

KITCHEN DISPOSAL UNITS (KDU) IN STOCKHOLM

Stockholm Water's pre-study on the preconditions, options and consequences of introducing KBU in households in Stockholm.

May 2008

To connect a kitchen disposal unit (KDU) in a household to the public sewerage system in Stockholm, according to the Act on Public Water Services and Stockholm Water's local water and sewerage regulations, requires a special permit. Up to now, Stockholm Water has had a very restrictive position on the connection of KDUs.

The current report shows, within some areas of Stockholm, that there are the preconditions for allowing more KDUs. Increased connection of KDUs, however, requires the creation of a control and follow-up system as well as a review of the current tariff system.

The decision on how KDU connections in Stockholm are managed is taken by the company's management. Therefore, this report is only to be considered as a part of the information on which the decision is based.

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SUMMARY

The study was carried out by Stockholm Water to determine the preconditions for, and to establish the company's position to, the options for installing kitchen disposal units (KDU) in households¹ within the company's area of operations - Stockholm and Huddinge.

The study concerns Stockholm Water's area of operations, which cover both Stockholm City and Huddinge municipality, but as a simplification only the word "Stockholm" is used from now in this report.

In the evaluation are included assessments of the effects on the sewer system and sewage treatment plant, as well as an estimate of the market interest and the connection density.

The study has concluded that KDUs can be installed and connected to the sewer system in Stockholm. However, some areas have been found to be unsuitable for KDUs. It is the condition and status of the local sewer system that is decisive for whether or not KDUs can be installed. Therefore, Stockholm Water's approval will be required before the installation of every KDU within the company's area of operations.

The affect of KDUs on the water/sewerage system, in general, depends on how great the connection density will be i.e. how many, from all the households in Stockholm, install a KDU.

The study deems that the interest from households to install a KDU in Stockholm will be moderate. The primary motive for installation will be ease, to raise the standard of the kitchen, simpler waste management and to reduce the risk for smells. A KDU, however, implies an extra cost for the household's waste management. The costs are estimated roughly as ca. 3,000-5,000 SEK for purchase/installation and connection fee. In addition, there is also an annual fee. The connection density in Stockholm, therefore, is estimated by the study to be ca. 0.5-1% per year. Thus, in 10 years' time 5-10% of all households may be connected, i.e. there will be ca. 20,000 - 40,000 KDUs in Stockholm.

The affect on the water/sewerage system will be very limited at this connection density. This applies for both the negative effects such as, for example, increased load of organic material and increased sludge production and for the positive, such as increased biogas production. In both cases, it is a question of a difference of a few percent, which can be related to KDUs.

With these results as a basis, the study recommends that Stockholm Water's, up to now, very restrictive approach to the installation of KDUs be revised. If the company decides to take a more open approach to KDUs, resources should be assigned, at the same time, to build up and develop this new area of operations.

Waste management in Stockholm is part of the area of responsibility for the Traffic Administration/Department of Waste Management (Trafikkontorets/Avdelning för avfall - TKa). Therefore, the use of KDUs in Stockholm must be regulated in the City's waste collection and disposal regulations.

¹ Note! The study only considers KDUs in households (houses and apartments) that can be directly connected to the sewers. Disposal units in restaurants/food shops must not be directly connected to the sewer system, but instead must be connected to an enclosed tank.

PREFACE

"Kitchen disposal units (KDU) in Stockholm" is the final report on Stockholm Water's study on the preconditions, options and consequences of introducing KDUs in the company's area of operations.

The study has been financed by the so-called "Environmental Billion" fund; an environmental investment financed by Stockholm City, and constitutes a complement to Stockholm Water's previous work on collection and biological treatment of food waste in Stockholm.

The study has been performed by a project group, which has been composed of the following people: Marta Tendaj – main project leader as well as sub-project leader for Market. Åsa Snith and Mathias von Scherling – responsible for sub-project Sewer System with Åsa as the sub-project leader. Daniel Hellström and Agnes Mossakowska – responsible for the sub-project Sewage Treatment Plant with Daniel as the sub-project leader. Daina Millers-Dalsjö from SWECO VIAK has provided consultant support to the project. The steering group consisted of Åke Jonsson, Lennart Berglund and Lars-Gunnar Reinius - Heads of Department for Market, Sewer System and Sewerage respectively.

Section 4 of this report, "KDUs and Sewer System" constitutes a report from the sub-project Sewer System, and was written by those responsible for the sub-project.

Section 5, "KDU and Sewage Treatment Plant", constitutes a report from the sub-project Sewage Treatment Plant, and was written by those responsible for the sub-project.

The other sections have been written by the main project leader and the consultant.

1 INTRODUCTION

Background: Why has the KDU question once again become current?

Stockholm Water is the region's largest producer of biogas for vehicles, and there is a desire to increase the production of biogas, which requires more organic-material arriving at the digester.

According to one of Sweden's national environmental goals, at least 35% (by weight) of food waste from households, restaurant, institutional kitchens and shops shall be recycled by biological treatment by 2010.

Stockholm Water, together with the Waste Collection and Disposal Administration (now the Traffic Administration/Department of Waste Management - TKa), has been commissioned by the City to determine how this goal can be achieved in Stockholm. The work has been financed by the "Environmental Billion" and was reported in February 2006². The proposed system assumes that solid food waste from households is collected in a separate container and transported to a central pre-treatment plant. Thereafter, the waste is shredded, diluted with water and transported by tanker to the digestion stage at the sewage treatment plant.

During the work on this project, KDUs have once again attracted attention as a possible complement to the collection of some sorted food waste in Stockholm. The system with KDUs does not require road transport since the food waste is transported together with wastewater by the sewer system. Therefore, Stockholm Water decided to carry out a general study on the preconditions and options for introducing KDUs in Stockholm as well as to assess what effects such a system would have on Stockholm Water's operations - sewer system, sewage treatment plant and biogas production. This study was also financed by Stockholm City through the Environmental Billion fund.

Purpose: Stockholm Water wants to establish its position on KDUs.

The purpose of this study, based on the current preconditions, is to develop and establish Stockholm Water's approach to the eventual introduction of KDUs in Stockholm.

The objective is to determine the advantages and disadvantages of KDUs, as seen from Stockholm Water's perspective.

The final report will be used to provide a basis for the company to determine its position on the preconditions, options and limitation of KDU installations in Stockholm.

Limitations: Only KDUs in households that are directly connected to the sewerage system.

There are a number of different applications and system solutions for disposal units. These are described in broad outline in Appendix 1.

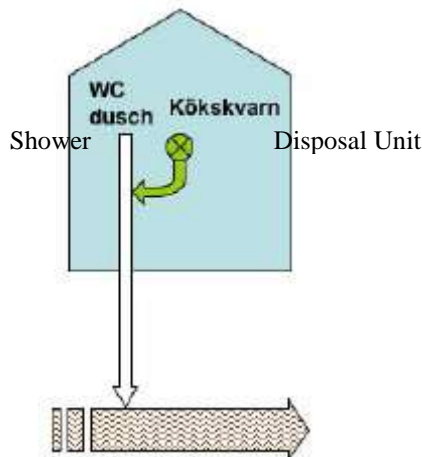
In general, all KDU systems can be divided into two main groups. In the first, the shredded food waste is introduced (directly or indirectly) to the sewer system, is transported by the sewers to the inlet to the sewage treatment plant and is treated there together with the wastewater. In the second, the shredded food waste is collected in a separate tank and transported by road directly to the digestion process at the sewage treatment plant.

This study only covers the system with domestic KDU as shown in Picture 1 on the next page.

The KDU is installed directly in the household's kitchen (in houses or apartments in apartment blocks) and connected directly to the sewer system. All food waste, shredded in the kitchen, will enter Stockholm Water's public sewer system, via the buildings drainpipe, and then be transported further, via the sewer system, to the sewage treatment plant.

NOTE! Disposal units in restaurants, institutional kitchens and food shops are not allowed to be connected directly to the sewers, but instead must be always connected to a tank or a separator, after approval from Stockholm Water.

² "Collection and biological treatment of food waste in Stockholm" dated 2006-02-28

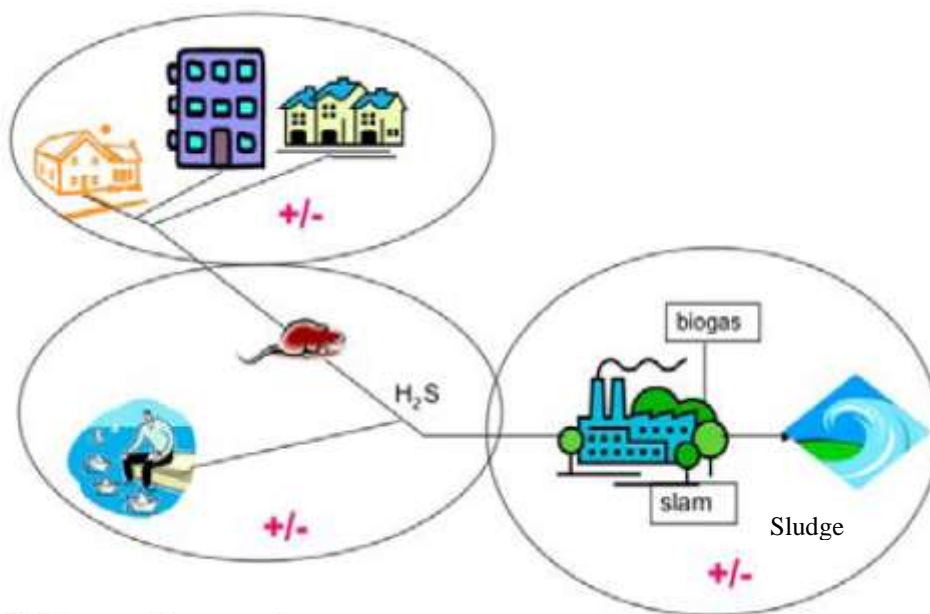


Picture 1 KDU in households

Method: Assessment based on the sewerage system, sewage treatment plant and the market.

Stockholm Water's assessment of the preconditions, options and consequences of the introduction of KDUs in Stockholm is based on three perspectives, namely, the sewer system, the sewage treatment plant and the market. See Picture 2 below.

Waste Disposal Units in Stockholm?



Picture 2. KDUs from three different perspectives

The work was carried out in the form of a single project with three sub-projects, which were responsible for their specific area. Each sub-project generated information on which to base the assessment of the consequences that the introduction of KDUs in Stockholm can be expected to give rise to within the respective areas. These assessments, thereafter, have been weighed together to constitute the basis for Stockholm Water's common position on the introduction of KDUs in Stockholm.

The study has been performed from the perspective of Stockholm Water, and thus does not constitute any evaluation on the questions of total environmental affect and national economy of KDUs.

The study's work has been based on literature studies and interviews, calculations and models as well as a study visit to Surahammar.

The structure of the report

The report consists of eight chapters. In the appendices, 1 - 9, can be found information that is more detailed.

Chapter 1 "Introduction" describes the study's background, objectives, purpose, limitations and the report's structure.

Chapter 2 "General Section" presents a summary of KDU use in Sweden and worldwide, contains technical data and information on the regulatory framework.

Chapter 3 "Stockholm City Today" contains a short description of the management of household waste and the water/sewerage system in Stockholm. **Chapter 4** "KDUs and Sewer System" constitutes the report from the sub-project Sewer System and describes the sub-projects methods for the study and the results and assessment of KDUs from the perspective of the sewer system.

Chapter 5 "KDUs and Sewage Treatment Plant" constitutes the report from the sub-project Sewage Treatment Plant and describes the sub-projects methods for the study and the results and assessment of KDUs' effects on the sewage treatment plant.

Chapter 6 "Market" contains the overall assessment of the KDU effects on the water/sewerage system as well as an estimate of the market potential.

Chapter 7 "Conclusions" - summarises the study's most important conclusions

Chapter 8 "Recommendations" - gives proposals for decisions and continued development

Appendices 1-9

2 GENERAL SECTION

KDU before and now, in the world and in Sweden

The KDU was launched in the USA during the 1930s as a hygienic way of dealing with food waste. At present, ca. 50% of all households in the USA have waste disposal units in the kitchen. For a period, New York City had a ban on KDUs connected to the sewer system, but this was repealed after a 21-month study, at the start of this century.

The EU Commission, in a letter dated 11/6/2003, to the Vestfjordens Avlopssllskap in Norway, has pointed out that the Commission does not intend to ban KDUs, instead, on this issue, it is for every Member Country to decide on the rules.

One of the largest KDU manufacturers is In-Sink-Erator (sold by Disperator in Sweden), which sells ca. 6 million disposal units per year in the USA and ca. 150,000 disposal units per year in Europe, whereof half in Great Britain. Other KDUs are sold in Italy, Spain, Denmark, Norway, Poland and Russia. The European sales increase by about 20% annually. In Norway, ca. 35,000 KDUs have been installed since 1999 (Aquateam, Report 05-079.) In Great Britain, it is stated that ca 6% of households have KDUs. Worcestershire County Council (includes Herefordshire and Worcestershire, total ca 740,000 inhabitants) has set a goal, for the expansion in KDU usage, of 50% of households. The reason for this is to reduce the landfill of easily decomposable waste, in accordance with the EU's directive on waste landfill.

In Sweden, KDUs have been recently installed in Malmö (60 apartments in Bo01, 2001, and 147 apartments in Turning Torso, 2005) as well as in Göteborg (130 apartments in Skogaberg, 2005). In Malmö, the shredded food waste is led to a sludge and fat separator, where organic material is separated for road transport to the digestion chamber, and excess fluid is led to the normal water/sewerage system, where it is mixed with municipal wastewater. In Skogaberg, the blackwater is mixed with the disposal unit's output and led, in a separate system, to a local treatment plant.

KDUs that are directly connected to the sewer system can be found in Surahammar's municipality (nearly 2,000 disposal units, the number increases as more and more apartment blocks have their main drainpipes renovated), Smedjebacken (ca. 600 disposal units), Kalmar (ca. 150 continuously fed disposal units), Bokenäs in Bohuslän (ca. 100 disposal units for the own waste plant mixed with blackwater), Nässjö as well as Staffanstorps municipality, where ca. 50 disposal units are still in operation of the original 100 that were installed 20 years ago.

In Appendix 1 can be found updated information on new studies and in Appendix 3 can be found system solutions from a number of locations in Sweden where KDUs are in use.

Technical information on KDU

Vendors in Sweden

Disperator sells American In-Sink-Erators (ISE) KDUs for households and their own manufacture for institutional kitchens. Avfallskvarn AB sells Chinese Jegon. In addition, Waste King can be found in Sweden.

Installation

KDUs are connected below the sink to the kitchen drain and the outlet is connected to the water seal in the normal way. The sink unit must be securely fastened in place, to avoid vibrations from the KDU. Electrical connection is made to a normal 220/230 V socket. In Sweden, there is information that the dishwasher should be connected to the KDU for extra cleaning. The manufacturers recommend that hot water be not run through the disposal unit to avoid damaging the seals and to ensure that fat, which has collected in the unit, does not dissolve and thereafter solidify in the pipes.

Function

KDUs shred the waste into small bits, which thereafter pass a slotted disc (4 - 5 mm in diameter) out in to the drain. The KDU performance depends on the design of the shredding chamber and the shredder ring, rotational speed (1,400-2,700 rpm) and motor power (varies from 0.25 - 0.75 kW, in Sweden normally 0.5 kW for domestic disposal units) as well as on whether the KDU can reverse. High motor power is required to cope with hard and tough waste. A KDU does not have blades that need sharpening.

KDUs that are batch fed are started with a cover in place, which reduces the risk for accidents when the KDU is run. Continuously fed KDUs are started with a manual switch and are mostly used in institutional kitchens where there are large volumes of food waste. Both types exist in Sweden.



Picture 3. InSinkErator disposal unit in cross-section and installed under a sink.³

What can be shredded?

What can KDUs shred? It depends on the KDUs design and motor power, and varies between different models. The vendor specifies for each model what the KDU can manage. Food waste and preparation waste, coffee filters, meat, vegetables, potato peel, eggshell, prawn shells and such like are OK. The disposal units are designed for waste sorting - since it is not wanted to have cloth, wood and metal in the drain, so food waste that similar to these cannot be shredded. In a standard KDU, it is not possible to shred hard meat bones, mussel shells, tough and long materials such as fish skin and sinews, dough or large quantities of fat.

The flushing water for the disposal unit should be cold. It is stated that hot water can damage the disposal unit's seals.

In Appendix 3, further instructions on sorting waste food for KDUs can be found.

How fine is the waste shredded?

The disposal unit's slotted disc determines how fine the waste can be shredded. The holes are about 4 - 5 mm.

In Malmö, the regulations state that, in apartments there shall be sludge and fat separators after the disposal unit. In order to separate the food waste it must not be shredded too much. The current solution with the LPS unit's disposal units, which shred the waste a second time, means that the all too finely dispersed material does not settle in the tank, but instead enters the sewer system.

How finely shall the waste be shredded if it is separated, or not separated, locally before it is led to the water/sewerage system? The disposal units are developed for connection to the sewer system, therefore it can be assumed that the diameter of the holes is suitable for this application. The design of other applications that involve other aims than that of the shredded waste ending up in the sewage treatment plant may need to be studied more closely.

Electricity and water consumption

Electricity consumption can be estimated at 5 - 6 kWh per household annually, if the operating time is a couple of minutes per day, for a 500 W motor.

³ Source: The picture is supplied by InSinkErator

Water consumption, to flush the disposal unit until it is empty, is estimated at 3 - 6 l/household per day (equivalent to flushing the toilet). The handling of the disposal unit determines the water consumption.

Sound and smell

The noise level varies with the model. In Staffanstorps, during installation in the 90s, 50-55 dB was measured with single peaks of 70 dB during use. This can be related to a dishwasher that gives 57 dB and a vacuum cleaner that exceeds 70 dB. The worst sound arises when large pieces must be disintegrated, e.g. a whole apple. If the apple is cut into a couple of pieces, it makes less noise and is finished sooner.

If the disposal unit smells musty, e.g. if too little water is used and the disposal unit is not run until it is clean, lemon peel can be run in the unit to freshen it up in an environmentally friendly way (InSinkErator). The smell from rubbish bags is reduced, since wet food waste is no longer stored under the sink.

Regulatory Framework and Responsibility

Extracts from the legislation, see Appendix 2.

Legislation and Ordinances

The municipalities' and property owners' entitlements and liabilities concerning the public water and sewerage services are regulated by the Act (2006:412) on Public Water Services.

Local water/sewerage regulations (public ordinances) for each municipality can be found in ABVA. In ABVA, there shall be ordinances for whether, and in which case, how KDUs can be connected to the municipal water/sewerage system, preferably with references to the municipalities ordinances on waste collection and disposal, where it is set forth how waste food may be handled. In connection with the new water services act, all municipalities will need to examine the relevant ABVA. In those municipalities where there are KDUs, clarification may be needed.

The handling of waste is regulated in the *Environmental Code (1998:808) Chapter 15*.

Food waste that arises in households, restaurants, institutional kitchens and the retail trade are included in the municipalities' responsibilities for waste collection and disposal. In addition, fluid waste such as septic sludge, fat separator sludge and latrines also come under the municipalities' responsibility for waste collection and disposal. How this will be managed is determined by the municipality's waste collection and disposal ordinance (RO, local by-laws) that are adopted by the municipal council. Where the municipality intends to sort out the food waste for biological treatment via KDU, this should be set forth in the RO.

To clarify the boundaries for the responsibilities between sewerage and waste, the regulations for KDUs should be coordinated between ABVA and the waste collection and disposal ordinances. RO regulates how food waste shall be handled; ABVA sets the conditions for the technical connection.

Responsibility boundaries for water/sewerage and waste

The property owner is often, but not always, the contracting party with the principals for water/sewerage and waste collection and disposal. In Surahammar, the municipality has inspected the service as well as the property's main drains, before granting permission for the installation of KDUs.

In many municipalities that have shown an interest for KDUs, the sewerage and waste management lie under the same principal. Customer registers and customer services can then be in common, and the customer receives a specified bill for water/sewerage as well as waste collection and disposal. In Stockholm city, the responsibilities for waste and sewerage management are divided.

Connection point - collection point

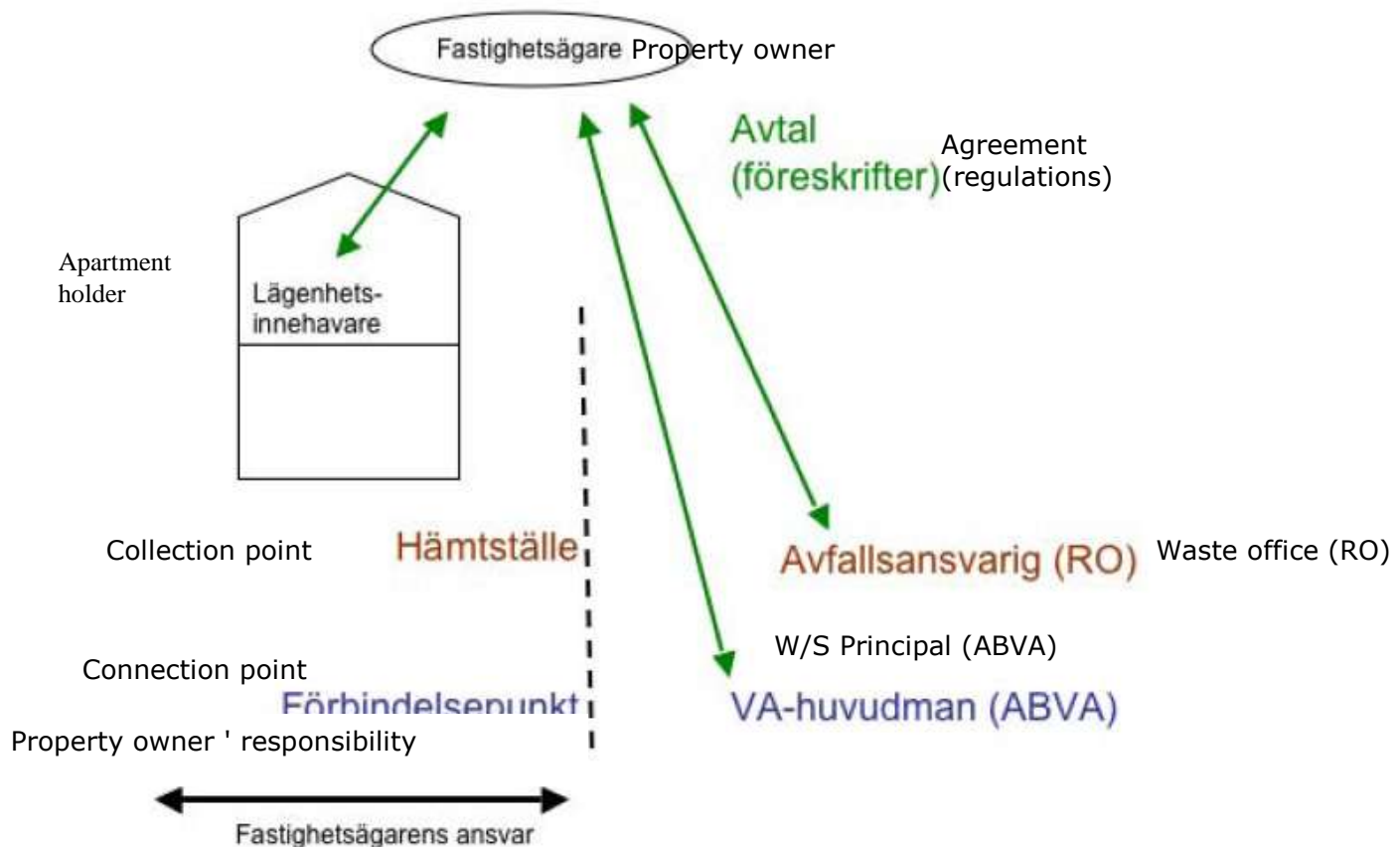
There is a similar boundary for waste and for water/sewerage to the property owner. Each property is connected to the water/sewerage system via a connection point, which clearly marks the boundary between the property owner and the water/sewerage principal. Generally, waste disposal units, sludge separators etc belong to the property. However, the principal can demand to inspect all connections that may affect the sewers pursuant to the Act on Water Services, § 41.

For waste management, this point corresponds to the collection point (e.g. waste room, connection point for sludge suction, location for rubbish bins are arranged by the property owner according to instructions from the waste collection and disposal office). In Stockholm, the property owner or the customer owns and maintains all the equipment in the waste room.

When does food waste become sewage?

When the shredded food waste is mixed with other wastewater, it is classified as sewage, for hygienic reasons. Shredded food waste that is not mixed with other wastewater and is collected in a tank is a waste (compare with latrine barrels).

In the picture below, the responsibility boundaries, concerning KDUs, are shown.



Picture 4. Responsibility boundaries concerning KDUs.

Apartment holder - property owner

Within the property, there is a responsibility boundary between the holder of the apartment and the property owner. The property owner often issues restrictions or grants permission for certain types of technical installations that concern ventilation and drains.

Where an individual apartment wishes to install a disposal unit, this should require the approval of the property owner, since the drainpipes in the property must be in good condition and these are the responsibility of the property owner. Since the property owner, in the normal case, is the water/sewerage customer, it can be hoped that the application for the disposal unit also reaches the water/sewerage principal, who gives an answer and can charge a fee for the connection of the disposal unit.

3 STOCKHOLM CITY TODAY

Management of household waste

The household waste, including food and institutional kitchen waste, in Stockholm City is covered by the municipality's responsibility for waste collection and disposal that is cared for by the Traffic Administration, Department of Waste Management, TKa (formerly the Waste Collection and Disposal Administration). At a meeting, 01-02-2007, with Nils Lundkvist, Anita Tärnström, Jonas Engström and Monika Visser of the Department of Waste Management, KDUs were discussed as a possible complement in the collection of food waste in Stockholm, the responsibility boundaries between water/sewerage and waste, tariffs, coordination of customer details and the use of existing installations.

Quantity of food waste

According to the current waste plan, 18,000 tons of food waste* will be collected in Stockholm and treated biologically in the year 2012.

The Department of Waste Management confirm the quantity estimate in the Waste Collection and Disposal Administration's report "Pre-treatment of food waste from households and restaurants", dated 17-02-2006. As a comparison, the real quantities that were collected in 2006 and 2007 are also shown separately.

Waste source	Theoretical quantity (ton)	Biological treatment (ton) Objective 2010	Collected quantity of sorted food waste 2006 (ton)	Collected quantity of sorted food waste 2007 (ton)
Single-family housing	10 000	4 000		
Blocks of flats	50 000	10 000	140	300
Restaurants	30 000	15 000	1 600	2 300
Food stores	6 000	4 000	1 100	1 100
Total	96 000	33 000	2 840	3 700

Source: Waste collection & disposal, TKa

As can be seen, the collection of sorted food waste in Stockholm is very limited.

Current collection system

Households in Stockholm sort their food waste into cornstarch bags and these are collected, via bins, mobile or stationary refuse vacuum pipe. Food waste from households is composted at SRV Återvinning (Recycling) AB in Huddinge. Food waste from institutional kitchens is mainly collected in a bin and is then pre-treated, to give pumpable slurry, and digested by Ecoferm - a subsidiary of SRV Återvinning AB.

TKa, with finance from the Environmental Billion, has also initiated a project to collect pumpable food waste from restaurants and schools. Included in the project is the installation of some 15 institutional kitchen waste disposal units, which will be connected to a separate tank where the shredded food waste will be collected. The food waste slurry is then transported, by road tanker, for digestion in Stockholm Water's plant in Henriksdal.

The purpose of this project is to create reference units for various vendors of kitchen waste disposal units with enclosed tank and with various sizes of disposal units. The purpose is to stimulate other restaurants/food shops and schools to install such equipment themselves. The quantity of pumpable food waste that comes from the disposal units in this project is estimated as up to 1,000 ton/year.

*Included in this is 35% of food waste from restaurants, shops and institutional kitchens (ca. 12,000 ton) as well as 10% of food waste from households (ca. 6,000 ton).

KDU as a part of the collection system

The installation of KDUs in households should be able of constituting a minor complement to the separate collection of food waste in Stockholm. If, on a time scale of 10 years, ca. 5 - 10% of all households (houses and apartments) would install a KDU in their dwellings ca 3,000 - 6,000 ton/year food waste could be collected directly via the sewer system, which corresponds to 9 - 18% of the objective.

However, it is uncertain if food waste that is shredded in KDUs and treated in the sewage treatment plant can be counted in this objective. The reply from the Swedish Environmental Agency to the Waste Cycle Office in Göteborg, dated 10-04-2006, runs as follows: "If sorted food waste is mixed with other waste, for example in the sewer system, in our judgement it should no longer be considered as sorted. Therefore, food waste that is mixed with other waste, for treatment in the sewage treatment plant, should not be counted in the objective for the recycling of food waste".

The above interpretation implies that food waste collected via KDUs cannot be reckoned in the 35% goal.

Quantity of food waste per person

In 2005, the city had ca. 771,000 inhabitants, which gives a key figure, according to the above, of ca. 78 kg as the theoretical quantity of food waste per person per year from households. If restaurants and food shops are removed, the quantity becomes 125 kg per capita per year.

At the meeting, TKa stated a key figure for sorted food waste of 0.8 - 1 kg food waste per person per week, which should give ca. 40 - 52 kg per person per year. If half of the inhabitants sort out 40 kg food waste/year, it gives over 15,000 tons of food waste/year.

For the calculations in Chapter 5 "KDU and Sewage Treatment Plant", the value of 54 kg food waste/person per year is assumed.

Stockholm City's water/sewerage system

Stockholm Water has the responsibility for the production and distribution of drinking water and the collection and treatment of wastewater in Stockholm and Huddinge.

Drinking water is produced at two waterworks - Norsborg and Lovö - and, in addition to Stockholm and Huddinge, is also supplied to a number of neighbouring municipalities. Wastewater from Stockholm, Huddinge and some neighbouring municipalities is purified in two sewage treatment plants - Bromma and Henriksdal. Part of the wastewater from Stockholm's area of operations is purified by Syvab at the Himmerfjärd's works.

Stockholm Water's sewage system (in Stockholm and Huddinge) consists of ca. 3,000 kilometres of pipes and ca. 200 pumping stations. Most of the pipes are made of concrete, and a smaller proportion of PVC, cast iron and other materials.

Henriksdal, Stockholm Water's largest sewage treatment plant, accepts wastewater from ca. 700,000 people, while the sewage treatment plant in Bromma purifies that waste from ca. 300,000 people. Annually these two sewage treatment plants treat ca. 135 million m³ wastewater. The purification process is similar at both of these plants and includes grills (3 mm gap width), sand capture, pre-sedimentation, and precipitation with iron sulphate, biological treatment according to the active sludge principle, with nitrification and pre-denitrification as well as filtration as the final step.

More detailed process diagrams for Bromma and Henriksdal can be found in Chapter 5 (Pictures 14 and 15). "KDU and Sewage Treatment Plant".

Sludge from the purification processes is stabilized by digestion and is dewatered. Ca. 75,000 ton of dewatered sludge is produced annually. The main part of the sludge is used for land restoration in Boliden's mining area in Aitik. A smaller proportion of the sludge, which is included in the ReVaQ project⁴, has been spread, during 2006, on arable land and a part has been used for the final cover of a rubbish tip.

Stockholm Water's biogas production at Henriksdal and Bromma amounts to ca. 13 million m³ raw gas per year. Biogas is used today for the production of vehicle fuel as well as the production of electricity and heat. In a few years time, all the biogas will be used as vehicle fuel.

⁴ReVaQ (Ren växnärning från avlopp) [Pure plant fertilizer from waste] is a cooperative project between LRF; foodstuffs industries, environmental movements, consumers, trade and a number of treatment plants, including Bromma.

There are today 39 KDUs connected to the sewage system that are registered with Stockholm Water (see Chapter 4 "KDU and the Sewage System").

Fat, in the wastewater from restaurants, institutional kitchens and food outlets, can solidify in the sewage pipes and, therefore, is removed in the fat separator. The separated fat sludge is collected by a sludge vehicle and transported for digestion at the sewage treatment plant. Stockholm Water has 2,600 fat separators in its customer register.

4 KDU AND THE SEWER SYSTEM

Introduction

The aim of the sub-project Sewage System is to investigate the consequences that follow from the introduction of KDUs, from the perspective of the sewage system.

The following questions must be answered to meet the most common worries concerning KDUs

1. How many will acquire a KDU
2. Is there an increased risk for sedimentation in the sewage system?
3. Is there an increased risk for blockages, which can lead to flooding and overflowing?
4. Is there a risk that the organic material creates an increased rat problem?
5. Is there an increased risk for hydrogen sulphide formation due to the oxygen deficiency arising from decomposition of the organic material in the sewage system?
6. In the event where an increased quantity of organic material is wanted, on the grounds of biogas extraction or carbon source for the purification process at the plant - is there a risk that the materials decompose before reaching the plant?
7. Does the water consumption increase?
8. Does it play any role what type of sewage system one has, e.g. combined or separate system?

There should also be studies of which areas are suitable/unsuitable for the introduction of KDUs.

The study is limited to Stockholm Water's sewers up to the connection point to the properties. That is to say, it does not investigate any problems that can arise within a property.

The investigation builds on a literature study and a survey of the preconditions in Stockholm as well as contacts with staff, with operational responsibilities, within Stockholm Water.

Literature study

Expected connection density for kitchen disposal units

In the USA, there are KDUs in 49 per cent of all households that are connected to the municipal sewage system. How large the connection density for KDUs would be in Stockholm depends on the way disposal units are introduced - active campaign or just the repeal of an earlier ban.

In those places where trials and campaigns with KDUs have been carried out, e.g. Surahammar, Staffanstorp etc., a 100% spread has not been achieved. For example, in Surahammar 40% of households had installed disposal units 1998. Areas with known problems were excluded.

International comparisons were made in a report (Andersen&Nielsen København A/S, 2006) with reference to Madsen (1996) where allowing the use of KDUs in England and Holland only resulted in an increase in use of between 5 and 10%. In the pre-study to the legalisation of KDUs in New York (New York City Department of Environmental Protection, 1997), an expansion rate of one per cent per year after the repeal of the ban was assumed.

Sedimentation in the sewer system

With the introduction of KDUs, the quantity of suspended substances that are to be transported increases without an equivalent increase in the quantity of water. The quantity of material to be transported can increase by some ten per cent, depending on the connection density, while at the same time the increase in water, from flushing, is marginal, 3-6 l/household per day. (Water/Sewerage Study 1999:9).

In the reports on Staffanstorp and Surahammar, there has not been reported any increase in sedimentation in the sewage system. However, in a Norwegian report (Nedland 2006) the deposit of coffee sump like sediment in pipes, which had increased the difficulty of video inspections was reported.

A study in Utanobori (Japan) has shown an increased frequency and occurrence of deposits in the sewage system. However, blockages as a consequence of the deposits were rare. Deposits were most frequent in sewers with a shallow gradient. (InSinkErator Policy Paper)

The New York City Department of Environmental Protection claimed that deposits as a consequence of KDUs did not occur in combined sewers that are self-cleaning and referred to the specific density of shredded waste being somewhat lower than that for sewage in general and a lot less than the density of solid particles in run-off water. (New York City Department of Environmental Protection, 1997)

Self-cleaning for a sewer depends on the flow and dimension. The gradient required for achieving self-cleaning in sewers of different dimensions can be read, for example, from the diagram in Swedish Water's publication P90. A rule of thumb for calculating the necessary gradient is that the slope must be at least 1 divided by the diameter in millimetres.

Blockage and overflows

In New York, KDUs were banned for a long time because of the risk for overflow to surrounding recipients. A study (New York City Department of Environmental Protection, 1997) repealed this ban, since it could not be shown that there was an increased risk.

According to the previous point, KDUs cannot be suspected to any great degree of causing deposits and risks for blockages. A hydraulic model has been constructed by Stockholm Water to evaluate the quantities of overflow water, etc. At the time of this report's completion, the study was not finished but in the future, it should be possible to locate areas upstream of frequent overflow points.

The question can be asked whether KDU waste overflows are really an over-fertilization problem. If this is not so, then it can be observed that overflows are themselves an undesirable phenomena and should be tackled separately, assuming that it cannot be determined that the KDU waste itself is not the cause of the overflow.

Rat problem

It has not been possible to demonstrate increased problems with rats as a consequence of KDUs. Shredded waste is not considered to appeal to rodents. However, some shredding trials have shown thread-like remains instead of particles, (Kärrman et al 2001). Whether thread-like food waste would attract rodents is not known.

From a wider waste perspective, some suggest that the rat problem increases when there is not food available in, and by, waste vessels and rubbish bins. KDUs should instead reduce the availability of suitable food and thereby should reduce the problem.

Hydrogen sulphide formation

Hydrogen sulphide arises from the anaerobic decomposition of organic material. Hydrogen sulphide is a toxic gas that can also corrode concrete pipes by transforming into sulphuric acid.

It has not been possible to prove that KDUs give an increased problem with hydrogen sulphide. The trial at Staffanstorps (Nilsson 1990) contains a theoretical calculation that showed that the increased quantity of organic material was too small to reach the critical value for corrosion of concrete pipes.

An important factor for hydrogen sulphide production is the residence time and oxygenation. Problems occur primarily in pressurised sewers or stagnant water. The residence time and oxygenation in the sewage system is not known. However, it can be observed (Kärrman et al, 2001) that it is unsuitable to introduce disposal units in areas that already have problems with hydrogen sulphide production in pressurised sewers.

Decomposition in the sewer system

Nedland et al (2006) refer to a report (Torell 1994) that presents a possible decomposition of 50% in the sewage system under aerobic conditions. In an anaerobic sewage system, the decomposition becomes just 1 - 2.5% per hour.

Cedergren (2007) shows that it is mostly the organic material that is already in dissolved form that decomposes during transportation in the sewage system. The particulate share, in contrast, does not decompose.

The flow time to the sewage treatment plant is less than 2 hours for the majority of subscribers in Stockholm. Flow times between 6 - 12 hours occur, partly for outer areas of Stockholm City, partly for subscribers who are connected to the Himmerfjärd's works (Syvab).

Samples taken in connection with the case study in Staffantorp (Nilsson et al, 1990) showed that the COD/BOD ratio sank after the introduction of KDUs, which can be explained by that the additional organic material consisted mainly of easily degradable fractions.

Decomposition is very dependent on the oxygen conditions, temperature and residence time. How the oxygen concentration varies in the sewage system is not known, which makes it difficult to assess how much degrades on the way to the sewage treatment plant.

Water consumption

The water consumption, as a consequence of the installation of KDUs, in all of the studies is assumed to increase very little. Naturally, it depends on the number of households that install KDUs. In one report, figures are presented for an increase of 3 -4 l/person/day and in another of 6 l/household per day. In total, this can give a 0.02% increase in water consumption at 3% installed disposal units, and 0.24% at 38% of households with installed disposal units. (InSinkErator Policy Paper)

Neither of the case studies in Staffantorp (Nilsson et al, 1990) or in Surahammar (Karlberg & Norlin, 1999) has been able to show an increase in water consumption after the introduction of KDUs.

Types of sewer systems

There are different systems for the disposal of sewage. In part, the combined system where rainwater and sewage from properties are directed away together and, in part, there are separate/duplicated systems, where rainwater (surface water) is led away separately from the sewage from the properties. In addition, there are pressurised sewers. In part of the area, where it is difficult to achieve sufficient fall in the sewers, there are different types of pressurised sewer. E.g., low-pressure sewage systems that are used in many transformation areas.

It has not been possible to discover any studies on whether KDUs in the sewage system are more or less suitable in different types of self-fall system.

It could be thought that blockages could occur more easily in a duplicated system since it is narrower, but at the same time, the consequences of a blockage could be greater in a combined system during heavy rain.

Problems with hydrogen sulphide primarily concerns pressurised sewers, which also include low-pressure systems.

Summary of the literature study

Considered together, the Scandinavian and foreign studies present few warning signs for KDUs. Common for the Scandinavian studies is that they deal with trials at isolated minor towns. At the same time, it appears there is a lack of critical studies, on KDUs 'to be or not to be', from the USA, where KDUs are used a lot. Perhaps this is because they consider KDUs as an equally natural component of the sewage system as the toilet. The study performed in New York, before the repeal of the ban, was based on their own pilot studies; however, comparisons were not made with the rest of the USA.

Survey of the preconditions for Stockholm Water

Stockholm Water's experience and viewpoints

Below follows a selection of problems and concerns that exist today for the sewer system. The information has been gathered from conversations with operating personnel in the northern and southern regions within Stockholm Water.

- The northern region of operations has a more positive attitude to the introduction of KDUs than the southern region of operation, which takes a more dismissive position.
- Common for both regions is a major worry for an increased rat problem. There is today a serious problem with rats, and one concern is that KDUs could increase this problem. There is currently a program underway with rat poison, together with the Environment and Health Administration.
- Sedimentation occurs in branch tunnels to the sewer tunnels as well as pipes with poor fall or reverse fall. In the western districts, there is a flushing program that means that each stretch of sewer is flushed once every 12 years. In the southern region, there is a corresponding program for area flushing.
- There is probably a risk for hydrogen sulphide formation in pump sumps; however, it is not stated to be a widespread problem.
- Large sections of Huddinge's sewage system have under capacity and flooding problems. Problems are so frequent that some property owners have ceased to report problems.
- They do not experience any major problems with overflowing. Only during heavy rain and in the event of blockages.
- The main sewer system has been modelled in order to estimate the annual overflow volumes, etc. The work is not completed, but overflow volumes have been identified that overflow more or less frequently.

Criteria - Critical parameters

Which areas are suitable/unsuitable for the introduction of KDUs? To answer this question, it is necessary to have a strategy. One strategy for the introduction of KDUs, which among others has been used in Surahammar, has been to avoid areas with problems that are already known so as to avoid the blame for any future problems being directed at the disposal units.

Based on the literature studies and contacts with operating personnel, the following critical parameters can be set up, so as to exclude areas where KDUs can cause problems or, in any case, may be blamed for problems that are not caused by KDUs.

- Hydraulic - Avoid areas with known hydraulic problems!
- Rats - Avoid areas that have problems with rats!
- Smell - Avoid areas that have problems with hydrogen sulphide or smell!
- Flow time - Avoid areas that have long flow times to the sewage treatment plant! I.e. a lot of decomposition will occur in the sewers, with possible oxygen deficiency and formation of hydrogen sulphide as a consequence.

To provide support for decisions, a survey has been performed with Stockholm Water's statistics for interruptions to operations, from VabasDuf⁵ and divided by the DUF areas⁶, as a basis. The statistic for disturbances to operations between 1998 and 2005 are presented in sections 1.3.6-1.3.8. The codes for operation disturbances that are the basis for the respective parameters are presented in Appendix 1.

The statistics for disruptions to operations are not complete and there are differences in how the reports have been made in the different regions. Rats are difficult to see and the reports mainly come from property owners who have had problems adjoining the property's services, but it is assumed here that they can also give an indication of problems in the sewer system. Similarly, the reporting of smells is not knife-sharp formulated and can have widely different causes, however, it is even so weighed in the overall assessment. It is worthwhile pointing out that even if the statistics for operational interruptions used are not complete, they are even so assumed to provide a good indication of which areas are the problem areas.

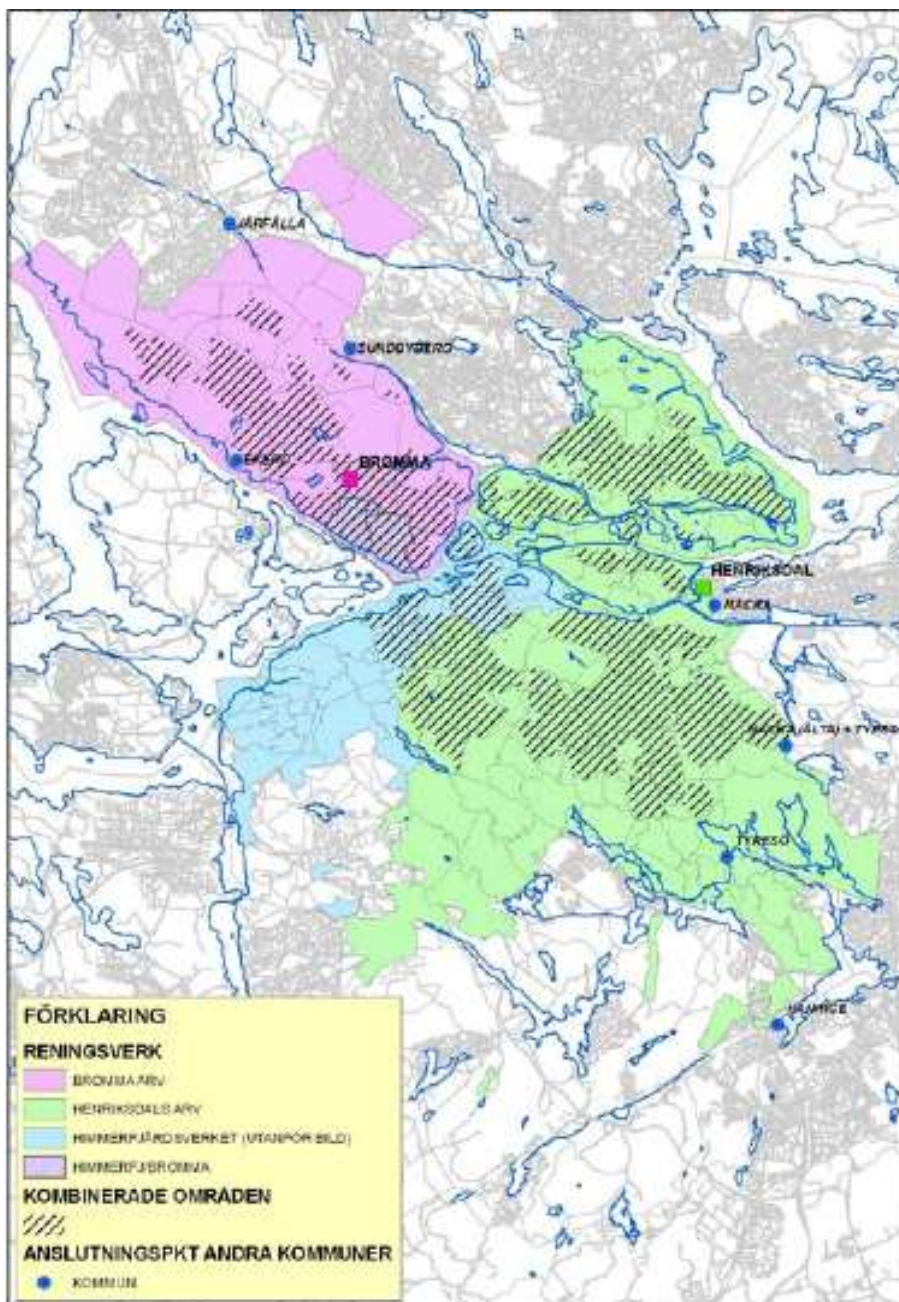
The following sections contain a survey of the preconditions, within Stockholm Water's area, and conclude with an overall assessment.

The assessment is based on the situation 2006/2007, and should be updated in step with changes to the sewage system and the load.

⁵VabasDuf is the name of the databases in which Stockholm Water, Swedish Water and many other municipalities store their statistics on operational disturbances and administer their digital sewer system. A few years ago, Sweden Water started to report their disturbances to operations in the program Cityworks, but the statistics are not yet comparable with the previous VabasDuf statistics.

⁶Stockholm Water has split up its sewer system into different DUF (drift [operation], underhåll [maintenance] och förnyelse [renovation]) areas, which divides the sewer system into different catchment areas.

Stockholm Water's sewer system



Explanation

Sewage Treatment Plants

Bromma
Henriksdal
Himmerfjärd's works
Himmer/Bromma

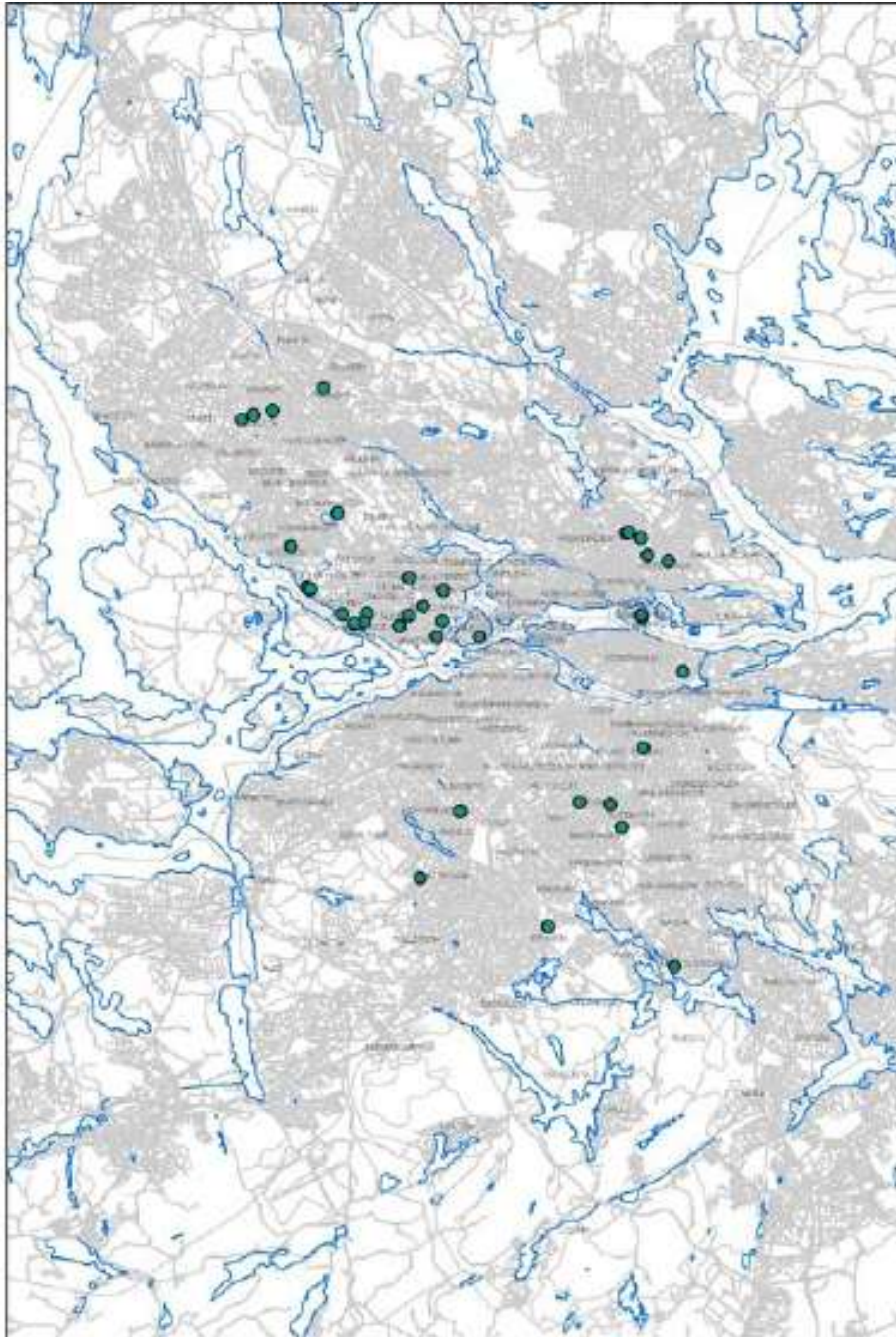
Combined Area

Connection pt other
municipalities
Municipality

Picture 5. Stockholm Water's area of operations for water/sewerage. Divided up by the different sewage treatment plants. Hatched areas have a combined sewerage system. There are no maps for areas with low-pressure sewerage systems, ITA. In addition, the flow of wastewater from other municipalities is marked on the map.

KDU today

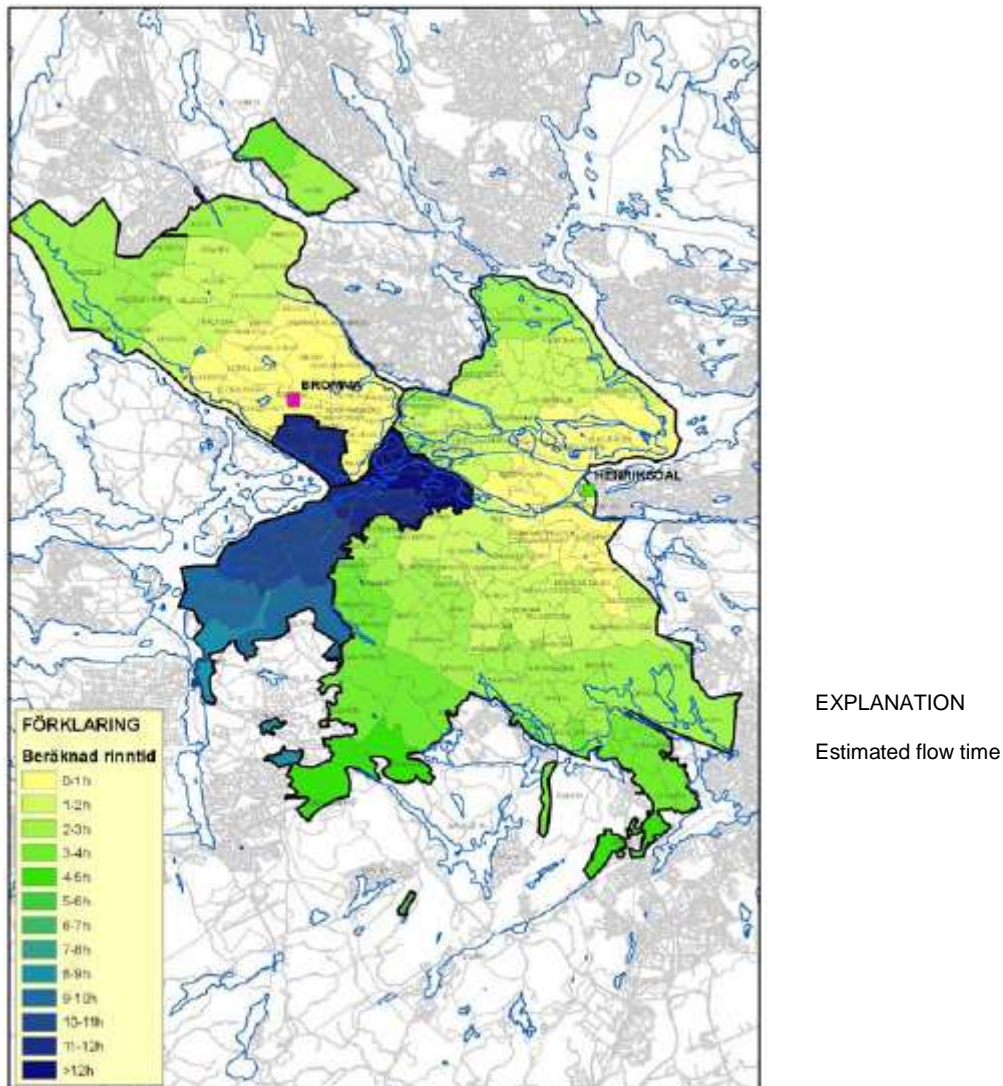
Today, there are more than 40 [customers], mostly households, who pay an annual fee of 390 SEK in order to have a kitchen disposal unit installed.



Picture 6. Subscribers who pay for kitchen disposal units,

Areas in the sewer system with a long residence time

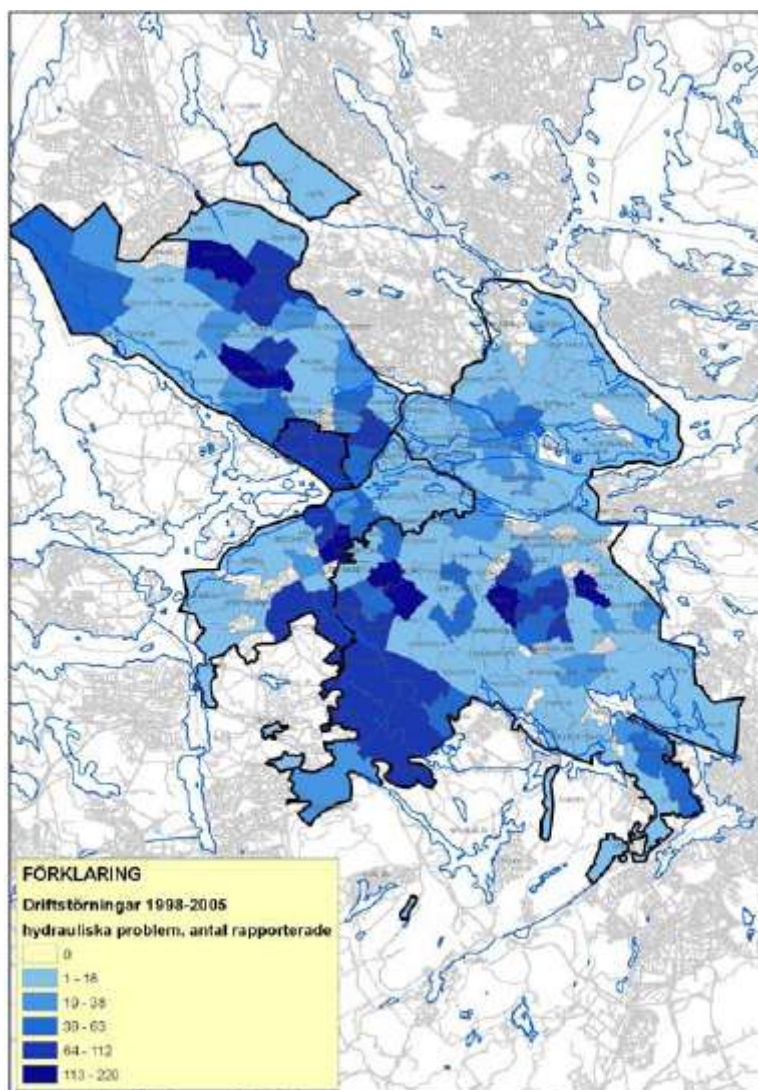
There are three sewage treatment plants that deal with the wastewater from Stockholm Water's area of operations. Bromma, Henriksdal and the Himmerfjärd's works (SYVAB), which lies outside of the map area. A simple calculation of the distance to the sewage treatment plant, see Appendix 1, gives that minimum flow times according to the figure below. The flow times vary from zero hours for those areas that lie closest to the plant, to over twelve hours for DUF areas within the Himmerfjärd works' catchment areas. The division is by DUF area.



Picture 7. The figure shows the minimum flow time to the sewage treatment plant, based on the distance. The thick lines refer to the boundaries between different catchment areas for different sewage treatment plants.

Areas in the sewer system with hydraulic problems

In the figure below are presented the reported disturbances in operations of the hydraulic type, see Appendix 7, during 1998-2005. The number of operational disturbances per DUF area varies between 0 and 220. In appendix 8, the gradients of the sewers in the system are presented and, in the main, they agree with the figure below.



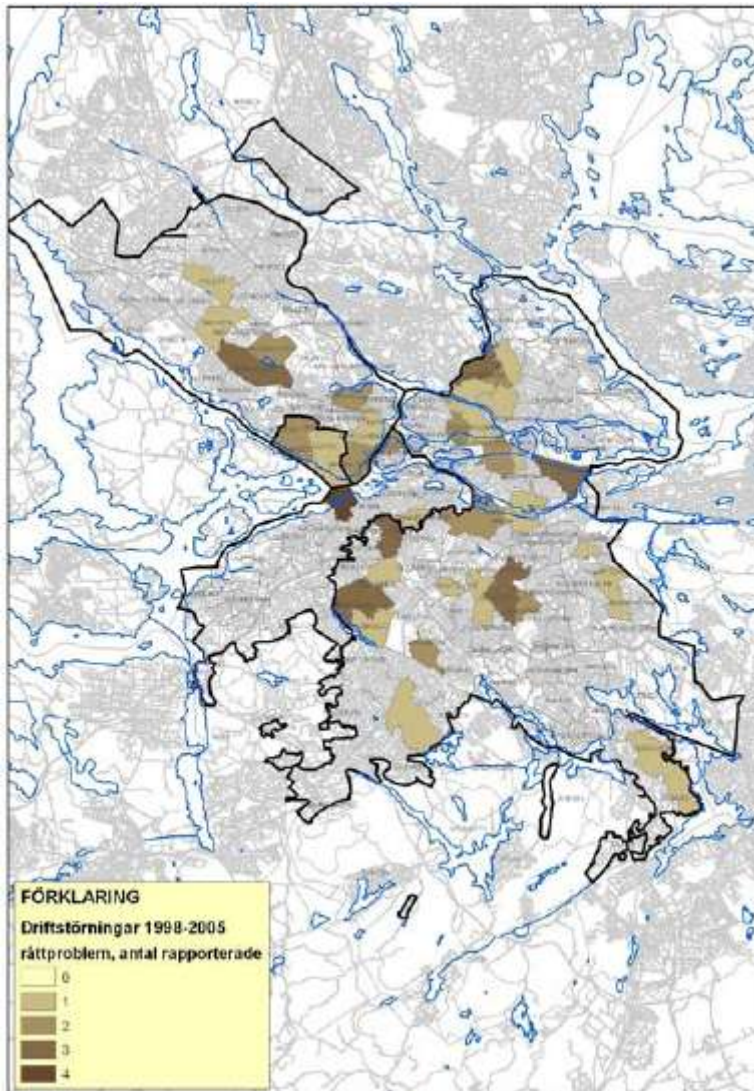
EXPLANATION

Disturbances in operation 1998-2005
hydraulic problems, number reported

Picture 8. In the figure, the number of reported disturbances in operations, of hydraulic type, is shown per DUF area between 1998 and 2005.

Areas in the sewer system with rat problems

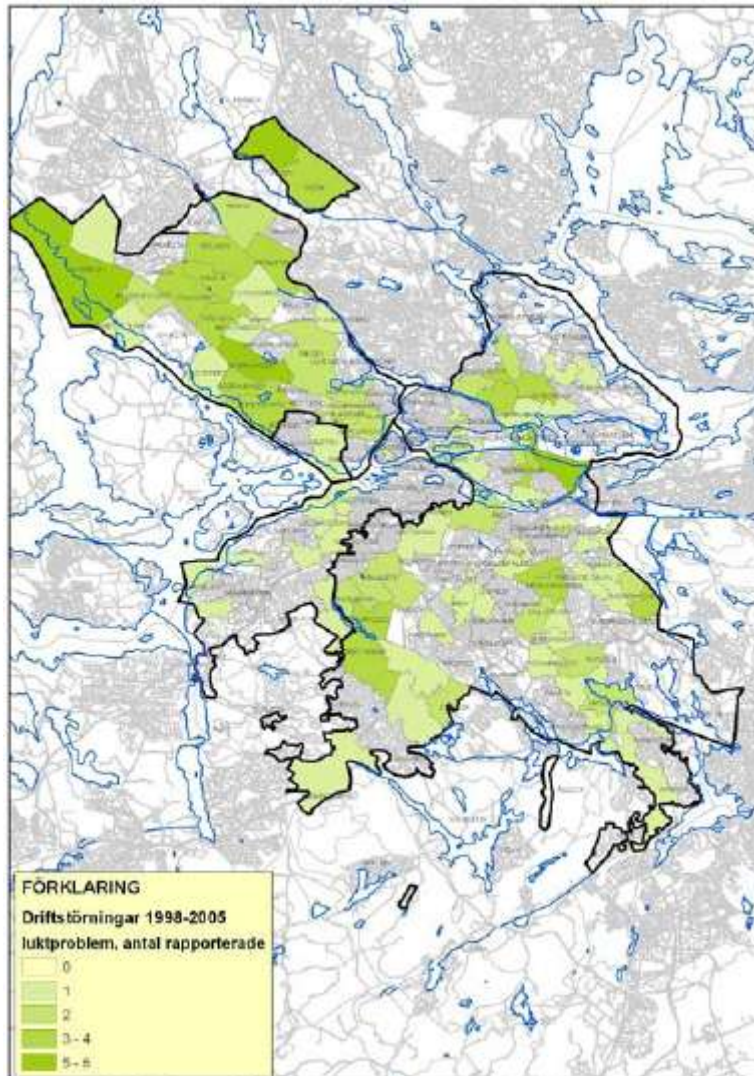
In the figure below are presented the reported operational disturbances concerning rats, see Appendix 1, during 1999 - 2005. The number of operational disturbances per DUF area varies between 0 and 4.



Picture 9. In the figure, the number of reported operational disturbances concerning rats is shown per DUF area between 1998 and 2005.

Areas in the sewer system with smell problems

In the figure below, the reported operational disturbances are presented concerning smells; see Appendix 1, during 1999 - 2005. The number of operational disturbances per DUF area varies between 0 and 6. It is assumed that smells can indicate problems with hydrogen sulphide.



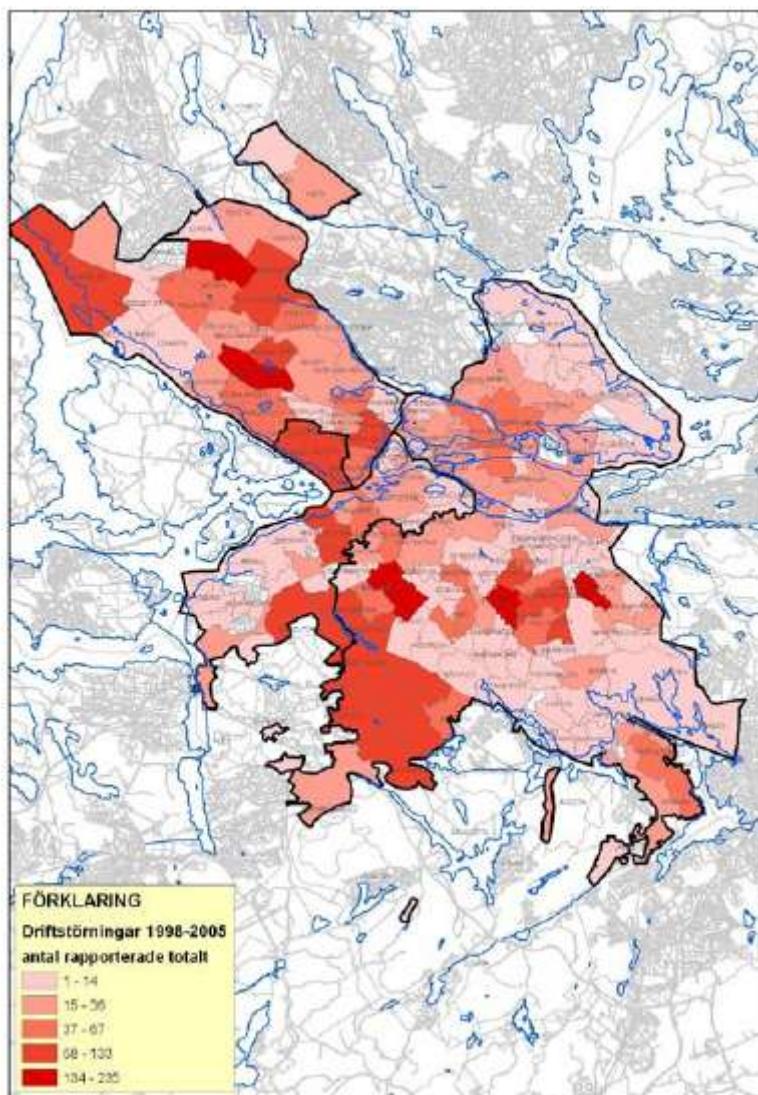
EXPLANATION

Disturbances in operation 1998-2005
smell problems, number reported

Picture 10. In the figure, the number of reported operational disturbances concerning problems with smells is shown per DUF area between 1998 and 2005.

Areas in the sewer system with many disturbances to operations.

In the figure below, are presented the total reported operational disturbances, see Appendix 1, during 1999 - 2005. The number of operational disturbances per DUF area varies between 0 and 235, with an average of 30. There is without doubt differences between operational regions in how conscientiously operational disturbances are reported, but they give, in any case, an indication of where there are many problems.



EXPLANATION

Disturbances in operation 1998-2005

total number reported

Picture 11. In the figure, the number of reported operational disturbances as a total is shown per DUF area between 1998 and 2005.

Assessment of the preconditions for Stockholm Water

Weighting of critical parameters

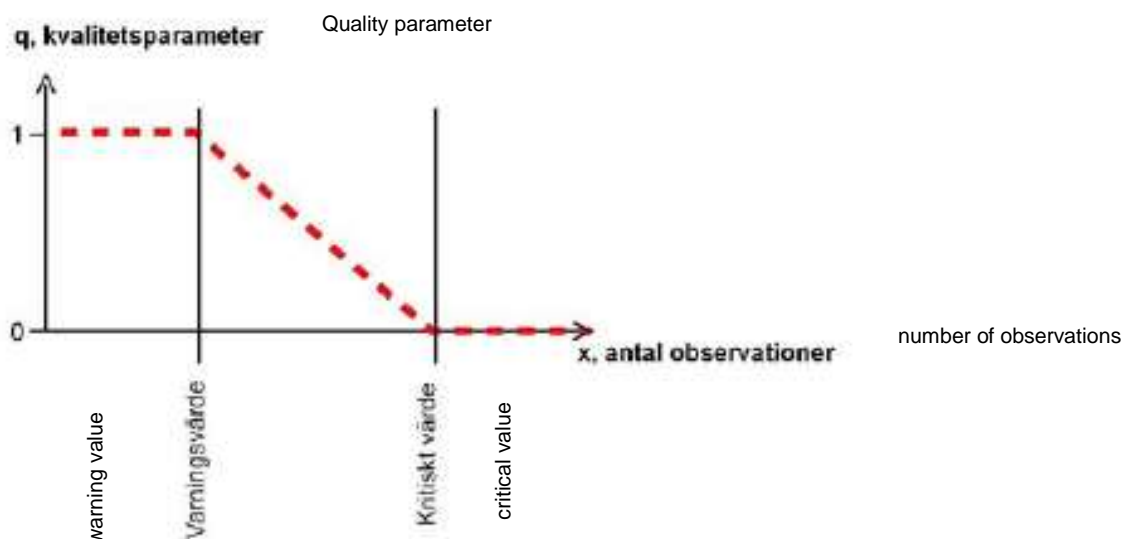
In order to be able to make an overall assessment of the different DUF areas' suitability for KDUs, a joint weighting must be made for the operational disturbances and other parameters presented above.

This is done in two steps. In the first step, the relevant parameter is given a grade that lies on a scale between 1 = 'approved' and 0 = 'not approved'. In the second step, a total grade is calculated that in principle is the average of all the grades, but with the finesse that if any of the grades included is 0 = not approved the total grade will also be 0.

Each parameter has the grade 1 until a warning value is exceeded. Between the warning value and a critical value, which, when it is exceeded, sets the grade to 0, the grade varies linearly. In table 1 below, the warning and the critical values are presented for the different parameters.

Table 1. Critical parameters' limits and grade as well as their variation. The standard deviation has only been presented for those cases where it is relevant. When it comes to rats and smells, the number of observations is too small for calculating the standard deviation.

parameter	unit	average	min	max	std deviation	warning value	critical value
flow time	hr	3.4	0	12.4	-	6	12
hydraulic	-	26	0	220	37	25	95
rats	-	0.4	0	4	-	1	8
smells	-	0.9	0	6	-	1	12
total number of disturbances	-	30	1	235	40	30	110



Picture 12. The grades' variation. As long as the number of observations (or the value), x, lies under a limit called the warning value, the grade 1 is given. If the warning value is exceeded, the grade is reduced linearly to the value 0, which occurs when x exceeds the limit called the critical value.

The individual grades are then weighted together by multiplication and division to give a total grade. The pooling is done as follows

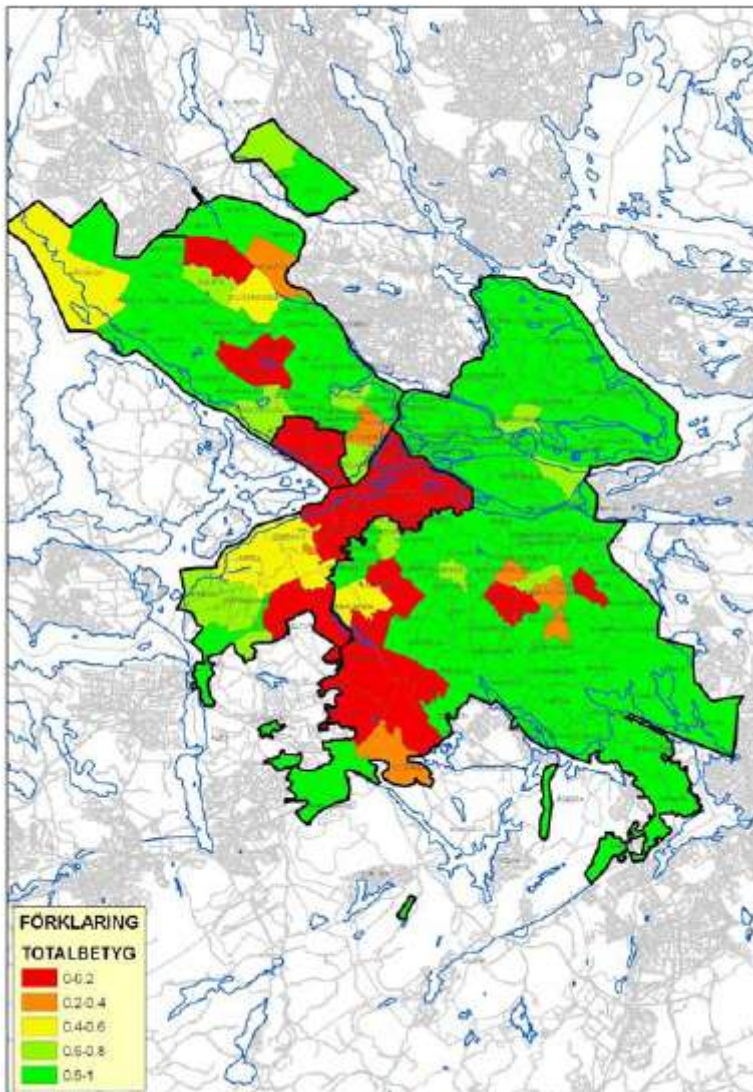
$$\text{Total grade} = \frac{\text{grade}_{\text{flow time}} \cdot \text{grade}_{\text{hydraulic}} \cdot \text{grade}_{\text{rats}} \cdot \text{grade}_{\text{smell}} \cdot \text{grade}_{\text{disturb Tot}}}{(\text{average value of individual grades})^4}$$

The multiplied individual grades are normalised by the average for the individual grades, raised to the number of individual grades minus one, in this case $5-1=4$. This method of calculation means that if all the individual grades are of roughly the same magnitude, the total grade will be roughly the same as the arithmetic mean for the individual grades, but if one grade is low then the total grade will be significantly influenced by this.

In the following section, the total grades for the different DUF areas are shown. In addition to the areas that in this way can be identified with respect to operational disturbances to be suitable/unsuitable for KDUs, assessments may be made from case to case, for example, for areas upstream of pumping stations with hydrogen sulphide problems; properties in problem areas that are not connected to a sewer with hydraulic problems etc. Other information can also be used, e.g. overflow mapping, sewer gradients and flushing lists.

Assessment of suitable/unsuitable areas

In the figure below, the total grade for the different DUF, areas are shown. In Appendix 6, the results are presented in table form.



EXPLANATION
TOTAL GRADE

Picture 13. The overall assessment of the suitability for kitchen disposal units in the DUF areas. The scale goes from red - unsuitable via yellow=warning to green OK

Other factors to take into consideration

In addition to the statistical summary of operational disturbances presented above, specific local factors can be used to exclude unsuitable placement of KDUs. e.g. such as

- Does the property lie on an end sewer with low flow?
- Does the property lie in an area with LTA?
- Does the property lie upstream of a wastewater overflow that overflows frequently?
- Does the property lie upstream of a pumping station with a problem with hydrogen sulphide formation?
- Does the property lie in an area with poor sewer gradients? (see also appendix)
- Has the property many fault already reported today? (also in the property)
- Other detailed information.

It is appropriate that an application to install a disposal unit is referred to the operation office for the area. To ease the handling, it is proposed that the tasks be geo-coded and presented in map form.

Conclusions sewer system

The study has not been able to show that the installation of KDUs in the sewage system will not function. Documented problems have mainly occurred within a property's service pipes and in areas that were already known to have hydraulic problems.

We recommend that the installation of KDUs be allowed, but that the installation shall be preceded by an application. Assessments should be made from case to case by Stockholm Water, with the support of this report, etc. Before a decision is taken, it is appropriate that the application be referred to the operation's officer for the actual area,

Further, addresses where KDUs are installed should be stored in a geo-database and a check should be kept of the number of KDUs installed.

⁷Low pressure sewer. Pressurised sewer system in contrast to conventional sewer systems that have self-fall. Normally in hilly areas. LTA is a Swedish version of LPS (Low Pressure Sewer). Since problems with hydrogen sulphide formation mainly arise in pressurised systems, this is seen as a possible risk.

5 KDU AND SEWAGE TREATMENT PLANT

Objectives

The objective of the sub-project is to determine the advantages and disadvantages of disposal units from the perspective of the sewage treatment plant.

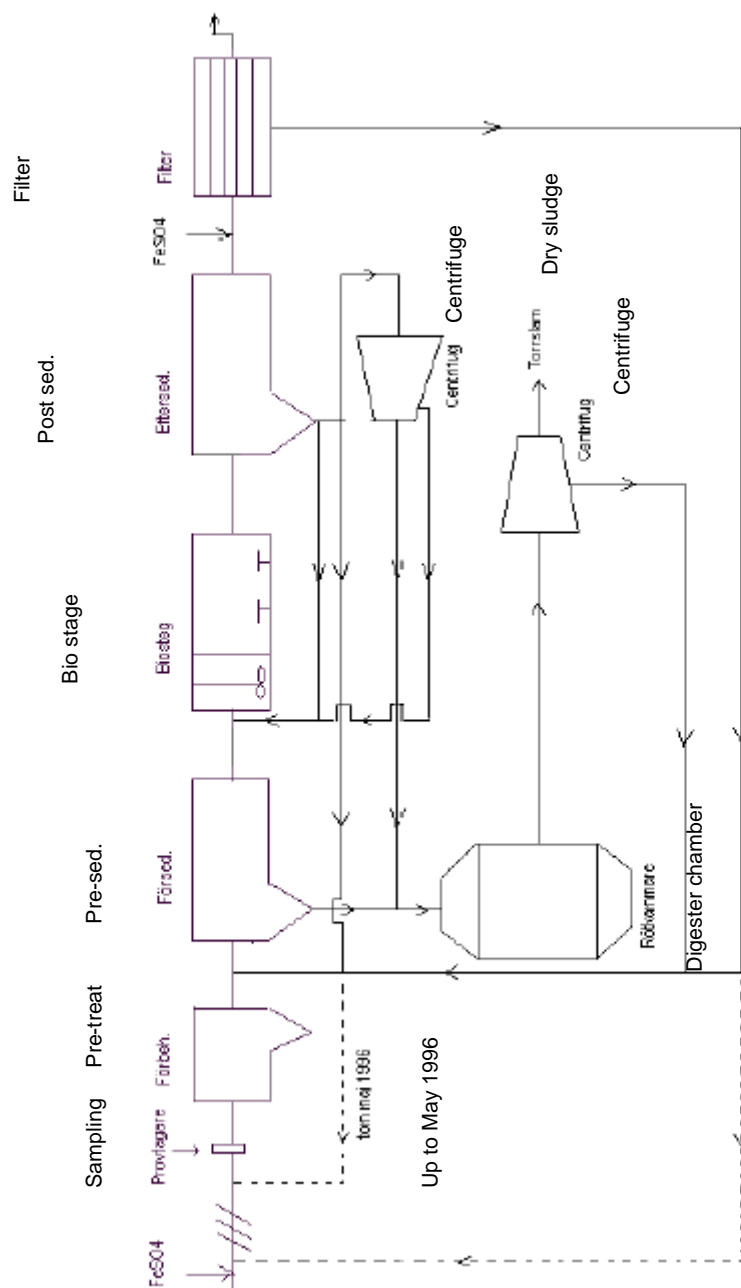
Method

Food waste, processes for Bromma and Henriksdal sewage treatment plants as well as the applied methodology for the report estimates are described here. The method is presented for individual process steps.

Food waste

In the table below, the food waste produced by people is presented: a total quantity and a quantity that goes via KDU (67% of the total quantity) to the sewer system and thereafter to the sewage treatment plant. The table information is taken from Urban Water-report 2005:6 and water/sewerage research report 1999-09.

Food waste	Total quantity (kg/p, year)	Via KDU (kg/p, year)
wet weight	80.41	53.87
TS	25.00	16.75 = 31 %
VS	21.00	14.07
FS (=TS-VS)	4.00	2.68
COD _{tot}	34.00	22.78
COD _{part}	34.00	22.78
BOD ₇	12.00	8.04
N _{tot}	0.60	0.40
P _{tot}	0.10	0.07



Picture 14. Process diagram Bromma sewage treatment plant



Beschreibung: 1987

Number of people connected and material arriving at the sewage treatment plant

The number of people connected to the sewage treatment plant is estimated from the nitrogen load to the sewage treatment plant and the nitrogen production/person (a standard value of 5.1 kg N/person⁸). For Bromma this implies that the number of people connected amounts to ca. 235,000 and for Henriksdal ca 706,000.

Based on the total quantity of food waste produced by one person amounts to 25 kg TS/year, it can be calculated that the people connected to Bromma produce 5,875 t TS material per year and people connected to Henriksdal produce 17,650 t TS food waste per year.

It is assumed that the proportion of the food waste (organic material) that goes via KDUs to the sewage system, and arrives at the sewage treatment plant, amounts to 67% of the total quantity of food waste produced by the people connected to the sewage treatment plant (Water/Sewerage Research report 1999-09). It is also assumed that there is no decomposition of organic material in the sewer system.

Based on these assumptions, it could be calculated that the quantity of food waste produced by one person via KDU amounts to 16.75 kg TS/year, and that the people connected to Bromma produce 3,936 t TS food waste per year via KDUs and people connected to Henriksdal produce 11,826 t TS food waste per year via KDUs.

Subsequently, calculations are presented for two cases:

Case 1 - 10% of people connected have KDU

Case 2 - 50 % of people connected have KDU

Cleaning grills and sand traps

Any reduction in organic material through cleaning grills and sand traps is not considered.

Pre-sedimentation

The purification effect through the pre-sedimentation (the reduction grade in different parameters that are needed for subsequent calculations) are calculated based on Wastedata (digital recording of process parameters), e.g. SS (COD_{part})- reduction for Bromma was up to 49% and for Henriksdal 59%. All these reduction grades are presented in the Appendix Purification Effect. It is also assumed that COD_{soluble} amounts to 16% of COD_{tot} that reaches the sewage treatment plant (LTH, Bulletin series W/S No 56). In this way, it could be determined how much of the organic material accompanies the primary sludge to the digestion chamber and how much goes further to the biological steps.

Bio-steps

Nitrogen removal

In the case of Henriksdal, it was considered that the plant already, for now, obtains the theoretical maximum reduction grade (pre cent purification effect) for the process used, namely pre-denitrification⁹. Therefore, it is noted that the output nitrogen levels will increase. The increase is estimated based on the assumption that all the arriving nitrogen from the KDUs is transformed to ammonia and that the reduction grade for this nitrogen is the same as for the existing process.

In Bromma's case, where denitrification is limiting for nitrogen removal, the nitrogen removal can be improved by the net addition of carbon source obtained via KDU. See explanation of the calculation in the chapter Denitrification.

Denitrification

First, it is calculated how large the addition obtained in carbon source and nitrogen is via the food waste (organic waste) from KDUs. Thereafter, it is assumed that all the arriving nitrogen will be denitrified and that to denitrify 1g NO₃-N requires 4 g BOD. The net carbon source addition is obtained as the difference between that total addition and the carbon source consumed for denitrification of the additional nitrogen.

⁸for Bromma this assumption means that the number of people will not reach the number connected according to the Environment Report 2005 (ca. 235,000 in this study against 287,900 in the Environment Report). For Henriksdal, the number of "nitrogen people" becomes ca. 706,000, while the Environment Report 2005 states 689,400 connected. In Henriksdal, the reject from the sludge digester centrifuges is included in the arriving nitrogen load and the number of people will be over estimated somewhat.

⁹The assumption is reasonable for Henriksdal since the purification effect is equivalent to that theoretically obtained for a pre-denitrification process that is run with a reasonable return recirculation (a recirculation grade of 4 times the incoming flow gives a reduction of 80%, if the reduction in nitrogen that is separated with the sludge is ignored) of nitrated nitrogen.

Nitrification

The affect on nitrification is not studied further. Any increase in oxygen requirements in the aeration basins is not considered either. Only the increase in nitrogen load for the two cases, 10 and 50% connection of KDUs, respectively, is presented.

Production of surplus sludge

The surplus sludge production was estimated with the help of a rough COD balance for the sewage treatment plant, this gave a production of ca. 0.3g CODsludge/g CODin.

Digestion chamber

The gas production is estimated by calculating what happens to the organic material from the disposal units in each process step and the results are presented below. The digestion grade for organic material via primary sludge to the digestion chamber was assumed to be 75%¹⁰ and the digestion grade for surplus sludge was assumed to be 23%¹¹. Gas production amounts to 0.35 Nm³ CH₄/kg COD_{red}. Based on these assumptions, it was estimated how much gas and sludge is produced from the organic material via KDUs. By comparing these productions with the real productions presented in the Environment Report, the pre cent increases in gas and sludge, due to organic material via KDUs, was estimated.

The gas production could also be estimated by assuming that the quantity of gas produced is proportional to the quantity of organic material arriving at the sewage treatment plant. However, this should be a cautious estimate since the proportion that is separated in the pre-sedimentation could be greater for organic waste compared to other organic material in the wastewater. Further, the digestion grade for the organic material from disposal units is higher than for sludge. This method has been used as an extra check on our calculations.

For Henriksdal, both of the calculation methods gave roughly the same results. For Bromma, a higher value was obtained for the assumption that the gas production is proportional to the arriving quantity of organic material. For Bromma, this can be explained in part by the quantity of the material arriving at the sewage treatment plant is low in relation to the gas production¹².

Results

Affect on gas production

Gas production at Henriksdal will increase by 3.7% (230 000 Nm³CH₄/year) for 10% KDU and 18.3% (1,152,000 Nm³CH₄/år) for 50% KDU.

Gas production at Bromma will increase by 3.2 % (66,600 Nm³CH₄/year) for 10% KDU and 16.0 % (333,000 Nm³CH₄/år) for 50% KDU.

Affect on sludge production

Sludge production at Henriksdal will increase by 3.4 % (520 tTS/year) for 10 % KDU and 17.2 % (2,600 tTS/year) for 50% KDU.

Sludge production at Bromma will increase by 2.9 % (173 tTS/year) for 10 % KDU and 14.5 % (863 tTS/year) for 50% KDU.

Affect on sludge quality

The addition of organic material via KDUs will improve the sludge quality somewhat, as expressed by the metal/phosphorus ratio. This applies equally for Bromma as for Henriksdal¹³.

Affect on denitrification

The net addition of carbon source corresponds to the denitrification of 0.7 mg N-NO₃/l at 10% KDUs and 3.3 N-NO₃/l at 50 % at Henriksdal. Since, today, Henriksdal has a high reduction, with respect to nitrogen, it can be assumed that carbon source is hardly limiting. Therefore, it is doubtful if further improvements will be really achieved with the introduction of KDUs.

¹⁰based on Davidson (2007) and talks with Anox (Lars-Erik Olsson) and JTI (Åke Nordberg)

¹¹assumption based on a comparison between digestion of primary sludge and surplus sludge (Leksell, 2005)

¹²There may be errors concerning the sampling and/or flow measurements of arriving water since even other parameters (e.g. phosphorus balance) do not agree for Bromma.

¹³Chrome analyses are uncertain.

The net addition of carbon source corresponds to the denitrification of 0.5 mg N-NO₃/l at 10% KDUs and 2.6 N-NO₃/l at 50 % at Bromma. Currently methanol dosing is used and the introduction of KDUs can reduce the methanol required. For Bromma, a connection of 10 % KDUs implies ca. 74 m³ methanol/year and 50 % KDUs implies ca. 370 m³ methanol/year, for methanol dosing year round¹³.

Affect on nitrification

The nitrogen load will increase by nearly 1 % at 10 % KDU and nearly 4 % at 50 % KDU, for both sewage treatment plants. For Henriksdal, this implies an increase of 0.3 and 1.6 mg N/l at 10 and 50 % KDUs, respectively. For Bromma, the levels increase by 0.2 and 1.1 mg N/l at 10 and 50 % KDUs respectively.

The effect on nitrification should be marginal, but further studies should be carried out. The effect of increasing the organic load on the nitrification may need to be analysed.

Affect on nitrogen removal

Since the pre-denitrification process is utilized at both plants, it can be difficult to achieve higher reduction grades than is already the case at Henriksdal. This means that the output levels can increase by 0.2 and 0.5 mg N/l at 10 and 50 % KDUs respectively. However, this assumption is based on the plants are already run today with complete nitrification and denitrification¹⁵ as well as that all arriving nitrogen from KDUs is transformed into ammonia. The values thus state a "worst imaginable" scenario.

However, for Bromma a positive effect on the nitrogen removal can be expected due to the improved denitrification. For the connection of 50 % KDUs, the estimated affect could be as large as a 20 % reduction in releases compared with the levels 2005. However, this may be an over estimate if the carbon source cannot be used all year round.

Conclusions

For Bromma, a positive effect is expected where it concerns the output quantity of nitrogen whilst for Henriksdal it may even mean a worsening.

For both Henriksdal and Bromma, however, positive effects are expected with respect to increased gas production.

Sludge production is effected to roughly the same degree as gas production for Bromma as well as for Henriksdal.

Taking consideration to the above, KDUs should initially be introduced in Bromma's catchment area. The connection of KDUs to Henriksdal's sewer system should wait, since attaining the nitrogen requirement must take precedence over biogas production.

¹⁴Assumes 1.2 kg COD/litre methanol or 1.5 kg COD/kg methanol. Methanol has a density of 0.79 kg/l (Grundestam, 2006). Further, it is assumed that only the easily degradable section (i.e. the BOD quantity) can replace the methanol.

¹⁵The assumption is reasonable for Henriksdal since the purification effect is equivalent to that theoretically obtained for a pre-denitrification process that is run with a reasonable return recirculation (a recirculation grade of 4 times the incoming flow gives a reduction of 80%, if the reduction in nitrogen that is separated with the sludge is ignored) of nitrated nitrogen.

6 MARKET

Overall assessment of the affect of KDUs on the water/sewerage system

Up to now, Stockholm Water has had a very restrictive position on the installation of kitchen disposal units in households. This is because of worries for the problems that it was believed could arise in the sewer system and at the sewage treatment plant after the introduction of KDUs.

This study demonstrates that KDUs will not have the significant negative effects on the sewage system and the treatment plants that were previously believed. At the same time, the positive effects, such as increased biogas production, will not be large. The effects that KDUs can achieve, both positive and negative, primarily depend on the connection density i.e. on how large a proportion of households in Stockholm will install KDUs connected to the water/sewerage system.

KDU and the environmental objectives

In Appendix 4, there is a list of the relevant national and regional environmental goals, as well as an extract from Stockholm's environmental program 2008-2011.

KDUs concern, in first hand, those goals that refer to recycling of food waste by biological treatment. (National level - goal 15, part goal 5, Regional level - 35% of food waste from households, restaurants, institutional kitchens and shops in the county, in 2010, shall be recycled by biological treatment as well as Stockholm's part goal 5.4 - 35% of food waste from restaurants and shops will be treated biologically).

According to an assessment from the Swedish Environment Agency, food waste sorted at source that is collected via KDUs and mixed with other waste, e.g. sludge in the sewage treatment plant, cannot be reckoned in the objective for the recycling of food waste¹².

The national objectives for waste management are under revision¹³. It is probable that KAKI can contribute to achieving the objectives according to the new proposals if the plant nutrients in the sludge are utilized.

Had there been in Stockholm a system, where all food waste from households, restaurants and shops was collected, and digested separately, KDUs could be considered as a competitor to such a system. However, today the collection of food waste is limited. According to Stockholm's environment programme 2007-2010, the collection of food waste will be from restaurants and shops, and not from households.

KDU use will increase biogas production, even if only to a small extent. The biogas replaces fossil fuels, which is in line with the objectives for climate effect and acidification (National level objective 1/1 as well as objective 3, Stockholm's objective - Environmentally effective transports).

Collection of food waste by KDUs implies no road transports, since the food waste is transported with the wastewater via the sewer system. Reduced traffic gives lower emissions and this also contributes positively towards the objectives above.

Connection density and expected number of KDUs

The KDU connection density in Stockholm is not expected to be great for voluntary connection.

International experience suggests that the legalisation of KDUs in England and Holland¹⁴ resulted in 5-10% of households using KDUs.

In New York's case⁵, it is judged, for voluntary connection, that ca. 1% of households will install disposal units annually. The disposal unit technique is significantly better known and established in the USA than in Sweden.

Therefore, in the study's judgement, if KDUs are allowed to a larger extent in Stockholm, and the installation is voluntary, ca. 0.5-1% of households will utilize this option per year.

There are today ca. 420,000 households in Stockholm. In 10 years time, this would mean that 5 - 10% of households would have installed KDUs, i.e. there would be 20,000 - 40,000 units in Stockholm.

The primary customer motive for installation of disposal units in Stockholm is expected to be ease, to raise the standard of the kitchen, hygiene aspects, simpler waste management and a reduced risk for smells.

The cost for purchasing and installing a KDU is not insignificant (ca. 3,000 - 5,000 SEK), but neither is it insuperable. Installation is relatively simple and there is good equipment on the market.

Limitations within the area of operations

The study shows that there are some areas in Stockholm, where, taking consideration to the sewage system, it is directly unsuitable for the installation of KDUs, or where a restrictive approach to KDUs is recommended, (see picture 13, Chapter 4).

Therefore, Stockholm Water must have complete control of the connection process in Stockholm. Therefore, Stockholm Water's approval will continue to be required in the future before every KDU installation within the company's area of operations. This is necessary both to prevent installations from taking place in unsuitable areas and to continuously track the connection rate and evaluate the KDUs effects of the sewage system and the treatment plants.

Division of responsibilities

Between Stockholm Water and TKa waste office

Waste management in Stockholm is part of the area of responsibility for the Traffic Administration/Department of Waste Management, TKa (previously the Waste Collection and Disposal Administration). Use of KDUs must therefore be written into the municipality's regulation for waste management/waste collection and disposal ordinances. The same applies for other municipalities within Stockholm Water's collection area.

Between Stockholm Water and property owners

Each property connects to the water/sewerage system via a connection point, which clearly shows the boundary between the property owner and water/sewerage principal.

The connection point will also constitute the boundary between responsibilities for Stockholm Water and the property owner when it comes to KDUs.

Thus, the property owner is responsible for all KDU installations within the property up to the connection point. After the connection point, Stockholm Water is responsible for the disposal and treatment of the shredded food waste.

The property owner, and housing associations in blocks of flats, are responsible for all joint installations in the house and permit installations of KDUs in individual apartments within their properties.

¹²The Environmental Agency's reply to the Waste Cycle Office in Göteborg, dated 10-04-2006 (see "KDU as part of the collection system" in Chapter 3).

¹³The Environmental Agency's proposal for the new objectives is "By 2015, at least 35% of the food waste from households, restaurants, and institutional kitchens will be dealt with so that the plant nutrients are utilised"

7 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study's most important conclusions are the following:

- Stockholm Water can allow more KDUs to be connected to the sewage system on the condition that the company has control of the connection process.
- The connection density is expected to be low, with voluntary connection. Ca. 0.5-1% of households in Stockholm will install KDUs annually.
- The KDUs' affect on the sewer system will be small. However, some areas are unsuitable for KDUs.
- KDUs' negative and positive effects on the sewage treatment plants will be small at the expected connection density, e.g. 3% increase in biogas production with 10% KDU connection.
- There is expected to be some interest in KDUs with Stockholm Water's customers - primarily for ease of use and to raise the kitchen standard.
- It appears the food waste collected via KDUs cannot be reckoned in the goal for recycling food waste¹⁶.

Recommendations

The objective of the study was to expand and establish Stockholm Water's approach to the eventual introduction of KDUs in Stockholm.

Based on the study's results, the study proposes that Stockholm Water softens its, up to now, very restrictive attitude to KDUs and allows installation of more KDUs in Stockholm, except in those areas that are unsuitable with consideration to the sewer system. The motive for this should primarily be to satisfy the customers' wishes and increase the company's range of services. Biogas production will only increase marginally.

It is important that Stockholm Water have full control over all KDUs that are installed and connected to the public sewer system. Each new KDU connection in Stockholm, therefore, must be approved by Stockholm Water. In this way, the company can control that KDUs are installed in suitable areas, record their number and placement, update the customer register and bill fees as well as follow up the connection density and any effects on the sewage system and the treatment plants. If the event that the company's management decides to take a more open approach to KDUs, resources should be assigned, at the same time, to build up and develop this new area of operations.

An organisation for information, approval, inspection and the follow up of KDUs in Stockholm must be established. Review and updating of KDU fees should also be performed.

¹⁶The Environmental Agency's reply to the Waste Cycle Office in Göteborg, dated 10-04-2006 (see "KDU as part of the collection system" in Chapter 3).

APPENDICES

APPENDIX 1 Disposal units in Sweden

APPENDIX 2 Legislation

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APPENDIX 1 Disposal units in Sweden

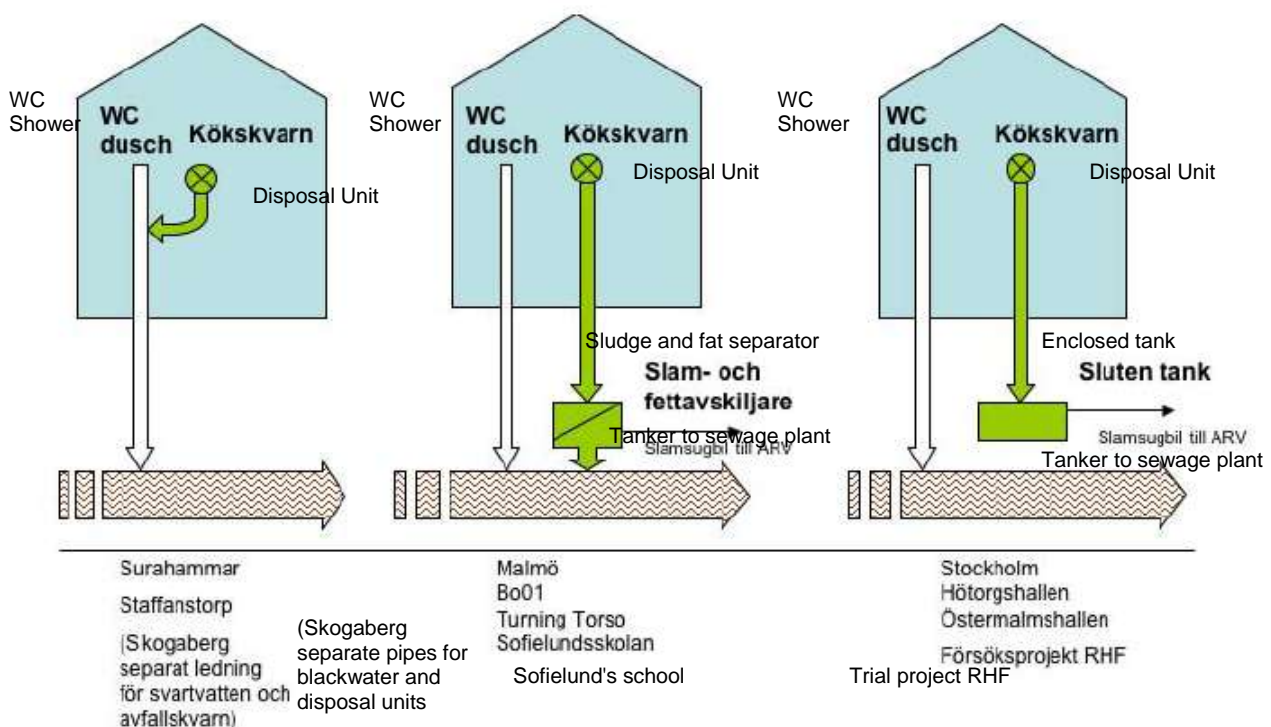
New studies

Studies in recent years have been carried out in Skogaberg/Göteborg 2005, Sundsvall (Luleå TU Exjobb 2003:187), Karlsruhe University (thesis Jörg Kegebein, Band 122, 2006), in Denmark (COWI, Effects of kitchen disposal units, 2006) and in Norway (Aquateam, Effects of the use of waste food disposal units, 2006).

Göteborg is currently working on an extensive pre-study that is planned to be complete June/July 2007. The results from this study are not expected to be available when this report is prepared.

System solutions

Kitchen disposal units can be used in several different applications. From previously always being connected directly to the existing sewage system, new system variants for disposal units have been tested in Sweden.

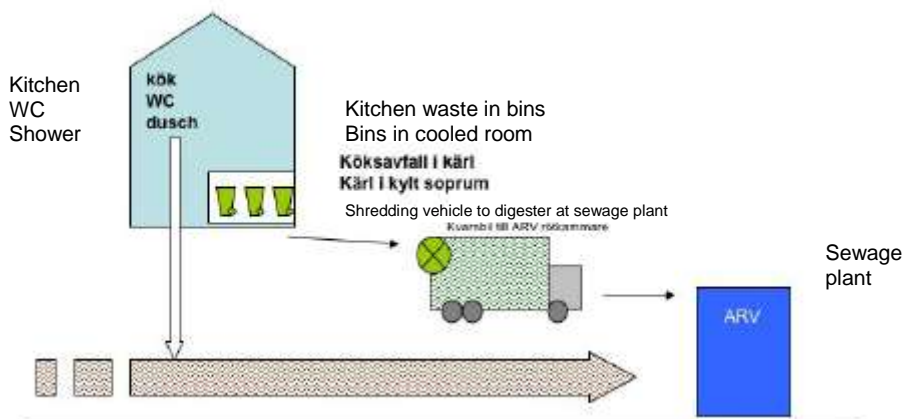
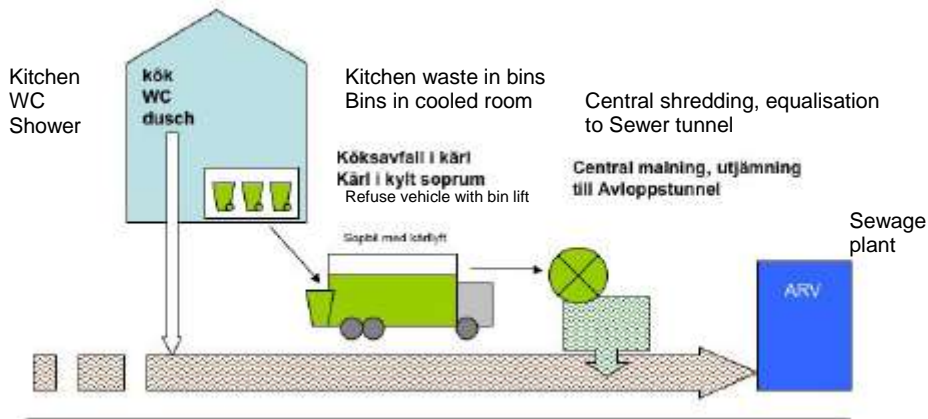


Kitchen disposal units connected to an enclosed tank for use in institutional kitchens have been installed in Stockholm since the mid-1990s. The Department of Waste Management (previously Waste Collection and Disposal Administration) is running (2007) a research project with 15 units, connected to enclosed tanks, installed in institutional kitchens. The shredded waste is driven by sludge collection tanker directly to digestion and is covered by the municipality's responsibility for waste.

In Malmö, the institutional kitchen and household disposal units are connected to the wastewater system via a rebuilt sludge and fat separator. The sludge and fat separator is emptied according to a timetable and transported by tanker to digestion at the sewage treatment plant.

In Skogaberg, on Hisingen, the toilet water and the output from food waste disposal units in the household is led in its own pipe, separate from the grey water, to a local treatment plant.

Disposal units coupled to the wastewater system are a complement to other methods for collecting and pre-treating food waste that is to be digested. Below are shown examples of two development concepts: central pre-treatment and input via drain tunnel or collection by mobile unit for transport to digestion, respectively.



APPENDIX 2 Legislation

The Public Water Services Act

The municipalities' and property owners' entitlements and liabilities concerning the public water and sewerage services are regulated by the Act (2006:412) on Public Water Services. A central definition is the Connection Point, which means the physical boundary between the property owner and the public installation. In connection with the installation of a disposal unit, the Principal may be able to demand to inspect the property side of this point pursuant to 41§.

41§ "The principal is entitled to such access to a real property unit as is needed in order to 1. investigate a water supply and sewerage installation and its use before the water supply and sewerage installation is connected to the public water supply and sewerage facility or when otherwise necessary to enable the principal to discharge his obligations,"

The interpretation of Stockholm Water's lawyers is that the principal can demand to inspect the connection in the property/apartment. Local by-laws (public ordinances) for each municipality can be found in ABVA. In ABVA, there shall be ordinances for whether, and in which case, how waste disposal units may be connected to the municipal water/sewer system, preferably with references to the municipalities ordinances on waste collection and disposal, where it is set forth how waste may be handled.

In connection with the new water services act, all municipalities will need to examine the relevant ABVA. In those municipalities where there are waste disposal units, clarification may be needed.

Water/Sewerage Rates

The right to charge a fee is regulated according to the Act (2006:412) on Public Water Services. Cost arising from the connection of disposal units. e.g., approval, maintenance of the sewer system, operations in the sewage treatment plant etc. can be reckoned in the water/sewerage rates.

Act (2006:412) on Public Water Services, extract

Liability to pay charges for public water services

24 § A property owner shall pay charges for a public water supply and sewerage facility if the real property unit

1. is located within the operational area of the water supply and sewerage facility and
2. having regard to the protection of human health or the environment needs a water service and the need cannot be better provided for in any other way. In assessing the need as referred to in subsection one, point 2, special consideration shall be paid to the extent to which alternatives compared accommodate the interests of good management of natural resources.

25 § A charge as provided in Section 24 shall refer to

1. water services provided to the real property unit through a connection point, from the time when the principal has ordered the connection point and informed the property owner as provided in Section 12, and
2. leading-away of water from the property unit other than through a connection point, from the time when the principal has ordered the devices needed for such leading-off and has informed the property owner thereof.

Size of charges and bases of their computation

29 § Charges as provided in Sections 24-28 are determined as facility charges and user charges.

30 § The charges may not exceed the amount needed to cover the necessary costs of ordering and running the water supply and sewerage facility.

31 § The charges shall be determined in such a way that the costs are reasonably and fairly apportioned between the parties liable to pay them.

If, due to special circumstances, the water services for a particular property or property units entail costs that notably deviate from those of other property units in the operational area, the charges shall be determined according to the differences.

32 § The facility charges shall be determined on computation bases whereby a property owner need not pay more than is commensurate with the property unit's share of the cost of ordering the water supply and sewerage facility.

34 § The amount of the charges and the manner of their computation shall be evident from a tariff. The charges may not be determined at amounts exceeding what is compatible with the provisions of Sections 30-33.

The municipality may issue prescriptions concerning the tariff. The municipality may delegate to the principal determination of the amount of the charges in accordance with bases of calculation in the municipal tariff prescriptions.

Disposal units that are directly connected to the sewage system normally pay an annual fee. In Malmö, 2006, the annual fee excluding VAT was 1,700 SEK/apartment and 3,600 SEK for other users.

Waste management

The handling of waste is regulated in the Environmental Code (1998:808) Chapter 15.

Food waste that arises in households, restaurants, institutional kitchens and the retail trade are included in the municipalities' responsibilities for waste collection and disposal. In addition, fluid waste such as septic sludge, fat separator sludge and latrines also come under the municipalities' responsibility for waste collection and disposal. How this will be managed is determined by the municipality's waste collection and disposal ordinance (RO, local by-laws) that are adopted by the municipal council.

Where the municipality intends to sort out the food waste for biological treatment via disposal units, this should be set forth in the RO.

Waste charges

The Environmental Code (1998:808), excerpt Chap. 27 4–6 §§

Refuse collection charges

Municipalities may issue rules concerning the payment of charges for the collection, transport, recycling and removal of waste that is arranged by them pursuant to this Code or to rules issued in pursuance thereof. The municipality shall decide whether the charges shall be paid to the municipality or to the operator of the refuse collection service.

The Measures against Pollution from Ships Act (1980:424) contains provisions concerning charges for the disposal of waste from ships.

5 § The charges referred to in section 4 first paragraph shall be payable annually or on some other periodical basis. Where the charges relate to occasional collection, transport and removal, the municipality may decide that they shall be payable for each occasion.

The charges shall not exceed the amounts that are sufficient to cover the necessary planning, capital and operating costs of refuse collection and disposal. The cost of using plant or equipment for purposes other than refuse collection shall be deducted from these costs. The charges may be collected in such a way as to encourage reuse, recycling or other environmentally sound waste disposal.

If the municipality contracts refuse collection out to another operator, the charges may be calculated on the basis of the agreement between them, where the cost is not significantly higher than if the municipality were to operate the services itself.

6 § Charges referred to in section 4 first paragraph shall be payable according to the list of rates fixed by the municipal council. The list of rates shall contain a specification of the basis for the calculation of charges not included in the list. The principle referred to in 5 § shall be taken into account. The list of rates shall contain provisions specifying who is liable for the charges and to whom they are payable.

The waste charges shall be designed to cover the costs for collection and treatment of the waste for which the municipality is responsible, as well as waste planning and necessary development.

APPENDIX 3 Overview - Some Swedish municipalities with disposal units

Malmö

Mimi Basement, Waste Coordinator Water/Sewerage Board, 040-34 14 11,

Rickard Engle son Water/Sewerage Engineer 040-34 16 45, Henry Aspirin (tariffs)

The Water and Sewerage Board has the responsibility for Malmö city's drinking water, wastewater and household waste. The Water and Sewerage Board treats the wastewater from Malmö, Burlap, Veiling and areas of Loma, Staffanstorp and Sedalia. Household waste is collected in from Malmö and Burlap. The customer receives a bill, specified for water/sewerage, sludge and refuse collection. Malmö does not consider disposal units, directly connected to the sewer system, as a practicable route due to problems that already exist with overflows. Units connected to sludge separators and output to the sewer system will be expanded, and are presented as one of several alternatives for the separate collection of food waste and refuse collection. The objective is for at least 35% of food waste to be collected for biological treatment by 2010. This implies a total of 10,000 tons food waste in Malmö, including disposal units, will be collected in 2010.

ABVA: 19. Disposal units may only be connected in exceptional cases, if the principal permits it after notification. Where such happens, measures shall be taken to separate organic material. ABVA will be rewritten.

Water/sewerage charges for Kitchen Disposal Units direct to the sewer system: annual fee per residential apartment 1,700 SEK, others 3,000 SEK (excl. VAT). The water and sewerage board does not want disposal units installed without sludge separators. Disposal units connected via sludge separator, see Refuse Collection Tariff. Special agreement for disposal unit + sludge separator - currently they are exempt from the annual fee for disposal units in the water/sewerage charge. The tariff will be changed in light of the new Public Water Services Act.

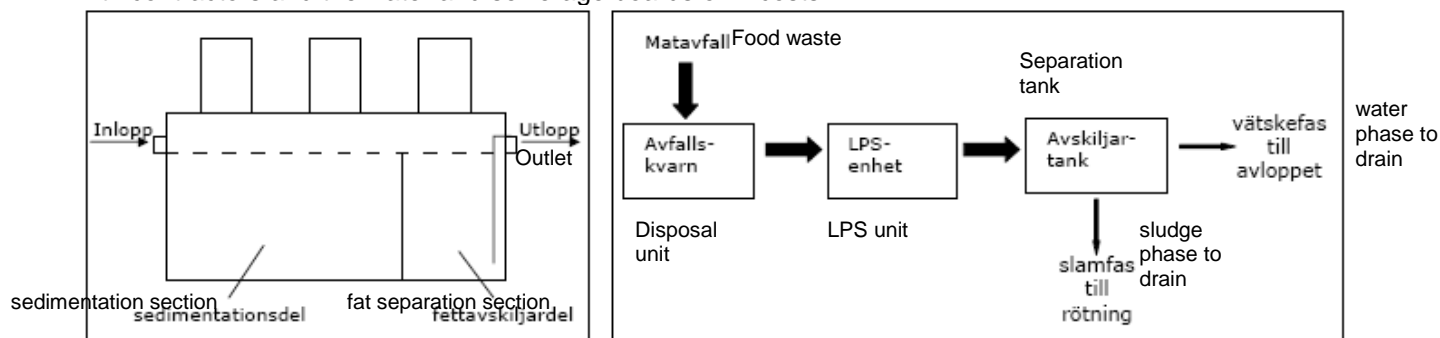
Waste management regulations: The property owner is responsible for installations; food waste is handled according to instructions from the water and sewerage board. Regulations are being prepared (2007). Disposal units are not mentioned in the waste management regulations.

Waste disposal rates: Sludge disposal for overflow tanks is included in Malmö City's Waste Rates 2007:

12.4 Food waste sludge from disposal units

	< 0.5 m ³ (kr/emptying)	< 0.6-1.5 m ³ (kr/emptying)	< 1.6-2.5 m ³ (kr/emptying)	< 2.6-3.5 m ³ (kr/emptying)	< 3.6-4.5 m ³ (kr/emptying)	< 4.6-5.5 m ³ (kr/emptying)
Planned emptying	655	945	1 583	2 228	3 036	3 746

Price for emptying and treating tanks larger than 5.5m³ are calculated based on prevailing contracts with contractors and the water and sewerage boards own costs.



System diagram (Source: Malmö City, Water and Sewerage Board, Final Report Bo01, May 2005)

Agreement between water/sewerage and waste disposal: The waste disposal board charge a fee according to the waste disposal rates for collecting sludge from the separator, and pay as fee to SYSAV, which rents from Malmö's ARV, for the biological treatment/digestion (ca 500 SEK /cubic m, compared to septic sludge that costs ca. 300 SEK(cubic m). SYSAV (a waste treatment company owned by the region's municipalities) has an agreement with Malmö water/sewerage board's sewage treatment plant to use the overcapacity in the digestion chamber for digesting sorted organic waste. SYSAV is responsible for reception and pre-treatment.

Existing disposal units with fat separators

60 apartments in Bo01 (2001-)

147 apartments in Turning Torso (2005-)

Disposal unit in sink in kitchen, with separate drain, via pressurised system, to LPS unit (Bo01) that shreds a second time (second shredding not required - food waste that is too finely shredded does not settle in the separator). Thereafter the sludge is led to a two-part sedimentation and fat separation tank (expanded 3 m³ fat separator of plastic/glass fibre where the sludge section is large and the fat separation section small), whose drain is connected to the sewer system. The sludge sediment and fat is collected every 14 days (Bo01), to every 4 weeks (Turning Torso), by sludge collection tanker for transport to Sjölanda sewage treatment plant, where it is digested.

Sofielund's School, institutional kitchen, with ca. 200 l food waste per day (Jan 2005-)

The kitchen has been equipped with a MicroVac disposal unit, where 6 l of waste is shredded with 2.5 l water in every batch. The sludge is led to a 4 m³ tank, where it is dewatered. The surplus water is led to the kitchen's fat separator, which is connected to the sewage system. The interval between emptying has varied from every 10 to every 6 weeks, due to problems with too thick a sediment and dry crusts.

Report "Collection of food waste in Sofielund's school" Malmö City/SYSAV Utveckling AB, can be found on the web site for the Water and Sewerage Board.

The property owner owns and is responsible for the maintenance of the unit.

Where is the connection point - before or after the fat separator?

Bo01 - the LPS unit and the sludge separator are located within the municipality's land and responsibility (trial project) Turning Torso - the connection point is located after the sludge separator. The fixed subscription for sludge collection is with waste disposal.

Surahammar

Per Andersson, Surahammar's Kommunalteknik AB, 0220-467 14

Surahammar's Kommunalteknik AB is owned by the municipality. The business includes the production of district heating, sales of electricity, water supply and sewerage as well as waste management.

ABVA 94: 15. Disposal units may only be installed if this is granted by the water and sewerage board after an application. (The approval is tied to the property, irrespective of the owner.)

Water and Sewerage Rates: There are no rates charged the subscriber for disposal units.

Waste disposal rates: the installation of kitchen disposal units is paid for by the property owner. Fixed fee/unit in 8 years: 320-528 SEK/year excl. VAT. After eight years, there is no charge. Where problems then arise, a new agreement can be signed for eight years and a new unit supplied, including service and support for a fixed annual cost.

In the calculation of the rate, a part of the costs for the mill is redistributed for the costs of the green rubbish bin.

Leasing agreement: a charge is paid for eight years. After eight years, the unit is transferred to the property. If it is desired to have continued service, an agreement on this can be drawn up.

The rates stimulate the use of disposal units. Under point 2.4, Separate agreement "the option is provided for the waste producer to separately sign an agreement with SKT concerning the installation of disposal units in blocks of flats." (This applies to a service contract with telephone and technical support.)

Waste collection regulations: 14. The household's organic waste. The organic part of the household waste may be shredded in a disposal unit installed within the property (requires connection to the public wastewater system). The disposal unit shall be of a type approved by SKT.

Agreement between Water/Sewerage and Waste Disposal A SKT board decision that money can be transferred from the income of the Waste Disposal Rate to the Water/Sewerage side in order for the waste to use the existing pipe system for transport and treatment.

Existing units:

1,260 disposal units in houses

724 disposal units in blocks of flats. Units introduced 1997-1998.

The number increases by ca. 65 per year. Corresponds to > 43% of households. Blocks of flats from the 40s and 50s that have not renovated their services cannot have units because of poor drainpipes, but as soon as the renovation takes place, they connect themselves, if the sewer system is suitable.

Staffanstorp

Lasse Karlsson 046-25 12 35, Olle Nilsson 046-25 14 30,

Staffanstorp is a small commuter municipality to Malmö. The Technical Committee's main tasks are to handle issues concerning streets, roads, parks and other public places, water and sewage treatment plants, waste disposal and public district heating. The household waste is treated by the regional company SYSAV, and wastewater from the area with disposal units is directed to Staffanstorp's sewage treatment plant.

ABVA 97: 8. Disposal units may only be installed if this is permitted by the water and sewerage board after an application.

Water and Sewerage Rates: There are no rates charged the subscriber for disposal units.

Waste collection regulations: Disposal units are not mentioned.

Waste disposal rates: Disposal units are not mentioned.

Agreement between Water/Sewerage and Waste Disposal: There is not one. The area is a trial area.

Existing units:

100 disposal units in the, then, newly built apartments in Housing Association Glasförgyllaren (1987-), there are now ca. 50-60 units remaining. The area is located close to Staffanstorp's sewage treatment plant. The digester sludge from the sewage treatment plant goes to agricultural uses.

Lasse Karlsson: The units that are still in use are now over 20 years old. If there had been service for the units and maybe another arrangement than that every apartment bought its own unit (but did not see its waste costs affected), there would probably be more units. The municipality does not market the units at all. There has never been any problem with blockages in the sewer system from the connection point to the sewage treatment plant.

Information to Users - example

YOU WHO HAVE A DISPOSAL UNIT

DO AS FOLLOWS:

Start by removing the plug/protective cover so you can see into the unit

- Flush with cold water
- Place the food waste in the unit
- Start the unit, which can be in one of two ways, depending on the model

A) with the switch

B) If there is not a switch, the unit is started by placing the protective cover in the unit. (Read the operating instructions.)

- Switch of the unit, by either using the switch or removing the protective cover
- Turn off the water

TIPS:

The unit makes a lot of noise and must work a long time when some types of material are to be shredded. Try flushing with more water or place material that is difficult to shred in the normal rubbish.

Examples of things that are difficult to shred are large bones from meat, fowl and fish as well as fibre-rich vegetables, beans and cornhusks. In order to shred things faster, cut corncobs, melon, grapefruit and banana peel into smaller pieces before shredding.

Avoid shredding larger quantities of fat, dough as well as long fish bones and sinews.

The most common reasons for stoppages are rectified by rotating the disk, for example, with the handle of a wooden spoon and plucking out objects with long-handled tongs.

NOTE:

The disposal unit is not dangerous to use, but read through the operating instructions carefully.

WHAT HAPPENS NEXT? The food waste is collected in buried tanks (not the same as the rubbish vacuum system). At regular intervals, it is sucked out by tanker and transported to Sjölund, where it is digested. It is important for the process that there are no contaminants in the food waste.

Instructions from the Water and Sewerage Board in Malmö for sorting at source in the Bo01 area.

Shreds in the unit Fish guts, vegetables, prawn shells, fruit, potato, eggshell Bread, biscuits Smaller meat, poultry and fish bone Kitchen paper and coffee filters "Soft" food waste	NOT in the unit Sinews and long fish bones Long-fibre vegetables - cornhusks, banana peel, celery, rhubarb (if this is not cut into shorter bits first) string, net Mussel and oyster shells Large meat bones, chop bones Large quantities of fat, dough
--	--

Information from Surahammar, where Disperator installed disposal unit model 78 with power 0.55-0.65 kW.

Model 78 food waste disposal unit

Operating Instructions

1. What can I shred in the unit?

Fish guts, vegetables, prawn shells, fruit, potato, eggshell
smaller meat, poultry and fish bone
household paper (not waxed) and coffee filters
other "soft" food waste

Tips: Banana peel is easier to shred if it is cut into pieces.

2. What can I NOT shred in the unit?

- * Sinews and long fish skin
- * vegetables with long fibres e.g. cornhusks
- * mussel and oyster shells
- * large meat bones, egg, chop bones
- * large quantities of fat and dough

3. What must not be placed/poured in the unit?

- * Explosive material
- * infectious
- * chemical, environmentally hazardous substances
- * glass, plastic, nappies, cloth, string and suchlike
- * hot water exceeding 60°C

4. This is how you run the food disposal unit

- * Remove the unit's protective cover.
- * Turn on the cold water.
- * Push in the food remains in the unit, do not over fill.
 - * Start the unit by replacing the protective cover. Lift the cover a little, to allow water through and turn fully (90°) to the right or left.
- * When the shredding is finished, the unit's empty running sound is heard. Wait 5-10 sec.
- * Switch off the unit by turning the protective cover back.
- * Turn off the water

Tips: For "drier" and "denser" food waste, take smaller batches at a time.

NOTE! If you have a dishwasher connected to the unit, ensure that the unit IS EMPTY before you start the dishwasher.

5. WARNING

- Rotating disk below the unit's inlet. Do not stick your hand or other objects in during operation!
- When the protective cover is removed, the unit should stop. If this does not happen, stop, disconnect the unit's plug from the mains socket. Call service.
- An earth current breaker shall always be connected as protection for the unit.

6. Maintenance

Make sure that the unit is emptied of leftover food after each use. After washing the dishes, please let the water with washing-up liquid flush out the unit. Before longer breaks in service (e.g. holidays), pour a little food oil in the unit and let it run empty, without water, for 10 sec.

7. Simpler fault finding and repairs

Cut the current to the machine, by pulling the plug from the mains socket and remove the fuse in the fuse box.

a) The unit makes a strange noise

Use tongs and pluck out the non-shreddable object from the unit. Reconnect the power and test start.

b) The unit slows down, stops or does not start. A droning sound can be heard from the motor.

Place the Allen key in the central hole in the bottom of the unit. Turn the key backwards and forwards, until it can be turned a full turn without resistance. See the figure to the left, below.

Wait 5 minutes, and then press the reset button on the bottom of the unit. See the figure to the right, below. Check that the fuse in the fuse box is OK. Continue as per point a) above.

c) If the fault remains, call authorised service personnel, local representative or contact Disperator.

Disperator AB -Box 2133 -128 23 Skarpnäck
Tel: 08-724 01 60 Fax: 08-724 60 70
E-mail: info@disperator.se

Doc. ref: Oper78/Sv/040101
Year of manufacture: 2004

Instructions from Disperator for batch fed disposal unit.

APPENDIX 4 Environmental objectives

National environmental objectives

After a decision in Parliament, 2005, Sweden has 16 objectives for environmental quality and 72 sub-objectives. The Environmental Objectives Council's report from June 2006, as in previous years, contained an assessment of the environmental objectives and sub-objectives. In order to achieve the objectives, efforts are required from everyone in all sections of society: authorities, municipalities and industry as well as organisations and consumers. The international environmental efforts are also very decisive. The 16 Swedish environmental quality objectives are listed in the table below. The relevant sub-objectives for this project have been written down. The most relevant environmental quality objective is no 15, sub-objective 5, but the other objectives that concern the recipients and atmospheric releases are also indirectly relevant.

The environmental objectives are not legally binding, but instead are set at a national level.

Environmental objective (source: http://miljomal.nu/)	Sub-objective description	Relevance for disposal units
1. Reduced climate impact	Sub-objective 1. The Swedish emissions of greenhouse gases, as a average for the period 2008-2012, shall be at least 4% lower than the emissions in the year 1990. The emissions shall be reckoned as carbon dioxide equivalents and include the six greenhouse gases according to the Kyoto Protocol and the IPCC's definitions.	Less transp. work?
2. Clean air		Better than composting?
3. Natural acidification only	Emission of nitrogen oxides	Transp.?
4. A non-toxic environment		Transp?
5. A protective ozone layer		NO?
6. A safe radiation environment		NO?
7. Zero eutrophication	1. Up to the year 2010, the Swedish water borne releases of phosphorus pollutants from human activities to lakes, streams and coastal waters shall have been reduced by at least 20% from the year 1995's levels. The greatest reductions shall occur in the most sensitive areas.	NO
8. Flourishing lakes and streams	2. Up to the year 2010, the Swedish water borne releases of nitrogen pollutants from human activities to the sea to the south of the Åland's sea shall have been reduced by at least 30 % from the levels in the year 1995.	Daniel?
9. Good quality ground water	3. By the year 2010, at the latest, the emissions of ammonia in Sweden shall have been reduced by at least 15% from the levels in the year 1995.	NO?
10. A balanced marine environment	4. By the year 2010, at the latest, the emissions of nitrogen oxides to the atmosphere shall have been reduced to 148,000 ton.	NO

Environmental objective (source: http://miljomal.nu/)	Sub-objective description	Relevance for disposal units
11. Thriving wetlands	Lakes and streams shall be ecologically sustainable, and their wealth of habitats shall be preserved. Natural production capacity, biological diversity, cultural milieu value as well as the landscapes ecological and water resource function shall be conserved, at the same time as the conditions for outdoor leisure activities are protected. The aim is that the environmental quality objective shall be achieved within a generation. Land and water. The aim is to achieve the environmental quality objective within a generation.	NO mainly aimed at fishing
12. Sustainable forests		NO
13. A varied agricultural landscape	The North Sea and the Baltic shall have a long-term sustainable production capability and the biological diversity shall be preserved. The coast and archipelago shall have a high degree of biological diversity, offer a wealth of experience as well as natural and cultural value. Commerce, recreation and other use of sea, coast and archipelago shall be run in a way that promotes sustainable development. Especially valuable areas shall be protected against interference and other disturbances. The aim is to achieve the environmental quality objective within a generation.	NO
14. A magnificent mountain landscape		Sludge?
15. A good built environment		NO
16. A rich diversity of plant and animal life	The value of land for crops and agricultural use has for biological production, and the production of foodstuffs, shall be protected at the same time as the biological diversity and the cultural milieu values are preserved and strengthened. The aim is to achieve the environmental quality objective within a generation.	
		YES
	Waste	
	5. The total quantity of waste generated shall not increase and the resource constituted by waste shall be utilised to as high a degree as possible at the same time as the influences and risks to health and the environment are minimised. In particular, it applies that:	
	- The quantity of landfill waste, excluding mining waste, shall be reduced by at least 50 per cent by 2005, based on 1994's levels.	NO
	- By 2010, at the latest, a minimum of 50 per cent of household waste shall be recycled by reuse of material, including biological treatment.	

Environmental objective (source: http://miljomal.nu/)	Sub-objective description	Relevance for disposal units
	- By 2010, at the latest, at least 35 per cent of food waste from households, restaurants, institutional kitchens and shops shall be recycled by biological treatment. The objective refers to sorted food waste for home composting as well as central treatment.	YES - how to measure?
	- By 2010, at the latest, food waste and thereby equivalent waste from the foodstuff industries etc. shall be recycled by biological treatment. The objective concerns such waste that arises without being mixed with other waste and is of such a quality that it is suitable after treatment for use as plant nutrient.	
	- By 2015, at the latest, a minimum of 60 per cent of phosphorus contaminants in wastewater shall be returned to productive land, whereof at least half shall be returned to arable land.	YES
	The biological diversity on land and in water is followed up and maintained.	
		YES?/CLEAN handling return
		NO Saltsjön?

Regional environmental objectives for the County of Stockholm

(source: official website <http://miljomal.nu>, regional objectives, Stockholm's county, updated 2006-11-29)

The county administrative boards have an general and coordinating role in the efforts with the environmental objectives as regional environmental authorities. Thereby, the county administrative boards have the responsibility regionally to adapt and specify all environmental quality objectives, with the exception of Sustainable Forests.

Relevant regional objectives, excerpt from the Environmental Objectives Portal:

Reduced climate impact

Reduced emissions of greenhouse gases. The emission of carbon dioxide in the country per person annually shall be reduced to 3.1 ton by 2010. (Regionalised objective)

Natural acidification only (indirect biogas in vehicles)

Reduced emissions of nitrogen oxides. The total emission of nitrogen oxides in the County of Stockholm shall be reduced by 60 per cent, from 1995's level, to 16,000 ton in the year 2010, and the transport sector's emission by 70 per cent, from 1995's level, to 9,000 ton in 2010.

(Regionalised objective)

Zero eutrophication

Reduced phosphorus emissions. The emission of phosphorus from human activities to the county's coastal waters shall be reduced by 15 per cent, from 1995's level, to 90 ton by 2010. (Regionalised objective)

Phosphorus concentrations in wastewater. From all of the county's sewage treatment plants, irrespective of size, the outgoing phosphorus concentration in the treated wastewater shall normally not exceed 0.3 mg/l. (Regionalised objective)

Emission from overflows. The release of untreated wastewater via overflows from the county's sewage treatment plants, from and including the year 2010, shall not exceed 1 per cent of the total releases of wastewater. (County's own objective)

Reduced emissions of nitrogen oxides. The emission of nitrogen from human activities to the county's coastal waters shall be reduced by 45 per cent, from 1995's level, to 2,900 ton by 2010. (Regionalised objective)

Reduced emissions of ammonia. The emission of ammonia in the county shall be reduced by at least 15 per cent, from 1995's level, by 2010.

A good built environment

Lower quantities of landfill waste. The quantity of landfill waste in the county shall be reduced by at least 50 per cent by 2010, based on the quantity of landfill in 1994, in proportion to the population and industrial activity. (Regionalised objective)

Recycling of waste from households, restaurants, institutional kitchens and shops. By 2010, at the latest, at least 35 per cent of food waste from households, restaurants, institutional kitchens and shops in the county shall be recycled by biological treatment.

Recycling of waste from the foodstuff industries.

Food waste and thereby equivalent waste from the foodstuff industries etc. in the county shall be recycled by biological treatment, by the year 2010 at the latest.

Relevant objectives - excerpt from Stockholm's environmental programme 2008-2011

Objective 5 Environmentally effective waste management

Sub-objective 5.2 The quantity of waste that is utilised, including biological treatment, from the city's activities is increased. At least 35% of food waste from the city's own activities is sorted out for biological treatment.

Sub-objective 5.3 The quantity of waste per Stockholm inhabitant is reduced as well as the waste quantity that is utilised increases. 35% of food waste from restaurants and shops is treated biologically.

35% of the food waste from restaurants and shops is treated biologically.

APPENDIX 5 Literature

Chapters 1 - 3

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- Ecoloop rapport 2005004, Systemstudie rörande insamling och behandling av lättnedbrytbart organiskt avfall i Malmö.
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Appendix 6 Sewer system

DUF area DUF	PARAMETER FLOW TIME	RATS	SMEL L	HYDRAULIC	ALL	INDIVID. GRADE FLOW TIME	RATS	SMELL	HYDRAULIC	ALL	TOTAL GRADE MEAN VALUE	TOTAL GRADE
412	1.00	0	1	143	141	1.00	1.00	0.001	0	0	0.00	0
417	2.00	0	2	175	161	1.00	0.010	0.003	0	0	0.04	0
462	1.00	0	0	144	152	1.00	0.020	1.00	0	0	0.00	0
500	1.21	0	4	125	100	1.00	1.00	0.001	0	0	0.00	0
512	12.2	0	0	7	0	0	1.00	1.00	1.00	1.00	0.00	0
616	2.01	0	2	100	102	1.00	1.00	0.003	0	0	0.01	0
712	0.101	0	0	230	200	1.00	0.020	0.003	0	0	0.44	0
715	12.4	0	0	15	17	0	1.00	1.00	1.00	1.00	0.00	0
802	3.14	0	1	112	120	1.00	1.00	0.010	0	0	0.00	0
812	12.4	2	0	4	7	0	0.100	1.00	1.00	1.00	0.10	0
865	12.3	0	0	7	11	0	1.00	1.00	1.00	1.00	0.00	0
864	12.1	0	0	3	4	0	1.00	1.00	1.00	1.00	0.00	0
910	3.04	1	3	112	123	1.00	0.010	0.100	0	0	0.00	0
101	0.12	0	1	105	112	0.210	1.00	0.010	0	0	0.40	0
622	10.8	0	1	120	102	0.200	1.00	0.010	0	0	0.42	0
717	0.103	2	0	07	102	1.00	0.100	1.00	0	0.0010	0.01	0
861	12.0	0	0	10	10	0	1.00	1.00	1.00	1.00	0.00	0
210	12.3	0	1	1	3	0	1.00	0.010	1.00	1.00	0.10	0
702	10.0	2	0	08	00	0.0010	0.100	1.00	0.100	0.100	0.41	0.010
700	10.0	1	1	07	00	0.0010	0.010	0.010	0.100	0.100	0.42	0.010
104	3.40	1	1	00	00	1.00	0.010	0.010	0.010	0.100	0.00	0.010
101	3.02	0	4	07	102	1.00	1.00	0.001	0.100	0.100	0.00	0.000
102	3.03	0	0	00	00	1.00	1.00	1.00	0.001	0.100	0.01	0.010
462	1.00	2	0	00	00	1.00	0.100	1.00	0.001	0.100	0.40	0.000
462	10.0	0	0	10	23	0.0010	1.00	1.00	1.00	1.00	0.01	0.000
442	10.1	1	0	5	0	0.0010	0.010	1.00	1.00	1.00	0.10	0.10
621	10.0	0	1	02	00	0.100	1.00	0.010	0.100	0.100	0.01	0.10
622	10.4	4	1	20	24	0.0010	0.00	0.010	0.001	0.000	0.00	0.10
112	0.00	0	0	00	01	0.001	1.00	1.00	0.210	0.200	0.01	0.10
621	10.3	0	0	02	00	0.100	1.00	1.00	0.401	0.000	0.00	0.10
720	1.24	0	4	15	07	1.00	1.00	0.001	0.200	0.100	0.02	0.10
860	1.17	0	3	02	07	1.00	1.00	0.100	0.100	0.200	0.00	0.10
702	0.000	1	2	10	02	1.00	0.010	0.003	0.200	0.200	0.00	0.10
461	1.01	0	1	00	02	1.00	1.00	0.010	0.210	0.000	0.10	0.10
860	1.20	0	1	14	00	1.00	0.020	0.010	0.000	0.010	0.00	0.10
802	4.02	0	0	10	01	1.00	1.00	1.00	0.210	0.000	0.10	0.10
812	10.0	0	0	0	0	0.100	1.00	1.00	1.00	1.00	0.00	0.10
814	10.0	0	0	3	0	0.200	1.00	1.00	1.00	1.00	0.00	0.10
810	3.21	0	2	12	20	1.00	0.020	0.003	0.020	0.400	0.00	0.10
810	10.1	0	0	0	0	0.210	1.00	1.00	1.00	1.00	0.00	0.10
722	1.10	0	1	00	01	1.00	1.00	0.010	0.010	0.003	0.10	0.10
720	2.00	0	0	00	01	1.00	1.00	0.001	0.001	0.003	0.00	0.10
810	10.0	0	1	24	20	0.240	1.00	0.010	0.010	0.020	0.10	0.10
112	10.4	0	0	10	10	0.200	1.00	1.00	1.00	1.00	0.00	0.10
812	10.2	0	1	1	2	0.001	1.00	0.010	1.00	1.00	0.00	0.10
811	10.2	0	0	7	7	0.001	1.00	1.00	1.00	1.00	0.00	0.10
810	10.1	0	0	0	2	0.110	1.00	1.00	1.00	1.00	0.00	0.10
810	10.0	0	0	0	0	0.010	1.00	1.00	1.00	1.00	0.00	0.10
810	10.0	0	2	00	00	1.00	0.020	0.003	0.000	0.000	0.10	0.10
800	0.02	0	0	0	0	0.040	1.00	1.00	1.00	1.00	0.00	0.01
800	0.00	0	0	3	4	0.010	1.00	1.00	1.00	1.00	0.00	0.01
702	0.000	2	2	07	07	1.00	0.100	0.003	0.040	0.003	0.10	0.01
802	0.10	0	0	1	1	0.210	1.00	1.00	1.00	1.00	0.00	0.00
800	0.00	0	0	3	4	0.001	1.00	1.00	1.00	1.00	0.00	0.01
800	0.00	0	0	5	0	0.010	1.00	1.00	1.00	1.00	0.00	0.01
720	1.00	1	4	00	00	1.00	0.010	0.001	0.000	0.000	0.10	0.00
810	2.00	0	0	04	00	1.00	0.020	1.00	0.001	0.000	0.10	0.01
801	0.04	0	1	5	7	0.410	1.00	0.010	1.00	1.00	0.00	0.01
804	0.100	0	0	10	11	1.00	0.020	0.000	1.00	0.000	0.00	0.01
802	0.00	0	0	3	4	0.410	1.00	1.00	1.00	1.00	0.00	0.00
810	0.40	0	0	0	0	0.410	1.00	1.00	1.00	1.00	0.00	0.00
802	1.02	0	1	02	01	1.00	1.00	0.010	0.010	0.000	0.01	0.00
802	0.40	0	0	0	0	0.410	1.00	1.00	1.00	1.00	0.00	0.00
800	0.21	0	1	1	4	0.400	1.00	0.010	1.00	1.00	0.10	0.10
114	0.10	0	0	0	2	0.410	1.00	1.00	1.00	1.00	0.00	0.10
700	0.001	0	4	40	04	1.00	1.00	0.001	0.010	0.100	0.01	0.10
701	0.070	2	0	00	00	1.00	0.100	1.00	0.040	0.010	0.01	0.10
420	1.01	0	0	10	00	1.00	1.00	1.00	0.000	0.010	0.00	0.10
800	1.00	0	4	40	11	1.00	1.00	0.001	0.100	0.100	0.02	0.10
700	3.07	0	0	0	12	1.00	1.00	0.000	1.00	1.00	0.00	0.10
100	3.10	0	2	40	00	1.00	1.00	0.003	0.100	0.100	0.00	0.01
310	1.10	2	4	0	10	1.00	0.100	0.001	1.00	1.00	0.00	0.01
102	3.20	1	0	40	40	1.00	0.010	1.00	0.210	0.100	0.00	0.01
121	0.42	0	0	10	11	0.000	1.00	1.00	1.00	1.00	0.00	0.01
121	0.42	0	0	0	0	0.001	1.00	1.00	1.00	1.00	0.00	0.00
860	1.00	0	2	40	41	1.00	1.00	0.003	0.100	0.100	0.01	0.00
311	2.00	0	0	10	10	1.00	0.020	1.00	1.00	1.00	0.00	0.01
860	1.10	0	1	40	40	1.00	1.00	0.010	0.100	0.000	0.00	0.00
420	2.00	0	1	40	40	1.00	1.00	0.010	0.100	0.000	0.00	0.00
720	1.00	0	4	14	20	1.00	1.00	0.001	1.00	0.000	0.01	0.00
301	1.42	1	3	20	44	1.00	0.010	0.100	1.00	0.020	0.00	0.00
141	0.10	0	0	0	0	0.040	1.00	1.00	1.00	1.00	0.00	0.00
304	0.011	0	4	20	31	1.00	1.00	0.001	1.00	0.000	0.00	0.00
302	0.040	0	4	10	24	1.00	1.00	0.001	1.00	1.00	0.00	0.00
700	2.40	0	4	17	21	1.00	1.00	0.001	1.00	1.00	0.00	0.00
302	1.10	0	4	17	20	1.00	1.00	0.001	1.00	1.00	0.00	0.00
710	0.410	0	3	24	20	1.00	1.00	0.100	0.010	0.000	0.00	0.00
811	1.10	2	2	20	20	1.00	0.100	0.003	1.00	1.00	0.00	0.00
340	1.21	1	0	20	00	1.00	0.010	1.00	0.040	0.100	0.01	0.00
302	1.00	2	0	27	40	1.00	0.100	1.00	0.010	0.010	0.00	0.00
710	1.21	1	3	24	20	1.00	0.010	0.100	1.00	1.00	0.00	0.00
842	2.40	0	0	40	42	1.00	1.00	1.00	0.100	0.000	0.00	0.00
340	1.21	2	1	11	21	1.00	0.100	0.010	1.00	1.00	0.00	0.00
710	0.004	0	0	20	44	1.00	1.00	1.00	0.010	0.020	0.00	0.00
810	1.00	0	3	24	20	1.00	1.00	0.100	1.00	1.00	0.00	0.00
820	2.00	2	0	2	0	1.00	0.100	1.00	1.00	1.00	0.00	0.00
314	1.00	1	2	12	23	1.00	0.010	0.003	1.00	1.00	0.00	0.00
312	1.10	1	2	10	20	1.00	0.010	0.003	1.00	1.00	0.00	0.00
300	0.004	1	2	1	0	1.00	0.010	0.003	1.00	1.00	0.00	0.00
804	2.10	0	2	20	23	1.00	1.00	0.003	1.00	0.003	0.00	0.00
700	2.01	0	2	10	22	1.00	1.00	0.003	1.00	0.010	0.00	0.00
840	1.01	1	1	10	21	1.00	0.010	0.010	1.00	1.00	0.00	0.00
810	0.010	1	1	10	22	1.00	0.010	0.010	1.00	1.00	0.00	0.00
805	0.004	1	1	0	12	1.00	0.010	0.010	1.00	1.00	0.00	0.00
301	0.001	1	1	0	14	1.00	0.010	0.010	1.00	1.00	0.00	0.00
801	2.00	0	2	0	4	1.00	1.00	0.003	1.00	1.00	0.00	0.00
700	0.003	0	2	20	22	1.00	1.00	0.003	1.00	1.00	0.00	0.00

[illegible]

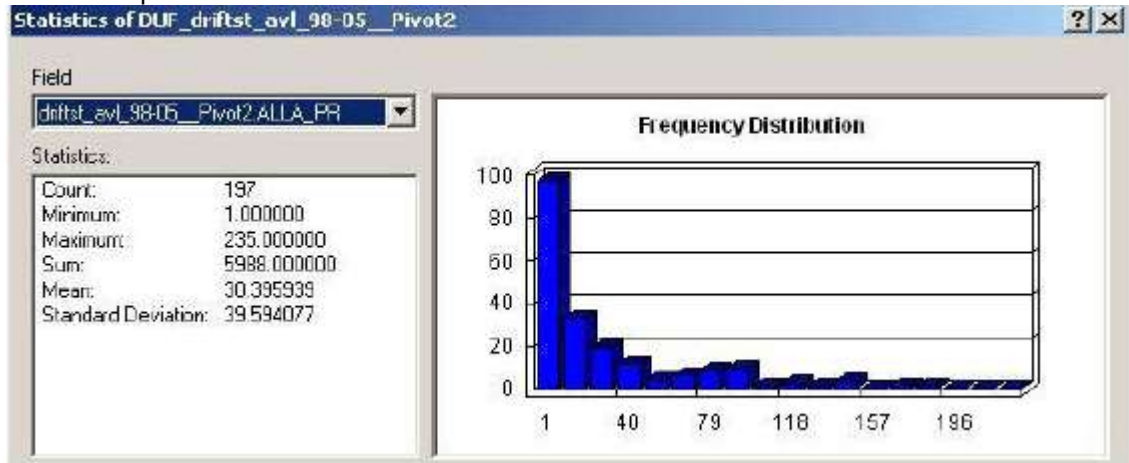
[illegible]

Appendix 7 Disturbances in Operations

Disturbances in operations 98-05 all disturbances

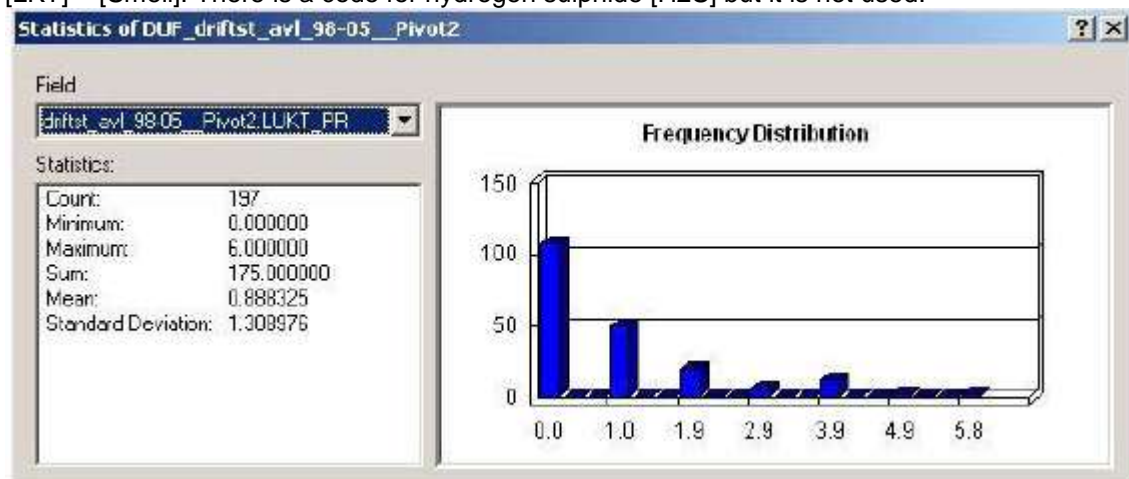
[AUT] + [BRD] + [DAF] + [DIN] + [DLU] + [DPK] + [DRI] + [DUT] + [DÄM] + [ELU] +
[EST] + [FAN] + [FBE] + [FBL] + [FEL] + [FET] + [FOF] + [FPA] + [FRF] + [FRÄ] +
[FTJ] + [HYP] + [IND] + [INF] + [JOB] + [KON] + [KRO] + [KÖV] + [LKT] + [MAS] +
[MÖV] + [OFE] + [OOR] + [PAJ] + [PST] + [PUS] + [RBR] + [ROT] + [RÄT] + [SED] +
[STO] + [SVA] + [SYS] + [UTL] + [VFR] + [ÖPR] + [ÖST] + [ÖVE]

= For an explanation of the codes we refer to VABAS documentation.



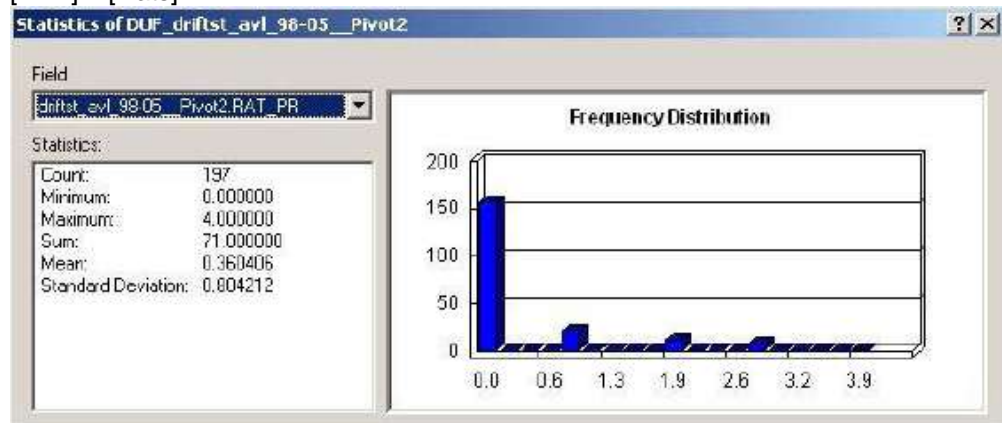
Smell problems

[LKT] = [Smell]. There is a code for hydrogen sulphide [H2S] but it is not used.



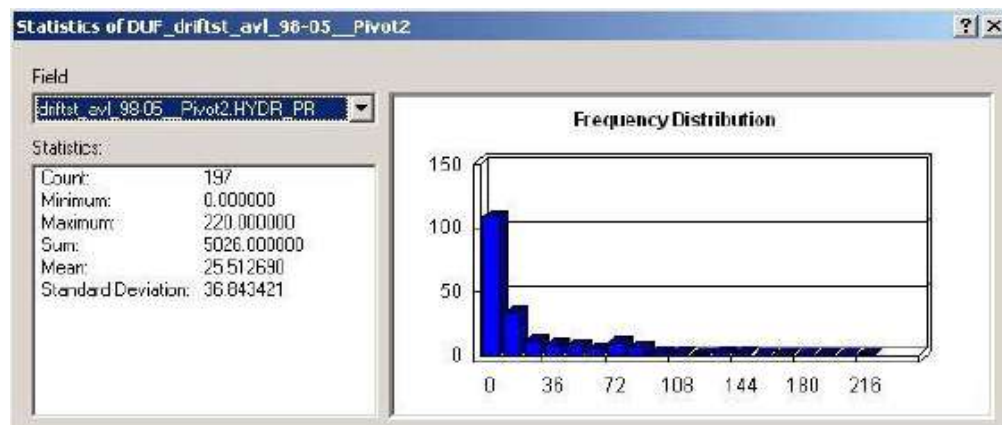
Rat problem

[RÅT] = [Rats]



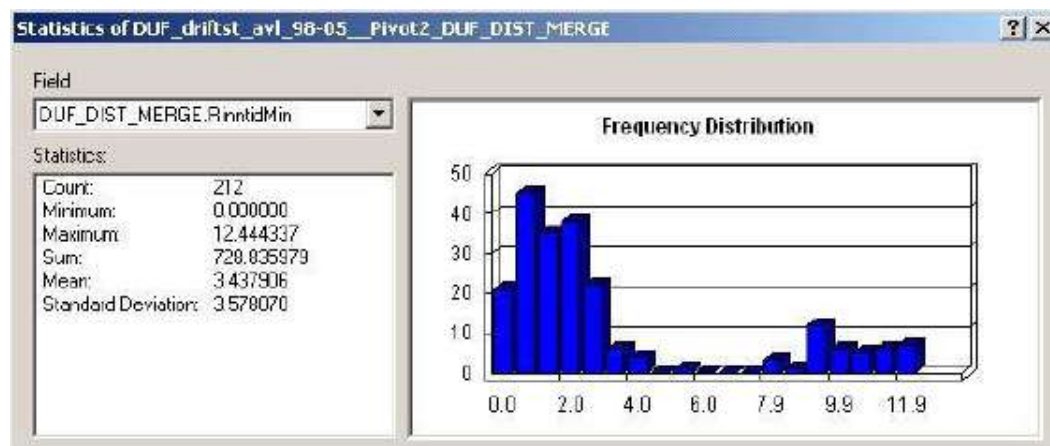
Hydraulic problems

[STO] + [DLU] + [FET] + [FTJ] + [SED] + [VFR] + [DÄM] + [KÖV] + [MÖV] + [ÖVE] + [SVA] =
[Sewer blockage]+[poor gradient]+[fat]+[freezing as result of ground frost]+[sedimentation]+[water leakage]+[damming]+[cellar flooding]+[land floods]+[overflow]+[cracks in pipes.]

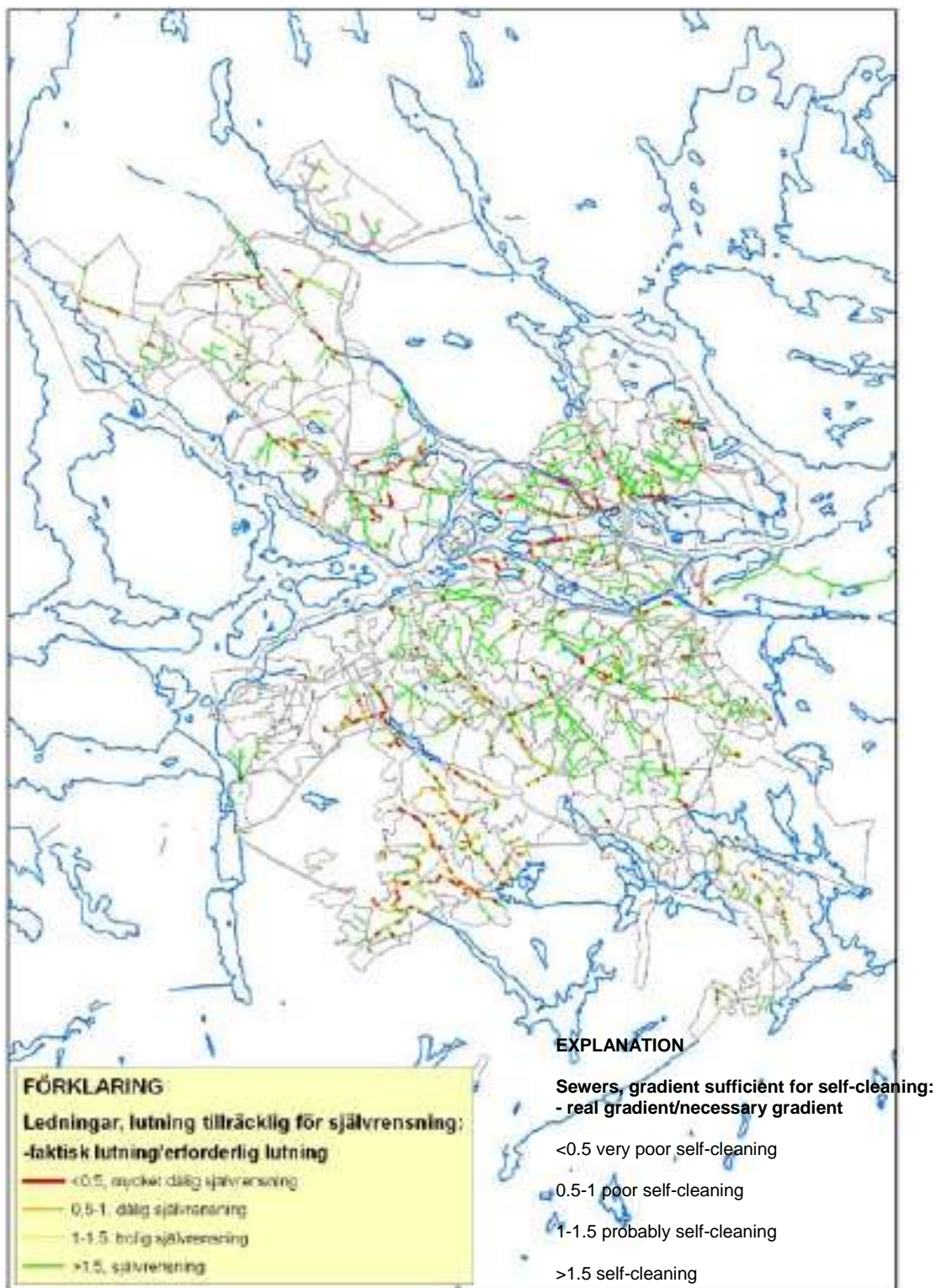


Flow time

Estimated based on a flow velocity of 1 m/s, for distance, as the crow flies to the treatment plant. The distance has been corrected by a factor of the square root of two, to take into consideration that the sewers often do not run straight but rather in perpendicular curves.



APPENDIX 8 Sewer gradients



The map shows that actual gradients of the sewer system compared with the gradient required for self-cleaning. To study the necessary gradient for self-cleaning, a rule of thumb given in Swedish Water's publication p90 was used. The rule of thumb states that the gradient shall be greater or equal to $1/\text{diameter}$ (in mm) in order to fulfil the requirements for self-cleaning. In reality, the self-cleaning is also dependent on how great the flow is in the sewer.

Appendix 9 Basis for the calculations

Cleaning effect

Cleaning effect pre-sedimentation, calculated with data from WASTE 2005

	Bromma In (mg/l)	Bromma FV (mg/l)	Bromma Red	Hdal In (mg/l)	Hdal FV (mg/l)	Hdal Red
SS	197	99.9	0.494	314	126	0.59
BOD	137	79.7	0.421	244	109	0.539
TOC,v	85	53.9	0.364	138	71.2	0.484
NH4-N	19.9	24.3	-0.22464	28	28	0.000
tot-N	29.2	31	-0,065	43.1	36.3	0.155

Cleaning effect treatment plant, Environmental report 2005

	Bromma In (mg/l)	Bromma Ut (mg/l)	Bromma Red, %	Hdal In	Hdal Ut (mg/l)	Hdal Red, %
NH4-N	19	3.1	84	28	1.200	96
tot-N	28	13	53	42	7.4	82

Purification effect with 10% KDU (based on data from 2005 and that the carbon source is limiting)

	Bromma In (mg/l)	Bromma Ut (mg/l)	Bromma Red, %	Hdal In	Hdal Ut (mg/l)	Hdal Red, %
tot-N	28.2	12.5	55.8	42.3	6.7	84.1

Purification effect with 50 % KDU (based on data from 2005 and that the carbon source is limiting)

	Bromma In (mg/l)	Bromma Ut (mg/l)	Bromma Red, %	Hdal In	Hdal Ut (mg/l)	Hdal Red, %
tot-N	29.1	10.4	64.2	43.7	4.1	90.7

Purification effect with 10% KDU (based on data from 2005 and that the maximum degree of reduction is obtained)

	Bromma In (mg/l)	Bromma Ut (mg/l)	Bromma Red, %	Hdal In	Hdal Ut (mg/l)	Hdal Red, %
tot-N	28.2	13.3	53.0	42.3	7.6	82.0

Purification effect with 50 % KDU (based on data from 2005 and that the maximum degree of reduction is obtained)

	Bromma In (mg/l)	Bromma Ut (mg/l)	Bromma Red, %	Hdal In	Hdal Ut (mg/l)	Hdal Red, %
tot-N	29.1	13.7	53.0	43.7	7.9	82.0

Henriksdal's sewage treatment plant

Data from UW report 2005:6		UW data				estimated from UW data				
Parameter	Household waste water without KDU (kg/p/year)	Organic material total quantity (kg/p/year)	Organic material via KDU household + restaurant (kg/p/year)	Organic material via KDU and PS to RK (kg/p/year). 100 % KDU	Gas production from KDU via PS Nm3 CH4/p, year (100% KDU)	Organic material via KDU and PS to sludge (kg/p/year) . 100 % KDU	Organic material via KDU to bio (kg/p/year). 100 % KDU	Organic material via KDU and ÖS to RK (kg/p/year). 100 % KDU	Gas production from KDU via ÖS Nm3 CH4/p, year (100% KDU)	Organic material via KDU and PS to sludge (kg/p/year). 100 % KDU
wet weight		80,41	53,87							
TS	53	25	16,75	9,88		3,66				3,72
SS										
VS	35	21	14,07	8,3		2,08	5,77		1,73	1,3
FS (=TS_VS)		4	2,68	1,58					2,42	
TOC										
CODtot	49,28	34	22,78	11,29			11,49		3,45	
CODfilt	14,42	-								
CODpart	34,86	34	22,78				4,06			
BOD7	27	12	8,04	3,98			0,2			
Ntot	5,1	0,6	0,4							
Ptot	0,76	0,1	0,07				20			
biogas production					2,96				0,3	
BOD/N	5,3	20					56,7			
change %										
COD/N	9,7	56,7								
change, %										
Action										
No. connected (estimated)	705,88235	1000+ connected estimated from nitrogen load								
Proportion of organic material that goes by KDU	0,67	Water/Sewerage Research report 1999-9								
Proportion of COD that reduces in sewers	0									
Proportion of COD lost at sewage works	0,16	from Staffanstorp								
Proportion of CODpart separated in pre-sed.	0,59	see spreadsheet "cleaning effect"								
Digestion grade org. mtrl. separated by PS	0,75	based on Davidson (2007) thesis and talks with Anox (Lars-Erik Olsson) and JTI (Åke Nordberg)								
Digestion grade ÖS	0,25	assumption based on comparison between digestion of primary sludge and surplus sludge (Leksell. 2005)								
surplus sludge production, CUDsludge/CODin	0,3	assumption based on rough COD balance								
Gas production Nm3 CH4/kg CODred	0,35	Theoretical value								

Henriksdal's sewage treatment plant

Data from Henriksdal

Data from UW report + Henriksdal's data

Surplus via KDU of COD (or BOD) when all inputed N is reduced (kg/p, year) 100% KDU	Henriksdal 2005 (ton/year resp Nm3 CH4)	Henriksdal 2004 (ton/year)	Henriksdal 2003 (ton/year)	Henriksdal (2005) kg/p, year	Henriksdal (2005) mg/l	In Hdal with 10% KDU (kg/p, year)	Increase by 10% KDU	In Hdal with 50% KDU (kg/p, year)	Increase by 50% KDU	Surplus via KDU of COD (or BOD) when all input N is reduced (kg/p,year) 10% KDU	Surplus expressed as quantity methanol (m3/year), 10% KDU
	15100										
	26000	29000	25000	37	300						
	12000	13000		17	130						
10,68	42360	45890	38000	60	459	62,29	3,8%	71,4	19,5%	1,07	
3,24	20000	21000	19000	28,3	230	29,14	2,8%	32,25	14,2%	0,32	181
	3600	3700	3300	5,1	42	5,14	0,8%	5,3	3,9%	0,08	
	580	710	570	0,82	6,7	0,83	0,8%	0,86	4,1%		
	6300000										
		5,7	5,8	5,6		5,7		6,1			
						1,02		1,1			
		12,4	11,5	11,8		12,1		13,5			
						1,03		1,14			

Henriksdal's sewage treatment plant

Extra nitrogen (mg/l) that can be denitrified due to KDU (10%)	Surplus via KDU of COD (or BOD) when all input N is reduced (kg/p, year) 50% KDU	Surplus expressed as quantity of methanol (m3/year), 50% KDU	Extra nitrogen (mg/l) that can be denitrified due to KDU (50%)	Increase in gas production, Nm3 CH4/year, 10%	Increase in gas production, Nm3 CH4/year, 50%	Increased production (%), 10% KDU	Increased production (%), 50% KDU	Increase in sludge production t TS/year, 10% KDU	Increase in sludge production t TS/year, 50% KDU	Increased sludge production (%), 10% KDU	Increased sludge production (%), 50% KDU
								520	2602	3,4	17,2
		5,34				3,8%	19,0%				
		1,62	954								
0,7	0,41		3,3								
				230483	1152417	3,7%	18,3%				

Data from UW report 2005:6

UW data

estimated from UW data

[illegible]

Bromma's sewage treatment plant

Data from Bromma						Data from UW report + Bromma's data						
Gas production from KDU via ÖS Nm3 CH4/p, year (100% KDU)	Organic material via KDU and ÖS to sludge (kg/p, year), 100%	Surplus via KDU of COD (or BOD) when all input N is reduced (kg/p, year) 100% KDU	Bromma 2005 (ton/year resp Nm3 CH4)	Bromma 2004 (ton/year)	Bromaa 2003 (ton/year)	Bromma (2005) kg/p, year	Bromma (2005) mg/l	In Bromma with 10% KDU (kg/p, year)	Increase by 10% KDU	In Bromma with 50% KDU (kg/p, year)	Increase by 50% KDU	Surplus via KDU of COD (or BOD) when all input N is reduced (kg/p,year) 10% KDU
0,35	4,28		5940		5750							
			8400	8700	9300	36	190					
	1,6											
			3700	4000		16	83					
		12,39	12654		15000	53,8	284	56,06	4,2%	65,17	21,2%	1,24
		3,76	5800	6700	7700	24,7	13	25,45	3,3%	28,67	16,3%	0,38
			1200	1200	1300	5,1	28	5,14	0,8%	5,3	3,9%	0,09
			160	170	180	0,68	3,6	0,69	1,0%	0,71	4,9%	
			2080000									
				5,6	5,9	4,8		5		5,4		
								1,02		1,12		
				0	11,5	10,5		10,9		12,3		
								1,03		1,17		

Bromma's sewage treatment plant

Surplus expressed as quantity methanol (m3/year), 10% KDU	Extra nitrogen (mg/l) that can be denitrified due to KDU (10%)	Surplus via KDU of COD (or BOD) when all input N is reduced (kg/p, year) 50% KDU	Surplus expressed as quantity methanol (m3/year), 50% KDU	Extra nitrogen (mg/l) that can be denitrified due to KDU (50%)	Increase in gas production, Nm3 CH4/year, 10%	Increase in gas production, Nm3 CH4/year, 50%	Increased production (%), 10% KDU	Increased production (%), 50% KDU	Increase in sludge production t TS/year, 10% KDU	Increase in sludge production t TS/year, 50% KDU	Increased sludge production (%), 10% KDU	Increased sludge production (%), 50% KDU
									173	863	2,9	14,5
		6,19			88105	440525	4,2%	21,2%				
74		1,88	369									
	0,5	0,47		2,6								
					66616	333082	3,2%	16,0%				

Metals

Plant	Lead	Cadmium	Copper	Chromium	Mercury	Nickel
	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>
Västerås food waste	<3	<0.1	14	<5	0.03	2.1
Bromma sludge 2005	25	0.9	350	22	0.8	20
Plant	Total Nitrogen	NH4-N	Total Phosphorus	Total Calcium	TS level	VS Level
	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mg/kg TS</i>	<i>mean in %</i>	<i>% of TS</i>
Västerås food waste	21,000	2,500	4,500			
Bromma sludge 2005	40,000	12,000	38,000	1,600	34	46
Plant	Pb/P	Cd/P	Cu/P	Cr/P	Hg/P	Ni/P
	<i>mg/kg</i>	<i>mg/kg</i>	<i>mg/kg</i>	<i>mg/kg</i>	<i>mg/kg</i>	<i>mg/kg</i>
Västerås food waste	<670	<22	3,111	<1,100	<7	467
Bromma sludge 2005	658	24	9,211	579	21	526
Västerås food waste/Bromma sludge	<102%	<92%	34%	-	<33%	89%

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