URBAN BIODEGRADABLE WASTE AMOUNT AND COMPOSITION

- CASE STUDY UPPSALA

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SUMMARY

This report is part of the project "Systems Analysis of Organic Waste", funded by the Swedish Waste Research Council (AFR). In the project a simulation model for analysing different scenarios of organic waste handling systems was constructed, ORWARE (ORganic WAste REsearch model). The results from simulations with ORWARE represent environmental impact and use of resources of the systems studied, i.e. energy and plant nutrients. The environmental impact depends on the contamination level of the waste that is treated. Also the distribution of the major constituents of the waste, such as carbohydrates, protein and fat, are of great importance for the performance of different biological treatments, compost, anaerobic digestion and sewage treatment, and thus of importance for both environmental impact and use of resources.

The objective of this report was to present the indata used in the simulation experiments performed in the Uppsala case study. The amount and composition of the organic waste are presented. The method for gaining knowledge on these objects was mainly literature studies but also personal communications. Organic waste from the following sources are investigated; households, parks and gardens, restaurants and caterers, trade, slaughterhouse (Farmek), other industries (Slotts, Pharmacia, Nordmills and three industrialised bakeries) and finally grease separators. The ORWARE model uses a large number of different waste constituents, both major constituents and contaminants such as heavy metals and organic pollutants. In the simulation experiments all input data had to be specified. Thus, when we could not find the data we had to make assumptions

The main result from this survey is that data concerning organic wastes are lacking, not only regarding contaminants but also the distribution of the main constituents and plant nutrients. One aspect that is relatively well investigated is the content of heavy metals in household waste and in waste from parks.

More research is needed primarily concerning the content of major constituents, the nutritives, such as carbohydrates, fat, protein etc. This is urgent since performance of the biological treatment processes depend on the composition of the feedstock. The content of organic pollutants in waste is not well investigated. However, better input data concerning these pollutants would not much improve the simulation results, since very little is known about the fate of these substances in the treatment processes.

TABLE OF CONTENT

1. INTRODUCTION

There is increasing interest in Sweden to improve the handling and treatment of waste, mainly because of environmental concern and as a part of the work with Agenda 21. This interest involves municipalities as well as companies. Regarding organic waste, interest is focused on possibilities to find new solutions that facilitate a higher degree of recirculation of plant nutrients without major drawbacks due, for example, to increased transport demand or hygienic hazard to people and livestock. These new handling systems often include composting, anaerobic digestion or recirculation of ashes from "waste to energy plants".

One of the major difficulties in the research that has been initiated in the above-mentioned field is the lack of data. This lack of data is severe both regarding composition and amounts, and it applies to waste generated within households as well as within companies and authorities.

Questions regarding which handling system for organic waste is preferable in a certain community or region, are dealt with in the research project "Systems analysis of organic waste" (Nybrant et al, 1996), funded by the Swedish Waste Research Council (AFR). In this project, a simulation model, called ORWARE (ORganic WAste REsearch model) has been developed and applied to the situation in the city of Uppsala. Within that project the present survey on the amounts and composition of the organic waste was performed. The objective was to supply indata to the model. Since ORWARE handles all wastes as large vectors (fig. 1) which describe their composition the need for data was correspondingly great. There were no sources that could provide data on the amount of all substances dealt with in ORWARE, so we had to use data from many different sources to fill in the tables on composition for all different wastes in the model. This demand for numbers in every position in the vector implies that some numbers are less reliable. We point out these numbers in the report.

The sources of waste described in this report are; households, public parks, private gardens, restaurants, trade, industries in Uppsala producing relatively small amounts of organic waste (Nordmills, Slotts, Pharmacia and some industrialised bakeries), the large slaughterhouse (Farmek), and grease separators.

Dry matter (DM)	CHX	Total N	Pb
Volatile solids (VS)	AOX	NH_3/NH_4^+	Cu
Total Carbon	Dioxin	NO_3^-	Cr
Slowly degradable organics	PCB	Total S	Ni
Medium degradable carbohydrates	PAH	Total Cl	Zn
Fast degradable carbohydrates	Phenols	Total P	Hg
Fat	Total H	Total Ca	Cd
Protein	Total O	Total K	
VOC			

Figure 1. The vector describing the flow of waste in ORWARE. In this report the wastes are described by this vector. For each position in the vector the flow is given in kg/year.

1.2 Abbreviations

In this report the following abbreviations are used:

- AOX for adsorbable organic halogens.
- CHX for volatile halogenated organic compounds.
- Chfd for fast degradable carbohydrates (i.e. sugars and starches).
- Chmd for medium degradable carbohydrates (i.e. hemicellulose and cellulose).
- Chsd for slowly degradable organics (i.e. lignin and humus).
- Ch-Tot for Chfd+Chmd+Chsd
- DM for dry matter content.
- PCB for polychlorinated biphenyls.
- PAH for polyaromatic hydrocarbons.
- VOC for volatile organic compounds, non-halogenated. One example is methane.
- VS for volatile substance, defined as DM minus ash.
- ww for wet weight.

2. METHODS

The methods used in this investigation were mainly literature studies but also personal communications with companies and local authorities as well as researchers in the field. Sometimes we found the appropriate data directly, but often we had to make assumptions and by combining data from different sources to get the figures needed. This means that the accuracy of the figures vary.

2.1 Structure of the report

Chapter three treats those substances we consider to have the same proportion, i.e. the same percentage of the content, for several wastes. After that the composition of nutritives in waste, which are similar in all waste types, is presented. Finally, each waste is presented, with its specific values in the vector.

3. SUBSTANCES WITH EQUAL PERCENTAGES IN SEVERAL WASTES

3.1 Phenols

Phenols are used in different kinds of detergents, car polish and as an additive to oils and resins (Kemikalieinspektionen, 1991). The content in household waste is considered to be 55 ppm of DM (SNV, 1993b). We assume that the content in waste from trade and restaurants is half of that, 27 ppm of DM. The other wastes, i.e., waste from industries, parks and gardens and grease separators, are assumed not to contain any phenols.

3.2 PCB

The daily intake of PCB in Sweden is 113 ng/kg body weight (Waz, 1993). Assuming an average body weight of 70 kg and using estimates of the DM content of some foods we get table 1. According to Waz (1993), all PCB in the food is of animal origin. Knowing the intake of each type of food per person and year (SCB, 1993), and using the assumptions above, we have calculated the content of PCB in different types of foods.

Table 1. Calculated content of PCB in different types of foods

Type of food	Intake of PCB µg/pers. & year (calculated from Waz, 1993)	Consumption kg wet weight/year & pers. (SCB, 1993)	DM content % of ww (SLV, 1993)	Calculated PCB content, µg/kg DM
Fish	1200	16.0	30	250
Meat	1124	55.4	35	58
Fat/grease	51	17.5	90	3
Egg	153	11.7	25	52
Milk products	358	184.6	15	13

Assuming that the composition of waste is similar to the composition of the Swedish average menu, we calculate a weighted average of the PCB content in the part of the waste that originally has been food. Milk has not been taken into account because that part of the food will not be found in the solid household waste. The weighted average in solid waste originating from animals is 59 µg/kg DM. This is calculated assuming that the DM content of all waste is 35%.

According to Halmstad kommun (1986), 13% of the compostable fraction is of animal origin. This leads to a PCB content of 7.7 µg/kg DM in the compostable household waste. SNV (1993b) analysed organic household waste from three different municipalities having sorting instructions similar to those in Uppsala. The average PCB content found in these wastes were 8.5 µg/kg DM. The mean of these two figures is 8.1 µg/kg DM, and we choose to use the rounded value of 8 µg/kg for household waste in ORWARE. The same concentration is used for waste from restaurants and caterers.

In waste from trade 6.2 % of wet weight originates from animals (chapter 6). Assuming that this animal-originated waste has the same DM content as the corresponding fraction in household waste, the proportion of animal-originated waste in trade will be 13.3% of DM. This implies a PCB content that is almost the same (8.0 µg/kg DM) as in household waste. We have used the same figure for trade waste as we used for household waste.

Table 2. Content of PCB in waste from different sources used in the Uppsala case study

Waste source	PCB content µg/kg DM
Households	8
Restaurants and caterers	8
Trade	8
Farmek (Blue, Red, sludge and blood water)	58 [a]
Grease separators	3 [b]
All others	0

[a] *Using the figure for meat in table 1.*
[b] *Using the figure for fat and oil in table 1.*

3.3 Dioxins

In the following text we will use the word dioxins when we are referring to 3-4-7-8 TCDD equivalents according to Eadon.

The first assumption is that dioxins, just as PCB, only are present in waste of animal origin (Funseth & Ilbäck, 1991). The dioxins in food are found in fish, meat and milk and dairy products, one-third, respectively (Funseth & Ilbäck, 1991). According to WHO, the daily intake of dioxins in Sweden is 1-3 pg/kg body weight and day (Funseth & Ilbäck, 1991). Assuming an average body weight of 70 kg (our assumption) this gives a yearly intake of 25550 to 76650 pg/person. In the calculations below we use the mean of these figures. As this amount originates one-third from fish, meat and milk respectively and the consumption of these foods is known (SCB, 1993) we are able to calculate the content of dioxins in these foods.

Table 3. Calculated content of dioxin in food

Type of food	Dioxin intake pg/pers. & year (Funseth & Ilbäck, 1991)	Consumption kg/pers. and year (SCB, 1993)	DM content % of ww (SLV, 1993)	Calculated content of dioxin pg/kg DM
Milk and dairy products	17033	180	15	630
Meat	17033	55	35	885
Fish	17033	16	30	3548

We assume that the waste of animal origin in the household waste has the same proportions as food of animal origin presented in table 3. Milk products are not taken into account in the solid waste. This leads to 1416 pg dioxin/kg DM in the part of the compostable fraction being of animal origin. Of the compostable household waste, 13% is of animal origin (Halmstad kommun, 1986). This implies a dioxin content of 184 pg/kg DM in household waste. The same figure is used in waste from restaurants and caterers. Waste from trade is also assumed to have the same content as household waste following the same reasoning as for the PCB content (chapter 3.3).

Table 4. Content of dioxin in waste from different sources used in the Uppsala case study

Waste source	Dioxin, pg/kg DM
Household	184
Restaurants and caterers	184
Trade	184
Farmek, Manure, Stomach content	0 [a]
Farmek, others	885 [b]
Grease separators	885 [c]
Others	0

[a] The reason that the animals "do not eat any" dioxins but still accumulates them is that the level of dioxins in the animal feed are not detectable in an analysis.

[b] Using the figure for meat in table 3.

[c] The same value as for meat is used. The reason for this is that we have not found any data and it seems reasonable that the figure should be at least as high as the value for meat.

3.4 PAH (Polyaromatic Hydrocarbons)

PAH are found in asphalt, oil, tar and rubber and are formed in combustion processes (VAV, 1989). This explains why there are high levels of PAH in smoked foods. The content in household waste is 1.0 ppm of DM (SNV, 1993b). The same content is assumed in waste from restaurants and caterers, trade, parks and gardens, industries and grease separators. This figure needs to be more thoroughly investigated.

3.5 VOC (Volatile, non-chlorinated compounds)

In household waste the content of VOC is 2.2 ppm of DM (SNV, 1993b). Waste from trade and also waste from restaurants and caterers are assumed to have half that content, i.e. 1.1 ppm of DM. This figure needs to be more thoroughly investigated. The same content is assumed in waste from restaurants and caterers, trade, parks and gardens, industries and grease separators. This figure needs to be more thoroughly investigated.

3.6 CHX (Halogenated, mainly chlorinated, volatile compounds)

The content of CHX in household waste is 0.01 ppm of DM (SNV, 1993b). Waste from trade and also waste from restaurants and caterers are assumed to have half that content, i.e. 0.005 ppm of DM. This figure needs to be more thoroughly investigated. The same content is assumed in waste from restaurants and caterers, trade, parks and gardens, industries and grease separators. This figure needs to be more thoroughly investigated.

3.7 AOX (Adsorbable Organic Halogens)

We have not found any data on AOX values for solid organic waste, since AOX is defined for material in the liquid phase. In the Uppsala case study, the content in solid waste is assumed to be 0.

3.8 Heavy metals

3.8.1 Background

In this chapter the sources of solid waste, with the exception of households and Farmek, are described. The reason for this is that household waste and also slaughterhouse waste have been well investigated concerning heavy metals, and waste from the other sources have not.

3.8.2 Waste from restaurants and caterers

Waste from restaurants and caterers consists mainly of food leftovers and from preparation. Since data is lacking regarding this kind of waste we have used analyses of food instead. Koivostinen (1980) presents figures on the mineral composition of Finnish food, presented as the content of different mineral elements in a large number of dishes and primary products. We assume that the composition does not differ much from that of Swedish food. SLV (1993) presents figures on, to some extent, the same minerals as Koivostinen (1980), but also some others. These figures concerns Swedish food. SCB (1993) gives the consumption of different groups of foods in Sweden.

Based on these data we have calculated the content of heavy metals in a fictive average Swedish diet. The heavy metal content of the waste was assumed to be the same as that of the diet.

Table 5. Calculated content of heavy metals in an average Swedish diet and in waste from restaurants and caterers

Heavy metal	Content in average diet, ppm of wet weight (SLV, 1993) and (Koivostinen, 1980)	Content in average diet, ppm of wet weight (SCB, 1993) and (Jorhem et al., 1984)	Mean value ppm of wet weight	Value used in Uppsala case study ppm of DM [a]
Pb	0.05	0.03	0.04	0.13
Cd	0.02	0.02	0.02	0.07
Hg	0.01		0.01	0.03
Cu	1.30		1.30	4.33
Cr	0.02		0.02	0.07
Ni	0.13		0.13	0.43
Zn	9.50	11.50	10.50	35.00

[a] *Using 30% DM, which is the figure presented under the heading "Waste from restaurants and caterers"*

3.8.3 Trade

In chapter 6 the composition of trade waste is given, divided into the fractions meat, bread and vegetables. In Koivostinen (1980) and Jorhem et al. (1984) the contents of heavy metals in each group are given. Together, these data made it possible to form table 6.

Table 6. Calculated heavy metal content in trade waste (ppm of DM)

Heavy metal	Content in meat (6.2% of the waste)	Content in bread (5.6% of the waste)	Content in vegetables (88.2% of the waste)	Value used in the Uppsala case study, weighted mean value
Pb	0.02	0.06	0.03	0.03
Cd	0.00	0.03	0.02	0.02
Hg	0.005	0.003	0.001	0.001
Cu	1.50	2.90	0.60	0.80
Cr	0.04	0.04	0.01	0.01
Ni	0.05	0.26	0.10	0.10
Zn	30.00	18.00	2.20	4.80

3.8.4 Grease separators

We assume that this waste consists of 50% butter and 50% vegetable oil. Using data from Koivostinen (1980) this assumption gives table 7.

Table 7. Calculated heavy metal content in waste from grease separators, (ppm of DM) (Koivostinen, 1980)

Heavy metal	Value used in the Uppsala case study
Pb	0.04
Cd	0.01
Hg	0.003
Cu	0.18
Cr	0.04
Ni	0.10
Zn	0.65

3.8.5 Parks and gardens

Figures from Widén (1993), Bengtsson & Fergedal (1991) and Uppsala public works office (1993a) on the heavy metal content in compost were used to calculate the heavy metal content in the fresh waste. We have assumed a 33% mass loss during composting when recalculating the content of the composts to the composition of "fresh" waste before composting.

Table 8. Content of heavy metals in waste from parks and gardens (ppm of DM)

Heavy metal	Content (Bengtsson & Fergedal, 1991)	Content (Widén, 1993)	Content (Uppsala publ. works, 1993a)	Value used in the Uppsala case study
Pb	7.6	12.4	18.1	12.7
Cd	<0.5	0.2	0.1	0.2
Hg	0.05	0.05	0.03	0.04
Cu	12.3	21	14.7	16.0
Cr	5.3	13	12.1	10.1
Ni	3.5	6.2	6.4	5.4
Zn	66.0	76.0	60.0	67.3

3.8.6 Slotts

Slotts produces jams, marmalades, ketchup and mustards. We assume that the waste from Slotts consists of 25% sugar, 37.5% oranges and 37.5% tomatoes. This is how the products from Slotts are composed, and the compostable fraction of the waste has practically the same composition as the products.

Table 9. Calculated content of heavy metals in waste from Slotts

Heavy metal	Content ppm of wet weight (Koivostinen, 1980)	Content ppm of wet weight (Jorhem et al., 1984)	Mean value ppm of wet weight	Value used in the Uppsala case study [a] ppm of DM
Pb	0.08	0.03	0.06	0.14
Cd	0.01	0.01	0.01	0.03
Hg	0.002		0.002	0.005
Cu	0.25		0.25	0.60
Cr	0.01		0.01	0.02
Ni	0.04		0.04	0.10
Zn	0.80	0.90	0.85	2.10

[a] *We have used 42% DM, according to chapter 8.2.*

3.8.7 Bakeries

The figures for "bread" in table 6 are used in the Uppsala case study.

Table 10. Content of heavy metal in waste from bakeries

Metal	Value used in the Uppsala case study ppm of DM
Pb	0.06
Cd	0.03
Hg	0.003
Cu	2.90
Cr	0.04
Ni	0.26
Zn	18.00

3.8.8 Nordmills

Nordmills is a mill situated in Uppsala. Since their compostable waste consists of moulded wheat, the contents of heavy metals in their waste is assumed to be the same as in wheat.

Table 11. Content of heavy metals in waste from Nordmills

Metal	Content ppm of wet weight (Koivostinen, 1990)	Content ppm of wet weight (Jorhem et al., 1984)	Value used in the Uppsala case study ppm of DM
Pb	<0.05	0.06	0.05
Cd	0.02	0.03	0.03
Hg	<0.004		0.004
Cu	6.20		6.20
Cr	0.04		0.04
Ni	2.00		2.00
Zn	25.00	22.00	24.00

4. CHEMICAL COMPOSITION OF NUTRITIVES

4.1 Background

We have found literature data on the content of nutritives, such as proteins, fats and carbohydrates, in wastes from different sources. These data have been used to calculate the contents of C, O, H, N and S. First the assumed compositions of the nutritives are given. These were used when calculating the contents of C, O, H, N and S in wastes from different sources.

In the ORWARE vector, five nutritives are represented;

- Fast degradable carbohydrates.
- Medium degradable carbohydrates.
- Slowly degradable organics.
- Proteins.
- Fat.

Fast degradable carbohydrates consist mainly of sugars and starch. The medium degradable carbohydrates consist of cellulose and hemicellulose, whereas the slowly degradable organics consist of lignin and humus. The other two groups are self-explanatory.

4.2 Composition

The calculated composition of these five groups is presented in Tables 12, 13, 14, 15 and 16.

4.2.1 Fast degradable carbohydrates (Chfd)

This group is a mixture of saccarides and starch. We have assumed that it consists of 75% starch and 25% disaccarides.

Table 12. Composition of fast degradable carbohydrates (% by weight)

	C	H	O
Monosaccharides *(Enquist, 1964)*	40.0	6.7	53.3
Disaccharides *(Enquist, 1964)*	42.1	6.4	51.5
Starch *(Enquist, 1964)*	44.4	6.2	49.5
Values used in the Uppsala case study	43.8	6.3	49.9

4.2.2 Medium degradable carbohydrates (Chmd)

This group is a mixture of cellulose and hemicellulose. We have assumed a composition of 25% hemicellulose and 75% cellulose.

Table 13. Composition of medium degradable carbohydrates (% by weight)

Carbohydrate	C	H	O
Hemicellulose *(Fries, 1973)*	40.1	5.2	54.3
Cellulose *(Fries, 1973)*	49.7	3.0	47.3
Values used in the Uppsala case study	47.0	4.0	49.0

4.2.3 Slowly degradable organics (Chsd)

According to Fries (1973) lignin consists of phenyl-propane units that are combined in different ways. Humus is assumed to have the same composition. The average composition is presented in table 14.

Table 14. Composition of slowly degradable organics (Fries, 1973) (% by weight)

	C	H	O
Values used in the Uppsala case study	65.3	4.5	30.2

4.2.4 Protein

We have used a factor of 0.165 to calculate the nitrogen content from the protein content in all wastes except from Nordmills , where we used 0.175 (Handbook of chemistry and physics, 1979). The figures used for calculating the content of the other compounds in protein are presented in table 15.

Table 15. Composition of protein (Handbook of chemistry and physics, 1979) (% by weight)

	C	H	S	O	N
Values used in the Uppsala case study	52.5	7.0	1.5	22.5	16.5

4.3 Fat

From Enquist (1964) we got the amount of different fatty acids in different fats. From the same reference, we got the chemical composition of fatty acids. Together, these data provide the chemical composition of fats.

Table 16. Calculated composition of fats (% by weight)

Kind of fat	C	H	O
Fat from cattle (Enquist, 1964)	76.0	12.3	11.7
Fat from pigs (Enquist, 1964)	76.0	12.3	11.7
Values used in the Uppsala case study	76.0	12.3	11.7

5. HOUSEHOLD WASTE

5.1 Amount

The amount of organic waste from households is calculated from the number of households and the amount per household. The amount per household depends on whether it is a one-family dwelling or an apartment. The figures from Uppsala public works office (1993b) originate from two different sorting analyses made in Uppsala. The figures from SNV (1993a) are useful for comparisons, they originate from three municipalities that have source separation similar to Uppsala.

Table 17. Amount of organic household waste (kg wet weight per household and year)

Type of household	Uppsala public works office (1993b)	SNV (1993a) Range	Mean	Values used in the Uppsala case study
One family dwelling	240	237-300	265	240
Apartments	130	114-125	120	130

We choose to use the figures from Uppsala kommun (1993b) because they originate from Uppsala and they are in the same range as the figures from SNV (1993a). The number of households within the system limits are 9600 one-family dwellings and 55700 apartments.

5.2 Composition

No single analysis has been found that has covered all the different substances in the ORWARE vector. We have had to use figures from several different analyses. The problem with this method is that different methods have been used and it is sometimes very difficult to estimate the impact of the differences. Also, certain substances have not been analysed in waste at all. For these substances we have used figures from other materials that are in some sense similar to waste.

5.2.1 Distribution of organic carbon

C-protein: We have assumed that all nitrogen is found as protein (Widén, 1993). Thus, the protein content is given by N-total*6.25 (SLV, 1993). In table 21, describing the composition of the household waste, we find 2.0% N of DM, which means a protein content 12.5% of DM:

C-fat: The following assumptions have been made;

- The proportion of fat in the household waste is the same as the proportion of fat in average Swedish food.
- The total intake of fat in Sweden is 121 g/day and person (SCB, 1993).
- The total intake of food is 564 g DM/day and person (SCB, 1993). This means that the percentage of fat in food is 21.4% of DM.
- Accounting for the soft paper in the waste, 17% of the organic fraction of MSW (Halmstad kommun, 1986), lowers the percentage of fat to 17.8% of DM.

C-carbohydrates: Gijzen et al. (1987) presents figures on the distribution between fast degradable carbohydrates, medium degradable carbohydrates and slowly degradable organics in organic fraction of MSW in the Netherlands.

Table 18. Distribution of some organics in waste from the Netherlands (Gijzen et al. ,1987)

Substance	% of sum of carbohydrates+lignin
Lignin	8.8
Cellulose and hemicellulose	46.5
Sugar and starch	44.7

The percentage of total carbohydrates in the waste is calculated as follows; 100-ash-protein-fat. Since the ash content is assumed to be 20% (table 21) this gives: 100-20-12.5-17.8=49.7% carbohydrates of DM.

Table 19. Composition of organic fraction of MSW used in the Uppsala case study (% of DM)

Substance	Protein	Fat	Slowly degradable organics	Medium degradable carbo-hydrates	Fast degradable carbo-hydrates	Total
Distribution of nutritives	12.5	17.8	4.4	23.1	22.2	80.0
C	6.6	13.5	2.9	10.7	9.7	43.4
O	2.8	2.1	1.3	11.4	11.1	28.7
H	1.0	2.2	0.2	1.0	1.4	5.8
N	2.0					2.0
S	0.1					0.1

5.3 Composition of household waste according to some references

The references mentioned in table 20 are briefly presented, below:

1. Widén (1993) analysed source-separated organic waste from Uppsala city, both before and after composting.
2. Uppsala public works office (1994) is an analysis of mature compost from Uppsala, a 50/50 mix of organic household waste and chipped park waste.
3. Koivostinen (1980) presents composition of average Finnish food, which means that no soft paper, potato peel etc. is included.
4. Halmstad kommun (1986) is an analysis of organic fraction of manually sorted MSW, sorted after collecting.
5. Eriksson (1991) is an analysis of source-separated household waste from Uppsala.
6. Sundqvist (1991) is an analysis of is source-separated organic household waste from Botkyrka near Stockholm.
7. Heie (1981) is a Norwegian analysis of food.
8. SNV (1993b) is an average of analyses of source-separated organic household waste from six municipalities in Sweden.

When mature compost has been analysed, we have assumed that 33% of the mass of the waste was lost during composting.

Table 20. Composition of organic household waste according to different sources

Substance	Ref.1 fresh	Ref.1 compost	Ref.2	Ref.3	Ref.4	Ref.5	Ref. 6	Ref.7	Ref. 8
DM (% of ww)	40.6			40.8	30	31.6	30	37.2	
Ash (% of DM)	36.6			12.2	30	21.4	16.7	31.8	
C-Tot (g/kg DM)	24.9 [a]			41.8		44.2	43.4	39.0	
Chfd (g/kg DM)							19		7.8
Chmd (g/kg DM)							0		8.6
Protein (g/kg DM)							9.2		6.6
Fat (g/kg DM)							15.2		13.5
O-Tot (g/kg DM)				35		26.0	31.2		23.9
H-Tot (g/kg DM)				5.4		6.2	6.8		5.2
N-Tot (g/kg DM)	2.11			1.9		1.9	2.7	1.85	2.0
S (g/kg DM)	0.24	0.22		0.25		0.23		0.20	0.1
P (g/kg DM)	0.46	0.40	0.40					0.26	
K (g/kg DM)	1.13	1.21	0.65					0.73	
Ca (g/kg DM)	3.01	2.65	3.15					2.23	
Cl (g/kg DM)						0.39			
Pb (ppm of DM)	26.0	99	166		102			38	
Cd (ppm of DM)	0.34	0.87	1.6		1.2			0.66	
Hg (ppm of DM)	0.10	0.21	0.27		1.0			0.38	
Cu (ppm of DM)	48 [b]	119	273		145			44.2	
Cr (ppm of DM)	53	21	21.4		37			13.4	
Ni (ppm of DM)	10	15.4	31.2		27			10.0	
Zn (ppm of DM)	141 [c]	254	397		347			230	

[a] *This low carbon content is explained by the high ash content.*
[b] *Varied between 32 and 5500*
[c] *Varied between 86 and 1885*

The heavy metal analysis by Widén (1993) show large variations. There were small pieces of metal in the waste which gave these large variations. The analyses of the mature compost showed less variation, probably due to corrosion of the metals during composting.

Note that the ash content is higher in analyses from source-separated waste than in food and waste separated after collection. This is probably due to the fact that in the "compostable fraction" the public are instructed to put wastes with high ash content such as cat-sand and soil from pot plants.

5.4 Composition of organic household waste used in the Uppsala case study

Column two of table 21 shows the composition of the organic household waste with the present contamination levels. This composition was used in the scenarios describing the near future in the Uppsala case study. Column three of the same table presents the composition assumed for a cleaner, future waste used for simulating scenarios describing future systems, with lower contamination levels in society.

Table 21. The composition of household waste used in the Uppsala case study

Substance	Present waste	Cleaner waste (Sundquist pers. comm. 1994)
DM (% of ww)	35.0	
VS (% of DM)	79.9	
C-Tot (% of DM)	43.4	
C-Chfd (% of DM)	9.7	
C-Chmd (% of DM)	10.7	
C-Chsd (% of DM)	2.9	
C-Prot. (% of DM)	6.6	
C-Fat (% of DM)	13.5	
O (% of DM)	28.7	
H (% of DM)	5.8	
N (% of DM)	2.0	
S (% of DM)	0.24	
P (% of DM)	0.38	
Cl (% of DM)	0.4	
K (% of DM)	0.93	
Ca (% of DM)	2.8	
Pb (ppm of DM)	86	10
Cd (ppm of DM)	0.93	0.3
Hg (ppm of DM)	0.39	0.1
Cu (ppm of DM)	126	20
Cr (ppm of DM)	29	5
Ni (ppm of DM)	19	3
Zn (ppm of DM)	274	130

6. TRADE

The waste from trade originates from two different kinds of business activity, retail trade and wholesale. They differ in amount but also in composition.

6.1 Amount

6.1.1 Retail trade

The amount, and to some extent the composition, of waste from trade was calculated as follows: Figures on percentages of sold foodstuffs that are thrown away in grocery stores are presented in Becker et al. (1985). The consumption of different foods in Sweden are presented in SCB (1993). Assuming that the people in Uppsala do not differ significantly from the rest of the population in Sweden, we calculated the losses in the stores. We also assumed that 90% of the population in the municipality of Uppsala do their daily shopping within the system's limits. This means that the number of shopping persons are 156 600.

Table 22. Calculated amount of organic waste from grocery stores

Product	Wastage, % of sold amount (Becker et al., 1985)	Consumption per capita, kg/year (SCB, 1993)	Consumption in Uppsala, tonnes/year	Wastage in Uppsala, tonnes/year
Beef, fresh	2.2	7.6 [a]	1 184	26
Pork, fresh	0.5	13.4 [a]	2 408	12
Citrus and apples	1.0	68.4	10 711	107
Carrots, onions and tomatoes	1.1	43.9	6 880	76
Plain bread	0.6	32.3	5 058	30
Buns	0.4	3.5	553	2
Pastry	0.4	3.4	536	2

[a] *Assuming that 80% of all meat is sold fresh (i.e. not frozen or canned).*

Columns 2 and 5 in table 22 represent the amount of food that really ends up in the trash can. Some provisions are taken back by the supplier, for example bread, which is returned and to some extent becomes waste at the bakeries. Eriksson (1991) studied the amounts of organic waste in Uppsala that are available for anaerobic digestion and used another method, mainly interviews. This makes it interesting to compare her figures with those calculated.

Table 23. Comparison between table 23 and figures presented by Eriksson (1991)

Foodstuff	Proportion of the organic waste, % (Table 22)	Proportion of the organic waste, % (Eriksson, 1991)
Meat	14.9	20 [a]
"Vegetables"	71.6	74
Bread	13.5	6

[a] *This figure includes cheese*

6.1.2 Wholesale

DAGAB, a major wholesale company, has approximately 18% of the Uppsala market and generates 65 tonnes of organic waste per year (Eriksson, 1991). Assuming that this is the average for wholesale, the gross figure for wholesale in Uppsala is 360 tonnes per year. This waste is practically 100% of vegetable origin (Edström, pers. comm. 1992).

6.1.3 Retail trade and Wholesale

The total amount and composition of organic waste from trade are calculated as the sum of the amount of waste from retail, 235 tonnes, divided into three categories, and the amount of waste from wholesale 360 tonnes, that is 100% of vegetable origin.

Table 24. The amount and composition of waste from trade used in the Uppsala case study

Provision	Amount, tonnes/year	Part of the waste (%)
Meat	38 [a]	6.2
Bread	34 [a]	5.6
"Vegetables"	543 [b]	88.2
Sum	615	100.0

[a] *These figures are for retail only*
[b] *This is the sum of amounts from retail and wholesale.*

By comparison, the total amount of waste from trade can be estimated to 500-700 tonnes/year, according to Eriksson (1991), Lindman (1990) and Edström (pers. comm. 1993).

6.2 Composition

The composition of the waste from trade was calculated using the composition of the three groups, meat, bread and vegetables, given by SLV (1993).

Table 25. Composition of meat, bread vegetables and total trade waste

Provision	Part of total, %	DM, %	Part of DM %	Carbo -hydr. % of DM	Chfd % of DM	Chmd % of DM	Chsd % of DM	Fat % of DM	Prot. % of DM	Ash % of DM
Meat (SLV, 1993)	6.2	35	16	0	0.0	0.0	0.0	39	56	5
Bread (SLV, 1993)	5.6	65	26	82	76.2	4.5	1.3	4	12	2
Vegetables (SLV, 1993)	88.2	9.2 [a]	58	89	53.4	33.4	2.2	2	6	3
Value used in the Uppsala case study					50.1	20.5	2.0	8.4	15.6	3

[a] *According to Edström (pers. comm. 1993).*

The carbohydrates and slowly degradable organics mentioned in table 25 are distributed as follows:

Bread: 7% fibres (SLV, 1993), of which 42% is cellulose, 36% hemicellulose and 22% lignin (Bränslen från jordbruksgrödor, 1986).

Vegetables: Cellulose 24.2%, Hemicellulose 13.3%, lignin 2.5% and fast degradable 60% (Gijzen et al., 1987).

Table 26. Chemical composition of waste from trade, from chapter 4 and table 25 (% of DM)

Substance	Fat	Protein	Chfd	Chmd	Chsd	Sum
Distribution of nutritives	8.4	15.6	50.1	20.5	2.0	97
C	6.4	8.2	21.9	9.6	1.3	47.4
O	1.0	3.5	25.0	10.0	0.6	40.1
H	1.0	1.1	3.2	0.9	0.1	6.3
N		2.6				2.6
S		0.2				0.2

The composition used in the Uppsala case study is calculated using chapter 4 and weighted averages of tables 25 and 26. Note that the percentages presented above are reduced in order to account for the amounts of P, K, Ca and Cl, which were not included previously.

Table 27. The composition of waste from trade used in the Uppsala case study

Substance	Percentage	Note
DM, % of wet weight	14.0	
VS (% of DM)	91.8	
C-Chfd (% of DM)	21.5	
C-Chmd (% of DM)	13.0	
C-Chsd (% of DM)	1.2	
C-Fat (% of DM)	3.1	
C-Protein (% of DM)	4.8	
C-Tot (% of DM)	43.6	
O (% of DM)	41.4	
H (% of DM)	5.5	
N-Tot (% of DM)	1.5	
S (% of DM)	0.15	
P (% of DM)	0.5	Same figure used as for household waste
Cl (% of DM)	0.4	Same figure used as for household waste
K (% of DM)	1.2	Same figure used as for household waste
Ca (% of DM)	2.9	Same figure used as for household waste

7. FARMEK

Farmek is a major slaughterhouse in Uppsala. Today Farmek`s waste is divided into six categories due to the treatments used. These categories need different hygienisation. The waste categories are; manure from the stables on the site, stomach content, sludge from the internal sewage work, blood-water, "blue" waste and finally "red" waste.

The blue waste is offal that is hygienically acceptable. It has to be heated to 70°C to be considered hygienic. The red waste is offal that in some way is infected, it has to be heated to 130°C to be considered hygienic.

7.1 Manure from stables at the slaughterhouse

7.1.1 Amount

The amount is 2000 tonnes/year, wet weight. This figure is calculated from Eriksson (1991), taking into account that the number of slaughtered animals has increased between 1991 and 1994.

7.1.2 Composition

The composition of this waste is assumed to be the same as for normal manure. The composition is presented in tables 28, 29 and 30.

Table 28. Nutritive composition of manure (% of DM, unless otherwise stated)

Substance	Composition	Source
DM, % of wet weight	16.0	Databok för driftplanering (1983)
Ash	22.0	Biology of anaerobic micro-organisms (1988)
Protein	8.8	Databok för driftplanering (1983)
Fat	0.6	Databok för driftplanering (1983)
Chsd	8.0	a
Chmd	61.0	a
Chfd	0.0	a
N-Tot	2.0	b
NH_4^+-N	0.6	Databok för driftplanering, 1983

[a] *Calculated using Databok för driftplanering (1983) and Biology of anaerobic micro-organisms (1988). Biology of anaerobic micro-organisms (1988) gives the proportions of carbohydrates which are listed as others in the composition according to Databok för driftplanering (1983).*
[b] *Calculated as part protein/6.25*

Table 29. Chemical composition of manure, calculated from table 28 and chapter 4 (% of DM)

Element	Chsd	Chmd	Fat	Prot	Sum
Distribution of nutritives	8.0	61.0	0.6	8.8	78.4
C	5.2	26.9	0.5	4.6	37.2
O	2.4	31.4	0.07	2.0	35.9
H	0.4	2.7	0.07	0.6	3.8
N				1.5	1.5
S				0.13	0.1

Andersson (1977) presents contents of heavy metals in Swedish manure, and Managing livestock wastes (1975) is an investigation from the USA

Table 30. Composition of manure from the stables used in the Uppsala case study, % of DM, unless otherwise stated

Substance	Content	Source
DM (% of wet weight)	16	Table 27
VS	78	Table 27
C-Chfd	0	Table 27
C-Chmd	26.9	Table 27
C-Chsd	5.2	Table 27
C-Fat	0.5	Table 27
C-Protein	4.6	Table 27
C-Tot	37.2	Table 27
O-Tot	36.0	Table 27
H-Tot	3.7	Table 27
N-Tot	2.0	Table 27
NH_4^+-N	0.6	Table 27
P-Tot	1.0	Databok för driftplanering (1983)
S-Tot	0.13	Table 27
Cl-Tot	0.4	Same as household waste
K	1.75	Databok för driftplanering (1983)
Ca	1.0	Mean value of several
Pb	$6.6*10^{-4}$	Andersson (1977)
Cd	$0.32*10^{-4}$	Andersson (1977)
Hg	$9*10^{-6}$	Andersson (1977)
Cu	$4*10^{-3}$	Andersson (1977), Managing livestock wastes (1975) state $3*10^{-3}$ % of DM
Cr	$5.2*10^{-4}$	Andersson (1977)
Ni	$7.8*10^{-4}$	Andersson (1977)
Zn	$22*10^{-3}$	Andersson (1977), Managing livestock wastes (1975) state $12*10^{-3}$ % of DM

7.2 Stomach content

7.2.1 Amount

The amount of stomach content is approximately 3000 tonnes of DM per year (Edström, pers. comm. 1993).

7.2.2 Composition

The stomach content is assumed to be a 50-50 mix of fodder and manure. The composition of manure is the same as mentioned above and the values for fodder are presented below.

Because fodder for pigs and cattle are quite different we have to calculate how much of the stomach content that comes from each kind of animal. The weight of the slaughtered pigs is 32 000 tonnes and the weight of the cattle is 16 250 tonnes (Eriksson, pers. comm., 1993). From Östlund (1980) we get the part of the weight that consists of stomach content in fatstock, 16% for cattle and 6% for pigs. Together these figures give us the mix of the fodder part in stomach content; 57% cattle fodder and 43% pig fodder.

Unfortunately, these figures lead to a total amount of 4500 tonnes/year and we state that it is only 3000. The explanation probably is that the figures 16 and 6% are rather old and the routines for feeding the animals before slaughter have changed during recent years. Still, we assume that the proportions between pigs and cattle are the same.

The next assumption concerns the fodder composition. We assumed that fodder for pigs is 100% grain and fodder for cattle is 75% hay or silage and 25% grain.

Table 31. Composition of "average fodder", manure and stomach content (% of DM)

Substance	Wheat (Bränslen från jordbruks-grödor, 1975)	Timothy grass (Bränslen från jordbruksgrödor, 1975)	Weighted average (i.e. fodder)	Manure (tab. 28)	Stomach content
Ash	1.5	3.5	3	22.0	10.0
Protein	11.0	10.5	11	8.8	10.0
Chfd	76.5	32.0	57	0.0	28.0
Chmd	8.5	40.0	22	61.0	42.0
Chsd	2.5	14.0	7	8.0	8.0
Fat	2.5	0.0	0	0.6	0.3

In table 32 the calculated figures are compared with one reference from literature.

Table 32. Nutritive composition of stomach content (% of DM)

Substance	Table 31	Solyom (1978)	Value used in the Uppsala case study	Note
DM		11.0	11.0	
Ash	10.0	7.3	10.0	
Protein	10.0	10.7	10.0	
Fat	0.3	10.0	5.0	
Chfd	28.0	[a]	27.0	
Chmd	42.0	[a]	40.0	
Chsd	2.5	[a]	8.0	
N-Tot		1.6	1.6	Calculated as protein/6.25
NH_4^+-N			0.2	

[a] *Solyom (1978) states that 73% of DM are total carbohydrates*

Table 33. Chemical composition of stomach content (% of DM), calculated from table 32, Handbook of chemistry and physics (1979) and chapter 4

Substance	Chfd	Chmd	Chsd	Fat	Prot	Sum
Distribution of nutritives	27.0	40.0	8.0	5.0	10.0	90.0
C	11.8	17.9	5.2	3.8	5.3	43.9
O	13.5	20.4	2.4	0.6	2.2	39.1
H	1.7	1.7	0.4	0.6	0.7	5.1
N					1.6	1.6
S					0.1	0.1

Table 34. Composition of stomach content used in the Uppsala case study (% of DM, unless otherwise stated)

Substance	Content	Note
DM, of ww	11.0	
VS	90.0	
C-Chfd	11.7	
C-Chmd	17.9	
C-Chsd	5.2	
C-Fat	3.8	
C-Protein	5.3	
C-Tot	43.9	
O	39.1	
H	5.1	
N	1.6	
NH_4^+-N	0.2	
P	1.0	Databok för driftplanering (1983)
S	0.13	Same as manure
Cl	0.4	Same as household waste
K	1.75	Databok för driftplanering (1983), same as manure
Ca	1.0	Managing livestock wastes (1975)
Pb	$6.6*10^{-4}$	Andersson (1977)
Cd	$0.32*10^{-4}$	Andersson (1977)
Hg	$9*10^{-6}$	Andersson (1977)
Cu	$4*10^{-3}$	Andersson (1977), Managing livestock wastes (1975)
Cr	$5.2*10^{-4}$	Andersson (1977)
Ni	$7.8*10^{-4}$	Andersson (1977)
Zn	$22*10^{-3}$	Andersson (1977)

7.3 Sludge from the internal sewage work

7.3.1 Amount

The amount of sludge from the internal sewage work at Farmek is 4000 tonnes per year (Edström, pers. comm. 1993).

7.3.2 Composition

The composition of the sludge from Farmek's internal sewage work is presented in table 35, 36 and 37.

Table 35. Nutritive composition of sludge from the internal sewage works (% of DM, unless otherwise stated)

Substance	Content	Source
DM (% of wet weight)	18	Edström, pers.comm. (1993)
Ash	11	Edström, pers.comm. (1993)
Protein	40	Tritt & Schuchardt (1993)
Fat	44	Edström, pers.comm. (1993)
Carbohydrates	0	
N-Tot [a]	6.4	
NH_4^+-N	0.3	Tritt & Schuchardt (1992)

[a] *Calculated as protein/6.25*

Table 36. Chemical composition, from table 35, Handbook of chemistry and physics (1979) and chapter 4 (% of DM)

Substance	Carbohydrates	Fat	Protein	Sum
Distribution of nutritives	0	44.0	40.0	84.0
C	0	33.5	21.0	54.5
O	0	5.1	9.0	14.1
H	0	5.4	2.8	8.2
N			6.6	6.6
S			0.6	0.6

Table 37. Composition of sludge from Farmek`s internal sewage works (% of DM, unless otherwise stated) used in the Uppsala case study

Substance	Content	Note
DM, % of ww	18.0	
VS	88.5	
C-Ch Tot	0.0	
C-Fat	35.3	
C-Protein	22.1	
C-Tot	57.4	
O	14.8	
H	8.6	
N	6.8	
NH_4^+-N	0.3	
P	0.9	Tritt & Schuchardt (1992)
S	0.6	
Cl	0.3	Same as blue waste
K	0.1	Tritt & Schuchardt (1992)
Ca	1.0	Managing livestock wastes (1975)
Pb	$2*10^{-6}$	Chapter 3.8
Cd	$0.2*10^{-6}$	d:o
Hg	$0.5*10^{-6}$	d:o
Cu	$150*10^{-6}$	d:o
Cr	$4*10^{-6}$	d:o
Ni	$5*10^{-6}$	d:o
Zn	$3*10^{-3}$	d:o

7.4 Blood water

This waste fraction is a result of the fact that Farmek has increased its amount of slaughter. Normally the blood is sucked out of the carcasses and used in the production of cured meats. Due to the increase mentioned above, there is no capacity to utilise all blood, and some is flushed away with water and thus becomes waste.

7.4.1 Amount

The amount is 1500 tonnes per year (Edström, pers.comm. 1993).

7.4.2 Composition

The composition of the blood water from Farmek is presented in table 38, 39 and 40.

Table 38. Nutritive composition of blood water (% of DM, unless otherwise stated)

Substance %	Content	Source
DM, of ww	7.0	Edström, pers.comm. (1993)
Ash	8.0	SLV (1993)
Protein	89.0	SLV (1993)
Fat	2.2	SLV (1993)
Chfd	0.5	SLV (1993)
Chmd	0.0	
Chsd	0.0	
N-Tot [a]	14.2	
NH_4^+-N	1.0	Tritt & Schuchardt (1992)

[a] *Calculated as protein/6.25*

Table 39. Chemical composition of blood water (% of DM), from table 38, Handbook of chemistry and physics(1979) and chapter 4

Substance	Chfd	Fat	Protein	Sum
Distribution of nutritives	0.5	2.2	89	91.7
C	0.2	1.7	46.7	48.6
O	0.3	0.2	20.0	20.5
H	0.0	0.3	6.2	6.5
N			14.7	14.7
S			1.4	1.4

Table 40. Composition of blood water (% of DM, unless otherwise stated) used in the Uppsala case study

Substance	Content	Note
DM, % of ww	7.0	
VS	91.6	
C-Chfd	0.2	
C-Fat	1.7	
C-Protein	46.7	
C-Tot	48.6	
O	20.5	
H	6.5	
N	14.5	
NH_4^+-N	1.0	
P	0.5	Koivostinen (1980)
S	0.6	Koivostinen (1980)
Cl	0.6	Van Nostrand`s Scientific Encyclopaedia (1989) [a]
K	0.6	Koivostinen (1980)
Ca	0.1	Koivostinen (1980)
Pb	0.0	Koivostinen (1980)
Cd	$2.5*10^{-6}$	Koivostinen (1980)
Hg	$1*10^{-4}$	Koivostinen (1980)
Cu	$4.5*10^{-4}$	Koivostinen (1980)
Cr	$5*10^{-6}$	Koivostinen (1980)
Ni	$10*10^{-6}$	Koivostinen (1980)
Zn	$17.5*10^{-4}$	Koivostinen (1980)

[a] *Van Nostrand`s Scientific Encyclopaedia (1989) presents the content of NaCl in blood as 180 mg/100 ml blood which implies 110 mg Cl/100 ml blood. With current DM content this makes 0.6% Cl.*

7.5 "Blue" slaughterhouse waste

Hygienically satisfactory offal is called "blue waste". It consists of the parts of the animals we do not eat. For example hearts, lungs, udders, bones, skulls and so on. Presently this waste is transported to a fodder-producing industry in southern Sweden. For hygienisation it is heated to 70°C during one hour.

7.5.1 Amount

Farmek does not have data on the composition, but the amount is well known, being 2830 tonnes per year (Eriksson, pers. comm. 1993).

7.5.2 Composition

The composition of the blue slaughterhouse waste from Farmek is presented in table 41, 42 and 43.

Table 41. Nutritive composition of blue offal (% of DM, unless otherwise stated)

Substance	Content	Source
DM (% of wet weight)	30	Edström, pers.comm. (1993)
Ash	10	Edström, pers.comm. (1993)[b]
Protein	50	Edström, pers.comm. (1993)
Fat	37	Edström, pers.comm. (1993)
Chfd	3	Edström, pers.comm. (1993) [b]
N-Tot [a]	8	
NH_4^+-N	0	

[a] *Calculated as protein/6.25.*
[b] *Edström (pers.comm. 1993) states ash+C-Ch=13%, we assume 10% ash and 3% C-Chfd.*

Table 42. Chemical composition of blue offal (% of DM), from table 40, Handbook of chemistry and physics (1979) and chapter 4

Substance	Chfd	Fat	Protein	Sum
Distribution of nutritives	3.0	37.0	50.0	90.0
C	1.2	28.1	26.3	
O	1.6	4.3	11.2	17.1
H	0.2	4.6	3.5	8.3
N			8.2	8.2
S			0.8	0.8

Table 43. Composition of blue offal (% of DM, unless otherwise stated) used in the Uppsala case study

Substance	Content	Sources and notes
DM, % of ww	30.0	
VS	90.0	Table 41
C-Chfd	1.2	Table 42
C-Fat	28.1	Table 42
C-Protein	26.3	Table 42
C-Tot	55.6	Table 42
O	17.1	Table 42
H	8.3	Table 42
N	8.0	Table 42
NH_4^+-N	0.0	
P	1.0	Koivostinen (1980) [b]
S	0.8	Table 42
Cl	0.3	[a]
K	0.6	Koivostinen (1980) [b]
Ca	1.0	Koivostinen (1980) [b]
Pb	$2*10^{-6}$	Chapter 3.8
Cd	$0.2*10^{-6}$	Chapter 3.8
Hg	$0.5*10^{-6}$	Chapter 3.8
Cu	$1.5*10^{-4}$	Chapter 3.8
Cr	$4*10^{-6}$	Chapter 3.8
Ni	$5*10^{-6}$	Chapter 3.8
Zn	$30*10^{-4}$	Chapter 3.8

[a] *This is half the content in blood, according to Van Nostrand`s Scientific Encyclopaedia (1989) the Cl-content in blood is higher than in other tissues.*

[b] *This is an assumption based on figures for different guts and bones from Koivostinen (1980).*

7.6 "Red" slaughterhouse waste

This waste has a lower hygienic status than blue waste and originates from animals that have died of natural causes and from parts of or whole animals that have been rejected by the veterinary control. In Sweden this type of waste may not in any form be used as fodder for animals that are used for food production.

7.6.1 Amount

Farmek has a precise knowledge of the amount, 350 tonnes per year (Eriksson, pers. comm., 1994).

7.6.2 Composition

We assume that the composition is the same as blue offal, table 43. The reason to have it in a grade of its own is that it has to be heated to 130°C before it can be considered hygienic.

8. INDUSTRIES APART FROM FARMEK

8.1 Pharmacia

Pharmacia is a medical industry in Uppsala, producing a polyglucose solution waste which originates in the production of infusion nutrient. This waste is extremely clean, there is hardly any contamination, the reason it becomes waste is that it is not absolutely sterile.

8.1.1 Amount

The amount is 5300 tonnes per year (Edström, pers.comm. 1993).

8.1.2 Composition

As mentioned above, this is a pure polyglucose solution, n*($C_6H_{12}O_6$). Thus all other positions than those in table 44 in its ORWARE vector are zero.

Table 44. Composition of waste from Pharmacia (% of DM, unless otherwise stated)

Substance	Content
DM, % of w. weight	2.0
VS	100.0
C-Chfd	40.0
C-Tot	40.0
O-Tot	53.3
H-Tot	6.7

8.1.1 Energy consumption for evaporation

This waste is today utilised as fodder for dairy cows. To simplify the handling and use, its DM content is increased, from 2% DM to 25% DM, by evaporation. The evaporation is performed in a three-stage process. We assume 55% heat regeneration. The change in entalphy between 20°C and 80°C is 2507 kJ/kg water (Mörtstedt & Hellsten, 1987). The 55% heat regeneration means that 1128 kJ/kg water is needed. An increase in DM from 2 to 25% implies that 46 kg water is to be removed per kg DM. This in turn implies an energy consumption of 46 kg/kg*1.128 MJ/kg DM=51.9 MJ/kg DM.

8.2 Slotts

The waste from Slotts consists of batches of marmalade, mustard and ketchup that have been rejected for some reason. The problem is that these products are wrapped in glass or plastic, which may make them difficult to utilise.

8.2.1 Amount

There are no exact figures on the amount of waste. Today all waste is thrown into a skip and the company does not know how much that is biodegradable. Eriksson (1991) states 150 tonnes per year and Jonsson (1993, pers. comm.) mentions 50 tonnes/year. We used the figure 75 tonnes/year.

8.2.2 Composition

We assume that the waste from Slotts has the following constituents; tomato ketchup, orange marmalade and mustard, all to the same extent. The compositions of the three constituents according to SLV (1993) and Koivostinen (1990) are given in table 45.

Table 45. Composition of the different constituents in waste from Slotts (% of DM, unless otherwise stated)

Substance	Ketchup		Marmalade		Mustard		Mean
	Koivo-stinen (1990)	SLV (1993)	Koivo-stinen (1990)	SLV (1993)	Koivo-stinen (1990)	SLV (1993)	
DM, % ww	30.00	30.00	55.00	58.00	34.00	37.00	41.0
Fat		1.70		0.00		17.30	6.3
Protein		5.00		0.34		15.40	6.0
Carbo-hydrates		79.30		98.80		54.90	77.7
Ash	10.30	10.30	0.45	0.34	7.30	8.10	6.1
N	0.67		0.1		2.10		1.0
S	0.53		0.01		0.47		0.3
K	1.33	1.33	0.06	0.03	0.32	0.44	0.6
Ca	0.09	0.02	0.05	0.03	0.23	0.26	0.1
P	0.13	0.07	0.004	$3.4*10^{-3}$	0.32	0.46	0.2
Zn		$0.67*10^{-3}$		0.00		$1.9*10^{-3}$	$0.86*10^{-3}$
Na		3.17		0.03		2.05	1.8

We assume that the carbohydrates consist of 50% starch and 50% disaccharides (i.e. only fast degradable material). The figure for Cl is calculated using the content of Na, assuming that all Na and Cl occur as NaCl.

Table 46. Chemical composition of waste from Slotts, from Table 45 and chapter 4 (% of DM)

Substance	Chfd	Fat	Protein	Sum
Distribution of nutritives	77.7	6.3	6.9	90.9
C	33.4	4.8	3.6	41.8
O	39.4	0.8	1.6	41.8
H	4.9	0.8	0.5	6.2
N	0.0	0.0	1.1	1.1
S	0.0	0.0	0.1	0.1

Table 47. Composition of waste from Slotts, from Table 45, Table 46 and chapter 4 (% of DM unless otherwise stated)

Substance	Value used in the Uppsala case study	Note
DM, % of ww	41.0	
C-Chfd	33.4	
C-fat	4.8	
C-protein	3.6	
C-Tot	41.8	
O	41.7	
H	4.9	
N-Tot	1.1	
S	0.1	
Cl	2.7	Calculated as 1.5*Na content
K	0.6	
Ca	0.1	
P	0.2	
VS	92.3	Calculated so that sum of org. matter+ash= 100

8.3 Bakeries

There are a number of industrialised bakeries in Uppsala. The waste from these industries is of two kinds, flour and dough (Eriksson, 1991).

8.3.1 Amount

The amount of flour is 30 tonnes/year and dough 53 tonnes per year (Eriksson, 1991). This waste is generated uniformly throughout the year and it is not packed in any way.

8.3.2 Composition

The DM content of flour is 86% and of dough 36% (Eriksson, 1991). This, together with the amounts mentioned above, leads to a relation on DM basis of 60% flour and 40% dough. These figures are used for weighting the averages in the following tables.

Table 48. Nutritive composition of waste from bakeries (% of DM), from chapter 4, SLV (1993), Bränslen från jordbruksgrödor (1975)

Nutritive compound	Flour	Dough	Weighted average	C	O	H	N	S
Carbo-hydrates	88.4	82.8	86.2					
Chfd	76.9	77.0	77.0	33.7	38.4	4.9		
Chmd	9.1	4.5	7.3	3.3	3.6	0.3		
Chsd	2.4	1.3	2.0	1.3	0.6	0.1		
Fat	1.5	4.7	2.8	2.1	0.3	0.4		
Protein	9.9	12.1	10.8	5.6	2.4	0.8	1.9	0.16

Table 49. Composition of waste from bakeries, figures from table 45 are diminished in proportion to take the minerals (3% of DM) into consideration (% of DM unless otherwise stated)

Substance	Dough		Flour		Table 46	Value used in the Uppsala case study
	SLV (1993)	Koivostinen (1980)	SLV (1993)	Koivostinen (1980)		
DM, % of ww	36.0		86.0	86.0		55.0
VS	97.0	97.0	99.5	99.5		98.5
C-Tot					44.7	44.7
C-Chfd					32.7	32.7
C-Chmd					3.3	3.3
C-Chsd					1.3	1.3
C-Fat					2.0	2.0
C-Protein					5.4	5.4
O					43.9	43.9
H					6.3	6.3
N-Tot		2.2		2.4	1.9	2.3
S		0.1		0.2	0.2	0.1
P	0.2	0.2	0.1	0.2		0.2
Cl	1.2 [a]		0.5 [b]			0.8
K	0.3	0.3	0.1	0.19		0.2
Ca	0.1	0.1	0.0	0.0		0.05

[a] *Calculated as the natural Cl content (see footnote b) and the content calculated from the Na content, assuming that all Na and Cl is present as NaCl.*
[b] *According to Fries (1973), the natural Cl content in plants are between 0.14 and 1.10 % of DM. We assume 0.5% of DM.*

8.4 Nordmills

This waste consists of wheat grain that moulds during storage. This waste occurs very unevenly in time and amount, if one silo gets mouldy, the whole volume has to be condemned. This complicates the handling of this waste. Normally there is no waste and then suddenly there are 10-50 tonnes all at once.

8.4.1 Amount

The assumed amount is 50 tonnes/year, which is the figure for 1990 (Eriksson, 1991).

8.4.2 Composition

The DM content in dried grain is supposed to be below 15%, so we assume 15% for the grain that is mouldy.

Table 50. Nutritive composition of waste from Nordmills (% of DM) calculated using chapter 4

Substance	Åkerberg et al. (1965)	Bränslen från jordbruks-grödor (1975)	Value used in the Uppsala case study	C	O	H	N	S
VS	95.8	98.5	97.0					
Protein	12.6	10.6	12.0	6.3	2.7	0.8	2.0	0.2
N-Tot [a]	2.0	1.7	1.9					
Chfd	[b]	76.5	74.0	32.4	37.0	4.6		
Chmd	[b]	8.5	8.5	4.0	4.2	0.3		
Fat	2.3	2.5	2.5	1.9	0.3	0.3		

[a] *Calculated as protein/6.25*
[b] *Sum of Chfd and Chmd is 80.5% of DM*

Table 51: Composition of waste from Nordmills (% of DM unless otherwise stated)

Substance	Value used in the Uppsala case study	Source or note
DM, % of ww	85.0	Table 50
VS	95.6	Table 50
C-Chfd	32.4	Table 50
C-Chmd	4.0	Table 50
C-Chsd	0.0	Table 50
C-Fat	1.9	Table 50
C-Protein	6.3	Table 50
C-Tot	44.6	Table 50
O	44.2	Table 50
H	6.0	Table 50
N-Tot	1.9	Table 50
S	0.15	Koivostinen (1980) states 0.16
P	0.25	Mean from Koivostinen (1980) and SLV (1993)
Cl	0.5	Table 49
K	0.3	Mean from Koivostinen (1980) and SLV (1993)
Ca	0.04	Mean from Koivostinen (1980) and SLV (1993)

9. RESTAURANTS AND CATERING

There are several investigations regarding organic waste from restaurants and catering. The problem is that the results differ widely, both concerning the amount and the composition.

9.1 Amount

According to Berg (1992) the amount of waste from restaurants and caterers can be calculated as a function of the number of employees in restaurants and hotels. The municipality of Uppsala has 62% of the inhabitants in the county of Uppsala (SCB, 1993). We assume that the proportion of the labour force that works in the above-mentioned business in Uppsala is the same as in Sweden as a whole (the statistics only give the national level proportion). We also assume that 95% of the employees in restaurants and hotels work within the city and only 5% work in the countryside and thus are outside the system's boundary. The employees in restaurants number 1162 and in hotels 642 according to the reasoning above, combined with data from SCB (1993). The amount of waste per employee is 1258 kg/year in restaurants and 1000 kg/year in hotels. The figures above lead to 2100 tonnes/year, as an estimate of the amount of organic waste from restaurants and catering.

This is the figure chosen, being within the range 1650 tonnes/year (Lindman, 1990) to 5100 tonnes/year (Eriksson, 1991), which are the two extreme values found in literature.

9.2 Composition

We assume that this waste has the same composition as the average intake of food in Sweden according to SCB (1993). This assumption is based on the fact that waste from this branch mainly consists of food leftovers and to some extent of preparation waste. These materials are likely to have a similar composition to the food we eat.

Table 52. Intake of nutritives in Sweden

Nutritive	Intake, g DM/person*day (SCB, 1993)	Distribution of nutritives, % of DM	Distribution of nutritives (Anderberg, 1980), % of DM	Chosen value, [a] % of DM
Protein	90	15.9	15.8	13
Fat	121	21.4	30.6	24
Chfd	326	57.8		19 [b]
Chmd				20 [b]
Chsd	27 [c]	4.8 [c]	53.6 [c]	4 [b]
Sum	564	100.0		

[a] *The chosen values have been reduced to account for the ash content of 20%.*

[b] *The distribution of carbohydrates is presumed to be the same as in household waste.*

[c] *Sum of Chmd and Chsd.*

Table 53. Nutritive composition of waste from restaurants and caterers (% of DM)

Nutritive	C	O	H	N	S
Protein	6.8	2.9	0.9	2.2	0.2
Fat	18.2	2.8	3.0		
Chfd	8.3	9.5	1.2		
Chmd	9.3	9.9	0.8		
Chsd	2.6	1.2	0.2		
Sum	45.2	26.3	6.1	2.2	0.2

Table 53 together with some single data from other references and also from household waste gives the assumed composition of waste from restaurants and caterers used in the Uppsala case study (Table 54).

Table 54. Composition of waste from restaurants and caterers (% of DM unless otherwise stated)

Substance	Value	Source or note
DM, % of ww	30.0	Widén (1993), Wikberg & Mathisen (1991)
VS	79.6	Widén (1993), Wikberg & Mathisen (1991)
C-Chfd	8.3	Table 53
C-Chmd	9.3	Table 53
C-Chsd	2.6	Table 53
C-Fat	18.2	Table 53
C-Protein	6.8	Table 53
C-Tot	45.2	Table 53
O	26.3	Table 53
H	3.1	Table 53
N-Tot	2.2	Table 53
S	0.2	Koivostinen (1980) states 0.16
P	0.1	Mean from Koivostinen (1980) and SLV (1993)
Cl	0.4	Same as household waste.
K	1.2	Mean from Koivostinen (1980) and SLV (1993)
Ca	2.8	Same as household waste.

10. GREASE SEPARATORS

The grease separators are installed in connection with restaurants and caterers and consists of a devices that decreases the fat content of the waste water. Fat may cause problems in the sewers and in the sewage plant.

10.1 Amount

The amount is 3000 tonnes/year (Edström, pers. comm. 1993).

10.2 Composition

The composition is calculated using the assumption that 90% of DM is fat and the residual being fast degradable carbohydrates. The DM content is 2% (Edström, pers.comm. 1993).

Table 55. Composition of fat water (% of DM unless otherwise stated), Koivostinen (1980), SLV (1993) and chapter 4

Substance	Fat (90% of DM) (chapter 4)	C-Chfd (10% of DM) (chapter 4)	Fat (Koivo-stinen, 1980)	Fat (SLV, 1993)	Value used in the Uppsala case study [a]
DM, % of ww					2.0
VS			99.0	98.0	98.0
C-Fat	67.9				66.6
C-Chfd		4.4			4.3
C-Tot					70.9
O	10.5	4.9			15.3
H	11.1	0.6			11.6
N			0.1	0.1	0.1
S			0.1		0.1
P			0.03	0.02	0.05
Cl [b]				1.0	1.0
K			0.02	0.02	0.02
Ca			0.02	0.02	0.02

[a] *Some figures are decreased in proportion to the VS content.*
[b] *Assumed that all Na and Cl is bound as NaCl, since the content of Na is known, the Cl content can be calculated.*

11. PARKS

11.1 Amount

According to Uppsala kommun (1993b) the amount of waste from parks is 11 kg/inhabitant, and in Uppsala this implies 1900 tonnes/year.

11.2 Composition

The nutritive composition of park waste is presented in table 56. The figures originate from several investigations. Thereafter the chemical composition is presented in table 57, using data from chapter 4 to transform the data from table 56.

Table 56. Nutritive composition of waste from parks (% of DM unless otherwise stated)

Substance	Part of DM [a]	DM	VS	Chfd	Chmd	Chsd	Prot
Wood	70	75 [b]	97 [b]		70 [e]	24 [e]	4 [d]
Leafs	20	40 [c]	75 [c]	27 [f]	27 [f]	20 [f]	1 [f]
Grass cuttings	10	20 [d]	94 [d]	32 [d]	40 [d]	14 [d]	10 [d]
Weighted average		61	90	8	59	22	4

[a] = Jonsson (1993, pers. comm.)
[b] =Statens energiverk (1985)
[c] = Fries (1973)
[d] = Bränslen från jordbruksgrödor (1975)
[e] = Tillman (1978)
[f] = Wessén (1983)

Table 57. Chemical composition of park waste (% of DM unless otherwise stated), calculated from table 56 and chapter 4

Substance	Chfd	Chmd	Chsd	Protein	Total
Distribution of nutritives	8.0	59.0	22.0	4.0	93.0
C	3.5	26.6	14.4	1.8	46.3
O	4.0	28.0	6.6	0.8	39.4
H	0.5	2.5	1.0	0.3	4.3
N				0.6	0.6
S				0.05	0.05

Table 58. Composition of waste from parks (% of DM unless otherwise stated)

Substance	Value used in the Uppsala case study	Source or note
DM, % of ww	60.0	Table 56
VS	90.2	Table 56
C-Chfd	3.5	Table 57
C-Chmd	26.6	Table 57
C-Chsd	14.4	Table 57
C-Protein	1.8	Table 57
C-Tot	46.3	Table 57
O	39.0	Table 57
H	4.0	Table 57
N-Tot	0.7	Table 57
S	0.05	Table 56, Widén (1993) states 0.06
P	0.1	Average of Widén (1993) and Bengtsson & Fergedal (1991.)
Cl	0.5	Table 49
K	0.5	Average of Widén (1993) and Bengtsson & Fergedal (1991.)
Ca	1.0	Average of Widén (1993) and Uppsala public works office (1993a)

12. GARDENS

Organic waste from gardens consists of all waste that is generated in private gardens and in some way treated. This implies for example that grass clippings that remains on the lawn is not included. The treatments can be composting, burning or depositing it on a landfill.

12.1 Amount

The amount of waste from private gardens are 15 kg/year and one-family dwelling and 5 kg/year and apartment (Berg, 1992). This figure represents only the waste that is presently collected. Many garden-owners take care of their garden waste themselves. Since the aim of the ORWARE model is to compare different handling systems for all organic waste, we increase the amount from one-family dwellings by 100%, i.e. to 30 kg/year and garden. With the numbers of households in Uppsala we get 560 tonnes/year.

12.2 Composition

We use the figures for park waste with the difference that there are no grass clippings, the wood part is 85% and the leaf part is 15%.

Table 59. Nutritive composition of waste from gardens (% of DM unless otherwise stated)

Substance	Part of DM	DM	VS	Chfd	Chmd	Chsd	Prot
Wood	85	75 [a]	96 [a]	54 [d]	24 [d]		4 [c]
Leaves	15	40 [b]	75 [b]	27 [e]	27 [e]	20 [e]	1 [e]
Weighted average		70	92	4	64	23	3

[a] =Statens energiverk (1985)
[b] = Fries (1973)
[c] = Bränslen från jordbruksgrödor (1975)
[d] = Tillman (1978)
[e] = Wessén (1983)

Table 60. Chemical composition (% of DM), calculated from table 59 and chapter 4

Substance	Chfd	Chmd	Chsd	Protein	Total
Distribution of nutritives	4.0	64.0	23.0	3.0	94
C	1.8	29.8	15.3	1.6	48.5
O	2.0	2.5	7.1	0.7	12.3
H	0.3	2.5	1.1	0.2	4.4
N				0.5	0.5
S				0.05	0.05

Table 61. Composition of waste from gardens (% of DM, unless otherwise stated)

Substance	Value used in the Uppsala case study	Source or note
DM, % of ww	70.0	Table 59
VS	92.4	Table 59
C-Chfd	1.8	Table 60
C-Chmd	29.8	Table 60
C-Chsd	15.3	Table 60
C-Protein	1.6	Table 60
C-Tot	48.5	Table 60
O	41.7	Table 60
H	4.4	Table 60
N-Tot	0.5	Table 60
S	0.05	Table 60
P	0.1	Average of Widén (1993) and Bengtsson & Fergedal (1991.)
Cl	0.5	Table 49
K	0.5	Average of Widén (1993) and Bengtsson & Fergedal (1991.)
Ca	0.5	Average of Widén (1993) and Uppsala public works office (1994)

13. DISCUSSION

The main result from this survey is the lack of data concerning organic wastes, not only regarding contaminants but also the distribution of the main constituents and content of plant nutrients.

There are different levels of accuracy in the numbers given in this report. The accuracy can be divided into three levels. The highest level, where we have found good data, include:

- Heavy metal content in most waste fractions. There were few data for the industry waste, but instead there were data available for the food that the waste originated from.
- The amounts of waste from all sources, except grease separators, are fairly easy to get data on. This is the measure used in the economic system, the companies are charged by volume or tonne of waste that they generate.
- Some waste fractions from the slaughterhouse, manure and stomach content. These fractions are used in agriculture as fertilisers or soil amendments and therefore are analysed, both concerning content of nutrients and heavy metals.

The medium level of accuracy concerns;

- The distribution of the major constituents and plant nutrients in household and park waste.
- Most waste fractions from the slaughterhouse, sludge, blood and slaughter waste. No analyses were performed on the waste but relatively good assumptions could be made using data from animal physiology and food chemistry.
- The distribution of major constituents and plant nutrients in the other industrial waste, Slotts, Nordmills, Pharmacia and industrialised bakeries. As for the slaughterhouse waste, no analyses have been performed on the waste, but since the waste is well-defined

regarding "ingredients", mainly food, it is possible to use data for food to estimate the composition of the waste.

The substances where the presented numbers are insufficiently substantiated are:

- The amount of organic pollutants (CHX, VOC, PAH, PCB, AOX, dioxins and phenols) in all waste fractions.

The greatest need for more research concerning the composition of organic waste, as we see it in the light of the simulations with ORWARE, is primarily concerning the major constituents, the nutritives, such as carbohydrates, fat, protein etc., in addition to the content of plant nutrients. This is urgent since the performance of the biological treatment processes is dependent on the composition of the feedstock. The content of organic pollutants in waste is not well investigated. However, since the knowledge is small concerning the fate of these substances in the treatment processes and to some extent also concerning their environmental impact, a better knowledge of the content of organic pollutants will not automatically increase the accuracy of the simulation results.

REFERENCES

Anderberg, Å. Tallrikssvinn - resultat av åtta undersökningar, (Wastage from plates - result from eight analyses, in Swedish) Livsmedelsteknik, 7 (1980), p 372-373.

Andersson, A. Some aspects on the significance of heavy metals in sewage sludge and related products used as fertiliser. Swedish Journal of Agricultural Research 7 (1977), p 1-5. Uppsala.

Bengtsson, L., Fergedal, S. 1991. Kompostering av parkavfall-studie i Uppsala kommun (Composting of waste from parks in Uppsala municipality, in Swedish). Swedish Institute of Agricultural Engineering (JTI), Rapport 131. Uppsala.

Berg, P. 1992. Manual för beräkning av avfallsmängder (Manual for calculating waste amounts, in Swedish). Naturvårdsverket, Rapport 4081. Stockholm.

Biology of anaerobic micro-organisms. 1988. John Wiley and sons inc. New York.

Bränslen från jordbruksgrödor. 1986. Möjlig produktion -Råvarukostnader och värde av sidoprodukter (Fuels from agricultural crops, Possible production and value of by-products, in Swedish), Projekt Agrobioenergi, Rapport för etapp 5 1983-1986, SLU & Swedish Institute of Agricultural Engineering (JTI). Uppsala.

Databok för driftplanering. 1983. (Databook for farm management, in Swedish). SLU, Speciella skrifter 14. Uppsala.

Enquist, T. 1964. Organisk kemi (Organic Chemistry, in Swedish), Almqvist & Wiksell, Uppsala.

Eriksson, A. 1991. Biogas i Uppsala - Potential och teknik (Biogas in Uppsala - Potential and technology, in Swedish). Royal Institute of Technology (KTH), Institutionen för värmeteknik, Examensarbete 1/1991. Stockholm.

Fries, N. 1973. Fysiologisk botanik (Physiological Botany, in Swedish), Biologi 3. Almqvist och Wiksell. Stockholm.

Funseth, E. & Ilbäck, N-G. 1991. Dioxin och dess effekter på vårt immunförsvar (Dioxin and its effects on our immune defence, in Swedish). The National Food Administration (SLV), Rapport nr 10 1991, Uppsala.

Gijzen, H.J., Lubberding, H.J., Verhagen, F.J., Zwart, K.B. & Vogels, G.D. Application of rumen micro-organisms for an enhanced anaerobic degradation of solid organic waste materials. Biological Wastes 22 (1987), p 81-85.

Halmstad kommun renhållnings AB. 1986. Avfallssammansättning och rågasdata (Waste composition and combustion gas data, in Swedish). Halmstad municipality. Sweden.

Handbook of chemistry and physics, 60 th. edition, 1979. CRC. USA

Heie, A. 1981. Utnyttelse av matavfall (Utilisation of food waste, in Norwegian). Hovedrapport NTNF-projekt 210876.00/214092.01. Trondheim. Norway.

Kemikalieinspektionen. 1991. Kemiska ämnen, Nonylfenol (Chemicals, Nonylphenol, in Swedish). Kortfaktablad, Kemikalieinspektionen. (National Chemicals Inspectorate). Stockholm.

Koivostinen, P. (Editor). Mineral element composition of Finnish foods: N, K, Ca, Mg, P, S, Fe, Cu, Mn, Zn, Mo, Co, Ni, Cr, F, Se, Si, Rb, Al, B, Br, Hg, As, Cd, Pb and ash. Acta Agriculturæ Scandinavica, supplementum 22 (1980). Stockholm.

Lindman, K. 1990. Inventering, komposterbart material i Göteborg - Enkelriktade materialflöden (inventory of compostable material in Gothenburg - One way flows of material, in Swedish). Göteborgs reningsverk, projektavdelningen. Göteborg.

Managing livestock wastes. 1975. The proceedings of the 3rd international symposium on livestock wastes, American Society of Agricultural Engineers. University of Illinois. USA.

Mörtstedt, S-E & Hellsten, G. 1987. Data och Diagram- Energi och kemitekniska tabeller (Data and Diagrams - Tables on energy and chemical technological data, in Swedish). Esselte studium. Stockholm.

Nybrant, T., Jönsson, H., Frostell, B., Sundqvist, J-O., Thyselius, L., Dalemo, M., Mingarini, K.& Sonesson, U. 1996. System Analysis of Organic Waste - The ORWARE model, Case study Uppsala. Swedish Waste Research Council, AFR-report 109. Stockholm.

SCB. 1993. Statistical abstract of Sweden 1992. Official Statistics of Sweden. Stockholm.

SLV. 1993. Livsmedelstabeller (Food Composition Tables). The National Food Administration (SLV). Uppsala.

SNV. 1993a. Karakterisering av avfallsfraktioner från källsortering-delrapport, (Characterising waste fractions from source separation, partial report, in Swedish). Naturvårdsverket & RVF. Naturvårdsverket rapport 4194, RFV-Rapport 1993:2:4. Malmö.

SNV. 1993b. Källsorterat hushållsavfall - Kompostering och förbränning-huvudrapport (Source separated household waste - Composting and incineration, main report, in Swedish). Naturvårdsverket & RVF. Naturvårdsverket rapport 4185, RFV-rapport 1993:2. Malmö.

Solyom, P. 1978. Slakterinäringens avfallsproblem (Waste problems in the slaughter industry, in Swedish). Swedish Environmental Research Institute, IVL-B 431. Stockholm.

Statens energiverk. 1985. Energiskog, resultat, slutsatser och förslag från det svenska energiskogsprogrammet (Energy forest, results, conclusions and suggestions from the Swedish energy forest program, in Swedish). Statens energiverk. Stockholm.

Sundqvist, J-O. 1991. Källsorteringsförsök i Botkyrka -sortering av hushållsavfall i brännbart, organiskt och deponirest (Field trials with source separation in Botkyrka - sorting of household waste in burnables, organics and remnant, in Swedish). Royal Institute of Technology (KTH), miljövårdscentrum, avfallsgruppen, Stockholm.

Tillman, D. 1978. Wood as an energy resource. Academic Press. New York. USA.

Tritt, WP. & Schuchardt, F. Materials flow and possibilities of treating liquid and solid wastes from slaughterhouses in Germany, a review. Bioresource technology 41 (1992), p 235-245. Elsevier Applied Science.

Uppsala Public Works Office. 1993a. Analys av komposter (Analyses of composts) 930629. Uppsala municipality.

Uppsala public works office. 1993b. Förslag till reviderad avfallsplan för Uppsala kommun, Remissutgåva 1993-05-09. (Revised waste plan for Uppsala municipality, circulated for consideration by the parties concerned, in Swedish). Uppsala municipality. Uppsala.

VAV 1989. Organiska föroreningar i kommunalt avloppsvatten och slam, (Organic pollutants in municipal waste water and sewage sludge, in Swedish). VAV, Meddelande M68, Maj 1989. Stockholm.

Van Nostrand`s scientific encyclopaedia 1989. 7:th ed. Van Nostrand Reinhold. New York. USA.

Waz, R. 1993. Organochlorine contaminants in Swedish foods of animal origin and in human milk 1973-1992. SLU, Deptarment of Food Hygiene, Dissertation. Uppsala.

Wessén, B. 1983. Decomposition of some forest leaf litters and barley straw- some rate determing factors. SLU, Deptartment of Microbiology, Report 19. Uppsala.

Widén, P. 1993. Kompostering av källsorterat hushållsavfall i Uppsala-nedbrytningsförlopp, tungmetall-och växtnäringsinnehåll (Composting of source separated household waste in Uppsala-decomposition, content of heavy metals and plant nutrients, in Swedish). SLU, Deptartment of Soil Science, Examensarbete. Uppsala.

Jorhem, L. Mattsson, P. and Slorach, S. Lead, Cadmium, Zink and certain other metals in foods on the Swedish market. Vår Föda, Volym 36, Supplementum 3 (1984). The National Food Administration (SLV), Uppsala.

Becker, W. Ekman, J. Hambraeus, L. (editors) Svinnet i livsmedelshanteringen (Food wastage in Sweden, in Swedish). Vår föda, Volym 37, supplementum 1 (1985). The National Food Administration (SLV). Uppsala.

Åkerberg et al. 1965. Bättre brödsäd (Better cereals, in Swedish). LT:s förlag. Kristianstad.

Östlund, K. Efter döden får vi av oxen såväl biff som korv (After the death we get from the ox sausage as well as beef, in Swedish), Livsmedelsteknik 7 (1980), p 314-315.

Personal communications

Edström, M. 1993. Swedish Institute of Agricultural Engineering (JTI), Uppsala.

Eriksson, J. 1993. Farmek, Uppsala.

Jonsson, M. 1993. Uppsala public works office. Uppsala.

Sundquist, J-O. 1994. Swedish Environmental Research Institute (IVL). Stockholm

Wikberg & Mathisen, 1991. Swedish Institute of Agricultural Engineering (JTI). Uppsala.