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)

The Literature

The 95 pieces of literature found to be applicable are listed below along with the main findings taken from each report.

Where possible the funding body and study area for each piece of research are also listed.

Title	Date	Summary	Measured or Observed Impact of FWD	Type of literature	Study Area	Commissioning/ Funding Body
Atwater, R.M. (1947) The Kitchen Garbage Grinder. Editorial Amer. J. Public Health 37 573-574	1947	Reviewing the first 10 years' experience of FWD (300 municipalities) and found that engineers' apprehensions were unfounded. Will increase water use, solid and BOD content, which will increase cost, but believes these will largely be offset by reduced waste costs. Sewage with ground solids 'settles better'	Positive	Desktop study		
Poole, B. A. and Erganian G. K. (1951) Public Health Benefits from the Disposal of Garbage in Sewers. Amer. J. Public Health (1951) 41 1106-1111	1951	Reviewed experience when 800 of 1200 homes had installed FWD. "research has generally satisfied engineers that a sewer system adequately designed would not be adversely affected by ground garbage; the installation of hundreds of thousands of garbage disposal units testifies to the fact that these units can be built to meet the exacting standards demanded by America's housewives." 24 hour surveys undertaken of sewers and sewage and no adverse problems reported. BOD and suspended solids greater as expected, but not found to be a problem. "New WwTW built at same time as FWD rollout and all surveys in this report done within	Positive	Primary Research	USA	

		12 months of FWD rollout.				
Ligman, K.; Hutzler, N.; Boyle, W.C. (1974) Household wastewater characterization. Journal of the Environmental Engineering Division. 201-213	1974	Small samples of no more than 40 hh, rural and urban. All apartments and 50% of urban hh had FWD. FWD had lower water use than other activities (dishwashing, toilet, shower etc.) but higher BOD and suspended solids.	Neutral	Primary Research	USA	
Thackray, J.E.; Cocker, V.; Archbald, G. (1978) The Malvern and Mansfield studies of domestic water usage. Proc. Inst. Civ. Eng. (1978) 37-61	1978	Water use. Too little water use with FWD when compared with other areas to register	Neutral	Primary Research	UK	Severn Trent Water Authority
Wicke, C. A. (1987) The effect of the household garbage disposer on the environment. 43pp	1987	Collates existing research up to that point, including Ketcham- 13 references. >80% FWD of hh in Los Angeles. 2-5% increase in BOD and suspended solids, but disadvantages negligible and outweighed by benefits. Chicago - problem is diapers, not FWD. No significant increase in cost related to sludge. Ban in NY due to combined sewers, but think that up to 25% FWD would not cause problems	Positive	Desktop study		InSinkErator

InSinkErator (1989) Understanding septic tank systems.	1989	Leaflet from InSinkErator	Positive	Promotional literature		InSinkErator
Jones, P. H. 1990 Kitchen garbage grinders (KGGs/food waste disposers) the effect on sewerage systems and refuse handling. Institute for Environmental Studies, University of Toronto.	1990	Literature review then Canadian study - 45 hh out of 180 participated (25%) - no detectable impact on water supply, sewage flow or quality. Increase in concentration, but decrease in flux of suspended solids, BOD and TKN. Phosphorus decreased in both concentration and flux.	Positive	Primary Research	Canada	InSinkErator
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	CCTV, water use, number of starts for 100 apartments without and with FWD. 15 year lab simulation of FWD use and effect on pipes. No increase in water use. No fouling of pipes. 96% user satisfaction. Recommended FWD as option. Very comprehensive study. No blockage indoors. No deposits or obstructions in sewage pipes.	Positive	Primary Research	Sweden	Support from the REFORSK foundation and Sattens Energiverk (Swedish national energy agency)
Economic and Environmental Impacts of Disposal of Kitchen Organic	1994	Gold Coast study comparing compost bins with FWD. FWDs do not present an unmanageable load on the existing sewage treatment	Positive	Primary Research	Australia	InSinkErator

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 - August 1994		facilities. 25% penetration = 4% increase in sludge volume.				
Raunkjaer, K.; Hvitved-Jacobsen, T. and Nielsen, P.H. (1995) Transformation of organic matter in a gravity sewer. Water Environment Research, Volume 67, Number 2, 181-188	1995	Measured removal of easily degradable OM as wastewater flows through sewers but particulate OM is not affected. Doesn't mention FWD usage in the area.	N/A	Primary Research	Denmark	C.W.Obel Foundation and the Danish Technical research Council
Ketzenberger, B.A. (1995) Effect of ground food wastes on the rates of scum and sludge accumulation, University of Wisconsin-Madison.	1995	Part 2 of thesis. Find increased suspended solids, BOD and FOG which will reduce soil absorption if septic tanks not emptied more frequently, but doesn't impact septic tank processes.	Neutral	Primary Research	USA	InSinkErator

Uitdenbogerd, D. E. (1995) Kitchen waste disposal treatment: an evaluation. Agricultural University, Wageningen. 27pp	1995	AD best option, followed by composting then FWD. Fewer pollutants released through FWD than composting, but they end up in the sludge, so problem shifts to sludge treatment. Costs for FWD will be in sewage treatment and drying of sludge. 10% of food waste being disposed of through FWD would increase sewage sludge volume by 5%.	Neutral	Secondary research	Netherlands	InSinkErator 'Principle' for the report
Ketzenberger, B.A. (1995) Water use by kitchen food waste disposers in households. MS thesis, University of Wisconsin-Madison.	1995	MSc thesis, Part1. Metered kitchens in staff members' housing to measure water use, starts etc.	Positive	Primary Research	USA	InSinkErator
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 indoor or outdoor pipes even at very shallow gradients. No increase in hydraulic load and negligible effect on biological load. Increased cost per person of treatment and sludge = 0.05% of current WwTW cost. 1995 5% penetration in UK; 10% max expected penetration in Netherlands; 1995 50% penetration in US (90 areas made mandatory). No evidence in literature of any sewer blockage. Cold water in FWD congeals FOG so sewers will not be coated with grease. 5% penetration will increase average waste water flow	Positive	Secondary research	Netherlands	InSinkErator

		by 0.07%. 100% penetration= 1.35% increase. Biogas increase of 17.4l/per/day. Final sludge increase of 0.13 l/per/day				
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.	1998	Summary by InSinkErator Staff Engineer of 4 year research project. "Of the five alternative food waste systems measured, a food waste disposer processing food waste through a publicly owned treatment works has the lowest cost to the municipality; the least air emissions especially greenhouse gases; converts the food WASTE to a RESOURCE which may be recycled; and as a result overall is the most environmentally friendly and sustainable option for recycling non-edible food RESOURCES. The food waste disposer is also the most convenient method of disposing food waste and is most likely to be used as the vehicle for source separation of food waste from the solid waste stream." Sludge the biggest impact. Not good for septic tanks, due to clogging of soak away. Processing cost = $0.50/100kg food waste. FWD best option when sludge is	Positive	Article		InSinkErator

		spread on land and AD at WwTW. 50%-75% of MSW cost is in the collection. FWD would be most sustainable if non-potable water used.				
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	Results of first trial of FWD in apartment buildings then launch of different waste charges and Fwd. installation going from 0% to 30%. No effect on CCTV of sewers. No effect on activated sludge electricity use. Increase in biogas. Small increase in screened material. No increase in aeration of sewage. FWD energy requirement=3-4KWh/hh/yr. 2 sites, control and 32/39 FWD. Reduction in residual collections from 6 bins twice a week to 3 bins once a week (but larger sorting project across both sites). 22% claimed had some problem with FWD, mostly because of internal blockages (rectified by pipe changes e.g. elbows) and materials caught in FWD. 96% satisfaction. No difference in sewers after Yr1. WwTW no noticeable impact apart from increased gas. Concludes that case was picked because of capacity at WwTW and suitability of network, so not representative of Sweden.	Positive	Primary Research	Sweden	VA - FORSK, an R&D program funded by the municipalities within Sweden

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	1999	Largest field controlled study of FWD – 573 apartments with FWD in 3 locations. Ban rescinded in 1997. No adverse effect on sewers. Minimal impact on water consumption. Assumed 1% penetration a year and that after a decade there would be a relatively small ($4.1m out of $1.5bn current spend (1997 rates)) increase in wastewater treatment and sludge handling costs. Increase cost increase of less than 1% in water rates. If reached max penetration of 38%, waste savings of $4m a year.	Positive	Primary Research	USA	DEP, in conjunction with the plumbing industry, representatives of FWD manufacturers and their consultants, and the Department of Sanitation
USEPA (2000) Onsite Wastewater Treatment Systems - Special Issues Fact Sheet 2. High-Organic-Strength Wastewaters (Including Garbage Grinders)	2000	Report on high concentration wastewater in septic tanks. Recommends increased emptying and need for better soak away. In-sink garbage disposal units increase septic tank loadings of BOD by 20 to 65%, suspended solids by 40 to 90%, and fats, oils, and grease by 70 to 150%.	Negative	Desktop study	USA	Environmental Protection Agency
Galil, Noah L. and Yaacov, Lila (2000) Integrated solid waste systems including domestic garbage disposers. 5th European Biosolids & Organic Residuals Conference	2000	LCA of FWD is good compared with other options. Penetration of >60% may cause 50%-70% increase in biogas, 23-27% increase in treatment cost and 26-30% increase in maintenance cost. Waste volumes fall by 3.3-18.7%.	Neutral	Secondary research	Israel	

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	2000	5 different studies, including lab studies, LCA and cost-benefit. LCA of FWD is good compared with other options and centralised composting is poor. FOG, BOD will not cause operational sewer problems up to 15% penetration. Increase in sewage flows is very small (less than 0.1% increase in Instantaneous Maximum Flow at 50% penetration). LCA said home composting was best, FWD second, followed by co-disposal and centralised composting. FWD most expensive, home composting cheapest. Cost most significant above 25% penetration as capital investment in treatment needed.	Positive	Primary Research	Australia	InSinkErator
MAEJIMA KEN (2001) The Trend of Drainage Technology(3). Food Waste Grinder Drainage Systems. Kuki Chowa, Eisei Kogaku 75;NO.3; 207-212	2001	Author abstract which doesn't give results of studies and isn't clear on country viewpoint, other than there are existing regulations that need to be complied with.	N/A	Primary Research	Japan	
Rosenwinkel, K.-H. and Wendler D. (2001) Influences on the anaerobic sludge treatment by co-digestion. IWA, “Sludge	2001	Concludes that FWD should only go to cities with separate sewerage system, in good condition, with minimum gradient of at least 2%, to WwTW with AD. 30-50% increase in final sludge, 90-100% increase in biogas. Approves of	Neutral	Desktop study	Germany	

management entering the 3rd millennium. Taipei, Taiwan		FWD subject to conditions, but reminds that primary function of WwTW is to clean water and therefore recommends monitoring.				
Galil, N. and Shpiner, R. J. (2001) Additional pollutants and deposition potential from garbage disposers. CIWEM 15 34-39	2001	Ground particles should not cause blockages in gravitational sewers of normal design. Heavy materials such as eggs shells and bones could. Faster rotation and smaller particle size from FWD will cause least problems.	Neutral	Secondary research	Israel	
Galil, N.I. and Yaacov, L. (2001) Analysis of sludge management parameters resulting from the use of domestic garbage disposers. Water Sci. & Tech. (2001) 44 27-34	2001	60% market penetration of FWD would lead to: energy potential of biogas increase by 50%-70%; investment in WwTW increase by 23-27% and increase operating costs by 26-30%.	Neutral	Secondary research	Israel	
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	2001	Swedish material flow analysis comparing FWD with separate food waste collection and composting... Positive environmental impact. Negative in terms of potential discharges of pollutant to water. FWD "three times less global warming than composting', generates more energy than consumed, 10% in sludge production for 50% pen. FWD negative is discharge of pollutants to water. FWD more	Neutral	Secondary research	Sweden	Recycling Board of Goteborg, Swedish Water and Wastewater Association, Swedish Association of Waste Management, Sustainable Urban Water Management

Conference		expensive than composting if the state pays, less expensive if the hh pays for purchase and installation.				
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	2001	Lab tests in Germany. Particle size distribution of FWD output of cafeteria waste and mixes of foods, also biogas yield. Settling more likely to happen on sides than bottom. No problem with normal water flows.	Positive	Primary Research	Germany	
Unione Imprese Difesa Ambiente – "Environmental Defense Initiatives Union" (2002) Food waste disposers	2002	Summary doc. No change in WwTW up to 15-20% penetration, some change in 20-35%, >35% and additional works needed to plant. Considers in detail the legal case for and against and believes FWD are legal. Tabulates advantages and disadvantages.	Positive	Desktop study		Prepared by the ANIMA Federation, Federation of the Italian Associations of Mechanical and Engineering Industries
Jun'ya, T.; Hiroyuki, K.; Hiroyasu, S. and Takashi, M. (2003) Environmental	2003	Environmental impacts of the introduction of the garbage grinder in Tokyo were calculated in terms of total CO2 emission and energy consumption in the sewer system	Neutral	Primary Research	Japan	

impact assessment of introduction of the garbage grinder in Tokyo. Proceedings of Annual Meeting of Environmental Systems Research. 31 159-166		and the waste treatment system, and BOD discharge from the sewer system. Two types of garbage grinders were considered: grinders with and without biological treatment facilities before discharging the ground garbage into the sewer. The following two sewage flow conditions were compared: the flow condition at the present time and that after the CSO control project of Tokyo is completed. It was implied that intensive use of garbage grinder is acceptable only when effective use of organic matters in the sewage for energy recovery is achieved together with completion of the CSO control project of Tokyo. (Author abstract.)				
CECED (2003) Food Waste Disposers: An integral part of the EU's future waste management strategy	2003	European Committee of Manufacturers of Domestic Appliances document arguing against potential ban in Bio Waste Directive.	Positive	Position paper		
CIWEM (2003) Food Waste Disposers. Policy Position Statement	2003	Review of FWD by CIWEM's Wastewater Management Panel. Does not find enough evidence to be against FWD.	Positive	Position paper		

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	Italian lab tests including investigating settling rates for solids in lab conditions. No blockages, cost savings, better processing at WwTW. No smells as there is no fermentation before sewers. Study compared lab tests with literature and found ok. FWD enhances biological nutrient removal by increasing Carbon: nutrients ratios. FWD save money. FWD don't block sewers.	Positive	Primary Research	Italy	
Gruvberger, C.; Aspegren, H.; Andersson, B.; La Cour Jansen, J.(2003) Sustainability concept for a newly built urban area in Malmö, Sweden. Water Sci. & Tech. 47, 33-39	2003	2001 Study looking at Eco cycle systems in Malmo new build development. Compares source separation with FWD, shows no problem with FWD so far. FWD studies being done by Lund Uni and behaviour studies to start in 2002	Positive	Primary Research	Sweden	
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	Article based on authors' 1998 study. Desk based LCA study looking at 5 scenarios for food waste disposal. FWD to public sewers was joint 2nd best, along with collecting and landfilling. AD not included as collection option, or WwTW option.	Positive	Secondary research	USA	Partial support received from the National Association of Plumbing-Heating-Cooling Contractors (InSinkErator is an affiliate member)

Koning J de (2004) Environmental aspects of food waste disposers. Possible advantageous effects of food waste disposers for wastewater treatment plants. Food waste disposers versus "biobak" as system for collecting food waste. Tech. Univ. Delft	2004	Report for InSinkErator that says same as Koning J de (2004)	Positive	Article	Netherlands	InSinkErator
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	Summary of evidence. “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."	Positive	Desktop study		
Evans, T.D. (2004) Food Waste Disposers - Water Use	2004	The question of water use arose from CIWEM’s Policy Position Statement (PPS, 2002) on food waste disposers (FWD) which says: "The change in water usage associated with operation of FWD has been measured to be trivial or	Positive	Desktop study		

		not significant. “David Howarth (Environment Agency, Water Resources Policy Manager, Demand Management) queried this conclusion because of the citation by Paul Herrington (1996) that water usage by FWD was 35 litres per use. The purpose of this paper is to review the source from which Herrington got his data and compare it with other studies. Looks at 12 studies and concludes that Thackray et al (1976) over-estimated water use and that it is negligible.				
Parex Appliances (2004) Stage Two Report	2004	Marketing study for FWD companies. Householder marketing survey. Noise is not a reason for not getting one; main reason is people not seeing the need, followed by environmental concerns.	Positive	Primary Research	New Zealand	Parex Appliances (Distributor of In-Sink-Erator)
Koning J de (2004) Effects on wastewater treatment focused on additional production of biogas. Tech. Univ. Delft	2004	Dutch study on potential impact of FWD at WwTW. 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 p.e. will be minimal or negligible.	Positive	Secondary research	Netherlands	In-Sink-Erator
Waste management in buildings — Code of practice. BS 5906:2005	2005	BSI standard. Includes FWD as a 'complimentary tool to methods of waste storage and collection'. Developers should consult about	N/A	Position paper	UK	

		discharge of any wastes to sewers.				
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."	Negative	Primary Research	Japan	
Crockett, P. M. (2005) Report PPW17-05 Costs/Benefits of Utilizing Garbarators to Divert Household Organic Waste for The Regional Municipality Of Halton.	2005	Canadian report for Halton Municipality arguing against FWD. Will achieve a lower diversion rate than segregated collections and is more expensive. Concerned about using capacity at WwTW that is already full and will restrict potential of the area to grow.	Negative	Secondary research	Canada	

Lundie, S. and Peters, G.M. (2005) Life cycle assessment of food waste management options. J. Cleaner Production 13 275–286	2005	Article based on the 2000 LCA work by same authors. LCA in Sydney of composting options. Home composting came out best. FWD performed well on energy use, climate change and acidification potential, less well on eutrophication and toxicity potential.	Positive	Article	Australia	InSinkErator and the Cooperative Research Centre for Waste Management and Pollution Control
Davis, R. D.; Graham, A. and Hearn, K. (2005) Policy document on food waste disposers. WRC, Report No.: UC6689/2	2005	WRc report for AMDEA and CESA. Summarises existing studies.	Positive	Desktop study		AMDEA, CESA
Evans, T.D. (2005) Impact Of Domestic Food Waste Disposers On Wastewater Treatment	2005	Summary of evidence	Positive	Desktop study		InSinkErator
In-Sink-Erator Food Waste Management Position Paper. Facts to Consider for the Various Methods of Managing Food Waste	2005	Industry summary showing FWD to be the best option.	Positive	Position paper		InSinkErator
Legislative Assembly of the Australian Capital Territory (2005)	2005	Ban on FWD rescinded. Was in place to save water, but found the impact of FWD is negligible.	Positive	Position paper	Australia	

Water and sewerage amendment regulation.						
Browne, P. (2005) Food Waste Disposers as a means of waste diversion from landfill. Report to County Surveyors Society Waste Committee 22 November 2005	2005	Report by Head of Waste and Passenger Transport Mgt at Worcestershire CC for CSSWC. Estimates 50% penetration would decrease MSW to 15% of current level in 10 years.	Positive	Primary Research	UK	
Marashlian, N. & El-Fadel, M. (2005) The effect of food waste disposers on municipal waste and wastewater management. Waste Manage Res 2005: 23: 20–31	2005	Lab tests in Beirut. Total food in MSW falls from 63% to 58% with 25% penetration. Increase in water ranges from 0.72% to 2.35%. Few concerns about sewer blocking, but is area specific. Overall, net economic benefit of between 7.2 and 44%, depending on penetration and cost of MSW disposal.	Positive	Primary Research	Lebanon	
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. 7litre/kg food waste. 2.3 uses per day. No deposits in external sewers. Level of deposits found in culverts (mainly eggshells) was 1.3 to 3 times greater. Deposits considered minor as limited blockages as a consequence. No difference in n-Hex in sewers. Increase in BOD and sludge, but	Positive	Primary Research	Japan	Edited by InSinkErator

		no discernible increase in influent. Popularization of FWD would not increase environmental burdens. Overall cost saving when compared to current incineration solution. Results from first field trial in Japan. 301 FWD installed over 3 years. From 200 to 2004, 12 reports of blogged discharge traps (S traps), 4 of blocked house drains and 19 of disposer failure. Survey showed about 40% had some clogging of pipes, 80% said kitchen hygiene was improved, 70% were 'very' or 'fairly' bothered by noise and vibration.				
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	2005	Looked at agricultural impacts of sludge and blackwater treatment. Relevant comment for FWD:"This means that installation of food waste disposers only had a minor influence on the environmental impact categories studied."	Positive	Secondary research	Sweden	MISTRA

Ayako, Y.; Hiroki, Y.; Hiroaki, M.; Toshiaki, Y.; Masahiro, T. (2006) Garbage Grinder's Use and Pollution Loads in Hotel's Kitchen in Utanobori Town, Hokkaido. J. Japan Sewage Works Association.43 116-126	2006	Abstract only on hotel FWD, showing larger impact	N/A	Primary Research	Japan	
Basic research regarding the evaluation of the horizontal pipe's performance to carry waste water contain food waste disposed of using a food waste grinder. Part 2: Examination on carrying performance in house drain. Journal of Environmental Engineering, Vol 603. pp85-91	2006	Abstract only, no results	N/A	Primary Research	Japan	

Is it OK to use a food waste disposer? Leo Hickman's guide to a good life. Guardian 8th August 2006	2006	Newspaper column. Opinion piece.	Positive	Article		
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	2006	Article based on 2005 work by same authors. LCA of wastewater system, including agricultural production (displacing mineral fertilisers). Based on Surahammar, with FWD as 'control', separate collection and usual WwTW as 2nd option, and FWD and blackwater as 3rd. Reduced mineral fertilisers in blackwater example were cancelled out by increased infrastructure and need for transport. Yields also impacted by soil compaction. But less eutrophication than FWD. "Not assessing FWD, but phosphate recycling. However, "No significant difference in environmental impact appeared when the existing disposer system and the sludge utilisation system were compared. This means that installation of food waste disposers only had a minor influence on the environmental impact categories studied."	Positive	Article	Sweden	MISTRA
Kegebein, J. (2006) PhD summary FWD Uni of Karlsruhe	2006	PhD summary, only abstract in English. Only looked at separate sewers, not combined. In case of	Positive	Primary Research	Germany	

		separate sewers, no evidence of increased rats, poss. increase in maintenance, FWD more expensive than collection due to cost of FWD, but if this borne by householder, than savings for authority. LCA shows better than composting and less good than AD.				
Malmqvist, P-A.; Heinicke, G. (2006) Strategic planning of the sustainable future wastewater and bio waste system in Göteborg, Sweden. Proc. Cities of the Future: Urban Sustainability and Water. IWA World Water Congress, Beijing	2006	Swedish strategic study looking at bio waste and wastewater planning in Goteborg. FWD was 1 of 4 (out of 8) options that was considered 'equally sustainable'. The others were; food collections to AD, nutrients extracted at WwTW and incineration with ashes going to land. From a long-term environmental point of view, including nutrient lock-in. Results were weighted to take account of politics and public attitudes.	Positive	Secondary research	Sweden	MISTRA
Food waste disposers: part of the solution or the problem? Materials Recycling Week November 9 2007 16-17	2007	MRW article arguing for and against	Neutral	Article		

LARAC National and Regional Feedback Sheet from 'Sink Macerators - A Solution to Food Waste' event. October 2007	2007	Arguments for and against FWD.	Neutral	Article	UK	
Davidsson, Å.; la Cour Jansen, J.; Appelqvist, B.; Gruvberger, C.; Hallmer, M. (2007) Anaerobic digestion potential of urban organic waste: a case study in Malmö. Waste Manage Res 25: 162–169	2007	Swedish study looking at AD potential for sewage and food wastes. FWD gives higher gas yield at mesophilic, but source-seperation gives higher at thermophilic, where FWD not stable. Issues around stability of AD depending on the base substrate and mix of materials.	Neutral	Primary Research	Sweden	Oforsk, the committee for Science and Research in the Oresund Region and the Danish Ministry of Science, Technology and Innovation
Androulla Constantinou. MSc Dissertation 2007. The Impact of Household Food Waste Disposal Units on the Water Industry. Imperial College.	2007	Desktop study calculating hypothetical increased FWD uptake in Anglia Water region. Shows increased water use, wastewater flow, BOD and COD, ammonia and phosphorous and sludge production. Concludes this will increase costs of primary treatment and sludge disposal by 5.15% between 2006 and 2035 in best case and 30.4% in worst case. Concludes that it depends on sewer network, cost-benefit of alternatives and impact on behaviour. Cost transfer issue needs to be sorted.	Neutral	Secondary research	UK	

Battistoni, P.; Fatone, F.; Passacantando, D.; Bolzonella, D. (2007) Application of food waste disposers and alternate cycles process in small-decentralized towns: A case study. Water Research 41 893 – 903	2007	Measured effect of FWD in village in Italy. 67% equivalent market penetration. Improved wastewater treatment; more cost effective over 4-5 years than source separate collections due to rural nature of area, no adverse impacts on sewer network.	Positive	Primary Research	Italy	Gagliole Municipality and the COSMARI public utility
2007 “Systemstudie Avlopp” future sustainable sewage systems - Gothenburg-English summary.doc	2007	Sustainable future sewage systems in Gothenburg, weighted for importance, main factor being nutrient recycling. Blackwater bottom. FWD joint top with phosphorus extraction and AD. Looking more at nutrient recycling, so food waste isn't as important as blackwater. However no issues raised with FWD.	Positive	Secondary research	Sweden	Recycling Committee, Gothenburg Water and Sewage Administration, Gryaab (a regional sewage works)
Evans, T.D. (2007) Environmental Impact Study of Food Waste Disposers: a report for The County Surveyors’ Society & Herefordshire Council and Worcestershire County Council,	2007	Presentation of H&W study and international research. Shows good carbon footprint, cost savings and no recorded negative impact on sewer network.	Positive	Secondary research	UK	The County Surveyors' Society

published by Worcestershire County Council.						
Evans, T.D. (2007) Environmental impact study of food waste disposers. for the County Surveyors' Society & Herefordshire Council and Worcestershire County Council	2007	Financial and GWP implications of different options for food waste, shows FWD to have lower CO2e impact and be more cost effective	Positive	Secondary research		The County Surveyors' Society
Lawton, M. (2007) Food Waste Disposal Options Study. Braidwood Research and Consulting Ltd.	2007	Looked at whether FWD should be banned on new housing development; concluded no. No evidence that blocked sewers or were worse than other options, esp. when compared to existing situation - going to landfill as MSW. Many drivers, some misinformation. FWD makes sense where sewage system is modern, well-designed and operated, adequate WwTW, AD and useful use of digestate. Do not use where history of blockages. Home composting best option. Shortage of data about FWD.	Positive	Secondary research	New Zealand	Hobsonville Land Company

EPA Strive Report Series No 11: Examining the Use of Food Waste Disposers	2008	Desktop study looking an international literature and local situation in Ireland. Concludes that existing WwTW do not have capacity, that CSO are used too frequently, that FWD does not promote source separation, or waste hierarchy, or waste prevention, or polluter pays principle; states that cost burden will be passed on to all water users, regardless of FWD use. Recommends regulatory controls based on local area and by-laws to restrict FWD use at both waste and water level. Irish WwTW do not have capacity or capability to take extra loads (11% structural failed, 13% mechanically failed, 28% under-capacity, <30% of plants serving <15k pop met effluent standards.)	Negative	Secondary research	Ireland	Irish Government under the National Development Plan
Market Transformation Programme (2008) BNXS43: Food Waste Disposers – an overview	2008	Desktop study looking at impact of FWD in terms of water, energy and waste reduction. Does not consider impact on sewer network.	Neutral	Desktop study		Defra's Market Transformation Programme

Down the drain. WRAP study. March 2008	2008	Research on amount of food waste going down sinks. Estimates it's currently 1.8m tonnes, approx. 1.5m of that is avoidable. Can't quantify impact of macerators as sample size of homes with them too small in this study	Neutral	Primary Research	UK	WRAP
Gustafsson, A. (2008) Slopad avgift för avfallskvarn. Svenska Dagbladet 1September 2008	2008	Article stating that Stockholm Water wants to scrap annual FWD fee to incentivise use	Positive	Article	Sweden	
Ulfves, V; Cocks, J. and Evans, T. (2008) Food Waste Management in New Zealand. Report for Parex Industries Ltd. MWH New Zealand Limited	2008	Report for Parex Industries in New Zealand (InSinkErator distributor) to explore potential for FWD and issues. Concludes is viable if AD used at WwTW and need for BNR. But home composting best option.	Positive	Desktop study		Parex Industries LT (Distributer of InSinkErator)

Tendaj, M.; Snith, Å; von Scherling, M.; Hellström, M.; Mossakowska, A. and Millers-Dalsjö, D. (2008) Kitchen Disposal Units (KDU) in Stockholm. Stockholm Water's pre-study on the preconditions, options and consequences of introducing KDU in households in Stockholm. Stockholm Water	2008	Very comprehensive study for Stockholm Water evaluating current position of FWD ban. Concludes changing to allow them under permitting system, so they only go where sewer network can cope and up to certain penetration level. Only looks at public network, not individual households; says one WwTW will not work due to nitrogen removal, but for other will improve. Slight increase in biogas production. Negligible increase in water use.	Positive	Primary Research	Sweden	Stockholm Water
Town of Banff (2008) Composting Trial. Participate in Banff's new organics composting effort	2008	Copy of website page promoting doorstep food waste collection or use of FWD, which were previously discouraged, but now ok due to upgraded WwTW.	Positive	Promotional literature	Canada	

Cassirer, T; Luthman, T.; Safi, I.; Svanmo, J. and Talebi, Z.S. (2008) Waste disposers - A viable option for increasing biogas production at Käppala WWTP? Project Report Chemical Engineering KTH Chemical Engineering Högskoleingenjörsutbildningen	2008	Swedish study investigating potential to increase biogas yield at Kappala plant by introducing FWD. Plant has 20% over-capacity, no need for increased pumping power, marginal increase in energy in WwTW processes, no other problems at plant. Increased biogas yield of 7m2/person/yr. Largest cost is FWD itself, payback over 1-5 yr. depending on supplier. FWD considered most environmentally friendly option. Main risk is in pipes with 90degree bends and sewer with history of overflow. Calculations all based on Kappala system, which is large and has constant flow. Net economic gain at WwTW.	Positive	Secondary research	Sweden	
MEL Research North East Public Sector Food Waste Research Project. A Study of Public Sector Food Waste Arisings and Processing Options within the North East Region ORGANICS PROJECT PHASE 2 2009-10 p38	2009	Research on organic waste arisings in public sector buildings in NE. Found that the one prison surveyed and 67% of hospitals surveyed used FWD.	N/A	Primary Research	UK	RENEW, the Environment Agency, NISP, John WarrenABP Limited and Eric Evans of Bio Recycling Solutions

Water UK Position Paper on Macerators, Feb 2009	2009	Macerators are not BPEO, use large volumes of water, undermine waste reduction messages, put unnecessary load on sewer network, will cause blockages and flood incidents. Includes the problems of macerators used for care home and hospital sanitary wastes and flushable products. Concerned about FOG and other debris.	Negative	Position paper	UK	Water UK
Butler, L. (2009) Food waste disposers under the spotlight. The Loop	2009	Loop magazine with opinion pieces and articles for and against FWD.	Neutral	Article		
Tulloch, J. (2009) Waste Not, Want Not: How Malmö Recycles Waste	2009	Article on Malmo's waste. Mentions the use of FWD as one of the tools	Neutral	Article	Sweden	
Phil Mills, Speech at Cranfield University "FOGs build up and removal: problems and solutions', 24 March 2010	2010	FOG leads to sewer blockages. FWD can contribute to sewer abuse.	Negative	Article		
Birmingham City Council, Total Waste Strategy 2010	2010	Reviewed literature, found not enough evidence to be conclusive either way	Neutral	Desktop study		Birmingham City Council

Defra. WRc National Food Waste Programme. Comparison of the Sustainability of Food Waste Disposal Options. Dec 2010	2010	Greenhouse gas emissions lowest for kerbside with AD, highest for kerbside with IVC, FWD in the middle. Financial cost highest for FWD, lowest for kerbside with AD, IVC in middle. "The differences observed between the options considered were within the range of uncertainty in these estimates. Within the recognised limitations of this modelling approach the following conclusions can, however, be drawn;")	Neutral	Secondary research	UK	UKWIR, Defra
Better by design - Enabling Londoners to boost recycling in the home through new technologies. Outcomes report from LSX Executive lunch. Dec 2010	2010	Explores new tech, including FWD, which AMDEA promote. Call for better awareness and joined up work between councils, water companies and private business	Positive	Article	UK	AMDEA, Energise London, Food Waste Disposer Group and supported by London Councils
Brachman, S.; Diggelman, C.; Gitter, M. and Keleman, M. (2010) Final Report: Food Waste to Energy and Fertilizer. WasteCap Resource Solutions for Wisconsin Department of Natural Resources.	2010	1 yr. study looking at control, commercial FWD into sewer network and FWD into Tanks and hauled to WwTW. Concludes FWD good, no blockages in main, some issues at local pipe due to diameter, no BOD etc. problems, cost effective.	Positive	Primary Research	USA	Wisconsin Department of Natural resources, In-Sink-Erator

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	2010	Desktop study of WwTW data from 1995 to 2009. FWD in 50% of households: no impact on sewers, no significant change in flow, BOD or Nitrogen loading; 46% increase in biogas (P=0.01). Overall result of waste strategy was 60% reduction in waste to landfill	Positive	Primary Research	Sweden	InSinkErator Europe
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	Installed FWD and measured reduction in solid waste generated-volume reduction of 40%. No recorded impact at WwTW.	Positive	Primary Research	Japan	
Thomas, P. (2011) The effects of food waste disposers on the wastewater system: a practical study. Water & Env. J. 25: 250-256	2011	Thames Water lab study of output from FWD fed with food waste accumulated by 18 volunteers. Output allowed to settle in bucket for 2 hours, ammonia, nitrogen and phosphorous all in high levels in supernatant, suggesting value will be lost during secondary treatment.	Negative	Primary Research	UK	Thames Water

Evans, T. D. (2012) Domestic food waste, the options compared (particularly food waste disposers) and their carbon and financial costs. Municipal Engineer	2011	Article summarising research in favour of FWD.	Positive	Article		Worcestershire County Council, The County Surveyors' Society, InSinkErator, Monsal, Scottish Water, Severn Trent and Yorkshire Water
AMDEA FWD Group Position Paper: The Science	2011	Runs through 10 reports over last 15 years supporting FWD.	Positive	Position paper		AMDEA
CIWEM (2011) Food waste disposers – policy position paper	2011	FWD valid tool, better than composting and incineration and as good as source seperation to AD.	Positive	Position paper		CIWEM
DeOreo, W.B. et al. (2011) California Single-Family Water Use Efficiency Study. Report for California Department of Water Resources. Aquacraft, Inc. Water Engineering and Management	2011	Water use in 735 homes across 10 water agencies metered and logged. 85.6% had FWD. 49.5 l/hhd.d less water use from taps in homes with FWD could be linked to dishwasher use. "Water agencies should not consider disposals as water wasting appliances."	Positive	Primary Research	USA	California Department of Water Resources

Boyle, W.C. (1985) Effect of garbage grinders on wastewater characteristics. University of Wisconsin-Madison. Project 1640 M-213	1976-1984	62 (100% FWD) +163 (45% to 93% FWD during study) households, 9 year monitoring study. "The impact of garbage grinder use on wastewater characteristics in two Wisconsin residential areas over a nine-year period was not measurable."	Positive	Primary Research	USA	
Bush, E.M.MSc Dissertation (2011). The Recycling of Organics: Opportunities for Municipal Programs and a Case Study for Philadelphia. University of Pennsylvania	2011	Programs should be specific to each city. FWD is a 'smart alternative. 'Minimal impact on the city's sewage system and wastewater facilities. Energy and water use negligible	Positive	Secondary research	USA	
Parry, D.L. (2012) Sustainable Food Waste Evaluation - Final Report. Water Environment Research Foundation	2012	FWD economically attractive with minimal area footprint requirements, with low staff and diesel requirements. Lower carbon footprint than landfilling though higher than compost and collection schemes.	Positive	Secondary research	USA	InSinkErator
Clean Kitchen, Green Community Pilot Programme Press Release (2012). Philadelphia Streets Department	2012	Pilot programme to assess the use of FWD in the city. 100 free FWD will be installed and installation encouraged elsewhere. Volume and composition of waste tested before, during and after the pilot. A focus is made on the cleanliness of the system.	Positive	Article	USA	InSinkErator are providing the FWD for the study

Kitchen Sinks Go Green, The Philadelphia Inquirer. March 24, 2012	2012	Newspaper Column. Opinions on the Philadelphia FWD pilot project	Neutral	Article	USA	
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	FWD would lead to additional costs to water industry but savings to local authorities. Policy intervention needed, either to support FWD to produce savings for the local authority or to ban them and reduce costs to the water authorities. Currently in the Anglian region, savings to the local authority are not significant enough to cover the extra expense for the water authorities, especially considering the high water stress prevalent in the region	Neutral	Secondary research	UK	

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
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- 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

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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
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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.

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