[Title:]
Food Waste Disposers – Effects on Wastewater Treatment Plants

A Study from the Town of Surahammar

Tina Karlberg
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[Scrambled words:]
Sludge quality
Sorting at source
Congestion
Nitrogen emissions
Smell
Sedimentation
Biogas
Water consumption
Screened matter

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Food Waste Disposers – Effects on Wastewater Treatment Plants

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Abstract: The report describes the effects of a large-scale installation of food waste disposers in the town of Surahammar, and their effect on Haga wastewater treatment plant. No negative conclusions were reached during the follow-up period.

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SUMMARY

The Swedish authorities have long maintained a restrictive attitude toward food waste disposers. During recent years, several municipalities have shown interest in using waste disposers in their waste disposal systems. Before disposers are installed, it is important to consider the issues surrounding, among other things, the sewage treatment in general, the limitations of the sewage system, and the design of the wastewater treatment plants.

In the municipality of Surahammar, food waste disposers have been introduced as a sorting at source alternative for the organic household waste. At the end of 1998, there were waste disposers in approx. 40 percent of the households connected to the municipal *sewage* system. The prognosis was that the percentage of households using food waste disposers would approach 50%. The report shows the results of a case study performed during 1998. The conditions at Haga wastewater treatment plant have been studied and compared to reference operational data from the period prior to the installation of the disposers. Furthermore, the results from investigations (sewage system, local resident survey) performed by Surahammar KommunalTeknik are discussed.

Based on the study performed, the following conclusions, among others, have been reached:

- The sewage system has exhibited no problems during the investigation period. No overflow was detected during 1998.
- No service interruptions have occurred at the wastewater treatment plant.
- During 1998, a slight increase in the amount of screened matter was detected.
- It has not been possible to detect any increase in the amount of incoming nitrogen, phosphorous or BOD from the water analyses. However, an increase in the ratio BOD/N shows that the composition of the wastewater has changed during the investigation period.
- The biological step does not seem to be affected; the aeration demand has not increased.
- The increase in gas production seems to correspond to the theoretical biogas potential of the waste, but no effects on the sludge treatment have been detected otherwise.
- The emissions of N, P and BOD have not increased at Haga wastewater treatment plant.
- The fluctuations in the measured data, as well as a decrease in the load, makes it difficult to reach conclusions that are very certain. This is why results/observations which in certain cases point in different directions cannot be fully explained.
- In order for a study of this type to provide anything further, the investigation period must be considerably longer and characterize the situation during stable operating conditions.

The waste disposers have had no effects other than positive on the operations at Haga wastewater treatment plant. *Neither has the sewage system exhibited any problems*. In order to be able to reach more certain conclusions and to gather more knowledge, both a longer investigation period and a process-specific experimental program is needed. The project at hand should be regarded as a background study. An interesting question

in this context is whether Surahammar is particularly well suited to exploit the use of waste disposers, or whether the project has succeeded because of careful planning.

1 BACKGROUND AND PURPOSE

Food waste disposers have historically seen very restricted use in Sweden. The reasons for this are among other things the fear of problems with the sewage system (sedimentation and congestion), increased oxygen consumption at the wastewater treatment plant, and the risk of an increased influx of unwanted material and objects to the wastewater treatment plants. Furthermore, there has been a fear of increased emissions of oxygen consuming substances and nutritive salts from the wastewater treatment plants.

There are a number of reasons why a future increase in the use of food waste disposers could be expected.

1. The risk of receiving unwanted, non-degradable objects (e.g. bottle caps and similar) with the wastewater is less for modern food waste disposers than for older disposers.
2. The advertised deposit tax must result in a decrease in the deposited amounts. Merged digestion with the municipal sludge is one way of reducing the levels, particularly if the rest product can be marketed for use in agriculture.
3. An increased interest in the production of biogas has made the alternative of organic waste digestion more attractive.
4. In many cases, there exists today a surplus capacity in the digestion step at municipal wastewater treatment plants in Sweden. Thus, there is often space available to introduce additional organic matter, without having to make any significant new investments.
5. The sorting at source of waste is costly. The combined transport of waste with the wastewater could save resources.

In Surahammar, food waste disposers have been installed in approx. 1,500 households (December of 1998). About 40 percent of the households are connected to the municipal sewage system and Haga wastewater treatment plant. Within the municipality, food waste disposers constitute one of three existing sorting at source alternatives for the household food waste; the remaining two are home composting and the use of a designated refuse containers with centralized handling.

By studying the conditions at Haga wastewater treatment plant before and after the installation of food waste disposers, we wish to increase the knowledge of how the use of disposers affect the processes and operations of a municipal wastewater treatment plant.

2 A BRIEF HISTORY

Food waste disposers have been used in household applications since the 1930s. The first generation food waste disposers were designed to effectively grind both food and bone remnants. Other accounts even state that it was no problem grinding both cutlery and beer bottles and other items one wished to get rid of in a trouble free and easy way.

[Cartoon strip:]

"What are you going to do with all the trash in the sink, Ernie?"
"Grind it in the kitchen disposer, Spencer."
"What about the dishes? What are you…"
"I'm too tired to bother with them now. I'll do them later."

Today's food waste disposers are designed to grind only soft food waste. *The disposer shreds rather than grinds the waste*, and is unable to grind hard bones and materials that are too tough, such as fish skins.

2.1 The Development in Sweden

In Sweden, the Environmental Protection Agency, municipalities and VAV have consistently maintained a very restrictive attitude toward food waste disposers, in the beginning because the biological treatment *stage at sewage works* was not *added* and a large increase in emissions was predicted if food waste disposers were allowed. There have also been concerns as to how the sewage system would handle the increasing load of suspended matter, regarding risks of congestion and hydrogen sulfide production, among other things.

Later, the authorities and the environmental public opinion have been skeptical toward food waste disposers also for a different reason. It is believed that it in principle is wrong to first mix the food waste with water and later to separate out the useful matter from the sludge. The low acceptance of sewage sludge has also contributed to an unwillingness to mix in the pure food waste.

In conclusion, much of the criticism can be traced to the fact that primarily the effects on the wastewater treatment have been considered, where the cost certainly could increase, but also the revenue. The effects on waste *handling* with reduced emissions from transportation, less problems at the *landfills* and an improved working environment have not been discussed to the same extent.

Today the view on food waste disposers has become somewhat less categorical and many municipalities are interested in the technology. The reason for this, among other things, is the following:

- Sorting at source and treatment of household waste has proved more expensive and more complicated than what was predicted at first. Therefore, interest in other technological alternatives has awakened, such as suction systems and food waste disposers.
- Many wastewater treatment plants have a surplus capacity in their digestion tanks, or could create a surplus capacity with minor modifications.
- The biogas technology has undergone a renaissance.

It is primarily among the municipally owned companies, *who singularly have the responsibility for both waste and sewage management,* that interest has increased. Within these organizations, it is easier to see and discuss the advantages and disadvantages, and possible cost effects, of integrated systems for waste and sewage.

Food waste disposers are not in any way considered for use in areas where wastewater treatment plants are not equipped with digestion tanks and thus are incapable of gas extraction.

Most municipalities allow the use of food waste disposers after dispensation has been given. Generally, very few dispensations are granted, but this could also be because the dispensation requirement is unknown to most subscribers. In certain municipalities, a higher fee is assessed from households that request dispensation and install food waste disposers. Stockholm (Stockholm Vatten AB) is one example of this.

Food waste disposers may, based on the sales statistics of Disperator, exist in less than 1 percent of the Swedish households.

2.2 The Situation Abroad

In the United States, there are food waste disposers installed in 49 percent of the households connected to the municipal sewage system. Over 95 percent of American cities allow the use of food waste disposers, but a few cities have prohibited installation due to lacking capacity, or for other reasons (Wicke, 1987). In 1992, more than 90 municipalities had requirements regarding the installation of food waste disposers for new construction, among those Detroit, Indianapolis and many municipalities and towns in California. The total number of disposers in active use has been estimated at 45 million. ISE (In-Sink-Erator) is the world leader with an approximate 80 percent share of the US market.

Food waste disposers are less common in European countries. In Great Britain and Holland, scarcely 5 percent of the households have disposers (de Konig & van der Graaf, 1996; Mortensson, 1996).

New York City expressly prohibited the use of food waste disposers in the beginning of the 1970s (Wicke, 1987). The reason for this was among other things an overflow of untreated wastewater. Therefore, it was desired not to introduce unnecessarily large amounts of organic material by permitting the installation of disposers.

This ban in New York apparently provoked a large number of studies in the United States, praising the food waste disposer in the same unreflecting way some European studies have vilified it.

A survey of the literature shows that the issue of food waste disposers is, or has been, much fought over in many Western countries, Holland, Denmark, Australia and Japan among others. It can further be concluded that several of the disposer investigations in circulation are purely commissioned reports, initiated and funded by a disposer manufacturer, even though they have been conducted at a university or an R&D institute.

3 THIS IS HOW A FOOD WASTE DISPOSER WORKS

3.1 Comprehensive Functional Description

Food waste disposers are manufactured by a number of different companies. They are mounted underneath the kitchen counter and are connected to the sink (diameter of 90 mm). A dishwasher may be connected to the disposer as well, and the outlet from the disposer is connected to a U-shaped drain trap. Both continuously working disposers and batch fed disposers are available.

[Picture]

When a batch fed disposer is used, the food waste is first fed into the disposer. After *flushing* with water, the disposer is turned on by shutting a stopper in the run position. A continuous disposer is turned on with a manual switch mounted on the counter while the waste is flushed into the disposer by the water.

In the most commonly used disposer on the Swedish market, the waste *is flushed* onto a rotating disk with a number of 3-4 mm wide holes in it. The disk rotates at approx. 1,400 rpm. Outside the rotating part sits a fixed, saw-toothed shredder with approx. 2-mm wide slotted openings. *By centrifugal force the waste is thrown* onto the *rotating* shredder, passes it through the holes and into the outlet pipe. Thus, it can be concluded that modern food waste disposers really do not incorporate a traditional grinding function.

The limited hole diameter of the disposer causes harder, non-shreddable materials to stay in the upper part of the disposer. Such material must be removed manually when the disposer is turned off. *Furthermore, the electrical supply to the motor is broken if overload.*

Other facts

- Retail price about SEK 3,000, not including VAT
- Water flushing requirement 5-7 liters per minute
- Annual energy requirement 3-4 kWh/household
- Water consumption 3-6 l/household and day

Particles size of the food ground waste is an interesting question for several reasons (sewage system sedimentation, intake screen and sedimentation basin processes, etc.). However, there are differing opinions on the actual size that the particles from the disposer have. Disperator states that their disposers (ISE) normally produce particles of up to 3-5 mm. During a thesis study conducted on an ISE disposer at Mälardalens högskola (college), it was found that particles of up to 20 mm were common and that also pieces up to 40-50 mm could be found after the disposer (Jenny Nilsson, 1998). This occurred most often in the case of waste fractions such as onion and potato peel. In a Japanese study aimed at characterizing the waste fractions from a disposer manufactured by SinkMaster, a dispersion was obtained of between 2 and 5 mm.

3.2 Grindable Waste

The question of how much of organic household waste is grindable has been investigated or discussed earlier in some projects. Data from two Swedish reports (Lagerkvist &Karlsson, 1983; Nilsson et al., 1990) is shown in Table 1.

Both reports indicate that approx. 20 percent of the food waste suitable for composting is not suitable for grinding in a food waste disposer. This could for example be skin from chicken and sausage, pork chop bones, avocado pits, and other hard materials. Nilsson et al. (1990) further show that an additional 24 percent of the material suitable for composting is not ground since it is wrapped in packaging, which is not cleaned out, and put directly into the general refuse.

Table 1: Amounts and fraction of grindable waste, according to two Swedish reports: 1) Lagerkvist & Karlsson, 1983 and 2) Nilsson et al., 1990.

Parameter			1		2
Suitable for composting	kg/yr	110	100 %	88	100 %
Grindable (directly)	kg/yr	86	78 %	49	56 %
Indirectly grindable	kg/yr			21	24 %
Not grindable	kg/yr	24	22 %	18	20 %
Total amount of household waste	kg/yr	245		195	

A current national study (Olsson & Retzner, 1998), based on a “pick” analysis of household waste from six Swedish municipalities, showed that the food waste made up approx. 40 % of the household waste. From the report data, it can further be obtained that one person today generates about 75 kg of food waste annually. Assuming 20 percent of this cannot be ground down, 60 kg/person and year remains. We further assume that, for various reasons (see above), an additional 10-15 % is lost ("indirectly grindable") by being put with the general refuse. Based on this reasoning we assume the following specific amounts of grindable and non-grindable food waste:

- Amount of food waste that is ground: 50 kg/person and year (67 %).
- Amount of food waste put with the general refuse: 25 kg/person and year (33 %).

The assumption is based on general data and has not been adjusted to the conditions in the municipality of Surahammar. However, from Olsson & Retzner (1998) it can be concluded that there is a limited variation in the generated amounts of waste between different municipalities. In Surahammar, the intention is to make their own estimate of what portion of the food waste is ground, as opposed to put with the general refuse.

International data varies on how great the grindable portion is. This could partly be due to the differing food preparation patterns of different countries, and partly that the amount data also internationally is based on assumptions or investigations using small data sets. One example of this is given by de Koning & van der Graaf (1996) who assume that the grindable amount is 44 kg/person and year.

The amount of waste to be collected from the households decreases if food waste disposers are installed. The work involved in vehicle transportation could therefore be ì¥Á Y ┘ ↕ ¿ ┼ ┘ `P┌

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3.3 WóW

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me time estimate that the household water consumption does not change because of disposer use. These conditions could be described in terms of an increase in the contaminant amount and content and a flow which remains constant.

The specific contaminant contributions from wastewater and food waste respectively can be described based on general standard rules. These are shown in Table 2 together with the percent increase in the contaminant load resulting from the fact that 25 and 50 percent respectively of the individuals connected sort their waste at source using food waste disposers (fwd).

In the table below is also the ratio BOD_7/N shown for the different fractions. This ratio is shown since it can be used as a "flow independent" indicator, showing if and to what extent the waste affects the composition of the wastewater. The ratio BOD_7/N is in this respect a slightly more efficient standard of value than the ratio BOD_7/P, because nitrogen is input from the food waste in a relatively smaller amount than phosphorous. (BOD_7= oxygen consumption over seven days, N=nitrogen, P=phosphorous)

From the numbers in Table 2, the consequences of 25 and 50 percent respectively of the connected individuals using food waste disposers may be calculated. In the case of 25 percent connected, a 12 percent increase in the BOD amount would be expected and a 2 percent increase in the amount of phosphorous and nitrogen. A 50 percent connection means that the increase is doubled, i.e. the BOD amount increases by roughly 25 percent and the amount of phosphorous and nitrogen by roughly 4 percent. The conclusion is that the input from waste of nutritive salts and oxygen consuming substances into the wastewater is expected to be moderate also for a considerable systems expansion. The theoretical load increase for Surahammar, based on regional waste data, is shown later in the report (Table 6).

In addition, the effects from the increase in wastewater contaminant content do not have to imply a corresponding increase in the load at the plant. For example, the production of digester gas increases proportionally to the BOD increase only if the incoming BOD can be transferred to the digestion tanks to the extent that BOD is transferred from the wastewater. Varying decomposition and separating processes in the pipelines and at the wastewater treatment plant could lead to different conditions.

Table 2: Theoretical contaminant contributions from sewer and food waste disposers (fwd). General sewer and waste data has been used.

Parameter		Sewer[1]	Waste[2]	Combined amount at 50 % fwd	25 % fwd
Dry matter	g/person and day	175	48	199	187
Glow losses (VS)	g/person and day	122	36	140	131
BOD_7	g/person and day	48	25	60	54
Total phosphorous	g/person and day	2.1	0.2	2.2	2.15
Total nitrogen	g/person and day	13.5	1.0	14	13.75
Ratio BOD_7/N		3.6	25	4.3	3.9
Ratio BOD_7/P		23	125	27.5	25.2
Potassium	g/person and day	4	0.5	4.2	4.1
Led	mg/person and day	3	4.8	5.4	4.2
Cadmium	mg/person and day	0.6	0.02	0.61	0.60
Copper	mg/person and day	7.2	4.7	9.6	8.4
Chrome	mg/person and day	5	5.5	7.8	6.4
Mercury	mg/person and day	0.07	0.007	0.074	0.072
Nickel	mg/person and day	3.1	1.7	3.4	3.5
Zinc	mg/person and day	61	24	73	67
Amount		200 l/person and day	0.14 kg/person and day		

1) Data obtained mainly from the Swedish Environmental Protection Agency, 1995.
2) The amounts refer to 67 % of what is generated in the households as food waste. Data from Olsson & Retzner, 1998; RVF, 1996 (averages) and Wicke, 1987. Data from the latter refers to the waste BOD content, which in the investigation indicates a very large spread in the data for the BOD_7 content of the ground waste. Different sources claim between 10 and 38 g of BOD_7 per person and day.

If the input of heavy metals into the waste is examined, it is observed that the effects could become large for certain parameters. The degree of sorting at source determines entirely the amount of heavy metals in the contaminant input from the food waste disposer. Both the solid sewage products as well as the solid waste should contain – for optimal sorting at source – only heavy metals coming from the consumed foodstuff.

4 CONDITIONS IN THE MUNICIPALITY OF SURAHAMMAR

4.1 Haga Wastewater treatment plant

Haga wastewater treatment plant is the main plant for Surahammar. All wastewater from the towns of Surahammar and Ramnäs and the village of Haga is routed to the plant.

4.1.1 Description of the Wastewater treatment plant

Haga wastewater treatment plant was designed for mechanical, biological and chemical treatment of wastewater. In the mechanical stage, coarser solid contaminants (screened matter) are separated out by a cleaning screen (mesh size 3 mm), while sand is separated out in a sand trap. The primary sedimentation then follows. The biological stage is designed for the activated sludge process and the chemical treatment takes place through joint precipitation in the biological stage. Spent pickling baths (ferrous sulfate) from Surahammar Steel works are used as the precipitation chemical. Following the joint precipitation, a (final) sedimentation takes place before the treated wastewater is routed to the recipient, Kolbäck creek, via a 200-m long outlet pipe. During parts of the year, the outgoing flow is used in the irrigation of energy grasses on the plant property. The wastewater treatment plant is also equipped with a postprecipitation assembly, currently not in use.

The produced sewage sludge, extracted from the primary sedimentation basins at the plant, is led directly to a digestion plant for stabilization. The digestion stage consists of two digestion tanks connected in series, where the first one undergoes total mixing and is heated, while the second could be considered more of an intermediate storage (with gas extraction, however). Sewage sludge from Virsbo wastewater treatment plant is also collected and treated at Haga, and is fed to the plant via the thickeners. The digested sludge does not undergo mechanical dewatering, but is transferred to sludge drying beds that also function as intermediate storage. An elementary flowchart of the wastewater treatment plant is shown in Appendix 1.

4.1.2 Connection and Design

The wastewater consists mainly of household wastewater. The two main industries connected to the plant, Surahammar Steel Works and Adtranz, only contribute smaller amounts of permeates from ultra filtration plants. Design data for Haga wastewater treatment plant is shown in Table 3.

Table 3: Original design data for Haga wastewater treatment plant. (pe=population equivalent, q_{dim}=design flow)

Parameter	Total load		Specific load	
Connection	12,000	pe		
Flow	8,150	m^3/d	680	l/pe,d
BOD_7	960	kg/d	80	g/pe,d
Total phosphorous	45	kg/d	3.8	g/pe,d
q_{dim}	approx. 435	m^3/h		

4.1.3 Current Load and Treatment Results

The connection to the wastewater treatment plant, according to the environmental reports from the past couple of years, has been approx. 9,500 population equivalents while the actual number of connected individuals has been approx. 8,830. Measured load data for incoming wastewater for 1995, 1996, 1997 (environmental report data) is shown in Table 4.

Table 4: Load during 1995, 1996 and 1997.

Parameter	1995	1996	1997	Average	
Average flow	5,690	4,910	4,570	5,060	m^3/d
BOD_7	427	540	468	480	kg/d
Total phosphorous	21	21	19	20	kg/d
Total nitrogen	131	132	124	129	kg/d

If we reduce the industrial share of the load (approx. 670 pe with the specific contaminant amounts normally associated with a population equivalent: 70 g of BOD_7/pe,d; 14 g of N/pe,d and 2.5 g of P/pe,d), we obtain the following data for the approx. 8,830 individuals connected:

- 49 g of BOD_7/p,d (Standard household from the Swedish Environmental Protection Agency: 48 g/p,d)
- 2.1 g of P/p,d (Standard household from the Swedish Environmental Protection Agency: 2.1 g/p,d)
- 13.5 g of N-tot/p,d (Standard household from the Swedish Environmental Protection Agency: 13.5 g/p,d)

From this we conclude that the specific load at Haga wastewater treatment plant almost exactly follows the standard figures for household wastewater from the Swedish Environmental Protection Agency (Swedish Environmental Protection Agency, 1995).

This illuminates the difficulties with the concepts of individual and population equivalent for the issue of what specific BOD_7 is to be used for the description of an operation.

The contaminant content of the incoming and outgoing wastewater for 1995, 1996 and 1997 is shown in Table 5.

Table 5: Contaminant content of the incoming and outgoing wastewater (in → out) for 1995, 1996 and 1997.

Parameter	1995	1996	1997	Average	
BOD_7	75 → 3.1	110 → 4.9	102 → 4.9	96 → 4.3	mg/l
Total phosphorous	3.7 → 0.27	4.3 → 0.3	4.1→ 0.27	4 → 0.3	mg/l
Total nitrogen	23 → 18	27 → 20.8	27 → 19.4	26 → 19	mg/l

According to the current requirements, the residue of the outgoing wastewater must not exceed 15 mg of BOD_7/l and 0.5 mg of phosphorous/l. These requirements have been met with good margin during the past couple of years. No requirements exist for the reduction of nitrogen. Table 5 shows the following average reduction for 1995-1997:

- 96 % BOD_7
- 92 % phosphorous
- 27 % total nitrogen

4.1.4 Sludge Management

Following the treatment (digestion and drying in beds), the majority of the sewage sludge has been used on cultivated lands (growing of energy crops). Sewage sludge is now also used in the production of construction soil. Screened matter from the preliminary treatment is transported to Vafab's (Västmanlands refuge collection authority) waste treatment plant in Västerås for landfill, while sand from the sand traps is spread out on the drying beds. The sludge quality has been varying during the past couple of years. The heavy metals led, cadmium and zinc have been close to the current limit values.

During a period in 1997, experiments were conducted on the digestion of ensilage with sewer sludge. During the reference operations preceding the grass digestion experiments, the production of digester gas amounted to approx. 3,000 m^3/d. With the addition of ensilage, the digester gas production increased by approx. 370 m^3/d. The specific production in both cases amounted to approx. 0.5 m^3 per kg of added wet matter *(VS = wet substance).*

The *methane* gas produced at the digestion plant is used internally in the production of electricity and heat. During 1995-1996, the average gas production has been 335 m^3/d. From the current specific gas production (0.5 m^3 per kg of added VS, wet substance), it is shown that the daily raw sludge has corresponded to approx. 960 kg of dry matter (TS = dry substance) per day (at 70 percent VS of TS).

This corresponds to 350 tons of TS per year, or barely 9,000 m^3 of raw sludge annually at a TS content of 4 percent. Spread over the stated population equivalents contributing sludge (Haga 9,500 pe and Virsbo approx. 2,000 pe), we obtain a specific sludge production of approx. 85 g of TS/pe,d, which is low compared to the standard data. (If we calculate the pe values using traditional methods, the corresponding sludge calculation yields 120 of TS/pe,d which is similar to the standard data.)

4.1.5 Sewage System and Overflow

The amount of separate systems in the wastewater sewage system is roughly 96 percent. The drainage water coming from a large number of properties is connected to the wastewater treatment plant, which means that significant amounts of melted and rain water reach the plant during snow melting and rain. In relation to the pure water consumption within the municipality, the incoming amounts of wastewater during the past years have been 30-50 percent higher on an annual basis. During the past year, a considerable amount of work has been put into searching for and fixing water leaks. This has resulted in a reduced flow to the wastewater treatment plant, but the effects have not been quantified.

Overflow in the sewage system and at the treatment plant only occurs as an exception because the sewage disposal system of Surahammar has a considerable surplus capacity. Overflow may occur at the C5 main pumping station and at the wastewater treatment plant. The overflow points at the plant lie after the intake screens (overflow occurs at flows exceeding 4 x q_{dim}) and after the primary sedimentation (overflow occurs at flows exceeding 2 x q_{dim}). During 1995 and 1996 no overflow took place at all, while during 1997 an overflow of approx. 28,000 m^3 occurred at the C5 pumping station (sewage system work) and 2,000 m^3 at the plant.

If the incoming wastewater during a high-flow period contains 50 mg of BOD_7/l and a total overflow of 2,000 m^3, this results in an increase in the BOD_7 emissions by 96 kg of BOD_7 annually. Using food waste disposers at the level corresponding to October of 1998, this number would theoretically increase by approx. 8 percent to 104 kg annually. This should be compared with the BOD emissions for the treated wastewater, which is approx. 7,000 kg annually.

4.2 Waste Management in Surahammar

Surahammar KommunalTeknik AB is responsible for the management of both waste and wastewater for the municipality. Since 1997, there are new refuse collection regulations in place for the municipality.

4.2.1 Sorting at Source of Waste

The new refuse collection regulations state that, using a charge system, the households may choose from three alternatives for their food waste sorting at source. At the households, so-called general refuse (everything but packaging, hazardous waste, and bulky waste) is conventionally collected by truck every other week.

This fraction of the household waste is transported to the Vafab waste treatment plant in Västerås.

For organic waste suitable for composting, three alternatives have been offered at different fees:

1. Food waste disposer (see Chapter 4.2.3)
2. Home composting
3. Special container for organic waste

The alternative of home composting means that the occupants themselves compost their waste using so-called *warm* composting. The households are expected to purchase and pay for the upkeep of their compost containers, and to make sure that the compost product is used in an environmentally friendly way. Home composting carries the lowest charge of the various alternatives.

The container collection alternatives mean that the households receive an additional waste container. Emptying of the containers takes place once or twice a week, depending on the season. The organic waste is then transported to a central treatment plant for composting or digestion.

4.2.2 Experiments with Food Waste Disposers – the Housing Cooperative Skivlingen

In 1993, a first experiment with food waste disposers was started in an apartment block belonging to the housing cooperative Skivlingen in Surahammar. The disposers were installed in 32 of the 39 apartments belonging to the cooperative in connection with changing the mains for the block. The installation of disposers was a part in a larger sorting at source program for Skivlingen. The total effect on the waste side was that the refuse collection could be reduced from emptying six 400 liter containers twice a week, to emptying three once a week (SKT, 1992).

Among other things, the experiment was followed up by surveys in 1993 and 1995. At both times, the apartment occupants were mostly satisfied with their disposers. In the second survey, 96 percent were satisfied while 22 percent claimed they had experienced some problems with the disposers. Most of the time the *incorrect items* had ended up in the disposers, and there had been difficulty in removing objects or food scraps. On the average, the disposer is used 3-4 times a day. 75 percent and 78 percent respectively of the apartment occupants responded to the surveys at these two *occasions*.

An important part of the experiment was to examine the effects on the sewer system belonging to Skivlingen. The investigation began with flushing and video-filming of the pipes joining two identical apartment blocks at Skivlingen 1 and Skivlingen 2. Skivlingen 1, which did not receive any food waste disposers, would serve as the reference object, while Skivlingen 2 was the object where disposers were installed. Little over a year following the installation, the pipes were video-filmed for the first time after flushing. No differences could be detected between Skivlingen 1 and 2. Two years later, another inspection was performed when the service line for Skivlingen 2 was flushed using high pressure.

The personnel could not detect any accumulation of particles, sludge or grease this time either. The flushing initiative was taken by the cooperative, wanting an additional inspection of the pipes.

Another observation made is that the water consumption at the cooperative Skivlingen was reduced by 25 percent during 1993-1996. However, Surahammar KommunalTeknik does not wish to reach the conclusion that this is due to the disposers, since fittings in the apartments were changed out during the same period.

4.2.3 Food Waste Disposers on a Large Scale

Since the experiment at the housing cooperative Skivlingen turned out well, Surahammar KommunalTeknik decided to introduce food waste disposers as an alternative in the new refuse collection charge. The alternative means that the households either purchase the disposers themselves and are responsible for the installation, or that the disposers are installed by Surahammar KommunalTeknik for a fixed charge spread out over an eight year period. If the latter is chosen, video-filming of the sewage service line is also performed before the installation, free of charge.

The installation of the waste disposers started in May of 1997, and in October of 1998 roughly 1,100 households, mainly one-family households, had made their choice and had had their disposers installed. Within the field of activity of Haga wastewater treatment plant, there are 3,700 households of which the majority received the offer for a food waste disposer through Surahammar KommunalTeknik. The connection in October of 1998 thus meant that 30 percent of the households had disposers installed. The prognosis was then that approx. 1,900 households (roughly 50 percent of the households within the field of activity of Haga wastewater treatment plant) would be equipped by the end of the summer of 1999.

The installation of food waste disposers is an operation that has a certain drawn-out effect on the wastewater treatment plant. Per capita, the rate of expansion has been about 60 households per month. The load on the treatment plant can be expected to increase at the same rate. In the investigation, this has been considered when relevant.

Based on the waste and wastewater data, we have calculated how great an effect the current installation of disposers will have on the load increase at the Haga wastewater treatment plant. Note that we in this calculation have used standard figures obtained from the regional waste management company Vafab, which we believe will be more valid for the conditions in Surahammar. It is therefore not possible to directly compare the general information of Table 2 with Table 6.

Vafab normally calculates the household based waste amounts as follows:

- Food waste (gross) from single homes: 5.5 kg/week
- Food waste (gross) from apartment block households: 2.5 kg/week

Using the same grinding factor as earlier, 67 percent, we obtain that the 1,100 connected households (900 single houses and 200 apartments) in Surahammar together deliver 520 kg of waste per day to the sewage system. The wastewater is assumed, as shown earlier, to correspond to approx. 5,000 m^3/d. The load increase that 1,100 households with disposers are assumed to create in Surahammar is shown in Table 6.

Table 6: Theoretical load increase due to food waste disposers in 1,100 households in Surahammar. Regional waste data has been used.

Parameter	Wastewater Average 95-97	Waste October of 98	Total		Load increase %
Household	3,700	1,100		st	
Dry matter	1,545	146	1,691	kg/d	9.5
Org. matter	1,080	131	1,210	kg/d	12
BOD_7	480	76	556	kg/d	16
P total	20	0.9	20.9	kg/d	4.5
Tot-N	130	3.4	133.4	kg/d	2.6
BOD/N	3.7	16.3	4.2		13.4
BOD/P	24	81	26.5		10.4

5 METHOD AND PROCEDURE

The investigation is based mainly on a comparison of the conditions in the sewage system and at the treatment plant before and after the installation of waste disposers in Surahammar during the spring of 1998.

5.1 Selection of Samples

During normal operation, the sample collection at Haga wastewater treatment plant has been performed according to the instructions of the current inspection program. This means the following sample collection routines:

- Incoming wastewater: BOD_7, COD_{cr}, Tot-P, Tot-N, NH_4-N
- Outgoing wastewater: BOD_7, COD_{cr}, TOC, Tot-P, Tot-N, NH_4-N
- Treated sewage sludge: pH, TS, Glow losses (GF), Tot-P, Tot-N, NH_4-N, CaO, heavy metals and organic environmentally damaging substances

The incoming wastewater is sampled over a 24-hour period, 13 times a year, while the outgoing water is sampled the same way 25 times a year. The sludge sampling is performed as collection samples twice a year. For the above analyses, there thus exists historical data for a large number of years stretching back in time. At the same time, it could be concluded that, aside from normal analysis, only a limited historical data set exists for the remaining parts of the treatment plant.

5.1.1 Water

With regards to additional water inspections, additional samples were obtained during a period of two months, according to the points of Table 7. The samples were obtained as weeklong samples, which was considered more relevant than the day samples. The following parameters have been analyzed: BOD_7 (filtered), BOD_7 (unfiltered), Tot-P, Tot-N, NH_4-N, N-org and suspended matter.

During the entire follow-up period, also pH, temperature, flow and oxygen content have been followed in the biological step. By paying particular attention to the phosphorous emissions during the period, the need for a change in the precipitation chemical dosage has been followed indirectly.

Table 7: Description of sampling points for additional wastewater sample.

Designation	Sample type	Description
P1	Incoming wastewater	Before the fine-mesh screen at existing sampling point according to the inspection program
P2	Mechanically purified water	Outgoing from the sand trap, alternatively incoming to the primary sedimentation[1]
P3	Primary sedimentation of water	Outgoing from the primary sedimentation, before the admixing of precipitation chemical
P4	Biologically and chemically treated water	Outgoing from the intermediate sedimentation, at the existing point according to the inspection program

1) Unfortunately it was noted that the water from this sampling point was affected by the surplus sludge, which is collected via the primary sedimentation. This data can therefore not be used.

5.1.2 Sludge

The study of the sludge has consisted in part of analyses of the sludge quality, and in part by measuring the amount of sludge, sand and screened matter. In addition, the conditions in the digestion tank have been observed, including the amount of produced biogas.

For the sludge analyses the following parameters were determined: TS, glow losses (VS), Tot-P, Tot-N, NH_4-N, TOC and heavy metals. The definition of the sampling points are given in Table 8.

Following the initial batch of analyses, the sludge sampling for S1 was interrupted. This was because no reference values could be obtained for the sampling point. For sampling point S2, the sludge quality was followed through the normal sludge sampling according to the inspection program.

Table 8: Description of selected sampling points for sewage sludge.

Designation	Sample type	Description
S1	Raw sludge	Outgoing sludge from primary sedimentation
S2	Digested sludge	Sludge from digestion tank

5.2 Observations

Aside from the investigations, ordinary observations regarding the operation are an important part of the follow-up. This part has been conducted within the framework of the normal plant supervision.

5.3 Operations data is shown for most of the parameters running up until December of 1998 when the study was concluded. A period with additional water sampling (week samples) took place during May-June. Analysis data from these did not deviate from the recurring and normal day samples. The week sampling was therefore discontinued after this.

It should further be noted that Table 6 only illustrates the theoretical load conditions for October of 1998. Since the expansion rate has been constant, this data represents the average load for the fall of 1998 which has been exploited in comparative studies of the gas production during different years.

6 RESULTS AND DISCUSSION

In this results chapter, both data registered during the follow-up period and observations are shown and discussed. The presentation follows the path of the wastewater and concludes with the results from the latest survey. A broader discussion of the results is presented in Chapter 7, "Comments and Conclusions".

6.1 Sewage system

The inspection of the sewage system is *something* into which Surahammar KommunalTeknik has put a lot of effort. Above all, all the service lines for the buildings choosing disposers were inspected prior to the installation, to determine if the service line had any defects, which would mean that the connection of waste disposers would be unsuitable. Only one area in Surahammar has so far been deemed unsuitable in this regard.

During the expansion period, also the general sewage system, through an expanded inspection program, has been inspected continuously through video-filming and recurrent flushes, among other things. The effort was above all concentrated to stretches that beforehand were deemed prone to congestion. Until October of 1998, no signs of congestion or accumulation of sludge or particles could be detected by the inspections. These observations are consistent with previous experience (refer to Chapter 4.2.2).

During emergency overflow in the sewage system or at the treatment plant, and when effluence is diverted past one or more treatment stages, impure or partly purified wastewater can be routed directly into the recipient. *This is a strong reason why authorities have a skeptical attitude toward food waste disposers.* In Surahammar, overflow normally occurs to a very limited extent, both in the sewage system and at the treatment plant. A fact illustrating this is that no overflow occurred until October of 1998, in spite of it being an unusually rainy year.

6.2 Incoming Wastewater

6.2.1 Flows

The incoming flow into Haga wastewater treatment plant decreased slightly during 1998 compared to earlier years. An explanation for this is that Surahammar KommunalTeknik put a lot of effort into renovating the lines (fixing leaks) during the year. At one of the points, there has been an estimated decrease in the overflow from the storm water sewage system to the wastewater sewage system by 30,000 m^3 per year.

The changes in the flow conditions, which have precisely affected the follow-up period compared to earlier years, to a certain extent makes the evaluation a bit more difficult. That one without this interruption could trace the cause of a change in the water consumption to the waste disposers is still uncertain.

If the households that have disposers installed would decrease their water consumption by 10 percent, it would mean a decrease in the flow by approx. 65 m^3/day. That amount corresponds to roughly 1 percent of the average flow.

A reduction in the leakage into the sewage system, unless the seepage water is contaminated ground or drainage water, should not affect the incoming *contaminant amounts*. On the other hand, the *contaminant content* of the wastewater should increase.

6.2.2 Composition

The load increase, as we might be expected after the addition of food waste, could not be traced in the analyses of the incoming water. One contributing factor for this is that the contaminant levels and amounts vary greatly from day to day. It is then not strange that a decrease by a few percent would be undetectable, which is the case with nitrogen and phosphorous.

Stranger is that a calculated increase in the BOD_7 amount by 15 percent has not been visible. The incoming amounts of BOD_7, with a moving average added, are shown in Figure 2. The diagram reflects the large variations caused by the current method of measuring (water sampling and flow measurements). The BOD load at the treatment plant does not seem to be increasing during 1998. The variation in the incoming BOD amount lies well within the variational limits of earlier years.

If the BOD_7 result is considered separately from other observations, the following possible explanations for the missing load increase, among other things, can be found:

- The expected increase in the BOD load is hidden by natural variations.
- The analyses and/or samples have not been reliable, because of:
  – Incorrect methods,
  – That the waste enters the treatment plant in batches and thus cannot be caught by the sampling,
  – That the day sampling, performed between Tuesdays and Wednesdays, has produced an incorrect picture of the waste amounts if the bulk of the food waste is generated during weekends.
- The incoming water contains less BOD_7 than expected, because of:
  – The waste contains less organic matter than assumed,
  – Food waste disposers are used less often than assumed,
  – Other sources of contamination have reduced their BOD_7 contributions, or that the conditions have changed in other ways (an effect of, for example, reduced leakage of "dirty water", due to renovations of the sewage system),
  – That considerable denitrification or decomposition for other reasons take place in the sewage system after the disposers were put into operation.

The summary points to two scenarios: either food waste does not enter the treatment plant, or the food waste does enter, but in such a way that it does not show up in the analyses of the water BOD_7 content. Which sequence of events lie behind this has not been determined within the framework of the project. However, what may be concluded is that observations of, for example, the amount of screened matter and production of gas, support the theory that food waste arrives at the treatment plant.

[Graph]

Figure 2. BOD_7 amounts (kg/d) in the incoming wastewater at Haga wastewater treatment plant, between December of 1994 and December of 1998. Moving average (15 intervals) is shown.

As was discussed earlier, the ratio of BOD_7 and total nitrogen can be used as a flow independent value parameter for changes in the wastewater composition. A change in the ratio could in any case indicate whether the incoming wastewater is affected by the food waste. Using this projection as a starting point, it is possible to reach the conclusion from Figure 3 that food waste disposers are in use and that they do affect the composition of the wastewater.

The progression of the curve for the ratio BOD_7/N indicates a change in the load at the same rate as the installation of disposers. Furthermore, it can be determined that the ratio BOD_7/N before the installation agrees with the theoretical value shown in Table 2, i.e. approx. 3.7. On the other hand, the ratio is not in agreement with the later period. The ratio is 4.5-4.6 in the diagram, while the theoretical prediction yields approx. 4.2. It would be easy to trace the deviation to the use of incorrect data for the food waste composition. This could indicate that the waste contains more BOD_7 or less nitrogen than has been assumed.

[Graph: "The installation of disposers began here"]

Figure 3. Progression of the ratio of BOD_7 and nitrogen in the incoming wastewater, between 1994 and December of 1998. Moving average (15 intervals) is shown.

If the results shown in the last diagrams are combined, two conflicting indications are found. In one case (BOD_7 amounts, kg/d), the effect of the disposers cannot be confirmed. The second parameter (the ratio BOD_7/N) shows that the effect of the disposers has been greater than what would be expected from a theoretical projection. As we are unable to confirm an increase in the incoming BOD amount, it can be concluded that a constant BOD_7 amount in the incoming wastewater, in combination with a reduced amount of incoming nitrogen, would cause this result. One explanation of this phenomenon would be that denitrification takes place in the sewage system.

To confirm whether anything unexpected happens to the BOD_7 and nitrogen content of the wastewater, a comparison has been made with the incoming phosphorous amount. Certainly, a tendency toward an increased influx of phosphorous is evident during 1998, but it must at the same time be kept in mind that historically the influx of phosphorous has varied considerably more than the 4.5 percent increase we expect here.

6.3 Screened Matter and Sand

The screened matter from the cleaning screen is collected in a container and a value for the produced amount is obtained from the weighing performed when it is hauled away. It can be assumed that the weighing of the screened matter does not provide an exact picture of the production. The water content and organic content are examples of parameters that more than likely vary from time to time. These parameters in particular should also be affected by whether the wastewater contains any food waste or not. Since no reference data exists for "normal" screened matter, no study of the screened matter properties has been conducted for the case at hand. Even if reference data from other treatment plants exists, it is doubtful it could be used in this study, due to the variation in the screened matter quality for different plants.

In the current study, we have therefore focused on observing the amounts of screened matter. Figure 4 shows the weighed amounts of screened matter removed from Haga wastewater treatment plant between 1996 and 1998.

[Graph]

Figure 4. Average amounts of removed screened matter (kg/d). The respective average amounts for the period 1996-97 and the latter part of 1998 have been indicated.

It can be concluded from the graph that the amount of screened matter from Haga wastewater treatment plant has increased since the disposers were installed. The average amount for 1996-97 was 26 kg/d, while the corresponding value for the period between March and December of 1998 was 46 kg/d, an increase by 20 kg/d. If it is assumed that the increase is due to food waste getting caught in the screen and, somewhat simplified, that the specific weight of the waste in the screened matter is the same as it is in the kitchen, barely 4 percent of the incoming waste gets caught in the screens. Even if the assumption contains large errors, it can be concluded that a lesser portion of the waste in the wastewater is caught in the screens.

That a small amount of food waste is caught in the screens is in itself not surprising due to the fact that relatively large particles may leave the disposer (refer to Section 3.1). (A general theory of sorting at source claims that the food waste in some households is flushed down the toilet to reduce cost. However, there is nothing indicating that this kind of abuse would have increased in Surahammar after the new sorting at source systems were introduced.)

If a fine-meshed cleaning screen is used as the first treatment stage, it could then be expected that more screened matter is produced because of the increased use of food waste disposers – and thereby also an increase in the handling cost (removal and landfill). The increased amount in this case, 20 kg/d, corresponds to over 7 tons annually. This effect can be reduced if some of the screened matter is let through by running the screens at shorter delay time intervals between cleanings.

Using a coarser screen could be another solution. Both methods run contrary to the prevailing ones. One method for reducing the negative effects from an increased amount of screen matter is to extract the energy content from the organic matter before the final disposal of the screened matter.

Regarding the quality of sand from the sand trap, the service personnel have noticed no changes compared with before.

6.4 Effects Within the Wastewater treatment plant

Approximately 50 percent of the incoming BOD_7 is separated inside the wastewater treatment plant before the biological stage. Even though the load on the primary sedimentation stage is relatively low (surface load: 1.67 m^3/m^2,h at the designed flow rate), this must be regarded as a rather high separation rate compared to what has been measured at plants with a similar design and load (systems where all the surplus sludge is extracted in the primary sedimentation stage). (Unfortunately, reference data from Haga wastewater treatment plant prior to the disposer installations does not exist.) If this assumption were correct, it would then be easy to explain a high BOD_7 separation level in the primary sedimentation stage by claiming that food waste particles are efficiently sedimented. However, what may not be determined is how much of the food waste is separated in the primary sedimentation stage, and how much continues into the treatment plant in dissolved form. An interpretation of the study performed by Nilsson et al. indicates that approx. 75 percent of the measured food waste BOD_7 would be in the form of particles, and 25 percent in dissolved form. Figure 5 shows the separation prior to the biological stage.

The effects on the biological treatment stage can be estimated only from collected data. The oxygen for the tanks is supplied by large aerators and turbo compressors. The turbo compressors are controlled by oxygen meters in the tanks, at a predetermined set point. It is therefore not possible to extract a load change from the oxygen level measurements alone. However, the power consumption of the turbo compressors can be used in detecting changes in the performed aeration work. Since the service personnel have not been able to measure any changes in the power consumption, it would seem that food waste does not affect the biological step to any greater extent. Assuming that food waste really does enter the treatment plant, this could happen if food waste is separated mainly in the primary sedimentation.

[Graph:]

Incoming

After primary sedimentation

Figure 5. BOD amounts in the incoming wastewater and after the primary sedimentation (prior to the biological step), respectively.

It documented that the increased electrical energy level required to decompose food waste in a biological stage, mainly corresponds to the increase in energy that can be extracted from the digestion tank (Mortensson, 1996). However, the information is based on conditions in Denmark, and even if it has not been stated explicitly, it is probable that those conditions are valid for the case when no sedimentation takes place prior to the aerobic treatment stage. Otherwise, a factor such as the age of the sludge in the biological step could be crucial to the energy result. Low sludge ages is prerequisite to a higher gas extraction, and at the same time a lowered aeration energy consumption.

During the course of the study, we have also been unable to detect any significant increase in the phosphorous content of the incoming wastewater. Therefore, no need has been perceived to increase the precipitation chemical dosage at Haga wastewater treatment plant. For precipitation chemicals, it has been recommended to use pre-precipitation in connection to waste disposer use. The advantage to this is that the pre-precipitation gives rise to a more efficient BOD separation prior to the biological stage, which in all likelihood should have a positive effect on the energy balance of the treatment plant (reduced aeration demand, increased gas production).

6.5 Sludge

A central question concerning the use of waste disposers is how much of the waste can be transferred to the digestion stage to be transformed into biogas. We have been able to conclude that the amount of screen matter increases, but that theoretically only a smaller portion should be separated there. Despite the fact that both primary sludge and bio/chemical sludge is extracted from the primary sedimentation, the changes in the amounts due to the food waste are not large enough so that the service personnel at Haga wastewater treatment plant have been able to notice any difference in the operation.

Separated sludge is pumped in the treatment plant to a conventional sedimentation thickener, which has operated normally during 1998.

The samples collected from digested sludge have shown no deviations when analyzed (except for metals) compared to samples from prior reference years. The sludge metal content has decreased noticeably during the past year. The most important reason behind this is that new condensation water purification equipment has been installed at the thermal plant. The remodeling has in part taken place parallel to the installation of disposers. The detected reduction in metal content should therefore be attributed to this effort, and not the food waste disposers.

According to the Waste Management Research Unit at Griffith University (1994), the amount of sludge can be expected to increase by 4 percent at a connection level of 25 percent. Similar figures are presented by de Koning & van der Graaf, 1996. If we assume that also the dewatered sludge increases by 4 percent, it would mean that the annual amount of sludge removed from Haga wastewater treatment plant would increase from 570 m^3/year to approx. 590 m^3/year.

6.6 Digestion and Gas Production

The gas production is measured continuously by a gas flow meter which measures all the gas produced. (The gas motor is measured separately, the gas boiler consumption is not measured.) The variation in the gas production is relatively high, and when compared to historical data it can be concluded that similar variations are normally occurring during the year. For example, an annually recurring "summer dip" can be clearly seen.

When studying the figures for gas production, one must take into consideration periods of change in the operation of the digestion plant because of digestion tests. The last time operations were altered was during the spring of 1998 when digestion tank 2 was not running at maximum potential due to by-passing (flow through the bottom valve). The digestion plant was put into full operation again during August-September, which is why the entire first portion of 1998 yields uncertain and above all lower gas production values. The complete picture for the 1994-1998 gas production is presented in Figure 6.

[Graph]

Figure 6. Gas production for the period between January of 1995 and December of 1998. A moving average (50 intervals) and a trend line shown.

It is obvious that an increase in the gas production can be seen during the latter part of 1998. In order to confirm that this is a lasting trend, it will be necessary to follow the development over a longer time. Since there are recurrent variations during the year, it is important that comparisons are made with the corresponding periods for different years. The average gas production is therefore presented in Table 9 for the months of September-December of 1995, 1996, 1997 and 1998.

Table 9. Average gas production for September-December of 1995, 1996, 1997 and 1998.

Year	Average Sep.-Dec.	
1995	327	m^3/d
1996	365	m^3/d
1997	301	m^3/d
1998	417	m^3/d

The above view also indicates a pronounced increase in gas production. A comparison between the current period in 1998 and the average periods of 1995 and 1997 shows that the increase is relatively large. However, it is questionable whether 1997 would be a relevant year because of the digestion tests that were performed. But, even if we limit ourselves to the 1995-1996 period and compare this to 1998, an approximate 70 m^3/d increase in the production is obtained on average.

At a methane content of 65 percent, the increased amount of gas corresponds roughly to an annual energy of 160,000 kWh.

A comparison with the biogas potential of the food waste shows that the result is of the correct magnitude. For direct digestion of a corresponding amount of food waste in a digestion tank, the energy efficiency is 180,000-210,000 kWh/year at a specific gas production of 600-700 liters of biogas per kg of incoming dry substance (VS). The difference between the various production figures can be best explained by decomposition and separation of organic material taking place in different sub-processes prior to the digestion.

Aside from the introduction of food waste disposers, nothing in the operation of the wastewater treatment plant has been found to explain such a pronounced increase in gas production. The service personnel have reported that the "down"- times, digestion tank temperatures, sludge pumping routines and other relevant operating parameters remain the same.

6.7 Outgoing Wastewater – Quality

One negative effect the use of waste disposers could result in an increased output of nutritive salts to the recipient. With such a small load increase as in the case of Surahammar, the risks associated with increased emissions should be low. One reason for this is that the purification stage for the phosphorous and BOD_7 reduction within certain limits can be adjusted to maintain the reduction capacity during a load increase. However, the same nitrogen treatment potential is not available in a treatment plant lacking active nitrogen purification. If a greater part of the waste nitrogen is in particle form, it could be expected that the increase in the outgoing nitrogen amount is limited and considerably smaller than the increase in the incoming amount. This is particularly true for a treatment plant such as Haga in Surahammar, where the digested sludge is not dewatered.

The results from the analyses at Haga wastewater treatment plant confirm that the emissions of nitrogen, phosphorous and BOD_7 are largely unaffected. During 1998, the outgoing wastewater levels have remained at the same average level as during the previous years. Naturally, this result is reasonable in light of the fact that no increase in the incoming wastewater levels could be seen either. Table 10 presents the outgoing levels from Haga wastewater treatment plant.

Table 10: Contaminant levels of outgoing wastewater during 1998, compared to average values for 1995-1997.

Parameter	Average 1995-1997	Average 1998	
BOD_7	4.3	4.3	mg/l
Tot-P	0.3	0.2	mg/l
Tot-N	19	17	mg/l

6.8 Survey

Surahammar KommunalTeknik conducted a survey in August of 1998, aimed at the households who had disposers installed during 1997/1998. The survey was designed to find out what the households thought about using food waste disposers, if they had performed as intended and if the tenants were satisfied with the installation work performed by SKT. The survey was sent out to 258 house-owners (one-family households) and when the last day for replying had passed, 60 percent of the persons asked had answered.

To the question of how households considered the food waste disposer functioned practically, ninety-six percent answered “very well” or “rather well”. Every fifth person answered yes to the question if they had had any problems with the disposer. Typical problem areas are blockages in the pipes within the building, materials caught in the disposer and problems due to incorrect installation, e.g. the disposer has vibrated loose. It can be concluded that the result of the survey gave positive answer to Surahammar KommunalTeknik, regarding both the project as a whole and the actions of the company during the implementation period. Furthermore, it can be concluded that there have been problems in certain buildings, but when these problems have occurred alterations or the changes to poorly functioning piping, for example elbow bends, have rectified the problem. For more information on the function of the disposers, and the attitudes of the users, please contact Surahammar KommunalTeknik.

7 COMMENTS AND CONCLUSIONS

We have several times in this report described the problems with finding trends in the data material, showing large fluctuations also during normal operation. For the parameters nitrogen and phosphorous – for which we can already state that the load increase should be small – it is convenient to claim that the increase is obscured by normal variations. It is more peculiar that an increase in the amount of BOD_7 cannot be found in the incoming wastewater, since this theoretically should be 15 percent. Here also is an example of contradicting results as the increase in the gas production indicates an increased influx of organic matter during the period.

The increase in the ratio BOD_7/N could indicate the same thing.

It is obvious that there are weak points in the data material, as well as many possible explanations for the fact that the results and observations in some cases point in different directions. For example, one circumstance that may give rise to inadequate data is that water samples have been collected during a Tuesday/Wednesday 24-hour period. It is conceivable that the households have prepared more and larger meals during weekends – thus creating more food waste – compared to a day in the middle of the week. In such a case, the water analyses do not reflect the real load on the treatment plant. One fact which complicates this reasoning is that precisely this aspect was investigated by the week-long samples collected during the summer of 1998. Nothing was then found which indicated the described effect.

Haga wastewater treatment plant is a plant with surplus capacity. A load increase by a few percent thus does not appreciably affect the operation or the purifying performance of the plant. At plants with higher loads, a lasting increase in the BOD_7 load by 5-10 percent could make it more difficult to meet the emissions requirements. At treatment plants incorporating biological reduction of nitrogen and/or phosphorous, the added waste could be positive since it means an addition of easily degraded carbon, while at the same time the nitrogen and phosphorous contents are relatively low. However, it must not be forgotten that emissions, due to emergency overflow, could increase when food waste disposers are installed in the sewage system. This problem must be put in proportion to other problems that potentially could be solved through disposers.

The project has not included any studies of the sewage system, nor issues regarding the attitudes of the users. As we summarize the most important conclusions below, we would also like to point to some results from investigations performed by Surahammar KommunalTeknik. The following conclusions pertain to a follow-up period ending in December of 1998:

Concerning the sewage system and the use of disposers

- No interruptions of the service, congestion, or other problems with the sewage system have been detected.
- No overflow has occurred during 1998.
- A satisfactory majority of the households state that they are pleased with waste disposers as a alternative for food waste sorting at source.
- Interruption or pipe congestion has occurred in a few buildings, but most of the problems have been easy to remedied.

Concerning effects on the wastewater treatment plant

- No interruptions of the service have occurred at the wastewater treatment plant.
- An increase in the amount of screened matter was found during 1998. The increase is estimated at 4 percent of the added theoretical food waste amount.

- No increase in the amount of incoming nitrogen, phosphorous or BOD_7 has been found for certain, which may be due to many factors. However, an increase in the ratio BOD_7/N indicates that the wastewater composition has changed because of the installation of disposers.
- There is nothing to indicate that the connection of disposers affect the functioning of the biological stage; no changes in the aeration demand have been found. If food waste enters the treatment plant, this indicates that the bulk of the BOD_7 originating from the solid waste is separated in the primary sedimentation.
- The service personnel have not noticed any changes in sludge handling (extraction of surplus sludge, pumping, thickening, etc.) due to disposers.
- Since the introduction of disposers, the increase in gas production corresponds to the theoretical biogas potential of the food waste.
- The contaminant emissions from Haga wastewater treatment plant have not increased, which therefore has not prompted any changes in the operation of the plant (e.g. increased use of precipitation chemicals).
- Fluctuations in the measured data and analyzed samples, in combination with a moderate load increase, make it difficult to reach sure conclusions from a relatively short assessment period. The sampling method used probably has had a large significance on the results.
- For a study of this kind to provide any further information, the follow-up period must be considerably longer and characterize the situation during stable operating conditions.

It can however be concluded that this project with disposer has so far had no dramatic consequences for Surahammar KommunalTeknik. The food waste disposers have not affected the operation of Haga wastewater treatment plant other than in a positive direction. As was discussed earlier, there are still questions remaining on how the waste affects the various process stages. In order to learn more and reach more definite conclusions, a longer follow-up period and experimental programs directed to specific processes are needed (e.g. for the sewage system or treatment steps at the plant). In view of this, the present project should be regarded as introductory study covering wider areas of approach.

An interesting question in this context is whether Surahammar is particularly well suited to exploit the use of disposers. It is evident that Surahammar KommunalTeknik has been critical in its evaluation of various stretches of the sewage system within the municipality, and has stated that certain areas cannot use disposers. But, is the remaining sewage system then uniquely suited for the task of transporting food waste? Haga wastewater treatment plant could be viewed in the same way, and it could be questioned whether this is a special plant compared to other treatment plants in Sweden. Certainly, the treatment plant does have a certain surplus capacity, a primary sedimentation stage and a digestion tank assembly. But there is, for example, no pre-precipitation, regarded by many as a prerequisite for achieving an efficient and energy-saving operation when food waste is added to the sewage disposal system. The conclusions reached are that in Sweden we still have a limiting understanding of disposers and their effect on treatment plants.

However, what this study does show is that Haga wastewater treatment plant in Surahammar, and also plants similar to this one, is able to receive food waste via the wastewater without running the risk of crucial interruptions.

Whether food waste disposers from an environmental point of view are positive or negative instruments in the waste management is a complex issue. Waste management in general, the limitations of the sewage system, and the process design of the wastewater treatment plant, are among many issues central to an municipality concerned with questions of waste handling. In some municipalities issues such as the purity of the sewage sludge and the market demand food waste counter the possibility of marketing it, could also be decisive.

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[Logo] HAGA WASTEWATER TREATMENT PLANT – FLOWCHART

OVERFLOW PRETREATMENT CHEM./BIOL. STEP POSTPRECIPITATION STEP
CHEM. (NOT IN SERVICE)

KOLBÄCK CREEK/
BALTIC SEA
SURPLUS SLUDGE RETURN SLUDGE

FINE SCREEN SAND TRAP PRIM. SEDIMENTATION AERATION SEDIMENTATION

SLUDGE FROM VIRSBO ENSILAGE

THICKENER

BIOGAS

GAS MOTOR GAS BOILER DIGESTION TANK SLUDGE DRYING BEDS AGRICULTURAL SLUDGE
(ELECT., HEAT) (HEAT)

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