GMIT

Design and Validation of a Domestic Waste Management Audit Tool

By

Ivor Heavey

Masters in Engineering

Galway Mayo Institute of Technology

Supervisors

Mr. John Hanahoe & Dr. John Lohan

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Abstract

This study was undertaken to design and validate a new domestic waste management audit tool (W-MAT) that would allow waste management companies to track waste trends more efficiently. The Environmental Protection Agency (EPA, 2007) identified the limitations of the current paper based domestic audit questionnaire that is used by local authorities to audit household waste and highlighted the need for an electronic audit tool. In 2007 Galway County Council (GCC), under the auspices of the Local Authority Prevention Demonstration Programme (LAPD), sought to develop such a tool, as the existing paper based audit methodology adopted was labour intensive and costly to administer.

The need for such a tool is driven by requirements to monitor domestic waste production and recovery rates. Landfill is decreasing and waste recovery rates have risen from 19% in 2004 to 26% in 2008. However, there is still some way to go to achieve the 50 % EU Landfill Directive (1999/31/EC) diversion target by 2013. This emphasises the need for a greater understanding of household waste composition, volume of specific waste streams and changing waste trends. Increased understanding of domestic waste streams will allow local authorities and waste management companies to identify and provide appropriate and efficient waste management options such as reduce waste production at source, reuse material where possible and maximise recycling. The local authority should also investigate other available options such as incineration with energy recovery, combined heat and power (CHP) plants, bio-refinery plants and commercial composting plants, as economically viable and environmentally sustainable alternatives to landfill.

GCC therefore identified a need for an audit tool that is:

- Electronic based, to reduce the cost associated with data capture, compilation and analysis
- Easy for the householder to use
- Capable of data storage and retrieval
- Suitable for online deployment
- Able to generate waste trends for large sample size (>1000)
- Modelled to provide a profile of the waste composition
- Designed to generate a summary of results, that is supported by result charts
- Administratively light for the local authority to deploy and implement

Reflecting International best practice it was decided to base the W-MAT audit methodology on a combination of the Zero Waste New Zealand and the Irish Waste Characterisation, 2008 methodology. The W-MAT was designed using best practice software design methods that involved needs analysis with all stakeholders, design review meetings and field trials with 28 households. The waste management audit methodology developed is based on the well known Excel spreadsheet software, which can be easily deployed on-line.

Both field trials demonstrated that the audit tool worked efficiently generating useful household audit results in the form of standard template reports. The results obtained were comparable with existing National data, generating confidence in both the quality of the data and the ability of the audit tool to capture accurate household waste trends. W-MAT was well received by GCC and it is expected that the EPA will roll out W-MAT to other stakeholders in the near future.

Table of Contents

List of Appendices

List of Figures

List of Tables

LAPD	Local Authority Prevention Demonstration Programme
LCA	Life Cycle Approach
LCA-IWM	Life Cycle Assessment tools for Integrated Waste Management
m≥	Metre cubed
MBT	Mechanical Biological Treatment Plants
MCC	Mayo County Council
MFA	Material Flow Analysis
MPRN	Meter Point Reference Number
MRF	Material recovery Facility
MSW	Municipal Solid Waste
MWCS	Municipal Waste Characterisation Survey
Mt	Million tonnes
N_2O	Nitrous Oxide
NCCS	National Climate Change Strategy
NWD	National Waste Database
NWR	National Waste Report
PET	Polyethylene Terephthalate
PFCs	Perfluorocarbons
PPP	Polluter Pays Principle
UNCED	United Nations Conference on Environment and Development
SEI	Sustainable Energy Ireland
SF_6	Sulphur Hexafluoride
SWA	Solid Waste Methodology
SWAT	Solid Waste Analysis Tool
UNCED	UN Conference on Environment and Development
VE	Visual Estimate
W-MAT	Waste Management Audit Tool
WCP	Waste Collection Permit
WP	Waste Permit
ZWNZ	Zero Waste New Zealand

recovery is increasing. Household waste diversion from landfill stood at 26% in 2008, compared to 19% in 2004. There is however still some way to go to achieve the 50% landfill diversion target set by the EU landfill directive 99/31/EC for household waste for 2013. The Waste Management Audit Tool designed in this study aimed to facilitate this transition with the collection of domestic waste data at source.

In 2008, 1.16 million tonnes of municipal waste was accepted for disposal at thirty one active landfills, compared to 1.99 million tonnes accepted at fifty landfills in 2001. The focus is on reducing the number of licensed waste facilities whilst ensuring that the remaining facilities are well maintained and run, thus reducing the adverse effects on the environment.

Three waste incinerators have been licensed by the EPA; two exclusively for municipal waste, the other dealing with municipal and hazardous waste. None of these facilities have commenced operations. The Confederation of European Waste to Energy Plants Ireland (CEWEPI) acknowledge the waste management hierarchy and state that waste prevention is the most favored option, followed by the reuse of waste material and recycling. Where municipal waste (household and similar wastes) remains after waste prevention, reuse and recycling activities, it can be used to produce both electricity and heat for industrial and household users by utilizing waste-to-energy plants, or incinerators with energy recovery (CEWEPI, 2009). They state that the benefits from incineration with energy recovery are:

- Recover the maximum energy value from waste, in line with the European waste policy to avoid waste or use waste as a resource (CEWEPI, 2009).
- Help meet European Landfill Diversion targets by providing an alternative to landfill for mixed residual biodegradable waste (CEWEPI, 2009).
- Help meet renewable energy targets, greenhouse gas emission targets and energy security of supply targets (CEWEPI, 2009).
- Reduce the volume of waste sent to landfill by up to 90% and render it inert, extending the lifespan and improving the quality of existing landfill (CEWEPI, 2009).

In this W-MAT study an extensive investigation of relevant factors associated with the auditing and management of household waste is reported. There is a need for better information describing the quantity and composition of waste being generated. This will allow the appropriate strategies to be identified from the numerous options that

This W-MAT study aimed therefore to develop a tailored, efficient and cost effective internet based audit tool to replace the current paper based audit methodology. The local authority has specified that the W-MAT tool methodology must be:

- Well structured (laid out in a logical sequence that facilitates audit repeatability).
- Electronic, capable of storage and retrieval of audit data to reduce the paper trail.
- User friendly to the householder (set at the appropriate literacy level and requires minimal set up- time and training).
- Electronically store data (facilitate the easy storage and retrieval of audit results).
- Capable of self generating audit results in template format, supported by graphs thus reducing the need for inputting duplicate data into two separate systems.
- Capable of resolving household waste trends by European Waste Codes (EWC codes) and household type and producing quantitive results.
- Of low administration cost to the local Authority.
- Accessible to a wide cohort of householders (compatible with web based applications).
- Validated in the field (design testing, protocol testing and field trials using a household field trial).

1.3 Aim and Objectives

The aim of this project was to design and validate an internet based domestic waste audit tool suitable for GCC, other local authorities and commercial waste facilities.

To achieve this aim, a number of objectives were set:

1. Conduct a literature review to identify various definitions, legislation and policy actions that relate to Irish domestic waste and examine state of the art National and International waste audit methodologies.
2. Establish a design methodology that allows all stakeholders to review, validate and comment on successive iterations of W-MAT during development.
3. Define metrics by which the outputs can be assessed and compared.
4. Design an audit tool that can be used to conduct household audits, that is easy for the householder to use and provides results that are easy to analyse.

1.4.1 Experimental Research

Gile (1990) states that "*over the years, experimental research has become very important in the eyes of researchers in many disciplines, inter alia in the behavioural sciences, psychology, linguistics and psycholinguistics in particular, to the extent that many equate 'science' with experimental research and deny 'scientific value' to any endeavours which are not experimental*". These studies are research activities in which the impact of an activity is measured by offering it to one group whilst withholding it from another. They are used to establish cause and effect and the emphasis is on controlling the variables in such a way that the cause of an effect can be attributed to one condition. The validity of this sort of research depends on random assignment of individuals to the groups that are being compared, the amount of control that is exerted over extraneous factors, how the treatment conditions are manipulated, what is measured as outcomes and how groups compare.

1.4.2 Survey Research

Surveys are used to describe attitudes, opinions and behaviors of a group. They are typically administered in one of two ways, either at a moment in time over a cross section, or over a length of time with the same population. This latter method is often used to find changes of opinion or to identify trends. In cross sectional research, the intention is sometimes to describe current practice or to evaluate a program or activity in which the participants have been involved. Surveys have been used in empirical research with both adults and children for many years with Bogdan and Biklen (1998) reporting that surveys were carried out with children as early as the 1890s. This approach is relevant to the validation of W-MAT and the results obtained as discussed in Chapter six.

1.4.3 Case Study Research

There are essentially two instruments for survey research; these are the questionnaire and the interview. In a questionnaire it is the participant that records the data, in an interview it is the researcher that records the data. Interviews can be carried out in one to one settings or can be in a group setting, often referred to as a focus group (Krueger, 1994). For the W-MAT software application it employs the questionnaire and its development is presented in Chapters four and five.

1.4.4 Action Research

Action Research is practitioner-led or practitioner-based research. It involves thinking carefully about what one is doing, so it is also called a self-reflective practice.

- Why is an audit tool required?
- How will it be designed?
- Who will benefit from the study?
- Who will complete it?
- How do participants access/return the information?
- How many feedbacks are required?
- How will the data be analysed?
- What are the results being used for?

These questions are resolved through chapter's three to six.

1.6 Existing Audit Methodologies

The initial review gives an insight into the Irish waste management framework. Since no single standard method of measuring waste composition exists, either at a local, national or international level, it is difficult to compare different survey methods used. The figures quoted by the EPA (2007) for uncollected household waste are estimates. The estimated quantity of uncollected waste is calculated by each local authority and is reported to the EPA on Sheet No. 2 of the local authority questionnaire. The uncollected waste quantity is generated by "average weight of waste collected per household served" multiplied by the number of households not served by a collection service. The local authority questionnaires are returned to prepare the Annual Environmental Report (AER). The EPA admits that there is an ongoing problem with municipal waste classification, particularly by operators at landfill. Waste operators using incorrect definitions for municipal, household and commercial wastes affect the accuracy of data collected and as a result they categorise the waste incorrectly. For the purpose of this study the definitions outlined by the EPA (2008) National Waste Report (NWR) is used. They define Municipal Solid Waste (MSW) or Municipal Waste as household waste, including commercial and other waste that, because of its nature or composition, is similar to household waste. However it excludes municipal sludge's and effluents. In the context of the NWR's municipal waste consists of three main elements - household, commercial (including non-process industrial waste), and street cleansing waste (street sweepings, street bins and municipal parks and cemeteries maintenance waste, litter campaign material, fly tipped material). The EPA (2008) define household waste as*" waste produced within the curtilage of a building or self-contained part of a building used for the purposes of living accommodation. Commercial waste is a term used to describe the non-household fraction of municipal waste, which is produced by commercial premises such as shops, offices and restaurants, as well as municipal premises such as schools and hospitals"*. It also

1.8 Thesis Structure

This study is presented in seven chapters as indicated in Figure 1.3 below.

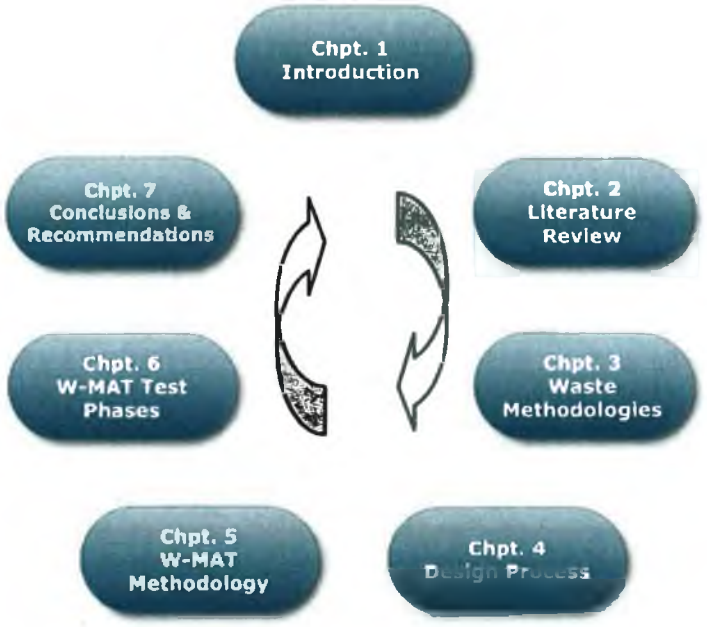

Figure 1.3 Thesis Structure

Chapter one presents a brief introduction to the study. The second Chapter is of a qualitative nature, describing a literature review of past and present environmental management trends. Various National and International waste audit methodologies are discussed in Chapter three. The W-MAT audit methodology will be designed based on a combination of the Zero Waste New Zealand (ZWNZ) and the Municipal Waste Characterisation Survey (MWCS) 2008, which incorporates the European SWA (2004) methodology. In Chapter four, various design models are discussed and a tailored design model is adopted to suit this application. The detailed design of the W-MAT audit tool is described in Chapter five. The results of the field trials are outlined in Chapter six. The field trial results show that the W-MAT tool operated efficiently during the test phase. Chapter seven provides conclusions and recommendations.

sustain their lives on this planet" are the grand challenges facing the international community at the dawn of the twenty-first century. By the time of the World Summit on Sustainable Development, held in Johannesburg in 2002, achieving sustainability had become a goal in international communities, and a key topic on many regional, national, and local political agendas.

Our activities through the burning of fossil fuels, land use changes and more intensive agriculture have resulted in an increase in the levels of Green House Gases (GHGs) in the atmosphere, especially carbon dioxide (CO_2). This increase in GHG's enhances the atmosphere's ability to trap heat leading to an increase in the average surface temperature of the earth. *"Mean annual temperatures in Ireland have risen by 0.74°C over the past 100 years"* according to Mc Elwain and Sweeney (2007). This increase largely occurred in two periods, from 1910 to the 1940s and from the 1980s onwards, with a rate of warming since 1980 of 0.42°C per decade. In Ireland, 6 of the 10 warmest years on record have occurred since 1995 with the warmest year within this period being 1997.

As a result of the increase in GHGs in the atmosphere the Kyoto protocol was agreed between leaders of industrialised nations to reduce the emissions of greenhouse gases into the atmosphere. Grubb (2007) states that in particular, it aims to limit the emissions of six main anthropogenic greenhouse gases, Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Perfluorocarbons (PFCs), Hydrofluorocarbons (HFCs), and Sulphur Hexafluoride (SF_6) of which CO_2 accounts for 80%. The protocol intends to reduce emissions of GHGs to the levels emitted in the 1990's in an effort to protect the environment for future generations.

The European Commission (2001) states that:

"Climate change impacts are only one of a number of environmental impacts that derive from solid waste management options. Other impacts include health effects attributable to air pollutants such as Nox, So_2, dioxins and fine particles, emissions of ozone depleting substances, contamination of water bodies, depleting of non-renewable resources, disamenity effects, noise, accidents etc."

Ireland is focused on GHG reduction. Desmond (2006) states that the management of waste in Ireland subscribes to a notion of sustainability, which effectively aims to decouple the generation of waste from economic growth. This orientation emphasises an 'integrated approach' (mix of options) to waste management, which is based on the

- generated revenues that can be applied in support of waste minimisation, recycling and other desirable waste management and environmental protection initiatives.

Household consumption is considered particularly important, as millions of consumers make decisions relating to which, and how much, of different products and services to consume. *"The increased use of resources in the economy now will inevitably lead to the increased generation of waste at some point in the future. Some resources consumed in the economy add to durable material stock (houses, infrastructure etc.). However virtually all materials used eventually become waste, whether this takes place within days (food packaging), years (electrical equipment) or decades (buildings refurbishment, redevelopment) of consumption."* (EPA, 2008).

In order to combat the increasing use of resources, achieving waste prevention in practice is particularly challenging, as in a similar way to climate change, societal behavioural changes are needed now with few immediately tangible benefits apart perhaps from some cost savings. Implementing waste prevention, producer responsibility and integrated policies in an increasingly competitive and globalised free-market economy, is an ongoing challenge for all stakeholders involved. In this study household waste may be waste, which is collected by or on behalf of a municipality, via pick up systems and or drop off systems depending on the county or region.

The EPA is proactive in its approach to waste management in Ireland. It has funded and promoted the waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme that was launched in 2006. The EPA (2008) states that the aim of the programme, is to assist local authorities to design and implement local integrated waste prevention programmes and projects. Assistance is provided by the CTCC and grant monies are provided by the EPA to increase capacity in waste prevention locally.

2.2 The Lifecycle Approach to Waste Prevention and Minimisation

The EU Waste Management Hierarchy shown in Figure 2.2 prioritises waste management options in order of preference; it aims to promote sustainable waste systems. The EU Commission (2001) states in its research that prevention and minimisation of waste are the most favourable options. Anything that cannot be prevented or minimised should be reused, repaired, recycled or composted. Energy

decade ago, there is considerable recent interest in designing industrial production processes that produce zero waste....the goal is a worthy motivator". A zero waste strategy leads one to identify inefficiencies in the use of materials, energy and human resources. To achieve a sustainable future, extreme efficiency in the use of all resources will be required in order to meet the needs of the earth's inhabitants. Zero Waste (2005) strategies consider the entire life cycle of products, processes and systems in the context of a comprehensive systems understanding of our interactions with nature and search for inefficiencies at all stages. With this understanding, waste can be prevented through designs based on full life cycle analysis. It is important that the general population work to design our wastes, if any, so that they have future applications.

2.3 European Waste Research

The European Environment Agency (EEA) (2005) identified that household consumption has grown continuously alongside gross domestic product (GDP) in past decades, but has also changed in its form.

Household consumption expenditure in the European member states between 1990 and 2002 increased by almost one third to more than €12,000 (constant price) per person per year on average. As can be seen in Figure 2.1 the consumption of major food and drink categories (kg/l per person, per year) has also increased over time and that also has an adverse effect on the waste quantity produced.

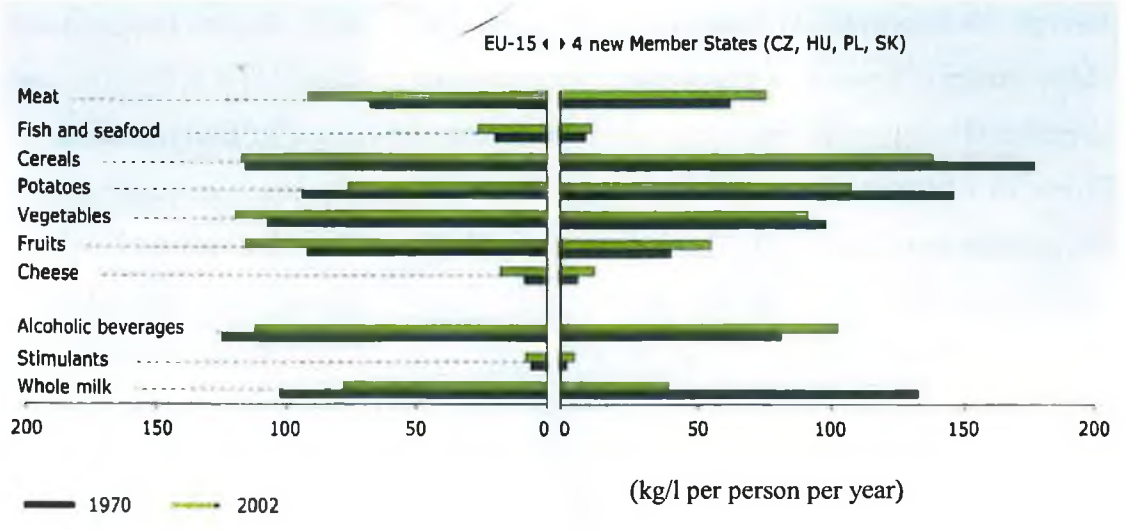

Figure 2.1 Changes in European consumption of major food and drink categories between 1970 and 2002 (FAO, 2005)

Unless the emphasis is focused on reduction of waste or energy use, their consumption will continue to increase placing greater pressure on the natural resources.

2.4 The Waste Management Legislative Framework in Ireland (1982 – 2010)

This section reviews the waste management trends in Ireland since 1982.

2.4.1 Waste Management in Ireland

Irish waste management legislation, policies and practices have undergone significant change since the 1990's. Prior to 1990 apart from the Litter Act (1982), legislation on solid waste related to the public health functions of the local authority. Cunningham (2001) state's that "*the root of Ireland's waste crisis lies in the traditional over reliance on landfill as the primary method of waste management*". Historically, landfills have been small in size and operation, and have been badly operated and maintained.

The inefficient use of landfills was the predominant waste management option due to its relatively low cost, and its ability to accept a variety of wastes. Its low cost in the past inhibited the development of alternatives.

2.4.2 Waste Management in Ireland since 1990

The establishment of the EPA under the Environmental Protection Agency Act, 1992 enabled the establishment of a national waste database. The Department of the Environment Heritage and Local Government (DoEHLG) (1994) introduced a National Recycling Strategy, '*Recycling for Ireland*' and the motto became the 3 R's of recycling, Reduce, Reuse, Recycle. The waste hierarchy shown in Figure 2.2 expands on the 3 R's slogan, and lists the least and most favoured waste options. Prevention and minimisation are at the tip of the pyramid whilst energy recovery and disposal are at the base of the pyramid.

- A levy of up to €0.19 on the supply of plastic bags by retailers and potentially the extension of the levy to other products
- A levy on the landfill of waste of not more than €19 per tonne initially with annual increases of not more than €5 per annum
- Establishment of an environmental fund for the development of Waste Management Infrastructure and Environmental Education (e.g. waste recovery activities and awareness initiatives)
- A change in the Litter Act that increased on the spot fines to €127

In 2003, the Protection of the Environment Act was enacted to increase the enforcement provisions given to the EPA and local authorities in relation to waste licensing, planning and charges. These provisions included the:

- Introduction of consultation between planning authorities and the EPA on IPPC licensing and facility emissions.
- Provision of new powers for the EPA to revoke or suspend operations of an IPPC license.
- Introduction of fines for breach of license provisions increased to €130,000 on indictment.
- Application of the requirements of Directive 80/68/EEC on 'The Groundwater Directive' to IPPC licensing.

The DoEHLG (2004) in the *National Draft Strategy Report on Biodegradable Waste* outlines a number of key targets. They aim to achieve the following targets by 2013:

- Divert 50% of overall household waste away from landfill
- Achieve a minimum 65% reduction in Biodegradable Municipal Waste (BMW) sent to landfill
- Develop biological treatment capacity of up to 300,000 tonnes per annum
- Recycle 35% of municipal waste
- Rationalise municipal waste landfills to a network of 20 state-of-the art sites
- Reduce methane emissions from landfill sites by 80%

There has been considerable change in waste management policy in Ireland over the past two decades. The EPA (2010) recognised that in the year 2000, Ireland landfilled approximately 90% of municipal waste arising. Whilst this has reduced to 62.5% in 2008, it is well above the European average of 42% in 2007 (EEA, 2009). Ireland remains predominantly reliant on landfill in managing waste. The 2004 strategy from

Under the EU waste directive requirements, this needs to be reduced to 0.916 million tonnes in 2010, 0.610 million tonnes in 2013 and 0.427 million tonnes in 2016 (See Figure 1.1) or Ireland will suffer heavy fines imposed by the EU.

Unfortunately Figure 1.1 highlights that Ireland remains predominantly reliant on landfill in managing waste. A greater effort needs to be placed on diverting the bio-degradable waste stream away from landfill. Chambers (2009) carried out a study at GMIT on the design and development of heat extraction technologies for the utilisation of compost thermal energy. Chambers used compost Heat Extraction Unit (HEU) to utilise waste heat from decaying matter. Chambers concluded that the HEU developed could be a useful renewable energy technology particularly for small-scale rural dwellers and growers with access to significant quantities of organic waste.

Table 2.1 Ireland's Municipal Waste Generation rates between 2002 to 2007 (EPA, 2007)

Waste Source (Tonnes)	2002	2003	2004	2005	2006	2007
Household	1,679,068	1,704,844	1,728,154	1,746,408	1,978,716	1,761,167
Commercial	975,744	1,141,264	1,202,824	1,235,629	1,327,068	1,549,075
Street cleaning	65,573	71,779	69,661	58,677	78,822	87,441
Total Municipal	2,720,385	2,917,887	3,000,639	3,040,714	3,384,606	3,397,683
% Change on previous yr		7.3	2.8	1.3	11.3	0.4

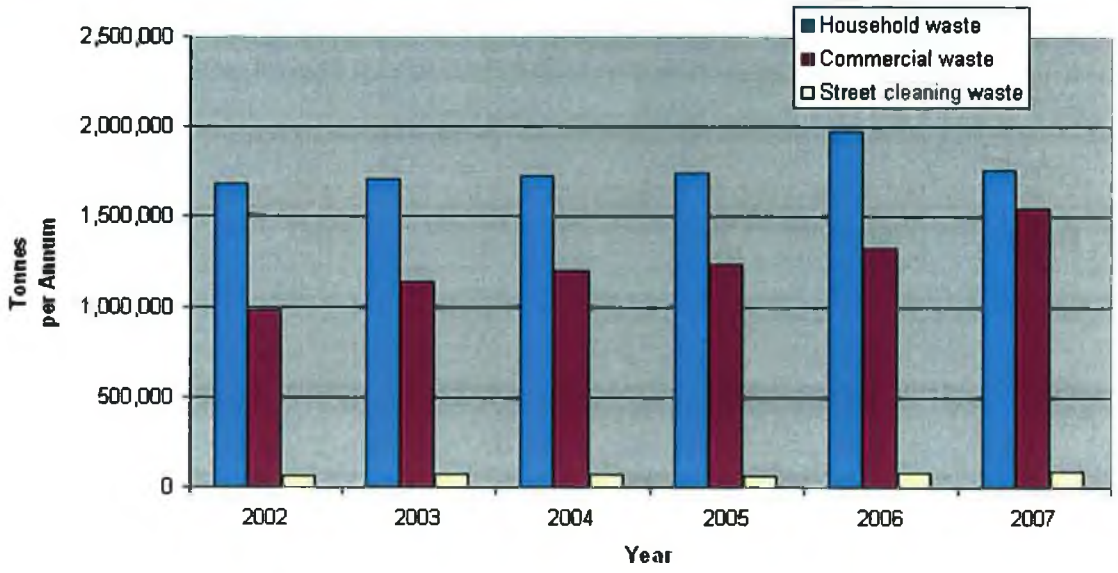

Figure 2.3 Trends in Ireland's municipal waste generation, 2002 to 2007 (EPA, 2007)

The EPA (2007) states that the reported quantity of household waste managed by the waste industry decreased in 2007 by 8% to 1,625,490 tonnes. The quantity of household waste recovered increased by 7.7% to 424,510 tonnes as indicated in Figure 2.4. The recovery rate was 26% in 2007, compared to 22% in 2006. The

from 57.3% in 2006 to 63.6% in 2007. These trends are tabulated by waste category or material in Table 2.3.

Table 2.3: Packaging waste generation, disposal and recovery 2007 (EPA, 2007)

Material	Gross Quantity Available (tonnes)	Quantity Landfilled (tonnes)	National Landfill Rate (%)	Quantity Recovered (tonnes)	National Recovery rate (%)
Wood	107,380	1,246	1.2	106,134	99
Paper & Cardboard	408,871	94,221	23	314,650	77
Ferrous	68,860	16,148	23.5	52,712	77
Glass	177,475	43,396	24.5	134,079	76
Aluminium	13,682	10,012	73.2	3,671	27
Plastic	237,685	184,900	77.8	52,784	22
Other Metals	831	831	100	0	0
Textiles	1,907	1,907	100	0	0
Other	39,260	31,659	80.6	7,601	19
Total	1,055,952	384,332	36.4	671,630	64

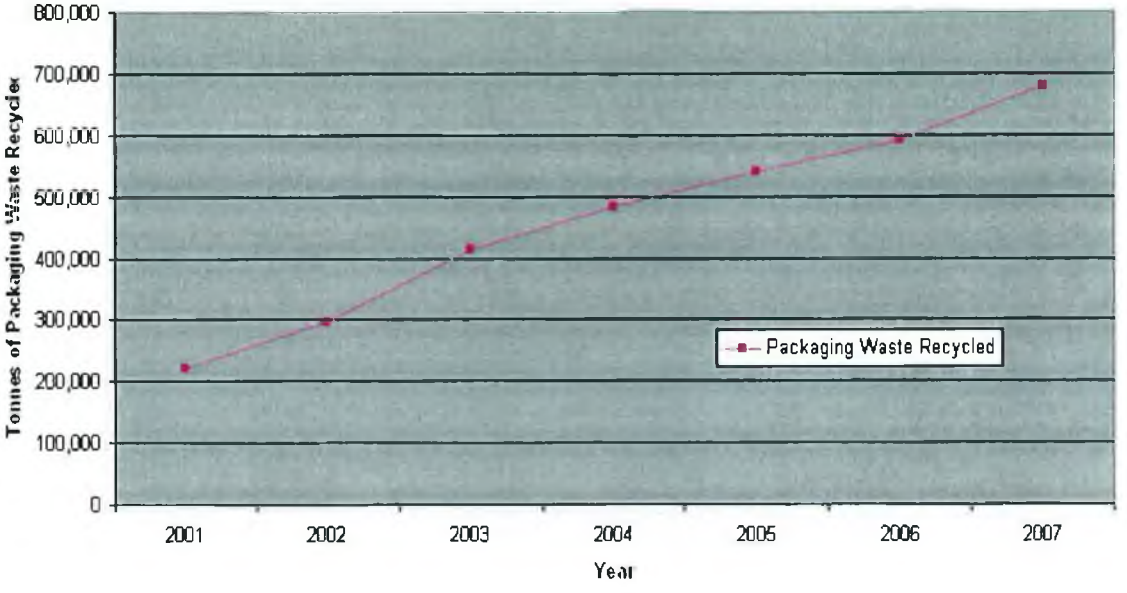

Figure 2.5: Growth in packaging waste recycling, 2001-2007 (EPA, 2007)

The overall waste generation in Ireland increased slightly in 2007 and this is best demonstrated by the slight increase of municipal waste (1.7%) and biodegradable municipal waste (4%) disposed to landfill. This illustrates where the implementation of waste policy should be prioritised, for example, waste prevention (to reduce overall generation) and diversion from landfill is the priority.

WEEE and unclassified incombustibles, made up 15.1 %, while fines (material <20mm), glass, metal and wood were all minor constituents.

The EPA (2007) also presented data on mixed dry recyclable household waste (green bin). The results shown paper and cardboard, at 69%, were the dominant constituents of mixed dry recyclable household waste in 2008. Plastics made up of mostly packaging, were the second largest component at 15.4%.

2.5.2 Connacht Waste Management Plan

The Connacht Waste Management Plan (CWMP) (2001) was prepared at a time when the concept of waste prevention was just emerging in the local authorities. Most local authorities at the time had little experience of waste prevention. Similarly, there were neither clear definitions of prevention, nor any coherent guidelines for waste prevention initiates provided by the local authorities. The Plan outlined a number of potentially effective measures for prevention/minimisation for the Connacht Region. Positive progress has been made since the adoption of the Plan in (2001).

2.5.3 Waste Quantities within Connacht's Household Sector

The quantity of household waste generated in Connacht during 2004 was estimated at 174,951 tonnes and Table 2.5 provides a breakdown per local authority area. The figures quoted by the local authorities are estimates as the uncollected waste quantity is generated by "average weight of waste collected per household served" multiplied by the number of households not served by a collection service.

Table 2.5 presents data on mixed household waste collected, segregated household waste collected, household waste delivered to recycling centers/landfills, household waste estimated to be uncollected and organic household waste estimated to be home composted.

By comparison, the total household waste arising in 1998 was estimated at 149,116 tonnes. The increase is due to the combined factors of population growth and increased waste production rates per person. In 2004, approximately 63% of households in the region were provided with a waste collection service (RPS, 2007).

Table 2.6: Household Waste Composition, Mayo Co. Co. Rural and Urban 2004 and Galway Co. Co. 2001 (RPS, 2007)

Primary Waste Category	2004 Mayo County Council Urban Household Waste Composition	2004 Mayo County Council Rural Household Waste Composition	2001 Galway County Council Urban Household Waste Composition
Organic Waste	8.3%	9.1%	27%
Papers	15.3%	18.0%	17%
Cardboards	1.9%	2.6%	6%
Composites	3.7%	6.8%	1%
Textiles	2.4%	7.0%	9%
Plastics	12.6%	17.8%	13%
Glass	4.4%	2.3%	4%
Metals	2.7%	5.7%	6%
Wood	-	-	-
Special Municipal Waste	0.4%	2.3%	1%
Unclassified Combustibles	19.9%	11.9%	-
Unclassified Incombustibles	12.6%	10.6%	-
Fines	15.8%	5.73%	-
Other	-	-	17%

A further study was conducted by GCityC in 2004 after the implementation of the 3-bin waste segregation system was in place in Galway City. The household recycling rate in Galway City in 2004 was calculated at 51% including for dry recyclables and organic waste collection and bring banks. Table 2.7 shows the results of the survey. Because of the high level of household segregation, there is a significant decrease in the percentage of organic waste going to landfill and the majority of waste going to landfill in the 2004 survey was found to be fines, organics and textile waste (RPS, 2007).

million tonnes of BMW was landfilled in 2008. Under the EU waste directive requirements Ireland needs to reduce the quantity of waste being landfilled by 35% between 2008 to 2016 or Ireland will suffer heavy fines imposed by the EU.

In order to do so, local authorities and private waste contractors must look to reduce BMW at source. To do so they must have a thorough understanding of the waste composition and volumes generated by domestic households. Sometimes known as pre-treatment, treatment includes but is not limited to the following processes:

- Source separation (such as home composting)
- Separate collections (as implemented by the 2 or 3 bin systems)
- Manual Sorting (home segregation and commercial segregation)
- Composting (building large scale composting plants)
- Energy recovery (composting plants with energy recovery)
- Thermal treatment (combined heat and power plants that can be fed by bio-fuels and bio-degradable wastes)
- Aerobic/anaerobic digestion

It is apparent from the research conducted to date that the current audit methodology used by the local authority is based on local authority staff conducting a waste audit and then logging the results using paper audit sheets. The staff subsequently analyse the collected data and input it into Microsoft packages to provide a report that is supported by graphs. The process is labour intensive, expensive to conduct and generates an inefficient paper trial.

In order to develop a more efficient process for waste auditing the local authority have outlined the need for an audit methodology that is repeatable. To conduct a waste audit it is important to have a set format so that the results are measurable and accurate. This enables a comparison to be made with previous or future studies. It is therefore apparent that there must be a logical sequence to the audit from survey planning, survey execution through to data collation.

A new waste audit methodology is required that will be supported by an electronic waste audit tool that will lend itself to the need outlined by GCC, hence the need for this W-MAT project to determine domestic waste streams at source. To facilitate the design of a new methodology and audit tool a logical engineering design approach will be used to plan the design through from the analysis of the problem statement right through to the finalisation of the finished W-MAT audit methodology. The

3.0 Waste Audit Methodologies

3.1 Introduction

This Chapter describes eight waste audit methodologies employed within Ireland, Europe and beyond. These offer insights into different approaches and outcomes and each methodology is accessed against seven evaluation criteria considered central to this W-MAT project. Some of the characteristics of the highest ranked methodologies are included within the W-MAT methodology.

Gorecki (2010) recognised that in the 1990's the waste management system was relatively straightforward compared to subsequent developments. In the 1990's all waste was placed in a single container, such as a bin, a bag for kerbside collection and then deposited in landfill. In 1995, for example, 95.7% of all Irish household waste was sent to landfill (DoEHLG, 1998).

This W-MAT study has been conducted in conjunction with GCC to design a methodology that can be used as the sequential approach to conducting household waste surveys, to assess waste production rates and the waste stream generated. GCC outlined that the audit tool developed must be easy to use, must store and retrieve data, produce waste output figures and be able generate audit results and charts, whilst been administratively efficient and cost effective. Before designing the W-MAT audit methodology, eight waste methodologies listed in Table 3.1 representing National and International best practice were reviewed

Table 3.1: Various Waste Audit Methodologies

Chapter Section	Name	Date
3.1.1	Municipal Waste Characterisation Methodology	1995
3.1.2	Programme for Municipal Waste Characterisation Surveys	2004
3.1.3	Municipal Waste Characterisation Surveys (MWCS)	2008
3.2.2	AWAST Methodology	2000
3.2.3	Analysis of Solid Waste Methodology (SWA)	2004
3.2.4	Database for the Evaluation of Waste Analyses (DEWA)	2005
3.2.5	Life Cycle Assessment tools for Integrated Waste Management (LCA-IWM)	2005
3.2.6	Zero Waste (ZW) Audit Methodology	2001

The EPA (2004) state that while the EPA Waste Characterisation Manual (1996) had proven useful in determining waste composition in a particular local authority area, it did not fully address the need to generate a national waste profile. Waste collection systems have also evolved significantly in the last decade increasing the workload needed to generate comprehensive results as indicated in Figure 3.1.

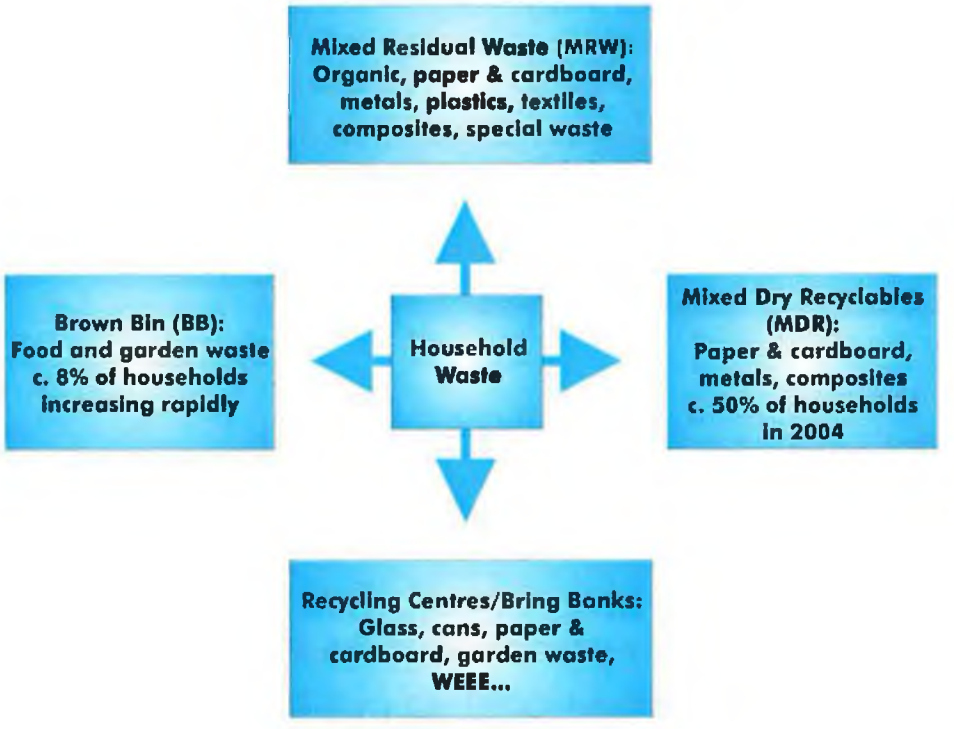

Figure 3.1: Pathways for Household Waste Collection (EPA, 2008)

The DoEHLG (2004) requested that Local Authorities implement use-related charging for household waste by January, 2005. The impacts of use-related charging for household waste were:

1. To provide an incentive for the reduction of waste, by changing shopping and lifestyle habits. The focus then changes to recycle as much waste as possible to lower the cost on the household.
2. Some negative side effects may occur; householders may be tempted to reduce waste bills by inappropriate use of recycling bins, or illegal dumping or burning of waste.
3. It also affects how often a bin is put out for collection, making it difficult to collect a sample of waste from a predetermined number of households on any one week.

For the MWCS survey RPS Group Ltd. a Consultant Engineering Company together with the CTCC were commissioned by the EPA in February 2008 to carry out a national survey of municipal waste, for both household and non-household waste. The following waste streams were targeted:

- Mixed residual waste
- Mixed dry recyclables
- Mixed organic waste.

With respect to non-household waste, it should be noted that the three categories mentioned do not necessarily apply to the households, as there are very few collection systems with 3 separate bins. However, because the methodology employed endeavoured to remove organic waste at source, and because all samples were fully analysed the results can be successfully aggregated with the household waste data. A full analysis is much more accurate than a sample taken by a Coning and Quartering technique. This technique involves the sample being thoroughly mixed, and then placed in a uniform pile of approximately 0.8 m high. The pile is divided into four quarters using straight lines perpendicular to each other. Either pair of opposite corners is removed to leave half the original sample. The process is repeated until the desired reduced sample size is obtained.

The Audit survey phase was sub divided into 3 steps, namely:

- Sample collection
- Reducing and mixing
- Sorting

The data analysis phase was sub divided into two stages, as follows:

- Analysis of results
- Data scale up

In total, 39 household waste samples were analysed; 36 of these were obtained from kerbside collections and 3 were obtained from Civic Amenity sites. The sampling was carried out over two campaigns; the first was undertaken from April to July 2008 and the second from August to November 2008. The results of the survey are shown in Figure 3.2 and comparisons between the MWCS (2008) survey are analysed in greater detail in Chapter 5. During the test phase 28 households participated in the testing of

that, during their annual review of local authority questionnaires returned, there was significant variability discovered in the local authority audit systems used across the local authorities and not all local authorities verify the data submitted by the Waste Permit (WP) holders. The EPA (2010) also report that the annual waste data required to compile the NWR's is gathered from local authorities, landfill operators, and recovery organisations every year (and industry every second year). The audits also uncovered some issues with regard to the classification of certain types of waste; for example, large quantities of industrial process waste were incorrectly listed as MW. For Construction and Demolition (C&D) waste, in some cases the EWC code and the waste descriptions did not match in the Waste Collection Permit (WCP) and WP AER's, and this error followed through to the subsequent master spreadsheets and the reported results.

3.2 International Waste Audit Methodologies

This section describes five International waste audit methodologies which were formulated in response to the European Directives that have being introduced since 1975. These Directives also apply to Ireland, namely:

- Directive 75/442/EEC (1975) established the fundamental principles for waste management in Europe. It introduces the waste hierarchy as shown in Figure 2.2. The aim is to move up the waste hierarchy by significantly reducing reliance on landfill to increased recycling, reuse, composting and recovery and ultimately waste reduction.
- Directive 91/156/EEC (1991) amended 75/442/EEC
- Directive on packaging and packaging waste [Directive 94/62/EC (1994)]
- Directive on the landfill of waste [Directive 1999/31/EC (1999)]
- Directive on the incineration of waste [Directive 2000/76/EC (2000)]

The amended Directive on Waste (DoW) [Directive 91/156/EEC (1991)] is based on the consideration of the following:

- Protection of human health and the environment against harmful effects caused by the collection, transport, treatment, storage and tipping of waste.
- Encouragement of the material recovery of waste and of the use of recovered materials in order to conserve natural resources.
- In order to achieve a high level of environmental protection, the Member States must, in addition to taking action to ensure the responsible removal and recovery

4. Process analysis as background
5. Application of the experience of Central and Western EU countries
6. Consideration of energetic and economic aspects within the whole waste management system.

Fehringer *et al.*, (2000) states that the MFA method used enables the description of systems of any complexity grade. It allows for depicting not only operational processes, cities, regions, nations but also entities such as the EU. The advantage of the MFA is the possibility for reducing complex systems to the key goods and processes relevant for the MFA study. MFA is a scientific method considering counting, describing and interpreting the metabolism processes within a complex system. By means of the MFA (the balances of goods and indicator substances) the fulfilment of the DoW objectives can be quantified, as shown in Table 3.2.

Table 3.2 Objectives of European Waste Management and Assessment Method

(MFA Manual, 2000)

Objectives of the Directive on Waste (DoW)	Assessment through MFA
1. Reduction of waste	Balances of goods
2. Reduction of harmfulness of waste	Balances of substances
3. Conservation of natural resources	Balances of raw materials
4. Recovery of waste	Balances of raw materials
5. Protection of human health and environment	Balances of substances
6. Disposal network	Balances of goods (waste)

The DoW goals are mass-related (waste reduction), substance-related (e.g. protection of humans and environment, resource-saving management) and disposal-related (disposal network). In order to implement goals 2, 3 and 5 in Table 3.2 the waste management is to be accorded to a material focus. Resource conservation implies the optimal utilisation of substances and energy. The substance composition of a waste category determines for example the type of the landfill it could be disposed on, or if it is worth joining a recovery process. This means that it is mainly the waste substances that decide on the waste assignation to a disposal or a recovery strategy for example, the substances determine the further destiny of the waste material. Thus, substance aspects should be considered in order to meet the DoW goals. The MFA is a method that could significantly support this process.

An essential component of a waste analysis involves waste characterisation or the determination of waste composition. There are four recommended stages to waste characterisation as follows:

- Pre-Investigation
- Analysis Design and Planning
- Execution of Waste Analysis
- Evaluation of Waste Analysis

A large number of factors may influence the composition or the amount of waste to be analysed, and these may in turn vary in effect between municipalities. Examples include:

- Residential structure
- Heating systems
- Seasonal variations
- Bin size
- Availability of civic amenity sites
- Holiday periods
- Type of collection system (separate collection)
- Levels of public education and awareness on waste issues

An important aspect of the SWA-Tool methodology is to provide users with sufficient information to enable them to determine which, if any, stratification criteria should be incorporated in their waste analysis design. This depends on the purpose of the waste analysis and the waste management conditions within the area of investigation. The stratification criteria adopted by the SWA methodology is shown in Table 3.3.

As citied in the EPA (2008) municipal waste characterisation survey, account of the EC SWA tool was taken during its development. Various similarities can be seen throughout both methodologies, in the design, collection and reporting of data in particular. These aspects also influenced the design of W-MAT as highlighted in section 4.2.3 and 4.2.6.

3.2.3 Database for the Evaluation of Waste Analysis (DEWA)

The EC (2005) developed DEWA, a Methodological Tool to enhance the Precision and Comparability of Solid Waste Analysis Data. The DEWA database system was set up to enhance the precision and comparability of solid waste analysis data.

The database system, DEWA, provides practical support for the evaluation of waste analysis, according to the proposed methodology of the SWA Tool for carrying out waste analysis. A prerequisite for the use of DEWA is that the waste analysis to be evaluated is conducted in compliance with the SWA Tool methodology. This means in particular, that the waste sample has to consist of a set of randomly selected sampling units of similar size and that sorting results are available for each sampling unit.

The data entry into DEWA follows a strict hierarchy, consisting of the following:

- Investigation (definition)
- Campaigns of the investigation
- Strata within the campaign
- Sampling units within strata
- Sorting data for each sampling unit

3.2.4 Life Cycle Assessment Tools for Integrated Waste Management (LCA-IWM)

The Life cycle assessment tools for the development of integrated waste management (LCA-IWM) strategies for cities and regions with rapid growing economies were developed in 2005. The objectives of the LCA-IWM (2005) project were to develop tools to support the planning of new and optimisation of existing waste management systems in European cities.

What to Sample?

In most cases it is too hard to audit everything that a household produces, so a sample of the waste must be taken. The sample taken needs to be representative of the total waste generated in the home.

Which bins to look at?

Some households may have more than one stream of waste (e.g. they might have hedge/timber off cuts, lawn trimmings etc.) that are collected or thrown out separately from other waste. It may be prudent to look only at the biggest stream or maybe the one that is most expensive for the household to dispose of, or where there is the biggest potential for them to reduce or recycle.

Seasonality?

Sometimes there are more or different types of waste produced at different times of the year. For example houses with gardens generate grass clippings, hedge trimmings etc. in the spring and summer time. Ideally two audits should be conducted, one in summer and one in winter time to account for seasonality.

When to do the audit?

When a household is audited, can have a big influence on the results obtained. It is best to audit during a normal audit period, where there are no exceptional events that may increase the waste output for that duration.

How many days to sample for?

The more samples that are taken the better, because it is less likely that the results may be affected by unusual variations. It is good to sample at least three days worth of waste, but ideally a waste audit should be conducted over a one week period at minimum.

How much waste to sample?

Depending on how much is generated, one can either sample everything that happens in one day or one can just sample a small proportion. Obviously the more waste there is the smaller the proportion of it the auditor will be able to analyse. The main thing is that the sample taken is as random and reflective of the waste output as possible.

relationship yields a linear rating scale and more evenly rated scoring. In the design matrix adopted, six of the reviewed audit methods are accessed against design criteria. The "L" shaped design matrix is shown in Table 3.5, adopting Yassine's score rating of 1 to 3, is used.

Symbol	Relationship	Score
◎	Strong	3
○	Medium	2
△	Weak	1

Figure 3.3: Symbol, relationship values (Syque Quality, 2010)

The NZWM (2001) scored highest when measured against the objectives of the audit tool, followed closely by the Irish Waste Characterisation (2008) study and the European SWA (2004) methodology, which share the same score. The W-MAT audit methodology was designed based on a combination of the NZWM and the MSWC survey 2008, which incorporates the European SWA (2004) methodology. Quintanar (2010) recommends that a matrix diagram is a good tool to use to compare the efficiency and effectiveness of alternative approaches/tools based on the relationship between two criteria. It uses criteria and symbols to visually depict the relationship between, for instance, cost and performance. Matrix diagrams can be used with up to four dimensions. There are several styles of matrix diagrams. The most common styles are the L, T and the Y-shape. As can be seen in Table 3.5 below the audit methodologies are listed on the left hand side and the objectives as set out by the local authority are listed across the top of the table.

Table 3.5: Design Matrix of Audit Methodologies v's Objectives

	DESIGN CRITERIA							
AUDIT METHODOLOGIES	Well Structured Audit Methodology	Electronic (require little or no training & easy access over internet)	Easy Use (require little or no training for the householder)	Electronically Store Data	Automatically Generate Graphs (Results that are easy understand)	Produce Quantitive Results	Low Admin Cost (for the local authority)	Totals
MWCS (2008)	◎	△	◎	△	△	◎	◎	15
AWAST	△	△	△	◎	○	○	△	11
SWA	◎	△	◎	△	△	◎	◎	15
DEWA	△	△	△	◎	○	○	△	11
LCA-IWM	△	△	△	△	△	△	△	7
NZWM	◎	△	◎	○	△	◎	◎	16
Totals	12	6	12	11	8	14	13	

The European DoW is the main driving force restricting the production of waste in member states, in particular by promoting clean technologies under the vision of a sustainable environment. To assist the member states to move towards a more sustainable environment the EC have developed a number of methodologies, namely:

- AWAST
- SWA
- DEWA
- LCA-IWM

It is clear from the analysis of the waste methodologies conducted that they do not lend themselves to the need outlined by GCC, hence the need for this W-MAT project to determine domestic waste streams at source. It is for that reason that a new methodology is required. The new design benefits from selecting attributes from a number of design models to create a tailored methodology that is specific to this study. The use of design science also lends itself to aid in the mapping or planning of how the design is taken from the problem statement right through to the finalisation of the finished W-MAT audit methodology. The newly designed methodology sets a definite sequence for the audit events so that subsequent audit studies can be analysed against previous ones. This facilitates the formation of household benchmarks over time.

et al. (2001). These greatly influenced the W-MAT design process and are reviewed in the following sections.

4.1.1 Voland Model

In 1999, Voland presented the design process template shown in Figure 4.1 to describe a five step iterative design process.

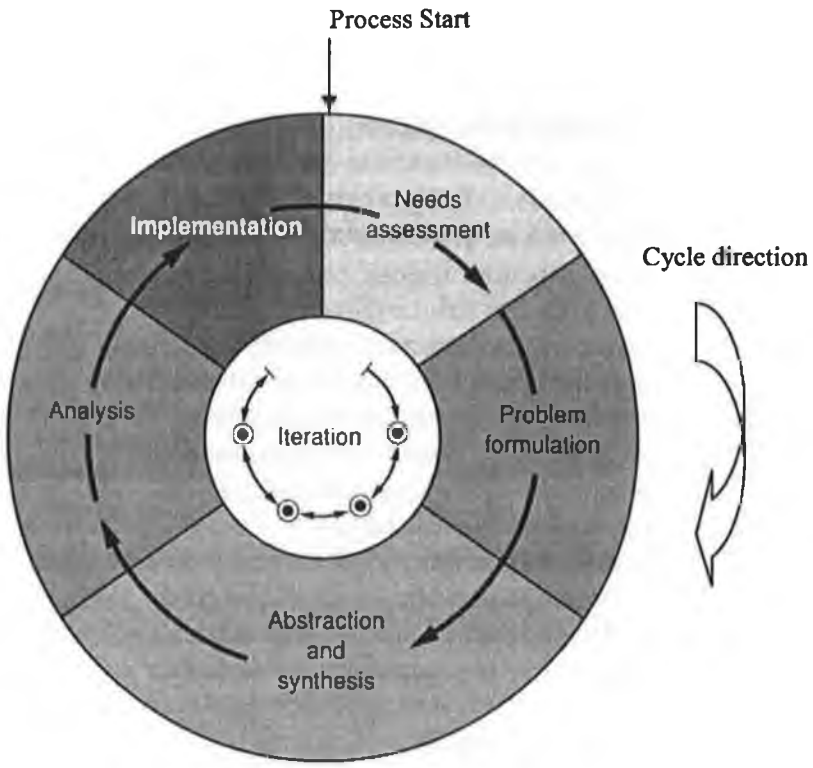

Figure 4.1: The engineering design process proposed by Voland (Voland, 1999)

It consists of the following five inter-related aspects:

1.	Needs assessment:	Identify the need for a solution
2.	Problem formulation:	Define problem in terms of design goals
3.	Abstract and synthesis:	Generate detailed designs
4.	Analysis:	Compare and evaluate alternative designs
5.	Implementation:	Develop and distribute final solution.

The Voland model identifies a needs assessment as the start point for any design project. A needs assessment is a valuable attribute to ensure that the project solution matches the need as identified prior to the commencement of the study. A needs analysis as recommended by Voland was therefore incorporated into the W-MAT design process.

manufacturing engineering. The other "technique" section is similar to the Voland model. However, the Pugh and Voland models appear more suited to Information Systems (IS) or the software design application.

4.1.3 Dym and Little Model

The Dym and Little design model shown in Figure 4.3 identifies 10 design steps between the Client Statement (The Need) and the Final Design (The Goal Achievement). This design model has a structured approach but lacks a feedback loop between steps 1-4 and 5-9. Without a feedback loop between the design process and the client statement or problem definition, it is probable that the end product may not fit the design specification due likely to subtle changes being made during the process.

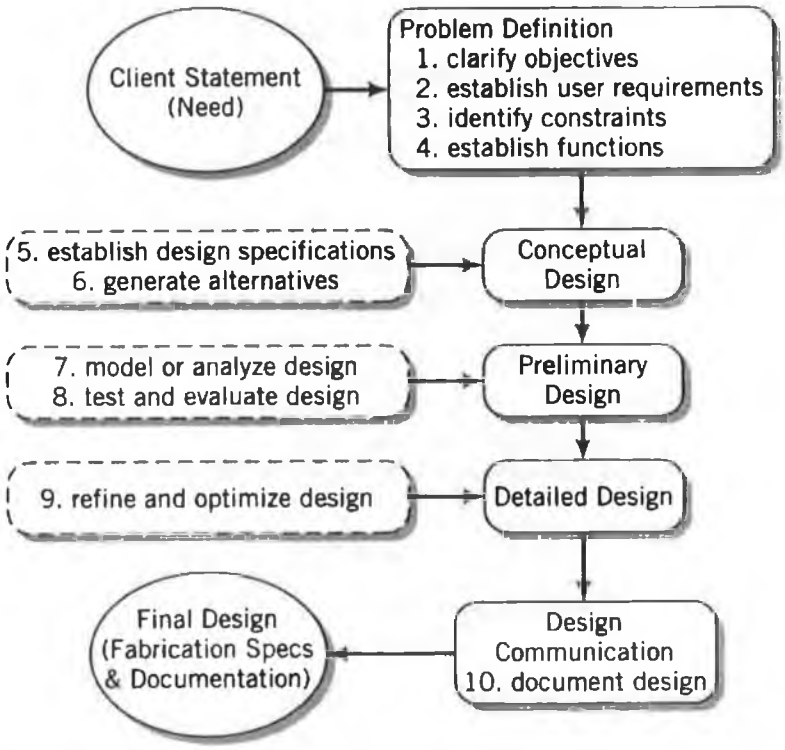

Figure 4.3: Dym and Little engineering design process (Dym and Little, 2000)

The Dym and Little model identifies a very logical sequence to the design process. Elements of this model are suited to the W-MAT project and were incorporated into the design model.

4.1.4 Dominick et al. Model

The Dominick *et al.* (2001) model presented in Figure 4.4 outlines the iterative phases of the design process in four distinct phases namely:

This model employs feedback loops between the various phases so that a product redesign can take place if a weakness is determined during the design review phase. This feedback is critical to the design process so that the finished product matches the need outlined in section 1.2 and 4.2.1. The design model adopted for this W-MAT study incorporated feedback as proposed by Dominick *et al.* (2001).

4.2 Adopted Design Model

After studying the design models presented in Section 4.1 it is apparent that there are a number of similarities such as the needs statement and a customised version of the cited models was employed as presented in Figure 4.5.

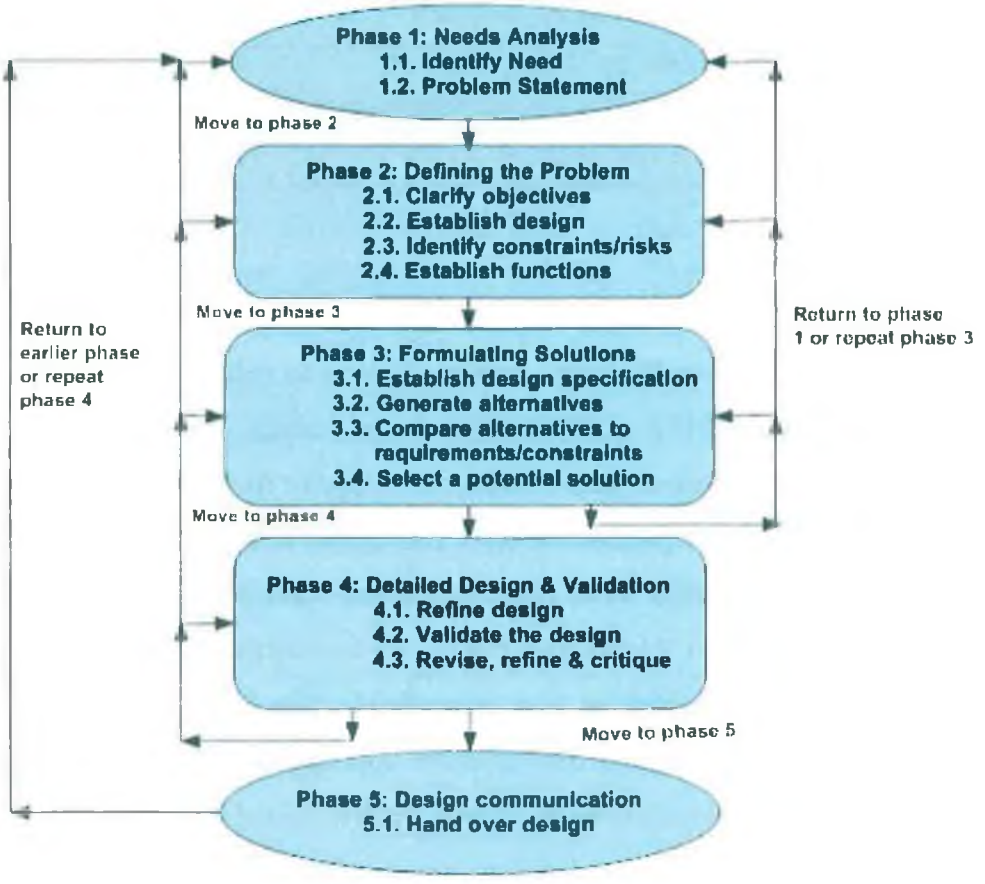

Figure 4.5: The W-MAT design model

The W-MAT model has a logical design sequence and employs process feedback during the cycle. The feedback loops allow successive phases to be linked and help stakeholder feedback to be incorporated into the W-MAT tool. The W-MAT model has five phases and fourteen distinct steps as listed in Table 4.1.

4.2.2 Outline the Problem Statement

The problem statement was previously outlined in Section 1.2. To recap the existing household audit methodology adopted by GCC involves:

- The physical examination of household waste by local authority auditors.
- The recording of audit data on hardcopy audit sheets.
- Translating the results into Microsoft Word.
- Inputting separate duplicate information into Microsoft Excel to compile result charts.

This approach to waste auditing is labour intensive, costly to facilitate, has an ineffective paper trail and has a limited sample size. A further drawback to this approach is that data collection, collation and analysis is slow, the process is difficult to repeat and is error prone. It is for these reasons that a new audit methodology is adopted using electronic based software to conduct the audit. The design specification for the audit tool is outlined in section 1.2. They stipulated that the W-MAT tool should be:

- Well structured (laid out in a logical sequence that facilitates audit repeatability).
- Electronic, capable of storage and retrieval of audit data to reduce the paper trail.
- User friendly to the householder (set at the appropriate literacy level and requires minimal set up- time and training).
- Electronically store data (facilitate the easy storage and retrieval of audit results).
- Capable of self-generating audit results in template format, supported by graphs thus reducing the need for inputting duplicate data into two separate systems.
- Capable of resolving household waste trends by European Waste Codes (EWC codes) and household type and producing quantitive results.
- Of low administration cost to the local Authority.
- Accessible to a wide cohort of householders (compatible with web based applications).
- Validated in the field (design testing, protocol testing and field trials using a household field trial).

limitations that affected the design of the audit tool from a designer's perspective was as follows:

- The designer must have knowledge of Microsoft Excel and Visual Basic.
- It must be designed with low cost to GCC.
- The audit tool must be presented in a format that is easy to use and understand.
- It must be suitable for future on-line deployment.
- The householders must have internet access to enable an upload of data.
- Inherent risks of on-line deployment, such as poor uptake or insufficient or inaccurate returned data.
- Must be compatible with palm held computer software.
- Must be available to a wide cohort of householders (compatible with web based applications).

There are a number of risks associated with the householder analysing the waste and logging the data:

- Data quality.
- Poor uptake rates.
- Computer literacy.

The households that participated in the Field Trials received instructions (See Appendix E) it details how to complete the waste audit. They are designed to guide the householders to audit and log relevant waste data. In order to improve the uptake it was considered that some incentive be offered by the local authority to promote the initiative to the public and to encourage their participation. By offering an incentive such as providing a free week's waste collection for the upload of a complete waste survey should increase public participation. It is envisaged that the local authority in the future will launch the W-MAT audit tool on line. Households who have a computer and have internet access will be able to upload the results online. By having the audit tool available online and by offering an incentive to users has the potential to generate/collect a vast amount of waste data.

4.2.6 Establish Functions

The W-MAT audit tool must meet the requirements of GCC and the CTCC or the design would be considered unsuitable. In order for the design to succeed it is important that the functions outlined are achieved and are tailored by the initial design

discover an effective solution to a problem. Problem solving can be viewed as utilising available means to reach desired ends while satisfying laws existing in the environment (Simon, 1996). Abstraction and representation of appropriate means, ends, and laws are crucial components of design science research. These factors are problem and environment dependent and invariably involve creativity and innovation. "Means" are the set of actions and resources available to construct a solution. "Ends" represent goals and constraints on the solution. "Laws" are uncontrollable forces in the environment. Effective design requires knowledge of both the application domain such as requirements and constraints and the solution domain, for example technical and organisational (Hevner *et al.*, 2004).

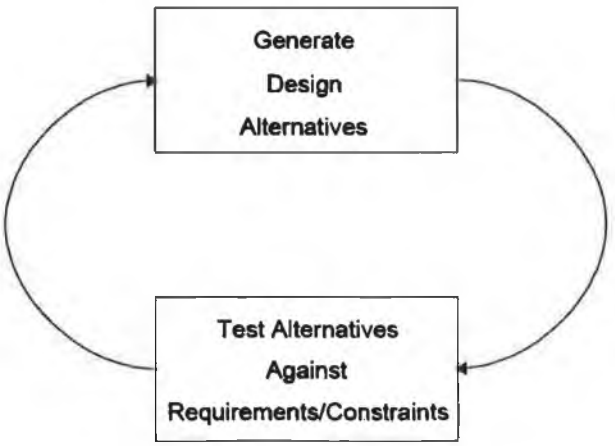

Figure 4.6: The Generate/Test Cycle (Hevner *et al.*, 2004)

As part of the W-MAT design process four iterations of the design cycle were presented to GCC as shown in Figure 4.7. A design review meeting was carried out with all three stakeholders (GCC, GMIT and CTCC) to analyse each draft.

The first three drafts tried to accommodate waste generation and energy usage within the domestic setting. However, design review meeting three considered that the inclusion of the former two streams (energy and water) gave rise to an over complex audit tool, that would be too difficult for a householder to complete, without close support or guidance. It was therefore decided to focus on just the domestic waste stream for the fourth draft and Field Trial I and II.

recommendations. Based on the feedback, the first draft of the W-MAT was re-designed to accommodate:

- The ease of use of the W-MAT audit tool was overly complicated by the number of spreadsheet tabs used to collect the audit data.
- The four separate waste audit tables on the Household waste spreadsheet over complicated the spreadsheet for the householder.
- The graphics used to analyse data was poor due to the audit tool not being complete.
- The summary report was not interactive with the questions answered in the questionnaire (Interactive is when the recommendation changes and is specific to the question answered).

4.3.1 Design Draft II

Due to the shortcomings identified in the first W-MAT design draft, a second draft was later reviewed by all stakeholders (Appendix H). Again, a design meeting of the stakeholders provided feedback as follows:

- The ease of use of the designed audit tool draft was increased by reducing the number of tables on the Household Waste spreadsheet.
- The waste audit template on the household waste sheet was modified to include the capability of storing and retrieving data from 4 separate audits. This is achieved by using Visual Basic (VB) programming code. The user may select audit number 1, then enter the field data, then select "Store" to save to store that audit. By selecting audit number 2 the user can save second and subsequent audits in a similar manner. To activate a stored audit the user selected the audit number from the drop down menu and presses "Retrieve". However, it was decided that the waste audit template was too detailed, and would require user training to aid navigation about the tool.
- The metric output for waste was based on selecting the waste output from a drop down menu provided and the weight of the waste was input as a result. The waste figure was therefore compromised as a result. The household energy demand was provided for by inputting the ESB bill information. The water was audited using a delivered water table that measured the water usage in (m^3). A

input data is analysed and "very poor" is the outcome an unhappy face appears, or when an "excellent" result is achieved a happy face appears. The macro is written in logic form as shown in Appendix D.

As can be seen by the macro described in Appendix D, the use of the statements and logic functions can create useful macrocode.

Design Review Meeting III Recommendations

- The waste dimension/output was based on selecting the waste output from a drop down menu provided and the weight of the waste was inputted as a result. It was decided by the design team that the weight selecting option from the drop down menu should be used.
- The recommendations are automatically provided in response to answers inputted during the audit.
- It was agreed at the meeting that a Field Trial would be conducted to evaluate the function ability of the W-MAT tool.

4.3.3 Selecting a Potential Solution

Field Trial I was run as discussed in section 4.3 in a real life application consisting of 10 households to validate the W-MAT audit tool. The results achieved are discussed in the next section.

4.4 Field Trial I

As part of the Validation process 10 householders in the East Galway region agreed to complete the W-MAT Field Trial I. The aim of the Field Trial was to assess domestic waste production, energy and water usage using the W-MAT audit tool by soliciting user feedback to obtain sample data. The W-MAT tool was configured to generate a report for the participant household on how best they could reduce the amount of waste going to landfill and to reduce energy and water consumption.

Each householder was visited to introduce W-MAT and to explain the Field Trial. The householders were also asked to complete a simple feedback questionnaire at the end of the audit. The questionnaire contained ten questions to obtain direct feedback on the design and usability of the audit tool. A sample of the questions asked is listed below:

4.4.2 Field Trial I Results Analysis

The result sheet for each household is shown in Appendix F-1 to F-10. The result table in Appendix F-11 highlights that the table is predominantly shaded green in colour indicating excellent results, particularly for the household waste section, where almost all houses scored an excellent result.

4.4.3 Field Trial I User Feedback

To obtain feedback on the operation and ease of use of the audit tool, each householder was asked to complete a simple questionnaire. The completed audit questionnaires are shown in (Appendix G-1 to G-10).

The results obtained from the feedback identify that 10% of householders found that the format of the audit tool was too detailed. The person who had difficulty did state that their involvement had increased their knowledge particularly in energy conservation and waste management.

As a result of the W-MAT Field Trial I it was decided by a review group at a fourth design review meeting, that the following changes be made:

- It was agreed that the audit tool incorporated a section on waste analysis, energy and water conservation and that the participants found it was too onerous.
- It was agreed that if the audit tool was too long or difficult to complete that it would have a negative effect on the image of the local authority or on the amount of feedback that they would receive should they launch it on the web.
- GCC therefore prioritised their main area of concern, waste analysis, and the collection of accurate waste generation figures, with a view towards waste minimisation or increased recovery.
- It was decided that the audit tool should be redesigned to focus on waste generation alone, and that the inputted waste data should be directly input (by user) not a generalisation as provided previously from the drop down menus on the waste audit sheet.
- It was also agreed that a subsequent field trial, Field Trial II would be required to test the new design.

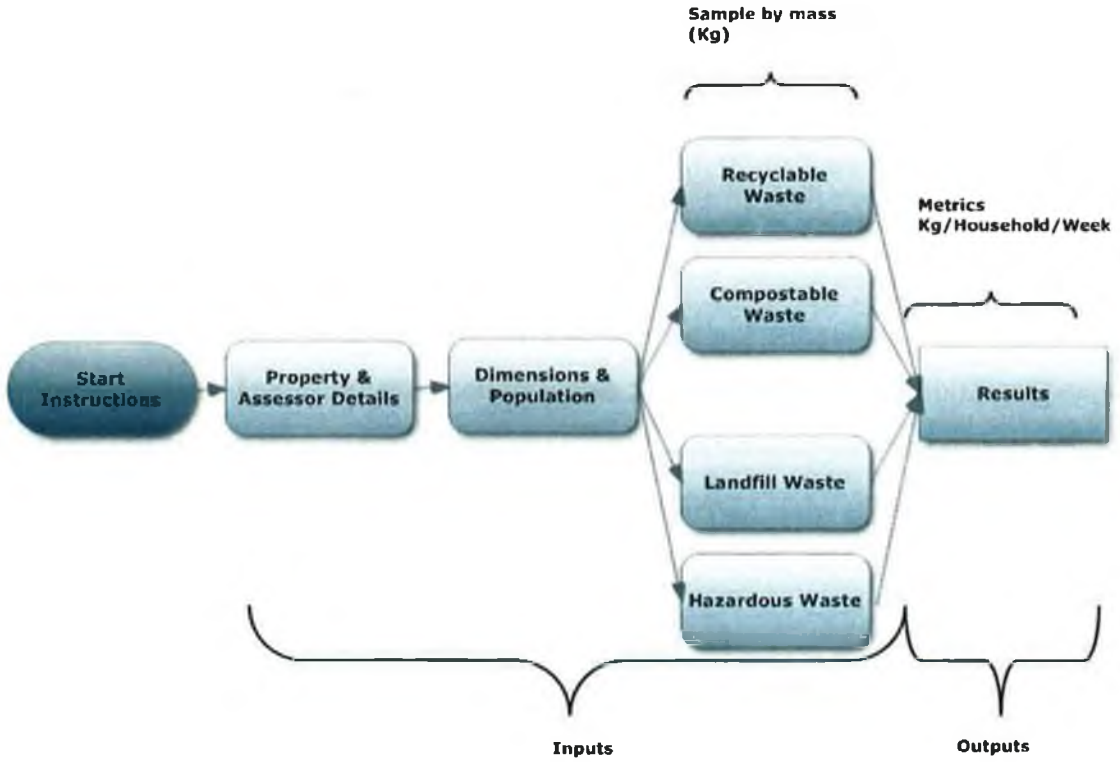

Figure 4.8 W-MAT IV Process Flow Diagram

At the fourth design review meeting, it was considered by the stakeholders that W-MAT IV was easier and faster to complete, yielding very useful data on household waste generation rates due to the direct input waste classification table format as per W-MAT IV in Appendix H. The feedback from the design meeting was as follows:

- Functionality; the review group were satisfied that W-MAT IV demonstrated that it had the capacity to collect relevant and useful audit data and that its structure, content and questionnaire length were improved, and that a second field trial was required to evaluate it.
- Effective graphic analytical tools were introduced. The removal of the macro loops helped to simplify its operation. The colours used in the tables within the spreadsheets improved the graphics and made the spreadsheets more visually pleasing to the user.
- The metric output for waste in W-MAT III was based on selecting the waste output from a drop down menu, and provided a generalisation of the weight of the waste output. The waste quantity weights in W-MAT IV were input direct into the audit tool and metric results are output from the tool in kg/household/week.
- The results are generated automatically from the waste audit data that is input into the audit tool. The resulting graphs and histograms are also generated

4.8 Hand over audit Tool

The W-MAT IV was handed over to the Environmental Department of the local authority who scoped the need for the audit tool at the outset, and was satisfied that it fully met the initial design specification and goals. In the initial stages of the study the local authority intended to run a widespread household study throughout County Galway. Unfortunately, their priorities changed in the interim and they have been unable to do so to date.

4.9 Summary

This Chapter detailed five developmental iterations of the W-MAT tool. Four design models were discussed and the strengths of some of these models were blended together to create a tailored design model that was tailored to suit the design and validation of the electronic audit tool. The adopted design model presented in Figure 4.5 had fourteen distinct steps that spanned the initial needs analysis through four design iterations. The final design was informed by five review meetings and two field trials that exposed the W-MAT tool to 28 different homeowners as part of the design process. The finished W-MAT IV tool was validated using 18 separate household participants and the initial results of Field Trial II showed that the domestic waste generation rates were closely aligned with accepted National trends, thereby generating confidence in the W-MAT methodology. Chapter 5 expands on the W-MAT methodology and Chapter 6 focuses on the validation of the data produced by Field Trial II against accepted National data.

An objective of the research is to improve data quality whilst designing an audit tool that is easy to deploy by the local authority and easy to use by the household, easy to analyse and easy to update or modify.

The W-MAT methodology is similar to MWC (1996), with the exception that streams of waste or quantities involved are smaller, due to the focus solely on household waste. It is best to establish norms or best practice equivalents when auditing. The data needs to be collected by consistent sampling techniques and the data must be properly logged.

To conduct an audit it is advisable to have a set format so that the results are comparable. For this study, it was decided that W-MAT would utilise a similar step-by-step sequence to the MWCS (2008) methodology employed by the EPA. The W-MAT IV audit methodology used a three-phased approach as shown in Figure 5.1.

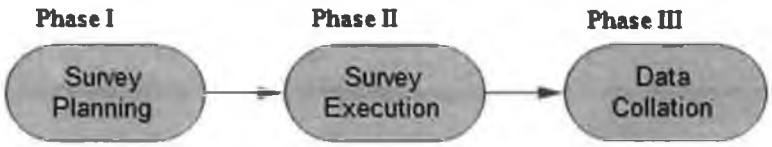

Figure 5.1: Three Phase Audit Methodology.

Each phase is divided to the sub-elements shown in Figure 5.2. Survey Planning (Phase I) is sub-divided into Background Research, Developing a Sampling Plan and Selection of a Representative Sample. The Survey Execution (Phase II) is sub-divided into Sample Collection and Data Analysis. Data Collation is sub-divided into Data Analysis and Reporting as shown in Figure 5.2.

5.2.1 Background Research

Using a traditional sampling methodology as adopted during the EPA's (2005) National Waste Characterisation Survey and the EPA (2008) National House Waste Survey (2008) the information listed below is required:

- Population statistics (Sample size)
- Number of Households (Population)

Such information is available from the EPA National Waste Report 2008 and Central Statistics Office census (CSO, 2006). The information comprised of National population statistics, waste management systems and existing information on waste composition. The findings are shown in Tables 5.1 to 5.4.

Table 5.1 Irish Demographics

Total Population	Surface Area (Km^2)	Density Pop/Km^2	Urban	Rural
4,422,100	70,182	63	60.7	39.3

Table 5.2 Housing and Waste Services

No. of occupied houses	No. of houses with a waste collection service	Houses with a single black bin collection service	Houses with a two bin collection service	Houses with a three bin collection service
1,500,274	1,192,451	62,350	878,246	251,855

Table 5.3 Household Waste Arising (Tonnes)

Household Waste 2005	Household Waste 2006	Household Waste 2007	Household Waste 2008	Recycling Centres (RC) 2008	RC Tonnes Collected 2008	Bring Banks (BB)	BB Tonnes Collected
1,633,266	1,672,213	1,672,025	1,677,338	96	200,455	1989	102,300

Table 5.4 Waste Collection

Kerbside	Kerbside Tonnes Collected	Containers/Bags/WB
Residual	899,938	Wheelie Bin
Recyclable	261,468	Wheelie Bin/Bags
Organic	38,004	Wheelie Bin

5.2.2 Select Sample

The W-MAT tool is designed to facilitate access to a wide cross section of the population using the World Wide Web (WWW). This novel aspect of waste auditing was investigated during the two Field Trials. The audit data was logged to a PC and

5.3 W-MAT IV Audit Methodology

The W-MAT IV tool uses Microsoft Excel an electronic spreadsheet programme that is part of Microsoft Office suite. The programme is very useful and relatively easy to use, which is important to the stakeholders in order to keep staff training requirements and costs to a minimum. The method of recording the waste figures is set out in the form of an audit tool methodology presented in Figure 5.3. The procedure consists of a step-by-step sequence of calculations within a series of individual tabs or modules within the Excel software. A calculation using this software works sequentially through the individual tabs as follows, leading ultimately to the display of results, conclusions and summary sheet.

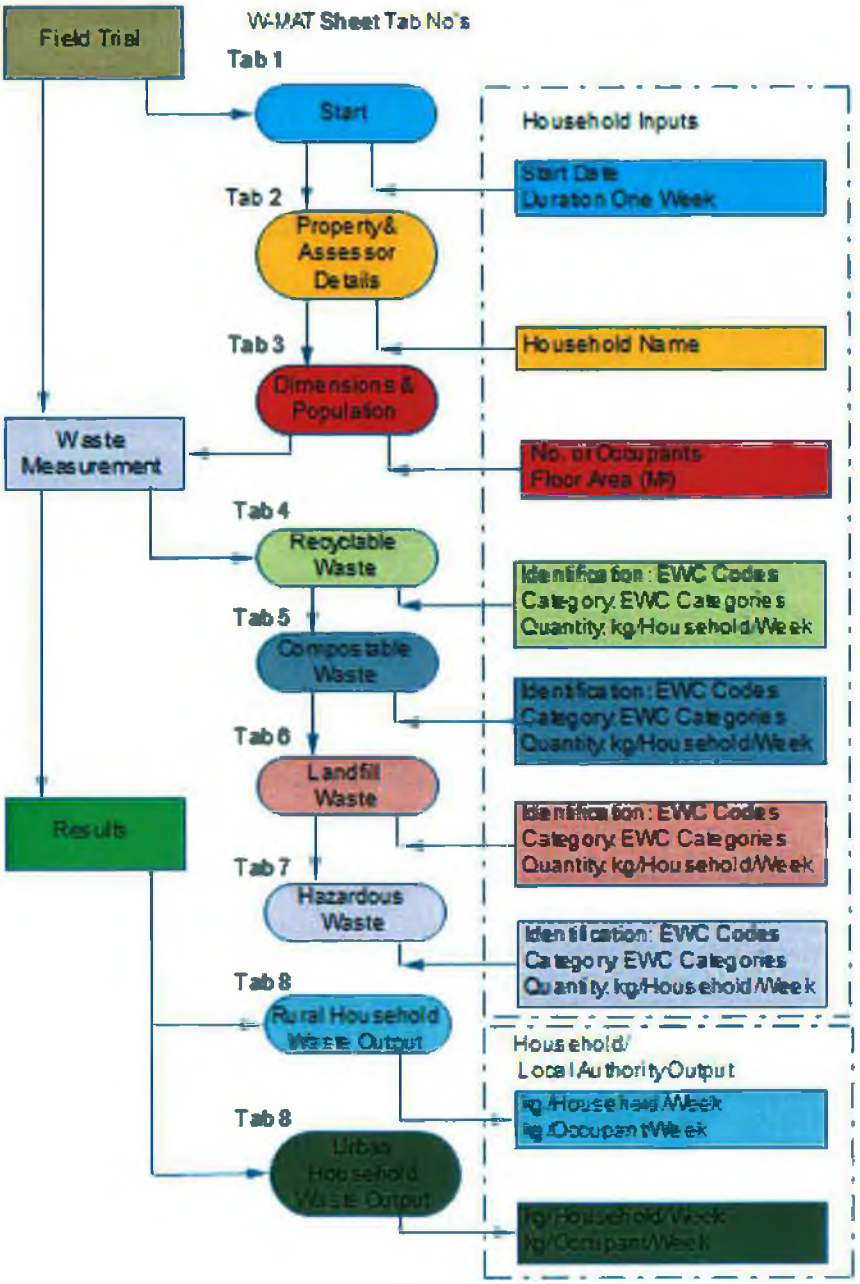

Figure 5.3 W-MAT IV Audit Tool Methodology

type, the year of construction, date of assessment and the MPRN number, which is an eleven-digit number that is allocated by the ESB and is unique to each house. The MPRN number is used by SEI as an identification number for each household to identify BER certificates against. The MPRN number appears on the top right hand corner of an electricity bill and is a unique identifier of the house.

5.3.2 Household Waste Audit "Dimensions and Population" Tab

The spreadsheet requires that the dwelling floor area be submitted. Linear measurements for the calculation of the floor areas should be taken between the finished internal faces of the appropriate external building elements.

The occupancy of the household is required as the subsequent results section calculates waste production rates based on the quantity of waste produced in kilograms divided by the number of persons in the household.

5.3.3 Household Waste Audit "Recyclable Items" Tab

The spreadsheet is designed to record the quantity of recyclable waste produced in a household over the audit period. The waste categories are sub-divided into internationally recognised categories such as those listed in Table 5.6 to aid analysis and reporting. The groups are further sub-divided using the standard European Waste Codes (EWC) and examples of the different categories are presented in Table 5.6. As the user inputs the audited waste quantities into the sample by mass column of the work sheet, the totals are automatically generated and an average weight (kg) of recyclable waste per household occupant is the output in Cell C55. An incentive such as a free week waste collection could be offered as an incentive to gain greater uptake/acceptance by householders.

5.3.4 Subsequent Tabs

The subsequent Tabs, namely compostable, landfill, hazardous waste and results tabs are very similar to the recyclable waste tab that was discussed in section 5.2.3.

Rather than discuss all of the worksheets in turn, only one worksheet is discussed in this document. However, the flowcharts that explain the compostable, landfill, hazardous material and results work sheets are attached in Appendix K.

5.4 Key Elements of Field Trial II

The key elements of the Field Trial II are the same as that outlined for Field Trial I in Section 4.3.1, except the scheme ran from 05 January to 12 January 2010.

Feedback from the W-MAT IV Field Trial II of 18 households showed an average occupancy rate of 4 persons and that on average each household produced 17.7 kg of landfill waste and 9.8 kg of waste suitable for recycling per week. The results of the field trial are evidence that the W-MAT tool works, producing data similar to that of the National Surveys, thereby creating confidence that the W-MAT methodology and tool was effective and useful. It demonstrated that the training/induction was sufficient, addressing a risk of this approach and that the tool was structured to provide relevant and useful data.

Household waste may be subject to stratification criteria such as seasonal variation or residential structure identified in Table 3.3. The significance of seasonal variations in quantity and composition between summer and winter/spring months was not investigated as both Field Trials were run during winter months. To gain a more accurate waste generation profile, it was envisaged that the local authority would conduct a study that would be conducted over two campaigns spanning summer and/or winter or spring seasons. It is also noted that residential structure can act as a significant stratification influence due to different residential types such as; rural areas, sub-urban areas, inner city, multiple dwelling, multi-storey dwellings. The field trial sampled waste in a rural and urban environment but inner city, multiple dwelling or multi storey dwellings were not accounted for which may have an effect on the reported results when compared to National results.

6.0 W-MAT Validation

6.1 Introduction

This Chapter presents an insight into the analytical (graphical, tabular and statistical) capabilities of W-MAT using data obtained from Field Trial II. The Field Trial II data is also compared with National data to validate W-MAT.

Table 6.1 outlines the data analysis capability that is automatically presented in tabular and graphical formats as the field data is input to the software. These pre-defined tabular and graphical formats are designed based on recognised formats in previous National Surveys.

Table 6.1 Standard analysis performed automatically by W-MAT

Tabular Analysis (kg/household/week)	Graphical analysis (% of total waste output)	Graphical analysis (kg/waste category/week)
Total recyclable waste output	Recyclable waste stream as a % of total	Recyclable waste stream quantity
Total compostable waste output	Compostable waste stream as a % of total	Compostable waste stream quantity
Total landfill waste output	Landfill waste stream as a % of total	Landfill waste stream quantity
Total hazardous waste output	Hazardous waste stream as a % of total	Hazardous waste stream quantity

Accurate and up to date information on waste is essential for monitoring progress with the implementation of waste legislation and waste management policies within Ireland and within EU member states. W-MAT is designed to provide an analysis of waste stream data. Its graphical analysis highlights trends in waste generation and helps to direct prevention efforts towards priority waste streams. The waste data and waste stream analysis generated can be used to deliver key indicators to regulators, policy makers and decision makers.

Waste stream data is also used to compile reports to the European Commission on the Waste Statistics Regulation (2150/2002/EC) and also on implementation of Directives and other statutory reporting needs, such as to demonstrate compliance with diversion of biodegradable municipal waste targets set in the Landfill Directive. New obligations have arisen in recent years in relation to specific waste streams such as waste electrical and electronic equipment, biodegradable municipal waste, end-of-life vehicles and batteries. The Waste Framework Directive (2008/98/EC) has to be introduced targets for preparing for reuse and recycling of 50% by weight of household derived paper, metal, plastic and glass and 70% by weight of C&D waste.

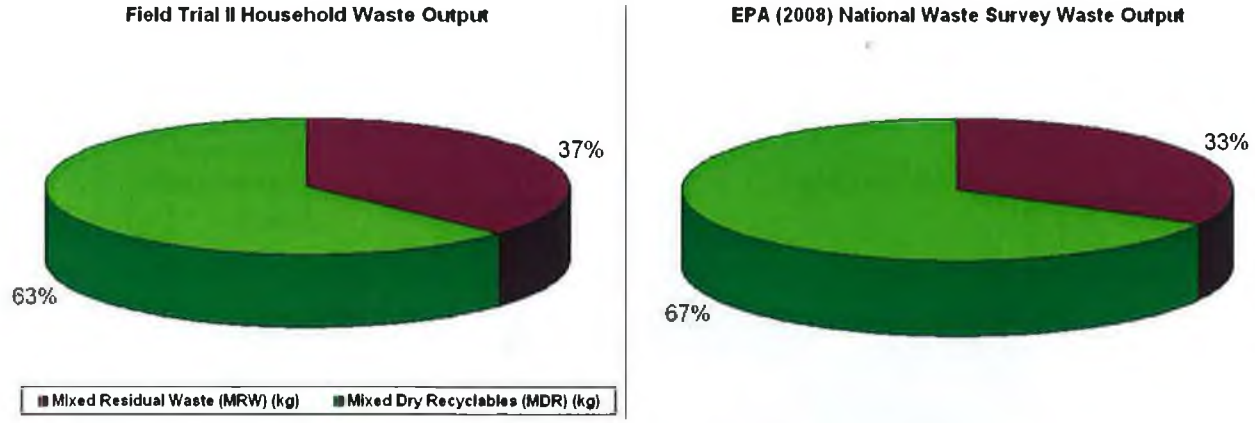

Figure 6.1 Field Trial II data comparison to EPA (2008) data showing Mixed Residual and Dry Recyclable Waste Composition by percentage (%)

The breakdown of waste composition by all 13 EWC codes of all the households that took part in Field Trial II is shown in Figure 6.2.

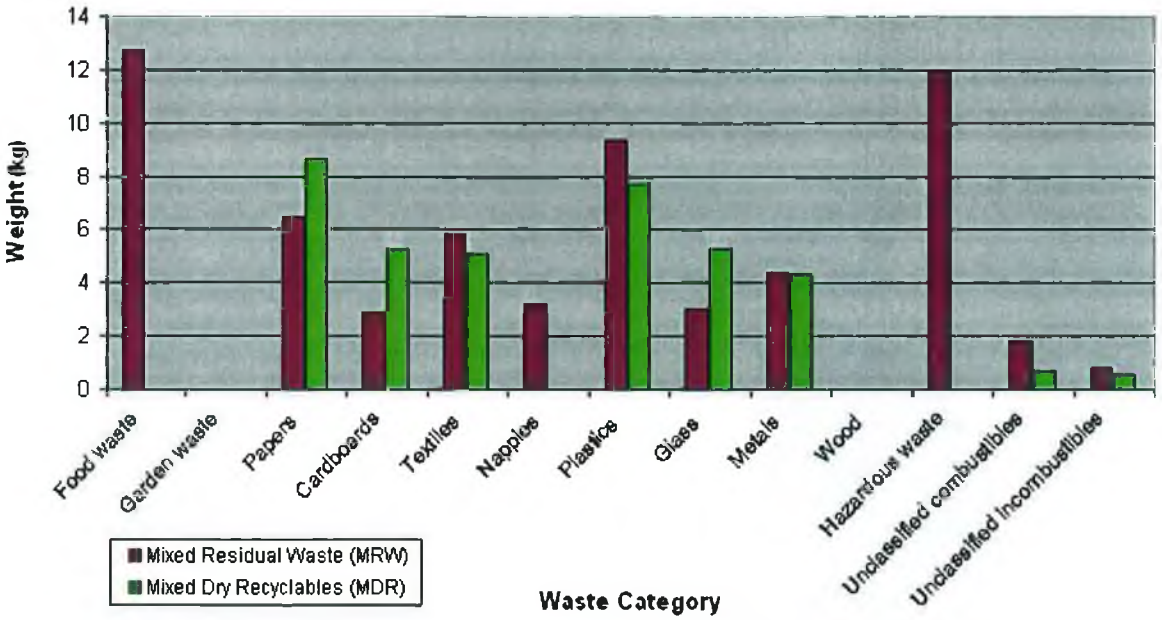

Figure 6.2 Composition by weight of total household waste produced by 18 households that responded to Field Trial II by EWC codes

Figure 6.2 shows the majority of the mixed residual waste (MRW) is composed of food waste, plastics and hazardous waste, whilst the majority of recyclable waste is composed of paper, plastics and cardboard. A table showing the MRW stream is shown in Appendix L.

Figure 6.3 uses the pie-chart graphical analysis to confirm that food waste accounts for the largest portion of MRW at 22%. Plastics make up 16% of the waste stream, hazardous waste is 15% of the waste stream and the other categories are all less than 10%.

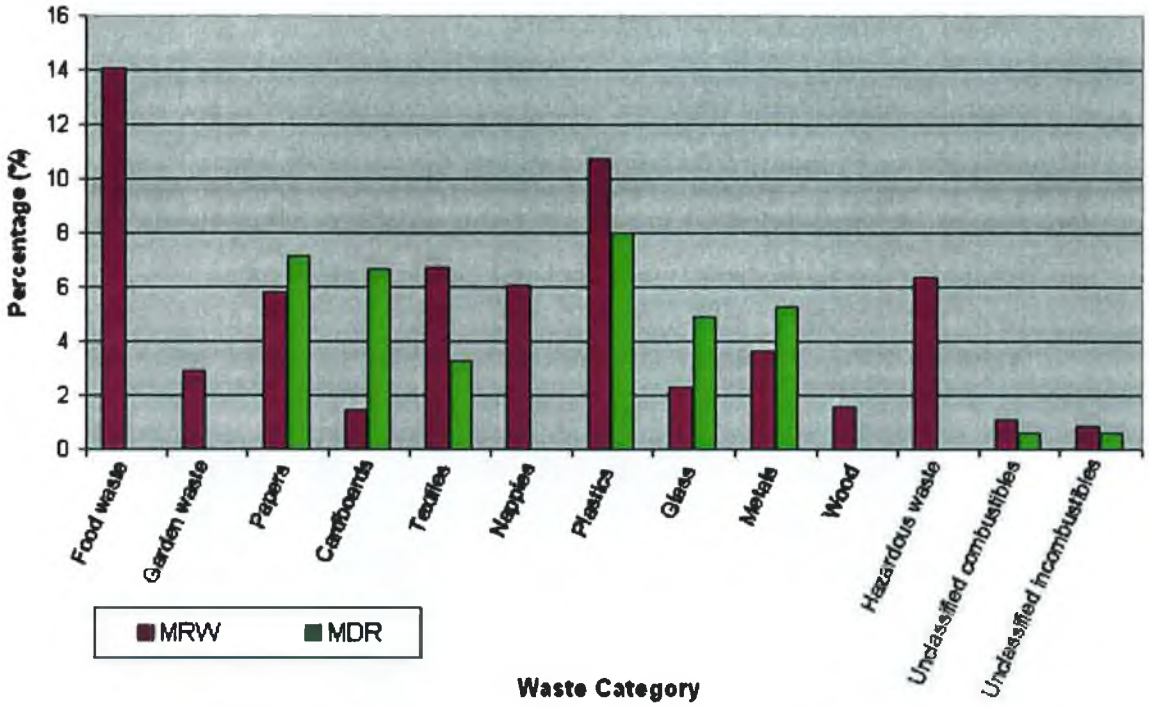

Figure 6.5 "Urban" household waste composition by %

The urban residual waste stream accounts for 63.5% of the total audited urban waste. It is clear from analysing the data submitted during Field Trial II that food waste (21%); plastics (17%) and textiles (11%) represent the greatest waste streams in the mixed residual waste category. This reflects similar trends noted during the MWCS, (2004 and 2008) National Studies. The composition of the mixed residual waste stream is shown in Figure 6.6.

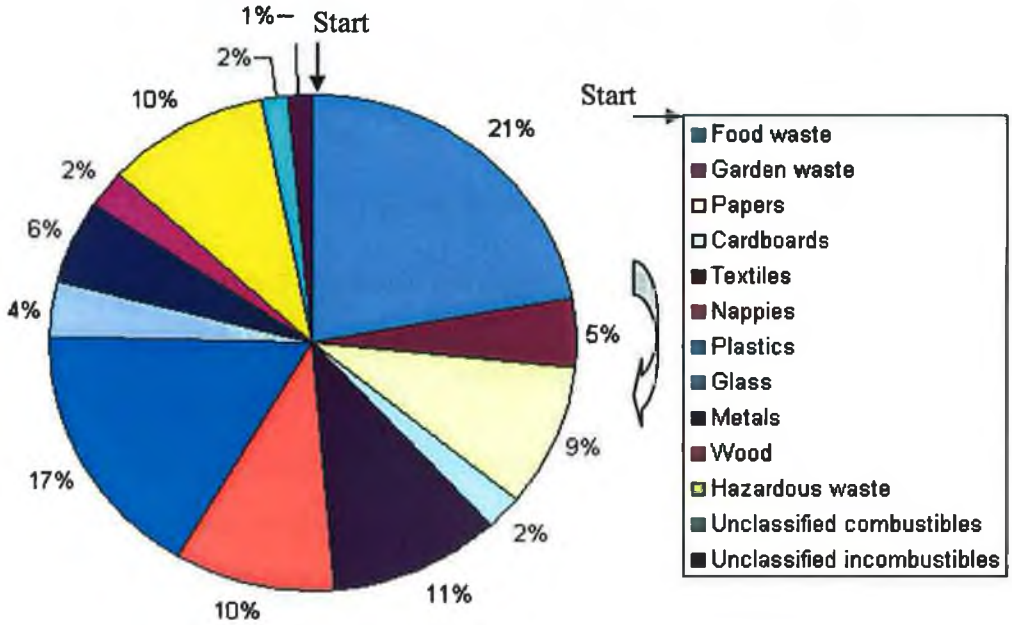

Figure 6.6 "Urban" mixed residual waste composition by %

The composition of urban dry recyclable waste, the rural household waste composition and waste stream breakdown of the rural waste is shown in Appendix M.

- Individual value plot diagram
- Histograms of group data

It is easy to transfer data from the W-MAT tool to Minitab. Figure 6.8 illustrates the variance within each waste category measured during Field Trial II in units of kilograms (kg).

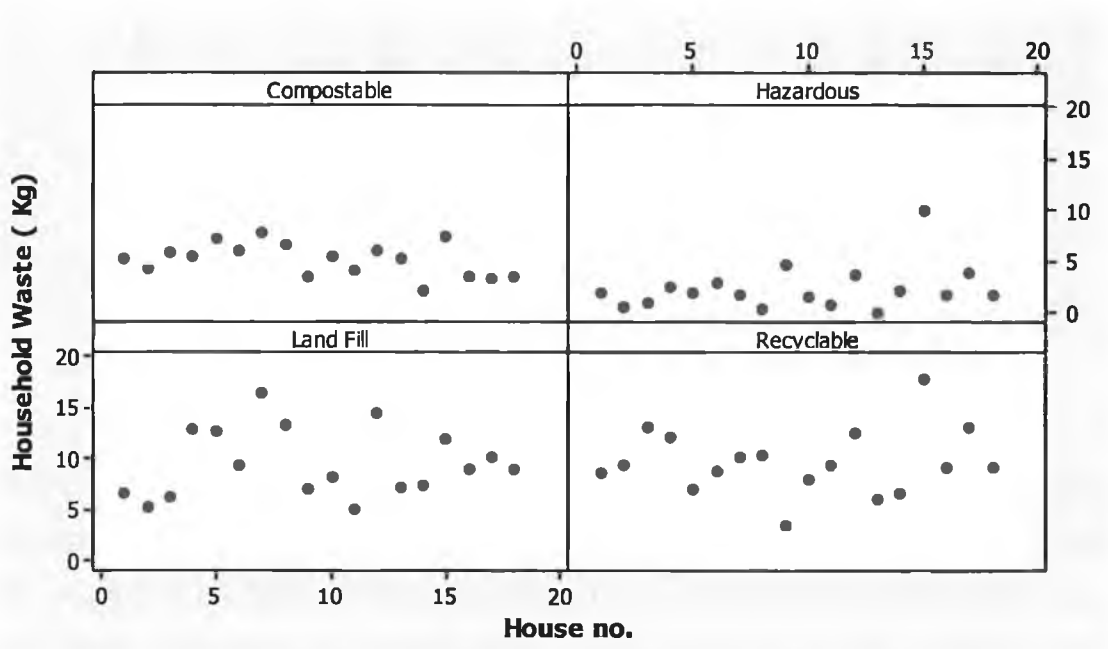

Figure 6.8 Scatter plot of Household Waste (kg) vs. House number

The scatter plot in Figure 6.8 shows that there are different degrees of variance for each category, however noticeably the two categories for compostable and hazardous waste show lower variance. The low variance in the compostable category is most likely due to relatively comparable quantities of food being consumed and disposed off in households. Similarly, with the hazardous waste stream the quantities produced per household is low and the variance in the data is low as a result.

The individual value plot shown in Figure 6.9 identifies the variation in accumulated Field Trial data.

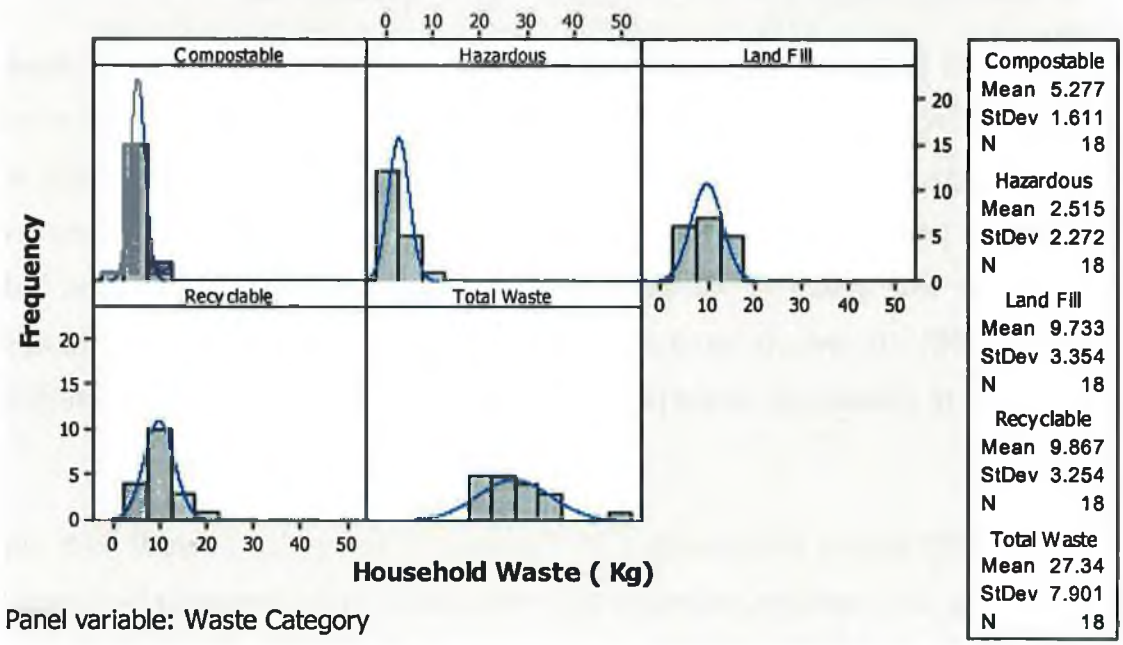

Figure 6.10 Individual value plot of Household Waste (kg)

In total, 18 households tested the audit tool and conducted a household waste audit using W-MAT. The sample size used to validate the audit tool is also half the sample size used by the MWCS (2008) study that was used to produce a National waste profile. Cunningham (2010) states that the sample size used are significant given that the samples were obtained within one electoral area or cluster. It was envisaged that the local authority would conduct a survey using W-MAT and that the sample size would be selected from a number of household clusters and that it would generate waste dimensions that would be representative of a National profile. Unfortunately, the local authority was unable to commit resources to the waste audit at this time. Ni Mhainin (2010) states that it is still high priority within the local authority and that hopefully a waste survey using W-MAT will be conducted in the future to generate household waste dimensions that can be measured against previous or future National studies. The results from the field trial conducted show that the average household size is four persons and that the average waste generation per household is 17.7 kg of landfill waste and 9.8 kgs of recycle waste. Field Trial II yields descriptive results for the households that participated. This is further evidence that the audit tool and methodology worked in the field and that it is suited to the application of a larger subsequent study that may be conducted by the local authority.

between the Field Trial II and the National survey. The comparison between the W-MAT Field Trial II results and the National results is evidence that the audit tool developed can be used to generate useful household waste generation figures and that those figures can be compared to previous waste studies.

Table 6.3 Results of the Household W-MAT Field Trial II Study

Clusters	Field trial (2 Bin Rural)	EPA, 2005 (2 Bin Rural)	EPA, 2008 (2 Bin Rural)	Field trial (2 Bin Town)	EPA, 2005 (2 Bin Town)	EPA, 2008 (2 Bin Town)
kg/household /week	26.49	24.87	34	28.52	24.27	16.00
Primary Waste Category						
Organics	12.7 %	26%	17.36%	18.5 %	28%	10.53%
Paper	15.1 %	19%	30.02%	12.98%	29%	37.66%
Cardboard	8.13%	8%	8.90%	8.11%	7%	7.65%
Composites	3.19%	3%	1.42%	3.45%	1%	1.45%
Textiles	10.9%	11%	11.83%	10.12%	7%	8.23%
Plastics	17.07%	13%	15.15%	18.76%	13%	18.89%
Glass	8.31%	5%	2.66%	7.27%	6%	3.44%
Metal	8.71%	3%	3.53%	8.99%	2%	3.56%
Wood	0%	1%	0.88%	1.58%	0%	0.12%
Special Municipal Waste	11.95%	2%	0.41%	6.35%	0%	0.97%
Unclassified Combustibles	2.5%	0%	0.47%	2.05%	0%	0.77%
Unclassified Incombustibles	1.33%	1%	1.06%	1.80%	2%	1.66%
Fines	0%	5%	6.31%	0%	4%	5.07%
Bulky waste + WEEE	0%	3%	0	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%

Similarities exist between the data sets:

- The three highest waste stream outputs are Plastics, Organics and Paper for all three studies.
- The Rural v's Urban households show similar trends between the Field Trial II and The EPA (2005) National study.
- The Paper, Textile and Cardboard Rural waste streams are very similar between the Field Trial II and The EPA (2005) National study.

As can be seen in Figure 6.12, the results of Field Trial II, and 2 bin rural waste output has similar results in a number of the waste streams, namely: Cardboard, Textiles and Plastics.

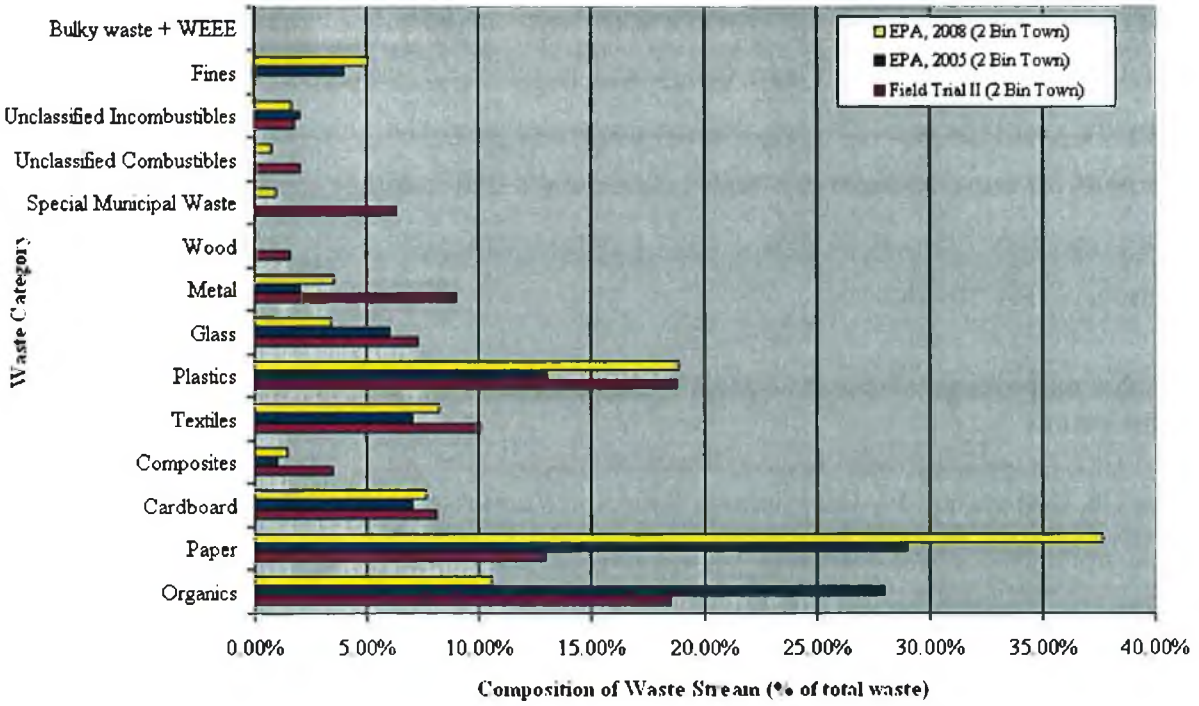

Figure 6.13 Comparison of W-MAT Field Trial II (2 Bin Town) Results with the 2005 and 2008 National Waste Survey Results

Figure 6.13 shows the results of the 2 bin urban waste output. The EPA (2008) results show a variation to the EPA (2005) particularly in relation to the Paper, and Organic waste streams. The 2005 survey involved surveying 37 houses in nine clusters, whilst the 2008 surveyed 39 households in ten clusters. As can be seen in Table 6.3 and Figure 6.11 the three highest waste stream outputs are Plastics, Organics and Paper for all three studies. There are similarities between the Cardboard, Plastics and Textile waste streams for all three data sets, however there is variation between the Organic and Paper waste streams and between the overall household waste output dimensions. Gibson (2010) states that the waste generation variation is most likely due to differing household waste practices in different clusters or regions throughout Ireland. This highlights the need for a waste survey that includes a greater sample size within a greater number of audit clusters. Although there is variation between the surveys conducted the Field Trial II are proof that the data obtained compared well in a number of areas and that the audit tool operated well in the recording and presentation of results. Cunningham (2010) states that the audit tool performed well and that the data output from the tool is a reasonable representation of the households in the

produce less than 350 kg of municipal waste per capita. Between 2005 and 2007, most countries saw an increase in municipal waste, only a few showed stabilisation (Germany) or a downward trend (Spain and the UK).

6.6 Summary

The W-MAT audit tool and the audit methodology adopted facilitated the collection of the Field Trial II data that was generated and analysed using the analytical capabilities of the W-MAT tool. It demonstrated that the audit data is collected in a standardised manner using EWC waste classification that permitted a comparative analysis to be made between the field data and previous National audits.

The W-MAT Field Trial II waste composition dimensions for mixed residual and dry recyclable waste compare well with the EPA (2008) National survey as shown in Fig 6.1. However, the EPA (2008) household results yields a variation in waste output of 28.35% in the rural households and 78.25% in the town households. The EPA (2005) results yielded a more uniform waste production between the two categories, as shown in Figure 6.11; the Field Trial II total waste output for rural and urban households is similar to the EPA (2005) results. From studying the National waste report data and various EPA household waste dimensions, it is apparent that variation in waste quantity results is common and that waste quantities vary in various clusters throughout the country (Gibson, 2010). This coupled with the misgivings in annual reported municipal waste quantities as outlined in Section 3.1.3 outlines the requirement for the collection of accurate waste data for local authorities and private waste contractors alike, for them to plan ahead and react to identified trends in municipal waste generation.

In order to generate an accurate National household waste profile that is representative of current waste trends, there is a need for a large survey of waste generation at source. The W-MAT tool has being tested in the field and should prove very beneficial to private waste contractors and local authorities alike to accumulate and analyse waste generation and waste stream data. The use of the W-MAT audit tool could respond to the need for accurate waste data, it would aid in the identification of changed trends in household waste generation and may prompt a swift response or change for the stakeholders.

7.3 Conclusion

Objective No.1

Conduct a literature review to identify various definitions, legislation and policy actions that relate to Irish domestic waste and examine state of the art National and International waste audit methodologies.

This was achieved by examining Irish and European environmental legislation and policies in relation to municipal waste production and the outcomes are documented in Chapter 2. The National and International waste audit methodologies were discussed in Chapter 3. The influence on W-MAT was as follows:

Conclusions

1. Pre 1990's there was very little waste legislation in place in Ireland. There has been considerable positive change in Ireland over the past 19 years or so as regards the introduction of environmental legislation and regulations. The new approach as outlined by the DoEHLG (2009) is in the direction of sustainability, in particular, to move away from mass burn incineration towards alternative technologies and to minimise waste going to landfill.

2. Ireland initially carried out waste audits using the Municipal waste characterisation (1996) methodology. The results were questionable, as the audit duration was not specified and the physical waste analysis involved using grab samples. The shortcomings identified prompted the EPA to carry out the Municipal Waste Characterisation (NWPP-2004-02) survey using a newly adopted methodology, which was further developed for the Municipal Waste Characterisation (2008) study. The 2004 and 2008 survey methodologies used are based on the European SWA (2004) methodology.

3. A sample of European and International methodologies were studied in Chapter 3. The research undertaken has emphasised the need for an Irish waste audit methodology that can be used to clarify National reported figures on waste generation. After studying Best Available Technologies (BAT) the new W-MAT methodology was designed to respond to the need outlined in section 1.2, it benefits from a selection of attributes from a number of methodologies as discussed in section 3.3 and has been validated during Field Trial II.

- Per person waste output – (kgs) per person per year
- Statistics – Calculated as percentages of total waste output

2. The households that participated during the W-MAT study produced an average of 27.5 kg of household waste per week, which consisted of 17.7 kg of landfill waste and 9.8 kg recycle waste per household. Field Trial II was conducted for one week during winter and does not account for seasonal variation or increased summer waste volumes due to garden waste etc.

Objective No.4

Design an audit tool that can be used to conduct household audits, that is easy for the householder to use, that can store and retrieve data and provide results that are easy to analyse.

This was achieved by designing an Excel based software application W-MAT that has eight steps that form the audit methodology, namely; Start, Property and assessor details, Dimensions and population, Recyclable Waste, Compostable Waste, Landfill Waste, Hazardous Waste and a Results section. The audit tool is designed to generate total waste quantity figures for the household and to generate graphs and charts that depict the waste stream percentages. The W-MAT tool CD is included in Appendix H.

Conclusions

1. The audit tool was validated in house prior to the W-MAT Field Trial and demonstrated that it could record waste generation data, could generate results and present graphical representation of the results.

2. The W-MAT tool was validated by 18 households. The sample size used to validate the audit tool is approximately half the sample size used by the MWCS (2008) study and it was used to produce a National waste profile. It was envisaged that as part of the study the local authority would conduct a survey with a sample size that would be reflective of the National profile. Unfortunately, the local authority was unable to commit to undertake that survey. The W-MAT tool worked efficiently during the field trials and demonstrated that it can store and retrieve household waste data, whilst being easy for the householder to use, and administratively light for the relevant stakeholders, as very little training if any is required to use the audit tool.

2. The householders logged the waste data directly to PC during the Field Trial thus reducing the need for paper audit forms. This reduces the time required to complete the audit, as there is no requirement to manually record results.

3. The use of the W-MAT tool eliminates the existing delay in feedback to the householder. The current procedure is that the audit data is analysed in the office and that the report is drafted and charts are added to support the report.

4. Using the W-MAT tool there is no requirement for audit staff to subsequently have to input the data into Microsoft Word and Excel to generate result reports. The W-MAT tool generates the summary report and graphs automatically as the information is inputted, so feedback is immediate.

5. The W-MAT programme can be loaded onto a Palm Held Computer which would further improve the accessibility to the data, as the data could be uploaded direct to a local authority computer from the audit site via the internet.

Objective No.6

Design an audit tool that can be deployed for future studies by the local authority or other stakeholders.

The W-MAT tool is designed to facilitate future audits for the local authority or other private waste contractors. As previously discussed in Section 3.1.3, the EPA (2010) report that during an annual return, a large quantity of industrial process waste was incorrectly counted as MW. That, coupled with the estimate that is made for uncollected household waste, may lead to a discrepancy in the reports or recorded figures.

Conclusions

1. As previously stated in section's 1.6 and 3.1.3 there is a recognised problem with regard to municipal waste classification in Ireland. Waste operators using incorrect definitions for municipal, household and commercial wastes has affected the accuracy of data collected and as a result waste has been categorised wrongly.

2. The results obtained are similar to the total weight per household results obtained in the EPA (2005) household study, which is additional prove that the audit tool works efficiently and can generate useful results.

3. Defra (2010) state that the total waste produced per English household averaged 20.6 kgs, which is 25% less than the Field Trial II results obtained.

4. From comparing the Field Trial II results to National waste dimensions it is apparent than a reduction in the amount of household waste is required. A greater focus on waste reduction, recycling or reuse is needed and possible advances in waste reduction such as composting or bio-refineries with energy recovery is needed to reduce the quantity of landfill waste been produced.

Objective No.8

Identify design improvements for W-MAT

The W-MAT study was a success. Audit data was collected from 18 households during Field Trial II. The sample size used to test the audit tool is also half the sample size used by the MWCS (2008) study that was used to produce a National waste profile. During the development of W-MAT, it was understood that the local authority would conduct a study with a large sample size. Unfortunately, this did not transpire, although it is still the intention of the authority that it will occur in the future. GCC found that the household waste generation dimensions/results generated during the field trial were useful and that they were a relatively good comparison to previous National waste studies. However, to further validate the W-MAT tool and its waste metrics, it would be prudent for the local authority to conduct a future audit with a large sample size

Conclusions

1. The W-MAT tool is easy to use and meets the requirements of the stakeholder, who wants an audit tool that:

    - Has the ability to replace written audit records
    - That is administratively light to implement
    - That is easy for the user to operate
    - That has the ability to store and retrieve audit data
    - That can calculate waste output metrics and generate result tables that are easily understood

3. The W-MAT Field Trial II was run to validate the audit tool. The study was run in a rural area in east Galway. Organic waste results are lower than the expected outcome or the National average. On consideration of the results obtained, it is possible that a portion of that waste stream is used to feed family pets or farm animals such as hens or pigs.

4. Field Trial II was run for a 1-week period in winter. The stratification criteria of seasonality are not accounted for in the field trial results. If a second study was conducted in summer time, it is more likely that garden waste such as lawn trimmings, hedge cuttings etc. would increase the quantity of waste produced during the summer months.

5. The Field Trial II was run in the Mountbellew electoral area. The field trial did not account for residential structure for example, inner city, multiple dwellings and multi storey dwellings were not analysed. To scale up the field trial results to a National profile would be questionable as a result, as the waste streams from the other residential classifications may differ from the households studied.

6. The W-MAT study conducted was used to validate the audit tool and evaluate its operational effectiveness. Eighteen households in a household cluster in the Mountbellew electoral area participated. To generate Regional/National benchmark figures a larger audit would be required with a greater number of household clusters selected or analysed throughout the country. In order to do research on a Regional basis, the co-operation of all the local authorities in the Connacht region would be required. This would require considerable co-operation between the various local authorities to run/launch the W-MAT tool on-line and to analyse results returned from the study.

7. During the W-MAT study it was anticipated that Galway Co. Co. would conduct a waste audit using the audit tool developed, and that the results of that audit would be used in the study to establish waste statistics and benchmark figures for waste generation in the Galway region. However due to changes in circumstances the survey has not been conducted to date, although it is still high priority on the agenda of the local authority and will hopefully be conducted as a follow on study at some time in the future.

and would have the added benefit of preventing those material from been mixed with residual waste.

General Recommendations

4. EU Landfill Directive (1999/31/EC) requires increased diversion of bio-degradable waste from landfill. By utilizing W-MAT and carrying out future audits programs a greater insight into the household waste streams can be obtained. By doing so Ireland can respond to any observed waste trends by generating the infrastructure to match those needs. The EC (2000) state that a composting plant in Barcelona uses 16,000 tonnes of bio-degradable waste per annum and produces agricultural compost. Ireland needs to divert bio-waste from landfill and to utilise the latent energy or by products that can be produced.

5. As shown in Figure 6.3 there is variation between the EPA 2005 and 2008 studies. This is likely caused by the limited sample size taken during the surveys and the variability in data would be increased when the data is scaled up to present a National profile. W-MAT has demonstrated that it can record total household waste produced and the waste streams generated. By launching W-MAT on line would greatly increase the capacity of stakeholders to attractive a response and to collect greater sample sizes for future surveys.

6. W-MAT has identified during its validation that household organic waste output is high and that that material is being disposed of to landfill. The roll out of household brown bin collection services by local authorities would divert organic waste from landfill and would assist in meeting Ireland's EU landfill diversion target.

7. A larger follow on household study would be beneficial to establish accurate household waste figures/benchmarks on a Regional or National level. Previous National waste report figures have been generated using total waste production dimensions divided by the population census figures to generate National averages. As seen in Figure 6.3 there is variation between the EPA 2005 and 2008 studies. By conducting a larger household audit using W-MAT, a more accurate National representation of the waste streams and quantities could be obtained.

8. W-MAT has demonstrated from the results obtained during this study that bio-degradable waste accounts for 66.6% of material disposed of to landfill. It is

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List of Appendices

Appendix

APPENDIX A

Table 3.1: Description of Assumptions used to Allocate Households in each Cluster.

	1-bin	2-bin	3-bin
Cities	Apartments with Residual waste collection only • Part of Dublin Region - 25,000* • Limerick City • Cork City • Part of Galway City • Part of Waterford City	Single unit dwellings and apartments provided with MRW + MDR collection • Part of Dublin Region -+25,000* - 143,000** • Part of Limerick City • Part of Cork City	Single unit dwellings and apartments provided with MRW + MDR + Organic collection • Part of Dublin Region +143,000** • Part of Galway City (15,000) • Part of Waterford City (16,000)
Towns	LAs with low recyclable collection rates (<10%) have a single bin in their rural areas • Part of Carlow • Part of Mayo • Apartments in towns in other LAs	All single dwellings in towns are provided with 2 bin collection as a minimum	• Ballinasloe • Urban part of Co. Waterford
Rural areas	LAs with low recyclable collection rates (<10%) have their rural areas with single bin • Part of Carlow • Part of Mayo • + Apartments in other LAs	LAs with recyclable collection rates >10% have their rural areas provided with 2 bin collection	• Rural part of Co Waterford • Rural part of Co. Westmeath

* 25,000 apartments are currently provided with a residual waste bin and a MDR bin in the 4 Dublin local authorities

** 143,000 single unit dwellings are also provided with a brown bin in Dublin City Council and Fingal County Council areas.

Table 3.2: Number of Households in each Cluster

	1 bin kerbside collection system	2 bins kerbside collection system	3 bins kerbside collection system	Total
Cities	70,484	286,298	174,000	530,782
Towns	42,855	368,960	18,917	430,733
Rural areas	71,503	582,272	6,583	660,357
Total	184,842	1,237,530	199,500	1,621,872

Table 3.3: Percentage of Households in each Cluster

	1 bin kerbside collection system	2 bins kerbside collection system	3 bins kerbside collection system	Total
Cities	4.3%	17.7%	10.7%	32.7%
Towns	2.6%	22.7%	1.2%	26.6%
Rural areas	4.4%	35.9%	0.4%	40.7%
Total	11.4%	76.3%	12.3%	100%

APPENDIX B

Table 3.4 shows that 18 samples were required during April 2008 and again in October 2008, giving a combined total of 36 samples.

Table 3.4: Proposed Survey Types for Household Waste Analysis

	1-bin kerbside collection system	2-bin kerbside collection system	3-bin kerbside collection system	Total
Cities	2 (6%)	4 (11%)	6 (17%)	12 (33%)
Towns	0	4 (11%)	6 (17%)	10 (28%)
Rural areas	0	8 (22%)	6 (17%)	14 (39%)
Total	2 (6%)	16 (44%)	18 (50%)	**18 (100%)**
Note: the percentage in brackets represents the percentage of samples allocated to each individual cluster.				

3.1.3 Selection of Waste Survey Areas

Taking into account the requirements of the brief, the locations shown in Table 3.5 were selected. It was planned to collect from a mix of households with an identical social class profile to the national social class profile.

Table 3.5: Survey Locations

Strata	1 bin	2 bins	3 bins
Cities	Cork City Council	Cork City Council	Galway City Council
Towns	N/A	Limerick County Council	Waterford County Council
Rural areas	N/A	Limerick County Council Longford County Council	Waterford County Council
Note: No survey were carried out in the Dublin Region as there was no facility available at the time to carry out the survey.			

3.2 PROGRAMME

In total, 39 household waste samples were analysed; 36 of these were obtained from kerbside collections and 3 were obtained from Civic Amentiy sites. Of the 36 kerbside samples, 34 were from collection routes serving individual houses and 2 were from collection routes serving apartment blocks.

The sampling was carried out over two campaigns; the first was undertaken from April to July 2008 and the second from August to November 2008. Tables 3.6 and 3.7 summarise the survey programme for each campaign and includes details of the location of the surveys, the project partners involved and the dates of each survey. 17 samples were analysed during Campaign 1 and 22 samples were analysed during Campaign 2. Campaign 2 comprised a repeat of the 17 samples analysed during Campaign 1, plus the two apartment samples and the three civic amenity samples.

It was originally intended to include samples from a 1-Bin system i.e households (namely apartments) served with one bin for mixed residual waste. However, no such system could be located owing to the apparent complete coverage of the 2-Bin system across the country. Instead, two samples were obtained from an urban 2-Bin system servicing apartment blocks, to include this element of the kerbside collections in the overall national sample. These samples were analysed during Campaign 2.

The first campaign of surveys was expected to be completed over the course of April and May 2008, to reflect springtime waste composition. Whilst the majority of surveys were completed within this time frame, there were delays in scheduling the 2-Bin City surveys. These were completed in partnership with Cork City Council in the second half of July 2008. CCC were implementing changes to their collection routes between April and July and could not facilitate the surveys until the end of July.

APPENDIX C

Table 3.6: Surveys Conducted during Campaign 1 April to July 2008

Collection System	Area	MRW Date	MDR Date	Organics Date	Project Partner	Location
City: 3 Bin-System	Galway City	23/5/2008	30/5/2008	30/5/2008	Galway City Council	Sandy Road Depot
City: 2 Bin System	Cork City	28/7/2008	21/7/2008	-	Cork City Council	Kinsale Road Landfill
Town: 3 Bin-System	Dungarvan County Waterford	3/5/2008	19/4/2008	26/4/2008	Waterford County Council	Dungarvan TS + MRF
Town: 2 Bin System	Adare County Limerick	30/4/2008	30/4/2008	-	Mr Binman	Mr Binman MRF
Rural: 3 Bin-System	Stradbally County Waterford	3/5/2008	19/4/2008	26/4/2008	Waterford County Council	Dungarvan TS + MRF
Rural: 2 Bin System	Patrickswell County Limerick	29/4/2008	29/4/2008	-	Mr Binman	Mr Binman MRF
Rural: 2 Bin System	Drumlish County Longford	28/5/2008	7/5/2008	-	Mulleadys	Mulleadys TS Longford
Total		**8**	**7**	**3**		

MRW = Mixed Residual Waste; MDR = Mixed Dry Recyclables

Table 3.7: Surveys Conducted during Campaign 2 August to November 2008

Collection System	Area	MRW Date	MDR Date	Organics Date	Project Partner	Location
City: 3 Bin-System	Galway City	26/9/2008	3/10/2008	3/10/2008	Galway City Council	Sandy Road Depot
City: 2 Bin System	Cork City	20/10/2008	13/10/2008	-	Cork City Council	Kinsale Road Landfill
City: 2 Bin System*	Cork City	26/8/2008	15/10/2008	-	Greenstar	Glanmire MRF
Town: 3 Bin-System	Dungarvan County Waterford	18/10/2008	13/9/2008	20/9/2008	Waterford County Council	Dungarvan TS + MRF
Town: 2 Bin System	Adare County Limerick	10/9/2008	10/9/2008	-	Mr Binman	Mr Binman MRF
Rural: 3 Bin-System	Stradbally County Waterford	18/10/2008	13/9/2008	20/9/2008	Waterford County Council	Dungarvan TS + MRF
Rural: 2 Bin System	Patrickswell County Limerick	9/9/2008	9/9/2008	-	Mr Binman	Mr Binman MRF
Rural: 2 Bin System	Drumlish County Longford	1/10/2008	24/9/2008	-	Mulleadys	Mulleadys TS Longford
Urban Civic Amenity	Ballyogan CRF Dublin 18	4/11/2008	-	-	DLRCC/ Greenstar	Ballyogan Recycling Park
Rural Civic Amenity	Dungarvan County Waterford	25/10/2008	25/10/2008	-	Waterford County Council	Dungarvan TS
Total		**8**	**7**	**3**		

MRW = Mixed Residual Waste; MDR = Mixed Dry Recyclables
* This survey was undertaken for a 2-Bin system for apartment households.

APPENDIX D

Macro Code for Result Graphics "Smiley"

```
Call Worksheet_Changes
End Sub
Sub Worksheet_Changes()
If Range ("C24") = "Excellent" Then
'MsgBox "Show"
ActiveSheet.Shapes ("Picture 19").Visible = True
ActiveSheet.Shapes ("Picture 20").Visible = False
ElseIf Range ("C24") = "Very poor" Then
'MsgBox "Hide"
ActiveSheet.Shapes ("Picture 19").Visible = False
ActiveSheet.Shapes ("Picture 20").Visible = True
Else
ActiveSheet.Shapes ("Picture 19").Visible = False
ActiveSheet.Shapes ("Picture 20").Visible = False
End If
```

Instruction

The macro loop uses logic "IF", "ELSE" and "ELSE IF" functions. The 1st line activates the macro to run when the sheet is opened. The next statement tells the macro to run and display the pictures as per the answer in the selected cell. For example, IF Range ("C24")="Excellent" Then 'msgBox "Show", this simply states that if the content of cell C24 displays "excellent" then show a message box containing a happy smiley figure. If the cell C24 contains "Very Poor", then a sad smiley figure is shown. There are four different categories displayed in cell C24 depending on the spreadsheet results. If C24 displays either "Poor" or "Good" then the last else part of the Macro is called, which displays no message box.

APPENDIX E

Purpose of the Waste Audit

The purpose of the waste audit is to determine:

- How much waste there is
- How much recyclables there is
- How much compostable there is
- How much hazardous waste there is
- How much landfill waste there is
- What the waste composition is

Methodology

Methodology is the method you use to carry out the audit. There are a number of factors that need to be analysed before commencing a waste audit such as:

What to sample?
Which bins to look at?
Seasonality of the waste?
When to do the audit?
Duration of audit?
What weight to sample?
Type of audit used?

To achieve best results a comprehensive waste audit should be done at least once per year, preferably twice a year as this would allow for seasonal variation i.e. presence of garden waste such as grass, hedge trimmings etc. during summer months. By using this audit tool you will be better able to determine a more accurate picture of what the waste is made up of, and also to see how well your household is recycling. Ideally an audit should be done early in the year and a follow on audit should be conducted later in the year. This would provide a clearer picture of the recycling efforts of your household and will also identify areas of the waste stream that need work to reduce it.

Scoping

Scoping is the initial step. It involves looking at the physical aspects, such as, number of bins, weight of bins, type of waste in the bins, where is most suited to, sort or spill the waste out and to determine if there are items or chemicals in the bins that are dangerous to ones health.

Health and Safety

Before starting an audit, a risk assessment must be carried out to safeguard the persons conducting the audit. A risk assessment is site specific to each different household as no two households are the same. This involves three basic things, namely:
Identify what the risks are,
Work out ways to eliminate, isolate or minimize the risks (i.e. Make a plan).
Put the plan into action. (This is on site).

Typical hazards that are encountered whilst conducting general waste audits are injuries due to sharp objects, such as needles, broken glass, chemicals or infectious waste. The bags or bins of waste can also be heavy, wet or difficult to grasp. As the house holder you should have a good idea of the waste composition or whether sharps have been placed in a bin. Implement a safety plan to protect you from health risks. Wear Personal Protective Equipment (PPE). The minimum list of items required for an audit is listed below:

- Gloves
- Antiseptic hand cleaner
- Shovel
- Tarp – (optional)
- Tongs (handling waste)
- Hose (clean the area after)
- Broom (cleaning)
- Sorting table (recommended)

- Bathroom Scales
- Suitable Clothing
- Suitable footwear
- Changing and washing facilities
- Audit W-MAT software

Setting up

In a waste audit firstly an area should be clear with adequate room provided so that waste can be spilled out. A protective film of plastic should be spread out over the ground to prevent ground contamination. The person conducting the audit should wear personal protective equipment as deemed necessary by the risk assessment. A sorting table should be set up in the middle of the designated area. Place the weighing scales near the waste bin so that you can dispose of items once you have weighed and classified them. The following tips are provided to assist you:

- An impervious floor i.e. a concrete or tiled surface or apron covered area that can easily be cleaned
- Good ventilation
- Safety, proper PPE, No Sharps etc..
- Location, isolated away from children or others
- Room for collection of bins/sorting
- Having hand washing or changing facilities. It is vital that auditors wash there hands thoroughly and change clothes and wash after an audit.

Sorting Waste

It is important to consider the size of the sample audited. In order to make the results obtained from your audit worth while, ensure that the sample is reflective of the normal waste generated in the household. Collect the household waste for one week e.g. from 00.00hrs Monday morning to the following 00.00hrs the following morning. Collect using 4 waste categories i.e. recycle waste, compost waste, hazardous waste, landfill waste.

1. Weigh each sorting bin whilst it is empty and perhaps record the weight on the outside of the bin.
2. Weigh the bag or bin you are sampling and record the weight on a record sheet.
3. Empty the bag or bin onto the sorting table.
4. Sort into the different category bins you are using.
5. Weight each bin of different category material separately and record the weight before disposing of the material (or recycling it if appropriate). Make sure the weight on the bin is subtracted from the recorded weight.
6. Keep going until all the waste has been sorted and the data has been logged into the W-MAT software programme.
7. Clean the place up and leave it as you found it.
8. Enter the data into spreadsheets to analyse it.

Managing data

To manage the audit data recorded it is good practice to save it to the C drive of the computer or laptop you use. Give it a name so that you can retrieve the audit data and results at a later date.

Analysing data

This is made simple by the W-MAT audit tool. Pie charts & bar graphs are automatically generated by the software to depict results. Depending on what the data collected will be used for, statistical analyse may need to be conducted, this can be done using a software programme such as Mini-tab. It is important to note that for any audit, how you are able to use the data will depend on how you collected it.

Follow up

Follow up is very important. The main objective for any audit is to provide a platform for action, and so the best conducted audit will be of little use without a follow up exercise.

APPENDIX F

General Information

Date	0
Household Name:	A
Address of Household:	A
Number of Occupants:	4
Total floor area [m^2]	196

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	1980's
Quantity of waste produced per week?	Full Bag
Annual Cost of waste disposal	€200-€300

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
77.00	House Details	Good
100.00	Household Waste	Excellent
90.00	Household Energy	Excellent
116.67	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	2.5
Newspaper/Mags	2.5
Aluminum cans	2.5
Glass	2.5
Plastic/Tetra Pak	3.75
Food waste/Organic	4
Hazardous Waste	3
Non Recyclables/Mixed waste	4
Textiles	2.5
Total weight of audited waste	25

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.6
Newspaper/Mags	0.4
Aluminum cans	0.6
Glass	2
Plastic/Tetra Pak	0.4
Total weight of audited waste	4

Energy Results

Category	Result
Electricty metre reading	100-110 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Factory Insulated
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	28
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	343.39
Annual achievable savings (Euro) €	201.54

Water Results

Category	Result
How is your water supplied	Group water scheme
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	189.57

eneral Information

Date	0
Household Name:	B
Address of Household:	B
Number of Occupants:	5
Total floor area [m^2]	195

welling Type

Category	Result
House Type?	Detached Dormer
Approximate year of construction?	2001-2005
Quantity of waste produced per week?	Half 140 Ltr Bin
Annual Cost of waste disposal	€400-€450

uestionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
67.00	House Details	Poor
90.63	Household Waste	Excellent
57.50	Household Energy	Very poor
87.50	Household Lights	Excellent
75.00	Household Water	Good

ousehold Waste Results

Waste Category	Weight per category
Cardboard	5
Newspaper/Mags	2.5
Aluminum cans	2.5
Glass	2.5
Plastic/Tetra Pak	2.5
Food waste/Organic	3
Hazardous Waste	3
Non Recyclables/Mixed waste	3
Textiles	2.5
Total weight of audited waste	25

Household Recycling Waste

Waste Category	Weight per category
Cardboard	2.3
Newspaper/Mags	4.6
Aluminum cans	2.3
Glass	11.5
Plastic/Tetra Pak	2.3
Total weight of audited waste	23

Energy Results

Category	Result
Electricty metre reading	90-100 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	Unsure

Lights Results

Category	Result
Number of light fittings	21
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	256.52
Annual achievable savings (Euro) €	166.08

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	154.79

General Information

Date	23/09/2008
Household Name:	C
Address of Household:	C
Number of Occupants:	2
Total floor area [m^2]	145

Dwelling Type

Category	Result
House Type?	Detached Bungalow
Approximate year of construction?	1960's
Quantity of waste produced per week?	Full Bag
Annual Cost of waste disposal	€300-350

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
67.00	House Details	Poor
92.63	Household Waste	Excellent
98.33	Household Energy	Excellent
116.67	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	3.2
Newspaper/Mags	1.6
Aluminum cans	0.8
Glass	2.4
Plastic/Tetra Pak	2.4
Food waste/Organic	2
Hazardous Waste	0
Non Recyclables/Mixed waste	2
Textiles	1.6
Total weight of audited waste	16

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.6
Newspaper/Mags	0.3
Aluminum cans	0.3
Glass	0.9
Plastic/Tetra Pak	0.9
Total weight of audited waste	3

Energy Results

Category	Result
Electricty metre reading	80-90 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	40
Annual Energy Usage (Kwh)	68
Annual Cost (Euro) €	519.18
Annual achievable savings (Euro) €	230.15

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	129.71

General Information

Date	0
Household Name:	D
Address of Household:	D
Number of Occupants:	1
Total floor area [m^2]	192

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	Other
Quantity of waste produced per week?	Full Bag
Annual Cost of waste disposal	€300-350

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
59.00	House Details	Very poor
100.00	Household Waste	Excellent
94.17	Household Energy	Excellent
100.00	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	3.2
Newspaper/Mags	1.6
Aluminum cans	0.8
Glass	2.4
Plastic/Tetra Pak	2.4
Food waste/Organic	2
Hazardous Waste	0
Non Recyclables/Mixed waste	2
Textiles	1.6
Total weight of audited waste	16

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.6
Newspaper/Mags	0.3
Aluminum cans	0.3
Glass	0.9
Plastic/Tetra Pak	0.9
Total weight of audited waste	3

Energy Results

Category	Result
Electricty metre reading	90-100 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	No Cavity Insulation
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	33
Annual Energy Usage (Kwh)	68
Annual Cost (Euro) €	422.09
Annual achievable savings (Euro) €	193.87

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	196.43

General Information

Date	0
Household Name:	E
Address of Household:	E
Number of Occupants:	5
Total floor area [m^2]	195

Dwelling Type

Category	Result
House Type?	Detached Dormer
Approximate year of construction?	2001-2005
Quantity of waste produced per week?	Half 140 Ltr Bin
Annual Cost of waste disposal	€400-€450

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
67.00	House Details	Poor
90.63	Household Waste	Excellent
57.50	Household Energy	Very poor
87.50	Household Lights	Excellent
75.00	Household Water	Good

Household Waste Results

Waste Category	Weight per category
Cardboard	5
Newspaper/Mags	2.5
Aluminum cans	2.5
Glass	2.5
Plastic/Tetra Pak	2.5
Food waste/Organic	3
Hazardous Waste	3
Non Recyclables/Mixed waste	3
Textiles	2.5
Total weight of audited waste	25

Household Recycling Waste

Waste Category	Weight per category
Cardboard	2.3
Newspaper/Mags	4.6
Aluminum cans	2.3
Glass	11.5
Plastic/Tetra Pak	2.3
Total weight of audited waste	23

Energy Results

Category	Result
Electricty metre reading	90-100 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	Unsure

Lights Results

Category	Result
Number of light fittings	21
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	256.52
Annual achievable savings (Euro) €	166.08

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	154.79

General Information

Date	0
Household Name:	F
Address of Household:	F
Number of Occupants:	4
Total floor area [m^2]	172

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	Other
Quantity of waste produced per week?	Full Bag
Annual Cost of waste disposal	€350-€400

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
59.00	House Details	Very poor
100.00	Household Waste	Excellent
76.67	Household Energy	Good
116.67	Household Lights	Excellent
87.50	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	1.6
Newspaper/Mags	1.6
Aluminum cans	1.6
Glass	1.6
Plastic/Tetra Pak	2.4
Food waste/Organic	2
Hazardous Waste	2
Non Recyclables/Mixed waste	2
Textiles	1.6
Total weight of audited waste	16

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.675
Newspaper/Mags	0.45
Aluminum cans	0.675
Glass	2.25
Plastic/Tetra Pak	0.45
Total weight of audited waste	4.5

Energy Results

Category	Result
Electricty metre reading	100-110 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	No Cavity insulation
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	31
Annual Energy Usage (Kwh)	68
Annual Cost (Euro) €	369.96
Annual achievable savings (Euro) €	157.90

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	185.07

General Information

Date	0
Household Name:	G
Address of Household:	G
Number of Occupants:	1
Total floor area [m^2]	169

Dwelling Type

Category	Result
House Type?	Detached Bungalow
Approximate year of construction?	1970's
Quantity of waste produced per week?	Half Bag
Annual Cost of waste disposal	€350-€400

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
71.00	House Details	Good
92.63	Household Waste	Excellent
68.33	Household Energy	Poor
108.33	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	2.8
Newspaper/Mags	1.4
Aluminum cans	1.4
Glass	1.4
Plastic/Tetra Pak	1.4
Food waste/Organic	1
Hazardous Waste	1
Non Recyclables/Mixed waste	1
Textiles	1.4
Total weight of audited waste	14

Household Recycling Waste

Waste Category	Weight per category
Cardboard	2.3
Newspaper/Mags	4.6
Aluminum cans	2.3
Glass	11.5
Plastic/Tetra Pak	2.3
Total weight of audited waste	23

Energy Results

Category	Result
Electricty metre reading	80-90 Euro
Window/Door glazing	Aluminum Frame double glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	Unsure

Lights Results

Category	Result
Number of light fittings	26
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	225.86
Annual achievable savings (Euro) €	112.52

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	151.24

General Information

Date	0
Household Name:	H
Address of Household:	H
Number of Occupants:	1
Total floor area [m^2]	156

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	Other
Quantity of waste produced per week?	Half Bag
Annual Cost of waste disposal	€100-€200

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
55.00	House Details	Very poor
85.25	Household Waste	Excellent
50.42	Household Energy	Very poor
75.00	Household Lights	Good
68.75	Household Water	Poor

Household Waste Results

Waste Category	Weight per category
Cardboard	1.2
Newspaper/Mags	1.2
Aluminum cans	0.4
Glass	1.2
Plastic/Tetra Pak	1.2
Food waste/Organic	1
Hazardous Waste	0
Non Recyclables/Mixed waste	1
Textiles	0.8
Total weight of audited waste	8

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.225
Newspaper/Mags	0.15
Aluminum cans	0.225
Glass	0.45
Plastic/Tetra Pak	0.45
Total weight of audited waste	1.5

Energy Results

Category	Result
Electricty metre reading	70-80 Euro
Window/Door glazing	Wooden frame single glaze
Insulation type on hot water store	Lagging Jacket
Attic Insulated	Fibre glass quilt
Cavity Insulation	No Cavity insulation
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	21
Annual Energy Usage (Kwh)	68
Annual Cost (Euro) €	313.75
Annual achievable savings (Euro) €	188.35

Water Results

Category	Result
How is your water supplied	Private well
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	64.88

General Information

Date	0
Household Name:	I
Address of Household:	I
Number of Occupants:	4
Total floor area [m^2]	196

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	1980's
Quantity of waste produced per week?	Full Bag
Annual Cost of waste disposal	€200-€300

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
77.00	House Details	Good
100.00	Household Waste	Excellent
90.00	Household Energy	Excellent
116.67	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	2.5
Newspaper/Mags	2.5
Aluminum cans	2.5
Glass	2.5
Plastic/Tetra Pak	3.75
Food waste/Organic	4
Hazardous Waste	3
Non Recyclables/Mixed waste	4
Textiles	2.5
Total weight of audited waste	25

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.6
Newspaper/Mags	0.4
Aluminum cans	0.6
Glass	2
Plastic/Tetra Pak	0.4
Total weight of audited waste	4

Energy Results

Category	Result
Electricty metre reading	100-110 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Factory Insulated
Attic Insulated	Fibre glass quilt
Cavity Insulation	Aeroboard
Renewable Energy	No renewable energy
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	28
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	343.39
Annual achievable savings (Euro) €	201.54

Water Results

Category	Result
How is your water supplied	Group water scheme
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	189.57

General Information

Date	0
Household Name:	J
Address of Household:	J
Number of Occupants:	6
Total floor area [m^2]	204

Dwelling Type

Category	Result
House Type?	Detached Two-Storey
Approximate year of construction?	1996-2000
Quantity of waste produced per week?	Full 240 Ltr Bin
Annual Cost of waste disposal	€550-€600

Questionaire Results

Percentage of scores obtained in Questionaires (%)	Energy Classification	Grade for each section
100.00	House Details	Excellent
100.00	Household Waste	Excellent
90.00	Household Energy	Excellent
116.67	Household Lights	Excellent
81.25	Household Water	Excellent

Household Waste Results

Waste Category	Weight per category
Cardboard	2.5
Newspaper/Mags	2.5
Aluminum cans	2.5
Glass	2.5
Plastic/Tetra Pak	3.75
Food waste/Organic	4
Hazardous Waste	3
Non Recyclables/Mixed waste	4
Textiles	2.5
Total weight of audited waste	25

Household Recycling Waste

Waste Category	Weight per category
Cardboard	0.6
Newspaper/Mags	0.4
Aluminum cans	0.6
Glass	2
Plastic/Tetra Pak	0.4
Total weight of audited waste	4

Energy Results

Category	Result
Electricty metre reading	110-120 Euro
Window/Door glazing	U.p.v.c Double glaze
Insulation type on hot water store	Factory Insulated
Attic Insulated	Pumped fibre insulation
Cavity Insulation	Pumped bead insulation
Renewable Energy	Solar
Type of fuel used?	Oil & Solid fuel
Temperature Boiler is set at?	60-70 degrees Celcius

Lights Results

Category	Result
Number of light fittings	28
Annual Energy Usage (Kwh)	60
Annual Cost (Euro) €	267.76
Annual achievable savings (Euro) €	157.39

Water Results

Category	Result
How is your water supplied	Group water scheme
Total Water Delivered (Metered amount (M^3))	0
Total Water Usage (Approximation Gallons)	189.57

APPENDIX G

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: A

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	Yes
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: B

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	No
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	Yes
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: C

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name:	D

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: E

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you **move** between worksheets easily?	Yes
3	Did you find it easy to **answer** the drop down **menus** provided?	Yes
4	Do you think the questions **are** appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain **results**?	Yes
8	Did you obtain the automatic **recommendations**?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name:	F

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: G

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	No
2	Could you move between worksheets easily?	No
3	Did you find it easy to answer the drop down menus provided?	No
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	Yes
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: H

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name:

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Household Audit Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name: J

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Table G.1 Household Audit Result Classification

Excellent Ex	<80%
Good (G)	<70>80%
Poor (P)	<60>70%
V. Poor (V.P)	>60%

Table G.2 Household Audit Results

Household Name	Household Details	Household Waste	Household Energy	Household Lights	Household Water
A	G	Ex	Ex	Ex	Ex
B	P	Ex	V.P	Ex	G
C	P	Ex	Ex	Ex	Ex
D	V.P	Ex	Ex	Ex	Ex
E	P	Ex	V.P	Ex	G
F	V.P	Ex	G	Ex	Ex
G	G	Ex	P	Ex	Ex
H	V.P	Ex	V.P	G	P
I	G	Ex	Ex	Ex	Ex
J	Ex	Ex	Ex	Ex	Ex

APPENDIX H

APPENDIX I

esults

Property Details:	
Address Line 1:	The Square
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	188
Occupancy	6

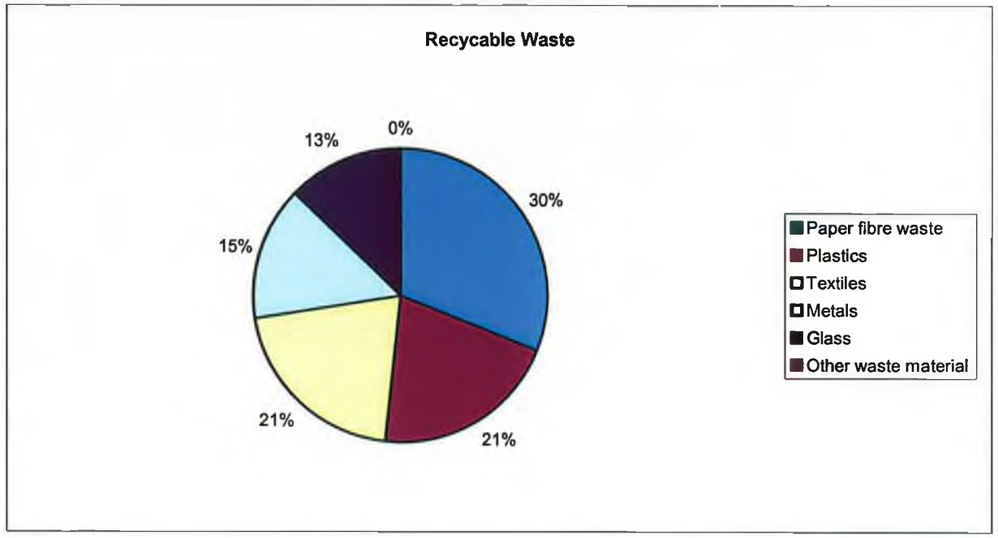
Assessor	
Name	Ivor H

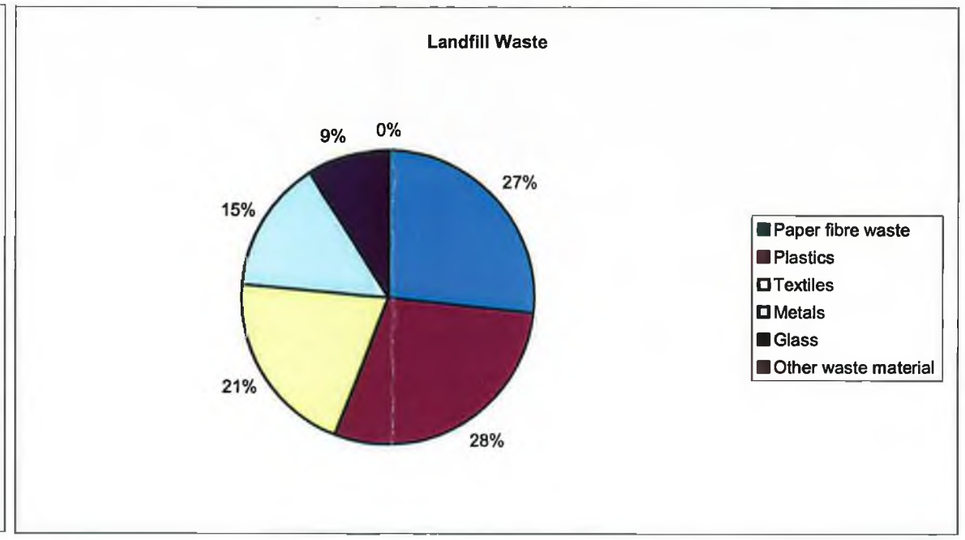
Recycable Waste	
Paper fibre waste	3.29
Plastics	2.18
Textiles	2.2
Metals	1.54
Glass	1.36
Other waste material	0
Total recyclable waste	10.57
Per occupant average	1.76

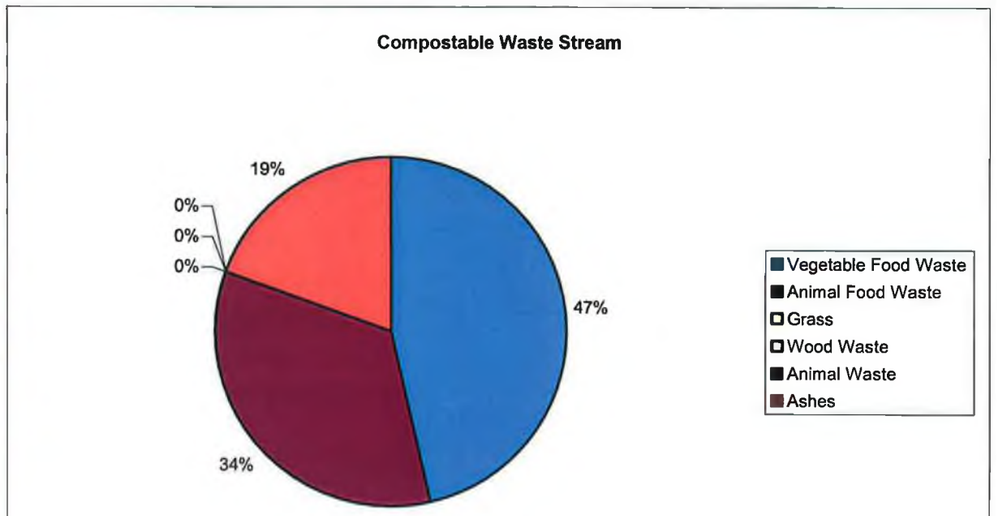
Compostable Waste	
Vegetable Food Waste	3.1
Animal Food Waste	2.3
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.3
Total organic waste	6.7
Per occupant average	1.12

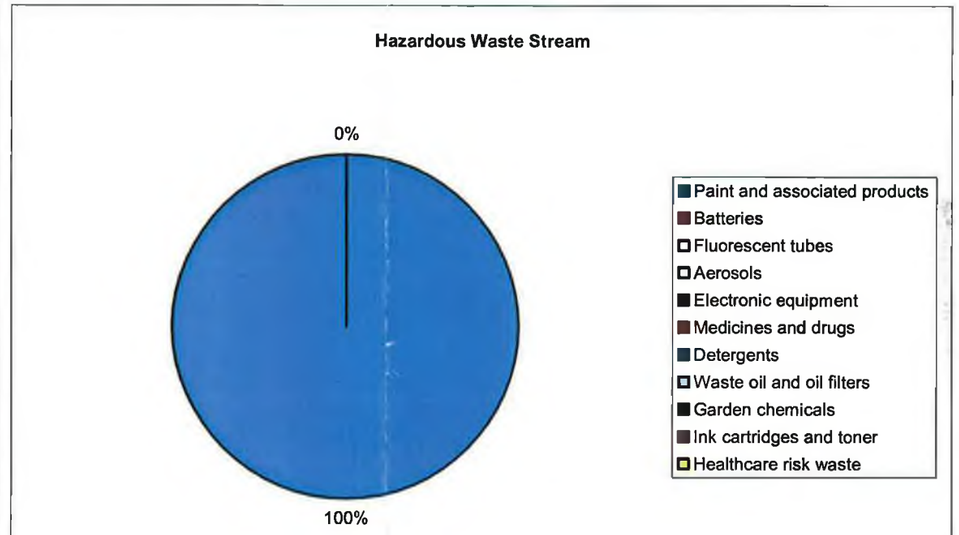
Landfill Waste	
Paper fibre waste	3.56
Plastics	3.94
Textiles	2.75
Metals	1.95
Glass	1.2
Other waste material	0
Total landfill waste	13.4
Per occupant average	2.23

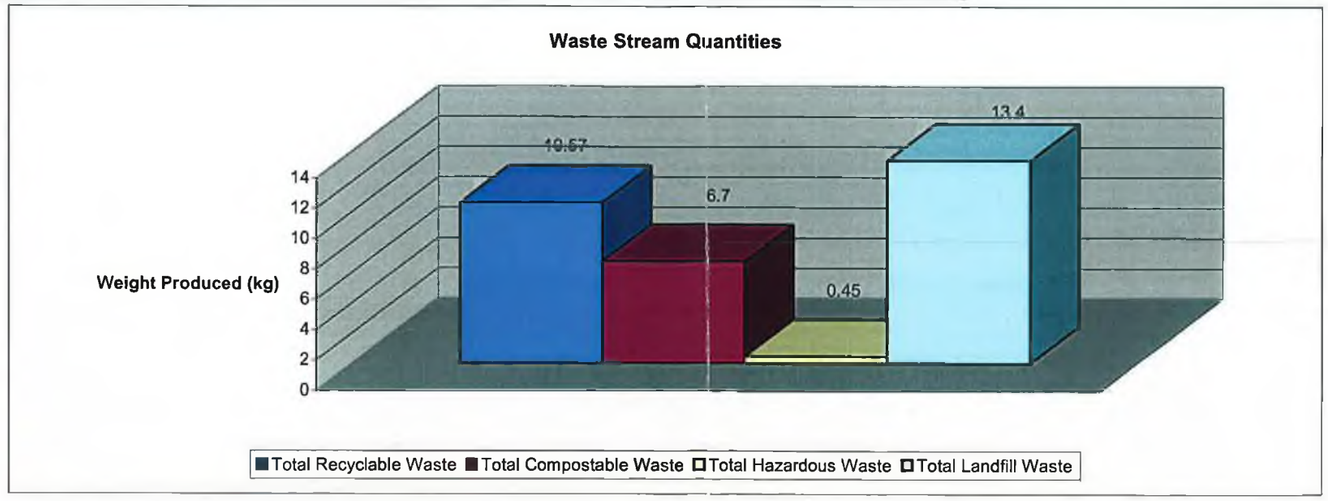
Hazardous Waste	
int and associated products	0.45
Batteries	0
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	0.45
Per occupant average	0.08











esults

Property Details:	
Address Line 1:	Newtown
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	158
Occupancy	5

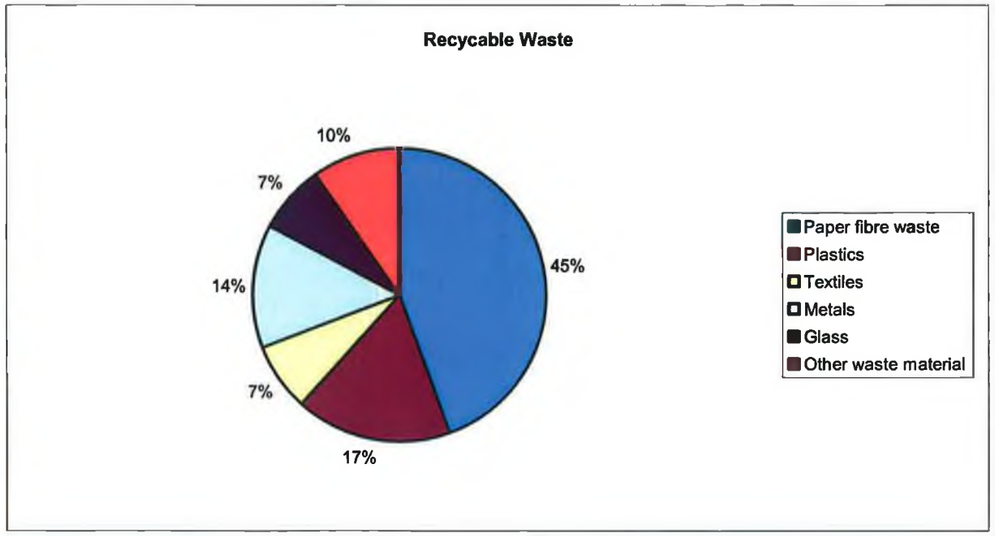
Assessor	
Name	Ivor H

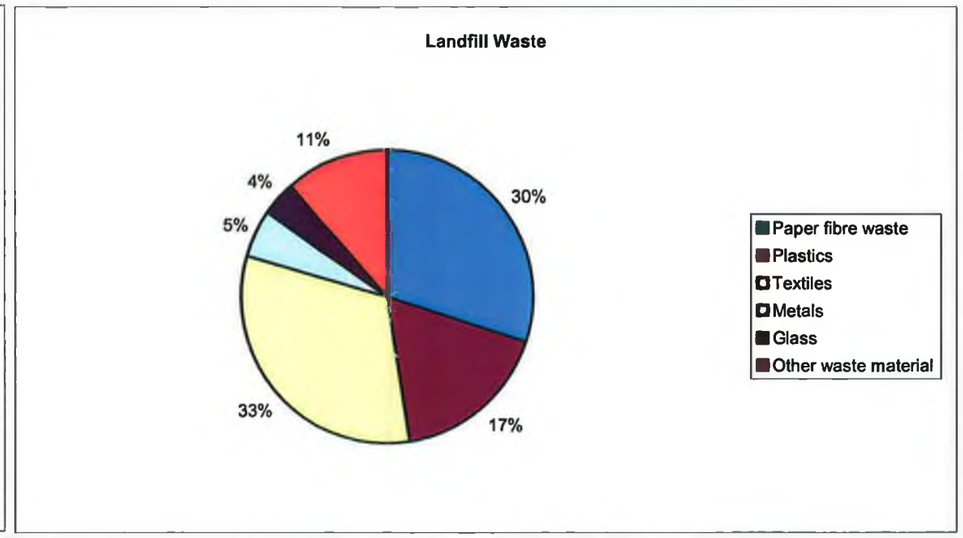
Recycable Waste	
Paper fibre waste	5.46
Plastics	2.13
Textiles	0.9
Metals	1.7
Glass	0.9
Other waste material	1.2
Total recyclable waste	12.29
Per occupant average	2.46

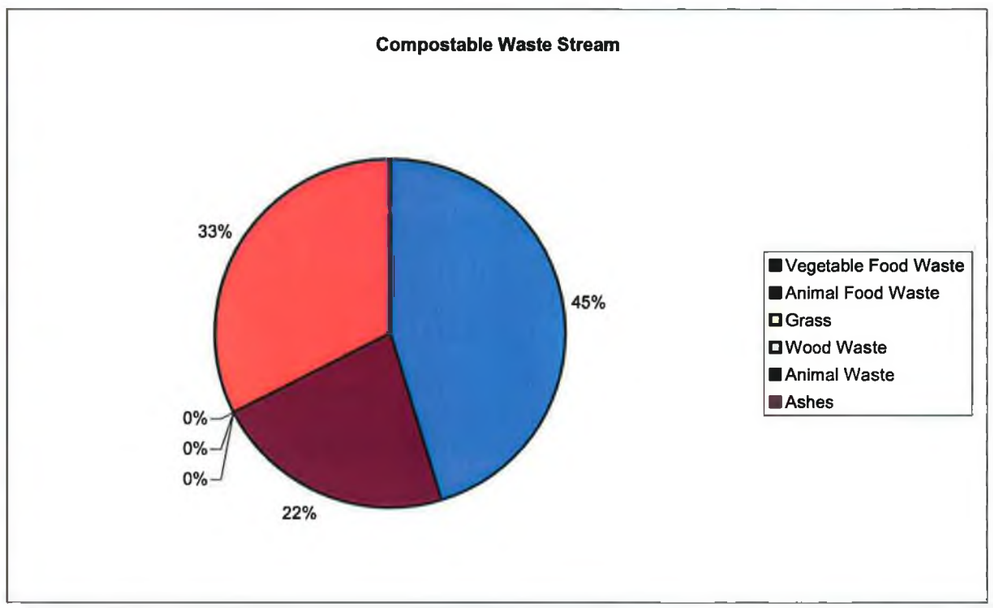
Compostable Waste	
Vegetable Food Waste	2.5
Animal Food Waste	1.23
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.8
Total organic waste	5.53
Per occupant average	1.11

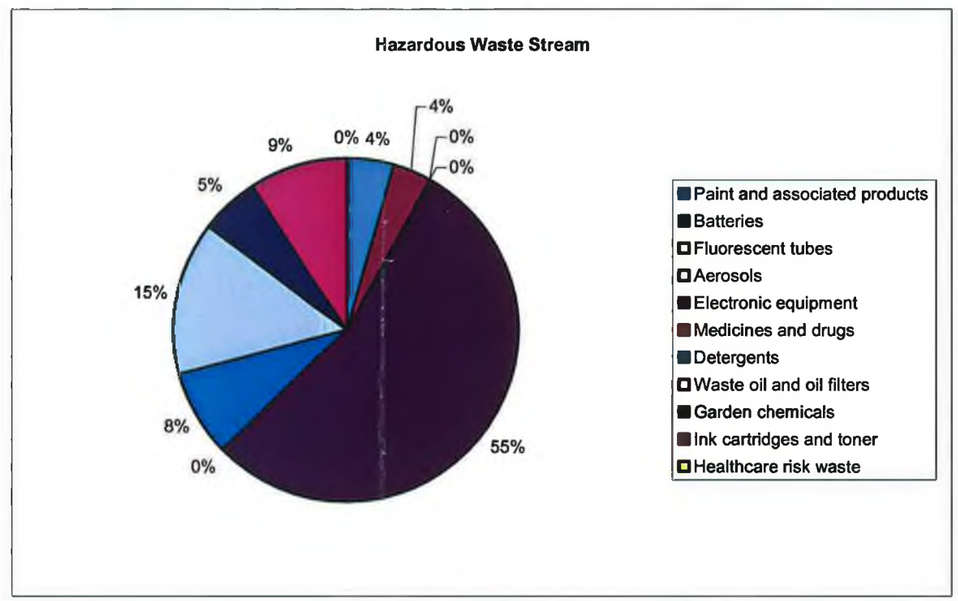
Landfill Waste	
Paper fibre waste	3.92
Plastics	2.29
Textiles	4.2
Metals	0.71
Glass	0.49
Other waste material	1.5
Total landfill waste	13.11
Per occupant average	2.622

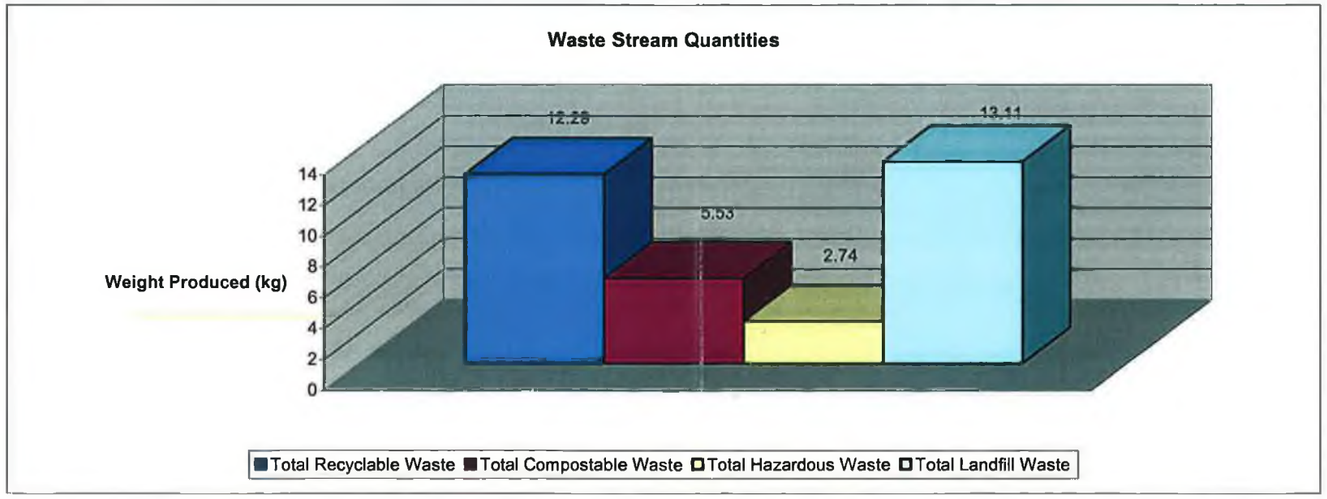
Hazardous Waste	
aint and associated products	0.12
Batteries	0.1
Fluorescent tubes	0
Aerosols	0
Electronic equipment	1.5
Medicines and drugs	0
Detergents	0.22
Waste oil and oil filters	0.4
Garden chemicals	0.15
Ink cartridges and toner	0.25
Healthcare risk waste	0
Total hazardous waste	2.74
Per occupant average	0.55











/-MAT Field Trial II Results

Property Details:	
Address Line 1:	Roscommon Rd
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	143
Occupancy	8

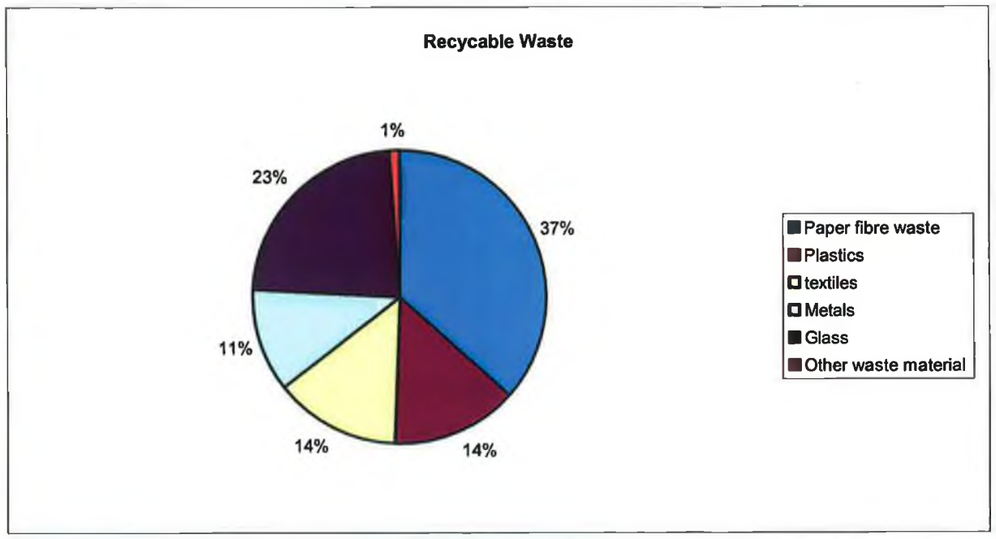
Assessor	
Name	Ivor H

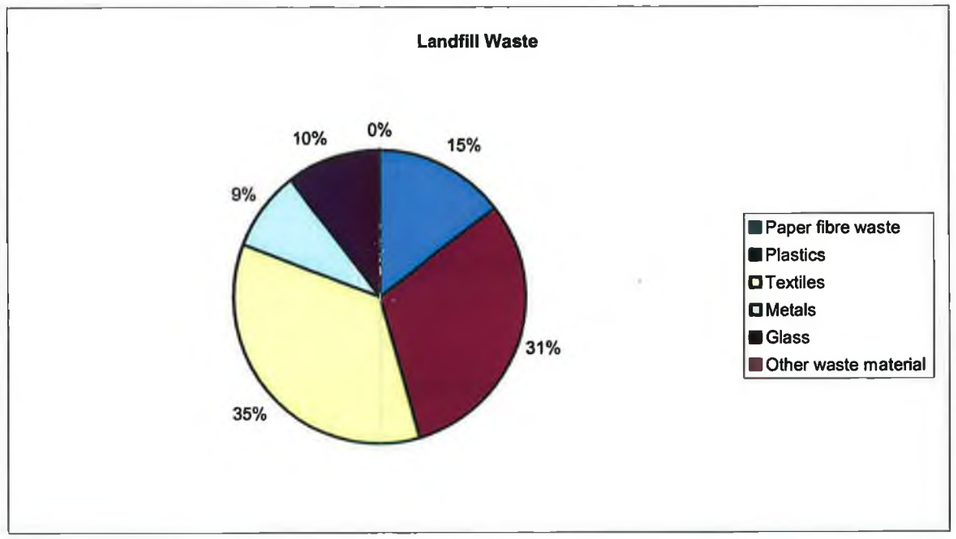
Recycable Waste	
Paper fibre waste	3.2
Plastics	1.2
textiles	1.2
Metals	1
Glass	2
Other waste material	0.1
Total recyclable waste	8.7
Per occupant average	1.0875

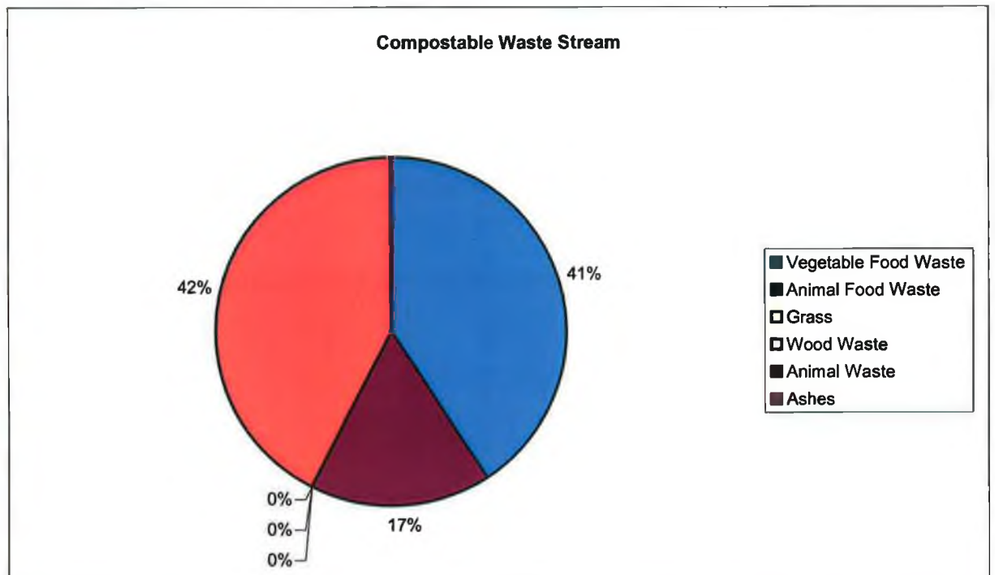
Compostable Waste	
Vegetable Food Waste	2.2
Animal Food Waste	0.9
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	2.3
Total organic waste	5.4
Per occupant average	0.675

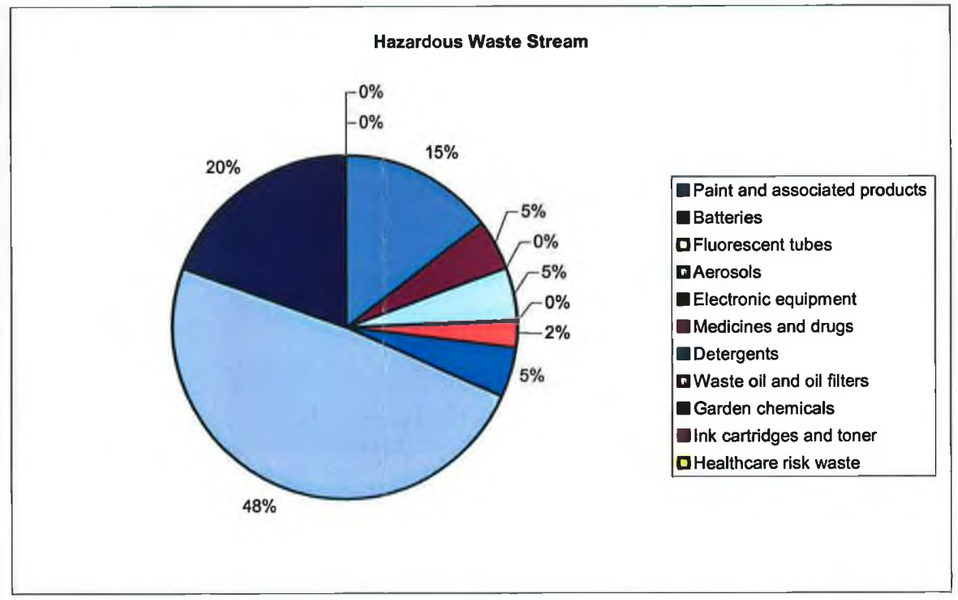
Landfill Waste	
Paper fibre waste	1
Plastics	2.1
Textiles	2.4
Metals	0.6
Glass	0.7
Other waste material	0
Total landfill waste	6.8
Per occupant average	0.85

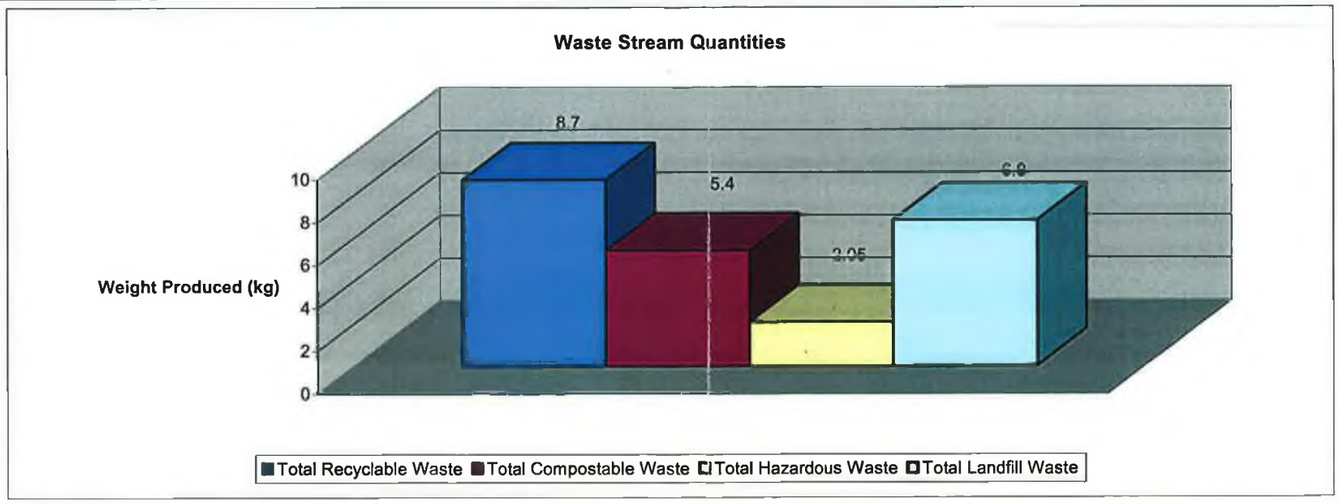
Hazardous Waste	
aint and associated products	0.3
Batteries	0.1
Fluorescent tubes	0
Aerosols	0.1
Electronic equipment	0
Medicines and drugs	0.05
Detergents	0.1
Waste oil and oil filters	1
Garden chemicals	0.4
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	2.05
Per occupant average	0











esults

Property Details:	
Address Line 1:	The Square
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	138
Occupancy	5

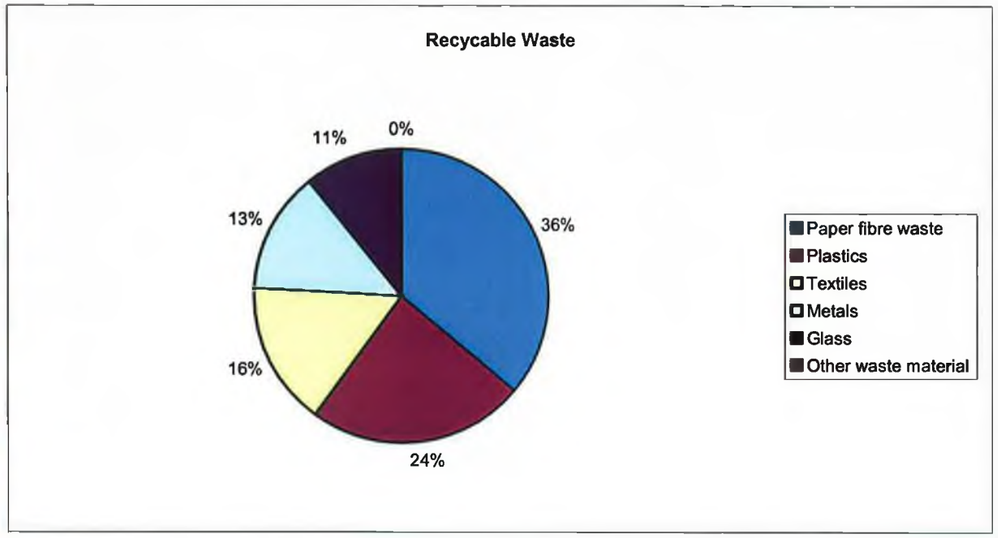
Assessor	
Name	Ivor H

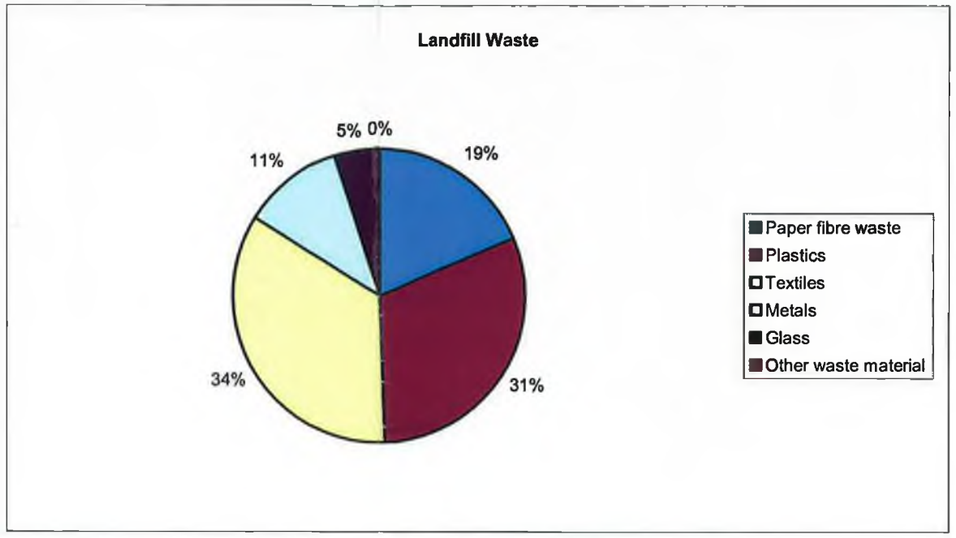
Recycable Waste	
Paper fibre waste	3.2
Plastics	2.12
Textiles	1.4
Metals	1.19
Glass	0.95
Other waste material	0
Total recyclable waste	8.86
Per occupant average	1.77

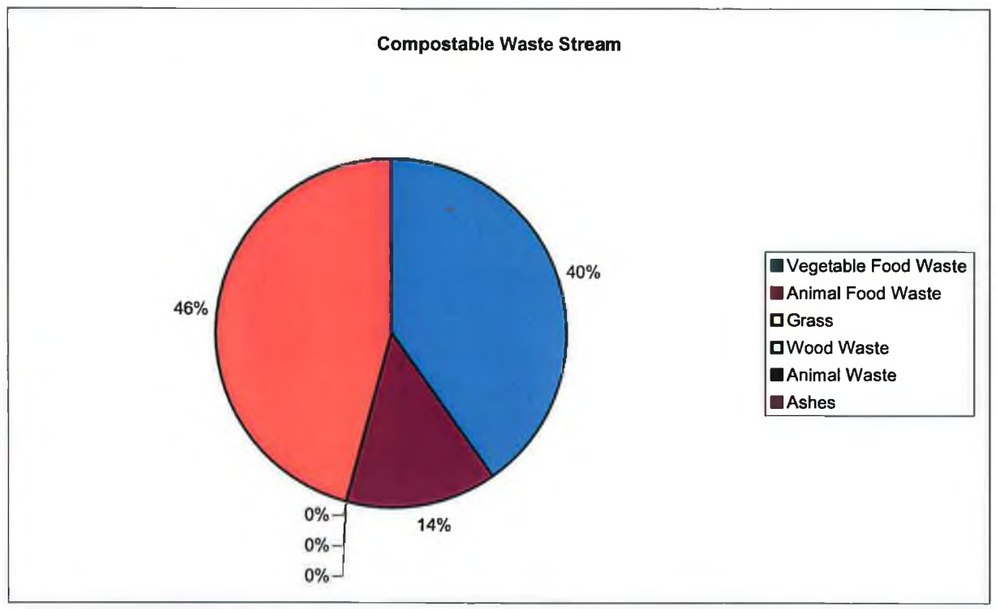
Compostable Waste	
Vegetable Food Waste	2.45
Animal Food Waste	0.85
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	2.8
Total organic waste	6.1
Per occupant average	1.22

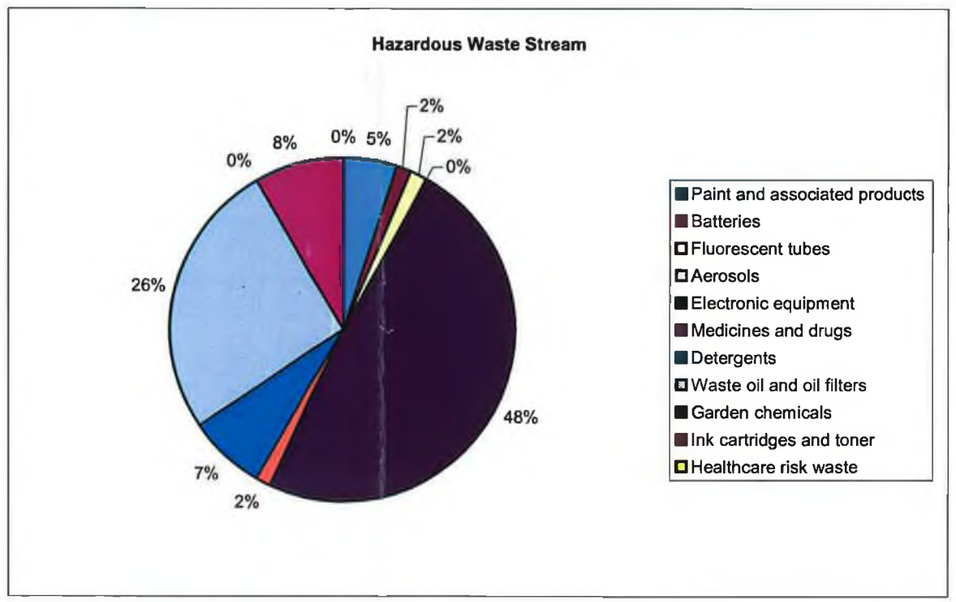
Landfill Waste	
Paper fibre waste	1.79
Plastics	2.95
Textiles	3.31
Metals	1.05
Glass	0.49
Other waste material	0
Total landfill waste	9.59
Per occupant average	1.918

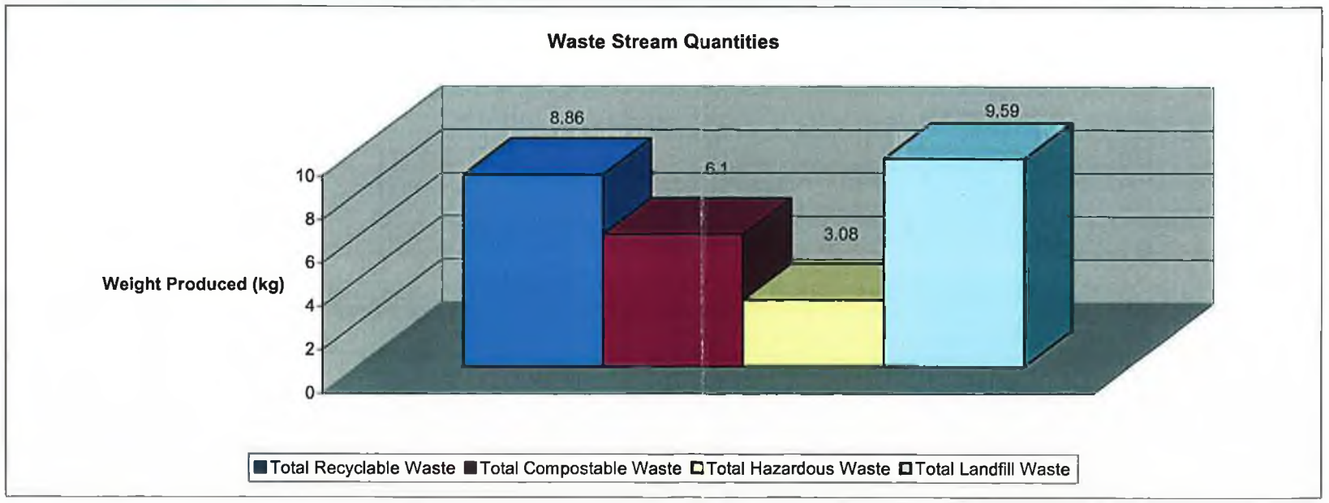
Hazardous Waste	
int and associated products	0.15
Batteries	0.05
Fluorescent tubes	0.05
Aerosols	0
Electronic equipment	1.5
Medicines and drugs	0.05
Detergents	0.22
Waste oil and oil filters	0.8
Garden chemicals	0
Ink cartridges and toner	0.26
Healthcare risk waste	0
Total Hazardous waste	3.08
Per occupant average	0.62











esults

Property Details:	
Address Line 1:	Greenville
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	128
Occupancy	3

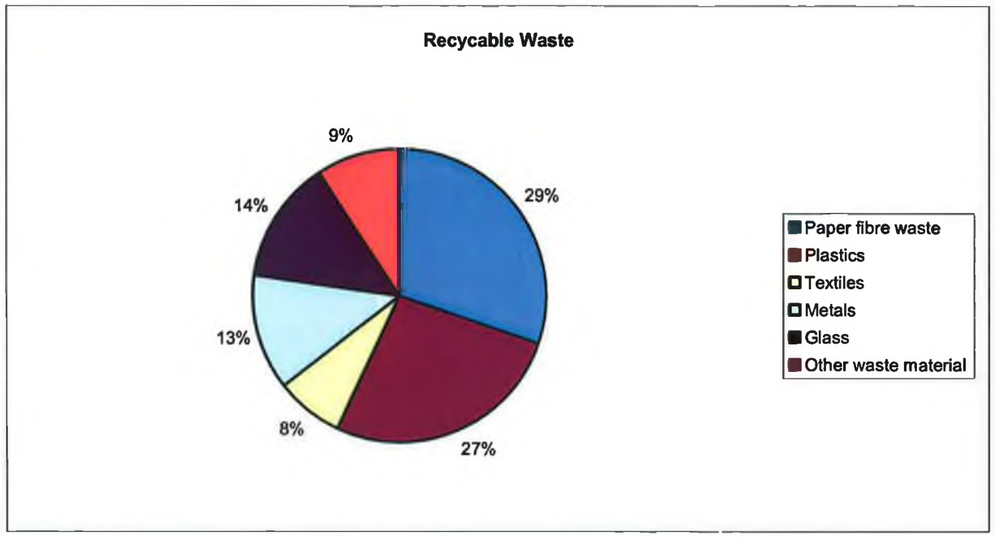
Assessor	
Name	Ivor H

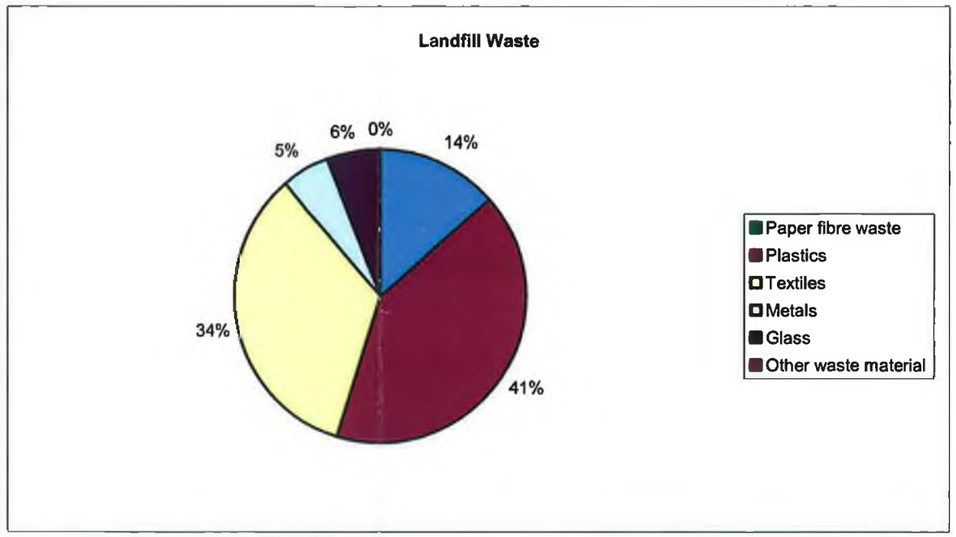
Recycable Waste	
Paper fibre waste	4
Plastics	3.55
Textiles	1
Metals	1.7
Glass	1.8
Other waste material	1.2
Total recyclable waste	13.25
Per occupant average	4.42

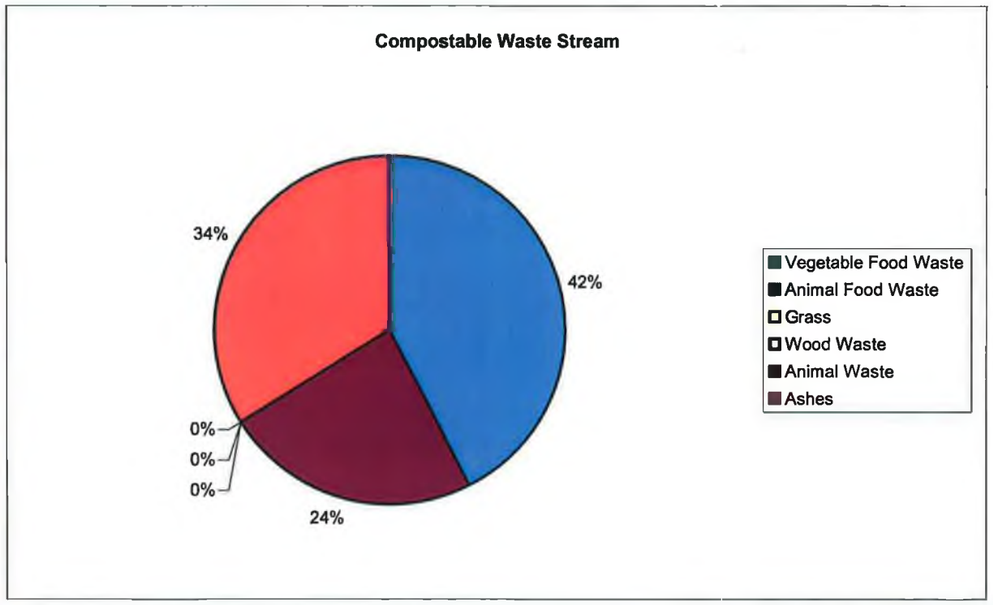
Compostable Waste	
Vegetable Food Waste	2.5
Animal Food Waste	1.4
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	2
Total organic waste	5.9
Per occupant average	1.97

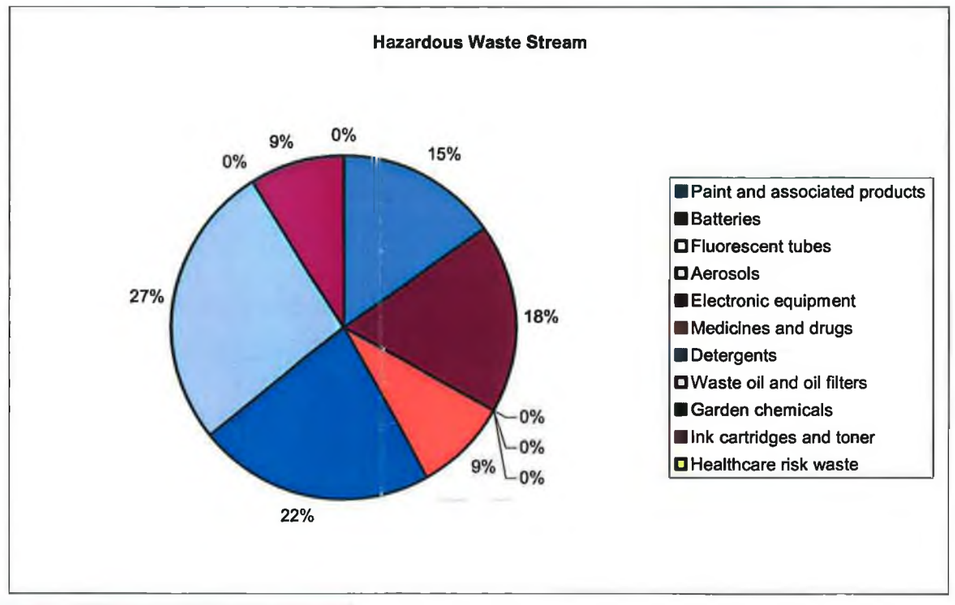
Landfill Waste	
Paper fibre waste	0.87
Plastics	2.64
Textiles	2.2
Metals	0.35
Glass	0.37
Other waste material	0
Total landfill waste	6.43
Per occupant average	2.14

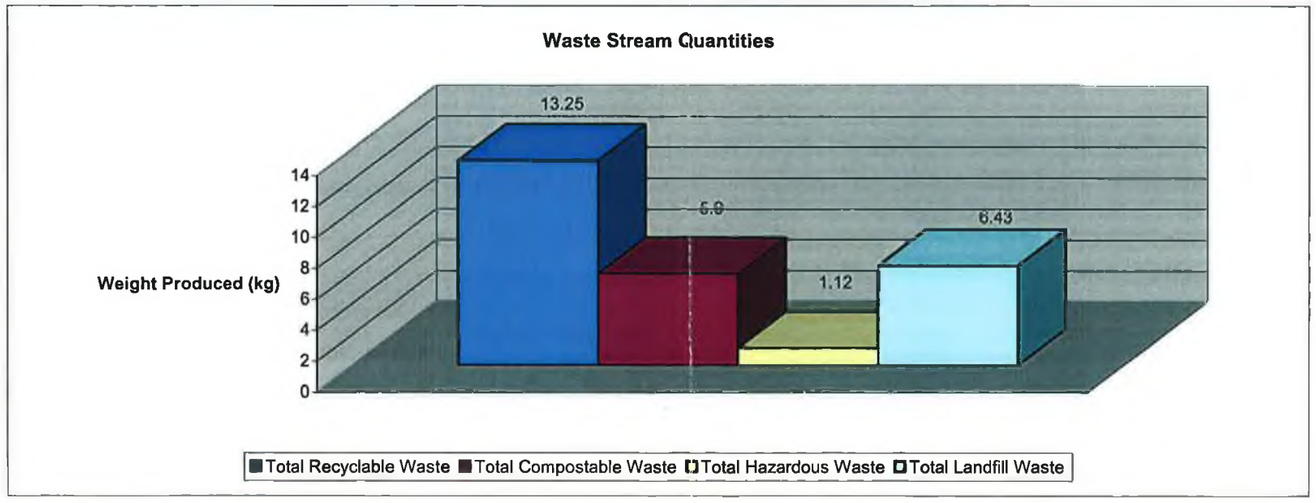
Hazardous Waste	
aint and associated products	0.17
Batteries	0.2
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0.1
Detergents	0.25
Waste oil and oil filters	0.3
Garden chemicals	0
Ink cartridges and toner	0.1
Healthcare risk waste	0
Total hazardous waste	1.12
Per occupant average	0.37











esults

Property Details:	
Address Line 1:	The Square
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	134
Occupancy	2

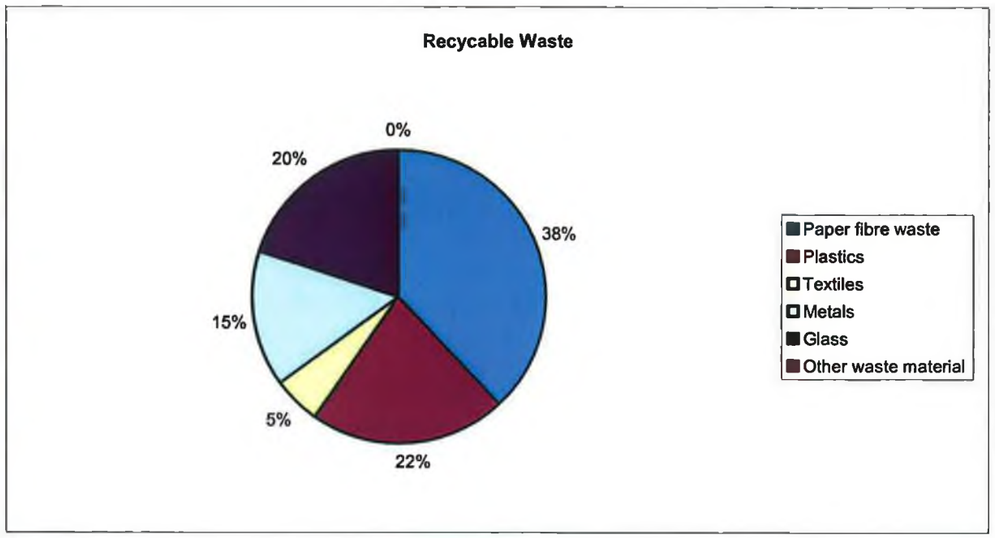
Assessor	
Name	Ivor H

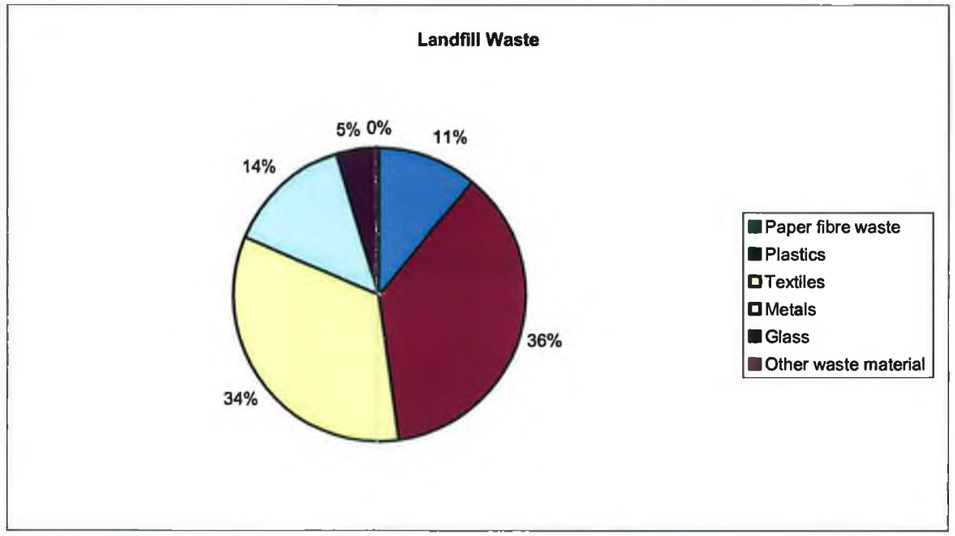
Recycable Waste	
Paper fibre waste	3.6
Plastics	2.05
Textiles	0.5
Metals	1.4
Glass	1.9
Other waste material	0
Total recyclable waste	9.45
Per occupant average	4.725

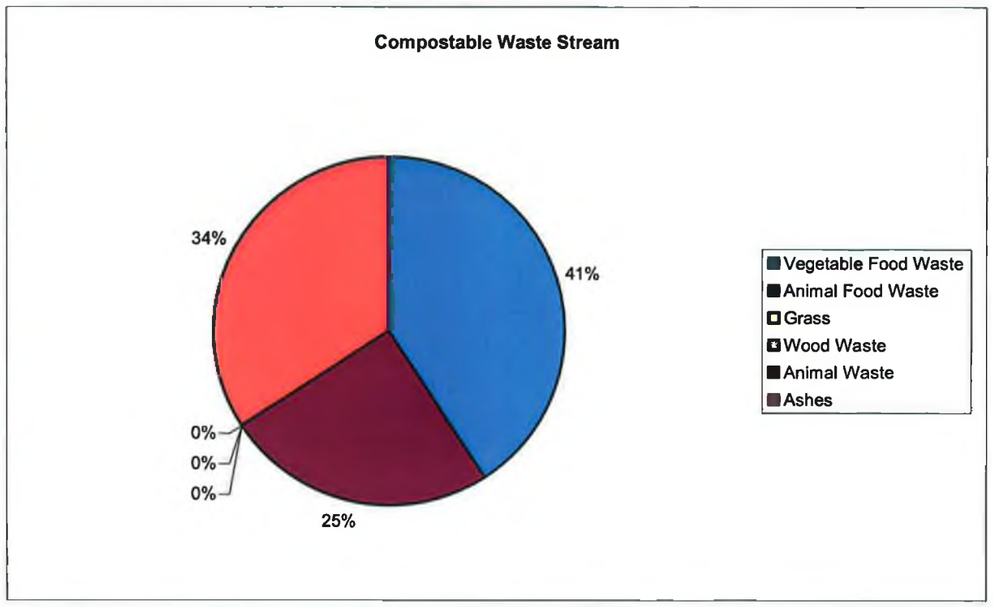
Compostable Waste	
Vegetable Food Waste	1.8
Animal Food Waste	1.1
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.5
Total organic waste	4.4
Per occupant average	2.2

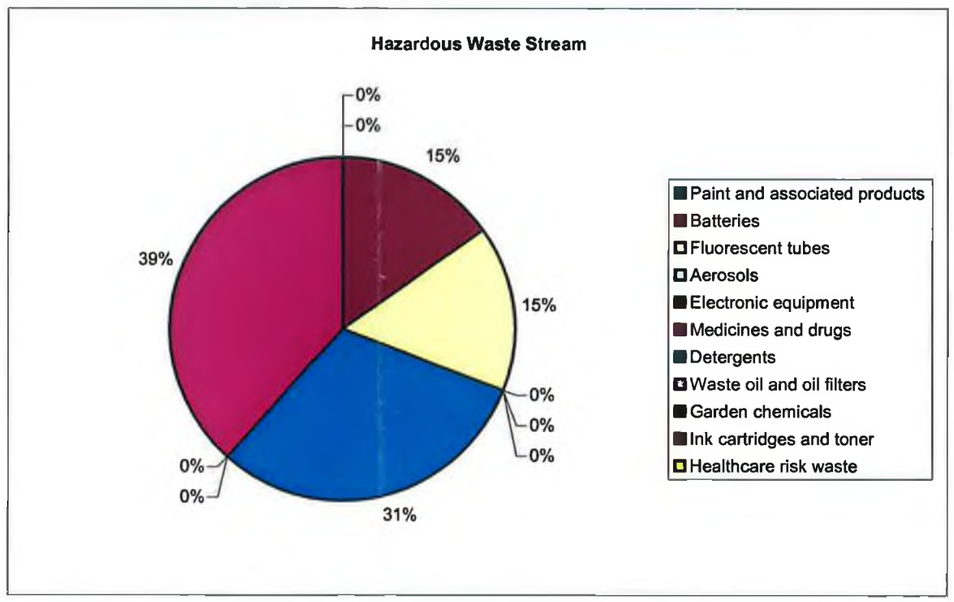
Landfill Waste	
Paper fibre waste	0.6
Plastics	1.95
Textiles	1.8
Metals	0.75
Glass	0.25
Other waste material	0
Total landfill waste	5.35
Per occupant average	2.675

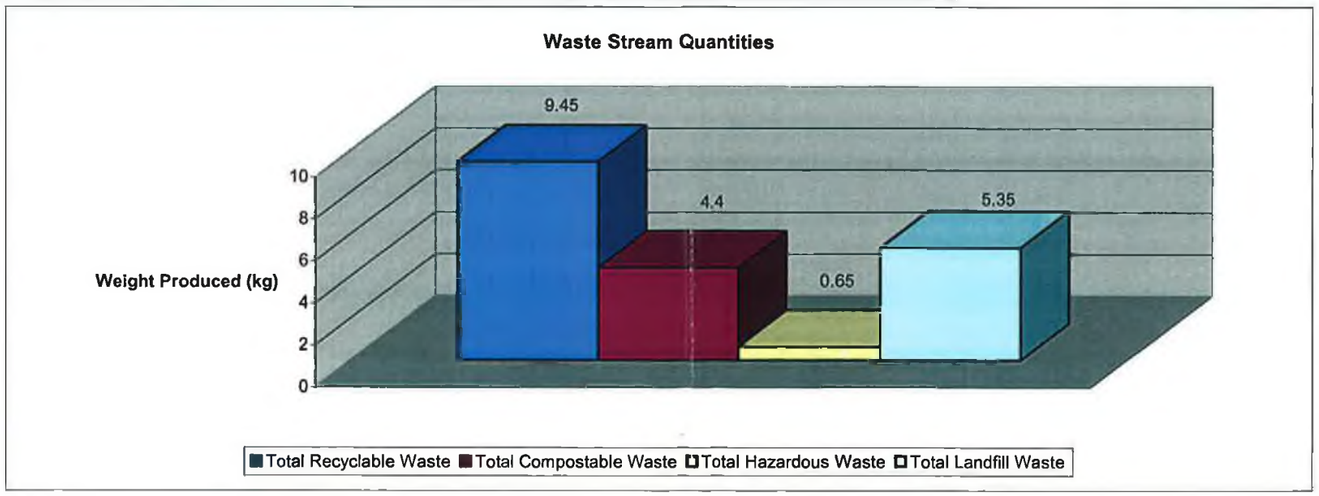
Hazardous Waste	
aint and associated products	0
Batteries	0.1
Fluorescent tubes	0.1
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0.2
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0.25
Healthcare risk waste	0
Total hazardous waste	0.65
Per occupant average	0











esults

Property Details:	
Address Line 1:	The Square
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	178
Occupancy	3

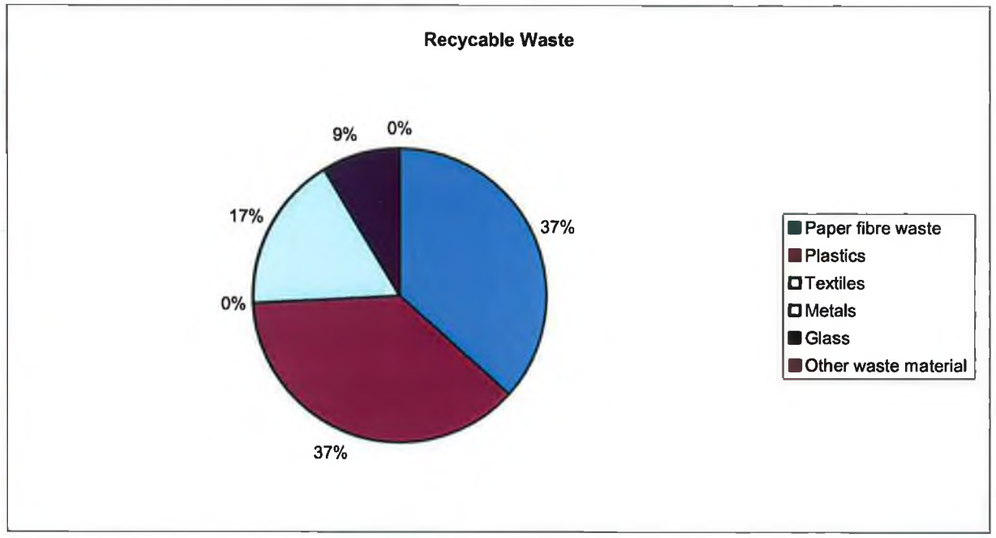
Assessor	
Name	Ivor H

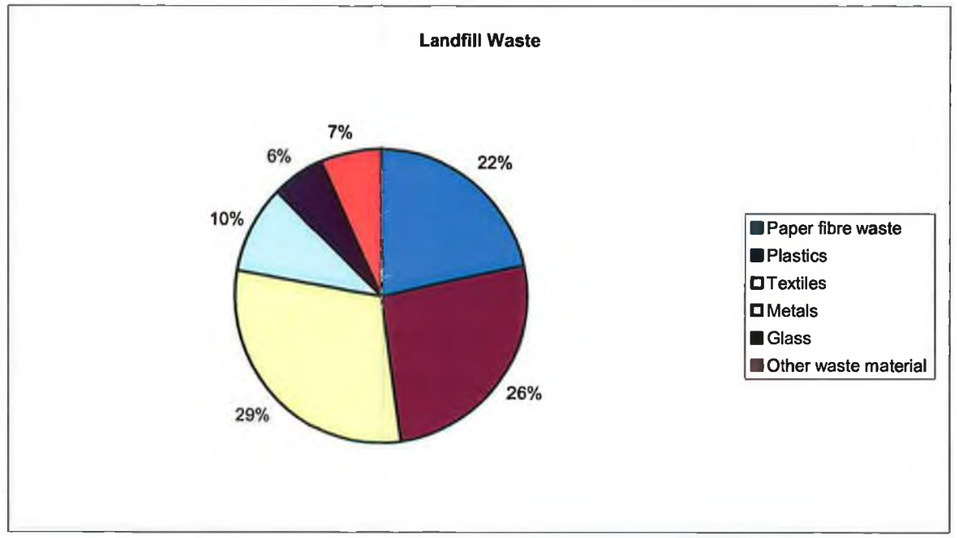
Recycable Waste	
Paper fibre waste	3.78
Plastics	3.88
Textiles	0
Metals	1.79
Glass	0.88
Other waste material	0
Total recyclable waste	10.33
Per occupant average	3.44

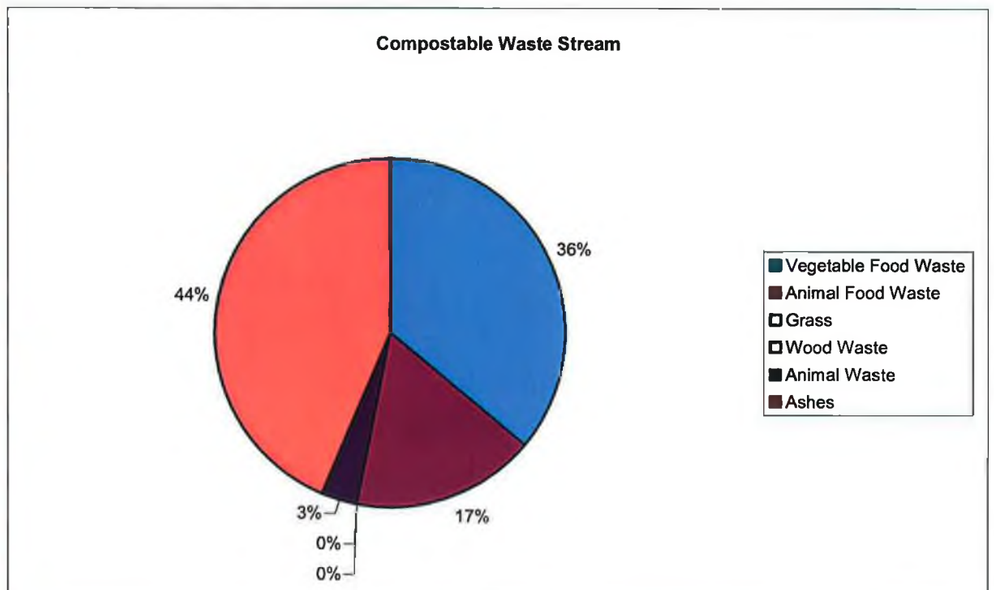
Compostable Waste	
Vegetable Food Waste	2.89
Animal Food Waste	1.37
Grass	0
Wood Waste	0
Animal Waste	0.26
Ashes	3.5
Total organic waste	8.02
Per occupant average	2.67

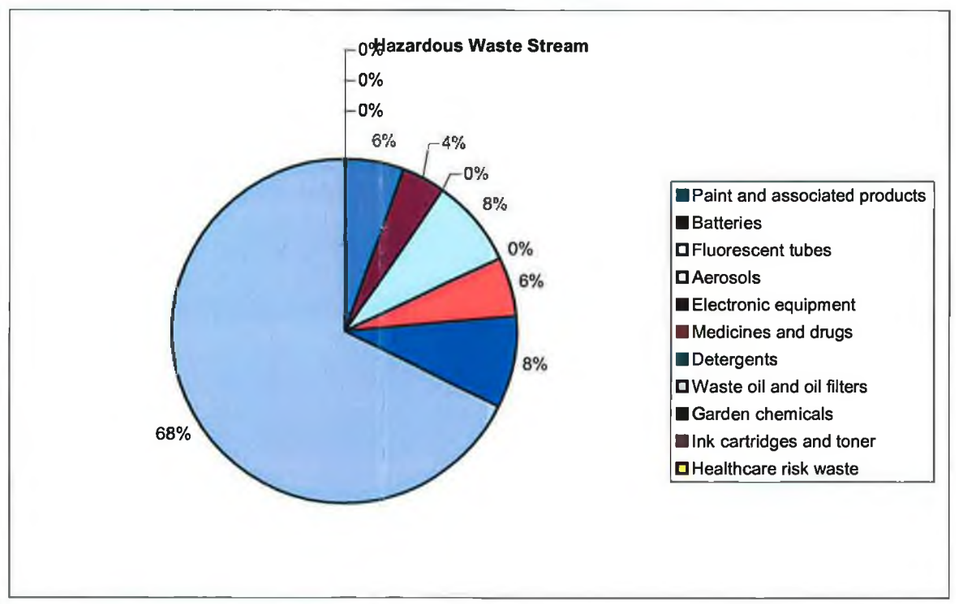
Landfill Waste	
Paper fibre waste	3.6
Plastics	4.32
Textiles	4.99
Metals	1.63
Glass	0.97
Other waste material	1.1
Total landfill waste	16.61
Per occupant average	5.54

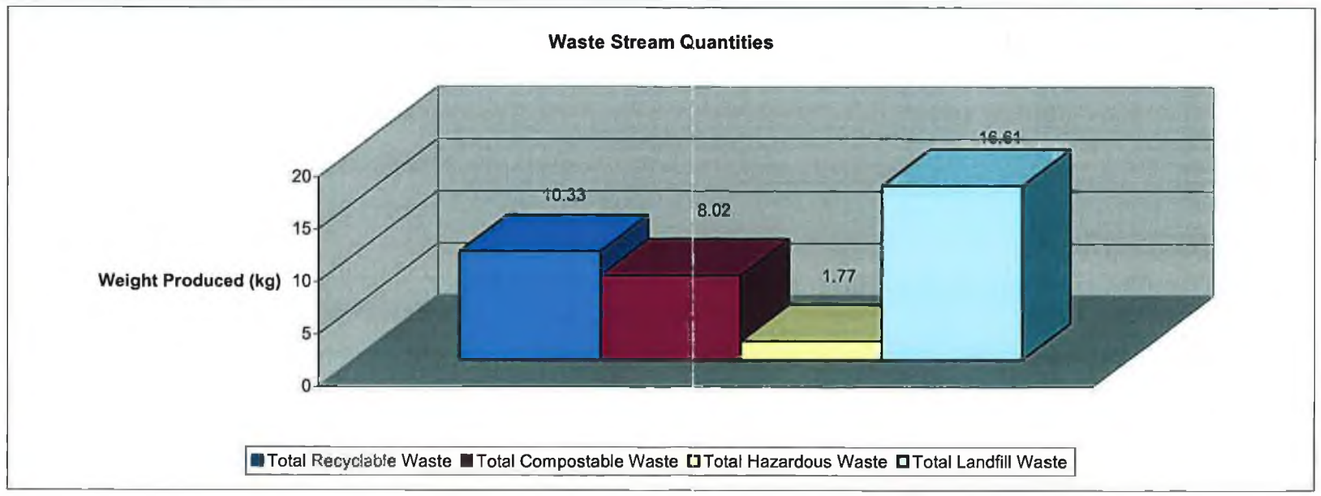
Hazardous Waste	
int and associated products	0.1
Batteries	0.07
Fluorescent tubes	0
Aerosols	0.15
Electronic equipment	0
Medicines and drugs	0.1
Detergents	0.15
Waste oil and oil filters	1.2
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	1.77
Per occupant average	0.59











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Property Details:	
Address Line 1:	The Demense
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	188
Occupancy	6

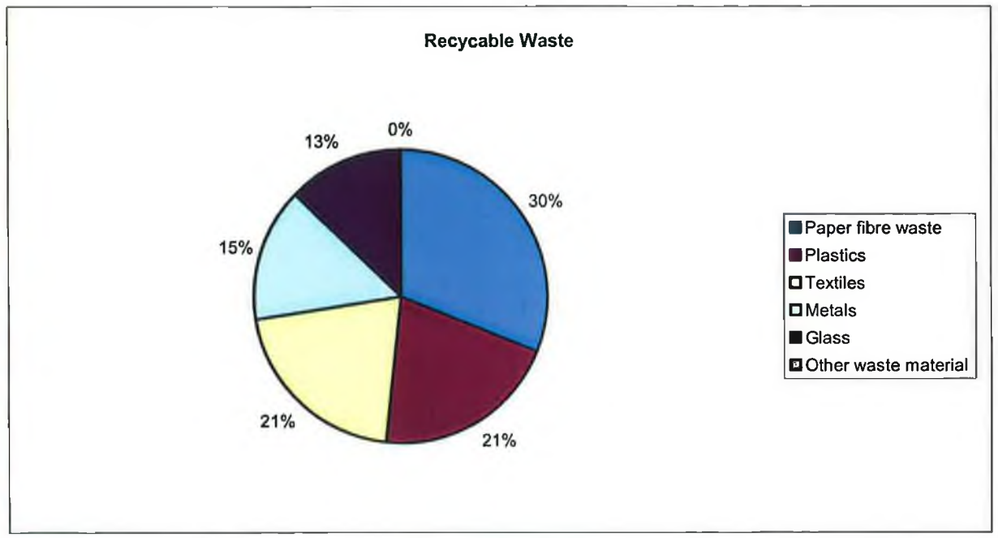
Assessor	
Name	Ivor H

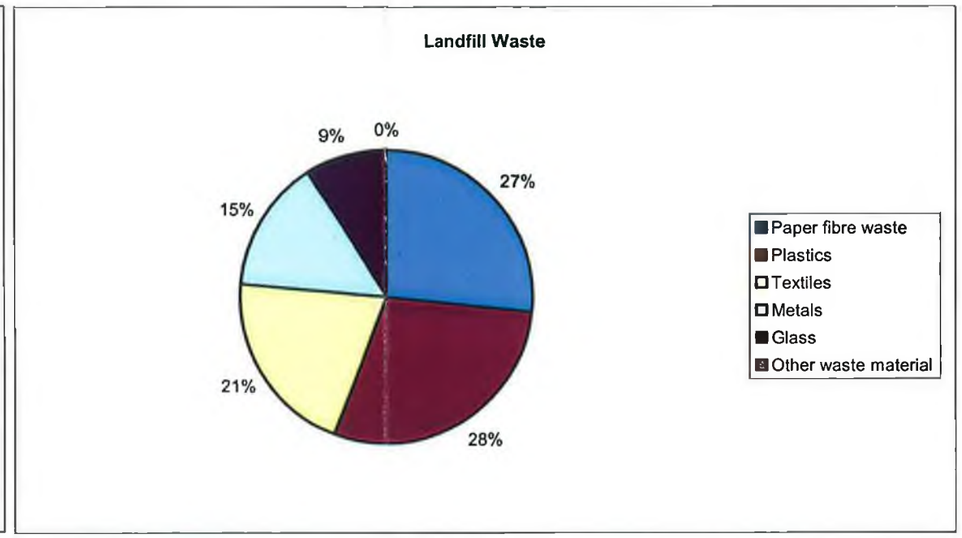
Recycable Waste	
Paper fibre waste	3.29
Plastics	2.18
Textiles	2.2
Metals	1.54
Glass	1.36
Other waste material	0
Total recyclable waste	10.57
Per occupant average	1.76

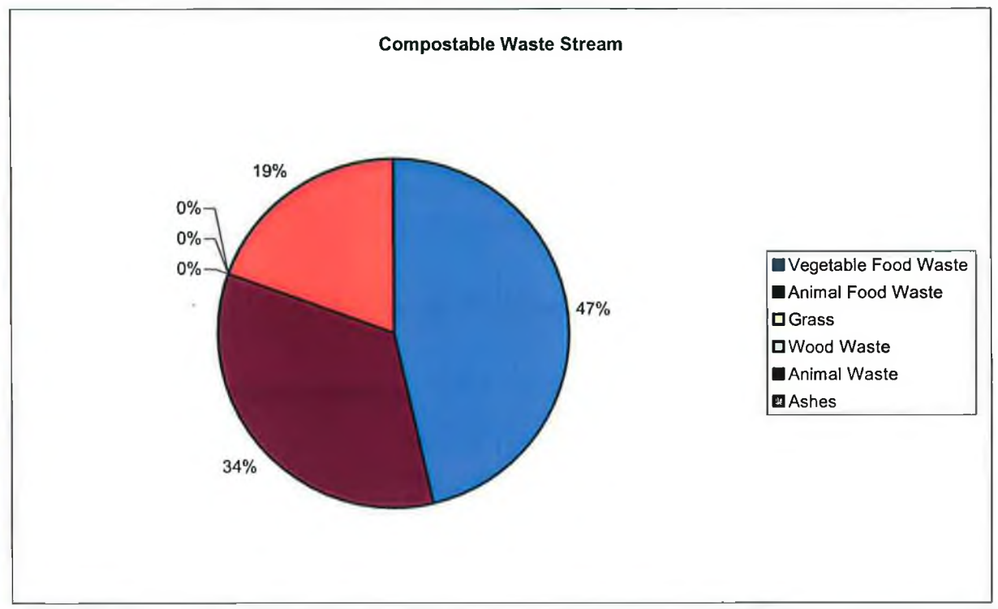
Compostable Waste	
Vegetable Food Waste	3.1
Animal Food Waste	2.3
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.3
Total organic waste	6.7
Per occupant average	1.12

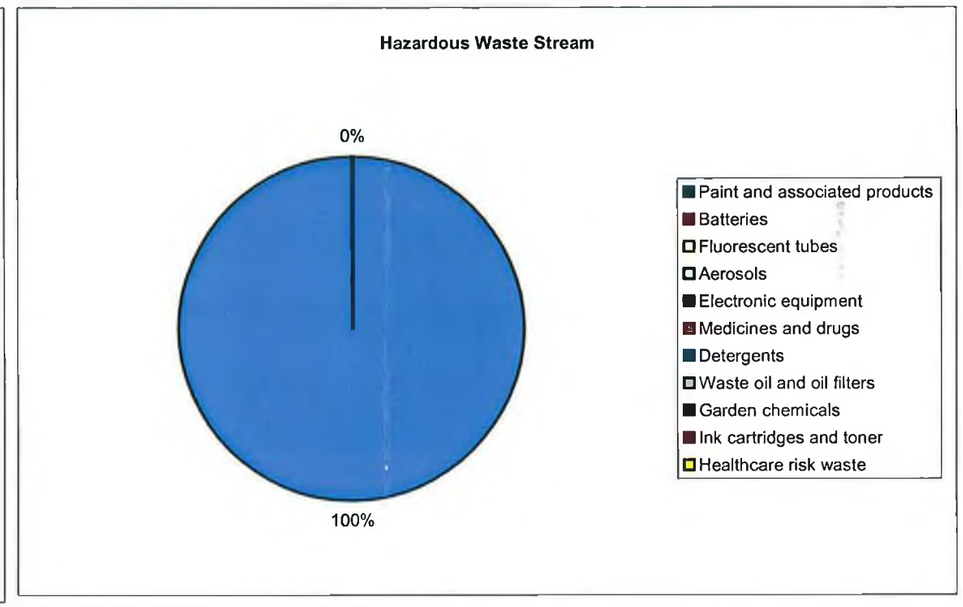
Landfill Waste	
Paper fibre waste	3.56
Plastics	3.94
Textiles	2.75
Metals	1.95
Glass	1.2
Other waste material	0
Total landfill waste	13.4
Per occupant average	2.23

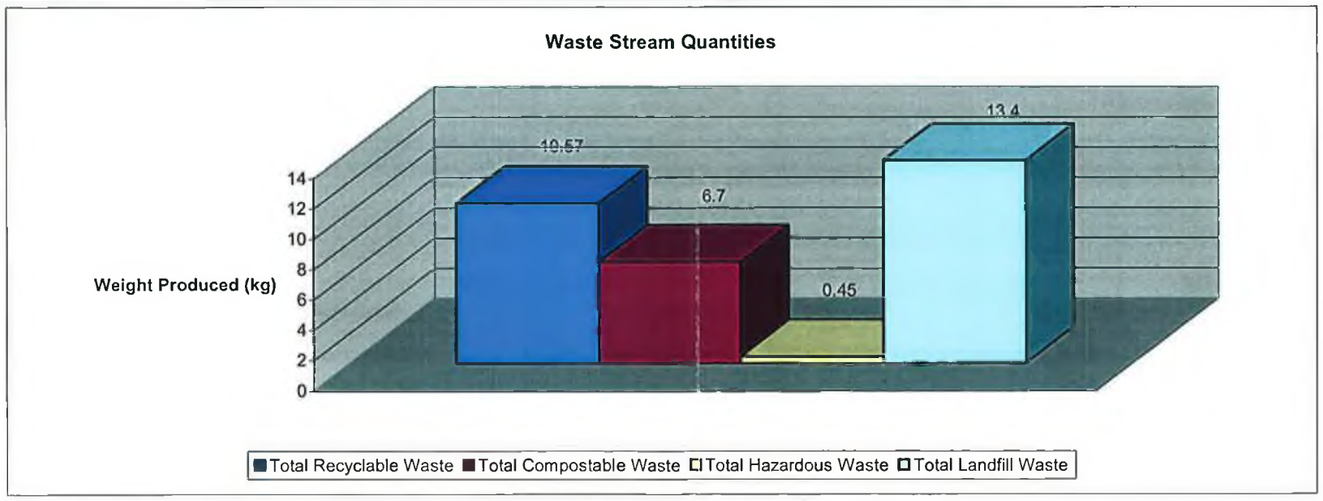
Hazardous Waste	
int and associated products	0.45
Batteries	0
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	0.45
Per occupant average	0.08











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Property Details:	
Address Line 1:	Greenville
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	114
Occupancy	1

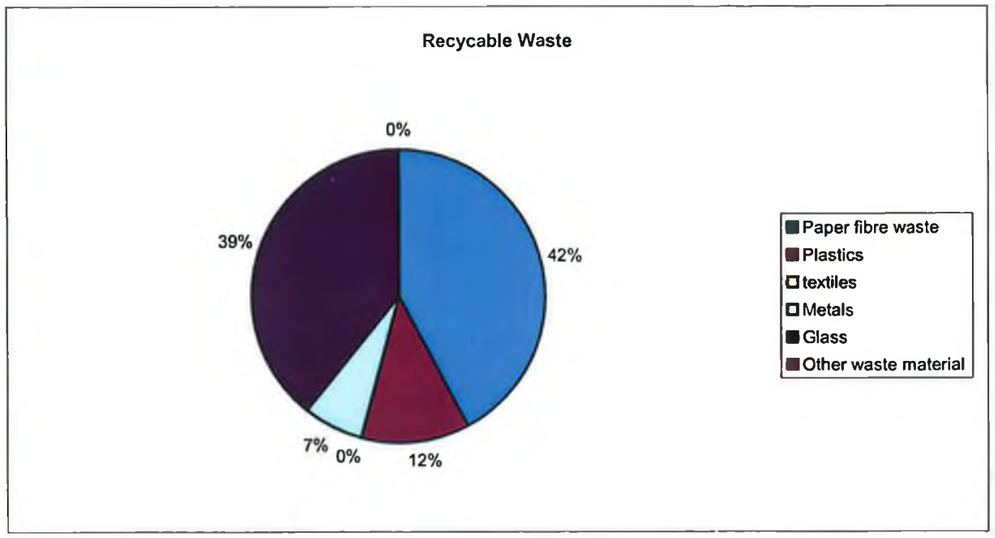
Assessor	
Name	Ivor H

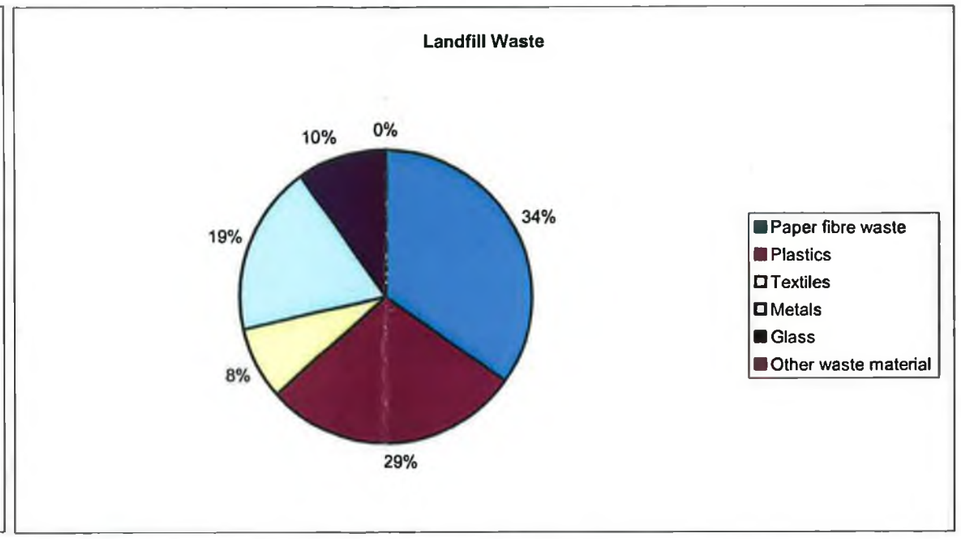
Recycable Waste	
Paper fibre waste	1.55
Plastics	0.43
textiles	0
Metals	0.25
Glass	1.43
Other waste material	0
Total recyclable waste	3.66
Per occupant average	3.66

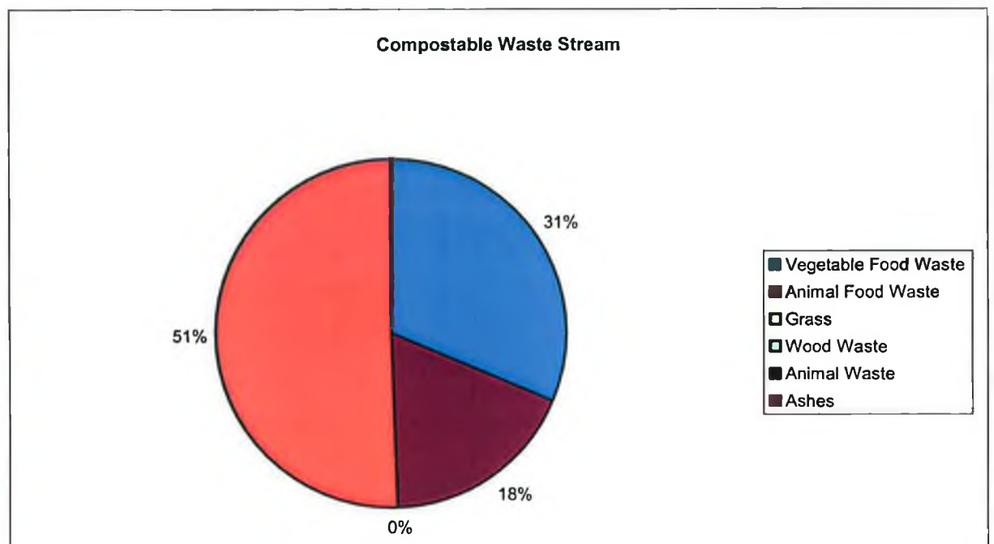
Compostable Waste	
Vegetable Food Waste	1.12
Animal Food Waste	0.65
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.8
Total organic waste	3.57
Per occupant average	3.57

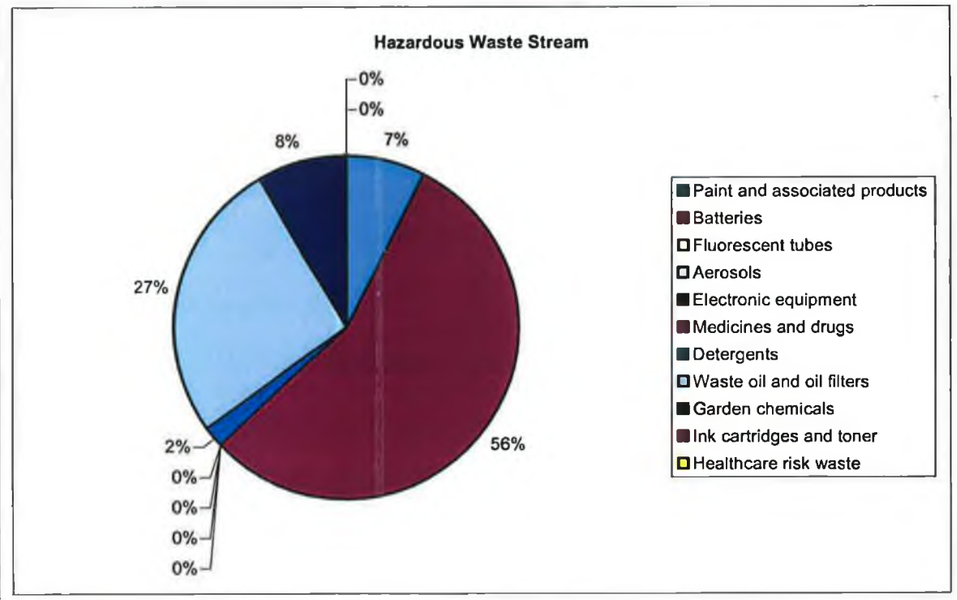
Landfill Waste	
Paper fibre waste	2.5
Plastics	2.06
Textiles	0.59
Metals	1.36
Glass	0.7
Other waste material	0
Total landfill waste	7.21
Per occupant average	7.21

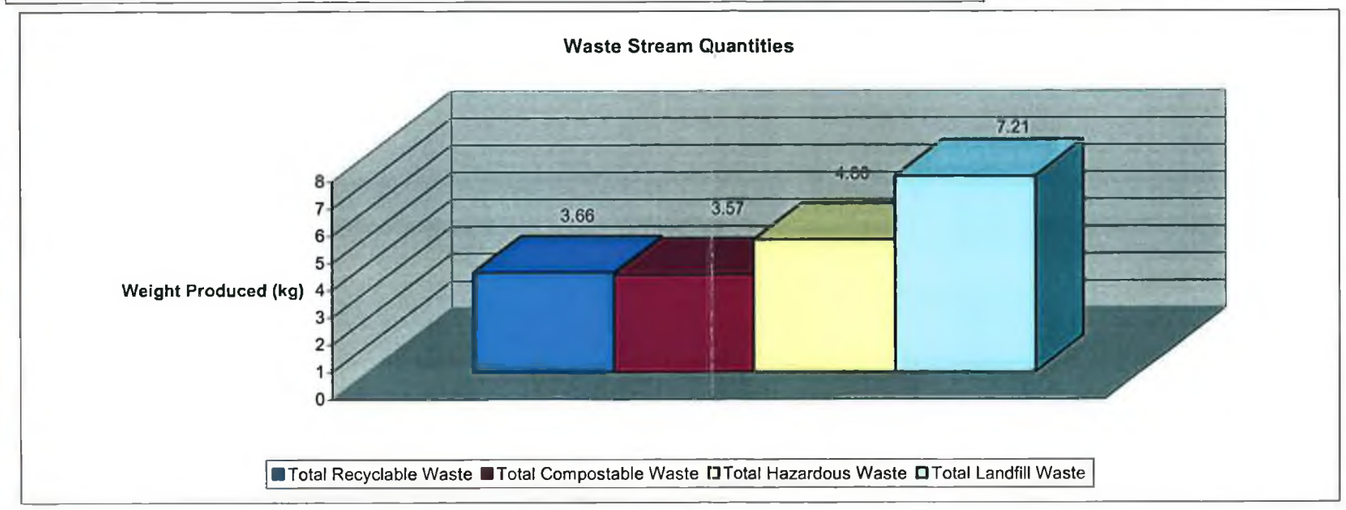
Hazardous Waste	
aint and associated products	0.36
Batteries	2.7
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0.1
Waste oil and oil filters	1.3
Garden chemicals	0.4
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	4.86
Per occupant average	4.86











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Property Details:	
Address Line 1:	Ballinahattina Rd.
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	148
Occupancy	3

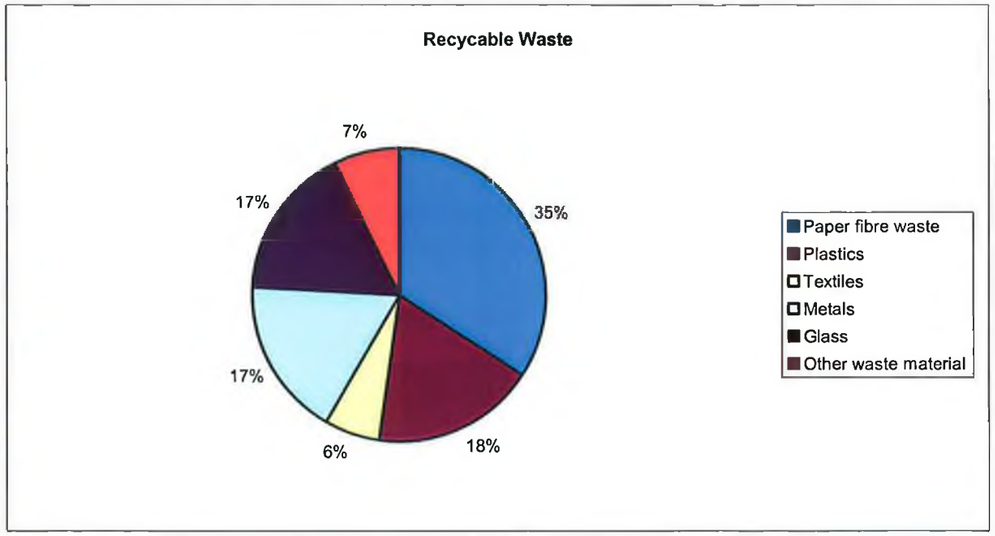
Assessor	
Name	Ivor H

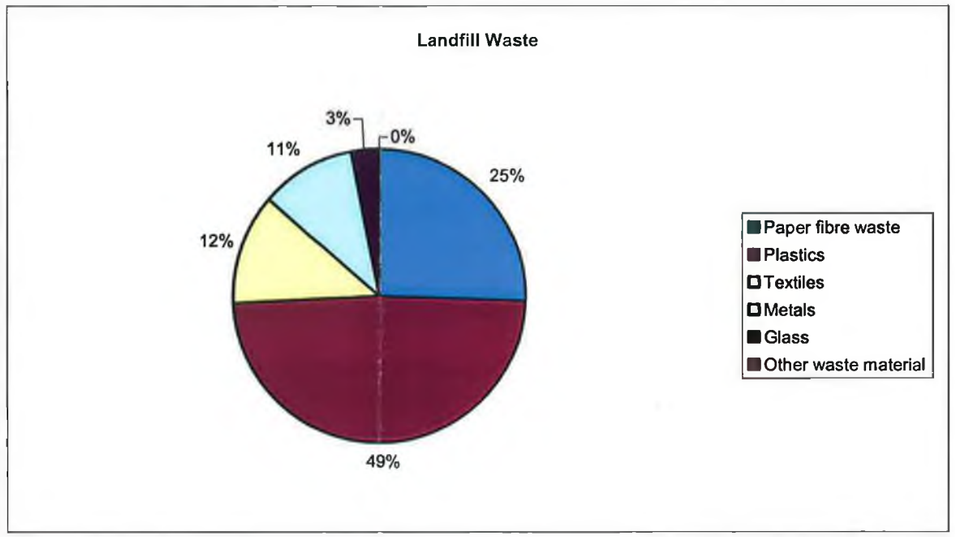
Recycable Waste	
Paper fibre waste	2.8
Plastics	1.47
Textiles	0.5
Metals	1.43
Glass	1.38
Other waste material	0.6
Total recyclable waste	8.18
Per occupant average	2.726666667

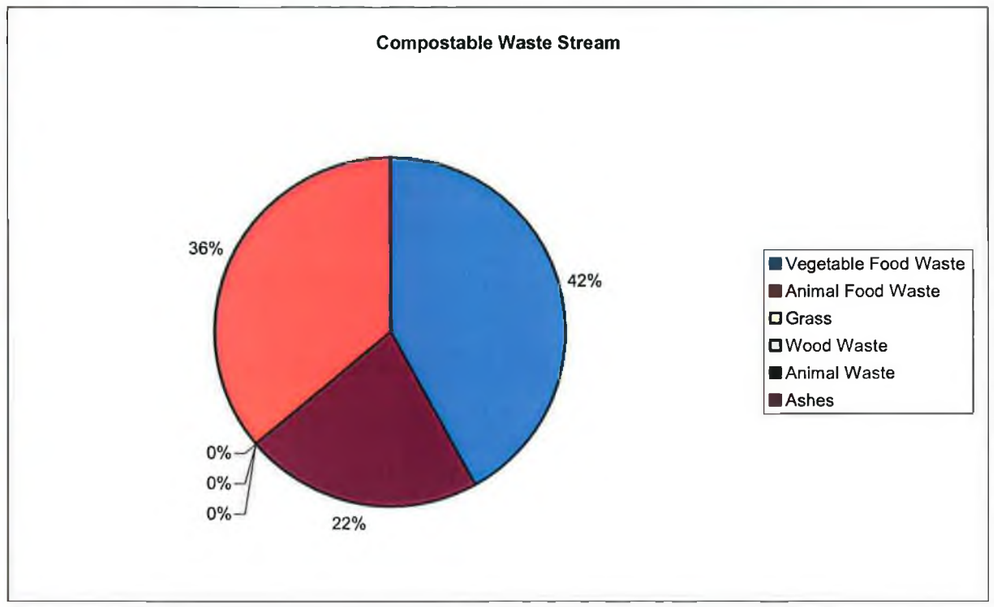
Compostable Waste	
Vegetable Food Waste	2.34
Animal Food Waste	1.23
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	2.02
Total organic waste	5.59
Per occupant average	1.863333333

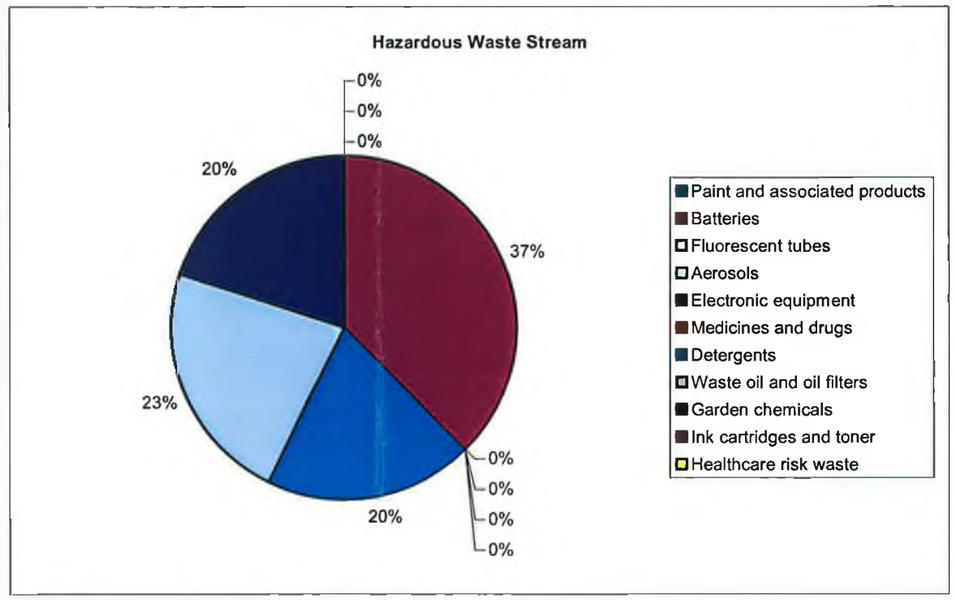
Landfill Waste	
Paper fibre waste	2.12
Plastics	4.06
Textiles	1.03
Metals	0.88
Glass	0.25
Other waste material	0
Total landfill waste	8.34
Per occupant average	2.78

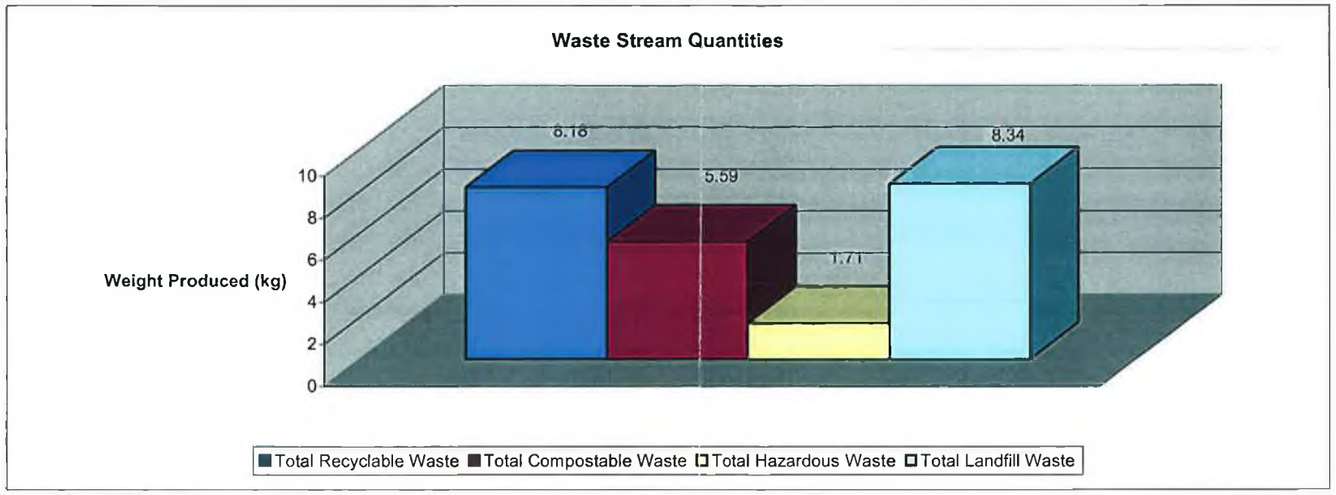
Hazardous Waste	
int and associated products	0
Batteries	0.64
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0.34
Waste oil and oil filters	0.39
Garden chemicals	0.34
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	1.71
Per occupant average	0.57











esults

Property Details:	
Address Line 1:	Clogher
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	127
Occupancy	3

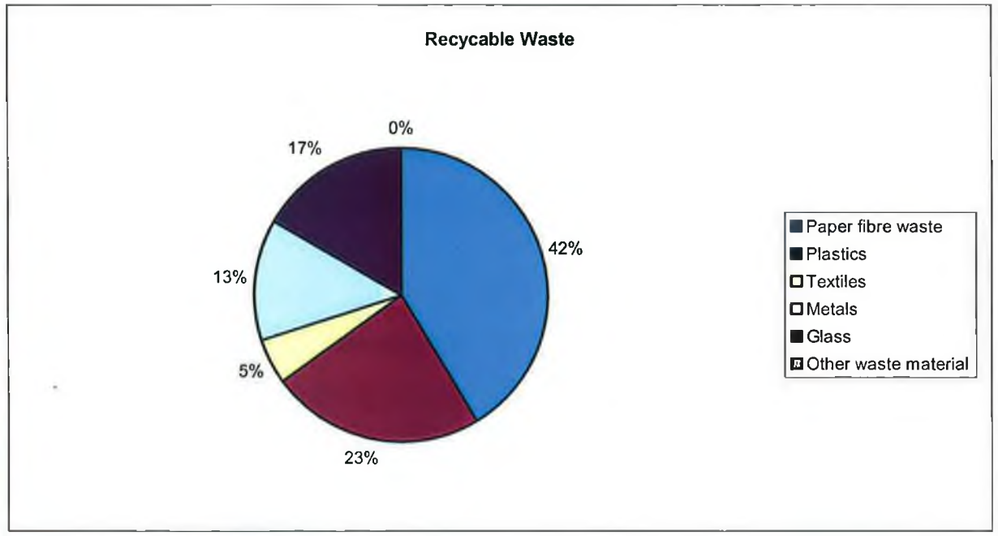
Assessor	
Name	Ivor H

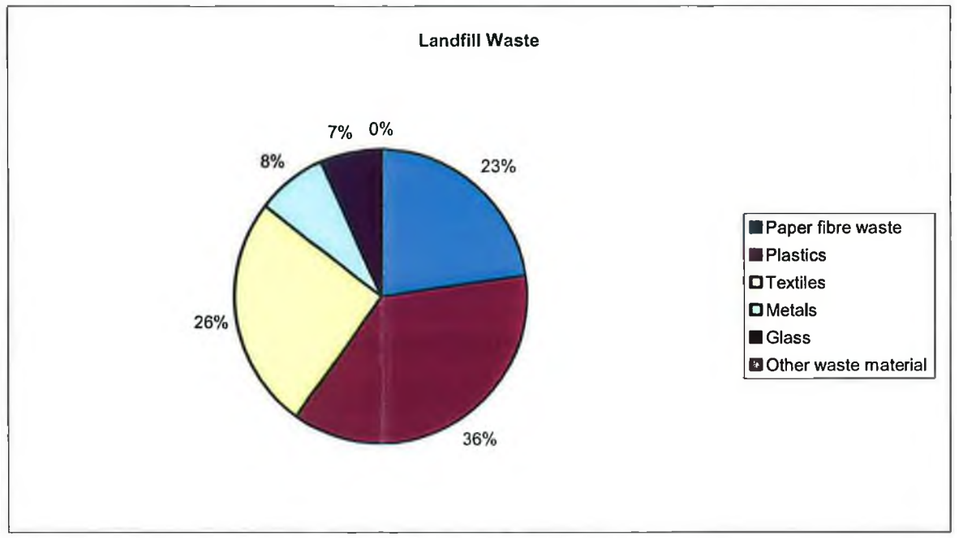
Recycable Waste	
Paper fibre waste	3.94
Plastics	2.23
Textiles	0.48
Metals	1.25
Glass	1.59
Other waste material	0
Total recyclable waste	9.49
Per occupant average	3.16

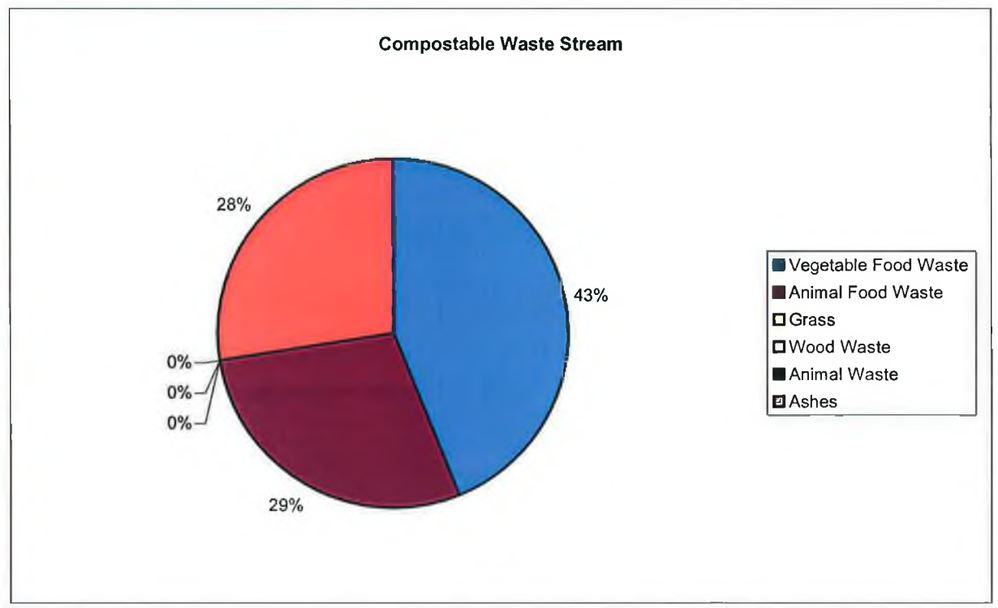
Compostable Waste	
Vegetable Food Waste	1.88
Animal Food Waste	1.23
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	1.18
Total organic waste	4.29
Per occupant average	1.43

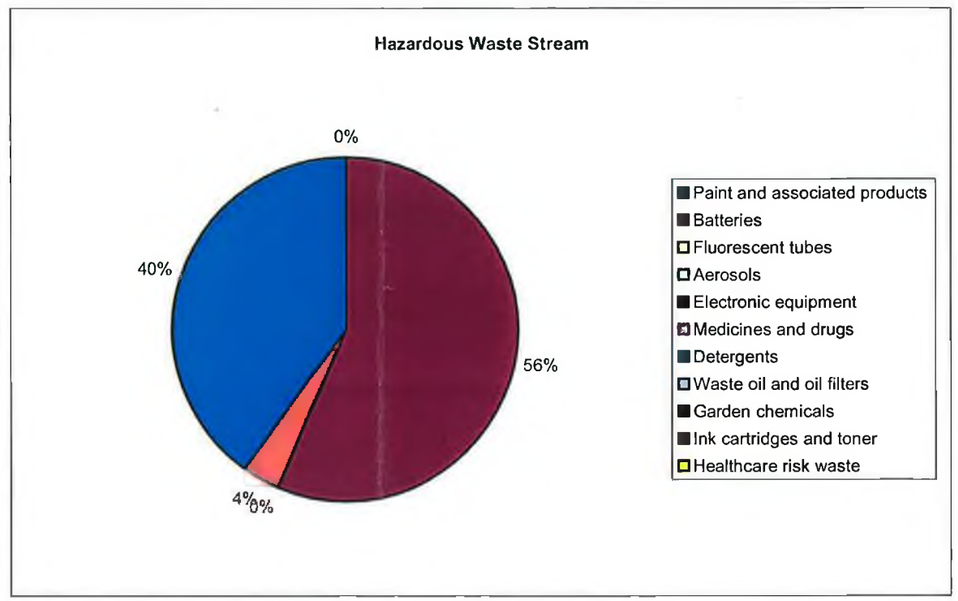
Landfill Waste	
Paper fibre waste	1.17
Plastics	1.89
Textiles	1.33
Metals	0.4
Glass	0.34
Other waste material	0
Total landfill waste	5.13
Per occupant average	1.71

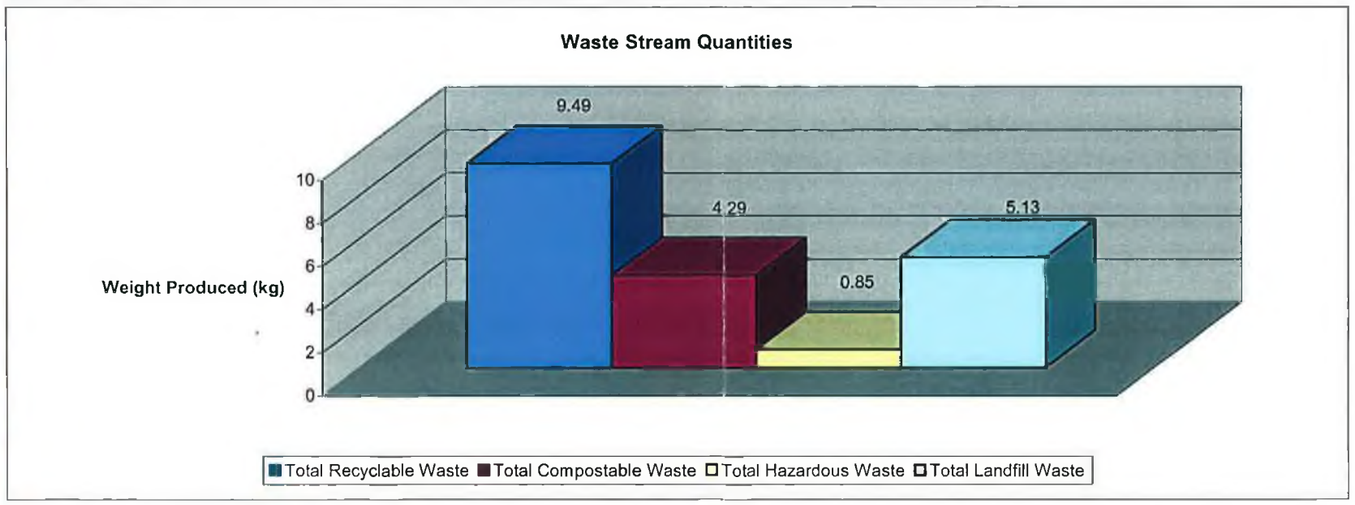
Hazardous Waste	
int and associated products	0
Batteries	0.48
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0.03
Detergents	0.34
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	0.85
Per occupant average	0.28











esults

Property Details:	
Address Line 1:	The Meadows
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	166
Occupancy	5

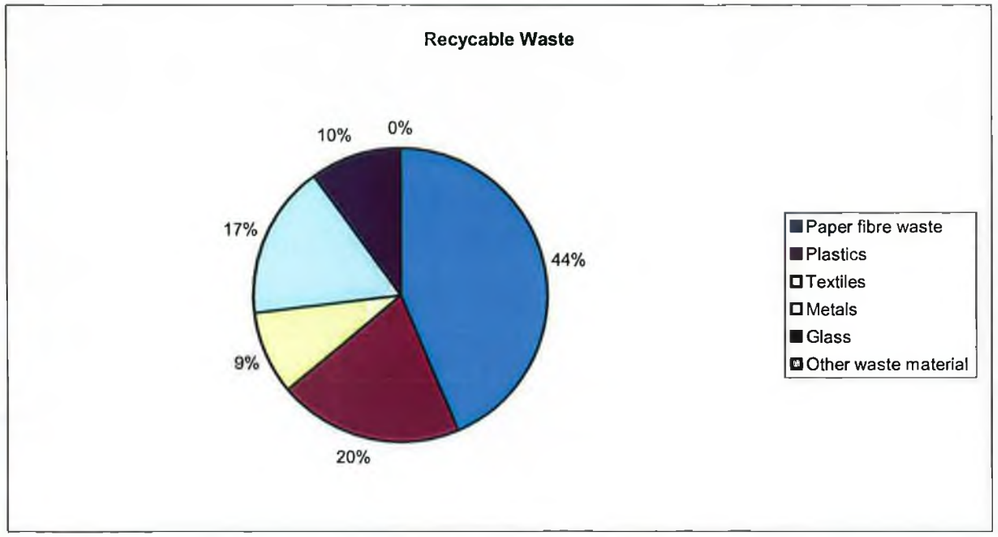
Assessor	
Name	Ivor H

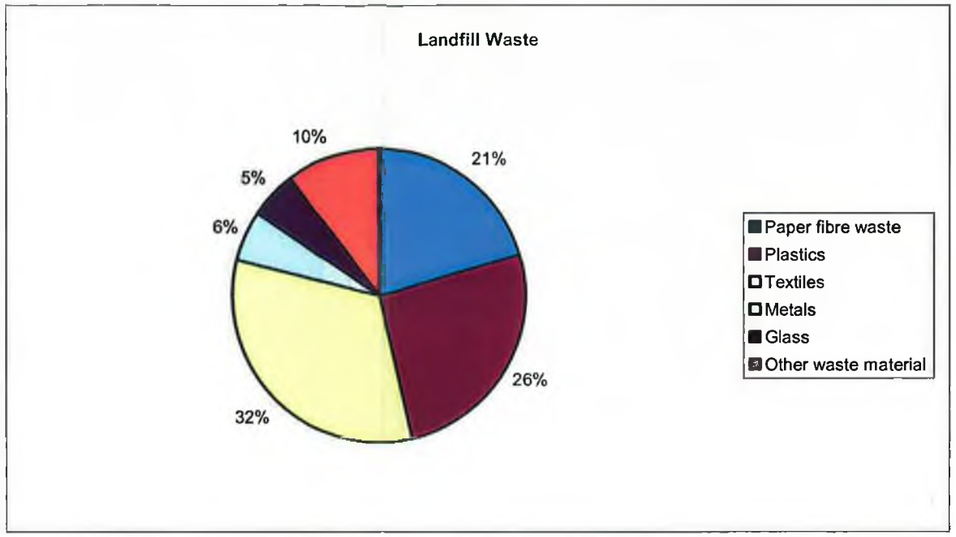
Recycable Waste	
Paper fibre waste	5.54
Plastics	2.59
Textiles	1.17
Metals	2.14
Glass	1.27
Other waste material	0
Total recyclable waste	12.71
Per occupant average	2.54

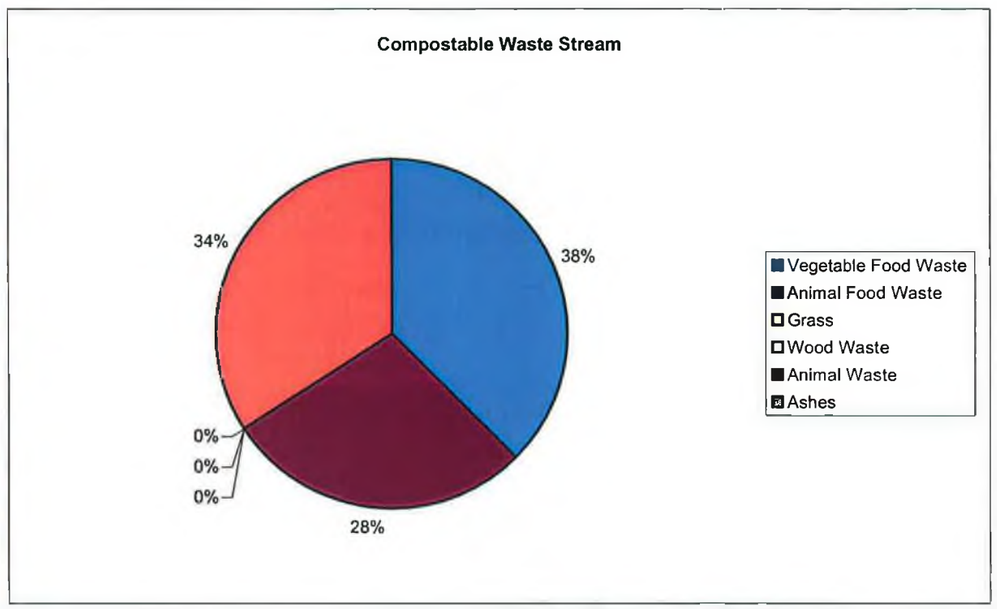
Compostable Waste	
Vegetable Food Waste	2.3
Animal Food Waste	1.73
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	2.1
Total organic waste	6.13
Per occupant average	1.23

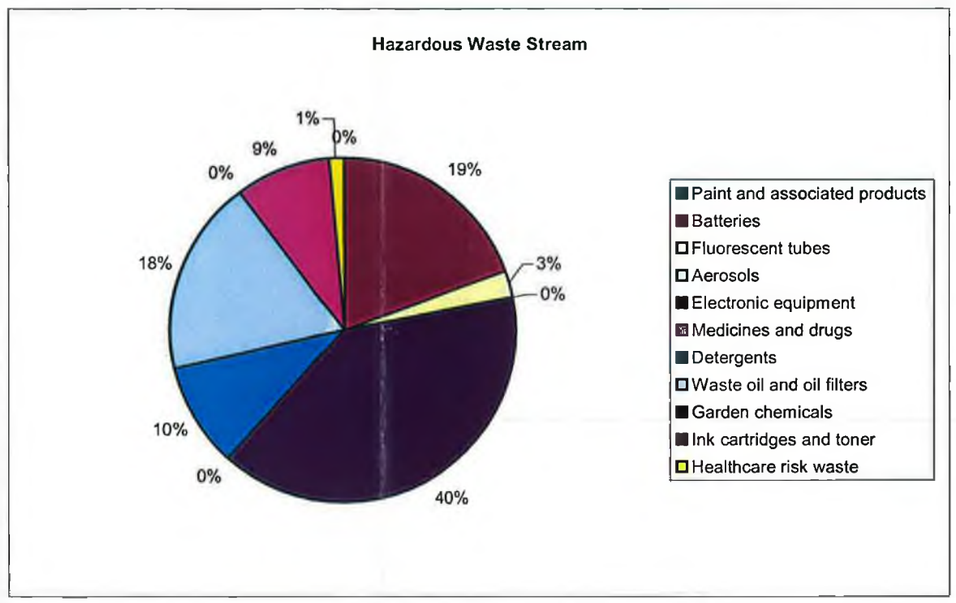
Landfill Waste	
Paper fibre waste	3.03
Plastics	3.78
Textiles	4.76
Metals	0.82
Glass	0.79
Other waste material	1.5
Total landfill waste	14.68
Per occupant average	2.936

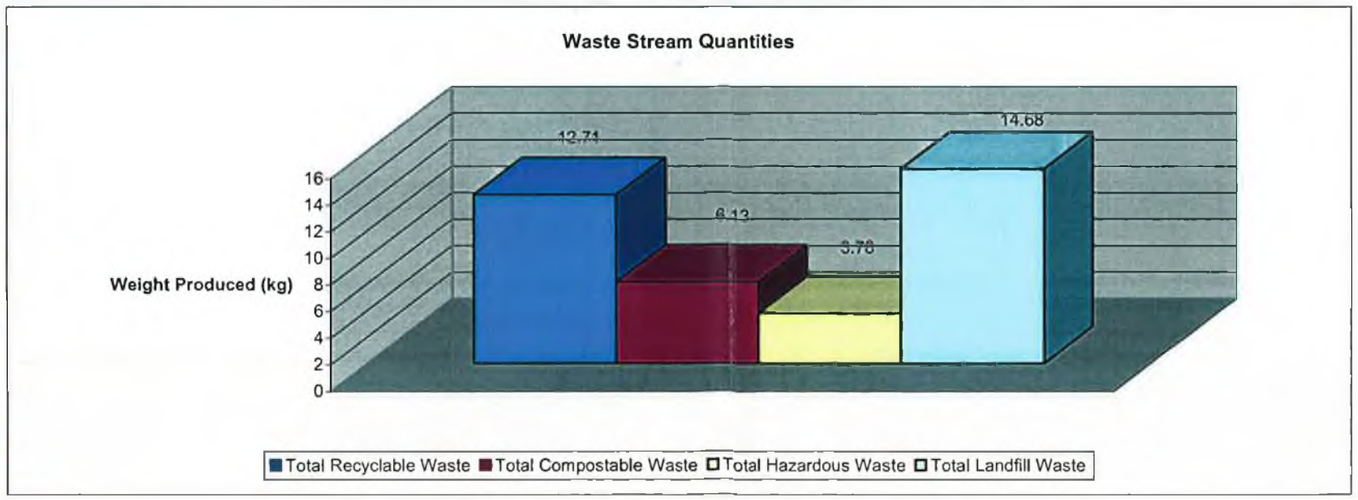
Hazardous Waste	
int and associated products	0
Batteries	0.73
Fluorescent tubes	0.1
Aerosols	0
Electronic equipment	1.5
Medicines and drugs	0
Detergents	0.37
Waste oil and oil filters	0.69
Garden chemicals	0
Ink cartridges and toner	0.34
Healthcare risk waste	0.05
Total hazardous waste	3.78
Per occupant average	0.76











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Property Details:	
Address Line 1:	Raheens
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	126
Occupancy	2

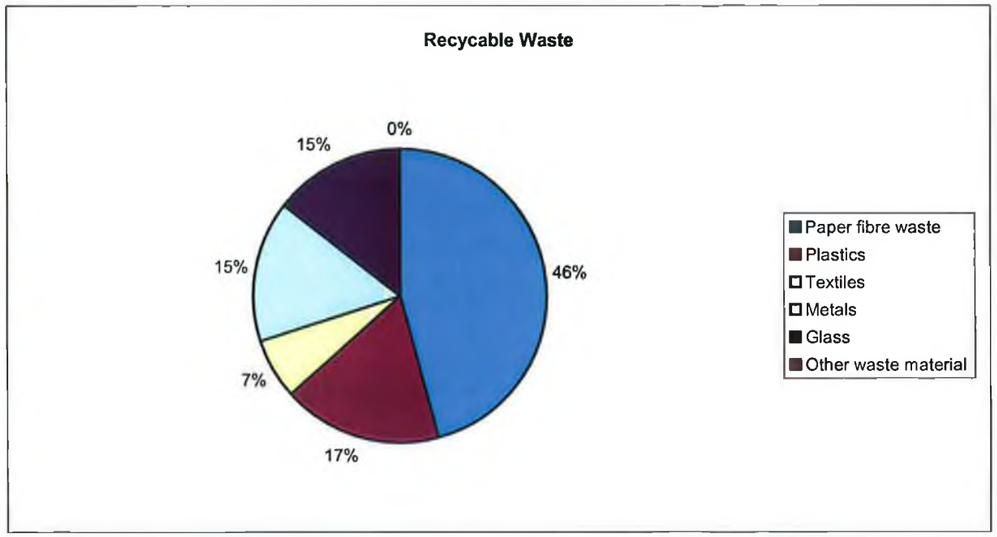
Assessor	
Name	Ivor H

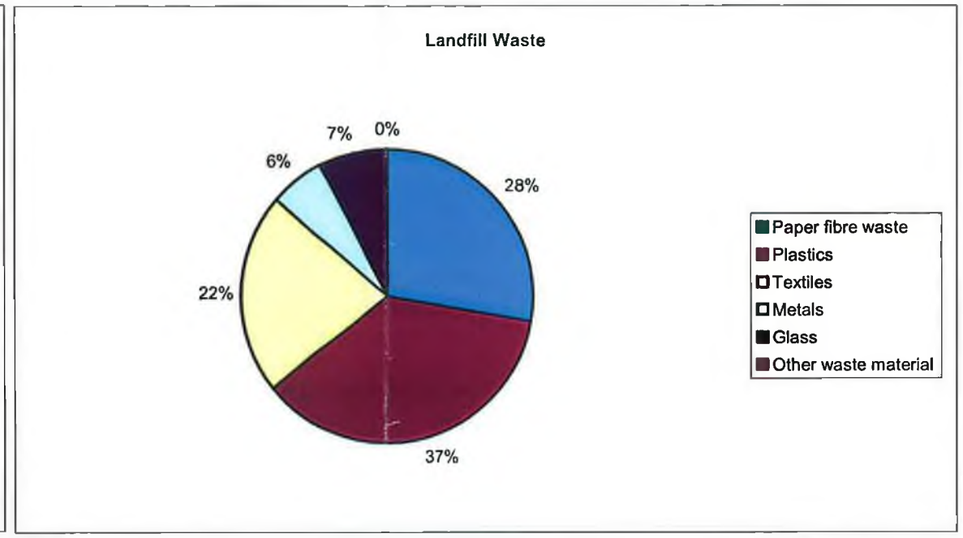
Recycable Waste	
Paper fibre waste	2.85
Plastics	1.08
Textiles	0.41
Metals	0.96
Glass	0.9
Other waste material	0
Total recyclable waste	6.2
Per occupant average	3.10

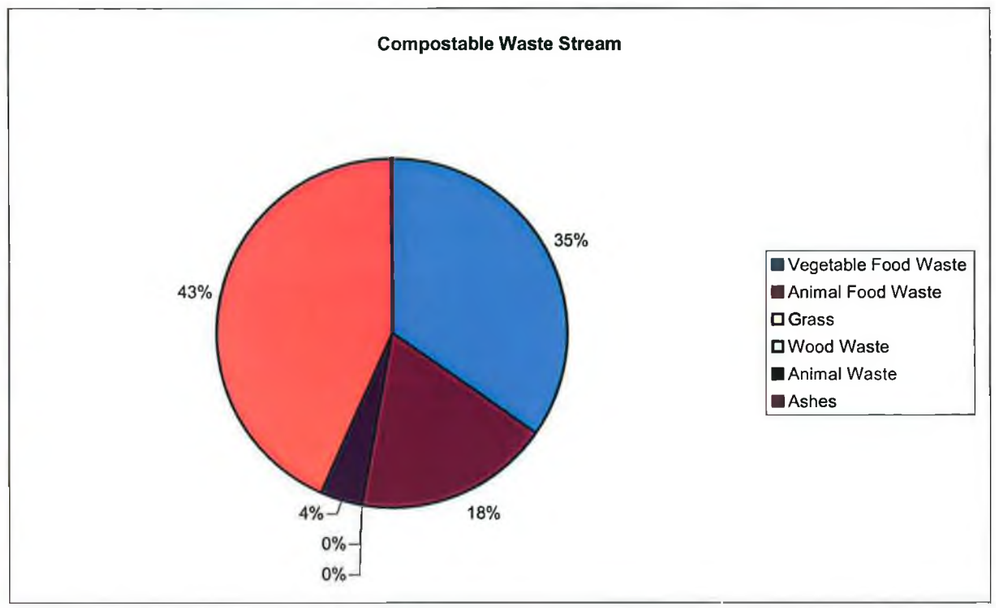
Compostable Waste	
Vegetable Food Waste	1.84
Animal Food Waste	0.97
Grass	0
Wood Waste	0
Animal Waste	0.21
Ashes	2.3
Total organic waste	5.32
Per occupant average	2.66

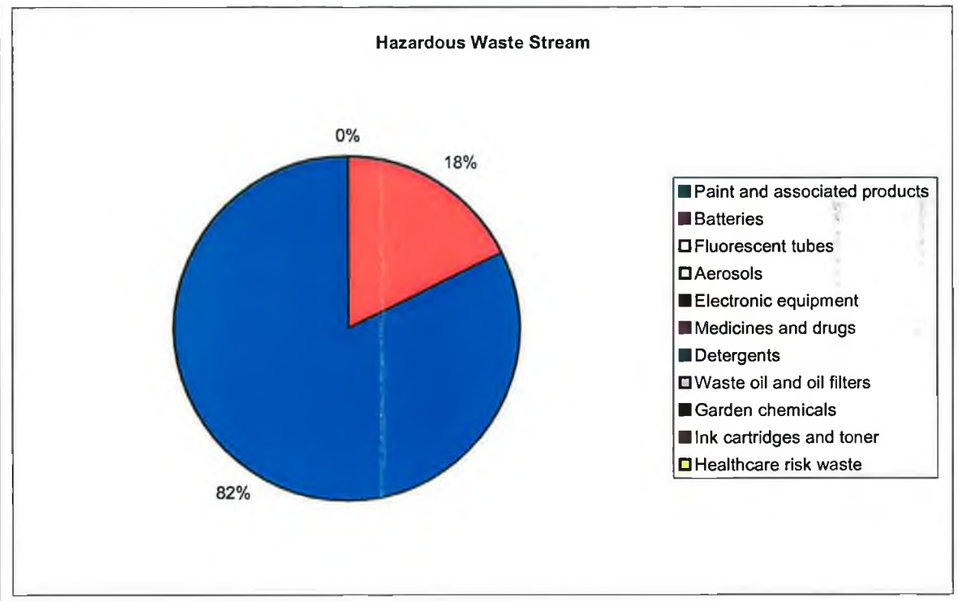
Landfill Waste	
Paper fibre waste	2.05
Plastics	2.7
Textiles	1.65
Metals	0.45
Glass	0.55
Other waste material	0
Total landfill waste	7.4
Per occupant average	3.7

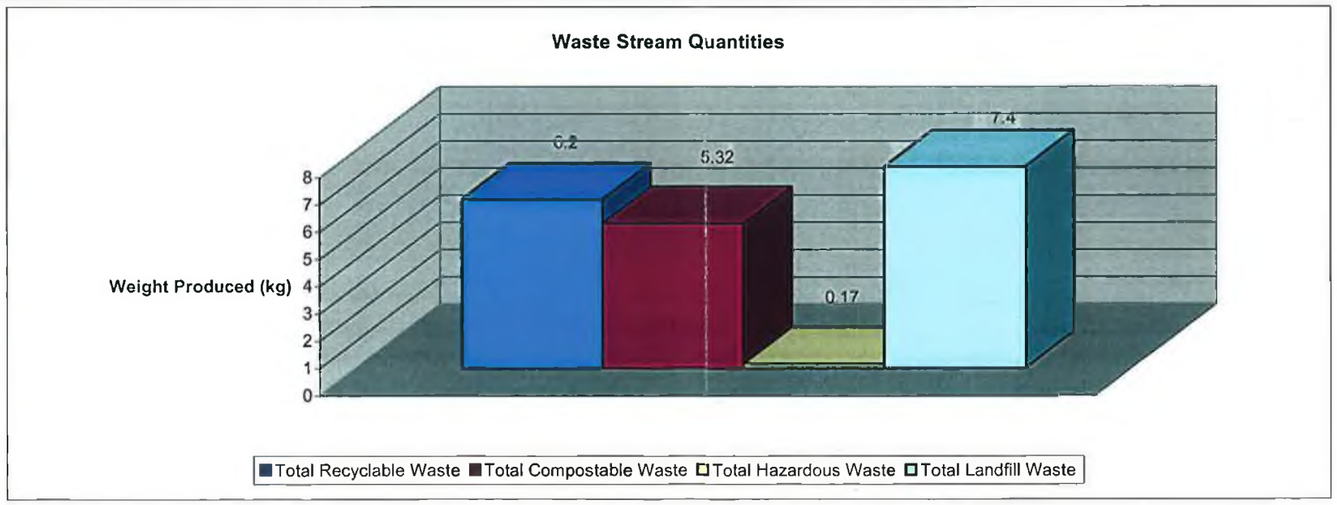
Hazardous Waste	
aint and associated products	0
Batteries	0
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0.03
Detergents	0.14
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	0.17
Per occupant average	0.09











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Property Details:	
Address Line 1:	Springlawn
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	124
Occupancy	4

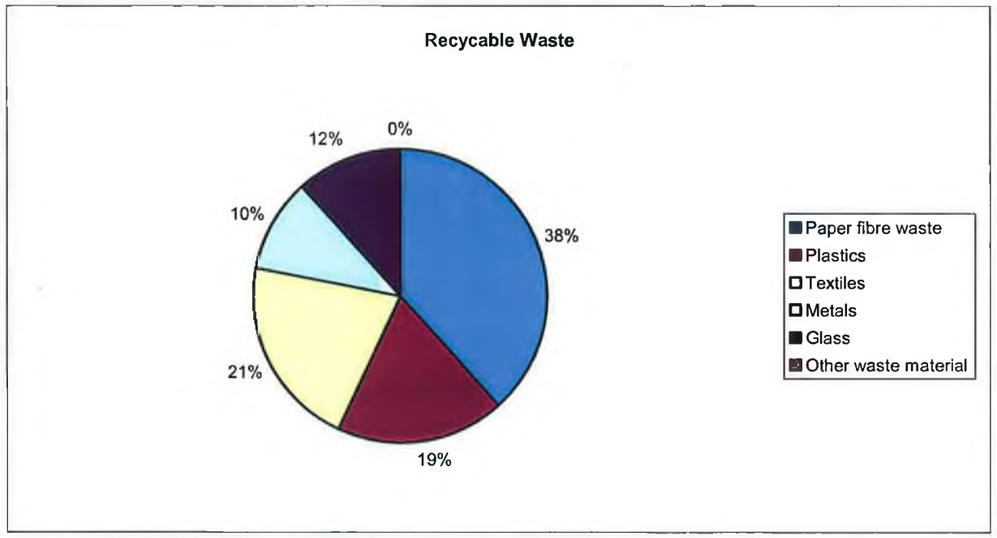
Assessor	
Name	Ivor H

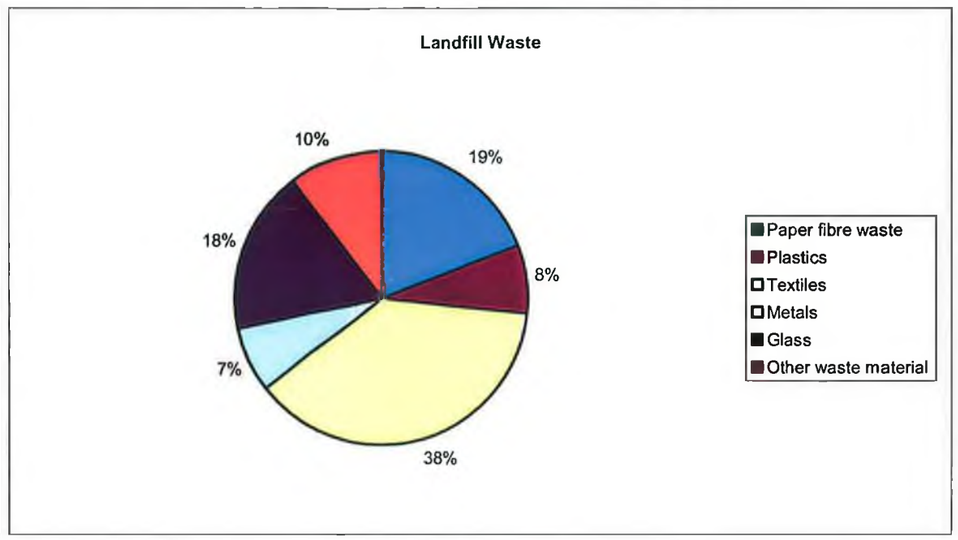
Recycable Waste	
Paper fibre waste	2.57
Plastics	1.25
Textiles	1.42
Metals	0.68
Glass	0.79
Other waste material	0
Total recyclable waste	6.71
Per occupant average	1.68

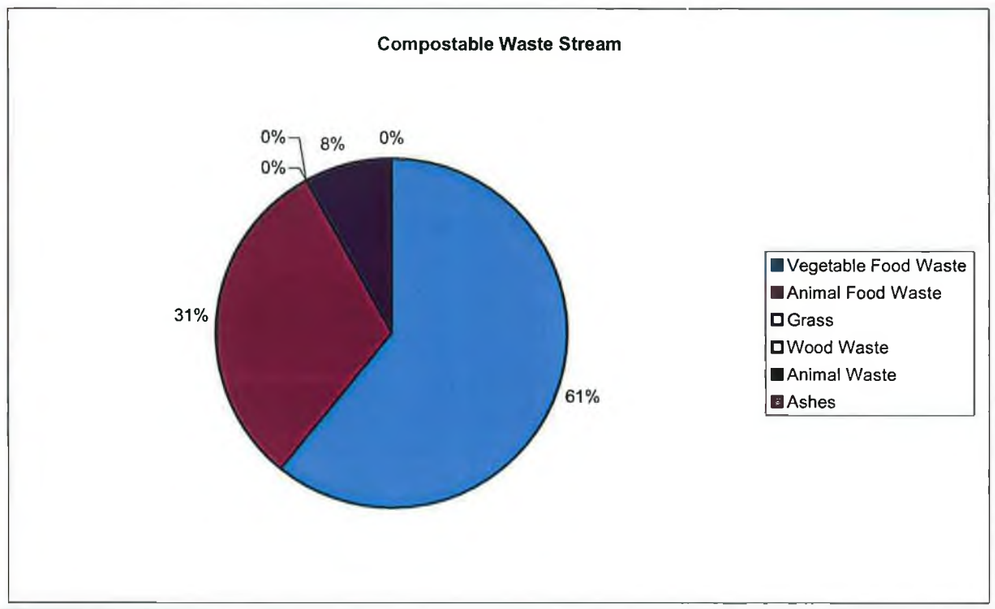
Compostable Waste	
Vegetable Food Waste	1.34
Animal Food Waste	0.68
Grass	0
Wood Waste	0
Animal Waste	0.18
Ashes	0
Total organic waste	2.2
Per occupant average	0.55

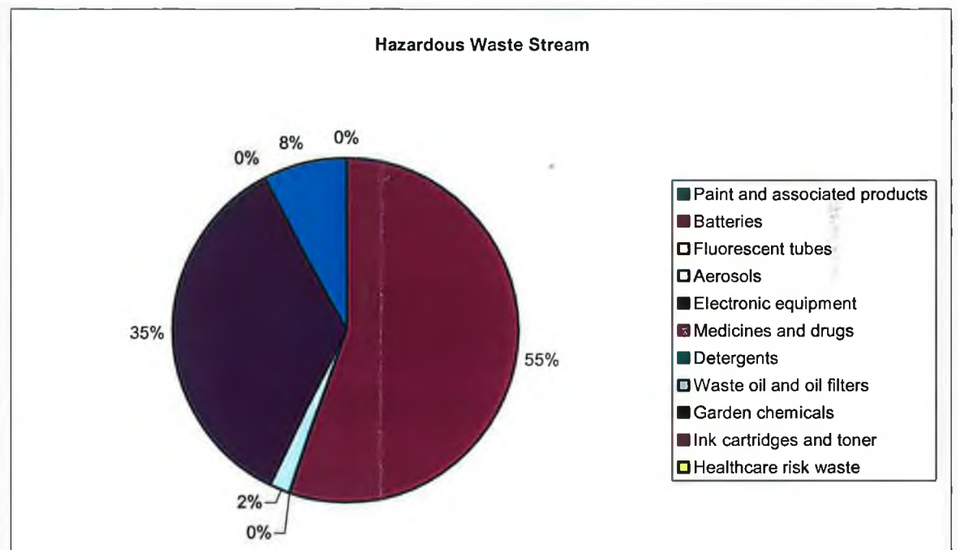
Landfill Waste	
Paper fibre waste	1.45
Plastics	0.58
Textiles	2.88
Metals	0.56
Glass	1.37
Other waste material	0.78
Total landfill waste	7.62
Per occupant average	1.905

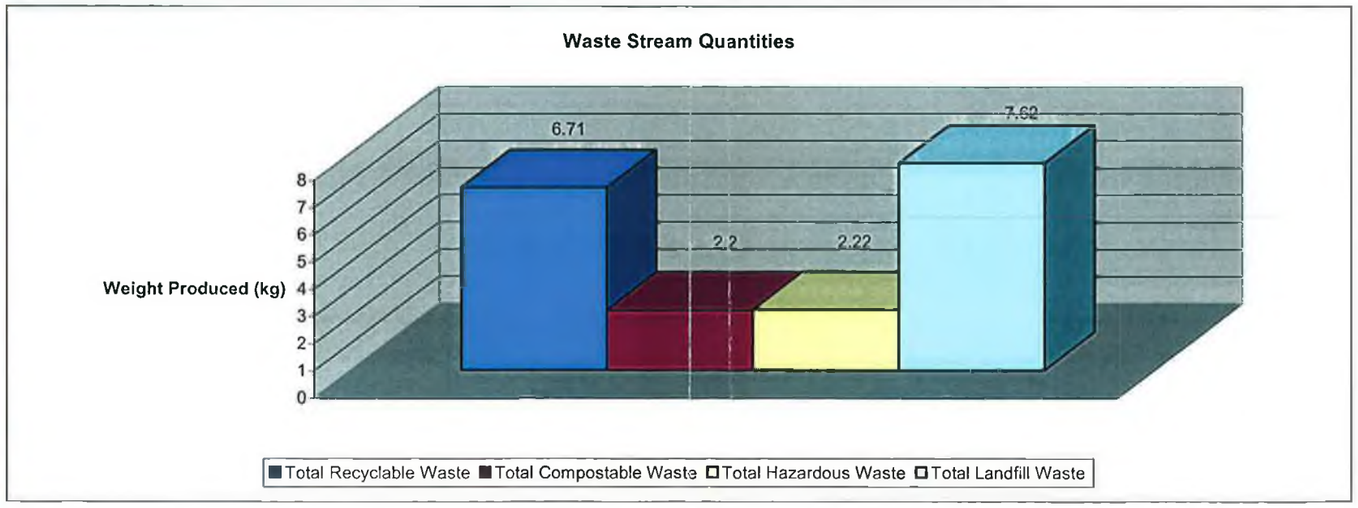
Hazardous Waste	
int and associated products	0
Batteries	1.23
Fluorescent tubes	0
Aerosols	0.04
Electronic equipment	0.78
Medicines and drugs	0
Detergents	0.17
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	2.22
Per occupant average	0.56











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Property Details:	
Address Line 1:	Castlegar
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	112
Occupancy	4

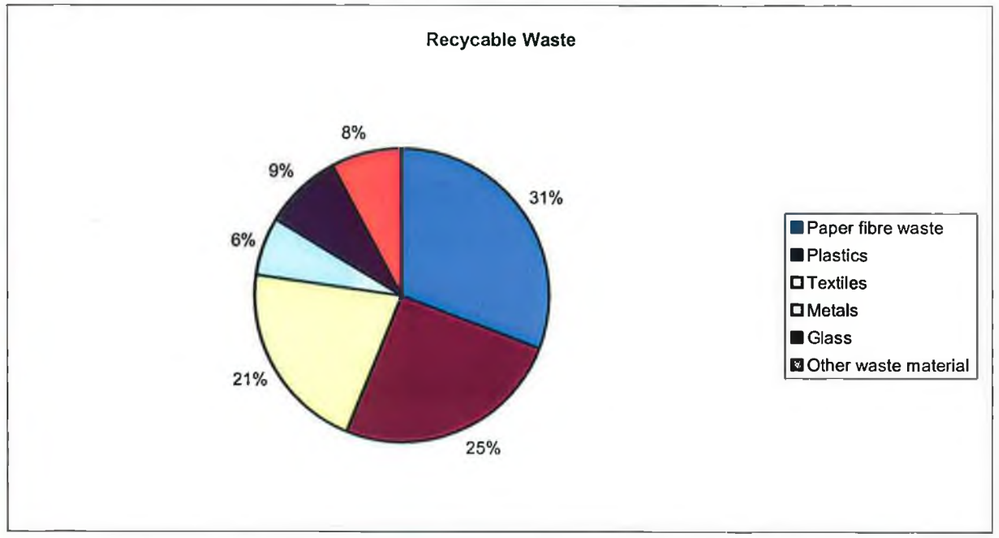
Assessor	
Name	Ivor H

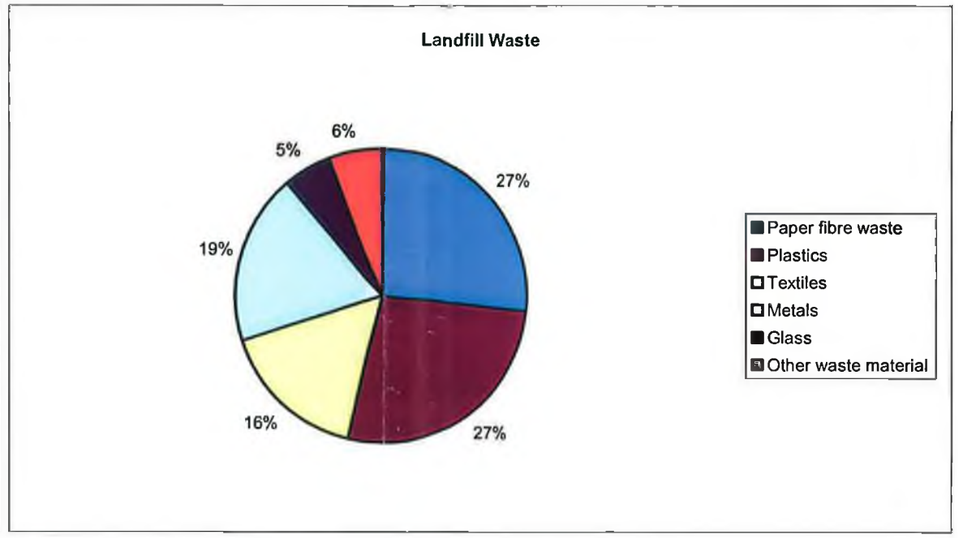
Recycable Waste	
Paper fibre waste	5.56
Plastics	4.54
Textiles	3.81
Metals	1.17
Glass	1.54
Other waste material	1.4
Total recyclable waste	18.02
Per occupant average	4.51

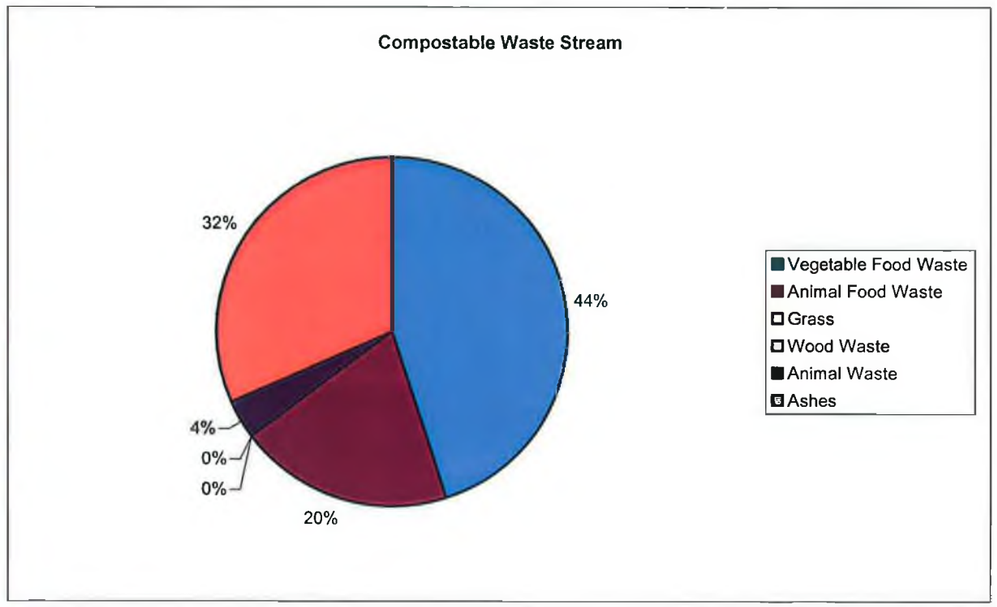
Compostable Waste	
Vegetable Food Waste	3.42
Animal Food Waste	1.48
Grass	0
Wood Waste	0
Animal Waste	0.28
Ashes	2.4
Total organic waste	7.58
Per occupant average	1.90

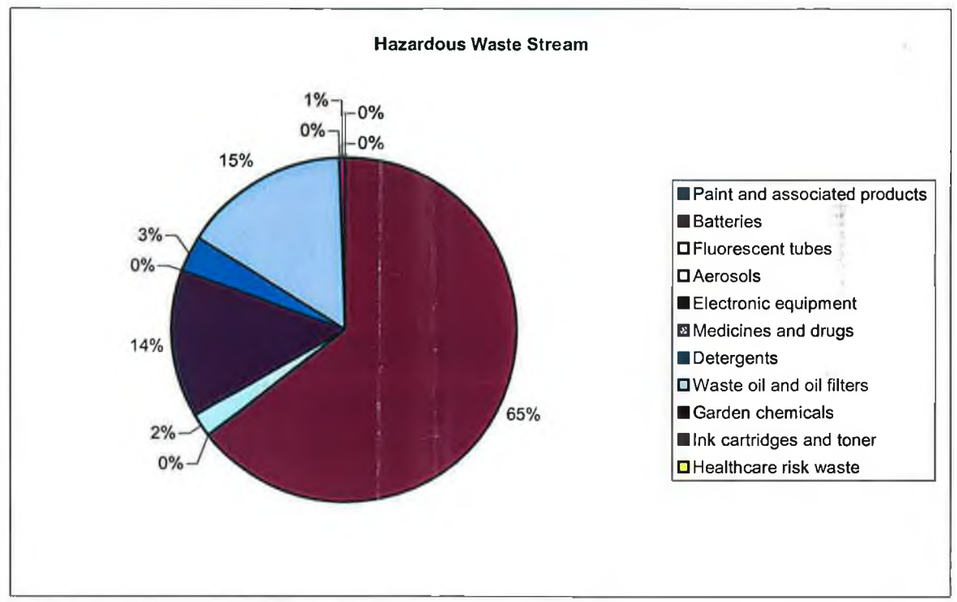
Landfill Waste	
Paper fibre waste	3.24
Plastics	3.24
Textiles	1.99
Metals	2.27
Glass	0.66
Other waste material	0.7
Total landfill waste	12.1
Per occupant average	3.03

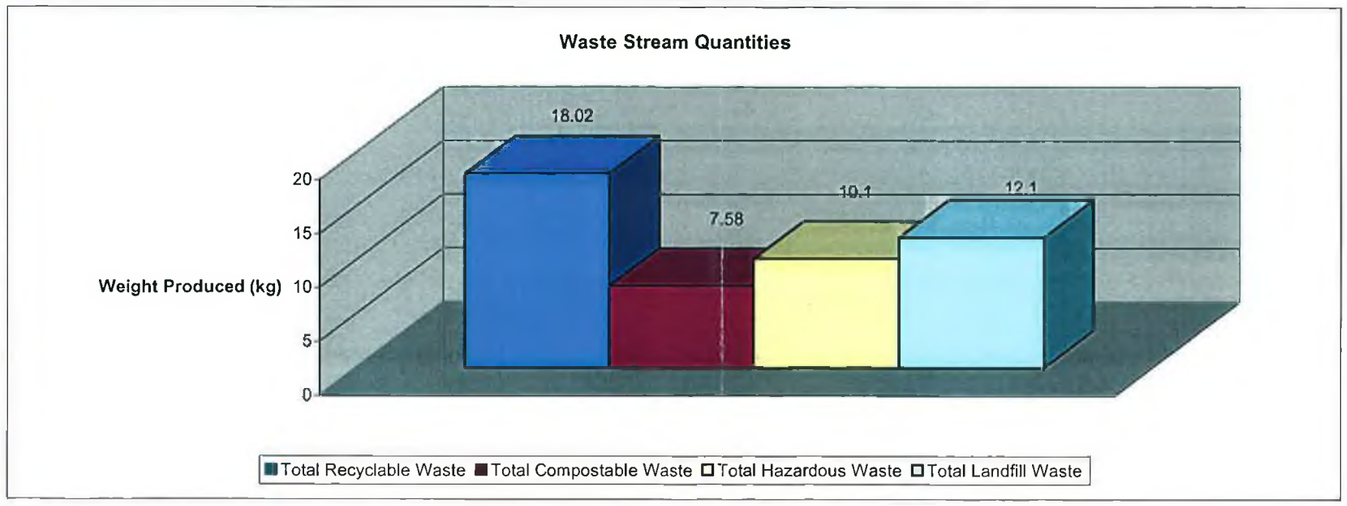
Hazardous Waste	
int and associated products	0
Batteries	6.5
Fluorescent tubes	0
Aerosols	0.23
Electronic equipment	1.4
Medicines and drugs	0
Detergents	0.34
Waste oil and oil filters	1.56
Garden chemicals	0
Ink cartridges and toner	0.07
Healthcare risk waste	0
Total hazardous waste	10.1
Per occupant average	2.53











esults

Property Details:	
Address Line 1:	Doonwood
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	172
Occupancy	6

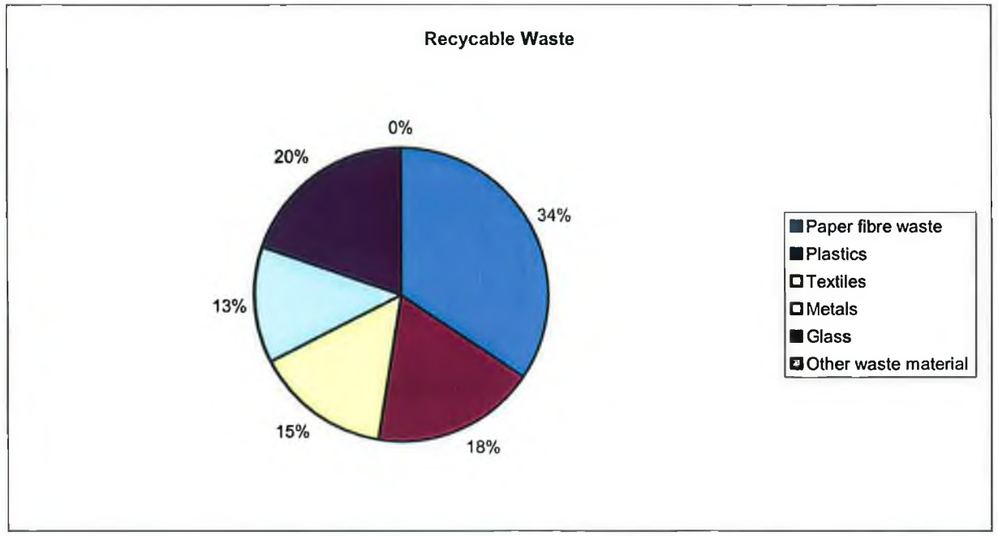
Assessor	
Name	Ivor H

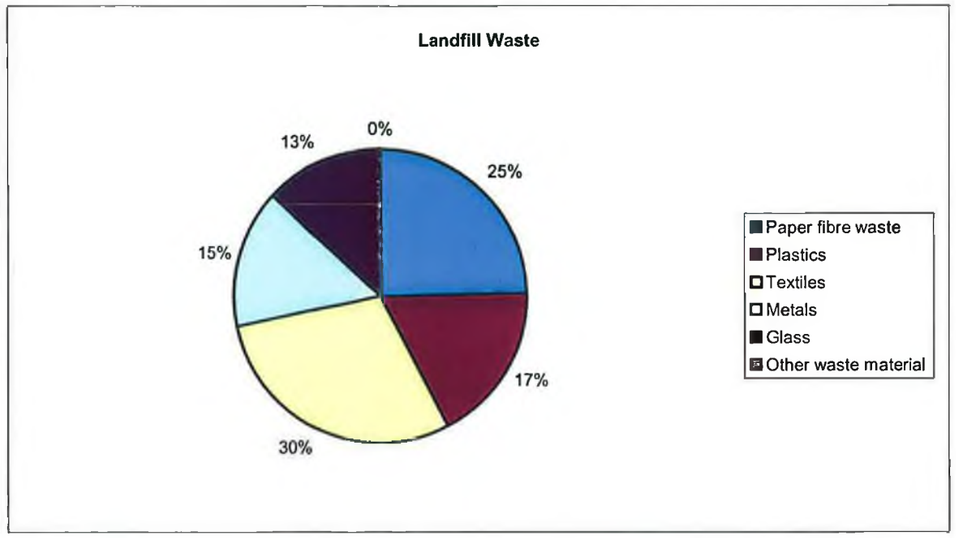
Recycable Waste	
Paper fibre waste	3.22
Plastics	1.7
Textiles	1.39
Metals	1.2
Glass	1.84
Other waste material	0
Total recyclable waste	9.35
Per occupant average	1.56

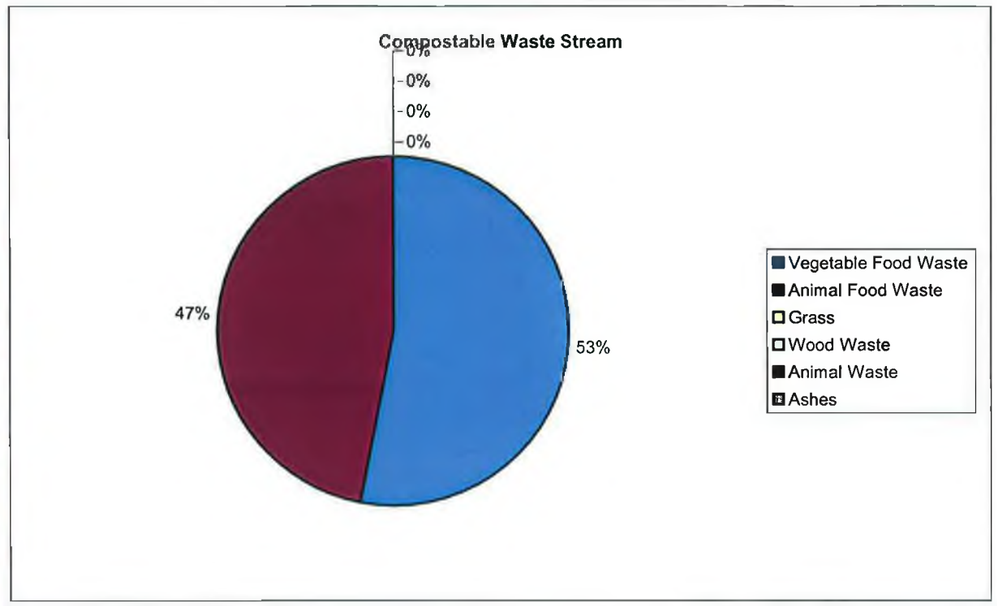
Compostable Waste	
Vegetable Food Waste	1.96
Animal Food Waste	1.74
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	0
Total organic waste	3.7
Per occupant average	0.62

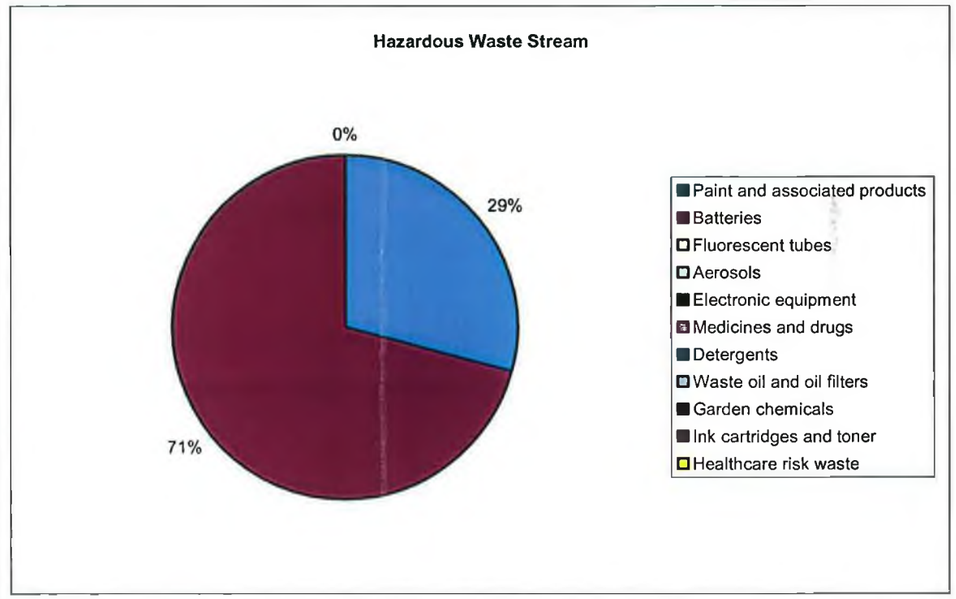
Landfill Waste	
Paper fibre waste	2.26
Plastics	1.58
Textiles	2.68
Metals	1.4
Glass	1.18
Other waste material	0
Total landfill waste	9.1
Per occupant average	1.52

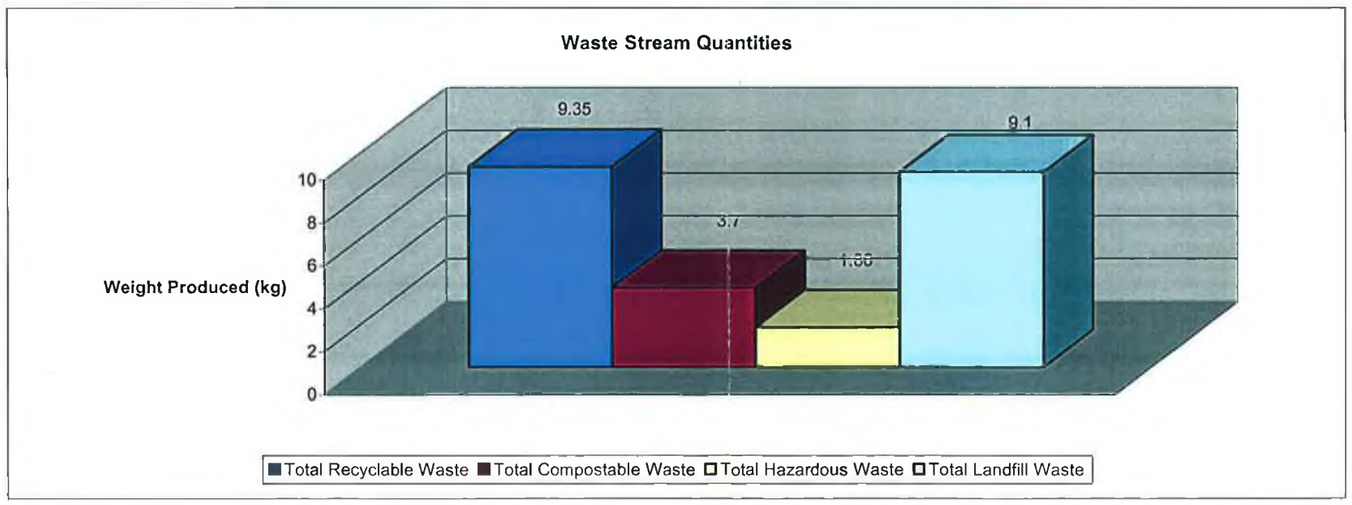
Hazardous Waste	
int and associated products	0.54
Batteries	1.32
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	1.86
Per occupant average	0.31











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Property Details:	
Address Line 1:	Pairc Na Gcon
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	143
Occupancy	3

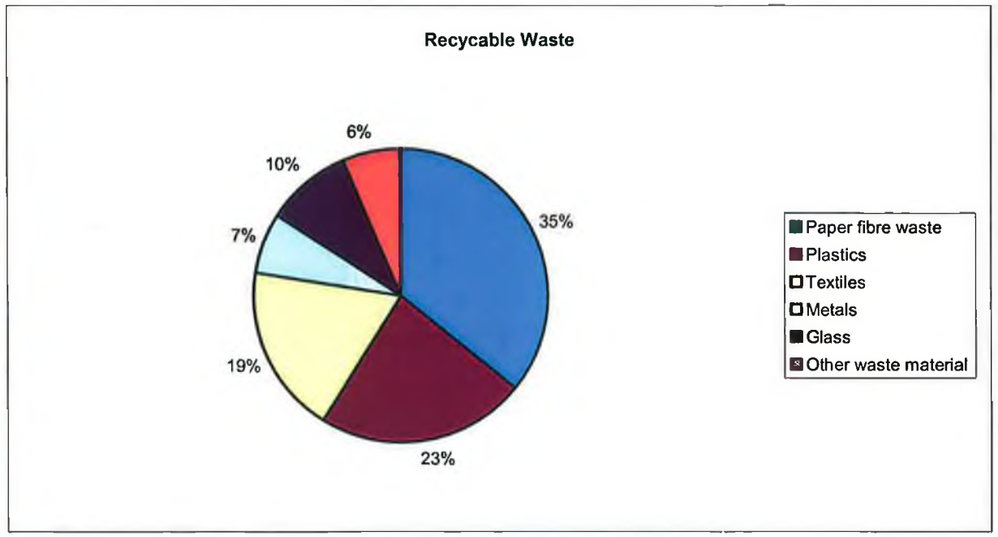
Assessor	
Name	Ivor H

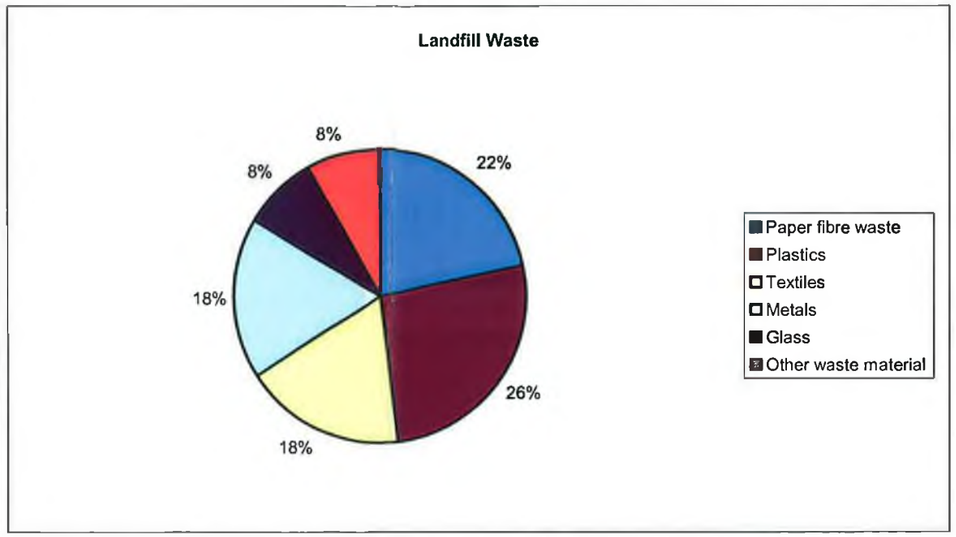
Recycable Waste	
Paper fibre waste	4.78
Plastics	3.06
Textiles	2.5
Metals	0.89
Glass	1.27
Other waste material	0.84
Total recyclable waste	13.34
Per occupant average	4.45

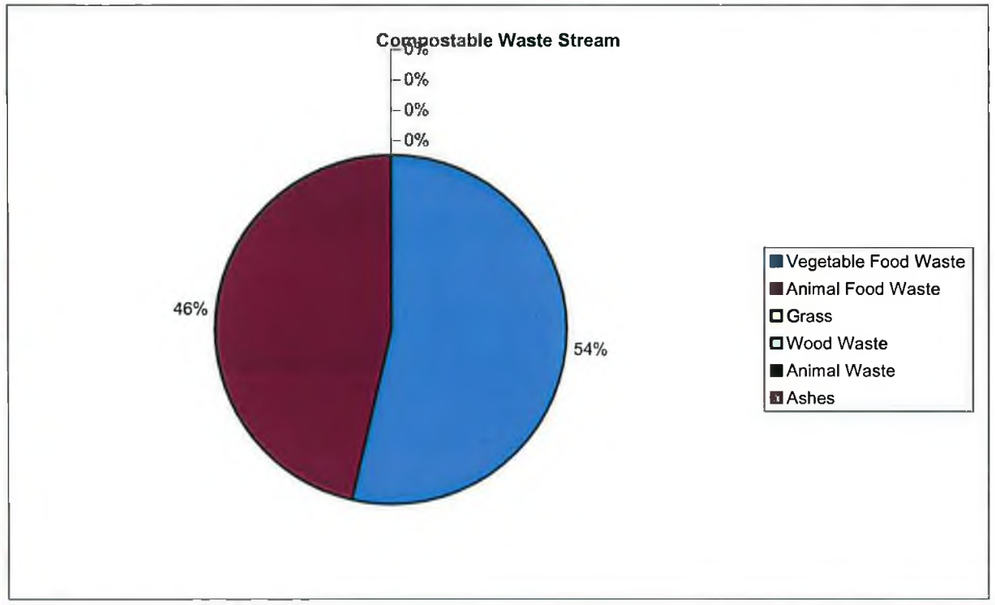
Compostable Waste	
Vegetable Food Waste	1.83
Animal Food Waste	1.58
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	0
Total organic waste	3.41
Per occupant average	1.14

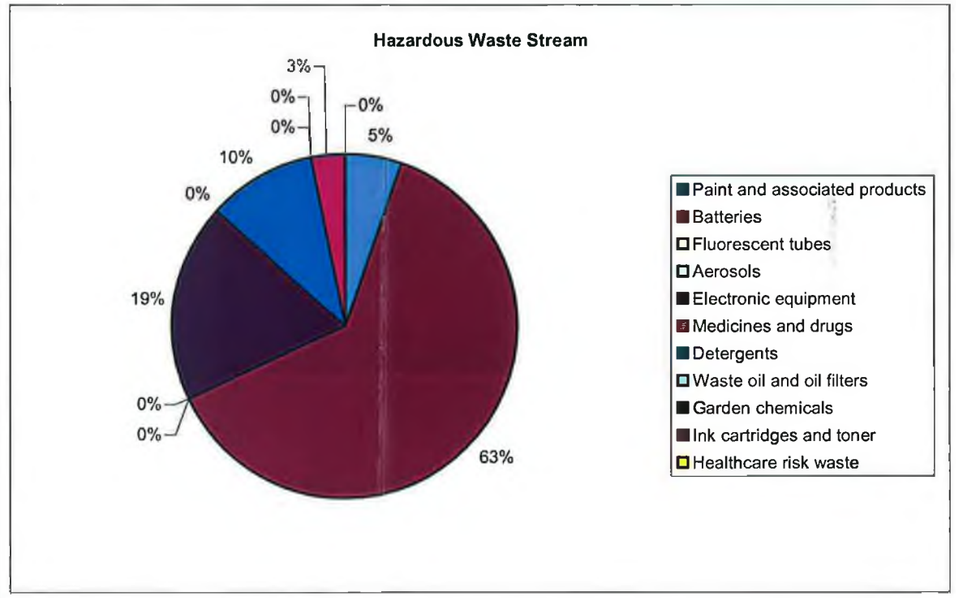
Landfill Waste	
Paper fibre waste	2.24
Plastics	2.75
Textiles	1.85
Metals	1.83
Glass	0.86
Other waste material	0.84
Total landfill waste	10.37
Per occupant average	3.46

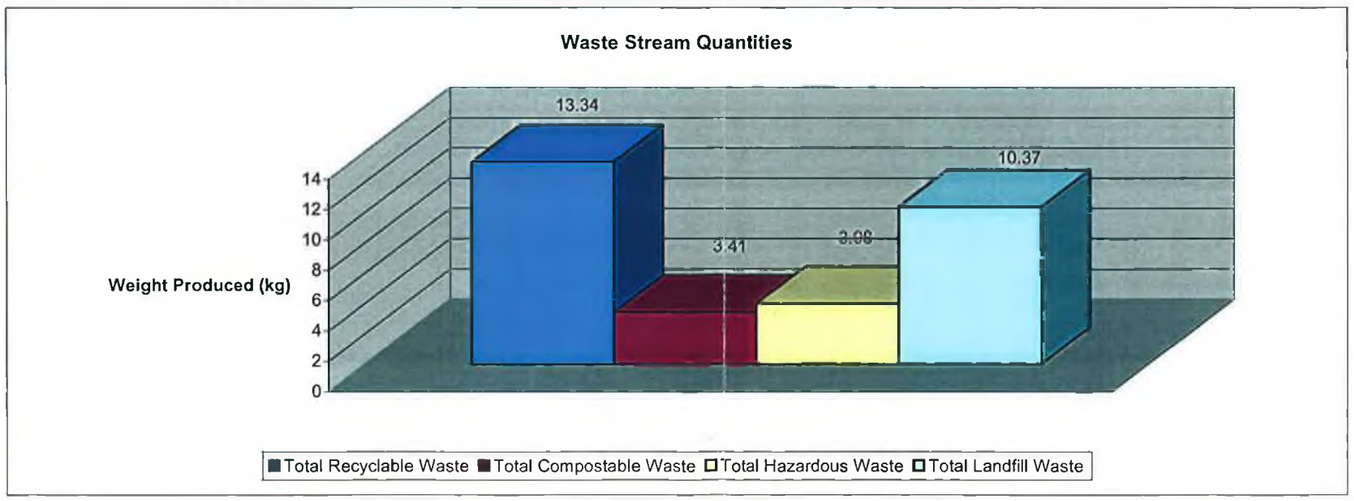
Hazardous Waste	
int and associated products	0.21
Batteries	2.5
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0.74
Medicines and drugs	0
Detergents	0.41
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0.12
Healthcare risk waste	0
Total hazardous waste	3.98
Per occupant average	1.33











esults

Property Details:	
Address Line 1:	Gurteen
Address Line 2:	Mountbellew
Address Line 3:	Ballinasloe
Address Line 4:	0
County:	Galway
Floor Area	172
Occupancy	6

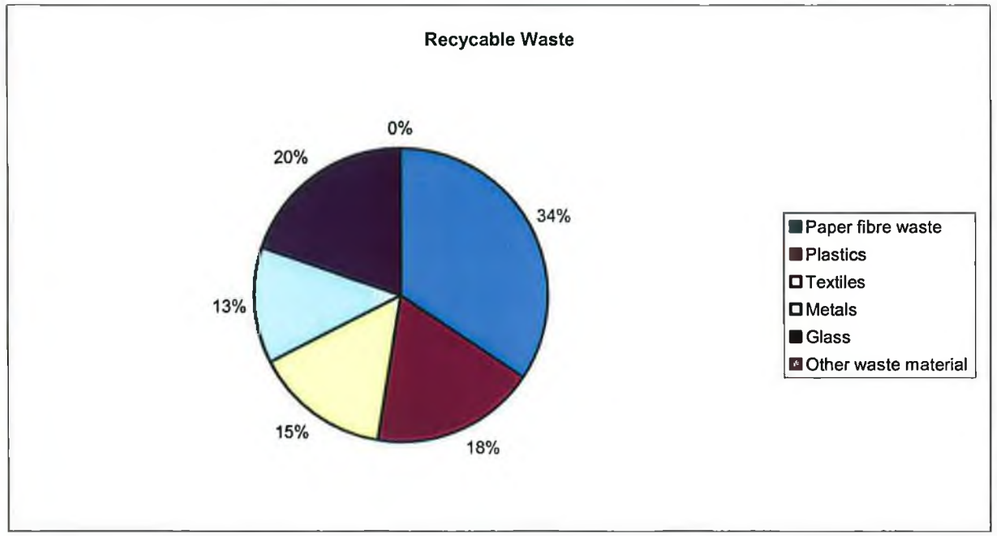
Assessor	
Name	Ivor H

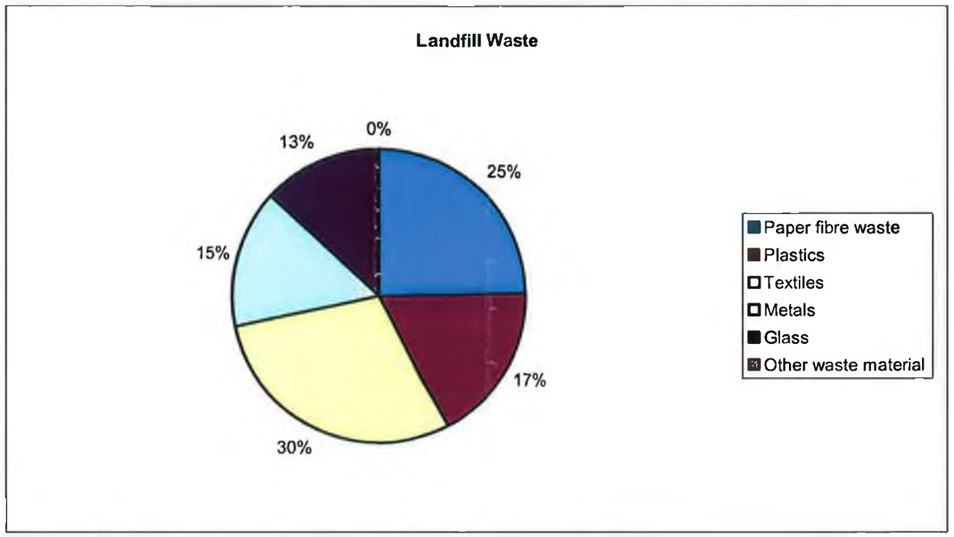
Recycable Waste	
Paper fibre waste	3.22
Plastics	1.7
Textiles	1.39
Metals	1.2
Glass	1.84
Other waste material	0
Total recyclable waste	9.35
Per occupant average	1.56

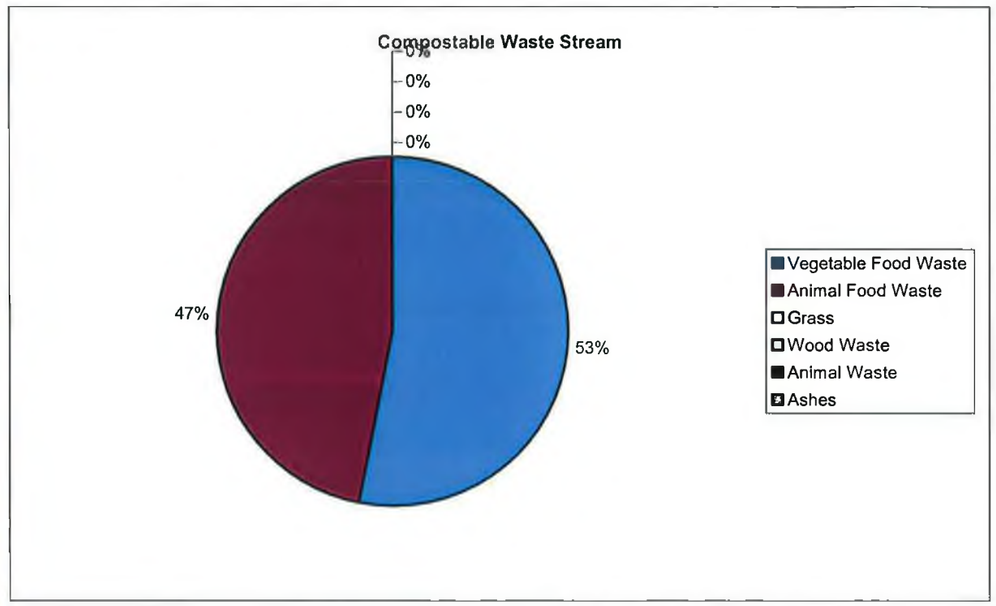
Compostable Waste	
Vegetable Food Waste	1.96
Animal Food Waste	1.74
Grass	0
Wood Waste	0
Animal Waste	0
Ashes	0
Total organic waste	3.7
Per occupant average	0.62

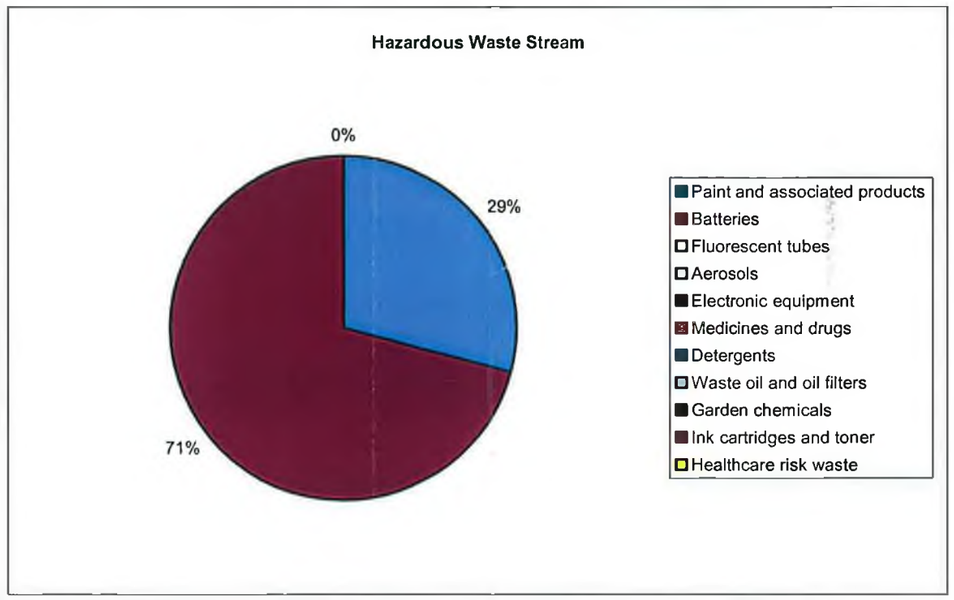
Landfill Waste	
Paper fibre waste	2.26
Plastics	1.58
Textiles	2.68
Metals	1.4
Glass	1.18
Other waste material	0
Total landfill waste	9.1
Per occupant average	1.52

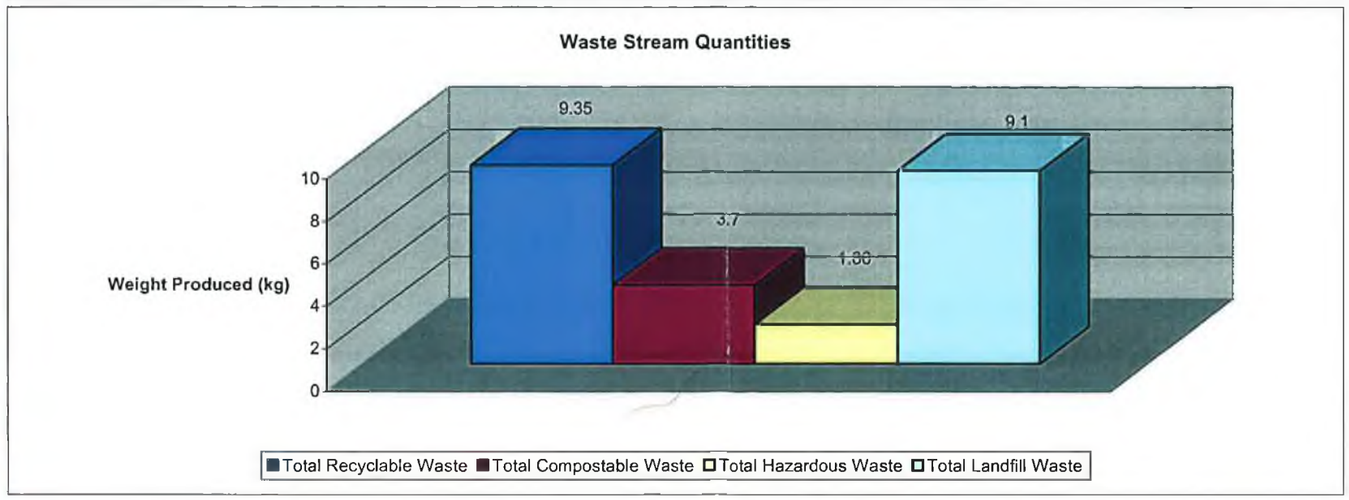
Hazardous Waste	
int and associated products	0.54
Batteries	1.32
Fluorescent tubes	0
Aerosols	0
Electronic equipment	0
Medicines and drugs	0
Detergents	0
Waste oil and oil filters	0
Garden chemicals	0
Ink cartridges and toner	0
Healthcare risk waste	0
Total hazardous waste	1.86
Per occupant average	0.31











APPENDIX I

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Did you obtain the automatic recommendations?	Yes
9	Will you adopt the recommendations provided?	Yes
10	Did you find the audit useful?	Yes

Household Name:	A

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: B

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropriate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: C

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: D

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name:	E

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: F

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name:	G

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detalled?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: H

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name:

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	No
3	Did you find it easy to answer the drop down menus provided?	No
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	Yes
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	No
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: J

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: K

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: L

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: M

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: N

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: O

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name: P

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name:	Q

Thank you for having particlpated in this pilot study. I hope you receive cost benefits as a result.

Field Trial II Questionnaire

Note: Please complete the ten questions below.
The questions have yes/no options available
to select from.

1	Could you operate the audit tool based on the instruction sheet provided?	Yes
2	Could you move between worksheets easily?	Yes
3	Did you find it easy to answer the drop down menus provided?	Yes
4	Do you think the questions are appropiate to your household?	Yes
5	Did you find the questionnaire format is to detailed?	No
6	Is the questionnaire visually pleasing?	Yes
7	Did you obtain results?	Yes
8	Could you easily understand the results?	Yes
9	Did you find the result graphs useful?	Yes
10	Did you find the audit useful?	Yes

Household Name:	R

Thank you for having participated in this pilot study. I hope you receive cost benefits as a result.

APPENDIX K

Figure 1 Flow chart of the Compostable sheet tab data entry process

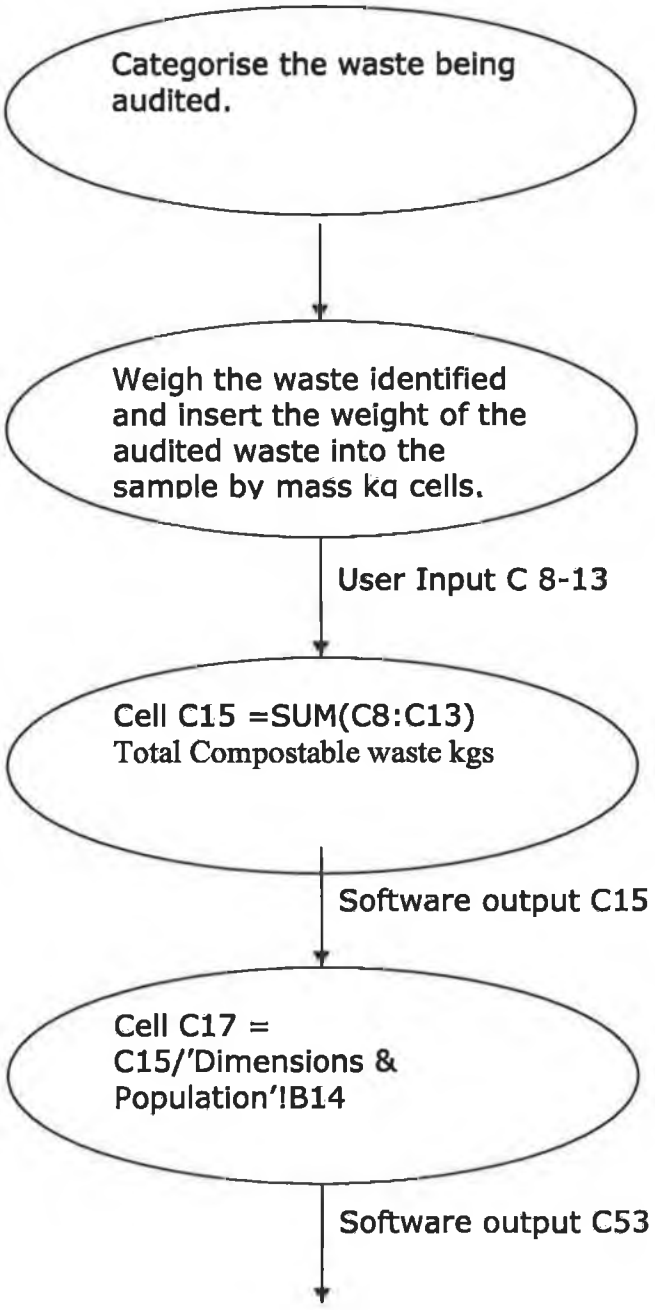


Figure 1.1 Flow chart of the Landfill material sheet tab data entry process

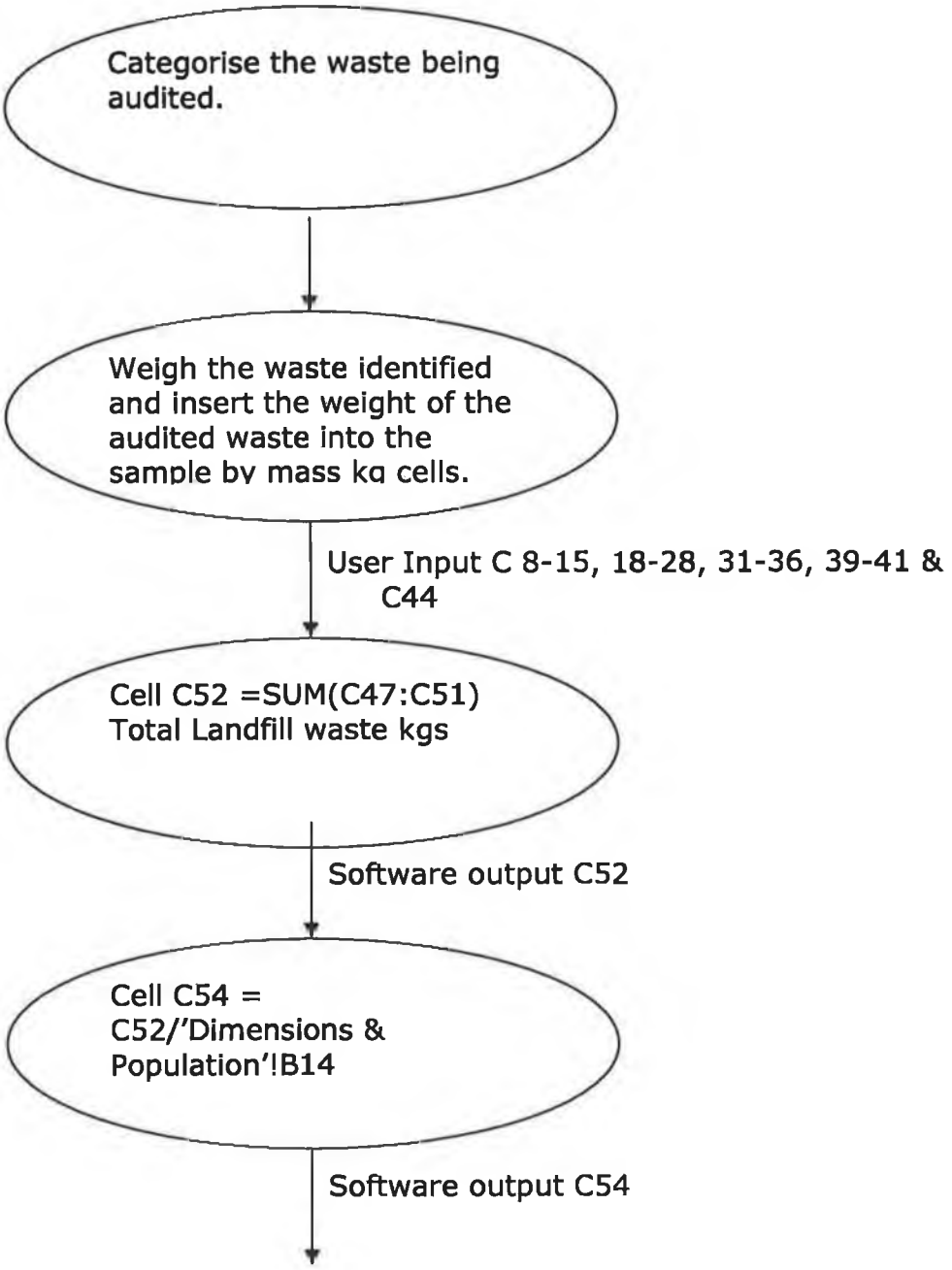


Figure 1.2 Flow chart of the Hazardous material sheet tab data entry process

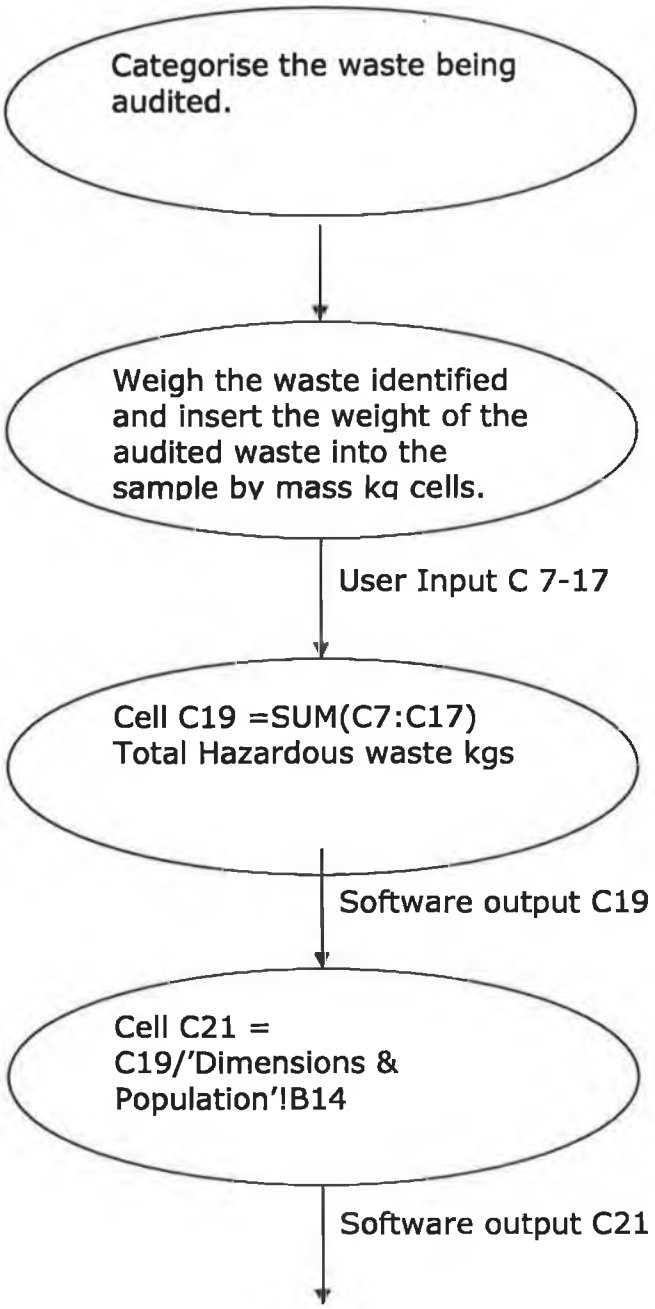
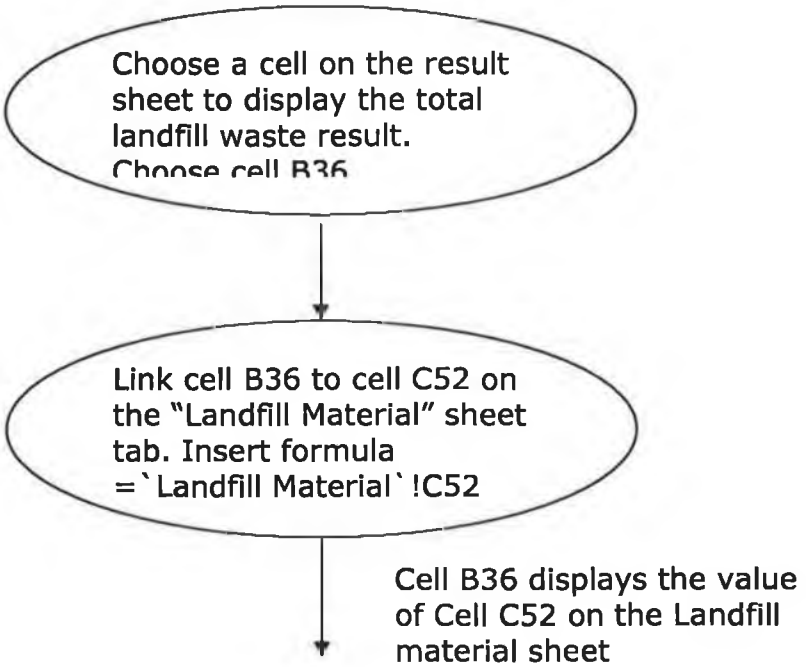


Figure 1.3 Flow chart of the Results sheet tab "

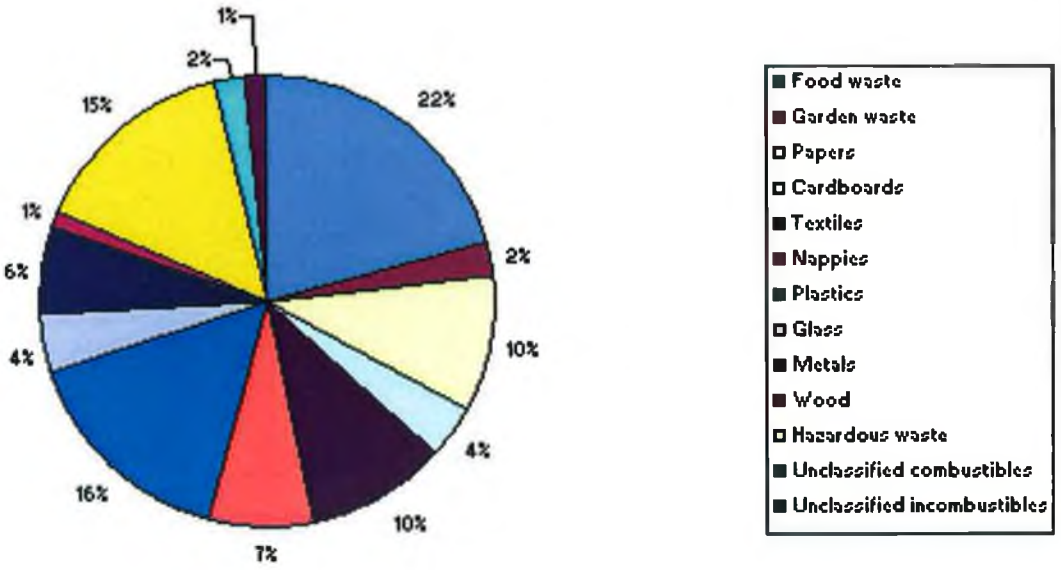


APPENDIX L

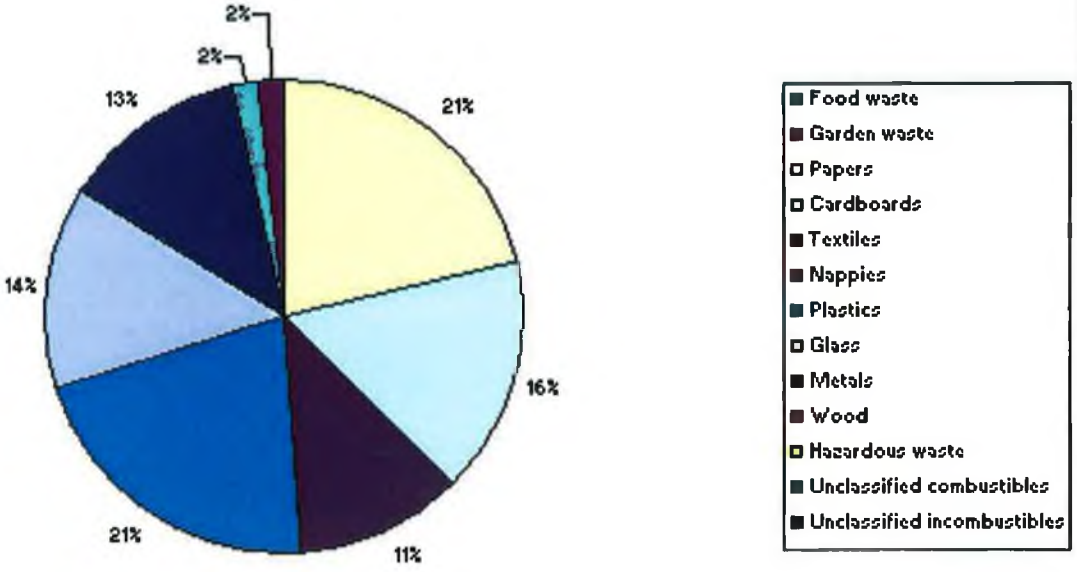
Waste composition (Kilograms)			
Landfill Material		Recycle Material	
Food waste	63.81	Food waste	0
Garden waste	6.31	Garden waste	0
Papers	29.41	Papers	38.1
Cardboards	10.61	Cardboards	28.14
Textiles	29.8	Textiles	20.27
Nappies	21.52	Nappies	0
Plastics	47.6	Plastics	37.56
Glass	12.82	Glass	24.34
Metals	19.28	Metals	22.67
Wood	3.45	Wood	0
Hazardous waste	44.77	Hazardous waste	0
Unclassified combustibles	7.02	Unclassified combustibles	3.13
Unclassified incombustibles	3.91	Unclassified incombustibles	2.6
Total (kg)	300.31	Total (kg)	176.81
Total Waste Produced (kg)	477.12		

Waste composition (Percentage)			
Landfill Material		Recycle Material	
Food waste	13.37	Food waste	0
Garden waste	1.32	Garden waste	0
Papers	6.16	Papers	7.98
Cardboards	2.22	Cardboards	5.89
Textiles	6.25	Textiles	4.25
Nappies	4.51	Nappies	0
Plastics	9.97	Plastics	7.87
Glass	2.69	Glass	5.1
Metals	4.04	Metals	4.75
Wood	0.72	Wood	0
Hazardous waste	9.38	Hazardous waste	0
Unclassified combustibles	1.47	Unclassified combustibles	0.66
Unclassified incombustibles	0.82	Unclassified incombustibles	0.58
Total (%)	62.92	Total (%)	37.08
Total (%)	100		

Mixed residual waste composition



Mixed dry recyclable waste



APPENDIX M

The composition of the urban dry recyclable waste is shown in Figure 6.7. The greatest proportions of the dry recyclable waste stream are plastics (22%), paper (20%), cardboard (18%), metals (14%) and glass (13%).

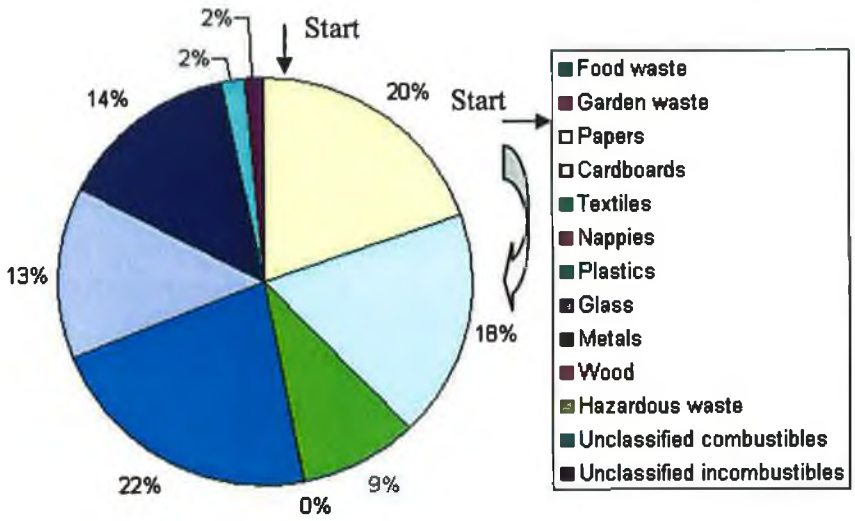


Figure 6.7 "Urban" dry recyclable waste composition by %

Ten households in the rural area of Mountbellew completed a waste audit using the W-MAT tool. The rural household waste composition reported is shown in Figure 6.7.

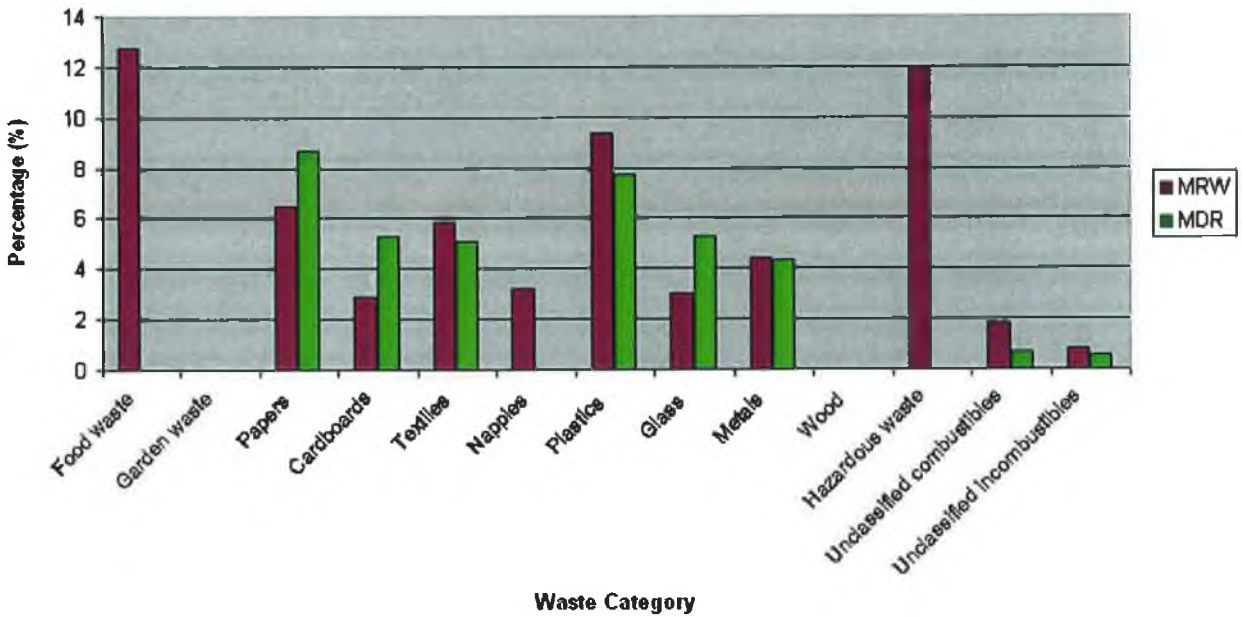


Figure 6.8 "Rural" household waste composition

As can be seen in Figure 6.6 and 6.7 the three greatest waste streams for the mixed residual waste category are food waste, hazardous waste and plastics. The composition of the mixed residual waste is shown in Figure 6.8.

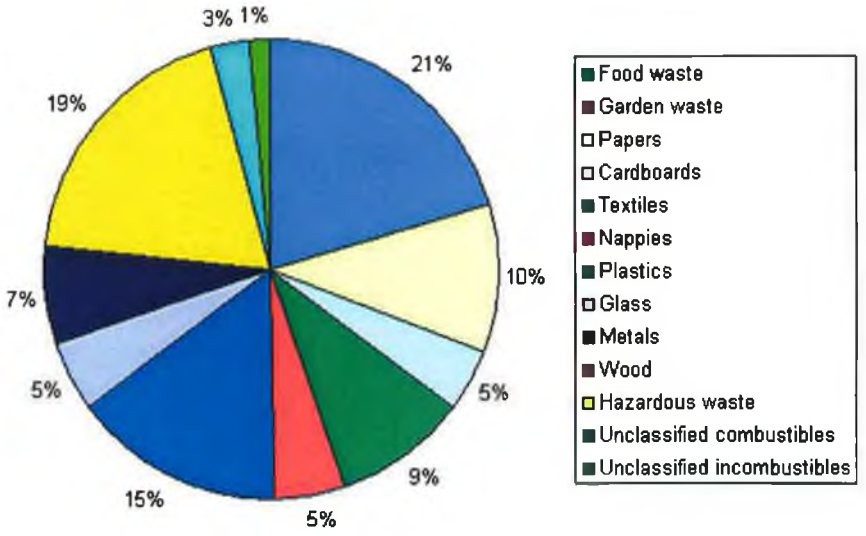


Figure 6.8 "Rural" mixed residual waste composition

The composition of the dry recyclable waste stream reported from the field test is shown in Figure 5.9.

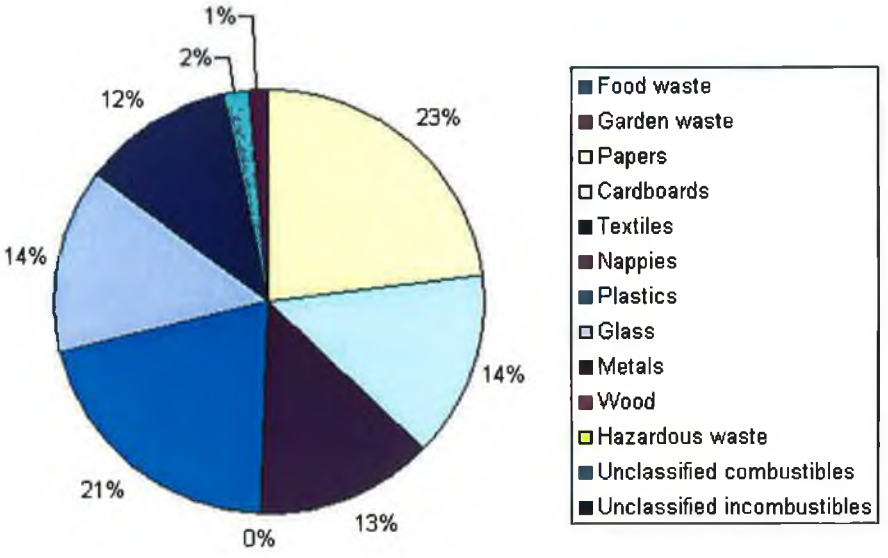


Figure 6.9 "Rural" dry recyclable waste composition

The W-MAT tool displays the composition of household waste based on the results of this study are summarised in Table 6.1 and Figures 6.10 & Figure 6.12.

APPENDIX N

an Chontae,
: na Radharc, Gaillimh.
an Chontae,
ɔect Hill, Galway.

Phone: (091) 509 000
/Fax: (091) 509 010
ɔn/Web: www.galway.ie
www.gaillimh.ie

Comhairle Chontae na Gaillimhe
Galway County Council

8th September 2009

RE: Local Authority Prevention and Demonstration Programme

To Whom It May Concern:

As one of four separate environmental initiatives undertaken as part of the Galway Local Authority Prevention and Demonstration Programme, Mr. Ivor Heavey, under the direction of his academic supervisor Mr. John Hanahoe of the Galway Mayo Institute of Technology and in conjunction with staff at Galway County Council undertook a research project to develop an **Electronic Domestic Waste Audit Tool**.

The programme commenced in 2007 and Mr. Heavey and his academic supervisor communicated regularly with Galway County Council's Environmental Department with regard to design developments and progress report meetings.

The Council is satisfied that a useful and practical domestic waste audit tool has been developed and that the results of the study conducted are most useful. It is the intention of Galway County Council to encourage the utilisation of this tool which will result in users being in a position to quantify their current environmental performance and work toward its improvement and enhancement.

The Council is grateful to Mr. Heavey for his efforts, dedication and enthusiasm.

If you require any further information on this matter please do not hesitate to contact me.

Yours sincerely,

Sinéad Ní Mhainnín
Environment Section
Galway County Council

htaí/Deontais Tithíochta
ing Loans/Grants
091) 509 301
ɔusing@galwaycoco.ie

:ais Tithíochta
'oplications
ɔ09 300
ɔusing@galwaycoco.ie

eallacht & Treidliachta
onment & Veterinary
091) 476 402
ɔvironment@galwaycoco.ie

re & Iompar
s & Transportation
091) 509 309
ıads@galwaycoco.ie

ıainní Daonna
ın Resources
091) 509 303
@galwaycoco.ie

rcháin
ɔr Taxation
091) 509 099
otortax@galwaycoco.ie

únais Tiomána
'ences
ɔ09 305
otortax@galwaycoco.ie

ıa dToghthóirí
ıter of Electors
091) 509 310
ectors@galwaycoco.ie

hísí Uisce
r Services
091) 476 401
ater@galwaycoco.ie

l & Fiontar
nunity & Enterprise
091) 746 860
ɔmmunity@galwaycoco.ie

áil
ıing
091) 509 308
anning@galwaycoco.ie

tais Ard Oideachais
ɛr Education Grants
091) 509 310
ducation@galwaycoco.ie

ıarlann
y
091) 562 471
ɔ@galwaylibrary.ie

Tá míle fáilte roimh chomhfhreagras i nGaeilge.