In-Sink-Erator Food Waste Management Position Paper

Facts to Consider for the Various Methods of Managing Food Waste

Executive Summary

A hierarchy of food waste management policy objectives should include reduction, reuse, and recycling, with disposal to a landfill being the least preferred strategy. Food waste is a reality, even in recognition of the best efforts to reduce or reuse. The next best environmental strategy is to recycle food waste and utilize the energy and nutrient value as a resource, while minimizing detrimental public health effects, fossil fuel consumption, and emissions in the process of recycling. EU waste management future strategy is shaped by a Landfill Directive and a Thematic Strategy for Soil Protection. These legal acts define three main elements: improve the soil quality, increase the recovery of organic waste in contrast to landfilling or incineration, and to improve sewage sludge quality.[1]

There are several food waste management techniques that can support this ideology, and one is the recovery of food waste generated from food waste disposers onto fields following stabilization at a municipal wastewater treatment plant (WWTP). In Europe, food waste disposers have been recognized only recently (in large contrast to the United States), which is the main reason that other food waste management options, such as composting, are further developed. However, many scholars, waste management firms, local authorities and residents recognize problems associated with collection of organic waste in inner-city districts. The collection rates are normally low, the collection process is labor and energy intensive and expensive, and the storage of organic waste causes aversions, due to foul odor and health concerns for both the households and waste handling staff.

- In the Netherlands, for instance, composting and collection schemes have been widely practiced and favored, however, this waste management policy is now in serious doubt as to whether this system is environmentally and economically sustainable, particularly in the inner-city.[1]
- In 2002, the Italian Senate lifted a ban on food waste disposers set out in the "Ronchi" decree 22/97.[1] The reason for overturning the ban was insufficient grounds for the ban in Articles 5, 6, and 32 of the law, and the recognized need for management alternatives to the process of the separate collection of organic waste.
- In 2005, the Legislative Assembly for the Australian Capital Territory (ACT) amended Water and Sewerage Regulation Subordinate Law SL2005 to remove provisions prohibiting the installation of in-sink waste disposal units in domestic plumbing work.[2] The action was prompted by recent evidence suggesting that even high levels of disposer market penetration will increase urban water use less than 1%, and the increase in organic matter entering the sewerage system will not present problems to the ACT WWTP.[2] In addition, disposers are seen as an alternative to composting in medium density dwellings, where suitable land is not available to residents to support composting.

[1]CECED-European Committee of Manufacturers of Domestic Appliances. Spring 2003. "Food Waste Disposers: An Integral Part of the EU's Future Waste Management Strategy."
[2]The Legislative Assembly for the Australian Capital Territory. 2005. "Water and Sewerage Amendment Regulation 2005: Explanatory Statement."

In no areas of the world are disposer restrictions based on empirical research and evidence, but rather on the application of the precautionary principle.[1] In fact, the use of a food waste disposer with subsequent WWTP treatment and biosolids land application is a complement to any landfill waste diversion plan. Food waste organics are stabilized through anaerobic digestion with the generated methane recovered as a renewable energy benefit. Biosolids are rich in nutrients and disposal for agricultural or land reclamation purposes serve as a recycling of the waste stream rather than using valuable landfill space.

There may be WWTPs that are close to their treatment capacity for which the additional organic loading would be a problem, but this is neither a general problem for all plants nor a suspected problem until disposer market penetration rates are high. Loadings for wastewater treatment and sludge digestion can be estimated well and, due to gradual disposer market penetration rates, WWTP loading is not uncontrolled and plants are not "overloaded overnight."[3] Additional costs to the WWTP processes are often offset with decreased costs for municipal solid waste collection and disposal. For instance, the New York City Department of Environmental Protection (DEP) conducted a thorough 21-month pilot program to study the effects of the use of food waste disposers in combined sewer areas. Conclusions were that the impact of food waste disposers to the sewer system, city water consumption, wastewater treatment and biosolids handling, water rates, and receiving water quality were insignificant or de minimus.[4] In addition, the NYC Department of Sanitation recognizes the positive impact (reduced costs) that disposers make on municipal solid waste collection, as the removal of kitchen waste results in waste that is drier and easier to handle.[4] An Utanobori, Japan disposer pilot study found that disposers reduced solid waste from 99 g/capita/day to 59 g/capita/day (i.e., an approximate 40% reduction).[5] Furthermore, a ban on food waste disposers does not necessarily translate into an increased composting participation rate as many people neither can, nor wish, to take part in composting schemes.

Also, contrary to popular belief, the usage of disposers does not produce a substantial increase in water consumption to disperse the ground food waste. The increase in water use has been calculated at 3 to 4.5 L/person/day, approximately the equivalence of a single toilet flush.[1]

In addition, disposers are feared for suspected negative impacts to the wastewater collection system, the most fragile element of the WWTP system. However, to minimize the risk of clogging or sedimentation, disposers are restricted by universal standards through international agreement as to the volume of particles that may pass through specified particle sizes. Specifically, the Association of Home Appliance Manufacturers (AHAM) and the American Society of Sanitary Engineering (ASSE) Standard 1008 specifies that all particles must pass through a 13 mm (0.51 in) sieve, and that no more than 28.35 g (1 ounce) of a 453.6 g (16 ounce) load can be retained on a 6 mm sieve (i.e., 93.75% must pass through a 6 mm sieve). With such strict standards, the potential discharge of inorganics or trash is remote, and the

[3]Rosenwinkel, K.-H. and D. Wendler. Institute for Water Quality and Waste Management. University of Hanover, Germany. "Influences of Food Waste Disposers on Sewerage System, Waste Water Treatment and Sludge Digestion."
[4]New York City Department of Environmental Protection. June 1997. "The Impact of Food Waste Disposers in Combined Areas of New York City."
[5]National Institute for Land and Infrastructure Management and Ministry of Land, Infrastructure and Transport, Japan. March 2005. "Report on Social Experiment of Garbage Grinder Introduction."

disposer becomes a natural source separation device, whereas, composting relies on the education and goodwill of the participants. In the compost system, a poor collection results in the additional (and costly) separation and second hauling of the trash to the landfill, or the production of poor quality compost with few useful attributes.

It has been stated that organic waste collection and processing management options that rate the highest in the energy field can be expected to be favored in the long-term future, owing attention to the Kyoto Protocol.[6] In this regard, food waste disposers that discharge to a WWTP utilizing anaerobic digestion have a clear advantage over the compost system. A Sydney, Australia life cycle study found that the disposal of food waste through a disposer/WWTP system generates less greenhouse gas (GHG) emissions (76.8 kg CO_2-equiv) than source separation combined with centralized composting (112.3 kg CO_2-equiv) or landfilling (172.0 kg CO_2-equiv).[7] This study also concluded that centralized composting (and landfilling) has a relatively poor environmental performance due to its energy-intensive collection activities. In addition, composting does not generate methane as a renewable energy source in contrast to a WWTP with anaerobic digestion.

[Note: Readers of the Sydney study should be cautioned that the beneficial use of by-products (compost or biosolids) was not part of the research. In addition, the WWTP depicted in the study did not utilize secondary biological treatment, in contrast to typical modern-day plants. These factors downgraded the disposer and centralized compost systems somewhat on an environmental scale, in favor of the home compost system. However, the home compost system, while it does have potential to divert organics without costly and noxious collection activities, is very much subject to the expertise and incentive of the homeowner to produce quality compost, as poor performance will contribute to air emission or groundwater contamination, or cause health concerns from the attraction of vectors.]

Of course, it is likely that those interested in efficient and environmentally responsible food waste management will wish to challenge all methods of waste management. At In-Sink-Erator, we, of course, welcome this, in contrast to those who reject disposers based on the precautionary principle and lack of scientific evidence. We encourage any evaluators to benefit from the experiences of others, and for this reason believe it is important to detail results of recent major evaluations of disposers and related activity. As we investigate and understand situations where there is a belief that "disposers are environmentally bad", it is clear that the facts are very different. Also, as municipalities themselves investigate disposers as a food waste management tool, more and more of them become proponents of disposers. However, In-Sink-Erator will not rest on its laurels, as internal research will continue to seek methods to further improve the effects that disposers have on the sewage collection system, WWTP processes, and septic (on-site) systems. This commitment, and documented evidence of positive environmental impacts, makes disposers the best management method of food waste.

[6]Waste Management Council advisory report memorandum to the state secretary of Housing, Spatial Planning and the Environment. July 2004. "Developments in Domestic Organic Waste Management in the Netherlands."
[7]Cooperative Research Centre (CRC) for Waste Management & Pollution Control Limited. December 2000. "Assessment of Food Disposal Options in Multi-Unit Dwellings in Sydney."

Overview
Municipalities world-over share a common dilemma for the best method to manage the ever-present wastes generated through food preparation and consumption residual. From a universal perspective, it is of utmost importance that these governing bodies incorporate the most environmentally responsible strategy when solving this dilemma. Utilizing green initiatives, food waste should be categorized as a resource to:

- Encourage energy, organic, and nutrient recovery from food waste;
- Minimize public health issues related to food waste management practices;
- Minimize the use of fossil fuels related to food waste management practices; and
- Reduce greenhouse gas emissions related to food waste remediation processes.

With this goal in mind, a hierarchy of food waste management policy objectives should include reduction, reuse, and recycling, with disposal to a landfill being the least preferred strategy. Reduction refers to promotion to minimize food purchase and reduce portion size with the intent to minimize waste volume. If food scraps cannot be reduced, then reuse through the utilization of the waste by existing sources (i.e., food pantries, livestock, or animal shelters) should be employed. If food scraps cannot be reused, then recycling is preferred in order to utilize the organic, nutrient, and energy value of the waste as a resource.

Growing concerns about resolving world hunger, conserving resources, and reducing environmental and economic costs have raised public awareness to the issue of food waste. Unfortunately, preventing all food waste is an impossible task. Food losses begin on the farm even before a commodity moves to market for consumption through preharvest losses, due to drought, flood, or pest infestation. Technological factors, such as increased mechanization, equipment malfunction, and management practices, also lead to harvesting losses. Many farmers mitigate harvesting losses by using the leftover crops as fertilizer or animal feed. Additional food losses occur in storage and transport, due to insect infestation, mold, deterioration, or improper handling. Food safety regulations also divert some product from human consumption. Food losses also occur when raw agricultural commodities are made into final food products. Some of these losses are a normal and necessary part of food processing. Other processing losses, such as the removal of skin and trimming of fat from meat and poultry, are due to consumer demand for more healthy food options.

However, foodservice and consumer food waste, from foods forgotten and spoiled to the uneaten leftovers, is the single largest source of food loss in the marketing chain. Foodservice wastes are generated from the over preparation of menu items, expanded menu items, unexpected fluctuations in food sales, and consumer plate loss from the “upsizing” of food portions. Household food losses occur because of over preparation, preparation discard, plate waste, cooking losses, spoiled leftovers, and breakage, spillage and package failure. A study by the University of Oregon examined the reasons that households discard food. This study suggested that consumer education may play an important role in reducing consumer food waste.[8] Education is also important in order to teach individuals the value of a healthy diet and reduced food portion size, and to distinguish between spoiled and safe food, which can lead to a reduction of food waste.

[8]Kantor, Linda Scott, Kathryn Lipton, Alden Manchester, and Victor Oliveira. Economic Research Service, USDA. 1997. “Estimating and Addressing America’s Food Losses.”

Reuse of food waste refers to the collection or recovery of wholesome food from farmer fields, retail stores, or foodservice establishments for distribution to the disadvantaged. Once surplus food has been recovered or prevented from going to waste, volunteers pickup and deliver the food to groups that serve the needy, either directly through charitable organizations or indirectly through food banks. In addition to providing additional quantities of food to the needy, the recovery of reusable food also provides charitable organizations with more variety and nutrients by adding fresh fruits and vegetables to the typical nonperishable canned and boxed goods. This additional food supply also allows these organizations to reallocate limited economic resources to other needed services. However, food reuse is not without cost. Recovery operations face a number of logistical and economic obstacles in the process of turning food waste into a reusable resource for human consumption.

Of course, not all food that is wasted is economically or environmentally reusable, or suitable for human consumption, as shown in Table 1. If not suitable for humans, then potential reuse markets are geared toward livestock operations and animal shelters.

Table 1. Food Waste Reusability[8]

Not Recoverable for Human Consumption	Recoverable for Human Consumption
Livestock condemned at slaughter because of disease	Edible crops remaining in farmer fields after harvest
Diseased or otherwise unsafe product	Produce rejected due to market "cosmetics"
Spoiled perishable food, including meat, dairy, and prepared items	Unsold fresh produce from wholesaler and farmer markets
Plate waste from foodservice establishments	Surplus perishable food from restaurants, cafeterias, caterers, grocery stores, and other food service establishments
Losses of edible portions associated with processing, such as skin and fat from meat and poultry, and peels from produce	Packaged food, including overstocked items, dented cans, and seasonal items

Food waste that cannot be reused is next best utilized, from an environmental perspective, toward recycling to take advantage of the organic and nutrient content, and alternative energy potential. Recycling is the preferred method of handling any material which reaches the solid waste stream. Many types of wastes, including paper, glass, aluminum, steel and plastics are readily recycled as base materials into new products, thus saving virgin material. The best recycling operations should then result in reduced risk to public health and minimized use of fossil fuels and emissions from remediation processes. In addition, food waste composition has been well-researched with similar conclusions. A University of Wisconsin study found food waste to be 70% water (30% solids), 95% organic, 2.7% nitrogen, and 0.44% sulfate.[9] Italian researchers determined food waste to be 74.4% water (25.6% solids), 96.5% organic, 3.2% nitrogen, and 0.2% phosphorus.[10] Thus, these characteristics must be considered when assessing

[9]Diggelmann, Dr. Carol and Dr. Robert K. Ham. Department of Civil and Environmental Engineering – University of Wisconsin. January 1998. "Life-Cycle Comparison of Five Engineered Systems for Managing Food Waste."
[10]David Bolzonella, University of Verona; Paolo Pavan, University of Venice; and Franco Cecchi, University of Ancona. Italy. "The Under Sink Garbage Grinder: A Friendly Technology for the Environment."

the best management system for food waste.

Municipal solid waste management system options for all wastes include landfilling and incineration. Organic waste management options are expanded to include composting (home and community). In addition, the use of a food waste disposer and discharge to a municipal wastewater treatment plant (WWTP) can be considered a compelling alternative organic waste management system for food waste only, due to the physical characteristics of food waste cited above. A thorough assessment of the management options is necessary for a thoughtful selection of the best alternative. Composting of certain materials or land application of WWTP biosolids may also be classified as recycling, due to the beneficial return of organics and nutrients to the land. In addition, WWTPs that incorporate anaerobic digestion for organics stabilization may utilize the generated methane as a renewable energy source.

Incineration is most practical with dry, high energy waste that may be utilized as a fuel source. Food residuals, which are 70% water, are not a good host for incineration since the net energy output is zero.[9] Incineration is most practical from an environmental view when the derived energy is used to generate electricity. In addition, a major cost and concern is the control of air emissions, especially dioxin, furan, nitrogen oxide and sulfur dioxide. Finally, the organic and nutrient components of food waste are subsequently burned and lost to the atmosphere. These points will invalidate incineration for food waste disposal as the system fails to comply with the green initiative listed above in regard to providing an environmental resource.

Landfilling should only be selected as a food waste management alternative when reuse and recycling is not possible. This is the least preferred management strategy because food waste will decompose anaerobically and readily, and the high water content will add residual leachate requiring remediation. Landfill gas (generated through anaerobic decomposition) is comprised of approximately 45%-60% methane and 40%-60% carbon dioxide.[11] Although, methane can be captured as a renewable energy source, the best designed and maintained landfills will still lose roughly one-third to the atmosphere, which is about 21 times more potent than carbon dioxide as a greenhouse gas (GHG).[9] Thus, by the time that the cap is placed on the landfill, the food waste will likely have already been decomposed leaving little methane value from this waste. The result, therefore, is that landfilling, like incineration, fails to meet the initiative criteria for providing an environmental resource.

In addition, solid waste collection must be considered during the course of selection of the appropriate remediation technologies. This is due to emission concerns and to the fact that of the total cost spent on solid waste management; approximately 50%-70% is attributed to the collection activity.[12] The cost of collection includes equipment capital and maintenance costs, and significant labor cost. A University of Wisconsin food waste management life cycle study found that municipal solid waste collection contributes from ½ to ¾ of the total cost, and 88% of the total energy, from systems that utilize this process.[9]

[11]Mohareb, Adrian K., Mostafa Warith, and Roberto M. Narbaitz. NRC Canada. 2004. “Strategies for the Municipal Solid Waste Sector to Assist Canada in Meeting its Kyoto Protocol Commitments.”
[12]Tchobanoglous, George and Frank Kreith. McGraw-Hill. 2002. “Handbook of Solid Waste Management, Second Edition.”

The GHG issue cannot be quickly dismissed in reference to food waste disposal. Since the onset of the Industrial Revolution, the concentration of GHGs in the atmosphere has continually risen, largely due to the consumption of fossil fuels for the production of energy. Human activity has also created increased levels of methane, nitrous oxide, and tropospheric ozone in the atmosphere.[11] The increased release of GHGs appears to be causing a change in the climate on a global scale. In June, 1992, the United Nations held the Conference on Environment and Development (UNCED) resulting in the United Nations Framework Convention on Climate Change (UNFCCC 1992). The goal was to achieve atmospheric stabilization of GHG that would prevent interference with the climate system. GHG emission targets were set at a 1997 conference in Kyoto, Japan, which resulted in the Kyoto Protocol.

Waste management decisions affect the amount of GHG emissions being generated by the waste sector. Source reduction decreases the volume of consumed materials, thereby eliminating all of the related GHG emissions. Recycling provides GHG emission reductions at many stages of the material life cycle, as it diverts waste from landfills and reduces emissions generated by virgin material processing. The diversion of waste organics, toward either composting or anaerobic digestion processes, results in the removal of this readily anaerobic degradable waste from landfills and a reduction in methane being generated. In addition, waste transportation must be considered in relation to GHG generation. Emissions from waste transport, while not insignificant, remain a small but growing fraction of total waste sector emissions. These waste transport GHG emissions are expected to increase as food waste organics source separation programs expand, and landfills become fewer in number and more distant from major cities.[11]

As implied here, incineration and landfilling are not good management options for food waste disposal, due to the realization that the output from neither system agrees with the green initiative for an environmental resource. Thus, for food waste disposal, the two best remediation options in regard to environmental benefit are composting, and the use of a food waste disposer with discharge to a WWTP. A comparison of these two alternatives completes this paper.

Composting
Composting is defined as the biological decomposition of the biodegradable organic fraction of municipal solid waste under controlled conditions to a sufficiently stable state.[12] The process is an ecological succession of micro-organisms inherently present in the waste. The product characteristics are a function of the environmental factors, the operational parameters, and the technology that is utilized. Environmental factors that must be balanced for successful composting include the availability of nutrients, the proper carbon to available nitrogen ratio (ideally 20-25:1), the size of the organic particle (microbial degradation is faster with smaller particles), oxygen availability (oxygen must be continually replenished or replaced), moisture content (ideally 50%-60%), pH level (ideally between 6.0 and 7.5), and temperature (microbe efficiency and speed decrease above 55°C).[12] The process must also continue until stabilization of the organics has occurred and pathogens (i.e., disease-causing organisms) and weed seeds have been destroyed. The actual time is a factor of the substrate, environmental conditions, and the operational technology and procedures employed. In short, composting is a highly variable process dependent upon the correct rationing of the available substrates. Maintaining product consistency is an integral requirement for successful marketing. Variation in consistency decreases the usefulness of the product, which results in a decrease in consumer confidence and interest.

An effective compost operation requires an effective municipal solid waste organic sorting operation. Composting will biologically break down easily degradable plant and animal matter, but does not appreciably change organics that are difficult to degrade (wood, leather, polymers), or inorganic substances (dirt, glass, ceramics, metals). Thus, food waste is typically sorted at the source (home or institution) and is transported to a preprocessing operation for contaminant removal. If source separation is performed poorly, then the contaminants removed must be transported again to the landfill for disposal. The storage and transportation of organic wastes creates extensive environmental health issues; including odors, bioaerosol exposure, and vehicle emissions and noise. In addition, for many European cities, truck collection presents problems due to the blocking of narrow streets. These preprocessing activities not only cause environmental concerns, but are costly as well.

Compost facility siting is critical for allowance of a buffer zone to residential areas, mainly due to odors. Offensive odors originate mainly from the raw waste. Raw yard wastes have little, if any, odor unless they include a high concentration of grass or food waste.[12] Compost processes fall into two broad groups of windrow or in-vessel. Windrows may be either the open and turned type, forced ventilation, or a combination. All designs for in-vessel systems have provisions for forced ventilation and are equipped to better remediate odors, provide improved operational control, require less land space, provide lower labor cost, and reduce process time than windrow systems. This degree of process improvement is balanced, however, by an associated increase in technology cost. In general, high labor and land costs favor in-vessel systems, and low labor and land costs favor windrow systems.[12] However, outside factors, such as odor concerns and land availability will also influence the selection of one process over another. The necessity for municipal solid waste source separation and transportation of food waste to the compost facility certainly adds to the overall process cost.

The primary use of compost is as a soil amendment. A distant secondary use is as a source of fertilizer nutrients, due to a typically low content of nitrogen, phosphorus, and potassium. However, this low nutrient content can be enhanced through a mixture with WWTP biosolids. Because it is predominantly organic and is an excellent medium for soil bacteria, compost improves the cultivation of soil, which enhances the soil productivity. Another benefit is that compost, when incorporated into the soil, can lower fertilizer expenditures by decreasing leaching and subsequent nutrient loss. Compost also has a high water retention capacity, and helps reduce topsoil loss through wind and water erosion. As previously stated, variation in process consistency will decrease the usefulness of the product.

Composting also entails potential negative environmental impacts with respect to water and air resources, and to public health. The negative impacts become more pronounced when an inadequate technology is applied, a typically adequate technology is not properly applied, or effective corrective measures are not applied. Residential home composting may have a higher potential for negative impact in the form of leachate loss to the groundwater or methane GHG air emissions, due to a lack of knowledge or process control. Research at Griffith University (Australia) concluded that home composting produces considerably more leachate when kitchen scraps are added to the mix, for which, there is no readily available mechanism to manage the leachate.[13] There is also no readily available mechanism to manage the production of methane, which will subsequently be released to the atmosphere.[13]

In addition, health concerns restrict some food waste as compost substrates. In association with European legislation, such as the 2003 Animal By-Products Order, regulations and quality control are increasingly determining the suitable substrate and technology to be used in composting.[14] The effect of this legislation is that windrow composting is not allowed for kitchen food waste because there is to be no risk of animals consuming by-products of their own species. The U.S. Environmental Protection Agency (EPA) advises that some products (such as citrus rinds, dairy products (butter, egg yolks, milk, sour cream, yogurt), and meat or fish bones and scraps) should not be composted due to odor, vector attraction (flies and rodents), or health concerns.[15]

Air quality can be negatively impacted from the compost operation through dust particles and aerosols. Several health studies have shown that the collection of source separated organic waste has been found to introduce health hazards, mainly respiratory inflammation, for workers and susceptible individuals that store or handle the waste. Decaying organic waste generates bioaerosols containing bacteria, bacterial and fungal spores, and microbial components like endotoxins and glucans.[16] Endotoxins are a measure of gram-negative bacteria and can cause respiratory disorders, such as chronic bronchitis and reduced lung function.[7] Glucans are a

[13]Jones, Prof. Philip H., Dr. David Moy, et al. Waste Management Research Unit. School of Environmental Engineering. Griffith University, Australia. August 1994. “Economic and Environmental Impacts of Disposal of Kitchen Organic Wastes using Traditional Landfill – Food Waste Disposer – Home Composting.”
[14]CIWEM Policy Position Statement. March 2005. “Composting – The Chartered Institution of Water and Environmental Management.”
[15]United States Environmental Protection Agency. Composting: Basic Information. [Internet. WWW]. Address: http://www.epa.gov/epaoswer/non-hw/composting/basic.htm.
[16]Heldal, K.K., A.S. Halstensen, J. Thorn, W. Eduard and T.S. Halstensen. ERS Journals Ltd. 2003. “Airway Inflammation in Waste Handlers Exposed to Bioaerosols Assessed by Induced Sputum.”

measure for mould concentrations and are considered to have similar human health effects.[7]

- The CRC in Sydney found that the measured concentrations of microbiological agents are 1.6 to 3.0 times higher per m^2 in households with separated organic collection than in households without.[7] However, the type of floor covering is very important. The concentration of microbial agents are 10 to 100 times higher for a textile floor covering (carpet, etc) than with a plain covering (wood, etc).[7] Thus, in a home with a textile floor covering and separated food collection, the concentration of microbiological organisms is 50 to 300 times higher.[7]
- A 1997 survey from a community near Oslo, Norway found that the collection of source separated organic waste introduced health hazards, mainly respiratory inflammation, for a number of workers that handle the waste.[16] The organic waste consisted of food and garden waste that was stored in closed containers and collected bi-weekly.
- An association was found between residents living in close approximation to a composting site (150-200 m) with the highest concentrations of airborne microorganisms (>10^5 CFU/m^3 residential air).[17] Shortness of breath was the most strongly associated complaint associated with residential exposure to the highest levels of bioaerosols, but sore eyes, diarrhea, excessive tiredness, and shivering were also positively associated.[17] However, residents living furthest away from the site (>400-500 m) still reported higher rates of health complaints than unexposed controls.[17]
- As organic waste microbial decomposition begins inside an organic waste bin, the bin may become an important source of bacteria and mold spores. Exposure to bacteria, especially endotoxins, is known to be associated with respiratory problems. It is also believed that molds initiate both allergic and nonallergic inflammatory reactions. The results showed that the presence of source separated organics stored indoors and a low bin emptying frequency (1 week or more) leads to significantly increased microbial concentrations.[18] The presence of a textile floor covering increased the concentration 20 to 100 times.[18] The combined effect of textile floors and an organic waste storage bin resulted in a 25 to 840 times increase in microbial agent levels.[18] An organic waste bin stored indoors that was emptied at least twice per week was associated with moderately increased microbial agent concentrations. Finally, the storage of non-separated waste had virtually no effect on microbial levels.[18]

As is the case for odor, vector attraction is an inevitable by-product of raw organic waste. Flies and rodents are more likely to be attracted to food wastes than if the compost operation treated yard waste only. Thus, the storage of organics in the home and preprocessing areas must be brief and careful housekeeping practices must be maintained in all phases of the organic waste storage and compost operation process. These negative intangibles greatly impact the incentive for people to participate in home organic separation and compost programs.

In the U.S., yard waste composting is practiced in many areas, especially since the early to mid-1990’s, in an effort to divert these wastes from landfills. Odor has been the greatest problem

[17]Herr, CEW. A zur Nieden, M Jankofsky, NI Stilianakis, R-H Boedeker, and TF Eikmann. Occup Environ Med. 2003. “Effects of Bioaerosol Polluted Outdoor Air on Airways of Residents: A Cross Sectional Study.”
[18]Wouters, Inge M., Jeroen Douwes, Gert Doekes, Peter S. Thorne, Bert Brunekreef and Dick J.J. Heederik. Applied and Environmental Microbiology. February 2000. “Increased Levels of Markers of Microbial Exposure in Homes with Indoor Storage of Organic Household Waste.”

issue to come from this experience.[12] The composting of food waste is showing increased interest, mainly in the western U.S. and Canada where land availability is greater. Incentives to reduce landfill solid waste disposal and extend the life capacity are the main reasons. Due to a more concentrated volume leading to more efficient separation and collection, organized food waste composting appears better suited for commercial generators than the residential sector.[12] Home composting has been implemented to varying degrees of success. In addition, the residential high-rise sector is not amenable to organics composting due to the logistical difficulties presented by source separation.

At the European Union level, the Landfill Directive requires the UK to divert biodegradable waste (25% by 2010 and 65% by 2020) away from landfills and into alternative forms of remediation.[14] Currently, however, over 80% of quality compost is generated from yard waste and only 7% is produced from curbside organic waste collection.[14] In the Netherlands, separate residential organic waste collection was begun in the early 1990's in an effort to reduce the volume of waste sent to landfills, and due to concerns regarding incineration capacity and dioxin air emissions. In 1994, a statutory obligation to collect organic waste was enacted. The National Waste Management Plan has since excluded some regions from mandatory organic collection, due to concerns for high composting cost, poor organic waste quality, or poor facilities for residents.[6] Thus; the exclusion implies that some local governments object to obligatory organic waste collection because it restricts options that are more cost/quality effective and innovative.

Food Waste Disposers

In-sink kitchen food waste disposers provide a convenient, simple, and hygienic organic waste recycling system. Food waste is safely ground through the disposer with the residuals dispersed through the sewage collection system to a WWTP. The WWTP is designed to efficiently process this organic waste, which is very similar in composition to human waste. The necessity for separating and storing odorous food waste, and for the costly and environmentally obnoxious usage of collection trucks is eliminated. A University of Wisconsin study found an incremental water usage of one liter per person per day for the disposer to flush the food residuals.[9] Based on a typical residential water use of 200 liters per person per day; this represents an increase of 0.5%. The same study also determined that the annual energy required for disposer use for a typical household was less than 5 kW-hrs (based on a total run time of less than one minute per day).

Grinding food waste through a disposer for degradation and stabilization at a WWTP offers several environmental benefits in comparison to other waste management systems. In contrast to an often mixed or negative resident attitude for organic source separation, people enjoy high levels of consumer satisfaction for disposer usage, due to the comforts of ease-of-use and convenience. This explains an approximate 90% consumer repeat purchase rate in the U.S. for disposers. A Surahammar, Sweden study surveyed disposer users and found 96% of respondents answered that the units were "very practical" or "pretty practical."[19] An Utanobori, Japan disposer pilot study consisted of installations in public housing (where residents were required to have disposers installed) and in private housing (where residents volunteered to have disposers installed). In both cases, the residents responded favorably to disposer use with 80% and 90%, respectively, indicating that they would want to continue using disposers in the future.[5] Also, as the existing sewer system is utilized for conveyance, transportation and labor costs, as well as vehicle emissions and noise, are eliminated. Food waste odor and bioaerosol health risks from laborious and offensive storage activities are also eliminated, as the waste is readily and hygienically dispersed on a journey to the WWTP.

After leaving the kitchen piping system, the food waste will migrate through the sewage collection system at a designed rate of about two feet per second. Arguments have been made against disposer usage due to negative effects on the collection system (i.e., blockages, odors, and increased vermin population). Food waste disposers will cause an additional loading to the sewer system. However, several examples in research indicate that, generally, the characteristics of food waste will not cause blockages in sewer systems:

- The New York City Department of Environmental Protection in 1997 stated that "in combined sewer systems built with adequate self-cleansing velocity (ex, sanitary sewers 0.6-0.8 m/s (2.0-2.5 ft/sec), storm sewers 0.8-0.9 m/s (2.5-3.0 ft/sec)), no additional deposits are expected due to ground food waste since its specific gravity of 1.01 is less than that of sewage (1.05), and much less than the suspended solids carried by storm runoff (2.65).[4] In addition, videotaping done before and after the study detected no noticeable deposits of solids build-up.[4]
- A Surahammar (Sweden) study found that sewer pipes were flushed and videotaped with no differences observed (i.e., no additional particle, sludge, or grease accumulation) after

[19]Karlberg, Tina and Erik Norin. VA-FORSK REPORT, 1999-9. "Food Waste Disposers – Effects on Wastewater Treatment Plants. A Study from the Town of Surahammar."

both 1 and 3 years following household food waste disposer installation.[19]

- The Cooperative Research Centre (CRC) found in a Sydney (Australia) study that 91% of solids in food waste grinder effluent are <1 mm (0.25 in) in size, and concluded that this small size would be unlikely to clog or become deposited in sewers or plumbing pipes.[7]
- The University of Karlsruhe (Germany) conducted laboratory half-scale flow channel tests. Their findings were that approximately 1/3 of the solids were solubilized after grinding kitchen waste through a commercial food waste disposer.[20] The residual non-solubilized solids were found to be transported evenly and sediment-free at low flow velocities. Thus, a daily minimum flow velocity of 0.5 m/s is seen as sufficient for transport free of sedimentation, as bio-waste particles density and settling velocity is very much less in comparison to mineral particles.[20]
- A corroborated university study (Italy) monitored three WWTPs to check the settling velocity of solids transported by sewers during dry weather. Settling tests performed on a representative mixture of food waste that was ground through a disposer were then compared with the velocity value obtained. The results showed that only 16.8% of total food waste solids settled in the sewers, whereas, 83.2% reached the WWTP.[10] Therefore, only a limited amount of solids from shredded organic wastes settled and the sewers should be considered a feasible method of transport.[10]
- A 4-year governmental study in Utanobori (Japan) reported that the frequency of occurrence of sewer deposits from disposer usage was 1.3 to 3.0 times higher, and the number of deposit sites 2.7 to 3.8 times higher after the introduction of disposers.[5] However, these deposits were very minor, with a <1% blockage rate for 80% of the sites. In addition, 76% of the deposits occurred in sections of inclined slope (0% or less) and 10.7% occurred in sections of gentle slope (0% to 5%).[5]

Of course, sewer blockages do happen and are typically caused by tree roots, grease accumulation, or piping system defects (inadequate slope or bends). Grease should never be poured down a sink as it will congeal and harden, resulting in an accumulation or blockage requiring physical removal. In-Sink-Erator instructs users to operate the disposer under cold water, which causes food waste grease to remain attached to the ground particles. It has been concluded that running cold water, while operating the disposer, will prevent coating of the sewer with grease.[21] Commercial institutions should implement grease “best management practices” by instructing employees on how to properly dispose of grease, and efficiently maintaining all grease traps and interceptors.

Upon arrival at the WWTP, the food waste is very conducive to the physical and biological unit treatment processes, as it is very similar in composition to human waste. A number of researchers have estimated the loadings to a WWTP due to food waste disposer usage.

- The U.S. Environmental Protection Agency has estimated typical household disposer discharge to consist of an organic content (in the form of Biochemical Oxygen Demand or BOD) to be 18.0 g/cap/day (28% increase per home with a disposer), Total Suspended Solids (TSS) to be 26.5 g/cap/day (37% increase), total nitrogen to be 0.6 g/cap/day (5%

[20]Kegebein, Jorg, Erhard Hoffmann and Herman H. Hahn. Institute for Municipal Water Treatment. University of Karlsruhe, Germany. “Co-Transport and Co-Reuse: An Alternative to Separate Bio-Waste Collection?”
[21]de Koning, Dr.ir. J. and Prof.ir. J.H.J.M. van der Graaf. Delft University of Technology. April 1996. “Kitchen Waste Disposer Effects on Sewer System and Wastewater Treatment, Concept.”

increase), and total phosphorus to be 0.1 g/cap/day (4% increase).[22]

- At a 15% to 20% disposer market share, loadings do not result in significant variations in the characteristics of sewage.[1] At a 20% to 35% market share, an increased WWTP system energy consumption is observed.[1] Beyond a 35% to 40% market share, additional works must be done at the WWTP.[1] EU market levels will not exceed 15% in 25 to 30 years. Thus, normal WWTP upgrades will allow for an accommodation of increased disposer loading. Disposer water consumption is 3.0 to 4.5 l/cap/day.[1]
- No WWTP operational problems are expected for market penetration levels up to 15% in regard to BOD and fats/oils/greases (FOG) loadings, or up to a 20% market share for additional TSS loadings.[7] Disposer water consumption is 2.95 l/cap/day.[7]
- Study results suggest the possibility that the basic unit of inflow household load to the WWTP increased by 20 % for TSS, BOD and COD; and about 10% for total nitrogen and total phosphorus.[5] No changes were noted in the amount of system water usage after the introduction of disposers.[5]
- Increased water demand from disposers is 0.02% (at a 3% market share) and 0.24% (at a 38% market share).[4] Therefore, no significant impacts in the city water supply is expected from disposer usage.[4]

At the WWTP, the preliminary treatment stage consists of screens and grit removal chambers. Most of the particulate food waste will settle in the primary settling treatment process, while the screens and grit chambers will only be affected to a small extent.[3] An actual WWTP case study in Surahammar, Sweden found that barely 4% of the incoming food waste gets caught in the screens.[19] Another case study at Utanobori, Japan stated that, after the introduction of disposers, it could not be clearly determined if there was an increase in influent solids and in the amount of foreign matter captured in the WWTP preliminary screens.[5]

Following the preliminary treatment, approximately 60%-70% of the total solids from typical sewage will be physically removed in the primary settling process, which removes readily settleable solids and floating materials. The primary treatment process also removes about 30%-40% of the organic component in the form of BOD. However, research has suggested that the characteristics of food waste will result in a higher settling rate in the primary stage than typical sewage. The solids that are removed are then pumped to the digestion process for further degradation and stabilization.

The dissolved, colloidal, and non-settling organic matter will leave the primary settling process and flow into the biological secondary treatment process. In this stage, active and abundant micro-organisms are provided with an ideal environment of oxygen and mixing, as the microbes eagerly feed and thrive on the organic food waste. The product is the formation of a biomass that is removed in the secondary settling process, which is often thickened through dewatering and pumped to the digestion process with the primary treatment solids.

In addition, the secondary process is also utilized for biological nutrient removal (i.e., nitrogen and/or phosphorus). Food waste can be an asset as it enhances the carbon-to-nitrogen ratio, a necessity for nutrient reduction. A University of Wisconsin study found that food waste contains

[22]United States Environmental Protection Agency. Table 3-8. February 2002. "Onsite Wastewater Treatment Systems Manual."

2.7% nitrogen and human waste contains 7.0% nitrogen, and calculated the stoichiometric net effect of adding 100 kg of food waste to a biological wastewater treatment plant to be a reduction of 0.22 kg of ammonia (which is produced following the biological conversion of nitrogen).[9] The resulting net loss results from the fact that less ammonia is produced in the hydrolysis of food waste (0.41 kg) than is used for biomass production (0.63 kg).[9] Thus, the soluble food waste fraction will lead to higher organic (BOD) loading within the biological treatment phase, which on one hand causes a higher oxygen demand, but on the other can serve as a cheap and continuously available carbon source to aid nutrient removal.[3]

Primary settling and secondary biomass solids are then stabilized to reduce odor and pathogenic organisms. The principal methods used to stabilize sludge solids are through alkaline addition (usually with lime), aerobic digestion, anaerobic digestion, or composting. Incineration is infrequently used by mainly very large WWTPs to produce and market a fertilizer product. However, this is not widely practiced, due to the large amount of energy and emissions cleanup required.

Stabilization is accomplished by the biological reduction of the volatile content (organics) and heat or chemical addition to make an unsuitable condition for disease-causing organisms to survive. Food waste is especially beneficial in anaerobic digestion and compost stabilization methods. A compost operation is enhanced through the abundant supply of nutrients to the final product, which are provided through the addition of WWTP biosolids. Anaerobic digestion benefits include the generation of methane, which is a byproduct of the biological destruction of organics and is available as a renewable source of alternative energy. Methane is not generated by any other solids stabilization process (i.e., lime addition, aerobic digestion, or composting).

Anaerobic digestion continues to be the dominant WWTP process for stabilizing sludge solids, due to the emphasis on successfully producing a biosolids product that can be beneficially recycled to the environment, and due to the emphasis on energy conservation. In addition, a WWTP can, in many cases, meet most of their energy demands for plant operation by producing a sufficient supply of anaerobic digester methane gas.[23] As food waste is 94.9% organic[24], it can be concluded that food waste will degrade thoroughly in the anaerobic digestion process (i.e., produce a high volatile solids reduction) and, thus, result in a pronounced source of methane gas. This effect has been researched and documented thoroughly.

- A City of Los Angeles Hyperion WWTP study utilized a food waste disposer to grind city airport kitchen scraps and pump them to a pilot thermophilic (i.e., 55°C) anaerobic digester. At a hydraulic retention time of 20.5 days, the study yielded an extremely high volatile solid reduction of 83.7% for the food waste over a 4-month test period (in comparison to 66.1% achieved for human waste).[24] Thus, the conclusion is that, "based on a volatile solid reduction of 83.7% for food waste, the value of the (methane) gas produced appears to exceed the cost of processing the food waste and disposing of residual biosolids."[24]
- A Surahammar, Sweden study at the Haga WWTP found a 20.2% increase in anaerobic

[23]Tchobanoglous, George, Franklin L. Burton, and H. David Stensel. Metcalf & Eddy, Inc. 2003. Fourth edition. "Wastewater Engineering: Treatment and Reuse."
[24]Hernandez, Gerald L., Kenneth R. Redd, Wendy A. Wert, An Min Liu, and R. Tim Haug. City of Los Angeles, Environmental Engineering Division. 2001."Hyperion Advanced Digestion Pilot Program."

digestion biogas production after the implementation of food waste disposers.[19] Aside from the introduction of food waste disposers, there were no changes detected in the WWTP operation to explain such a pronounced increase in gas production.[19]

- The Delft University of Technology concluded that food waste contains a high percentage of relatively easily digestible organic matter, of which, 90% is transferred to the WWTP settled primary treatment solids (and, thus, to the anaerobic digester).[25] This will then lead to an increased production of biogas and an increased self-supply in electricity, which will cancel out the costs for central sludge treatment for the addition of food waste solids.[25]

Biosolids produced from anaerobic digestion (or other WWTP stabilization process) are typically dewatered (to reduce volume and hauling costs) and are recycled to the environment through land application. The benefits of biosolids to land application are derived from the organic matter as an improvement to soil structure, cultivation, water holding capacity, water infiltration, and soil aeration; and from a supply of macronutrients (i.e., nitrogen, phosphorus, and potassium) and micronutrients (i.e., iron, manganese, copper, chromium, selenium, and zinc) as an aid to plant growth.[23] The nutrients present in biosolids also serve as a partial replacement for expensive chemical fertilizers. WWTP biosolids land application is highly regulated to protect public health and the environment, and must pass strict standards for organic content (i.e., volatile solids reduction), pathogens (i.e., disease-causing organisms), and heavy metals. The addition of food waste improves WWTP biosolids quality, as the waste is not a source of heavy metal or toxic contaminants.

Thus, implementation of a food waste disposer with discharge to a WWTP results in a complete recycling of food from growth, to processing, waste disposal, treatment, stabilization, and back to agricultural application. Further, the disposer accomplishes all desired green initiatives as the food waste is effectively managed as an environmental resource. The inherent organic and nutrient qualities are recycled back into the land. Stabilization by the anaerobic digestion process produces methane that is captured for energy renewal and is not released as GHG emissions. Public health is protected as organics storage and collections are eliminated in favor of an extremely hygienic and easy method of food waste disposal. Finally, fossil fuels are conserved as the need for waste transportation is replaced by the use of the existing sewer system.

[25] Dr.ir.J. de Koning. Faculty of Civil Engineering and Geosciences. Delft University of Technology. July 2004. "Environmental Aspects of Food Waste Disposers."