Local Government Association

Improvement

The potential of food waste disposal units to reduce costs

A literature review

Contents

Part 2

Introduction

Food waste disposal (FWD) units are small macerators that are installed in the kitchen sink outlet of domestic households. The householder separates food waste and flushes this into the unit with a small flow of cold water. Most foods are reduced to small particles and pass via the kitchen drain to the public sewer.

Low and Behold will be project managing a pilot on behalf of the Local Government Association (LGA) that will investigate the impact of food waste disposers (FWD) in households. Commercial FWD are not being investigated as part of this project. FWD may have the potential to remove organic waste materials from the residual waste stream, potentially reducing waste collection costs. There are concerns from the water industry about the impact on household behaviour and the sewer network and waste-water treatment works (WwTW). There are concerns from the waste industry about the impact on household behaviour and waste prevention messages.

A short survey has been undertaken to review the available literature on FWD. The aim is twofold. Firstly to provide a comprehensive list of research and opinion that will be a useful tool for others interested in this technology and subject area. Secondly to identify potential barriers to the proposed pilot study and to ensure that these will be fully mitigated against and investigated as part of the innovation project.

Part 1
Literature review

Executive summary

This is a summary of part 1 of the report and looks at the research and opinions available on food waste disposal (FWD).

147 individual pieces of information were assessed, of which 95 were deemed to be relevant for the purposes of this report.

Primary research[1] made up the largest category of the 95 relevant pieces of literature, accounting for 38 per cent of the work considered.

Secondary research[2] was the next largest category, making up 23 per cent of the literature investigated. The full breakdown of categories can be seen in the table below.

Table 1: Categories of studies investigated

Category	Number	Percentage
Article	15	16%
Desktop study	12	13%
Position paper	8	8%
Primary Research	36	38%
Promotional literature	2	2%
Secondary research	22	23%
Not relevant	52	
Total	**147**	

1 As defined in Section 2.0, Methodology.

2 As defined in Section 2.0, Methodology

Each piece of literature was labelled based on whether it found a positive, negative or neutral impact based on the use of food waste disposers (FWD). However it is important to note that each publication did not set out to examine the same impact, and so the headline figures given in this summary are indicative of a trend rather than representative of an opinion.

Overall, in terms of all the pieces of relevant literature reviewed, 60 of the 95, found a positive observed or measured impact from the use of FWD.

Seven out of the 95 found a negative observed or measured impact from the use of FWD.

Table 2: Summary total studies reviewed and outcomes

Category: Measured or observed impact of FWD use	**Number of studies**	**Percentage**
Neutral	22	23%
Negative	7	7%
Positive	60	63%
N/A	6	6%
Total	**95**	

15 articles and eight position papers were considered, the majority of which are opinion articles or statements of position from professional and trade bodies, or government departments. Two pieces of promotional literature were also considered. These 25 pieces of literature can largely be discounted for the purposes of this report as they do not include either any primary or secondary research and have not been presented to either a professional journal or a professional conference. This means that references are not fully cited, and in the cases where there are references, the source documents have already been included elsewhere in this study.

The remaining 70 pieces of literature form the bulk of this report. Of these, 17 found a balance of evidence or opinion that was both positive and negative in terms of either an observed, or measured, impact of FWD use.

5 studies observed or measured a **negative impact** resulting from the use of FWD.

43 studies observed or measured a **positive impact** resulting from the use of FWD.

These headline figures do not take into account the type of research and therefore the integrity of the evidence presented, nor do they differentiate between studies funded by industry or by water companies. The body of this report details the results in categories that give a better overview than the headline figures provided here as a summary.

1. Methodology

In order to review the existing research and literature on the impacts of FWD, the following organisations were contacted to build a list of potential sources of information:

- The Waste and Resources Action Programme (WRAP)
- Defra Resources and Sustainable Consumption Evidence Program
- The Water Services Regulation Authority (OFWAT)
- WRc (Water Research Centre)
- Chartered Institution of Water and Environmental Management (CIWEM)
- Chartered Institution of Wastes Management (CIWM)
- CIWM's Waste Prevention Group on linkedin
- Water UK
- Thames Water
- Association of Manufacturers of Domestic Appliances (AMDEA)
- Dr Tim Evans
- Professor Jan Gronow.

147 separate publications were assessed, of which 95 were deemed to be relevant for the purposes of this report.

The remaining 52 were deemed not relevant either because they were duplications of an existing piece of literature (for example in a different language) or because they did not specifically mention the impact of FWD. For example, there were a number of studies that investigated air quality and the resultant health impacts in composting plants, or that studied the lifecycle impacts of landfill and windrow composting. A full list of the studies not included in this report can be found in Appendix 2.

The 95 relevant studies were categorised into groups, which are described below. This categorisation was used because of the large amounts of information and the tendency of a number of studies to be desk-based reviews of previous works. For example, Surahammar in Sweden is a town with baseline data before the introduction of FWD to 50 per cent of households. The data from studies of this town are often quoted in articles. Therefore, to avoid duplication primary research and analysis is differentiated from a desktop study that reviews primary research.

The research has not been categorized by the specific topic, such as impact on the wastewater network, overall environmental impact and impact on the wastewater treatment plant as there are too many permutations; quick summaries have been made where appropriate in order to highlight areas that will need further investigation. Comparisons have not been made with other food waste disposal options, such as kerbside recovery and composting as the pilot does not intend to look at these areas.

In addition, it is thought important to distinguish between primary research; that is research that furthers our understanding of the subject through data collection and analyses of field trials or laboratory studies, from hypothetical desk-based calculations.

The categories that have been used are described below:

- **Article**
  An article in a newspaper or professional journal that either does not have cited references, or is referencing a single study that is included elsewhere in this report. Also includes reports of discussion events.
- **Desktop study**
  A desktop review of literature and research with no new analysis of data.
- **Position paper**
  A paper written by an industry or professional body, or government department explaining the reasons for a formal position.
- **Primary research**
  Research where laboratory or field studies are undertaken and where primary data is collected and analysed. This includes reports where the authors did not themselves collect the primary data, but conducted new analyses of data that was collected from a field trial or laboratory.
- **Promotional literature**
  A piece of literature promoting a product (such as FWD) or a service (such as a council waste collection service).
- **Secondary research**
  Desktop research where calculations are made based on a set of assumptions and on data from existing primary research to compare a series of waste management options or scenarios.

Each of the pieces of literature was checked to ensure that it was relevant to this report and was placed in one of the categories. A short summary of the literature was created and each piece was then labelled as either positive, negative, neutral or N/A, based on the observed or measured impacts of FWD use.

Literature that is labelled N/A is either discussing something other than FWD impacts, or is only available in a limited form, such as an abstract, and therefore cannot be labelled.

Literature that is labelled Neutral either opines or provides evidence for a range of positions. For example, it might find that FWD has a negative impact on sludge production, but a positive impact on gas production.

Where the literature conducted primary or secondary research, the geographical study area is listed.

Where available the funding source has been noted. They have been split into four broad areas for this report, FWD manufacturers, water and sewerage companies, governmental organisations and research groups.

2. Results

95 relevant pieces of literature were considered for this report. Primary research made up the largest category, counting for 38 per cent of the work considered.

Secondary research was the next largest category, making up 23 per cent of the literature investigated.

Table 3: Categories of studies investigated

Category	Number	Percentage
Article	15	16%
Desktop study	12	13%
Position paper	8	8%
Primary Research	36	38%
Promotional literature	2	2%
Secondary research	22	23%
Total	**95**	

In terms of all the pieces of literature reviewed, 60 of the 95, concluded that there was a positive measured or observed impact as a result of the use of FWD.

Seven of the pieces of literature reviewed (out of the 95) concluded that there was a negative measured or observed impact as a result of the use of FWD.

Table 4: Summary total studies reviewed and outcomes

Category: Measured or observed impact of FWD use	Number of studies	Percentage
Neutral	22	22%
Negative	7	7%
Positive	60	60%
N/A	6	6%
Total	**95**	

15 articles and eight position papers were considered, the majority of which are opinion articles or statements of position from professional and trade bodies, or government departments. One position paper relates to a change of legislation in the Australian Capital Territory[3]. These 23 pieces of literature can largely be discounted for the purposes of this report as they do not include any primary or secondary research and frequently refer to other pieces of research that are included elsewhere in this report.

Two pieces of promotional literature were considered. One was a copy of a webpage promoting Banff Council's waste collection service, including the promotion of the use of FWD. The second was a piece of literature from Insinkerator with guidance on how to use FWD with a domestic septic tank.

Primary research

Primary research took place in a number of countries over a large number of years, from 1951 to 2011. Laboratory tests were undertaken in Australia, Germany, Italy, the Lebanon, the UK and USA.

Field studies were conducted in Canada, Germany, Italy, Japan, New Zealand, the UK, a number of states in the USA, including New York City and in Sweden.

In summary, the majority of these studies concluded that there was a positive measured or observed impact as a result of the use of FWD. There were two studies, one laboratory study and one field study, which concluded that they should not be used. The details can be seen in the following table.

3 Legislative Assembly of the Australian Capital Territory (2005) Water and sewerage amendment regulation.

Table 5: Summary of conclusions from primary research

Neutral	6
Negative	2
Positive	23
N/A	5
Total	**36**

It is important to note that the country in which the study took place, and therefore current practices, have an impact on the conclusions reached in the studies. For example, studies in the Netherlands[4] and Sweden where very little food waste goes to landfill because MSW is incinerated found less benefit to FWD than US studies[5] were the alternative is more often landfill.

Out of the 36 studies, 9 were funded or supported by manufacturers of FWD and 5 were funded by water authorities. Governmental organisations and research groups supported 3 and 4 pieces of research respectively. 15 pieces of research did not declare any source of funding.

Neutral and not applicable

There are 11 pieces of literature that came to no conclusion or where the conclusion was not applicable to this report. These are often abstracts, rather than full reports, or looking at very specific issues and therefore came to no conclusion about the overall impact of FWD use.

Negative

There is one laboratory study that strongly concluded that FWD use would contribute significant problems to the sewer network. This study was conducted by Thames Water in laboratory conditions and investigated the level and speed of particle settlement. Using food waste from 18 volunteers in laboratory conditions using a bucket, the study investigated the output from FWD and concluded that after two hours settlement time there were high levels of ammonia, nitrogen and phosphorous detected in the supernatant. The author believed that this meant that their value would be lost during secondary treatment.[6]

4 Uitdenbogerd, D. E. (1995)

5 Sturtz Wisconsin, 1998

6 Thomas, P. (2011) The effects of food waste disposers on the wastewater system: a practical study. Water & Env. J. 25: 250-256

Positive

There are 23 pieces of primary research that conclude that FWD either have a positive environmental impact, or that they do not have a negative impact on the sewer network and WwTW and that their use should not therefore be restricted.

The 23 positive studies can be split into laboratory studies and field trials. There were three laboratory studies and the remaining 20 field trials took place in the following places:

- 1 * Gold Coast, Australia
- 1 * Penetanguishene, Canada
- 1 * Germany
- 1 * Italy
- 2 * Japan
- 1 * New Zealand
- 1 * Malmo, Sweden
- 1 * Staffanstorp, Sweden
- 1 * Stockholm, Sweden
- 2 * Surahammar, Sweden
- 1 * Hereford & Worcestershire, UK
- 1 * California, USA
- 1 * Indiana, USA
- 1 * Milwaukee, USA
- 1 * New York, USA
- 3 * Wisconsin, USA.

New York

The largest field trial is said to have taken place in New York. FWD were banned in the 1970s in areas with combined sewer system, to limit raw organic waste from discharging directly into waterways in wet weather and to also stop any potential deterioration in the sewer system. In 1997, in order to test the validity of the ban, 243 FWD were installed in 573 apartments, in three sets of buildings, with each set also having a control building.

The City modelled the impacts of FWD use, with a penetration rate of 1 per cent a year up till 2035, using information gained from the field study. This penetration rate was considered to be the worst case scenario, based on the experience in parts of the city with separate sewers, where FWD are allowed and penetration has never reached 25 per cent.

Two pertinent conclusions were reached from the 21-month field study and modelling exercise:

“The results of our analyses raise a cautionary flag at very high penetration rates. We believe it is prudent to monitor the introduction of FWDs to insure that the worst case analyses do not materialize.

To that end, Department for Environmental Protection (DEP) will track FWD installation using information provided pursuant to the existing Department of Building permitting requirements for the installation of plumbing appliances, including FWDs.[7]"

"A videotape survey was also conducted as part of the pilot study. Videotaping was conducted before FWDs were installed, during the study and at the study's completion. No noticeable deposits of suspended material were observed in the videotapes at the end of the relatively brief study period.[8]"

As part of this report, the New York City website was checked for updated data, and the following was found:

Residential Food Waste Disposers
Before 1997, NYC prohibited the use of FWDs in all parts of the City served by combined sewers. DEP conducted a comprehensive 21-month pilot program to assess the impacts of residential FWDs on the environment; the study (The Impact of Food Waste Disposers in Combined Sewer Areas Of New York City) showed that under conditions where limited numbers of homes installed FWDs, lifting the ban on residential dwelling would have manageable impacts. High rates of penetration for FWDs could have negative environmental consequences, though, especially given the increasingly demanding regulatory context for nitrogen discharges and combined sewer overflows. DEP continues to monitor the impacts of FWDs closely.[9]"

The website also stated that in 2008 a study had been undertaken to investigate Commercial FWD and that this had found they would have little environmental benefit in terms of diverting additional waste from landfill, but would have a detrimental effect on the wastewater network and treatment system.

7 New York City DEP (1999) The impact of food waste disposers in combined sewer areas of New York http://www.nyc.gov/html/dep/pdf/grinders.pdf p2.

8 Ibid, p8

9 New York City, Department of Environmental Protection website, accessed 17 Jan 2012 http://home2.nyc.gov/html/dep/html/residents/grinders.shtml

Surahammar

Surahammar is a town with a population of 9000 in Sweden where FWD usage rose from 0 per cent to 50 per cent of households. It is often quoted in FWD literature because it has good baseline data and continues to monitor the impact.

The first study between 1993 and 1997 was limited to 32 out of 39 apartments in a block and compared to a control block in the same area. CCTV monitoring concluded that there was no change in the sewer network.1 96 per cent of households were satisfied. 22 per cent had experienced some problems with their FWD, most being issues with incorrect items being inserted. This small trial led to the widespread installation of FWD between 1997 and the end of 1998 when it reached 30 per cent. The fast uptake of FWD occurred as differential charges were offered to residents depending on their choice of refuse collection. A larger annual charge was levied if the resident wished to have a kerbside collection, though no cost at all was levied if home composting was used.

There was a small increase in screened material at the WwTW, but no other noticeable impact at the plant, apart from an increase in biogas yields. There were no overflows during 1998, no interruptions in service, congestion or other issues with the sewer system.

However, the Haga WwTW at Surahammar had excess capacity before the project started, which was one of the reasons FWD were introduced in this area. They were also not introduced into parts of the town where it was deemed the sewer network was not suitable. The study therefore concluded that FWD posed no problems as a result of the careful planning of the project.[2]

The second study considered in this literature review was a desktop study in 2010 that looked at the Haga data from 1995 to 2009 and concluded that there was no significant change in flow, BOD or nitrogen loading, and that there was a 46 per cent increase in biogas[3].

1 Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.

2 Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.

3 Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households. Water Environ. J. 24:309-319

Secondary research

Secondary research involved calculations of the impacts of FWD in scenarios, often as part of the planning or policy process. Twenty-two studies fell into this category. Of these 22, five were funded by manufacturers of FWD, four by governmental bodies, three by research groups and two by water authorities.

Table 6: summary of conclusions from secondary research

Neutral	8
Negative	2
Positive	12
Total	**22**

Eight of the 22 studies are labelled Neutral because they calculated or measured a range of impacts as a result of the use of FWD. In some cases this means that they believe there is no basis on which to make a judgement either in favour or against the use of FWD. Much of the research explicitly states that the local circumstances are the most important factor and therefore remain neutral[7]. In other cases it was because a comparison was being made between FWD, kerbside collections with central composting[8] or AD[9] or blackwater recycling[10]. In these cases, FWD scored differently in different categories and different studies.

Twelve of the 22 studies calculated or measured a positive impact from the use of FWD. Again, the importance of local circumstances is raised[11], including the aims of the project. Some studies look at the impact of FWD from a waste disposal perspective[12] while others are investigating the impacts of the sludge on agriculture[13]. For this reason, as has been stated before, the headline figures give only an indication of a trend in opinion.

Two studies calculated or measured a negative impact from the use of FWD, the most recent being the Irish EPA report in 2008[14]. One of the key issues in both studies that calculated negative impacts was the available capacity and capability of the existing WwTW infrastructure, again demonstrating the importance of local factors.

7 For example; Galil, Noah L. and Yaacov, Lila (2000) and Karrman; Olofsson; Persson; Sander; Aberg (2001)

8 Karrman; Olofsson; Persson; Sander; Aberg (2001) Food waste disposers – a solution for sustainable resource management? A pre-study on Goteborg, Sweden. 6th European Biosolids & Organic Residuals Conference

9 Defra. WRc National Food Waste Programme. Comparison of the Sustainability of Food Waste Disposal Options. Dec 2010

10 Tidåker, P.; Kärrman, E.; Baky, A.; Jönsson, H. (2006) Wastewater management integrated with farming –an environmental systems analysis of a Swedish country town. Resources, Conservation and Recycling 47 295–315

11 For example; Lawton, M. (2007) and Malmqvist, P-A.; Heinicke, G. (2006)

12 For example; Diggelmann C. & Ham, R.K. (2003)

13 For example; Pernilla Tidåker, P.; Kärrman, E.; Baky, A.; Jönsson, H. (2005)

14 EPA Strive Report Series No 11: Examining the Use of Food Waste Disposers

Desktop studies

The Desktop Studies that were considered for this report were largely reviews of existing literature and research (8 out of 12).

There were four studies which did not limit themselves to just reviewing existing material. One study investigated the environmental impacts of FWD in terms of energy use, but not the impact on the sewer network[15]. One study reviewed the right conditions for installing FWD in Germany[16]. One is industry-funded and looking at the potential market in New Zealand[17]. The final study looks only at the impact on septic tanks and finds against FWD[18].

Five of the desktop studies were funded by the manufacturers and three were funded by governmental organisations.

Table 7: Summary of conclusions from desktop research

Neutral	1
Negative	1
Positive	8
N/A	2
Total	**12**

15 Market Transformation Programme (2008) BNXS43: Food Waste Disposers – an overview

16 Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, "Sludge management entering the 3rd millennium. Taipei, Taiwan

17 Ulfves, V; Cocks, J. and Evans, T. (2008) Food Waste Management in New Zealand. Report for Parex Industries Ltd. MWH New Zealand Limited

18 USEPA (2000) Onsite Wastewater Treatment Systems - Special Issues Fact Sheet 2. High-Organic-Strength Wastewaters (Including Garbage Grinders)

Part 2
Barriers to FWD from existing literature

Executive summary

This is a summary of part 2 of the report that looks to identify potential barriers to the proposed pilot study.

Altogether, 10 main impacts regarding the installation of FWD were discussed within the literature. They have been picked out in order to identify the key areas that will need to be monitored during the innovation project. These have been summarised in the table below.

Table 8: Summary of the main impacts found regarding FWD

Area	Impacts
Internal	Certain types of pipework (eg elbow joints) may contribute to blockages
Lateral	No clogging found in previous studies
Sewer network	• No clogging found in most studies. • A 2% minimum gradient in the pipework may be needed to ensure no clogging occurs. • Heavy materials may cause blockages if entered into the pipework.
FWD equipment	• 12 year lifespan • Material may get caught within the grind chamber
Screening and primary settlement	Sewage with ground solids may 'settle better'
Secondary stage processing	• Increased loads of COD, BOD and Nitrogen • Increased organic content
Anaerobic digestion impacts	• Increase in biogas content occurs, though amount is dependent on the percentage penetration • C:Nutrients ratio increase may enhance biological nutrient removal

Sludge	Increases found in all studies
Cost	Highly dependent on local circumstances
Residual Waste	Fall in volume

Of the 10 areas noted, nine of these have been identified to be monitored during the course of the pilot program. These include all aspects relating to the pipework, for example the internal, lateral and the sewer network as well as the equipment itself and impacts associated with the waste water treatment plants and residual collection. Behavioural change will also be analysed as part of the pilot project.

The cost will be analysed in a desktop study carried out on completion of the pilot.

3. Methodology

Part 2 of the Literature Review pulls out the main impacts expressed with potential concern in the literature about FWD. The aim is to bring together a list of the key impacts that will need examining as part of the pilot.

For the purpose of looking at the key impacts only the primary research, secondary research and desktop studies were looked at.

Any key impacts that were noted in Part 1 have been split into their specific area.

The categories used range from impacts associated with the sewer system (internal, lateral and sewer network), effects on the equipment itself and also any impacts found with the treatment processes, such as screening, second stage processing, anaerobic digestion and with the remaining sludge. Key financial impacts have also been collated.

This report does not cover issues concerning septic tanks. While many reports note general impacts, only the literatures that discuss specific impacts have been included in this report.

4. Results

Internal impacts
Internal impacts are those associated with the pipework connecting the FWD to the lateral pipework. Two pieces of literature noted problems with internal pipework, one noting blockages can occur when certain pipes are in place. This was easily rectified using pipe changes. The second noted the occurrence of positive pressures that may cause the destruction of the seal, though only the abstract was available for this piece of literature.

Details regarding these impacts can be seen in the table below

Table 9: Internal impacts within the literature

Reference	Year	Notes	Research Type
Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.	1999	22% claimed had some problem with FWD, mostly because of internal blockages (rectified by pipe changes eg elbows) and materials caught in FWD.	Primary research
Minami, Y. and Otsuka, M. (2005) Study On Occurrence And Influence Of Instant Positive Pressure In Model Of High-Rise Apartments: Part 1 Basic research regarding to the drainage performance evaluation to drainage stack system with food waste grinder. J. Env. Eng. (591) pp.53-60	2005	Abstract only: “It is reported that the food waste grinder drainage system was installed in 50000 houses in the 2003 year. In the drainage stack system with the food waste grinder drainage system, ground food waste accumulates near a leg joint of house drain and collides with flowing drainage water so as to generate instant positive pressure exceeding a judgment standard thereby causing seal destruction of trap. This has been regarded as a problem.”	Primary research

Lateral impacts

Lateral impacts are those that have been associated with the pipework connecting the household to the sewer line. Only one piece of literature mentioned this and no evidence of any clogging was found, as can be seen in the table below.

Table 10: Lateral impacts within the literature

Reference	Year	Notes	Research Type
Koning, J. de and Graaf, J.H.J.M. van der (1996) Kitchen food waste disposers, effects on sewer system and wastewater treatment. Technical University Delft.	1996	No evidence of clogging, even at shallow gradients	Secondary research

Sewer network impacts

Four pieces of literature noted the effects on the sewer network. Two of these found no evidence of clogging within the pipes, one suggested a 2 per cent minimum gradient would be needed to ensure no clogging would occur and another noted that hard materials, such as egg shells and bones may cause blockages if they were to get into the sewers. The table below provides more detail on the literature.

Table 11: Sewer network impacts found within the literature

Reference	Year	Notes	Research Type
Nilsson, P.; Lilja, G.; Hallin, P.-O.; Petersson, B. A.; Johansson, J.; Pettersson, J.; Karlen, L. (1990) Waste management at the source utilizing food waste disposers in the home; a case study in the town of Staffanstorp. Dept. Environmental Engineering, University of Lund.	1990	15 year lab simulation of FWD use and effect on pipes. No fouling of pipes found, no deposits or obstructions found.	Primary research
Koning, J. de and Graaf, J.H.J.M. van der (1996) Kitchen food waste disposers, effects on sewer system and wastewater treatment. Technical University Delft.	1996	No evidence of clogging, even at shallow gradients	Secondary research

Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, “Sludge management entering the 3rd millennium. Taipei, Taiwan	2001	A minimum gradient of at least 2% needed	Desktop study
Galil, N. and Shpiner, R. J. (2001) Additional pollutants and deposition potential from garbage disposers. CIWEM 15 34-39	2001	Heavy materials such as eggs shells and bones could cause blockages	Secondary research

FWD equipment

Three pieces of literature mention the FWD equipment itself. Few effects were found though it was noted that the equipment does generally have a lifespan and will need to be replaced at some point. One issue found was that of material getting caught within the grind chamber. In one piece of literature it was noted that 22 per cent of users had some form of problem with the equipment though another study found that 80 per cent of users would like to carry on using them, as can be seen in the table below:

Table 12: FWD Equipment within the literature

Reference	Year	Notes	Research Type
Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.	1999	22% claimed had some problem with FWD, mostly because of internal blockages (rectified by pipe changes eg elbows) and materials caught in FWD	Primary research
Diggelmann C. & Ham, R.K. (2003) Household food waste to wastewater or to solid waste? That is the question. Waste Management & Research 21 501 - 514	2003	12 year lifespan of equipment	Secondary research
Report on Social Experiment of Garbage Grinder Introduction. Technical note of National Institute for Land and Infrastructure Management, Japan. No. 226 March 2005	2005	80% of participants wanted to use FWD after trial.	Primary research

Screening and primary settlement

One piece of literature mentioned the screening and primary settlement of material.

Table 13: Screening and primary settlement within the literature

Reference	Year	Notes	Research Type
Atwater, R.M. (1947) The Kitchen Garbage Grinder. Editorial Amer. J. Public Health 37 573-574	1947	Sewage with ground solids 'settles better'	Desktop study

Secondary stage processing

Two pieces of literature have been found with regards to secondary stage processing. Both suggest increased loads into the secondary stage processing though one suggest that the increased organic content entering the system may be useful in those areas where values are dropping, while the second suggested that loads of COD, BOD and nitrogen entering secondary stage processing would be increased. The two pieces of literature are referenced in the table below.

Table 14: Secondary stage processing within the literature

Reference	Year	Notes	Research Type
Davis, Bob; Graham, Adele and Hearn, Kirstie (2004) Evaluation of food waste disposal units and their part in municipal waste management. 9th CIWEM European Biosolids and Biowastes Conference	2004	"In some European countries the organic content of wastewater has dropped so low that in order to achieve BNR synthetic carbon sources are added to wastewater. The Italian Ministry of Environment has suggested to its water authorities that they provide free FWD to inhabitants in cases where there is not enough organic material arriving at treatment works."	Desktop study
Thomas, P. (2011) The effects of food waste disposers on the wastewater system: a practical study. Water & Env. J. 25: 250-256	2011	Increased loads (COD, BOD and nitrogen) to secondary treatment	Primary research

Anaerobic digester impacts

Of the five pieces of literature that discuss the impacts imposed on an anaerobic digester by the installation of FWD four of them show an increase in biogas production, though this does depend on the penetration of the equipment. One study found that biological nutrient removal was enhanced as the material derived from food waste increased the carbon to nutrients ratio.

The literature found can be seen in the table below.

Table 15: Anaerobic digester impacts within the literature

Reference	Year	Notes	Research Type
Koning, J. de and Graaf, J.H.J.M. van der (1996) Kitchen food waste disposers, effects on sewer system and wastewater treatment. Technical University Delft	1996	Biogas increase of 17.4l/ per/day	Secondary research
Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.	1999	Increase in biogas production	Primary research
Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference	2000	50%- 70% increase at a penetration of >60%	Secondary research
Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, “Sludge management entering the 3rd millennium. Taipei, Taiwan	2001	90%- 100% increase	Desktop study
Bolzonella D.; Pavan P.; Battistoni P.; Cecchi F. (2003) The Under Sink Garbage Grinder: A Friendly Technology for the Environment. Env. Tech. 24, 349-359	2003	FWD enhances biological nutrient removal by increasing C: nutrients ratios.	Primary research

Sludge

Increase in sludge has been noted in four studies. The increase found was dependant on the penetration level of FWD and show a large variation. The different studies have been listed in the table found below.

Table 16: Sludge within the literature

Reference	Year	Notes	Research Type
Economic and Environmental Impacts of Disposal of Kitchen Organic Wastes using Traditional Landfill - Food Waste Disposer - Home Composting A Waste Management Research Unit - Griffith University Waste Management Research Unit - Griffith University Report Prepared for In-Sink-Erator	1994	25% penetration = 4% increase in sludge volume.	Primary research
Uitdenbogerd, D. E. (1995) Kitchen waste disposal treatment: an evaluation. Agricultural University, Wageningen. 27pp	1995	10% of food waste being disposed of through FWD would increase sewage sludge volume by 5%.	Primary research
Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, “Sludge management entering the 3rd millennium. Taipei, Taiwan	2001	30% - 50% increase	Desktop study
Karrman; Olofsson; Persson; Sander; Aberg (2001) Food waste disposers – a solution for sustainable resource management? A pre-study on Goteborg, Sweden. 6th European Biosolids & Organic Residuals Conference	2001	10% in sludge production for 50% pen.	Secondary research

Cost

Several studies have looked at the cost implications of installing FWD. Due to the large effect local circumstances can have on the costs and savings produced by installing FWD, it is very difficult to pin down the general impact. It should be noted that many of these reports are secondary research and the data may be too sensitive to be used in a more general sense.

Cost increases have been noted due to increased investment needed in the wastewater treatment, though the extra input may lead to increases in electricity generation at the plants and thereby reducing the overall cost to the plant. Savings on the part of the local authorities have also occurred in some scenarios.

Table 17: Costs within the literature

Reference	Year	Notes	Research Type
Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference	2000	23-27% increase in wastewater treatment investment and 26-30% increase in maintenance cost.	Secondary research
Koning J de (2004) Effects on wastewater treatment focused on additional production of biogas. Tech. Univ. Delft	2004	Concludes: The advantage of the increase in self supply in electricity partly compensates for the increase in the costs for central sludge treatment; the increase in costs per person will be minimal or negligible.	Secondary research
Iacovidou, E. et al (2012) Food waste disposal units in UK households: The need for policy intervention. Science of the Total Environment. 423:1-7	2012	Installation of FWD would lead to additional costs to water industry but savings to local authorities. Though a large penetration level would be needed to produce the best savings.	Secondary research

Residual waste

Several studies have looked at the changes that may occur within the general refuse stream due to the installation of FWD though in all of the studies no increase has been found. A fall in volume has been seen as well as a reduction in the amount of flammable garbage.

Table 18: Residual waste within the literature

Reference	Year	Notes	Research Type
Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.	1999	Fall in volume seen, from 6 bins twice a week to 3 bins once a week (though a sorting project also contributed)	Primary research
Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference	2000	Volumes fall by 3.3% to 18.7%	Secondary research
Yang, X.; Okashiro, T.; Kuniyasu, K. and Ohmori, H. (2010) Impact of food waste disposers on the generation rate and characteristics of municipal solid waste. J. Mater. Cycles Waste Manag. 12:17–24	2010	Volume reduction of 40%	Primary research

5. Discussion

All of the pieces of literature, except one[19] studied agree that the introduction of FWD will increase water use in individual households and that the increase will be negligible.

They also mainly agree that there will be an increase in total suspended solids, BOD, COD and sewage sludge. What they do not consistently agree on is the level of that impact and whether that impact is negative or positive.

For most pieces of literature an important issue is the level of market penetration. At low levels of market penetration, the impact of FWD is difficult to measure. The literature has a range of opinion about the maximum level of penetration that can be reached before new investment may be needed in WwTW infrastructure. The cut-off point varies in the literature from 15 per cent[20] to 60 per cent[21] [22].

From this review of the current literature on the use of FWD it is possible to conclude that local circumstances are important and that a UK pilot is critical to understanding the impacts better.

19 Except Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. Which found that water use dropped in the initial small study,but does not put this down to FWD specifically.

20 Wainberg, R.; Nielsen, J.; Lundie, S.; Peters, G.; Ashbolt, N.; Russell, D.; and Jankelson, C. (2000) Assessment of food disposal options in multi-unit dwellings in Sydney. CRC for Waste Management and Pollution Control Limited. Report 2883R

21 Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference

22 For example, New York City DEP (1999) The impact of food waste disposers in combined sewer areas of New York City. http://www.nyc.gov/html/dep/html/grinders.html states that at 38% penetration, there would be a cost saving to the city of $4m a year.

6. Appendices

Appendix 1 contains all of the references used in the report while appendix 2 contains all of the reference that were submitted but not used in the final report.

Appendix 1

List of references found in footnotes in the order that they appeared in the text.

- Legislative Assembly of the Australian Capital Territory (2005) Water and sewerage amendment regulation.
- Uitdenbogerd, D. E. (1995) Kitchen waste disposal treatment: an evaluation. Agricultural University, Wageningen. 27pp
- Strutz, William.F. (1998) A brief summary and interpretation of key points, facts and conclusions of Diggelmann, Carol and Ham, Robert K. (1998) Life-Cycle Comparison of Five Engineered Systems for Managing Food Waste. Department of Civil and Environmental Engineering, University of Wisconsin. January 1998.
- Thomas, P. (2011) The effects of food waste disposers on the wastewater system: a practical study. Water & Env. J. 25: 250-256
- New York City DEP (1999) The impact of food waste disposers in combined sewer areas of New York, accessed 07 August 2012 www.nyc.gov/html/dep/pdf/grinders.pdf page 2
- New York City DEP (1999) The impact of food waste disposers in combined sewer areas of New York, accessed 07 August 2012 www.nyc.gov/html/dep/pdf/grinders.pdf page 8

- New York City, Department of Environmental Protection website, accessed 07 August 2012 www.nyc.gov/html/dep/pdf/grinders.pdf
- Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.
- Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households. Water Environ. J. 24:309-319
- Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference
- Karrman; Olofsson; Persson; Sander; Aberg (2001) Food waste disposers – a solution for sustainable resource management? A pre-study on Goteborg, Sweden. 6th European Biosolids & Organic Residuals Conference
- Defra. WRc National Food Waste Programme. Comparison of the Sustainability of Food Waste Disposal Options. Dec 2010
- Tidåker, P.; Kärrman, E.; Baky, A.; Jönsson, H. (2006) Wastewater management integrated with farming – an environmental systems analysis of a Swedish country town. Resources, Conservation and Recycling 47 295–315
- Lawton, M. (2007) Food Waste Disposal Options Study. Braidwood Research and Consulting Ltd.
- Malmqvist, P-A.; Heinicke, G. (2006) Strategic planning of the sustainable future wastewater and biowaste system in Göteborg, Sweden. Proc. Cities of the Future: Urban Sustainability and Water. IWA World Water Congress, Beijing
- Diggelmann C. & Ham, R.K. (2003) Household food waste to wastewater or to solid waste? That is the question. Waste Management & Research 21 501 – 514
- Pernilla Tidåker, P.; Kärrman, E.; Baky, A.; Jönsson, H. (2005) Wastewater Management Integrated with Farming – An Environmental Systems Analysis of the Model City Surahammar. Department of Biometry and Engineering, Uppsala
- EPA Strive Report Series No 11: Examining the Use of Food Waste Disposers
- Market Transformation Programme (2008) BNXS43: Food Waste Disposers – an overview
- Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, Sludge management entering the 3rd millennium. Taipei, Taiwan
- Ulfves, V; Cocks, J. and Evans, T. (2008) Food Waste Management in New Zealand. Report for Parex Industries Ltd. MWH New Zealand Limited
- USEPA (2000) Onsite Wastewater Treatment Systems - Special Issues Fact Sheet 2. High-Organic-Strength Wastewaters (Including Garbage Grinders)
- Wainberg, R.; Nielsen, J.; Lundie, S.; Peters, G.; Ashbolt, N.; Russell, D.; and Jankelson, C. (2000) Assessment of food disposal options in multi-unit dwellings in Sydney. CRC for Waste Management and Pollution Control Limited. Report 2883R

- Karlberg, Tina and Norin, Erik, (1999) Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar. VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. VA-FORSK RAPPORT 1999-9.
- Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference
- Yang, X.; Okashiro, T.; Kuniyasu, K. and Ohmori, H. (2010) Impact of food waste disposers on the generation rate and characteristics of municipal solid waste. J. Mater. Cycles Waste Manag. 12:17–24

Appendix 2

List of literature submitted but not included in the findings of this report, excluding duplications.

- OIKO environmental supplement Kathimerini (2009)
- Residential Waste Water Treatment Systems – Field and Laboratory Studies Sybron Chemicals Inc. 1998
- Waste and resource management: challenges through to 2010 editorial (2006) Proceedings of the Institution of Civil Engineers, Waste and Resource Management 159 39–47
- Aspegren, H.; Bissmont, M.; Erlandsson, M. and Fagerström, B-M (2005) Slutrapport – Bo01
- Bünger, J.; Schappler-Scheele, B.; Hilgers, R. and Hallier, E. (2007) A 5-year follow-up study on respiratory disorders and lung function in workers exposed to organic dust from composting plants. Int. Arch. Occup. Environ. Health 80:306–312
- Cassirer, T; Luthman, T.; Safi, I.; Svanmo, J. and Talebi, Z.S. (2008) Avfallskvarnar - Ett hållbart alternativ för ökad biogasproduktion vid Käppalaverket? Projektrapport KHT
- Connolly, K. (2008) Emptying organic rubbish can damage health, say doctors. The Guardian I Thursday April 10 2008 p26
- Ducoste, J.; Kenner, K.; Groninger, J.; Holt, L. (2008) Fats, Roots, Oils and Grease (FROG) in Centralized and Decentralized Systems Water Environment Research Foundation.
- Harrison, D. (2010) Anaerobic Digestion of Biowaste in the UK. Proc. 15th European Biosolids & Organic Resources Conference & Workshop. AquaEnviro, Wakefield
- Jones, M. (2002) Waste Away Scheme - Phase Two: a quantitative survey of the effectiveness of The Moray Council's waste minimisation scheme to reduce organic kitchen food waste going to landfill. www.ecolinc.org.uk/docs/Main%20Report.pdf
- Kegebein, Jörg; Hoffmann, Erhard; and Hahn, Herman H. (2001) Co-Transport and Co-Reuse. An Alternative to Separate Bio-Waste Collection? Wasser-Abwasser GWF 142 (2001) Nr. 6 429-434
- Kirkeby, J.T.; Birgisdottir, H.; Hansen, T.L.; Christensen, T.H.; Bhander, G.S.; Hauschild, M. (2006) Environmental assessment of solid waste systems and technologies: EASEWASTE. Waste Manage Res 24 3–15

- Kirkeby, J.T.; Birgisdottir, H.; Hansen, T.L.; Christensen, T.H.; Bhander, G.S.; Hauschild, M. (2006) Evaluation of environmental impacts from municipal solid waste management in the municipality of Aarhus, Denmark (EASEWASTE). Waste Manage Res 24 16–26
- Levis, J. W., Barlaz, M. A., and Ranjithan, R. S. (2008) A Life-Cycle Inventory of Alternatives for the Management of Commercial Food Waste. Proc. Global Waste Management Symposium, Copper Mountain, Colorado,
- Levis, J. W., Barlaz, M. A., Themelis, N. J., and Ulloa, P. (2010) Assessment of the State of Food Waste Treatment in the United States and Canada. Waste Management Accepted for publication
- Maynard; S. J. and Cherrett, T. (2006) Transport impacts of household waste recycling centres. Waste and Resource Management 159 13–21
- McBain, M.C.; Warland, J.S.; McBride, R.A.; Wagner-Riddle, C. (2005) Micrometeorological measurements of N2O and CH4 emissions from a municipal solid waste landfill. Waste Man. Res. 23 409-419
- Meins, T. (2005) Black Water recycling at Skogaberg. Diploma Thesis University of Applied Science Lübeck
- Mendes,M.R.; Aramaki, T.; Hanaki, K. (2003) Assessment of the environmental impact of management measures for the biodegradable fraction of municipal solid waste in São Paulo City. Waste Management 23 403–409
- Mohareb, A.K.; Warith, M. and Roberto M. Narbaitz, R.M. (2004) Strategies for the municipal solid waste sector to assist Canada in meeting its Kyoto Protocol commitments. Environ. Rev. 12: 71–95
- Monteith. H.D.; Sahely, H.R.; MacLean. H.L.; Bagley, D.M. (2005) A Rational Procedure for Estimation of Greenhouse-Gas Emissions from Municipal Wastewater Treatment Plants. Water Env. Res. 77, 390-403
- Parfitt, J. (2002) Analysis of household waste composition and factors driving waste increases. WRAP
- Riedel, F. (2008) turning contaminated waste into clean renewable energy and PAS 110 compost – an overview of the inter engineering biowaste process. Proc. 13th European Biosolids & Organic Resources Conference & Workshop. AquaEnviro, Wakefield
- Shaffer, John; Steinbach, Stan; Hamlett, Bart; Troxel, Wyatt; Dryden, Frank; Wheatley, Nancy (2005) Fats, Oils, And Grease (FOG) Control Study Report FOG Control Building Blocks. Proceedings of the Water Environment Federation, WEFTEC 2005: Session 81 through Session 90 , pp. 6762-6784(23)
- Smith, A.; Brown, K.; Ogilvie, S.; Rushton, K.; Bates, J. (2001) Waste management options and climate change. Final report. Office for Official Publications of the European Communities, Luxembourg.
- Smith, S.R. and Jasim, S. (2009) Small-scale home composting of biodegradable household waste: overview of key results from a 3-year research programme in West London. Waste Management & Research 27: 941–950
- Tulloch, J. (2009) Waste Not, Want Not: How Malmö Recycles Waste

- Wouters, Inge M.; Douwes, Jeroen; Doekes, Gert; Thorne, Peter S.; Brunekreef, Bert and Heederik, Dick J. J. (2000) Increased Levels of Markers of Microbial Exposure in Homes with Indoor Storage of Organic Household Waste. Appl. Environ. Microbiol. 2000 February; 66(2): 627–631.
- Wouters, I.M; Spaan, S.; Jeroen Douwes, J.; Doekes, G. and Heederik, D. (2006) Overview of Personal Occupational Exposure Levels to Inhalable Dust, Endotoxin, β(1→3) - Glucan and Fungal Extracellular Polysaccharides in the Waste Management Chain. Ann. Occup. Hyg., 50, 39–53

This report is not intended to summarise each piece of literature reviewed, but to present an overview of the evidence and opinions that are stated within the literature. It is also not intended to differentiate between the different impacts measured, but rather to summarise the conclusions of the research.

Any enquiries relating to this report should be referred to the authors at the following address:

Low and Behold Ltd
Almswood House
93 High Street
Evesham
Worcs WR11 4DU
www.lowandbehold.co.uk
home@lowandbehold.co.uk

Local Government Association
Local Government House
Smith Square
London SW1P 3HZ

Telephone 020 7664 3000
Fax 020 7664 3030
Email info@local.gov.uk
www.local.gov.uk

For a copy in Braille, larger print or audio,
please contact us on 020 7664 3000.
We consider requests on an individual basis.

L12-715