/Kg	<20	<20
Pp-DDE	µg/Kg	<20	<20
pp-DDT	µg/Kg	<20	<20
pp-TDE	µg/Kg	<20	<20
Triffyuralin	µg/Kg	<20	<20
VOC scan on solids			
Chloroform	µg/Kg	1700	
Ethanol	µg/Kg	870	
3-Octanone	µg/Kg	3200	
3-Octanol	µg/Kg	2000	
trans-2-Undecen-1-ol			64
2,4,4-Trimethyl-1-pentanol			270

Legend:

<: Below detection limit

Sampled: Top., middle, bottom - 4 mushroom houses

Sampled: Oct 01 SWS Environmental

Table 13.6a: Dioxin/Furan Results SMC

Parameter	ng/kg	ng/kg
Raw SMC	0.13	26
Ashed 850°C	Not detected	5.0
Ashed 1100°C	Not Detected	3.9

Legend: Analysis based on 17 PCDD and PCDF contingers containing chlorine substitutions at the 2,3,7,8 positions used to calculate I-Teq values

Table 13.6b: Dioxin/Furan Results SMC

Totals	Raw SMC	Ashed 850°C	Ashed 1100°C
TCDF's	2.151	2.577	ND
TCDD's	1.719	ND	ND
PeCDF's	0.293	ND	ND
PeCDDs	ND	1.476	0.497
HxCDF's	1.087	ND	1.067
HxCDDs	ND	ND	ND
HpCDF's	ND	0.972	1.233
HpCDD	1.596	ND	1.149
OCDF	ND	ND	ND
OCDD	18.857	ND	ND
Total	**25.703**	**5.025**	**3.946**

Note: Detailed analytical results showing individual contingers along with further analytical details are not included here due to space considerations

Nd: Not Detected

Table 13.7 Average Combustion Gas Emissions - Spent Mushroom Compost

Test No			1		2	
Furnace O_2		%	7		6.6	
Plant Exit O_2		%	10.7		11.2	
NO_2	mg/m^3	ppm	0	0	1	1
As NO	mg/m^3	ppm	168	127	93	64
AS NO_2	mg/m^3	ppm	260		133	
SO_2	mg/m^3	ppm	51	19	12	4
CO	mg/m^3	ppm	68	57	112	95

(Source University of Ulster Report)

All data corrected to 11% O2 dry unless otherwise stated

Table 13.8 a - Poultry Litter Analysis

Poultry Litter Analysis Proximate Analysis

Moisture	%w/w	46.7
Ash	%w/w	8.9
Volatile Matter	%w/w	41.6
Fixed Carbon	%w/w	2.8

13.8 b Ultimate Analysis (on a dry basis)

Carbon	%w/w	28.4
Hydrogen	%w/w	4.9
Nitrogen	%w/w	4.7
Sulphur	%w/w	1.6
Chlorine	%w/w	<0.1
Calorific value	Btu/lb	4195
Bulk Density	g/ml	0.48
Phosphorous	%w/w	0.86
Potassium	%w/w	1.49
Nitrogen	%w/w	3.4
Cadmium	mg/kg	<0.5
Lead	mg/kg	0.79
Chromium	mg/kg	4.72
Nickel	mg/kg	2.75
Manganese	mg/kg	261
Copper	mg/kg	53.8
Antimony	mg/kg	<5
Tin	mg/kg	<5
Vanadium	mg/kg	<5
Arsenic	mg/kg	1.18
Mercury	mg/kg	4..5

Data from ETSU B/FW/00235/REP - Eye Power Station

Table 13.8 c Poultry Litter Ash Analysis

Ash Analysis	Precipitator Ash	Bottom
Cadmium	2.1	<0.1
Mercury	<0.1	1.3
Arsenic	7.6	<0.1
Lead	22.4	0.6
Chromium	26.7	2.3
Nickel	32.9	4.2
Copper	465	77
Manganese	690	365

Cobalt	13.8	0.63
Antimony	4.1	<0.1
Tin	2.9	16
Thallium	<0.1	0.8
Vanadium	17	28

Table 13.8 d Ash - PL - Dioxin/Furan Results

Sample Ref	Precipitator Ash	Bottom Ash
	ng/g	ng/g
2378 TCDD	0.01	<0.001
Total TCDD	0.36	<0.005
12378 -PeCDD	0.006	<0.002
Total PeCDD	0.55	<0.005
123478-Hx CDD	0.012	<0.003
123678-HxCDD	0.011	<0.003
123789-HxCDD	0.012	<0.003
Total HxCDD	0.28	<0.02
1234678-HpCDD	0.045	0.005
TotalHpCDD	0.085	<0.01*
OCDD	0.068	0.02
2378-TCDF	0.02	<0.001
Total TCDF	0.34	<0.005
23478-PeCDF	0.01	<0.001
12378-PeCDF	0.01	<0.001
Total PeCDF	0.12	<0.005
123478-HxCDF	0.013	0.004
123678-HxCDF	0.007	0.003
234678-HxCDF	0.006	<0.001
123789-HxCDF	0.001	<0.001
TotalHxCDF	0.045	0.01
1234678-HCDF	0.012	0.005
1234678-HpCDF	0.002	<0.001
Total HpCDF	0.02	<0.01*
OCDF	0.042	0.01
I-TEQ	0.028	<0.005
TCDD Recovery	>90	>90

Note: Total refers to all isomers of the congener group

*Interference of lock (suppression)

Table 13.8 e Poultry Litter Analysis - Data from ETSU B/FW/00235/REP - Eye Power Station

Parameter	Units	Results
Carbon monoxide	ppm	0-1000
O_2	%	0-25
NO/Nox	ppm	0-500
SO2	ppm	0-500
Furnace temperature	°C	0-1200
Sample Point Temperature	°C	0-500

Table 13.8 g Stack Gas - Dioxins and Furans

Sample Ref	Stack Gas
2378 TCDD	<0.02
Total TCDD	0.16
12378-PeCDD	<0.03
Total PeCDD	0.2
123478-Hx CDD	0.03
123678-HxCDD	0.03
123789-HxCDD	0.03
Total HxCDD	0.2
1234678-HpCDD	0.1
TotalHpCDD	0.2
OCDD	0.58
2378-TCDF	0.07
Total TCDF	1.5
23478-PeCDF	0.1
12378-PeCDF	0.12
Total PeCDF	1.4
123478-HxCDF	0.3
123678-HxCDF	0.14
234678-HxCDF	0.09
123789-HxCDF	0.03
TotalHxCDF	1
1234678-HCDF	0.47
1234678-HpCDF	0.05
Total HpCDF	0.73
OCDF	0.86
I-TEQ	<0.17
TCDD Recovery	>90

ITEQ= 0.222ng/Nm3 as corrected to ref conditions dry at 273oK 101.3 kPa and 11% O2

Total refers to all isomers of the congener group

Table 13.8 g VOC's as measured by Gresham Tube

Parameter	Units	vppm % mg/m^3	vppm % mg/m^3
Oxygen	O_2	5.7	5.6
Nitrogen	N_2	80	79.9
Hydrogen	H_2	ND	ND
Helium	He	ND	ND
Carbon dioxide	CO_2	14.3	14.5
Methane	CH_4	ND	ND
Ethane	C_2H_6	ND	ND
Ethylene	C_2H_4	ND	ND
Propane	C_3H_8	ND	ND
Propylene	C_3H_6	ND	ND
Acethyene	C_2H_2	ND	ND
Butanes	C_4H_{10}	ND	ND
Pentanes	C_5H_{12}	ND	ND
Hexanes	C_6H_{14}	ND	ND

Table 13.8 e Metal Emissions in the Flue Gas

Parameter	Units	Particulate	Vapour
Arsenic	mg/m^3	0.002	0.076
Cadmium	mg/m^3	0.005	0.079
Lead	mg/m^3	0.01	2.589
Nickel	mg/m^3	0.016	13.049
Copper	mg/m^3	0.044	0.541
Manganese	mg/m^3	0.015	1.3
Chromium	mg/m^3	0.017	10.398
Mercury	mg/m^3	0.001	0.018
Cobalt	mg/m^3	0.002	0.176
Antimony	mg/m^3		0.108
Tin	mg/m^3		0.006
Thallium	mg/m^3		0.012
Vanadium	mg/m^3	0.001	0.029
Total		28.49	

All expressed in mg/m3 corrected to 273K, 101.3KPa and 11% Oxygen, dry gas
1: PL only

2: PL and gas oil

Table 13.8 f Acid Gas Emissions

Parameter	Range of Detection mg/Nm^3	Average mg/Nm^3
NO	82-399	112.5
SO_2	22-196	109.2
HCl		181

Expressed as dry gas corrected to 11% O2

Table 13.8 g Particulate Emissions Levels

Parameter	Units	Results
Average Flue Gas Conditions		
Temp	Deg C	175
Oxygen Content	%v/v	6.3
Water Vapour Content	%v/v	18.2
Volume Gas Sampled Wet	m^3	1.769
Volume Gas Sampled Dry	m^3	1.446
Particulate emission level	mg/m^3	155

(based on dry gas)
Corrected to 273K 101.3kPa and 11% oxygen (dry gas)