Dioxins and other POPs in by-products, recyclates and wastes and their potential to enter the food chain

– Stage II –

Final Report

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European POPs Expert Team

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Contents

1 Background and objectives of the project

BACKGROUND

The project is funded by the European Commission, Directorate-General Environment in the framework of « Environment and Health» policy and in the framework of the implementation of the « Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee on a Community Strategy for dioxins, furans and polychlorinated biphenyls» (COM(2001)593), adopted by the European Commission in October 2001. This Communication announced to fund further research on the subject of the recovery of contaminated waste in the feedingstuff production.

As demonstrated by some recent accidents, the contamination of wastes and their industrial use in the feedingstuff industry may cause increased levels of persistent organic pollutants (POPs) - such as polychlorinated dibenzo-p-dioxins, dibenzofurans and polychlorinated byphenyls (PCDDs, PCDFs and PCBs[1]) – in feedstuff. By entering the food chain these contaminants are a potential risk to public health.

In 2000a study has been launched by the European Commission (Directorate-General Environment) to evaluate the current data situation concerning PCDD, PCDF and other POPs in wastes and their mass fluxes into feedingstuff. As in that study, following four wastes have been selected with a potential of POP contamination and with potential of being used in the feedingstuff industry, notably

1) olive pulp (as example for the group oil(seed) cake /oil meal)
2) used oils and fats
3) agricultural and industrial wastes with a high fibre content and
4) animal waste.

[1] as far as not other specified, the term “PCBs” in this study means the 12 “WHO PCBs” or “dioxin-like PCBs” or “DLPCBs”

OBJECTIVES

1. Against this background the objective of the present project is to close data gaps, that have been identified in the first study , by the means of **further research and data collection**.
2. When necessary data are not available or can not at least be approximated by existing data, data generation by collection and analysis of samples is necessary. Consequently, a second objective of this study is to develop a **sampling program and a sampling strategy** in order to allow an appropriate monitoring in the field of POPs and wastes related to the food chain.
3. Finally the results shall provide **information** which is required in order to define to which extent the **elimination** of certain contaminated wastes entering the food chain via feedingstuff might **reduce the overall human daily intake** of PCDD/PCDFs and other POPs.

Preliminary results of the study have been presented and discussed during a workshop[2] with international experts on POPs and POPs control in the EU. The workshop focused on the results for different relevant materials, the concept and methodology for the strategy to close data gaps and finally on weaknesses of current legislation, enforcement and control. The outcome of the discussions are incorporated in this report.

The following material flows into compound feedingstuffs will be investigated in this study:

- components from olive processing
- components from processing of used oils and fats
- components from processing of animal waste
- components from agriculture and industry with a high fibre content

In consultation with the European Commission it has been decided to include selected further types of materials such as catering waste, components from vegetable oil processing or components from vegetable and fruit processing. It could be demonstrated that the corresponding material flows also contribute to a POPs contamination of feed and food via the recovery of by-products, recyclates and wastes and consequently should be investigated to follow the general objective of lowering the feed and food contamination with persistent organic pollutants. In consultation with the European Commission and based on the above mentioned Community Strategy it has been further decided to focus on dioxins and PCBs within the group of POPs. However, the developed methodology and results with regard to legislation, enforcement and control cover all POPs.

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[2] International workshop, held at the European Commission in Brussels on 3 July 2002

All through the text, the project team has used a little bit indistinctly the words “waste, recyclates and by-products” to refer to the output of some processes of the agro-food industry which are used as input in feed stuff production. This was done to avoid a debate on waste - non waste as it is out of the scope of the present study to discuss the difference by-products, waste and recyclates (this would trigger a very lengthy legal discussion on the definition of waste).

Nevertheless, we would like to quote here the Community definition of waste to be found in Article 1, paragraph a) of Directive 75/442/EEC on waste “any substance or object which the holder discards or intends or is required to discard”. The key word in the definition is the verb “discard”. Only the European Court of Justice has the jurisdiction to provide a definitive interpretation of Community law.

The European Court of Justice, in a series of important cases has clarified the concept of the meaning of discard. From this it is clear that the following factors, amongst others, need to be taken into account in the light of the European Court of Justice’s jurisprudence:

- The fact that a substance/object is capable of economic reutilization is irrelevant to the question of determining the existence of waste: para 9 of *C-359/88 Zanetti*
- Irrelevant that a substance/object has a commercial value for determining waste status: para 52 in C-304/94 Tombesi
- The concept of ‘discard’ covers both the situation where a substance/object is recovered and disposed: para 27 *C-129/96 Inter-Environnement Wallonie*
- The central determining feature, namely whether the substance/object has been discarded, means that whether a substance/object has undergone a recovery operation is not necessarily conclusive as to the existence of waste. All the circumstances should be considered, taking into account the aims of the directive (environmental protection considerations) and provided its aims are not undermined or scope restricted (para 73, *C-418/97 ARCO)*.
    - method of treating the substance (eg if used as fuel is a common method of recovery) (para 69)
    - what is commonly regarded as waste (para 54)
    - where the substance is a production residue, ie a substance not in itself sought for in the production process or for which there is no other use other than disposal (paras 84-86)

According to the Court the concept of waste cannot be interpreted restrictively [3] and must accord with the environmental protection principles set out in the EC Treaty, principally in Article 175 EC.[4]

Therefore it is clear that these include where the substance in question is a residue from a production process, which can be subsequently recovered or disposed of. Therefore, for instance, a residue of a production process which is recycled (thus recovered) in a subsequent process is not excluded from the definition of waste.

In any case, where a substance is to be defined as waste it will be subject to Community legislation on waste and in particular Article 4 of Directive 75/442/EEC, which imposes that waste has to be recovered or disposed of, inter alia, without risk to animal health, human health or the environment. This obligation is crucial in the recovery of agro-food industry waste as feedingstuff. This type of recycling can not constitute a risk for human or animal health.

[3] Paragraph 40 of Court judgment.

[4] Paragraph 42 of Court judgment.

2 General methodology and methodology to close data gaps

2.1 Introduction to the basic methodological problems

A major problem in meeting the project targets can be seen in the fact that for a great variety of feedingstuffs with a lot of different components and many regional particularities data are missing. Consequently a huge amount of samples would be necessary to provide sufficient information for the decision making process. However, there are no resources to collect and analyse thousands of samples. Consequently a sampling strategy has to focus on the most important data gaps. In addition, data availability on the contamination of relevant materials is a continuous process and upcoming data have to be taken into consideration to avoid unnecessary sampling. On the other hand often available contamination data are not representative and difficult to compare. Therefore also the different quality of data has to be included.

Therefore, to serve as a basis for any decision making process a **"sampling and data collection strategy**" is necessary. As described such a strategy has to fulfill a lot of tasks. It finally shall enable an efficient implementation and provide – with a limited budget – a reliable decision base for measures against the POPs input into the food chain due to the use of by-products, recyclates and wastes for animal feed. Therefore a strategy has to go into details and for example offer names of institutions that might support the generation of new data by provision of samples or relevant information.

An answer to these questions and methodological problems has been developed by creating a strategy that is an open system in the sense that various types of data and especially upcoming data can be integrated. The developed strategy is a scientifically based "filter" which provides relevant and representative data taking into account existing and upcoming data.

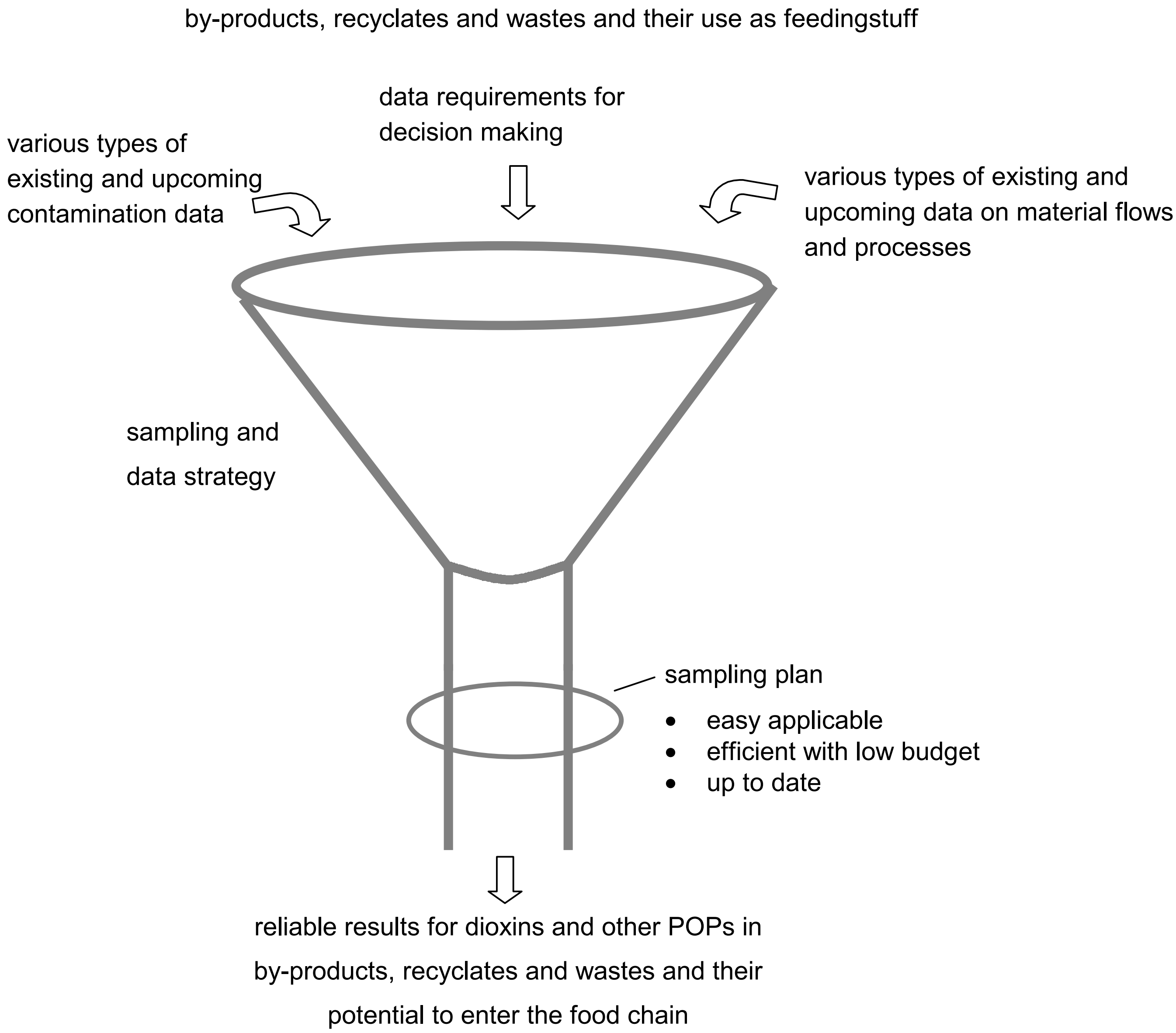


Figure 2-1: Filter principle

2.2 Methodological elements

As illustrated in Figure 2-1 the objective of a strategy is to get reliable results for dioxins and other POPs in by-products, recyclates and wastes that enter the food chain via feed material.

To this end a concept has been developed including the following methodological elements:

- integration of available contamination data (see chapter 2.2.1)
- material flow analysis (see chapter 2.2.2)
- contamination-volume-categories (see chapter 2.2.3)

- process step analysis (see chapter 2.2.4)
- theses of contamination (see chapter 2.2.5)
- indications for requirements for decision-making (see chapter 2.2.6)
- tools according to representativity criteria (see chapter 2.2.7)
- computer based sampling plan (see chapter 2.2.8).

These elements create both:

+ an overview for results based on already existing data taking into account the most up to date investigations
+ a sampling plan that fulfils the requirements to cover still existing data gaps efficiently.

2.2.1 Integration of available contamination data

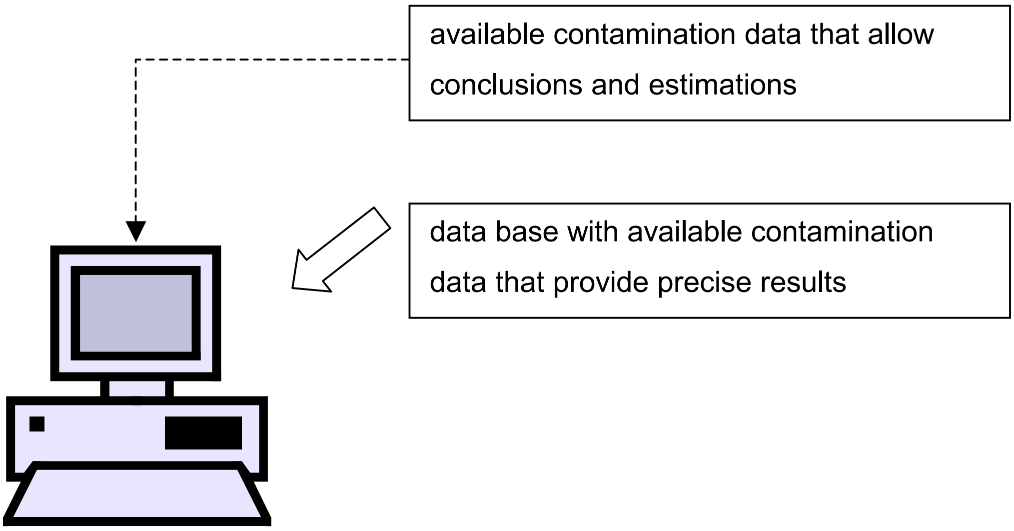
This methodological element aims at the integration of already existing data on contamination levels with POPs, in particular with dioxins and PCBs. To this end available data are identified (see chapter 2.3) and are evaluated with respect to data requirements for political measures. For this purpose the identified available data are evaluated according to their reliability and their usability in the sense of how these data can be used instead of taking new samples where knowledge is required. “Usable” data are appropriate to reduce the amount of samples that is required to close gaps in knowledge. They will consequently be taken into consideration for the establishment of the sampling plan. Furthermore it will be evaluated how and to which degree the data can be taken into consideration for the estimation of the importance with respect to feedingstuff contamination.

To integrate available information it is crucial to differentiate between

- available contamination data, that provide precise results and that consequently need no further analysis of samples
- available contamination data, that allow conclusions and estimations on possible contamination levels but that can not be used instead of results of an analysis of samples

Data that provide precise results directly influence the amount of required samples in the proposed sampling plan (see chapter 2.2.8). These data are selected from the other available data and documented in a database. This database is linked with the calculation of necessary samples (sampling plan).

As the strategy is designed as an open system, new data can easily be integrated into the database and reduce the necessary amount of samples in the sampling plan according to the information they provide for the project aims. This is realised by an EXCEL calculation sheet. The described methodological element enables an easy up-date of the sampling plan always according to the current state of knowledge and gives an overview on data that provide precise results for the relevant materials.



2.2.2 Material flow analysis

The tool is necessary to quantify the importance of by-products, recyclates and wastes as input material for feedingstuffs and the food chain. Material flows are described quantitatively by a differentiation of materials and flow stations. A balance of input and output of single flow stations allows developing a plausible structure of volumes.

Following the intention of the project the interface "intake of feedingstuff by livestock animals" defines one system boundary for material flows. All what happens after intake of feedingstuffs by livestock animals will not be analysed within this project. To start the mentioned flow analysis the relevant components of compound feedingstuffs have to be identified. They form elements of the material flow (see chapter 11).

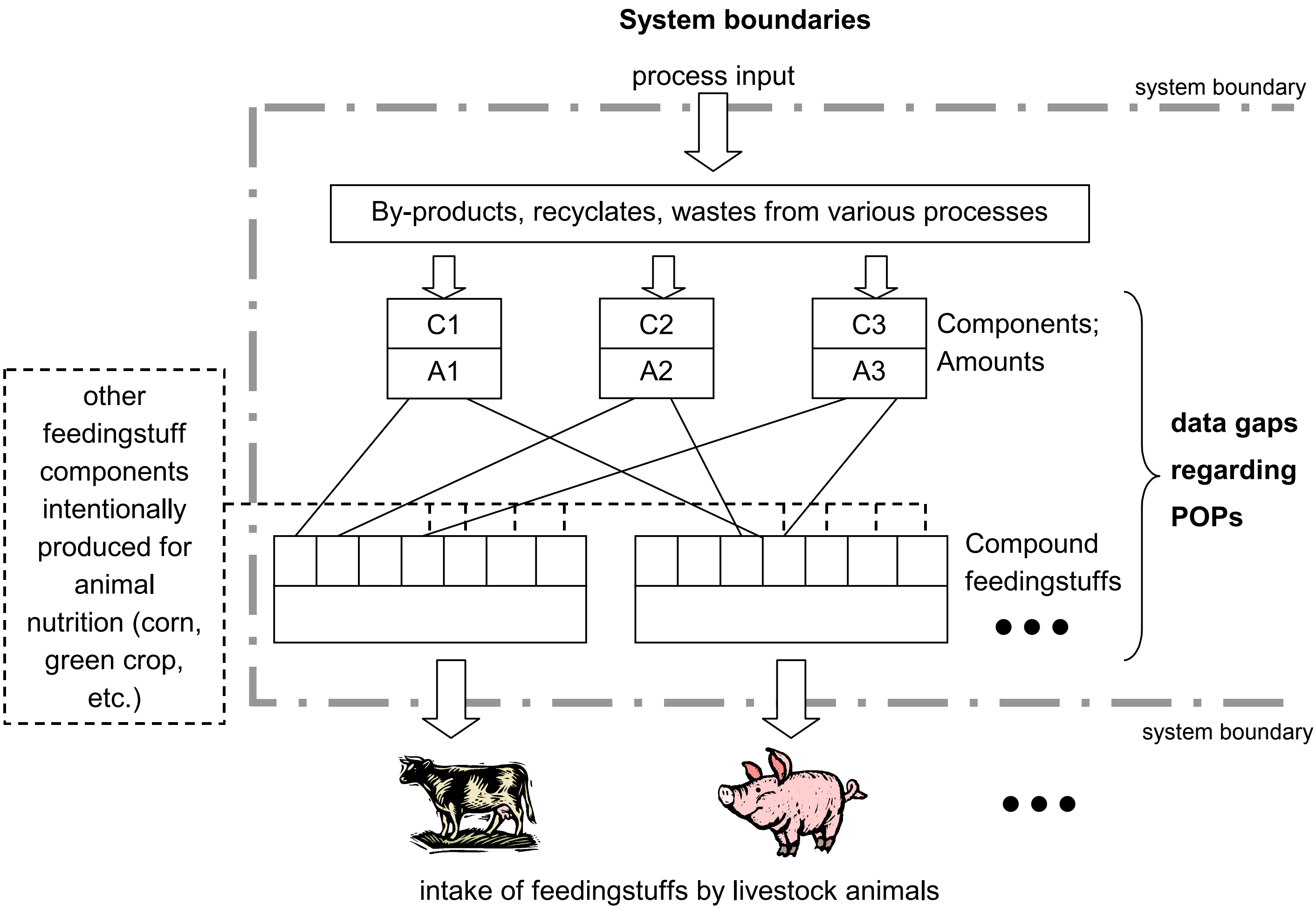


Figure 2-2: Identification and quantification of the components of compound feedingstuffs

These components of compound feedingstuffs are investigated in a bottom up approach following their way back to their origin. In many cases this origin lies in agricultural products (corn, green crop, etc.) that have been intentionally produced for animal nutrition. However an important amount of feed materials is derived from various other processes in the form of waste, recyclates or by-products. These processes and the related outputs define the upper system boundary for investigation. Consequently it is not foreseen to examine the contamination pathways during the growth of plants etc.

The corresponding material flows are important for the targets of the project and therefore have to be further analysed.

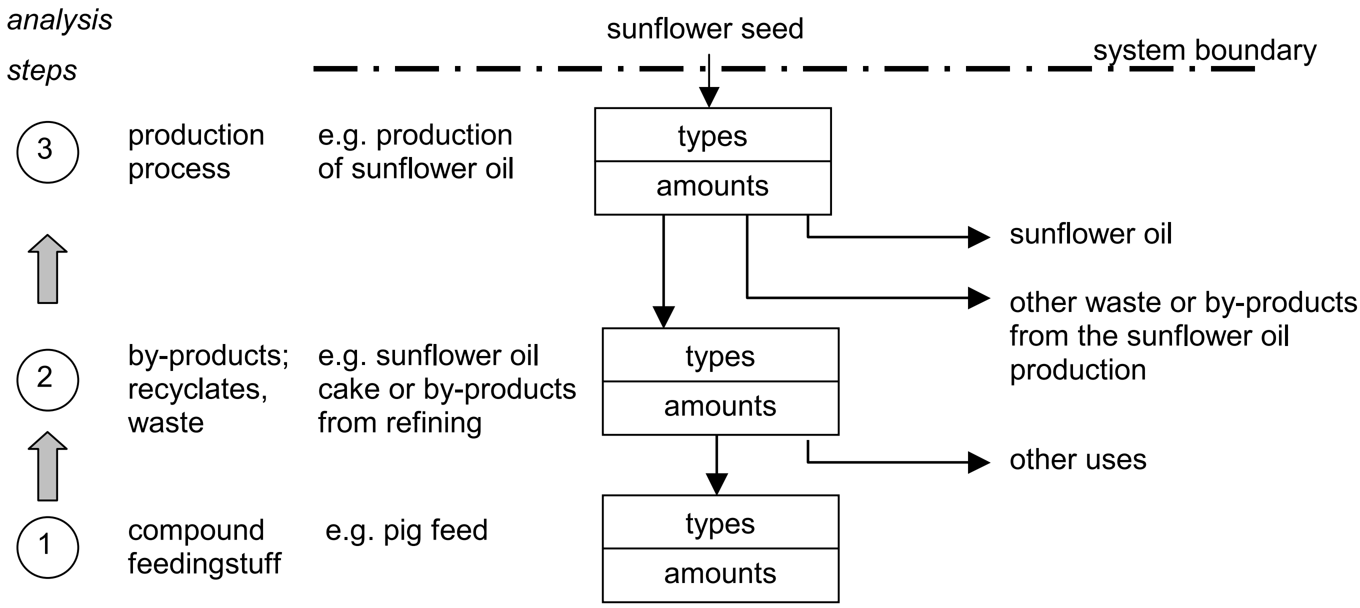


Figure 2-3: Example of bottom up approach of material flow analysis

The principle of material flow analysis requires the examination of the material flow by independent approaches. Thus a bottom up and a top down approach are applied. This other side of the system boundary – or the starting point of the material flow within the system – is defined by the input to processes resulting in the generation of waste, recyclates or by-products which are used in feedingstuff production or might be directly used for food production (the latter is comparatively seldom). Therefore the above mentioned second approach examines the relevant waste generating processes, the correlated input material and most important the waste fraction used for feedingstuff production (or directly for food production).

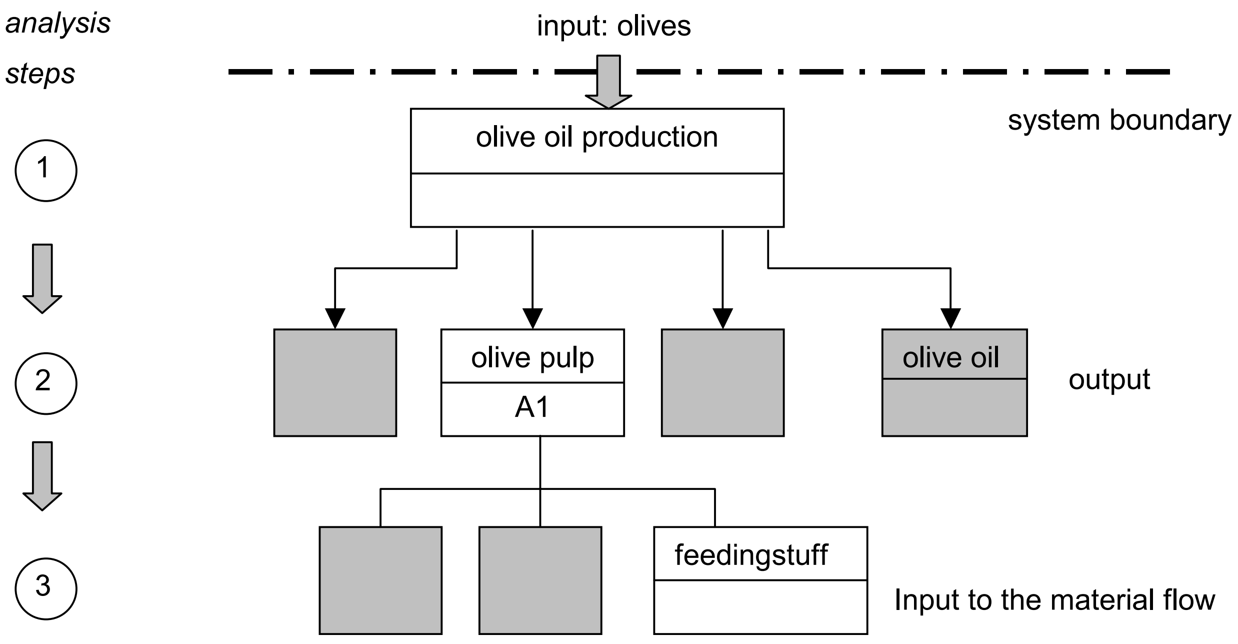
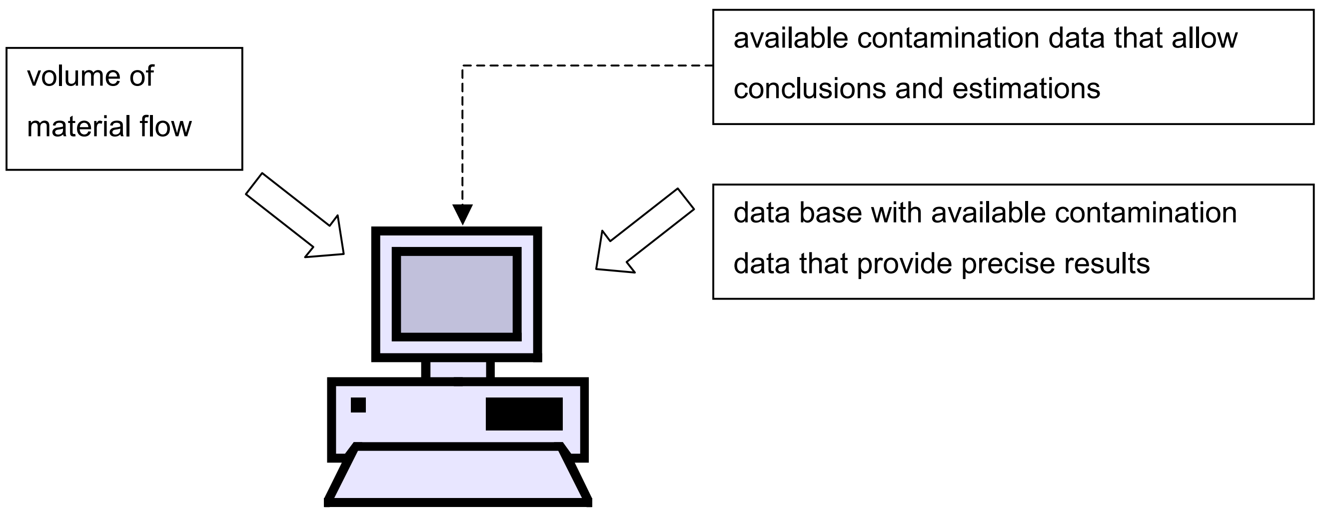


Figure 2-4: Example of a top down approach of material flow analysis

By comparing the two independent approaches uncertainties, in particular regarding incompatibilities of amounts of wastes, recyclates and by-products, can be identified. Additional investigation can be realised at identified focal points in an efficient way. Thus a higher quality of data and results can be achieved.

Following a plausibility check a realistic structure of the material flow can be derived after putting together single elements.

It has to be stated that material flows themselves do not give any indication on volumes of required contamination flow data. However, in combination with existing contamination data they are extremely necessary for the whole data and sampling strategy as they allow to assess the importance of the input pathways for contaminants into compound feedingstuffs.



2.2.3 Contamination-volume-categories

The importance with respect to WHO-TEQ input into compound feedingstuffs depends on two parameters: 1. the amount entering compound feedingstuffs and 2. the contamination levels of raw materials as they are not equally contaminated. Consequently it is necessary to know about the contamination level of different materials. As far as data are missing there is no objective information that allows to take samples in an efficient way from important material flows.

To overcome this problem the methodological tool of "contamination-volume-categories" has been developed. This tool provides a first indication about the importance of material flows following available data that allow estimations of contamination levels and consequently conclusions on the importance of material flows (see chapter 2.2.1). The contamination data are combined with the amounts used for compound feedingstuff in the EU Member States which result from the material flow analysis.

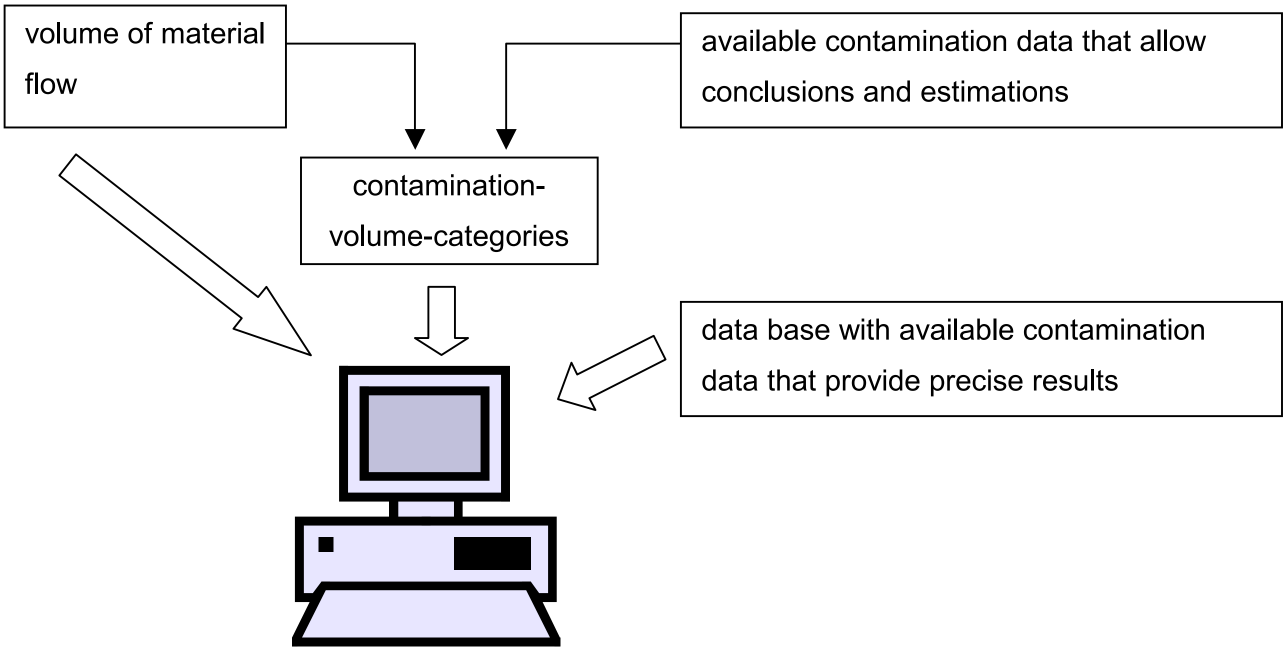
average contamination level	**X**	amount used for compound feedingstuffs	**=**	contamination volume

The resulting contamination volumes (dimension g WHO-TEQ for dioxins and PCBs) can not show precise values, therefore categories are formed:

WHO-TEQ input into compound feedingstuffs contamination volume [g/a]	Importance of WHO-TEQ input contamination-volume-category
0 – 0.1	low
> 0.1 – 1.0	medium
>1.0	high

Table 2-1: Contamination volume categories

If absolutely no contamination data are available, a plausible estimation has been made with the tendency to go on the "safe" side and choose a higher contamination category. The resulting contamination-volume-categories can be applied as an indicator for the importance of WHO-TEQ input into compound feedingstuff industry in the Member States. Consequently it has direct consequences on the amount of samples to be taken. This is due to the efficiency criteria that for more important flows into compound feedingstuffs more information is required. With the described procedure and the instrument of contamination volume categories it is possible to overcome the circle problems mentioned above.



2.2.4 Process step analysis

There is a wide range of production processes in the different industry branches that are related to the generation of relevant waste, recyclates and by-products. Some of the processes are comparatively complex and sometimes there are different technologies to run a process and correspondingly there is a different process related generation of wastes, recyclates and by-products. As a consequence POP contamination of the process outputs and thus the corresponding input into feedingstuffs may differ significantly.

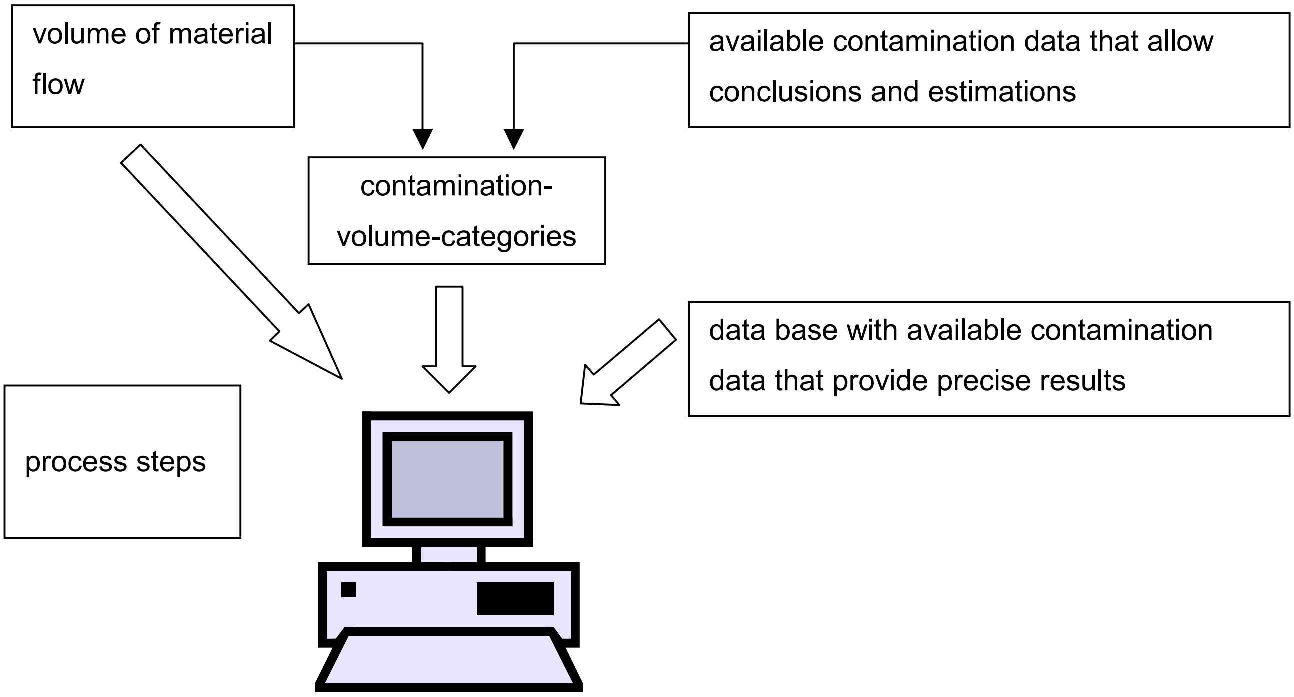
In order to identify pathways and possible sources but also possible sinks for POPs it is necessary to examine the corresponding processes. To this end the processes that are related to the relevant material flows have been differentiated in process steps. The process steps have been further characterised by related inputs, outputs and process conditions.

The tool "process step analysis" enables to develop a process based and production orientated data and sampling plan. This means that all relevant steps within the production chain can be covered by an adequate number of already existing data or by samples that still have to be collected. This approach leads to advantages compared with a consumption orientated approach that would only examine the interface of the intake of feedingstuff by livestock animals. Major advantages are:

+ accumulation and formation processes can be identified

+ literature data and already existing results of measurements can be included systematically

+ conclusions on pathways and potential sources can be drawn.



It has to be stated that the number or complexity of process steps do not give any indication on volumes of necessary contamination data. To solve the problem of the integration of process steps in the computer based strategy the methodological element "Theses of contamination" (see chapter 2.2.5) is necessary.

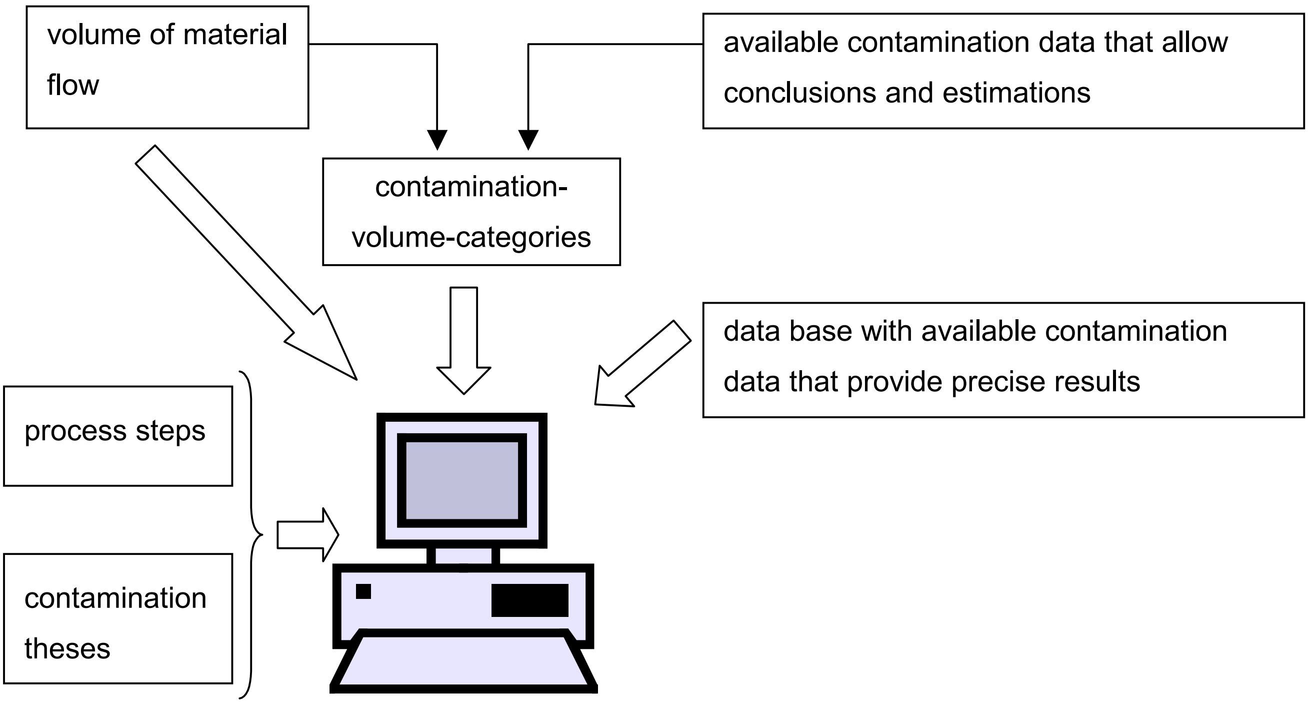
2.2.5 Theses of contamination

The various processes generating by-products, recyclates and wastes that are used for feedingstuffs would cause an unacceptable high number of data sets or samples respectively that would be required for reliable results. Therefore it is necessary to follow the filter strategy in another dimension. For this reason existing knowledge

- on available contamination levels of selected POPs (in particular dioxins and PCBs) for various components and process steps
- on mechanisms of generation (such as direct heating or certain chemical treatment) or separation/concentration (e.g. concentration in lipid rich materials or in separated surface particles) of these POPs

has been evaluated and has been combined with the characteristics of the process steps (involved substances, physical-chemical process conditions).

Based on this knowledge, theses have been derived regarding the steps within the processes where contamination with or generation of POPs may be expected. These theses can be verified or rejected by the analysis of available data or of corresponding samples. Following this procedure the structure and the amount of necessary data and hence the number of samples for reliable results can be further minimised.

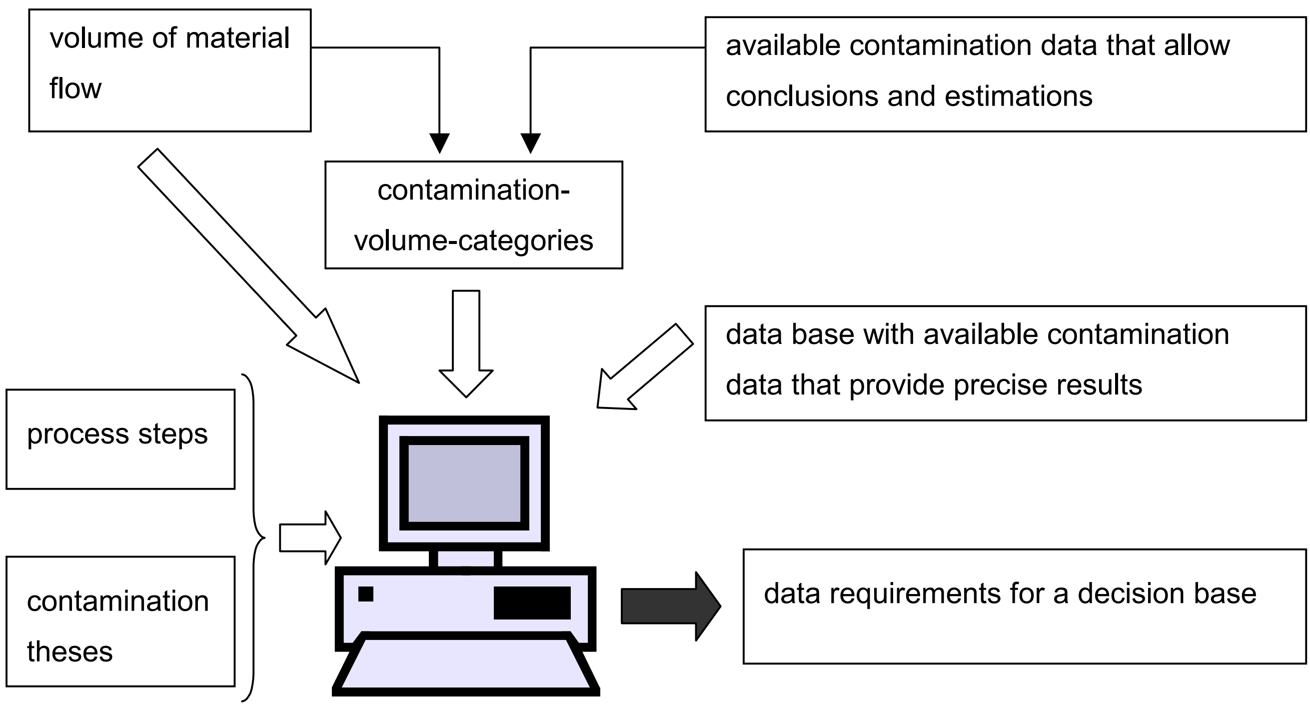


2.2.6 Indication for requirements for decision-making

The results of contamination-volume-categories (see chapter 2.2.3) and process step analysis in correlation with contamination theses (see 2.2.4and 2.2.5) indicate the requirements for a decision base. The high contamination-volume-category generally needs more data for political decisions than the medium or the low contamination-volume-category. Also the number and type of process steps and contamination theses defines data requirements.

A main purpose of the methodological element "process step analysis" (see chapter 2.2.4) in combination with "theses of contamination" (see chapter 2.2.5) is to identify critical points and critical types of material flows within processes. For these points and types data are necessary in order to provide information to the path of contamination and the relevance for material flows.

Such knowledge is crucial in order to decide efficient measures aiming at the reduction of POP flows into feedingstuffs.



2.2.7 Tools according to representativity criteria

After application of the up to now described methodological elements, still a huge amount of data would be needed and would require unacceptable budget and efforts for a comprising sample collection. By the means of the application of representative criteria it is possible to generate scientifically based statistical results. In this context the

- importance of material flows (results of material flow analysis)
- comparability of processes (results of process step analysis)
- regional distribution
- number of plants

play a major role for the adjustment of necessary data. In addition special tools correlated with representativity can be applied:

Mixed samples for typical contaminations

The following chart shows that the output of processes can be characterized in three types:

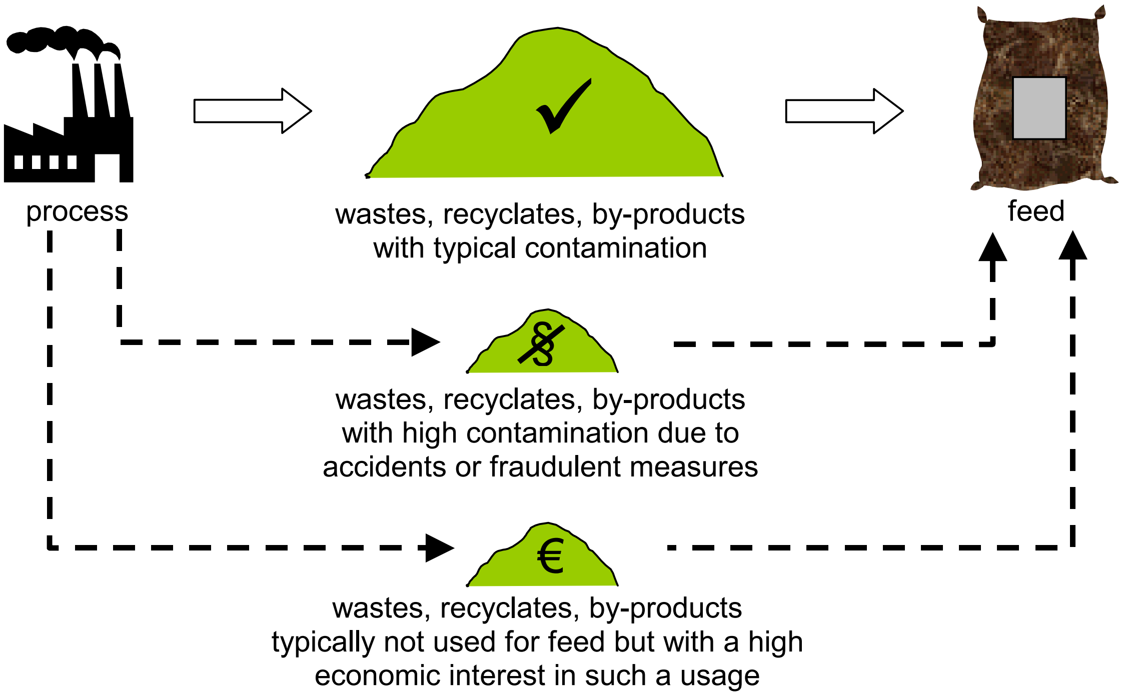


Figure 2-5: Types of process output relevant for the sampling plan

An objective of the project is to identify wastes, recyclates or by-products with potential POP contamination that might be legally or illegally used in the feedingstuff industry. POP contamination due to illegal measures is usually significantly higher compared to typical contamination levels of other material. Consequently the sampling strategy has to take into account materials with typical contamination but other materials with high contaminations due to accidents or fraudulent measures. Having in mind the recent incidents related to dioxins and PCBs it is important to cover

- materials with extraordinary high contamination due to accidents or fraudulent action or
- waste with high contamination levels due to it's use as feed material instead of an appropriate but expensive waste treatment

These two additional material flow types are illustrated in Figure 2-5. The data and sampling strategy takes these material flows into account. To this end for missing data mixed samples for accidental contamination are foreseen.

To analyse wastes, recyclates and by-products with typical contaminations the principle of mixed samples has proven to deliver reliable results in the case of information gaps. One background behind this principle is that every single analysis of a sample on POPs concentrations is quite expensive. However, if up to 20 individual samples of the same sample type are mixed together one analysis gives a broader picture on average contaminations. Consequently, with a given budget, more samples can be taken in order to increase the representativity and reliability of the results in a very efficient way.

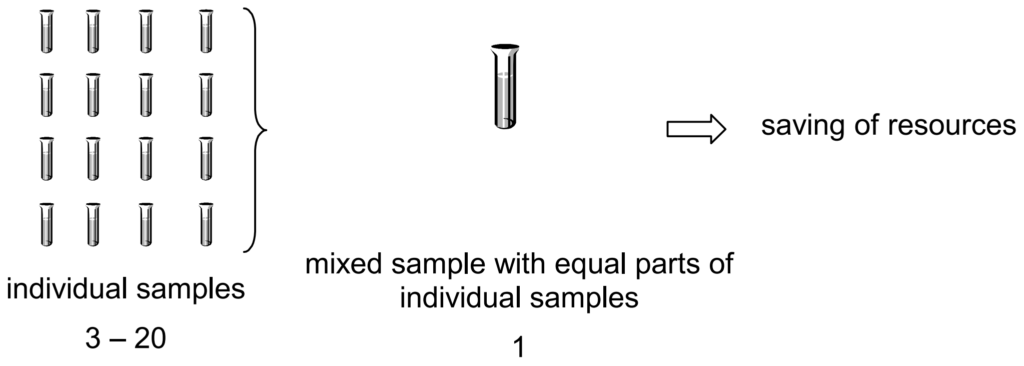


Figure 2-6: Mixed samples for typical contamination

However, one has to keep in mind that the information content of a mixed sample with 20 individual samples behind can not be the same as the information content of 20 analysed individual samples or 20 reliable data sets. In addition, to use the cost saving method of mixed samples it is necessary that the samples are taken, stored, treated and prepared in an identical way before they are mixed together and prepared for further analysis. Consistent quality control measures have to be applied. Furthermore it is crucial to keep back up samples so that contamination levels of mixed samples can be traced back and attributed to individual samples. Thus the sources of extreme values can be identified.

The precise number of individual samples that are mixed together to a mixed sample is calculated on statistical and representativity criteria (see chapter 2.2.8).

Mixed samples for accidental contaminations

The principle to analyse effects of high contaminations which might result from accidents, illegal measures or wastes that are not suitable to be used in the feedingstuff industry follows the principle of mixed samples as it is described for samples with typical contamination.

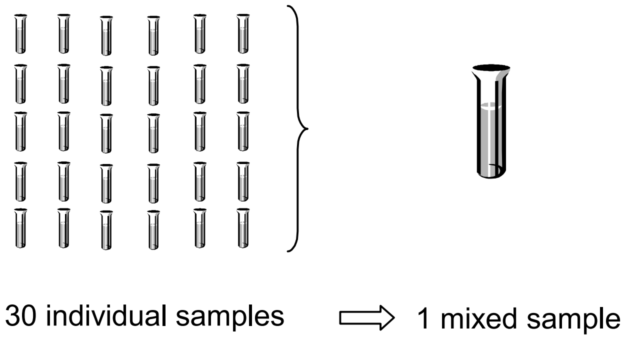
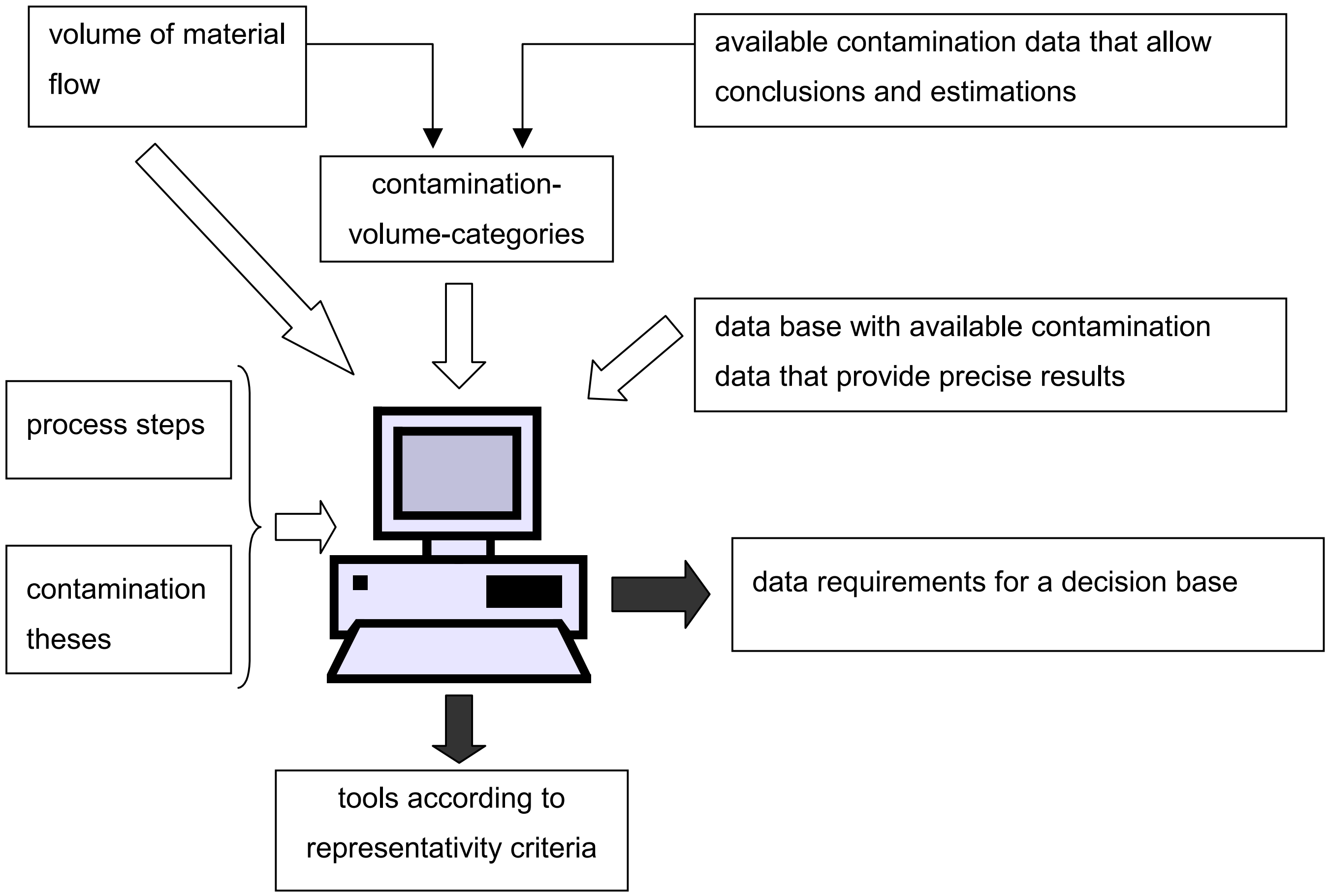


Figure 2-7: Mixed samples for accidental contamination

A higher amount (up to 30) of individual samples is mixed together to one mixed sample. In this way it is possible to identify an individual sample contaminated ~60 times higher than the expected average. In this case the resulting contamination of the mixed sample will be 3 times higher than the expected average value. It depends on the range of existing values whether the factor 3 can be interpreted as significant or not.

This is explained by the following example for a feed material with typical contamination values ranging from 0 to 2 pg/g fat with a mean of 1 pg/g fat:

- average expected contamination: 1 pg/g fat PCB
- typical values range: 0 - 2 pg/g fat PCB
- sample with high contamination: > 60 pg/g fat PCB
- mixed sample without high contamination sample: (30*1)/30 = 1
- mixed sample including high contamination sample: (29*1 + 1*60)/30 = 3
  → further analysis necessary because result is more than 3 times higher than expected
- identification of the highly contaminated individual sample (60 pg/g fat) is possible within 5 additional measurements



2.2.8 Computer based sampling plan

As described the data and sampling strategy has been outlined as a flexible open model that is able to respect possible alterations of background data and to include new data on amounts and contamination levels of materials used in compound feedingstuffs. Data that provide useful new information can be included in the model with direct consequences on the sample amounts as they are given in the sampling plan.

In order to achieve such a flexible model, the sampling plan is based on an EXCEL model that calculates the required sample amounts on the basis of existing information related to amounts and contamination data for the selected material flows. The model also allows to update the results after a certain time and to extend the strategy on further materials that turn out to be relevant.

The calculation model works with the elements described above. First step of the program is the calculation of the contamination-volume-category.

Second step is the correlation of the contamination-volume-category with the amount of process specific samples that result of the process step analysis and the contamination theses. If no contamination theses exist or if they are not essential the program foresees a 1 step procedure with output based samples, otherwise a 2 step procedure with process specific samples (step 1) and output based samples (step 2) is followed.

For process specific samples the mixed samples approach can not be applied, all samples have to be analysed individually in order to provide a clear picture of the POP flows within a specific process and in order to enable to identify the material flows that are relevant for POP input to feedingstuffs.

Typically only one set of process specific samples is taken per process at a typical plant (representative process conditions, input materials, etc.). However, the representativity and reliability of the process specific sampling approach may be increased by carrying out sampling and analysis of the whole process at several plants. This procedure may be reasonable if the evaluation of the first set of process specific samples shows unexpected results.

Another reason that requires process specific sampling at several plants are significant differences within important process technologies that are applied in the EU. In such cases it is necessary to analyse the different process variations in detail. For this purpose a multiplier is foreseen, that indicates, how many different process realisations have to be analysed by process specific samples.

Process specific sampling has to be differentiated from process output related sampling which defines the 1 step procedure and the second step of the 2 step procedure. Output related samples are taken only from the relevant output materials. Mixed sample strategies can be applied and will be suggested by the calculation program. As a result conclusions can only be drawn on the contamination of the specific output.

Low contamination volume category

If the contamination volume category is low, generally only samples for accidental contamination should be foreseen. 1 mixed sample consists of 30 individual samples.

Medium contamination volume category

If the contamination-volume-category is medium, generally samples for typical contamination and for accidental contamination should be foreseen. 1 mixed sample for accidental contamination consists of 30 individual samples, 1 mixed sample for typical contamination of 15 individual samples. A maximum of 7 countries should be covered with samples for typical contamination.

High contamination volume category

If the contamination-volume-category is high, generally samples for typical contamination should be foreseen. Due to the volume of samples also the accidental aspects are included into the samples for typical contamination. 1 mixed sample for typical contamination consists of 20 individual samples. All relevant countries of the EU are covered.

All numbers of the above mentioned procedure are corrected with the number of already existing data coming up with an efficient sampling plan.

All parameters with regard to the sample numbers can be changed by the user of the calculation program taking into account different requirements for a decision base or specific resource situations on sampling capacities. The adjusted parameters in the system reflect the experience of the project team and can be see as an indication and suggestion.

2.3 Tools to close existing data gaps

Apart from the application of the described methodology the closure of existing data gaps is important to realise the strategy and to achieve the aims of the project.

Major data gaps in this context are [Fiedler 2000]

- raw material fluxes (including recyclates) into feedingstuffs for different livestock species
- related concentrations of PCDD/PCDF and other POPs

The following tools to close existing data gaps have been applied:

- expert interviews with national authorities, associations and enterprises
- evaluation of the relevant current and proposed legislation
- evaluation of data bases as far as available and authorised for use
- evaluation of scientific literature and internet investigation

2.3.1 Expert interviews

The results from expert interviews are included throughout the report. Furthermore some experts have contributed to the improvement of the data availability by providing results on POP contamination levels of relevant materials.

2.3.2 Relevant current and proposed legislation

A detailed analysis of the legal situation related to wastes, recyclates and by-products and their potential to enter the feed and food chain was not a main objective of the project. Chapter 12 gives a short overview on the legal situation as a basis for the discussion of deficiencies and possible improvements in legislation, enforcement and control.

2.3.3 Available data bases

Data bases from national authorities, the European Commission, international organisations and individual experts have been used as far as available and permitted for use. For example SCAN, SCOOP and other more recent data such as recent literature (e.g. Dioxin 2000) have been used. Furthermore internal data and data from industry associations or individual plants could be integrated.

2.3.4 Literature and internet investigation

Recent literature has been analysed and a profound internet investigation has been performed with respect to data gaps. Appropriate data have been integrated into the database of available contamination data. All literature and internet sites quoted are documented in the data base or the references.

3 General introduction to compound feedingstuffs

3.1 Definitions and classifications

The term *"compound feedingstuffs"* is defined as "mixtures of feed materials, whether or not containing additives, for oral animal feeding in the form of complete or complementary feedingstuffs" [Article 2 (b), Council Directive 79/373/EEC of 2 April 1979 on the marketing of compound feedingstuffs].

Furthermore, this Directive applies the following definitions – which are also used as definitions in the present study - to feedingstuffs and feed materials:

- *"Feedingstuffs"* are (Article 2 [a]): "products of vegetable or animal origin in their natural state, fresh or preserved, and products derived from the industrial processing thereof, and organic or inorganic substances, used singly or in mixtures, whether or not containing additives, for oral animal feeding".
- *"Complete feedingstuffs"* are (Article 2 [d]): "mixtures of feedingstuffs which, by reason of their composition, are sufficient for a daily ration".
- *"Complementary feedingstuffs"* are (Article 2 [e]): "mixtures of feedingstuffs which have a high content of certain substances but which, by reason of their composition, are sufficient for a daily ration only if used in combination with other feedingstuffs".
- *"Mineral feedingstuffs"* are (Article 2 [f]): "complementary feedingstuffs composed mainly of minerals and containing at least 40 % crude ash".
- *"Feed materials"* are (Article 2 [k]): "various products of vegetable or animal origin, in their natural state, fresh or preserved, and products derived from the industrial processing thereof, and organic or inorganic substances, whether or not containing additives, which are intended for use in oral animal feeding, either directly as such or after processing, in the preparation of compound feedingstuffs or as carriers of pre-mixtures".

3.2 Industrial production of feedingstuffs

In Europe approx. 125 million tonnes of feed are annually produced by European manufacturers. 90 million tonnes thereof are consumed by farm animals finally resulting in a production of 35.4 million tonnes of meat, 121 million tonnes of milk and 5.2 million tonnes of eggs consumed by European consumers.

The biggest compound feedingstuff producers in the EU are France, Germany, Spain, the Netherlands, the United Kingdom and Italy, providing more than 100 million tons or about 80% of the total European annual production. Data for the year 2000 are shown in the following table.

Member State	Cattle	Pigs	Poultry	Milk replacer	Others	Total
DE	6.500	7.150	5.000	180	500	19.330
F	4.400	6.900	9.700	490	1.620	23.110
IT	3.650	2.550	4.550	170	1.280	12.200
NL	3.400	5.900	3.150	720	750	13.920
BE	1.120	3.450	1.400	53	180	6.203
UK	4.500	2.000	6.200	15	1.160	13.875
IRL	1.780	670	440	8	352	3.250
DK	1.300	3.900	700	0	131	6.031
ESP	3.200	9.000	4.300	70	1.300	17.870
PO	1.080	1.210	1.410	0	200	3.900
AT	300	190	380	0	160	1.030
SE	1.100	550	520	5	150	2.325
FIN	671	301	286	no data	101	1.359
EUR 15	33.001	43.771	38.036	1.711	7.884	124.403
% EU 15	26.5	35.2	30.6	1.4	6.3	100.0

Table 3-1 Industrial compound feedingstuff production in Europe in million tons (without Luxembourg and Greece) in 2000 [FEFAC 2002],

The production amounts did not change significantly from 1999 to 2002 (125,309 vs. 124,403 kt). The stable production pattern of the total compound feed production reflects stable trends per animal species on a EU basis whereas individual figures for member states diverge significantly. The impact of the BSE crisis was estimated to result in a significant temporary drop in cattle feed production in 2001 (estimated 5%) which did not take place in fact. In a similar way, the foot and mouth disease outbreak has not deeply affected pig feed production. As a whole, the industrial feed production appears to remain comparatively stable.

4 Components from olive processing in feedingstuff

4.1 Existing contamination data

In the European Union about 8.3 million tons of olives are processed every year. Some by-products of this process like olive pulp or non edible olive oil are used for feedingstuff. Existing contamination data indicate the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
olives	fat	no data available	~0.24
olive oil (pressed)	fat	~ 0.25	~ 0.2
olive oil (solvent extracted, refined)	fat	~ 0.09	no data available*
olive oil (solvent extracted, non-refined)	fat	~ 0.64	~ 1,0
olive pulp	product	0.08	~ 1,5
olive pulp (solvent extracted)	product	~ 0,05	~ 0,02
* according to estimations the contribution from DLPCBs (Dioxin like PCBs) to the total WHO-TEQ is about one third.			

Table 4-1: Olive processing: approximate WHO-TEQ levels on the basis of available data

6 data sets meet the process specific information requirements and can be directly used for a decision base at 5 relevant process steps. They are documented in annex 1.

4.2 Material flow

A bottom up approach leads to the following components of compound feedingstuff that might result from olive processing:

total amount of oil cakes and meals from oil seed including olive pulp 32,163 kt

oils and fats 2,144 kt

However, expert discussions with feedingstuff producers came up with the result that the amount of olive pulp going into feedingstuffs is less than 1 kt. In former years olive pulp has been used in animal nutrition in considerable amounts. Currently the use of olive pulp in feedingstuff production is very limited due to problems related to nutritional or to particular taste properties.

Feedingstuff producers further stated that the amount of "non edible olive oil" (meaning not edible for humans), that has to be seen as a by-product after solvent extraction, is used in quantities lower than 10 kt. Usually these oils are used after being mixed together with other feedingstuff components.

The top down material flow approach showed that olive pulp or olive oil cake (meal) is a by-product which results from the olive oil production. There is no intentional production of olive pulp. Due to its residual oil content the olive pulp is used for various purposes like feedingstuff, fuel or as fertiliser. The following relevant amounts result from the top down approach:

olives as raw material	8,300 kt
table olives (product)	600 kt
olive oil (product / by-product)	1,900 kt
olive pulp (by-product)	2,800 kt

A study of the DG Environment indicates the shares of the by-products and waste generated by the olive oil processing in Europe that are recycled to land (direct land spreading).

Country	waste arisings		recycling to land	
	waste water	solid waste	%[5]	kt
Italy	2,400	1,600	40%	~ 1,000
Greece[6]	1,400	800	40%	> 600
Portugal[6]	200	100	40%	> 100
Spain[6]	2,800	1,600	40%	>1,000
total	~ 7,000	~ 4,000		>3,000

Table 4-2: Estimates of waste generated from olive oil processing in 1999 [EC 2001 b]

The major problem with regard to the use of olive pulp in feedingstuff is its high content in phenols. As a consequence investigations have been made on possibilities to reduce the phenol content by the means of various treatments (e.g. solid state fermentation, fungi treatment, mixing with other raw materials). The investigations have not yet brought the desired

[5] for waste water only

[6] estimates

results and the use of olive pulp in compound feedingstuffs is at present of minor importance. Consequently the most important recovery options for olive pulp are combustion and recycling to land (e.g. direct land spreading, compost) . However, the future use of olive pulp for compound feedingstuff can not be ruled out depending on the progress and results from corresponding research.

For the further analysis a lower and an upper estimation is followed.

	lower estimation	upper estimation
olive pulp used for feedingstuff	< 1 kt	< 50 kt
non edible olive oil	< 10 kt	< 50 kt

The following figure gives an overview on the corresponding material flow in the EU member states.

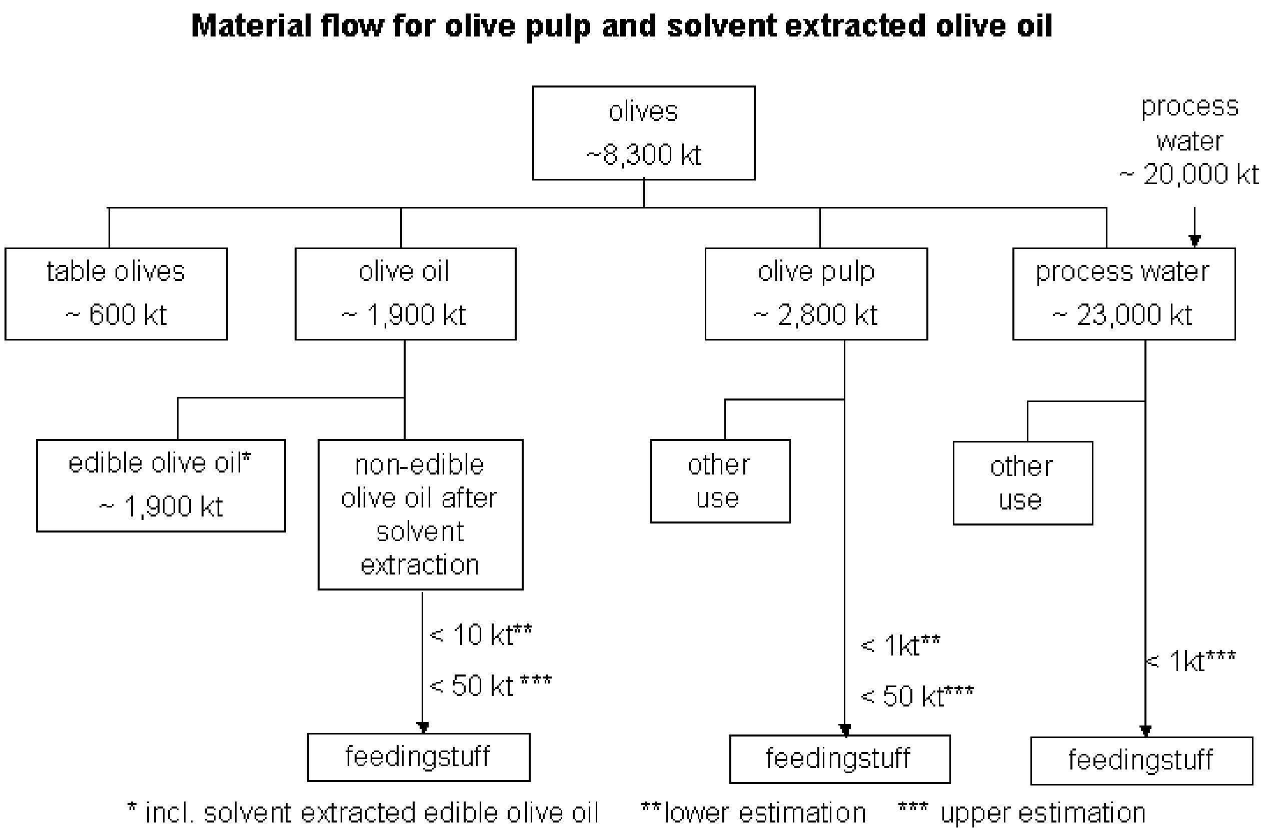


Figure 4-1: Material flow of olives in the EU based on [IOOC 2001]

The olive oil industry is characterized by a lot of small oil mills, especially in Italy and Greece. The following table illustrates the importance of Member States and the number of plants. It should be noted, that 36% of the growers produce less than 200 kg olive oil annually as the following table shows.

	produced olives (kt)	produced olive oil (kt)	resulting olive pulp (kt) (estimated)	olive mills	extraction plants	table olive processing plants
Spain	3,800	950	1140	1756	54	416
Italy	2,232	450	~ 670	5599	49	416
Greece	1,879	430	~ 560	3300	42	> 200
Portugal	287	44	~ 86	1130	12	24
France	13.5	2	~ 4	140	no data	no data
Total	8,212	1,876	2,460	11925	> 157	> 224

Table 4-3: Production of olives and olive oil 1998 (FAOSTAT Database, FAO, IOOC)

4.3 Contamination volume categories

Available contamination data lead to the following estimations for average WHO-TEQ levels:

	average WHO-TEQ level
olive pulp	~ 1.2 pg/g fat
(non edible) olive oil	~ 1,7 pg/g fat

Combined with the results of the material flow analysis the following WHO-TEQ freights result for a upper estimation

olive pulp	0.0042 g
non edible olive oil	0.085 g

Adding these upper estimations a total input to feedingstuff industry of 0.089 g WHO-TEQ might result. This leads to the **low contamination volume category** (< 0.1 g WHO-TEQ).

4.4 Description of processes

The following picture shows the main production steps of the olive oil processing:

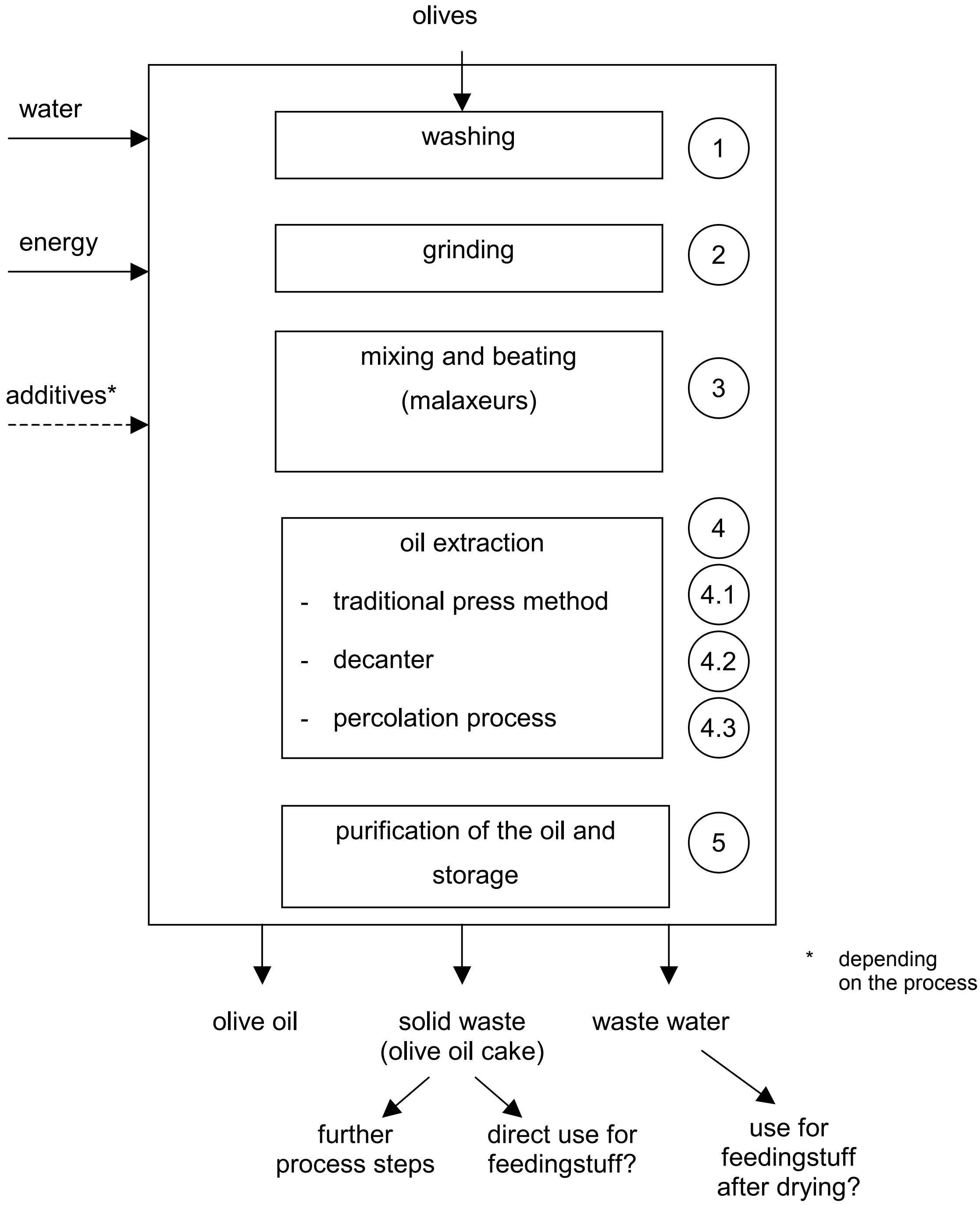


Figure 4-2: Overview over the production steps of the olive oil production

Steps of the main process

The typical olive oil processing starts with the cleaning of the olives. In the first process step the olives are separated from twigs, leaves, stones etc. by air, afterwards they get into a washing plant. The washing can be supported by worms, drums or other mechanical devices. Due to unwanted fermentation and related quality problems olives are often not washed in traditional processing.

After the cleaning the olives are transferred to a mill where the whole olives are crushed (process step 2). For this purpose stone mills (discontinuously), metal mills or hammer mills (continuously) are used. Oil mills normally use metal or hammer mills. If frozen or very dry olives are processed a small quantity of water has to be added to the grinding process.

The resultant sticky mass is then transferred to the downstream-arranged malaxeurs for kneading or beating (process step 3). To improve the extraction of oil salt may be added to the mush. This is in particular the case in the 2-phase-decanter process as described below. In hammer mills the grinding as well as the beating of the olive pulp also takes place. After the beating another grinding process may follow.

Depending on the production process the homogenous mush next is transferred in process step 4 to a hydraulic press, a three-phase-decanter or a two-phase-decanter for the separation of the oil.

Finally a purification of the oil takes place (process step 5) before storing the oil in tanks.

Oil extraction methods

For process step 4 three major technologies are applied.

<u>Traditional Pressing method</u>

Especially small oil mills still use the traditional pressing method in batch operation.

By the traditional pressing method approx. 20-50 l of water per 1,000 kg olives are added during the last grinding step. Then the mixed pulp is spread on nylon mats (filter) and pressed by means of hydraulic presses. The oil/water-mixture is separated by sedimentation and afterwards by centrifuging. To obtain a higher oil yield the pressing can be repeated several times. After the extraction the oil still contains small amounts of solids which can be removed by means of a centrifuge or by the sedimentation method.

The resulting solid waste of the traditional pressing method still contains up to 6% residual oil and approx. 25% water. For further treatment the solid waste usually is dried in hot-air driers or open air tanks.

3-phase-decanter

For this extraction method up to 1000 l of warm water (40 °C) per 1,000 kg olives are added to the malaxeur to obtain the specific viscosity of the pulp which is decisive for the result of the centrifugal separation process. From the malaxeur the homogeneous pulp is then pumped to a three-phase-decanter to be separated into impure oil, waste water and solid waste.

2-phase-decanter

Using this method the prepared pulp is separated by means of a two scroll centrifuge into oil and liquid/solid mixture with a residual water content of up to 60% and oil content of 2.5 – 3 %. The main difference to the 3-phase-decanter is that depending on the natural water content of the processed olives no or only a small quantity of additional water has to be added in the malaxeur. Consequently the amounts of resulting by-products of the olive oil extraction are reduced.

In the last few years 2-phase-centrifugation replaces more and more the traditional press technology and the 3-phase-decanter in the olive oil industry.

The following table shows the input-output relations of the three different oil extraction processes:

	production process		
	traditional pressing method	3-phase-decanter	2-phase-decanter
Input			
olives	1 t	1 t	1 t
water			
washing water	~ 100-120 l	~ 100-120 l	~ 100-120 l
fresh water	~ 20-50 l	~ 500 - 1.000 l	
water to polish the impure oil		~ 10 l	
Output			
oil	~ 200 kg	~ 200 kg	~ 200 kg
solid waste	~ 400 kg (~ 25% water + 6% oil)	500 – 600 kg (~ 50% water + 4% oil)	800 – 950 kg (~ 60% water + 3% oil)
waste water	~ 600 l (~ 88% water)	1,000 – 1,200 l (~ 94% water + 1% oil)	

Figure 4-3: Input-output-analysis of the olive oil production [IMPROLIVE 2000]

Further treatment of the solid and liquid waste

The further treatment of the solid and the liquid waste is of special interest because in this way a possible use of waste for feedingstuff can be investigated. It is not clear whether the use of liquid waste is relevant, however, solid waste definitely is an input for the feedingstuff industry.

The composition and quantity of the resulting solid and liquid waste of the olive oil production depends on the extraction process. Whereas from the traditional and 3-phase-decanter method solid waste and waste water results, the 2-phase-decanter only produces a solid fraction with a water content of about 60%.

The olive waste water which is polluted by fats, harmful substances (possibly including POPs) and solids is usually dried in evaporation basins by solar radiation.

As the solid waste of the main process - depending of the used oil extraction method - still contains up to 6% of residual oil an extraction of the oil by means of solvents is possible. The extraction of the residual oil usually is carried out by specialised plants. The use of olive pulp for feedingstuff therefore is possible in two ways: directly after the main process or after an additional extraction process. For the latter additional process steps have to be described.

Different treatment methods are available for the solid waste (alpeorujo) of the olive oil production:

- Drying / Evaporation
- Thermal treatment
- Biological treatment
    - Composting (aerobic treatment)
    - Anaerobic treatment
    - Fungi treatment

There are two principle ways to dry the alpeorujo

- field evaporation
- mechanical drying

At present field evaporation is the most wide-spread process. For this purpose the waste is collected in storage tanks and concentrated or dried.

The mechanical drying can be realised by the means of contact-, convention and radiation drying. In contact drying the heat is added by contact of the waste with hot surfaces, which are heated with saturated vapour or thermo-oil. There is no direct contact of the waste with the gases.

In convection drying the heat is transferred to the waste by the means of hot gases whereas by the radiation drying process the evaporation of the water is realized by transferring the heat to the waste in form of radiation.

In the last two processes the waste has direct contact with the heating gases and therefore may be polluted with impurities in the gas.

As the main aim of the waste treatment is to reduce the volume of the waste by removing the liquids, a concentration of possible contaminants may occur.

The treated solid waste can be used as fertiliser, for landfilling and for livestock feeding.

The treatment of the waste water (alpechin) mainly concentrates on the volume reduction. Following methods are possible as pre-treatment:

- aerobic treatment (lagooning, bioremediation)
- anaerobic treatment (only pilot projects)
- filtration (ultra filtration, membrane filtration)
- wet oxidation
- precipitation/flocculation
- adsorption
- evaporation
- electrolysis
- decolorization

Extraction of the residual oil

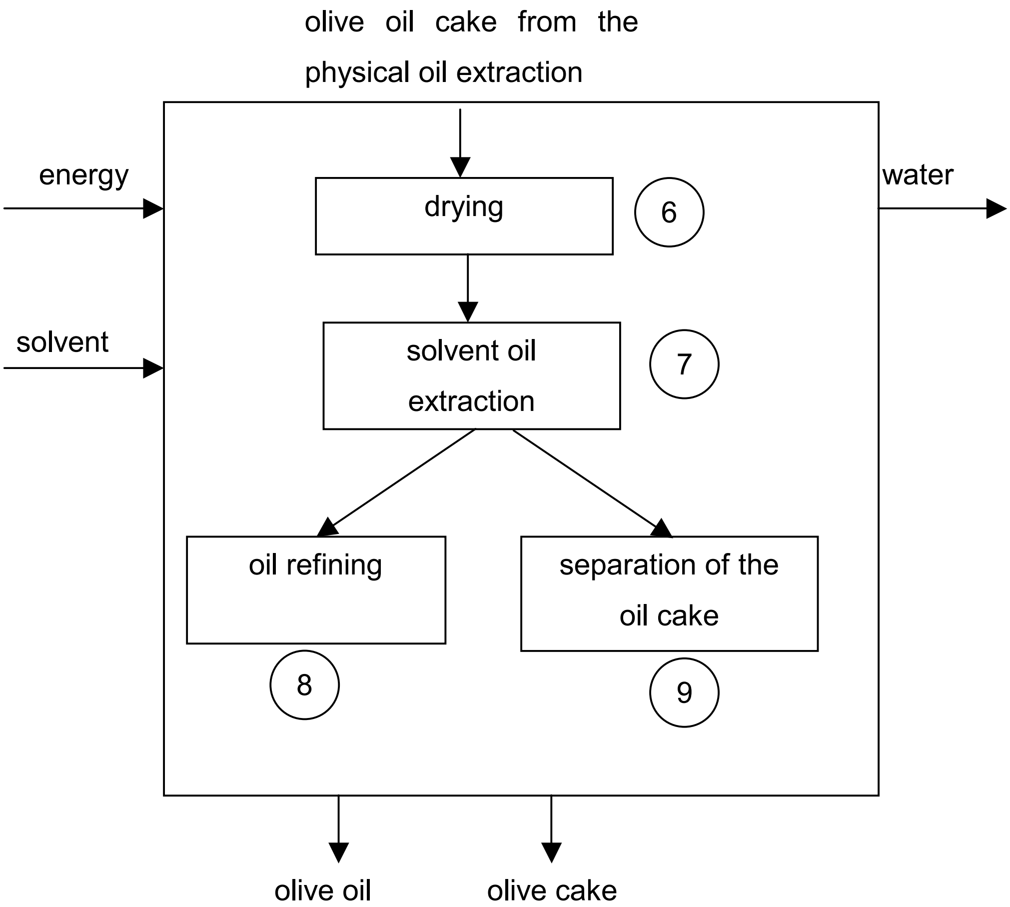


Figure 4-4: Process steps of the solvent oil extraction

Prior to the oil extraction the oil cake has to be dried (process step 6). Afterwards the oil is extracted usually with hexane as solvent (process step 7). By the solvent oil extraction residual oil content of the oil cake is usually less than 1%. Therefore the oil cake enters an extractor where solvent is passed repeatedly through the cake, picking up any remaining oil. The mixture of solvent and edible oil then flows through a series of evaporators where the solvent is recovered and reused. The solvent normally is recovered by evaporation at low temperature.

Because of concerns regarding the use of food grade solvents, the industry is investigating alternative methods of oil extraction, such as a hot water method of extracting edible oil from the oil cake.

The resulting oil has to be refined due to its lower quality (process step 8). There are two types of refining processes:

- Classic alkaline refining
- Physical refining

The classic alkaline refining consists of three phases:

-neutralisation
-bleaching
-deodorisation

The physical refining is different from the previous method as acid water is used instead of soda to purify the oil and the temperature is higher.

There are also plants which separate the pulp from the stone (process step 9). The resulting oil cake therefore has a higher feeding value. The stones are used as fuel.

The following figure gives an overview on the relevant production processes.

Production processes for olive pulp and solvent extracted olive oil

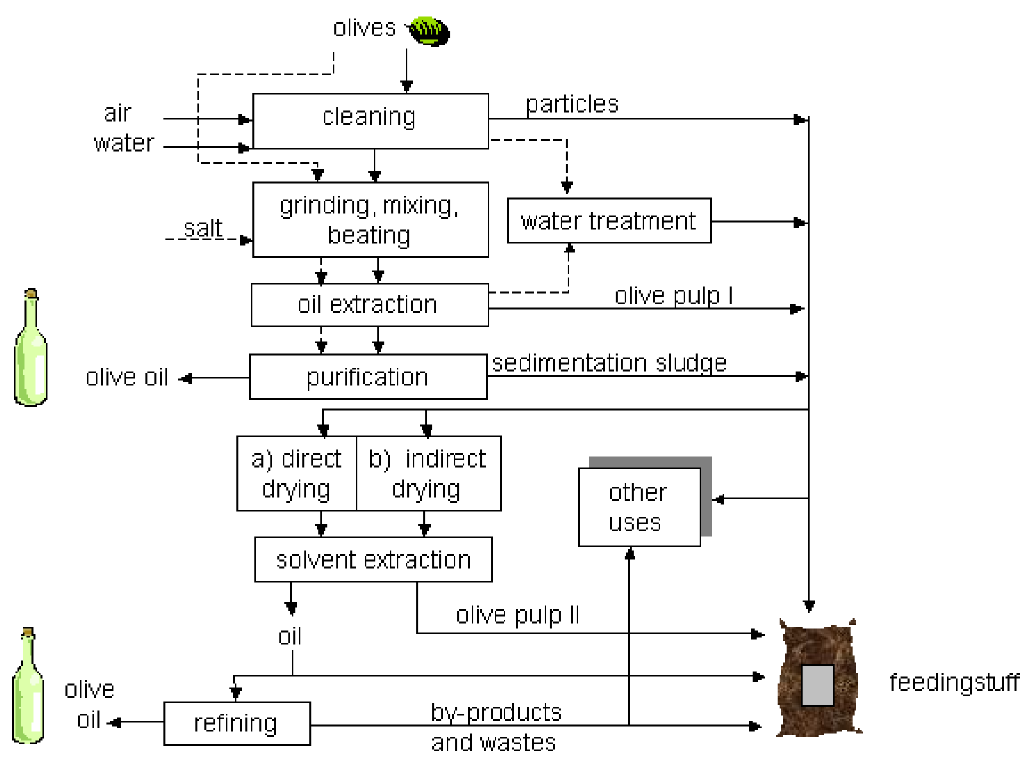


Figure 4-5: Production processes and contamination theses for olive pulp and solvent extracted olive oil

4.5 Contamination theses

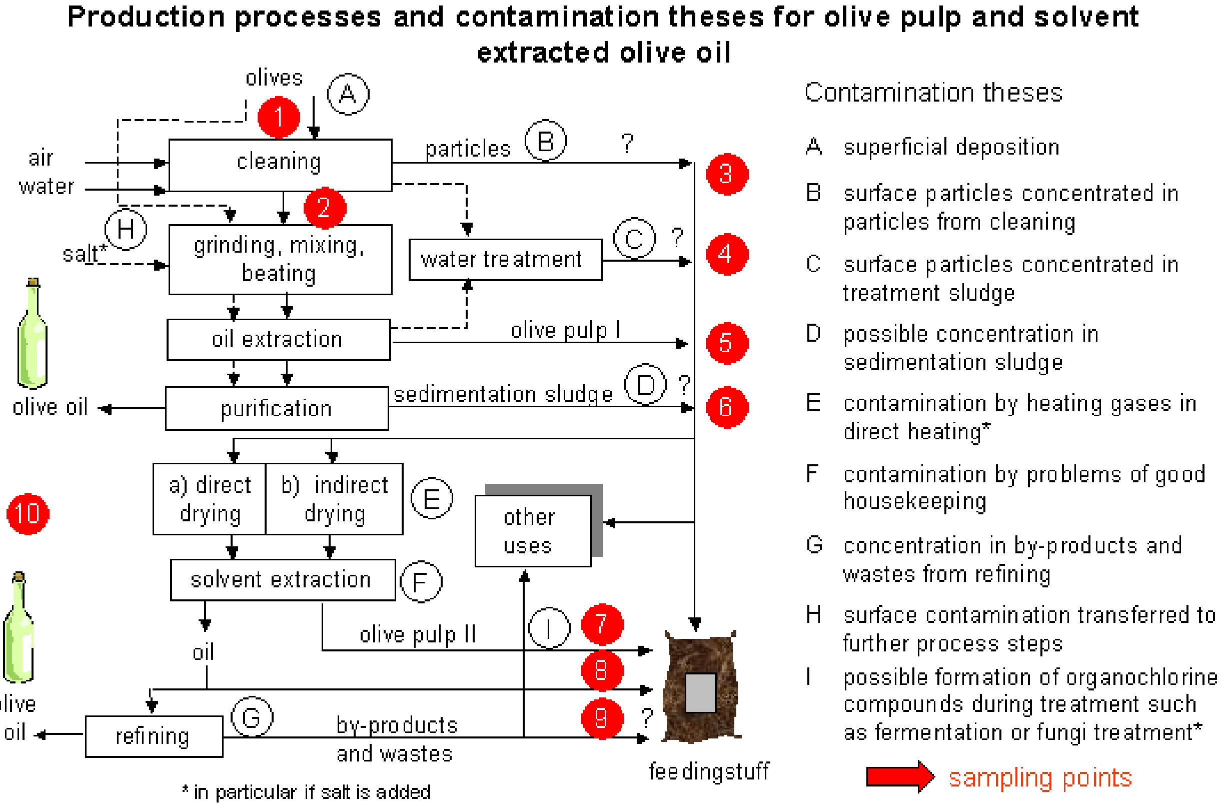


Figure 4-6: Production processes and contamination theses for olive pulp and solvent extracted olive oil

Dioxins and PCBs are transported via air either as gases or adsorbed to particles. The present air contamination causes deposition on plants leading to plant contamination by surface effects. As described above olive oil processing may start with the cleaning of the olives. The resulting solid residues or the sludges from process water evaporation finally contain the adherent dust and other particles from the olive surface and thus may be highly contaminated with dioxins and PCBs. These residues may be used in feedingstuffs either directly or mixed together with the olive pulp.

Olives processed without cleaning procedure may show a higher contamination because of adherent dust which is a source of dioxin and PCB contamination. This can be checked by an appropriate sample selection within the sampling strategy.

Usually during grinding, beating and mixing no obvious contamination or concentration of POPs occurs.

The addition of salt during grinding, mixing and beating may cause formation of dioxins in the following process steps such as direct drying for further solvent extraction or during further treatment such as fermentation or fungi treatment before the use as feedingstuff. Accordingly it might be of interest to investigate a corresponding process where salt is added.

The separation steps in oil purification may lead to POP concentration effects in the sedimentation sludge. If drying of the pulp is effected directly, additional contamination with PCDD/Fs can be expected depending on the heating material. Available data from recent measurements do not indicate an increase of PCDD/Fs during direct drying (see annex 1, data sets 1325 and 1326; heating material: dried olive pulp). However it should be mentioned that available data are based on one experiment only and confirmation with further experiments would be appropriate to draw final conclusions. It has to be beard in mind that due to common knowledge direct drying using waste materials like dried olive pulp as burning material is seen to be a risk factor for the formation PCCD/F. During solvent extraction and refining steps there is a certain contamination risk connected to deficits in good housekeeping (storage, transport, illegal mixing with other possibly contaminated substances, …).

Separation processes in the final oil refining steps may lead to concentration effects of POPs (see chapter 10.5.2). The following figure shows an overview to the process steps and the corresponding contamination theses.

The consequence from the connection of the process step analysis and the contamination thesis is the identification of sample types and points that are important for the understanding of the process against the background of possible measures related to the contamination with dioxins and PCBs.

The consequences that are resulting from the process step analysis and the contamination theses are shown in the following table:

Olive pulp and solvent extracted olive oil:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	olives	raw material before cleaning	1
2	cleaned olives	raw material after cleaning	1
3	particles from cleaning	before mixture with olive pulp I	1
4	water treatment sludges	before mixture with olive pulp I	1
5	olive pulp I from cleaned olives olive pulp I from not cleaned olives	after oil extraction	1/1
6	sedimentation sludge	before mixture with olives pulp I	1
7 a/b	olive pulp II (exhausted)	after solvent oil extraction	1/1
8 a/b	non-refined olive oil (solvent extracted)	after solvent oil extraction	1/1
9 a/b	by-products from refining	before mixture with oil or pulp	1/1
10	refined olive oil	after refining	1
			14

a) resulting from direct drying
b) resulting from indirect drying

Table 4-4: Consequences of production processes and contamination theses for olive pulp and solvent extracted oil

4.6 Requirements for decision-making

The low contamination volume category indicates that there is no need for a broad data base. At present there is no or little need for action in the field "components from olive processing" used for feedingstuff.

However, amounts of future use of olive pulp might change and there is considerable risk for accidental or illegal contamination. Thus the different processes and the contamination theses to the process steps lead to the necessity to examine the relevance of single process steps. Of particular interest might be investigations of formation of organochlorine compounds after adding of salt in subsequent process steps (heating) and biological treatment (fermentation) prior to the use of feedingstuffs. This knowledge would enable to describe possible technical measures that could lower the POPs contamination in outputs and to decide on the future use of outputs of olive processing technologies in the feedingstuff industry.

Available data indicate considerable lowering of PCDD levels during processing of solvent extracted olive oils by a factor around ten. Consequently an investigation of the corresponding process steps might be of interest.

4.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to carry out a 2 step procedure with a less important second step.

The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Olive pulp and solvent extracted olive oil:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	olives	raw material before cleaning	1
2	cleaned olives	raw material after cleaning	1
3	particles from cleaning	before mixture with olive pulp I	1
4	water treatment sludges	before mixture with olive pulp I	1
5	olive pulp I from cleaned olives olive pulp I from not cleaned olives	after oil extraction	1/1
6	sedimentation sludge	before mixture with olives pulp I	1
7 a/b	olive pulp II (exhausted)	after solvent oil extraction	1/1
8 a/b	non-refined olive oil (solvent extracted)	after solvent oil extraction	1/1
9 a/b	by-products from refining	before mixture with oil or pulp	1/1
10	refined olive oil	after refining	1
			14

a) resulting from direct drying
b) resulting from indirect drying

Table 4-5: Consequences of production processes and contamination theses for olive pulp and solvent extracted oil

Existing data cover already 5 of these sampling points (see annex 1). Consequently data are needed for the remaining 9 sampling points. For reasons of consistency it may however be appropriate to investigate one coherent process and to correlate the results with the already available data.

The second step of the data and sampling strategy meets output based samples.

For this step only few data are necessary due to the low contamination-volume-category. Only contamination levels due to accidents or fraudulent activities following the precautionary principle are of interest. This would result in 3 mixed samples for olive pulp, non edible olive oil and sludges from process water treatment. Each mixed sample should consist of 30 individual samples.

To conclude, the following table gives an overview on the resulting sampling plan indicating the required amount of required individual samples and necessary measurements:

Sampling plan			
step 1:	required:	14	process specific samples
	available:	- 5	covered by existing data
	remaining:	= 9	process specific data
step 2:	required:	1	mixed sample of 30 individual output based samples of olive pulp
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual output based samples
step 2:	required:	1	mixed sample of 30 individual output based samples of non edible olive oil
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual output based samples
step 2:	required:	1	mixed sample of 30 individual output based samples of sludge from process water treatment
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual output based samples
total necessary individual samples:		**99**	**(9 + 1*30 + 1*30 + 1*30)**
necessary measurements:		**12**	**(9 + 3)**

Table 4-6: Olive processing: sampling plan

5 Components from processing of used oils and fats

5.1 Existing contamination data

In the European Union about 5 million tons of oils and fats are used for hot cooking per year. After collection a significant part of the resulting volumes is entering compound feedingstuff production.

As far as no specific information on levels for used oils and fats are available, the contamination levels of used oils and fats have to be estimated. They can be expected to lie somewhere between the raw materials for cooking oils and fats (animal and vegetable oils and fats) and cooked material (different food items). Considering no formation of dioxins and PCBs during cooking and no external contamination, the contamination levels can thus be roughly estimated based on data for animal fats and vegetable oils/fats. Among other, the following selected data are reported (for further data see annex 2):

	TEQ level	TEQ	Source
vegetable oils	~ 0.2 pg/g fat	WHO-PCDD/F	SCAN 2000
animal fat	~1.0 pg/g fat	WHO-PCDD/F	SCAN 2000
vegetable oils	0,08 pg/g fat	WHO-PCB	EPET 2002
animal fat (pig lard)	0,13 pg/g fat	WHO-PCB	EPET 2002

Table 5-1: Reported contamination values for oils and fats

A rough estimation for used oils and fats that is based on existing contamination data for land animal and vegetable derived fat indicates average WHO-TEQ levels around 0,9 pg/g fat. DLPCBs contribute approx. 20% to this level.

Data are required from input and output at collecting facilities (industry, restaurants, households) and input in the feedingstuff industry. Some data are available on contamination levels of frying fats before and after use as they are used in restaurants (see annex I, data sets 1318/1319; 1320/1322; 1324/1332) [Schwindt, Hecht 2000]. The 3 data sets on used frying fat may be directly used for the decision base at 1 relevant process step. They are documented in annex 1.

5.2 Material flows

A bottom up approach shows that about 2.1 million tons of oils and fats are used for compound feedingstuff, which means a relative share of 1.7% of all inputs.

In this amount rendered fats represent about 1,000 kt and fish oils about 70 kt. Thus an amount up to approx. 1,000 kt might come from used oils and fats as a maximum (2,100 kt – 1,000 kt – 70 kt = 1,030 kt). However, according to feedingstuff producers this can not be expected as other oils and fats (for example soybean oil etc.) are also used for compound feedingstuff. Following expert interviews a volume of about 500 kt is expected for the input of components from processing of used oils and fats.

Following a top down approach there are two product groups which can be identified as main sources of used oils and fats: vegetable oils and animal fats. The volume of used oils and fats in the EU is not obvious, therefore for a top-down estimation a material flow has to be developed starting with the basic products.

According to FAO-Data in 1999 a total of about 20 million t was supplied in the EU and approximately 12.6 million t (63%) of this total supply was used for food.

According to [Gehrer 1991] about 60% or 7.6 million t of this amount is used “cold”, which mean it is directly eaten (butter, margarine, mayonnaise etc.) and therefore not relevant for the origination of used oils and fats.

Waste in form of used oils and fats is generated after the “hot use” of fats in cooking processes in households, restaurants and the food-industry. A total of appr. 5 million t are used in a "hot use" or "hot application".

The basic data is shown in the following picture

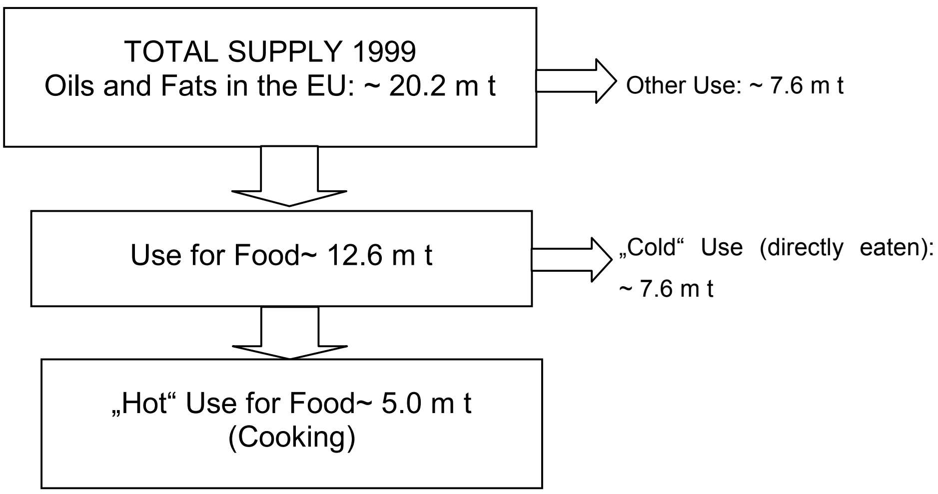


Figure 5-1: Material flow on oils and fat in the EU, 1999

The volume of the waste stream of used oil and fats which is available as a maximum for feedingstuff and which is coming out of the input of ~ 5.0 million t is determined by the following factors:

- The percentages of oils and fats which are used in the industry, restaurants and households (Austria 1998: Industry 13 %, restaurants: 27%, households: 60%).
- The intake of Cooking-oils and fats into food, which is strongly related to the efficiency of the cooking process ("cooking efficiency"). This efficiency is much higher in the industry (~80%) than in restaurants and households (~ 20%). An efficiency of 80% means that only 20% of the input oil and fat becomes waste and 80% remains in the food.
- The amount of collected used oil and fat, versus the amount which is dumped down in the sewage system. The percentages of collected used oils and fats in Austria in 1998 are 100% in the industry, 80% in restaurants and 5% in households. An estimation for the EU shows 70% in the industry, 40% in restaurants and 2% in households.
- There is a direct flow of food industry to feedingstuff producers. However, more than 50% of used oils and fats enter compound feedingstuffs via collecting systems.

The above-mentioned percentages are used to assess the amount of used oil and fat in the EU.

Actual Bottom-up-estimates for collected waste-oils and fats are:

Germany 100,000 – 120,000 t/a [Falk 2001]

Austria: ~ 15,000 t/a

This leads to an amount of 1.4 kg per capita and year. Up scaling this amount by the citizens of the EU (~ 375 million) indicates an amount of ~ 500,000 t of collected used oils and fats.

Adding the direct flow from industry to feedingstuff industry the material flows shown in Figure 5-2 seem to be quite reasonable.

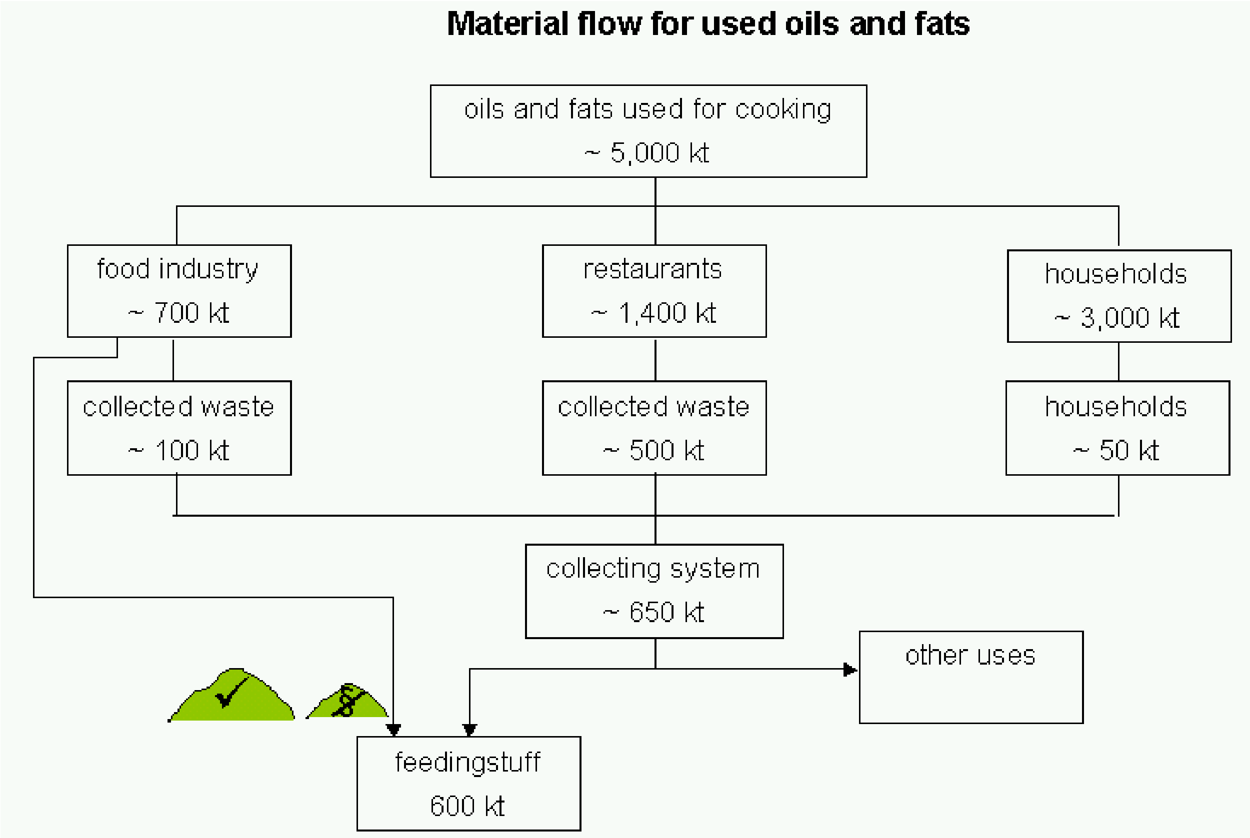


Figure 5-2: Material flow for used oils and fats

The collected used oils and fats contain ~15% of fat (melting point > 40°C), ~85% of oil and ~1% solid residues (sediments, solid waste) and water. The share of the fractions depends on the origin of the used oil/fat (industry, restaurant or households) and on the different diets in the countries of the EU. There is a north to south increasing use of vegetable oil (in particular olive oil) and vice versa an increasing use of animal fats from south to north. The pure oil fraction (without fats with a melting point > 40°C) can be used in different ways. The other recovery options besides the use as component in feedstuff are:

- ⇨ Esterfication to bio diesel oil
  (most important use besides the use as feedingstuff)
- ⇨ Purification for loss-lubricants (e.g. use of chain saws in areas where the use conventional oils is forbidden).
  Small amounts of used oils are used for loss-lubricants.

- ⇨ Saponifying to Soaps and Cleaning agents
  Used oil is in direct competition with new products of the chemical industry. Because of necessary high quality requirements for used oils, the recovery costs are – depending on world market prices of chemicals - often higher than raw materials.
- ⇨ Composting and bio gas production
  For both recovery technologies the collected used oil/fat can be used directly without any pre-treatment.

Comparing top down and bottom up approach of the material flow analysis both results fit quite well together and thus form a lower estimation with 500 kt and an upper estimation with 600 kt input to feedingstuff.

5.3 Contamination volume categories

Available contamination data lead to the following estimations for average TEQ levels:

	average WHO-TEQ level
used oils and fats	0,9 pg/g fat

Combined with the results of the material flow the following WHO-TEQ freight results for an upper estimation

used oils and fats	0.54 g

This leads to the **medium contamination volume category** (0.1 – 1 g WHO-TEQ).

In particular in the case of oily and fatty by-products, recyclates and wastes special attention should be given to the risk of accidental or illegal contamination. This risk can be assumed to be of special importance in the case of used oils and fats entering feedingstuffs via collecting systems as the collection involves many handling, transport and storage steps that are difficult to control. More than 300 kt enter compound feedingstuffs via collecting systems. A possible solution to allow appropriate action and to keep the risk low might be an appropriate monitoring for accidental contaminations and possible further measures.

5.4 Description of processes

As mentioned above used oil/fat as collected are in general terms a mixture of about 85% oil, 15% fat with a melting point above 40°C and a minor amount of solid waste and/or water.

The processes to make this material useable for the production of feedstuff are rather simple. Usually the collecting drums are heated slightly (30° - 40°C) and are emptied using a sieve for solid components.

There are two important primary recovery steps possible:

a) Gravimetric Process with or without fat – oil separation

Without fat separation the used fat/oil is filled into a tank and the undissolved fats and other solid components are eliminated after sedimentation. The share of these components is about 5 – 10% of the total input.

The fat separation uses additionally heat and water (about 4.5 m^3/t). The main output (~ 85 %) is an oil which can be directly used for esterification. The fat (~ 15%) can not be used for esterification but for composting or bio gas production.

b) Use of separating equipment (e.g. Decanter)

This technology is well known from other separating processes in the chemical industry. The economical break even point for the process is a capacity of about 2,000 – 4,000t/a.

The following picture shows the recycling process for used oils and fats in a broader way. Also process steps are included that are not necessary for a use of oils and fats as feedingstuff.

However, residues of process steps which are applied to receive for example fuel might also be used as feedingstuff and therefore the process is described with all its possible modifications:

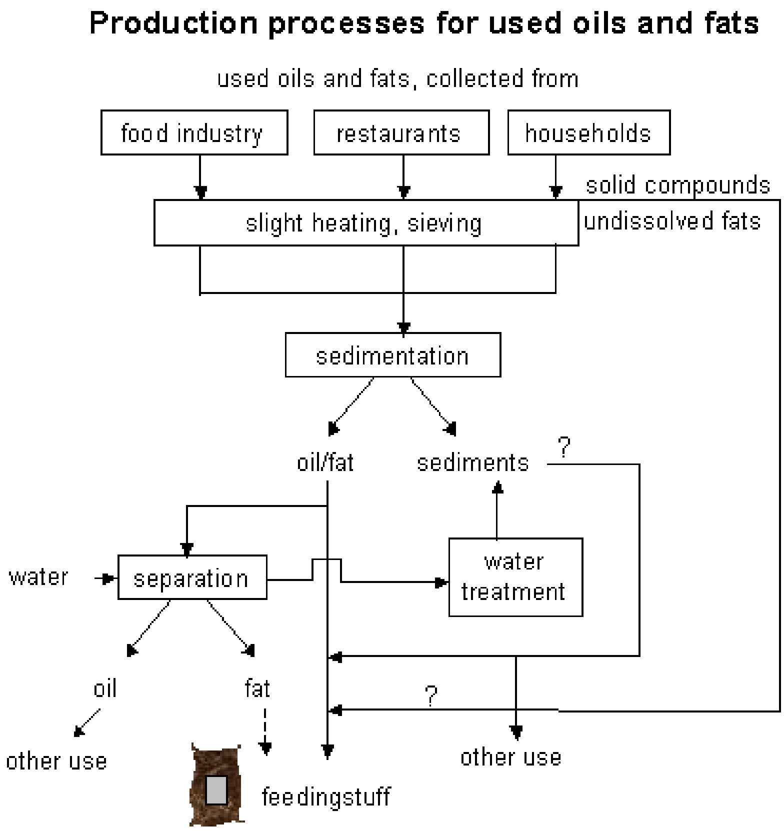


Figure 5-3: Production process for used oils and fats

5.5 Contamination theses

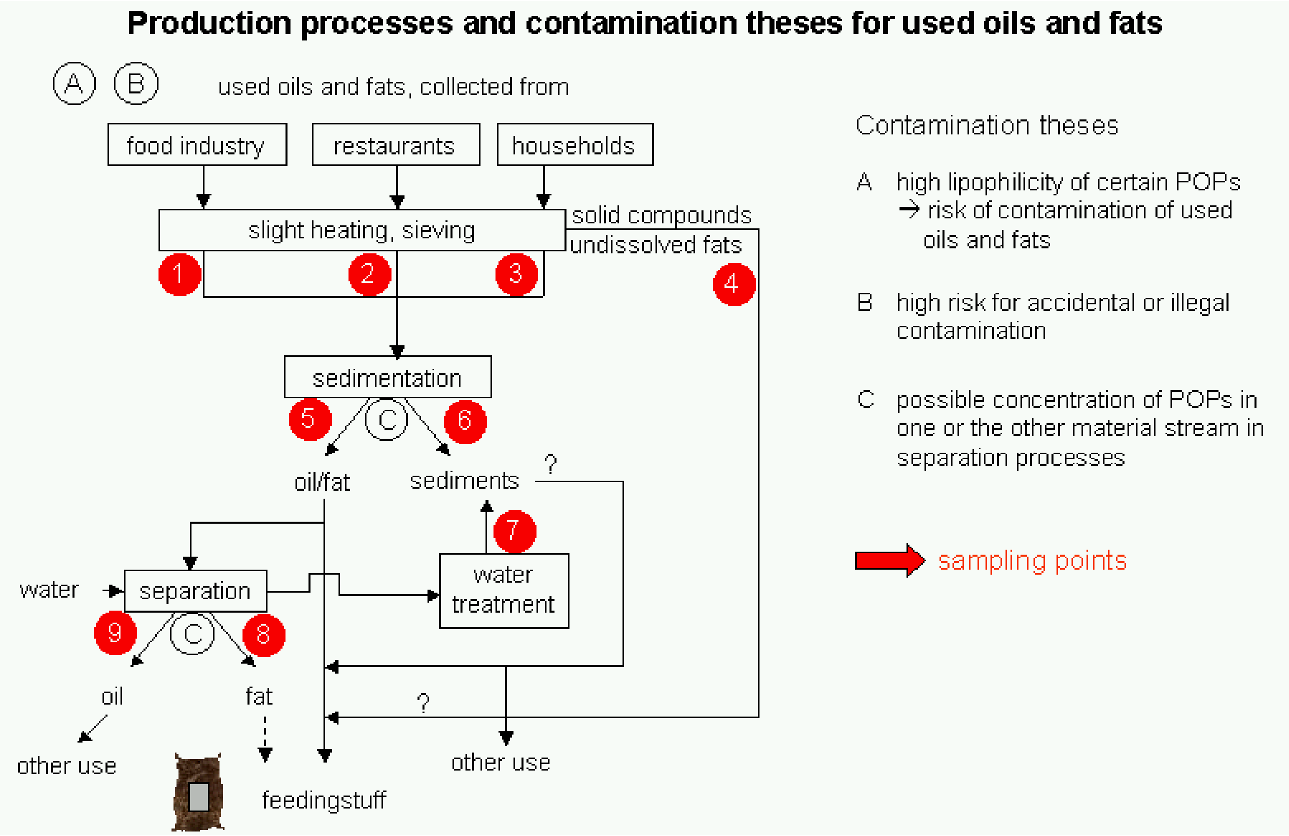


Figure 5-4: Production process and contamination theses for used oils and fats

Dioxins and PCBs show high lipophilicity and high persistence. These physical-chemical properties result in the well known effect of migration and accumulation in biological – in particular fatty – tissue. This so called effect of bioaccumulation is the reason for elevated levels in vegetable and animal fats and oils as these are derived from fatty animal and plant tissues. Furthermore, recent dioxin crisis have shown that in particular during handling, transport and storage of oils and fats the risk for accidental or illegal contamination is very high. (e.g. mixing with highly contaminated waste oils in not cleaned containers, open containers, etc.) is given (contamination theses A and B).

Concentration effects of POPs may furthermore occur in separation steps (sedimentation, separation) during processing (contamination thesis C). Such effects may lead to elevated contamination in sediments from sedimentation or water treatment. This thesis is e.g. supported by data on slightly elevated levels in the bottom sediment of frying fat (Schwindt, Hecht 2000).

The consequences that are resulting from the process step analysis and the contamination theses are shown in the following table:

Used oils and fats:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	used oils and fats from food industry	oil and fat collector before processing	1
2	used oils and fats from restaurants	oil and fat collector before processing	1
3	used oils and fats from households	oil and fat collector before processing	1
4	undissolved fats	after sieving	1
5	oil and fat mixture	after sedimentation	1
6	sediments	after sedimentation	1
7	water treatment sludge	after separation and water treatment	1
8	oil	after separation	1
9	fat	after separation	1
			9

Table 5-2: Consequences of production processes and contamination theses for used oils and fats

Some data are available on contamination levels of frying fats before and after use (see annexes I and II, data sets 1318/1319; 1320/1322; 1324/1332). The results indicate a slight contamination increase in used frying fats. This increase is probably not due the formation of dioxins during frying. It seems that a concentration exchange occurs between cooking oil/fat and cooked material. This interpretation is also supported by the congener pattern analysis [Schwindt, Hecht 2000]. The mentioned data sets may be directly used as results for used oils and fats from restaurants (sampling point 3). It has to be considered that the fried material was pig meat which is usually comparatively low contaminated. The data may thus lead to an underestimation of used oils and fats from restaurants.

5.6 Requirements for decision-making

The medium contamination volume category indicates that there is need for a broad data base, however, filling data gaps does not define the highest priority. At present there is no urgent need for action in the field "used oils and fats" apart from the above stated need for an appropriate monitoring for accidental or illegal contamination.

To conclude, amounts of POPs incorporated in feedingstuffs are not negligible and there is a comparatively high risk for accidental contamination due to various collection facilities (e.g. open tanks connected with the risk of accidental or illegal pollution with other waste oils). Thus the different processes and the contamination theses to the process steps lead to the necessity to examine the relevance of single process steps. Of particular interest might be the investigations of the average contamination of the several input flows (from households, restaurants, industry). This knowledge would enable to describe possible technical measures that could lower the POP contamination in inputs and to decide on the future use of inputs in the feedingstuff industry.

Maybe more important than process specific data also data on typical contamination should be available to generate reliable knowledge on the real spread of contamination as a basis for decisions on possible technical measures (e.g. decontamination) or discussions on the use of used oils and fats in feedingstuffs. The data collection should also allow to conclude on possible accidental issues.

5.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to have a 2 step procedure. The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Used oils and fats:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	used oils and fats from food industry	oil and fat collector before processing	1
2	used oils and fats from restaurants	oil and fat collector before processing	1
3	used oils and fats from households	oil and fat collector before processing	1
4	undissolved fats	after sieving	1
5	oil and fat mixture	after sedimentation	1
6	sediments	after sedimentation	1
7	water treatment sludge	after separation and water treatment	1
8	oil	after separation	1
9	fat	after separation	1
			9

Table 5-3: Consequences of production processes and contamination theses for used oils and fats

Existing data cover already 1 of these sampling points (used frying fat from restaurants, see annex 1). Consequently data are needed for the remaining 8 sampling points. For reasons of consistency it seems to be appropriate to investigate one coherent process and to correlate the results with the already available data.

The second step of the data and sampling strategy meets output based samples. For this step 7 mixed samples in the most important Member States are necessary due to the calculation model and the medium contamination volume category. For each mixed sample about 15 individual samples are foreseen. Situations in Member States not covered by mixed samples for typical contamination as mentioned above will be examined with another mixed sample standing for accidental contamination and covering 30 individual samples. Due to the above mentioned considerations it might be reasonable to focus the sampling for accidental contamination on used oils and fats from collecting systems.

Sampling plan			
step 1:	required:	9	process specific samples
	available:	- 1	covered by existing data
	remaining:	= 8	process specific data
step 2:	required:	7	mixed samples of 15 individual output based samples
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 30 individual output based samples
step 2:	required:	1	mixed samples of 30 individual samples
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 40 individual output based samples
total remaining individual samples:		**143**	**(8 + 7*15 + 30)**
remaining measurements:		**16**	**(8 + 7 + 1)**

Table 5-4: Used oils and fats: sampling plan

6 Livestock wastes and dead animals

6.1 Existing contamination data

In the European Union about 15 million tons of livestock wastes and dead animals are processed. Presently there are restrictions to use meat and bone meal, blood meal, feather meal and poultry meal for feedingstuffs, however rendered fat is still used in amounts about 1 million tons per year.

An overall estimation based on existing contamination data (see annex 2) indicate the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
animal meats	fat	~ 0.68	~ 0.96
animal meals*	product	~ 0.27	~ 0.06
animal fats	fat	~ 1.2	no data available
* excluding fish meal			

Table 6-1: Livestock wastes: approximate WHO-TEQ levels on the basis of available data

There are only very few data available on PCB-TEQ levels for animal fats (see annex 2). The melting process may have a lowering effect on dioxin and PCB levels. However, as far as there are no precise data available related to DLPCBs, the estimation has to be based on the present data for meat. This leads to an average estimated contamination of ~ 2.2 pg/g WHO-TEQ fat (1.2 from PCDD/Fs and 0.96 from DLPCBs).

Data are available that can be used to clarify the POP flows during production processes at 7 relevant process steps (on bovine meat, pig meat, poultry meat, sheep meat, other meat, meat and bone meal and animal fats). For output based samples there are no data available that can be used as a direct input to the decisions base.

6.2 Material flow

Following a bottom up approach about 2,100 kt of oils and fats are used as raw material for compound feedingstuff. This amount includes about 70 kt fish oil resulting from fish processing and 500-600 kt used oils and fats of cooking processes. Thus a maximum volume of about 1,500 kt rendered fat might be used in the compound feeding industry. According to expert interviews a volume of not more than 1,000 kt rendered fat is currently used as raw material input. Due to present restrictions in Member States on the use of animal fats some experts believe that this amount is slightly overestimated.

At present the feeding of animal meals is prohibited to farmed animals which are kept, fattened or bred for the production of food. Fish meal being prohibited for ruminants can be used in feedingstuffs for poultry and pigs, although under very strict conditions. In 2000 about 1.6% (~1.986 kt) of the input into compound feedingstuff were animal meals. This amount includes 1,032 kt fish meal. Consequently an amount of about 900 kt of animal meal can be assumed for the year 2000.

The top down approach shows that before measures have been taken with respect to the BSE-crisis various outputs of the rendering process were used as important protein supplier in feedingstuff. Depending on the input material the following amounts result form the rendering process of 15.000 kt of livestock wastes and dead animals:

- meat and bone meal 2,549 kt
- blood meal 124 kt
- feather meal 167 kt
- poultry meal 242 kt
- rendered fat 1,525 kt

Due to present legislation the major part of the produced animal meals have to be disposed of. The disposal and processing of animal waste and its placing on the market is regulated by the Council Directive 90/667/EEC from the veterinary point of view. Furthermore the recovery and disposal of rendered fats and meat and bone meals are subject to Community waste legislation. In particular, Directive 75/442/EEC on waste, Directive 91/689/EEC on hazardous waste (if it is risk material), Directive 1999/31/EC on the landfill of waste, Directive 2000/76/EC on the incineration of waste and Regulation (EEC) No 259/93 on the supervision and control of shipments of waste within, into and out of the EU.

Apart from the meat and bone meal, fat is the second important output of the rendering process. Animal fat can be used for several industrial processes (e.g. soap production) as well as for animal feed. The main function of the rendering process is to transform the perishable raw material into stable products with a defined quality.

The most important raw material for the rendering process are wastes from slaughterhouses. Less important are dead animals. In the EU in 1998 about 15% of the processed raw material have been dead animals.

The following picture describes the corresponding material flow:

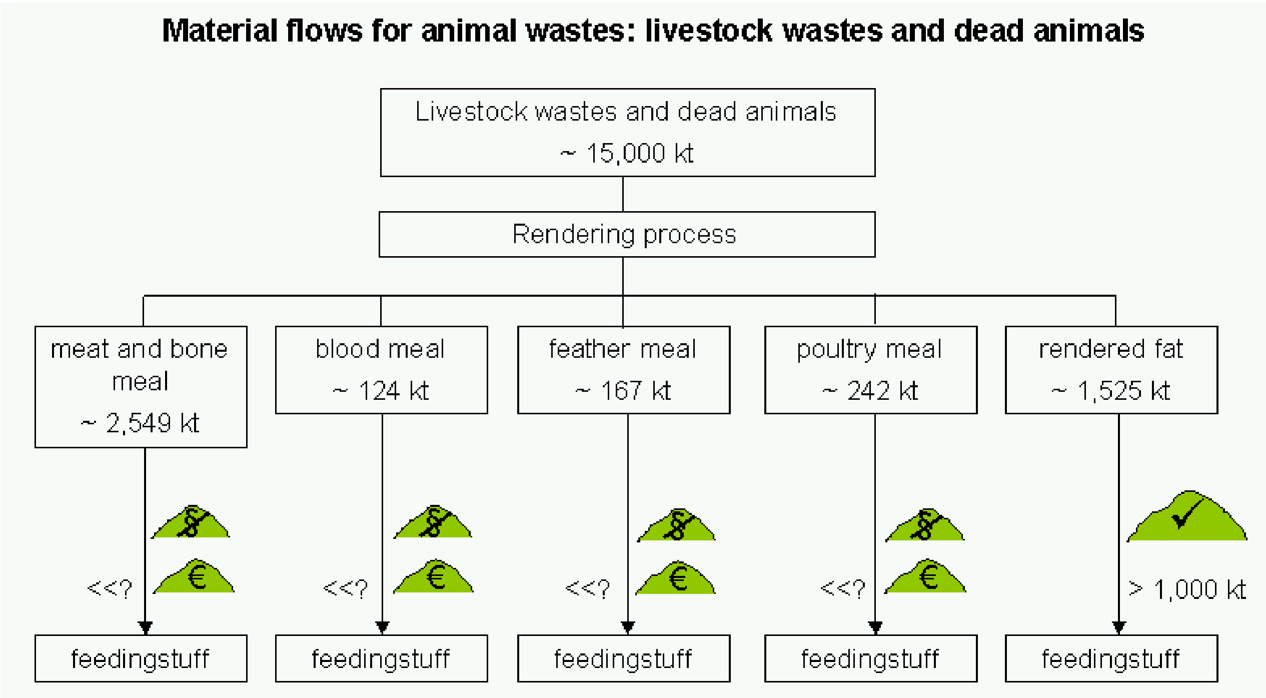


Figure 6-1: Material flow of livestock waste and dead animals, 1999 [EC 2001c]

A comparison of the bottom up and the top down approach leads to the following lower and upper estimation.

	lower estimation	upper estimation
rendered fat	< 1,000 kt	1,000 kt

6.3 Contamination volume categories

Available contamination data lead to the following estimations for average TEQ levels

	average WHO-TEQ level
rendered fat	2.16 pg/g fat

Combined with the results of the material flow the following WHO-TEQ freight results for an upper estimation

rendered fat	2.16 g

This leads to the **high contamination volume category** (> 1 g WHO-TEQ) for animal fat and to **low contamination volume** categories (< 0.1 g WHO-TEQ) for the animal meals.

6.4 Description of the process

The following figure gives an overview over the state of the art of the rendering process with the steam heat treatment as required by EU legislation.

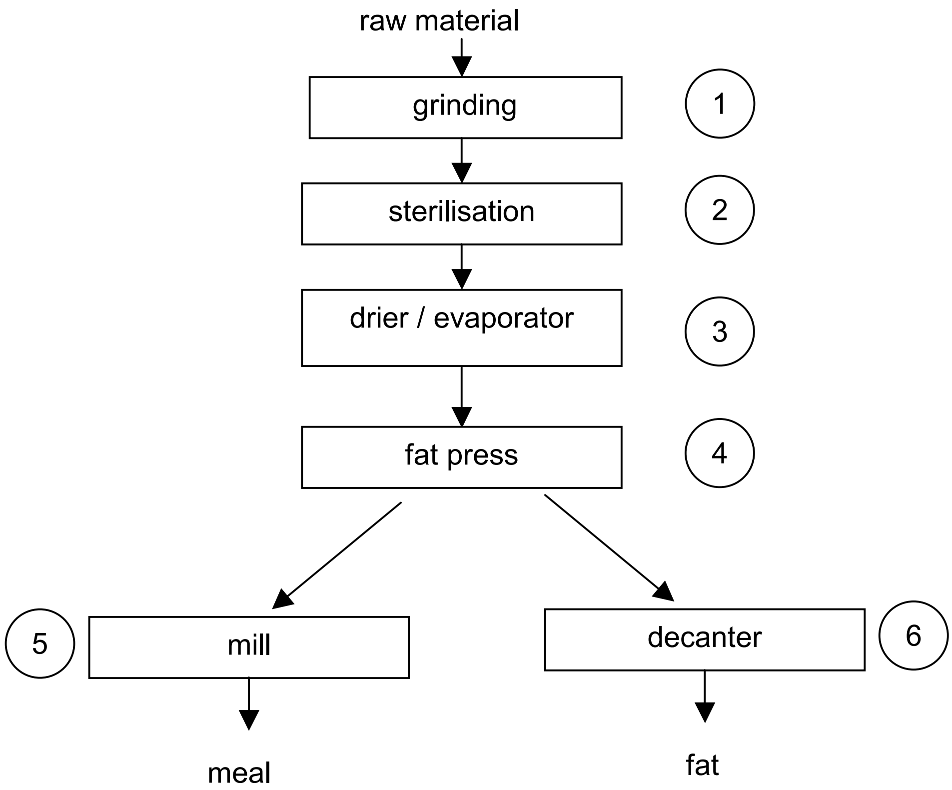


Figure 6-2: Production scheme of the rendering process

To obtain the required rendering products and the required quality the raw material has to be differentiated into special product groups and in some cases pre-treated, e.g. removal of the hide.

In the first process step the raw material is crushed in a grinder to pieces smaller than 50 mm. After crushing the raw material is transferred to a sterilisator (process step 2). The sterilisation is the most important process step of the whole rendering process. According to EU legislation (Council Directive 90/667/ECC) the raw material has to be heated up to 133°C for at least 20 minutes at a pressure of 3 bar. Several control systems have to assure that the required conditions are kept. During the sterilisation the meat mush has to be moved continuously.

Prior to the fat extraction the high water content of the meat mush of 60-80% has to be reduced. Therefore the meat mush passes a drier/evaporator (process step 3). After the drying process the water content is less than 5%. In the following fat press (process step 4) the separation of the fat and meal takes place. At the end the produced fat has to be cleaned in a centrifuge (process step 6) before storing. The solid residue of the fat press is transferred to a mill where it is ground before storing (process step 5).

For the production of feather and hair/bristle meal the raw material first has to be hydrolysed under pressure and high temperature. After drying the resulting product is ground and sieved. Feather meal and hair meal can be used as raw material in the compound feed industry. Hair meal also serves as raw material for organic fertilisers.

The processing of blood begins with the heating of the blood to separate the solid and the liquid substance form each other. The solid substance is sterilised, dried, ground and sieved to blood meal. The liquid fraction has to be treated in a water purification plant.

The following figure gives an overview on the relevant production processes.

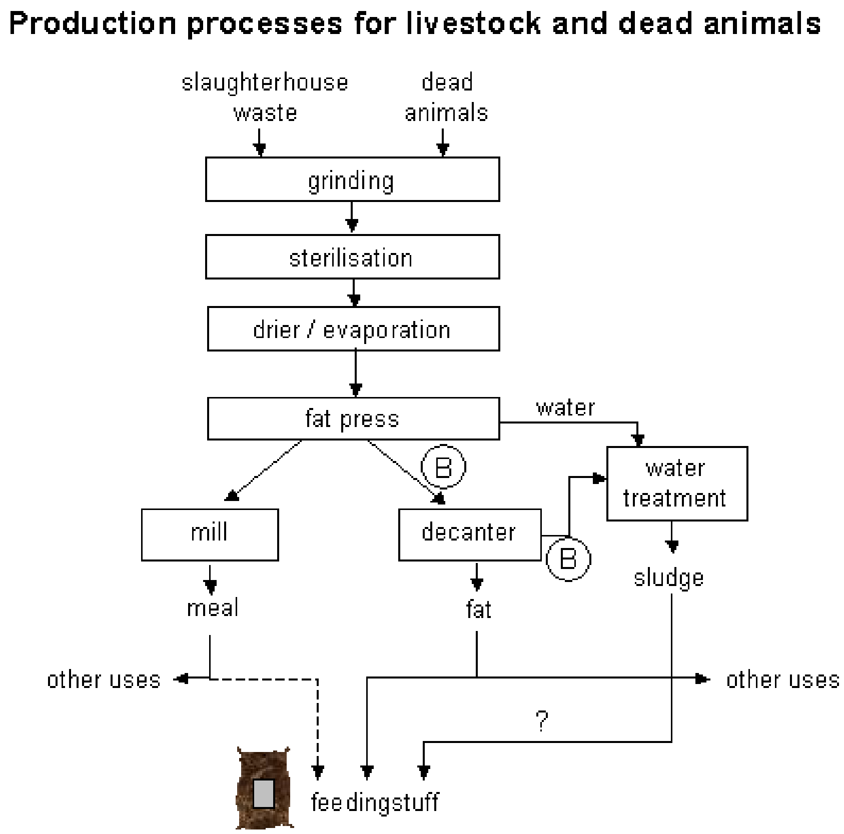


Figure 6-3: Production processes for livestock and dead animals

6.5 Contamination theses

6.5.1 Livestock waste and dead animals

The following figure shows the production processes for waste from livestock waste and dead animal of dairy products against the background of contamination theses and the consequences for sampling points.

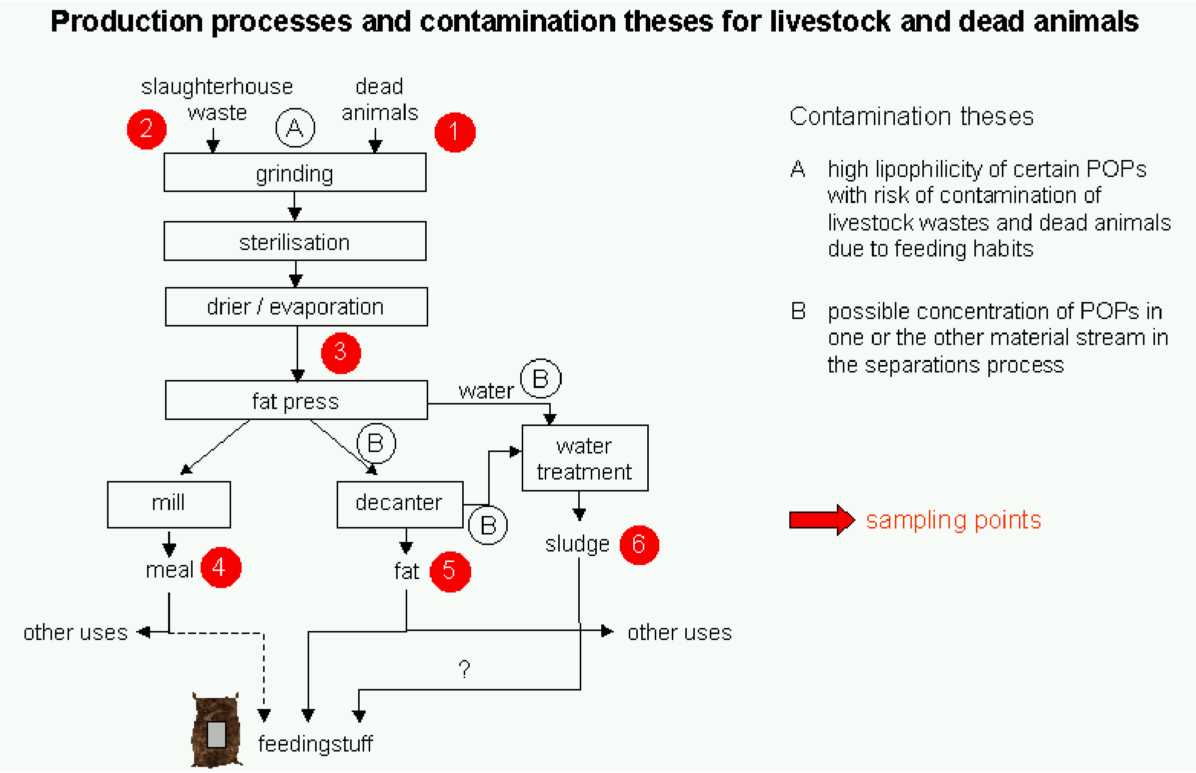


Figure 6-4: Production processes and contamination theses for livestock waste and dead animals

As explained above, dioxins and PCBs bioaccumulate and livestock wastes and dead animals accumulated these pollutants due to their feeding habits and feedstuffs during their lives.

During the rendering process concentration effects of POPs may occur in separation steps (fat press, water treatment). On the other hand it has to be kept in mind that the process steps also may have lowering effects.

The consequences that are resulting from the production process analysis and the contamination theses are shown in the following table:

Livestock animals and dead animals:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1a	origin animals, sub type bovine	before processing	1
1b	origin animals, sub type pig	before processing	1
1c	origin animals, sub type sheep	before processing	1
1d	origin animals, sub type poultry	before processing	1
1e	origin animals, sub type other	before processing	1
2	slaughterhouse waste	output slaughterhouse/before processing	1
3	dried and sterilised material	after drying, evaporation	1
4	meal	after mill	1
5	fat	after decanter	1
6	sludges	after waste treatment	1
			10

6.6 Requirements for decision-making

The high contamination volume category for rendered fat indicates that there is a strong need for a broad data base. Following the objective of lowering the POPs input to the feed and food chain there is need for action in the field "use of rendered fat for feedingstuffs". This need for action is not covered by the already existing limit (2.0 pg/g fat PCDD/F-TEQ) and action values (1.2 pg/g fat PCDD/F-TEQ) as future actions and measures might also belong to applicable technologies with a potential to lower POP contamination.

Thus the different processes and the contamination theses on the process steps lead to the necessity to carefully examine the relevance of single process steps. Of particular interest might be the applied separation process steps.

As far as the incorporation of animal meals into compound feedingstuffs is restricted, animal meals from livestock wastes as an input in feedingstuffs show a low contamination volume category and do not need further process specific investigations.

In addition to the mentioned requirements for a decision base on rendered fat it is necessary to gain knowledge on output based data. For rendered fat as a broadly used material for feedingstuffs it is suggested to establish a reliable data basis on typical contamination covering the individual situation of all Member States. The other components meat and bone meal, blood meal, feather meal and poultry meal show a low contamination volume category. Therefore there is no need for an examination of typical contaminations, however, there might be an economic interest or there might be illegal uses of these meals. Therefore data related to these aspects should be available for a decision base on further measures.

6.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to have a 2 step procedure with an important second step that might be also done simultaneously to the first step.

The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Livestock animals and dead animals: Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1a	origin animals, sub type bovine	before processing	1
1b	origin animals, sub type pig	before processing	1
1c	origin animals, sub type sheep	before processing	1
1d	origin animals, sub type poultry	before processing	1
1e	origin animals, sub type other	before processing	1
2	slaughterhouse waste	output slaughterhouse/before processing	1
3	dried and sterilised material	after drying, evaporation	1
4	meal	after mill	1
5	fat	after decanter	1
6	sludges	after waste treatment	1
			10

Table 6-2: Consequences of production processes and contamination theses for livestock animals and dead animals

Existing data cover already 7 of these sampling points (see annex 1). However, it has to be kept in mind that these data do not result from one investigated process and therefore can be mainly used for evaluation of the contamination theses. For reasons of consistency it may be appropriate to investigate one coherent process and to correlate the results with the already available data.

The second step of the data and sampling strategy meets output based samples.

For this step representative data on basis of all relevant Member States are necessary. Due to the developed methodology this means 15 mixed samples each with 20 individual samples for rendered fat and 4 mixed samples each with 30 individual samples for meat and bone meal, blood meal, feather meal and poultry meal.

Sampling plan			
step 1:	required:	10	process specific samples
	available:	- 7	covered by existing data
	remaining:	= 3	process specific data
step 2:	required:	15	mixed samples of 20 individual samples for rendered fat
	available:	- 0	covered by existing data sets
	remaining:	= 15	mixed samples of 20 individual samples for rendered fat
step 2:	required:	1	mixed samples of 30 individual samples for meat and bone meal
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for meat and bone meal

step 2:	required:	1	mixed samples of 30 individual samples for blood meal
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for blood meal
step 2:	required:	1	mixed samples of 30 individual samples for feather meal
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for feather meal
step 2:	required:	1	mixed samples of 30 individual samples for poultry meal
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for poultry meal
total necessary individual samples:			**423 (3 + 15*20 + 30 + 30 + 30 + 30)**
necessary measurements:			**22 (3 + 15 + 1 + 1 + 1+ 1)**

Table 6-3: Livestock waste and dead animals: sampling plan

7 By-products and waste from the fish processing industry

7.1 Existing contamination data

In the European Union about 2.3 million tons of solid fish waste result from total fish production. This fish waste enter the feedingstuff industry.

For fish a huge amount of data exists. Among other, the following selected contamination data have been reported:

Item	TEQ level	TEQ	Source
fish	~ 1 pg/g fat (very variable)	I-TEQ PCDD/F	SCOOP 2000
fish	~ 5 pg/g fat (very variable)	PCB-TEQ	SCOOP 2000
fish	~3 pg/g fat	WHO-PCDD/F	Nutreco 2002
fish	~ 13 pg/g fat	WHO-PCB	Nutreco 2002
fish	< 0.1-33 pg/g fat	WHO-PCB	RIVO 2000
fish	< 0.1-4 pg/g fat	WHO-PCDD/F	RIVO 2000
fish meal (Europe)	4.9 pg/g d.m.	WHO-PCB	SCAN 2000
fish meal (Europe)	1.2 pg/g d.m.	WHO-PCDD/F	SCAN 2000
fish oil (Europe)	19.2 pg/g fat	WHO-PCB	SCAN 2000
fish oil (Europe)	4.8 pg/g fat	WHO-PCDD/F	SCAN 2000
fish oil (Europe)	~ 26 pg/g fat	WHO-PCB	EPET 2002

Table 7-1: Reported contamination data related to fish

An overall estimation based on existing contamination data (see annex 2) indicate the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
fish	fat	~ 1 (very variable)	~ 5 (very variable)
fish oil	fat	~ 5	~ 20
fish meal (~ 10% fat)	product	~ 1.2	~ 5
fish silage(~ 10% fat)	product	~ 0.15	~ 0.91

Table 7-2: Fish wastes: approximate WHO-TEQ levels on the basis of available data

Due to the importance of fish there is increasing information available (see annex 2). It is difficult to derive reliable mean values from the data reported as there are big variations due to geographical, species, and age related reasons. The SCAN has estimated an approximate 5-fold contribution from PCBs compared to PCDD/Fs to the WHO-TEQ.

There are no data on fish waste or fish meal, fish oil and fish silage derived from fish waste. As far as these data are not available the contamination of these by-products can be assumed to be comparable to that from the whole fish.

Some process specific data available on the processing of industrial fish to fish meal and fish oil (see annex 2, data sets1379 to 1384 and 1392 to 1401) indicate that the contamination levels of dioxins remain more or less stable during processing (on a fat weight basis). These data are contradictory to the TEQ levels reported for fish and fish oil indicating on a fat weight basis a four to five fold contamination of fish oil compared to fish. Thus, further information is needed in order to find explanations for this contradiction.

There are no data on the processing of fish waste. However, data available on fish liver, fish oil, meal and silage can be used as an input to the decision base.

7.2 Material flow

Fish waste appears to be of special importance due to the known comparatively high contamination of fish and its following products with dioxins and PCBs [see e.g. SCAN 2000]. Consequently fish wastes which are used as raw material for animal feed contribute directly to the entry of POPs into the human food chain.

Following a bottom up approach the average consumption of fish meal in the European Union (without Eastern Europe and Norway) by farm animals including farmed fish from 1993 – 1997 was 1,032 kt (including fish meal from fish waste). The consumption can be attributed to pigs (32%), poultry (31%) and aquaculture (25%). The remainder (12%) was fed to pets, dairy cows, beef cattle and sheep. Biggest consumers are the UK, Spain, the Netherlands, Denmark and France.

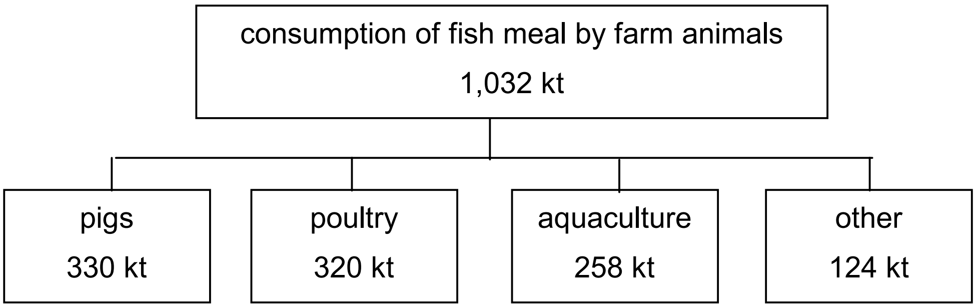


Figure 7-1: Material flow for the consumption of fish meal by farm animals in the Europe Union (without Eastern Europe and Norway); average values from 1993 to 1997 [IFOMA 1999]

The total amount of about 1,000 kt fish meal for feedingstuffs comes to 90% from industrial fish and is intentionally produced. This material flow therefore is not subject of this study. 10% or approximately 100 kt of the fish meal amount result from the processing of fish waste and thus are further investigated. The bottom up approach for fish oil shows a volume of 70 kt that is used for feedingstuffs. Again about 10% result of the processing of waste, the rest comes from processing of industrial fish.

The demand for fish oil – in particular for aquaculture feed – is expected to increase significantly. The increasing use of fish oils in aquaculture is partly due to increasing fish farming and partly due to increased incorporation in the diets. According to Commission Decision 2001/9/EC concerning control measures required for the implementation of Council Decision 2000/766/EC concerning certain protection measures with regard to transmissible spongiform encephalopathies and the feeding of animal protein, the feed of fish meal is authorised to farmed animals other than ruminants in accordance with specific conditions. This is in contrast to other animal by-products such as meat and bone meal derived from mammalians.

Fish silage is incorporated in considerable amounts in compound feedingstuffs (in particular in fish feed). According to expert interviews the use does not exceed an amount of 100 kt.

The top down approach shows the following:

The majority of fish caught is either used as food for human consumption or processed into fish meal and fish oil. In Europe annually about 5,500 kt[7] of raw material is processed to fish meal and fish oil. A share of approximately 10% of the raw material input is fish waste (trimmings) resulting from edible fish for human consumption [e.g. from cod]. The major share of approximately 90% is processed from wild fish. In Europe including Eastern Europe and Norway the consumption of fish meal/oil (1,559/686 kt) exceeds production (1,103/385 kt). World wide production is about 6.500 kt of fish meal and 1.200 kt of fish oil. Main producers are Peru, Chile, Thailand, USA, Denmark, Norway and Iceland [FIN[8]].

The following figure shows the material flow for production and consumption of fish meal and fish oil in Europe including eastern Europe and Norway. Production of fish meal amounts to 1,103 kt, thereof 317 kt in Denmark and 263 kt in Norway [FIN, estimated at 1999 level]:

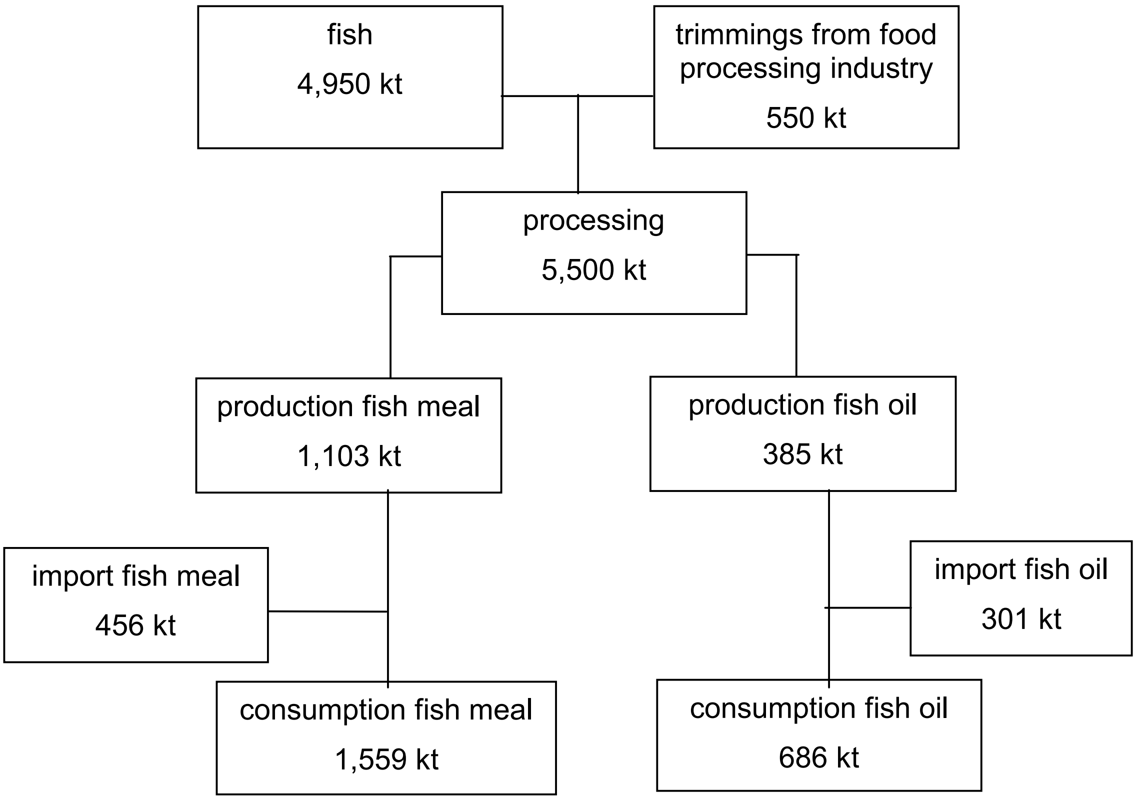


Figure 7-2: Material flow for the production and consumption of fish oil and fish meal within Europe (including Eastern Europe and Norway); average values from 1993 to 1997 [IFOMA 1999]

[7] according to the International Fish meal & Oil Manufacturers Association [IFOMA 1999]

[8] http://www.gafta.com/fin/finfacts.html

Fish waste or material resulting from industrial fish processing operations from either wild stocks or aquaculture are carcasses or parts of fish not intended for direct human consumption. It consists of carcasses, particles of flesh, skin, bones, entrails, shells or liquid stick water. The organic components of the waste have a high biological oxygen demand and, if not managed properly, can pose environmental and health problems.

Generally, the solid wastes in fish processing make up 30% to 40% of total production, depending on the species processed. Products derived from fish wastes such as meal, oil, silage or compost can be considered as by-products from the fisheries industry.

The following figure gives a schematic overview on the material flow for fish wastes:

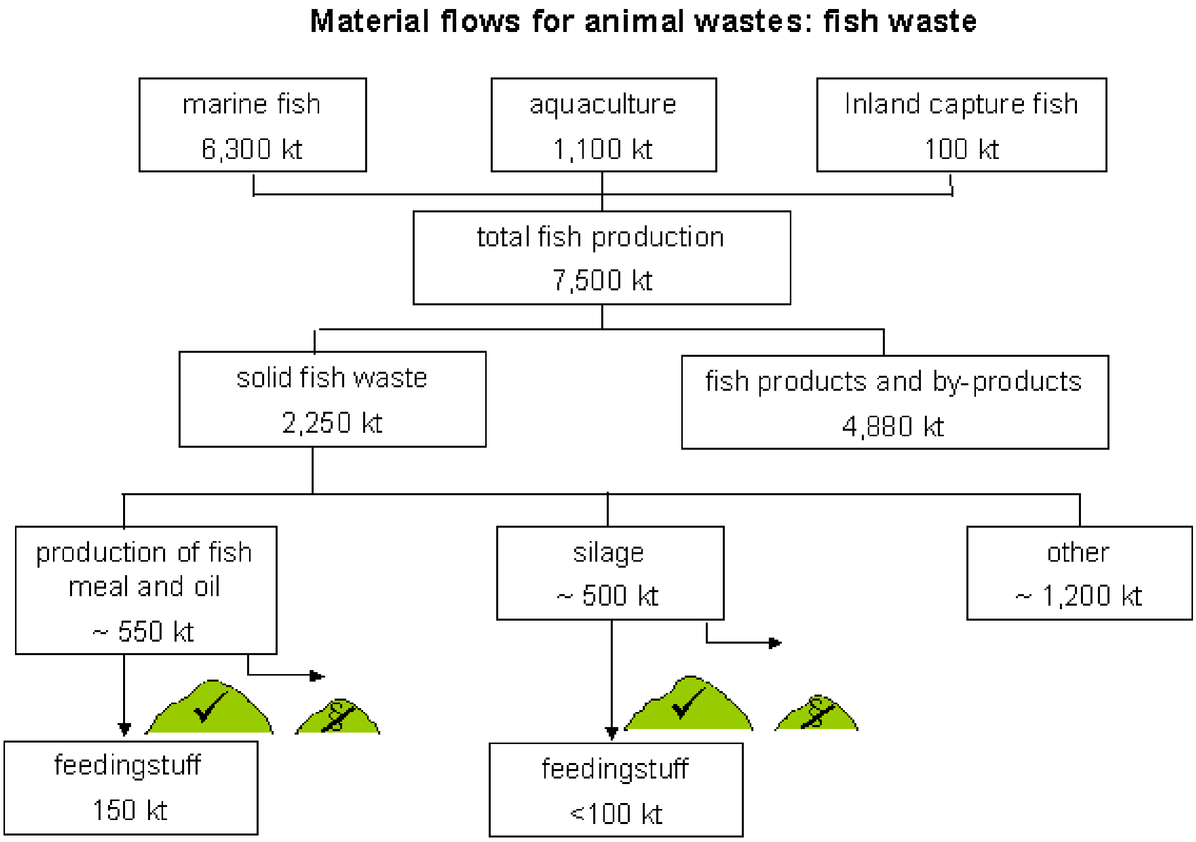


Figure 7-3: Material flow for fish waste in the EU;

A comparison of the bottom up and the top down approach leads to the following lower and upper estimation:

	lower estimation	upper estimation
fish meal	100 kt	100 kt
fish oil	10 kt	50 kt
fish silage	50 kt	100 kt

7.3 Contamination volume categories

Available contamination data lead to the following estimations for average TEQ levels

	average WHO-TEQ level
fish meal from fish waste (~ 10% fat)	~ 60 pg/g fat
fish oil from fish waste	~ 25 pg/g fat
fish silage from fish waste (~ 10% fat)	~ 10 pg/g fat

Combined with the results of the material flow the following WHO-TEQ freight results for an upper estimation

fish meal from fish waste	0,62 g
fish oil from fish waste	1,25 g
fish silage from fish waste	0,11 g
total fish waste products	1,98 g

This leads to the **high contamination volume category** for fish oil from fish waste (> 1 g WHO-TEQ) and the **medium contamination volume category** for fish meal and fish silage from fish waste (each between 0.1 - 1 g WHO-TEQ).

7.4 Description of the process

Processing of fish

Processing of fish varies considerable depending on production scale, fish species and final products. It involves main production steps from which liquid and solid fish wastes originate:

Process step	Input	Output
▪ descaling	water	water, scales
▪ bleeding	water	water, blood
▪ deheading	water	water, heads
▪ cutting and cleaning	water	entrails, kidneys, bladder, water
▪ cutting of fins		fins
▪ filleting		backbones
▪ cutting of ribs		ribs
▪ meat separation from backbones and ribs		backbones, ribs
▪ washing	water	water, final product
▪ packing	packaging	packaging waste

Table 7-3: Main production steps from which liquid and solid fish wastes originate

During fish processing, a large quantity of fish waste is produced (30 – 40 %) and its proper utilisation poses a problem. The fresh solid wastes can be processed further to

- fish meal and fish oil or
- fish silage

These fish by-products from fish waste are produced in different processes and they may be used as animal feed and contaminants can thus enter the human food chain.

Particularly for smaller processing plants fish meal and oil production is not profitable because of a low supply of the raw material, and thus production of liquid silage is a possible solution.

Production of fish meal and fish oil from fish waste

An appropriate fish waste management requires to consider waste treatment in the following hierarchy[9]:

1. reprocessing to fish meal (and fish oil)
2. production of silage; use as food for domestic animals/aquaculture; use in biochemical industry products
3. production of compost; use as fertiliser in land farming and reduction of liquid wastes by evaporation
4. energy recovery if possible
5. final disposal in an authorised landfill

All these waste treatment alternatives include a certain risk that contaminants in fish waste such as PCDDs and other POPs re-enter the food chain either directly (alternatives 1 and 2) by the use as animal feed or indirectly (alternatives 3) via other environmental compartments and further transport. The following focuses on the direct entry via re-processing to fish meal and fish oil and use as feed for domestic animals including farmed fish.

A further possibility with potential input into feedingstuffs is the use of fish waste in bio-gas plants and the following use of the residues in animal nutrition. This use for fish waste has been reported from Norway. The treatment in bio-gas plants includes fermentation and thus a certain risk of formation of organochlorine pollutants or de-chlorination to lower chlorinated and possibly more toxic compounds in addition to the inherent contamination. Whether such use is important in the EU Member States and whether the residues are incorporated in compound feedingstuffs in relevant amounts might be answered by further investigations on this specific question.

The time frame between production of the fish waste and its ultimate disposal has to be considered. Most fish wastes degrade rapidly in warm weather and can cause aesthetic problems and strong odours as a result of bacterial decomposition if not stored properly or disposed of quickly. If further processing of the waste to fish meal or silage is considered a viable alternative, it is essential that the waste is fresh.

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[9] London Convention 1972
according to the “Waste specific guidelines for fish offal and related material” under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter [LC 1972]

The following picture gives a schematic overview on the production process of fish oil and fish meal:

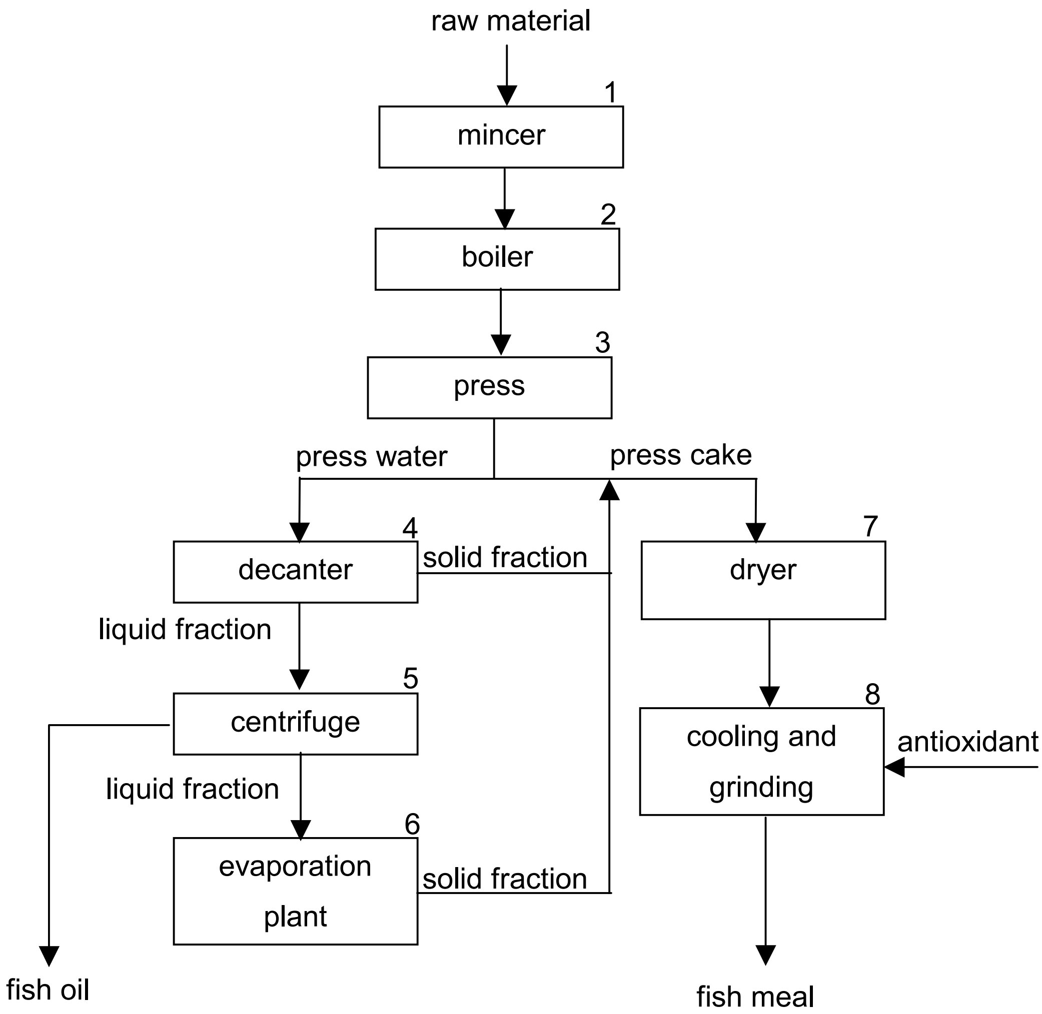


Figure 7-4: Production process of fish meal and fish oil

In short, the production process can be described as follows:

1. Large raw material parts are reduced in size in the mincer.
2. The raw material is boiled in its own juice (usually by indirect steam heating).
3. Pressing of the raw materials results in a solid fraction – the press cake – and a liquid fraction containing oil and some solids – the press water.
4. A decanter separates the liquid fraction from the solid fraction which is returned to the press cake.
5. The fish oil is removed from the liquid fraction by centrifuging.
6. The remaining liquid called, ”stick-water”, still contains small amounts of solids. These solids are concentrated by evaporating the water. The resulting product, called ”solubles”, may be added to the ”press cake” before the dryer when ”whole meal” is produced.

7. In the dryer the ”press cake” and the ”solubles” are dried (usually by indirect steam heating) to a fish meal with a desired moisture content (e.g. 5-10%).
8. Antioxidant is added to the fish meal which is then cooled and milled to the desired particle size to form the finished product.

Fish oil is used as an ingredient in animal feed but also to manufacture margarine and cooking fat. In order to prepare the fish oil suitable for human consumption it may be processed further e.g. in fish oil refining. The refining includes the following four process steps:

- neutralisation
- bleaching
- hydrogenation
- refining

It is noteworthy that such further processing may significantly reduce the contamination with dioxins and PCBs. PCB concentrations are reported to be reduced about 50% compared to the contamination in fish oil [see e.g. Hilbert 1998]. The quantitative reduction on a TEQ level basis is not reported.

In this context it is noteworthy that due to the maximum limits for dioxins and the foreseen limit values for dioxin-like PCBs, in the fish meal and fish oil processing industry there are ongoing activities aiming at the reduction of the dioxin and PCB contamination in products. It has to be assured that possibly high contaminated by-products of the corresponding decontamination process will not re-enter the food chain via use in animal nutrition in the future.

An exemplary composition of fish meal is dry matter 91.0 %, crude protein ca. 70 % dry matter, ash 18.0 % dry matter and major elements Ca (4.6), P (2.9), Mg (1.3), Na (2.5), S (0.7), in % dry matter.

Production of silage from fish waste

Production of fish silage (= fish hydrolysate or fish protein concentrate) is the cheapest way of utilising fish waste. Considering the capital needed and the operating costs for fish meal and hydrolysate production (cost ratio 4:1), production of the liquid form of this by-product is very profitable and it can be done by small plants. It is a simple technological process.

The raw material must be fresh. The main phases of processing are

- grinding
- acidifying of the pulp (with sodium pyrosulphite ($Na_2S_2O_5$) and sulphuric or hydrochloric acid)
- liquefying (which results from a self-digestion (autolysis) process)

The basic requirement of the process is to obtain a homogenous mix consisting of the fish, inorganic acid and sodium pyrosulphite by using slowly revolving mixers or other methods (turbulent mixing causes aeration of the mix and consequently oxidation of fatty acids).

An approximate chemical composition of fish silage is:

- protein - about 15%
- fat - 6-14% (depending on raw material)
- ash - 2.4%
- micro-elements and vitamins

Different forms of fish hydrolysate are used for feeding pigs, poultry, fur animals and fish. Hydrolysates contain very valuable, easily assimilated proteins and fatty acids, unaltered vitamins, micro-elements and digestive enzymes. For pig and poultry feed, fish hydrolysates can substitute fish meal, meat meal, bone meal and blood meal.

The following figure gives an overview on the relevant process steps:

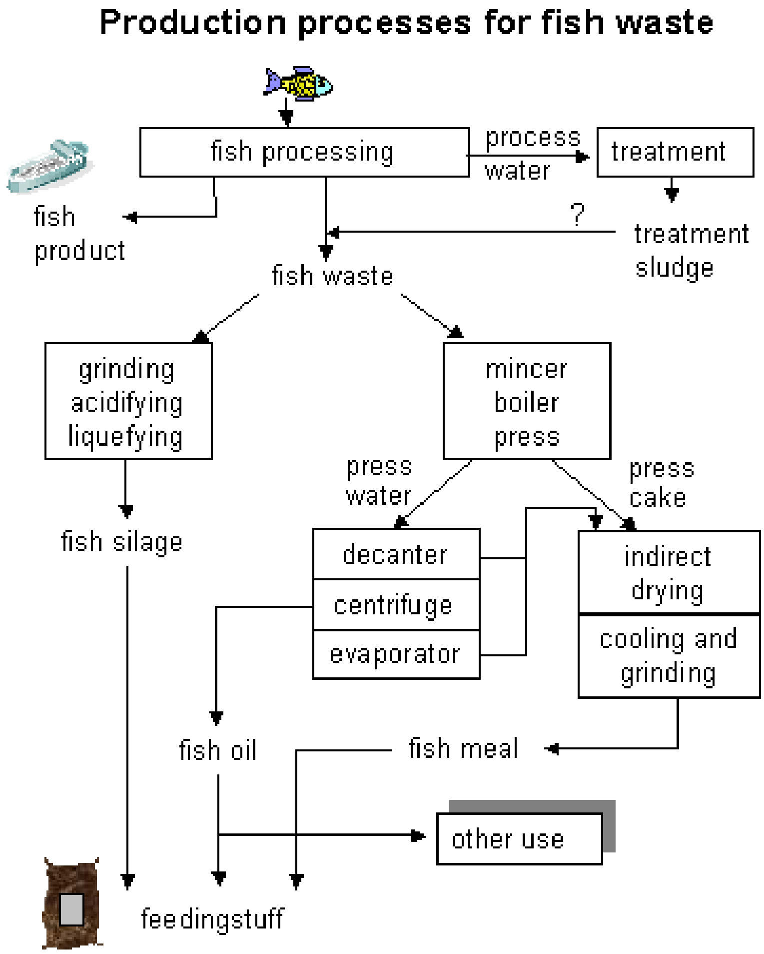


Figure 7-5: Production process fish waste

7.5 Contamination theses

The following figure shows the production processes for fish waste against the background of contamination theses and the consequences for sampling points.

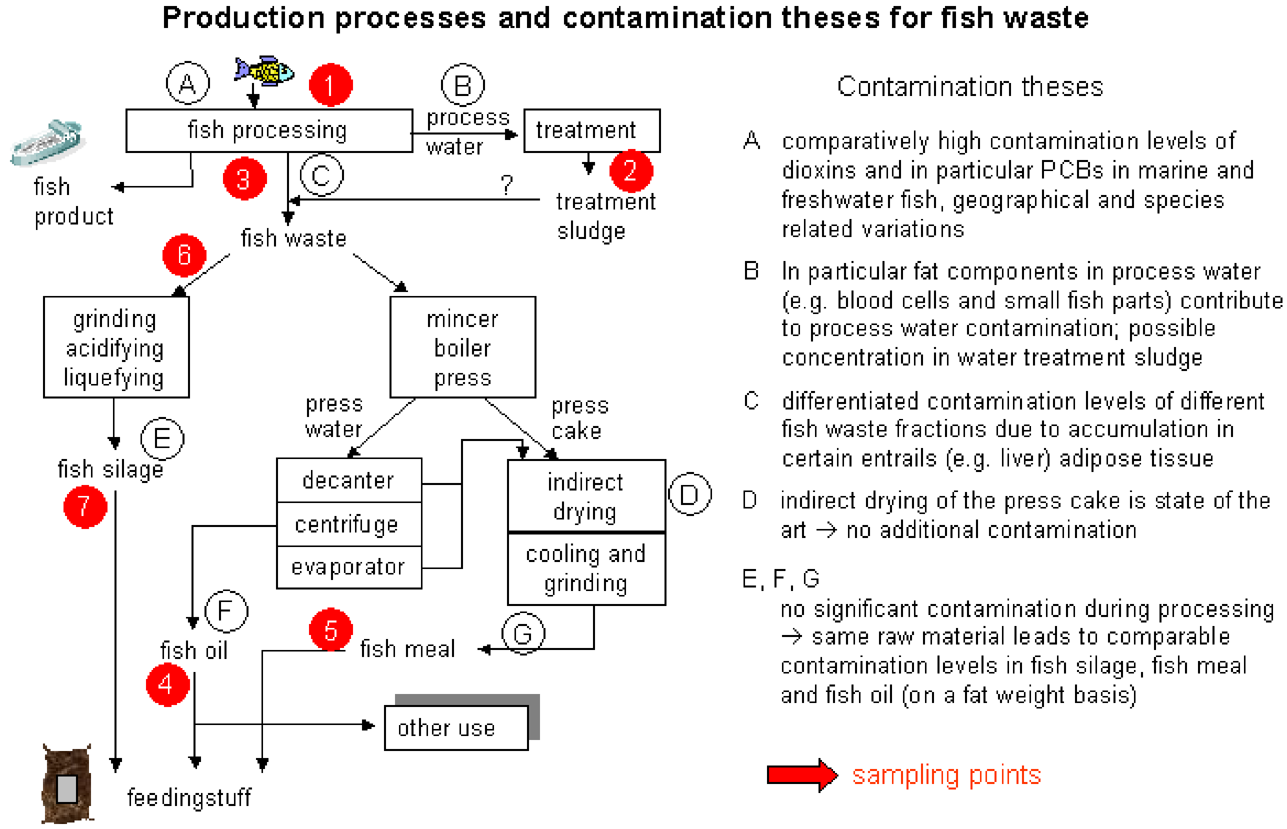


Figure 7-6: Production processes and contamination theses for fish waste

Typically, the contamination of fish waste as input material is comparable to that of the whole fish. Therefore analogous high contamination levels can be expected, in particular for PCB in marine and freshwater species. However, there might be a big variation of contamination depending on geographical and species related reasons and in particular on the fish parts that are processed. Consequently, the examination of the input material is rather important.

In most process steps no significant additional contamination is expected. It is assumed that the same raw material leads to more or less comparable contamination levels in fish silage, fish meals and fish oil (on a fat weight basis).

Different contamination levels can be expected for different fish waste fractions due to the accumulation in certain entrails (e.g. liver, see Annex I, data sets 12, 35, 232, 1799) or adipose tissue. Therefore investigation should be carried out to clarify whether a segregation of certain highly contaminated fractions might enable to lower the overall contaminations of the resulting material used for feedingstuff.

In the case of fish silage processing a certain risk has to be taken into consideration during fermentation. This treatment includes a possible risk of formation of organochlorine pollutants by micro-organisms. Additionally higher chlorinated (and low toxic) congeners (either PCBs or PCDD/Fs) may be de-chlorinated to lower chlorinated and possibly more toxic congeners and consequently increased WHO-TEQ levels.

During further processing of fish such as canning or production of prepared food fish parts may be cooked, smoked or fried. According to some information [e.g. Karl et al 1999] such processing may decrease contamination levels in fish. As a consequence, waste from further processing such as cooking or frying may contain POPs originating from the used raw material (e.g. used frying fat or effluents from canning industry) Consequently it seems to be reasonable to take these wastes into consideration in future investigations.

The consequences that are resulting from the production process analysis and the contamination theses are shown in the following table:

Fish waste:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	fish waste raw material	before processing	1
2	water treatment sludge	sludge after water treatment	1
3	fish waste fractions -scales -heads -entrails -kidneys -liver -bones -fins	from processing	7
4	fish oil	after grinding (in fish silage processing)	1
5	fish meal	after production	1
6	fish waste raw material	after production	1
7	fish silage	after production	1
			13

Table 7-4: Consequences of production processes and contamination theses for fish waste

A possible approach to increase knowledge about the effects of fish frying would be to investigate fresh and used frying fats from fish frying industry and the corresponding fresh and fryed fish. This could be carried out in the context of the process analyses for used oils and fats (see chapter 5) by looking closer at used oils and fats from fish frying industry or restaurants.

7.6 Requirements for decision-making

The medium and high contamination volume category for fish meal and fish oil from fish waste indicates a strong need for a broad data base. Need for action can be stated even if maximum limits and action values for PCDD/Fs are already available. Consequently the different processes and the contamination theses on the process steps lead to the necessity to carefully examine the relevance of single process steps. Of particular interest might be the investigation of different fish waste fractions and of applied separation process steps.

The medium contamination volume category of fish silage does not indicate to look at the process less carefully. Therefore it is suggested to analyse also the processing of fish waste to fish silage.

For a decision-making process additional output based data are necessary. For fish meals and fish oils it is suggested to have a reliable data base on typical contaminations covering the individual situation of all relevant Member States. For fish silage a reduced data base is sufficient due to the medium contamination category.

7.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to have a 2 step procedure with an important second step that might be also done simultaneously to the first step.

The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result. With these requirements fish meal, fish oil and fish silage are covered:

Fish waste:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	fish waste raw material	before processing	1
2	water treatment sludge	sludge after water treatment	1
3	fish waste fractions -scales -heads -entrails -kidneys -liver -bones -fins	from processing	7
4	fish oil	after grinding (in fish silage processing)	1
5	fish meal	after production	1
6	fish waste raw material	after production	1
7	fish silage	after production	1
			13

Table 7-5: Consequences of production processes and contamination theses for fish waste

Existing data cover already 4 of these sampling points, data on fish liver, fish silage, oil and meal (see annex 1). However, it has to be kept in mind that these data does not result from one investigated process and not from fish waste and therefore can be mainly used for evaluation of the contamination theses. For reasons of consistency it may be appropriate to investigate one coherent process and to correlate the results with the already available data.

Due to the developed methodology for output based samples 13 mixed samples (13 relevant countries) each with 20 individual samples for fish oils/fish meals, 7 mixed samples each with 15 individual samples for fish silage and 1 mixed sample with 30 individual samples for accidental contamination are necessary. Samples regarding accidental contaminations are covered with the analysis of these samples for typical contamination.

Sampling plan			
step 1:	required:	13	process specific samples
	available:	- 4	covered by existing data
	remaining:	= 9	process specific data
step 2:	required:	7	mixed samples of 15 individual samples for fish meal
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 15 individual samples for fish meal
step 2:	required:	1	mixed sample of 30 individual samples for fish meal
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for fish meal
step 2:	required:	15	mixed samples of 20 individual samples for fish oil
	available:	- 0	covered by existing data sets
	remaining:	= 15	mixed samples of 20 individual samples for fish oil

step 2:	required:	7	mixed samples of 15 individual samples for fish silage
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 30 individual samples for fish silage
step 2:	required:	1	mixed sample of 30 individual samples for fish silage
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for fish silage
total necessary individual samples:			**579 (9 + 7*15 + 1*30 + 15*20 + 7*15 + 1*30)**
necessary measurements:			**40 (9 + 7 + 1 + 15 + 7 + 1)**

Table 7-6: By-products and waste from the fish processing industry: sampling plan

8 Components from dairy products

8.1 Existing contamination data

In the European Union about 114 million tons of raw milk are processed. Various by-products and out of date products result of the production chain which starts with raw milk and are used for feedingstuffs. The total amount used as input into the feedingstuff industry is more than 1.6 million tons.

Existing contamination data indicate the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
milk and dairy products	fat	~ 1.0	~ 0.9

Table 8-1: Dairy products: approximate WHO-TEQ levels on the basis of available data

There are no data available on by-products as they are used in the feedingstuff industry. However, the contamination levels for milk fat in milk and dairy products (see annex 2) can be taken as an indicator for the contamination of the corresponding by-products and wastes that are used for compound feed production. However it can not be excluded that processing of milk and dairy products has an influence on contamination levels. As far as no appropriate data are available, the estimation has to be based on milk fat.

Data are available that can be used to interpret POP flows during production processes at 3 relevant process steps.

8.2 Material flow

Milk, milk products and by-products from the processing of milk are also relevant inputs to the feedingstuff industry. Following the bottom up approach about 1,600 kt dairy products are used as raw material for the production of feedingstuff which means a relative share of 1.7% of all inputs to the feedingstuff industry.

The top down approach shows that the most important by-products from the processing of milk are whey, buttermilk or skim milk. Only a part of these by-products of the milk processing is used in the food industry (included in fresh milk products) the biggest part serves directly or after further processing as input to the feed industry.

Skim milk powder is the main input from the dairy processing into the feeding industry. The amounts of produced milk powder products in the European Union for 2000 can be seen in Table 8-2.

skim milk powder	977.000 t
other milk powder (incl. whole-milk powder, partly-skimmed-milk powder, cream-milk powder and buttermilk powder)	998.000 t

Table 8-2: Production of milk powder products in Europe (EU 15) 2000 [Eurostat]

Besides the (milk processing) by-products also out of date products are used for animal feed or milkreplacers. The following list gives an overview on dairy products that are used as compounds in the feedingstuff industry:

Whole milk powder, milk protein concentrates

Dairy mixes (dairy powders)
Ice cream mixes
Industrial cheeses, Cheese powders
Butter, Butter powder
Buttermilk powder
Whey powder (sweet, acid, demineralized), whey protein concentrate
Yoghurt powder
Edible fats dairy
Skimmed milk powder
Fat filled milk powder
Full cream milk powder
Caseinates
Coffee whiteners

The following table illustrates the structure of the dairy industry in Europe 1997. Germany and France are the most important milk producers in the EU.

	EU	D	DK	F	I	NL	GB
dairies	5,740	240	31	564	1,806	11	1,063
milk delivery (million t)	117.0	26.6	4.4	23.6	11.7	10.4	15.1

Table 8-3: Overview over the European milk industry

The following chart gives an overview of the EU member states material flow of dairy products 2000.

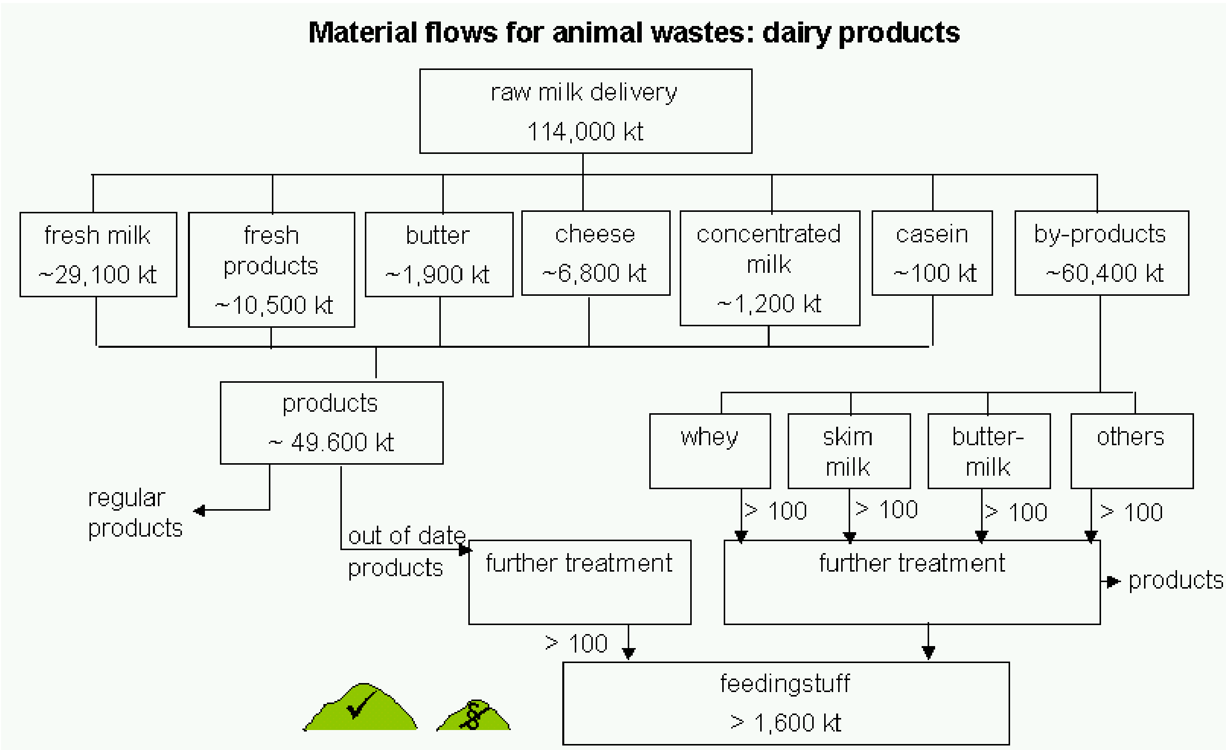


Figure 8-1: European material flow for dairy products, 2000 [Eurostat]

A comparison between bottom up and top down approach shows well fitting amounts, thus a volume of 1,600 kt is taken for an estimation of the relevant input into feedingstuffs.

8.3 Contamination volume categories

Available contamination data lead to the following estimations for average TEQ levels:

	average WHO-TEQ level
whey	
skim milk	
butter milk	1.9 pg/g fat
other milk by-products	
out of date products	

Combined with the results of the material flow and assuming an average fat content of 2 % for dairy products and by-products used in compound feedingstuffs, the following WHO-TEQ freight results for an upper estimation

whey	
skim milk	
butter milk	0.06 g
other milk by-products	
out of date products	

This lead to the **low contamination volume category** (< 0.1 g WHO-TEQ).

8.4 Description of the process

For reasons of an increased shelf-life, convenience, product flexibility, decreased transportation costs, and storage the liquid by-products of dairies which mainly consists of water have to be dried before further use in food or feedingstuff industry.

During the drying process the water content of the milk product has to be reduced from up to 90% to less than 5%. The reduction of the liquid results in a concentration of the milk ingredients. The following table gives an overview of the composition of milk product powders and whole milk.

	fat	protein	lactose	minerals	water
whole-milk (liquid)	3.8	3.2	4.9	0.6	87.5
whole-milk powder	25-28	25	39	6	4
skim milk powder	0,5	34	53,5	8	4
whey powder	0,9	12,5	74,6	8	4
fat concentrate powder	50	17	25	5	3

Table 8-4: Composition of whole milk in comparison with milk powder products in % [Hochdorf 2002]

The liquid by-products of the dairy industry like whey, buttermilk or skim milk typically have a low fat content. Therefore the nutrient value of these products in same cases are improved by adding vegetable or animal origin fats during the drying process.

The drying process of dairy products generally consists of the following main steps:

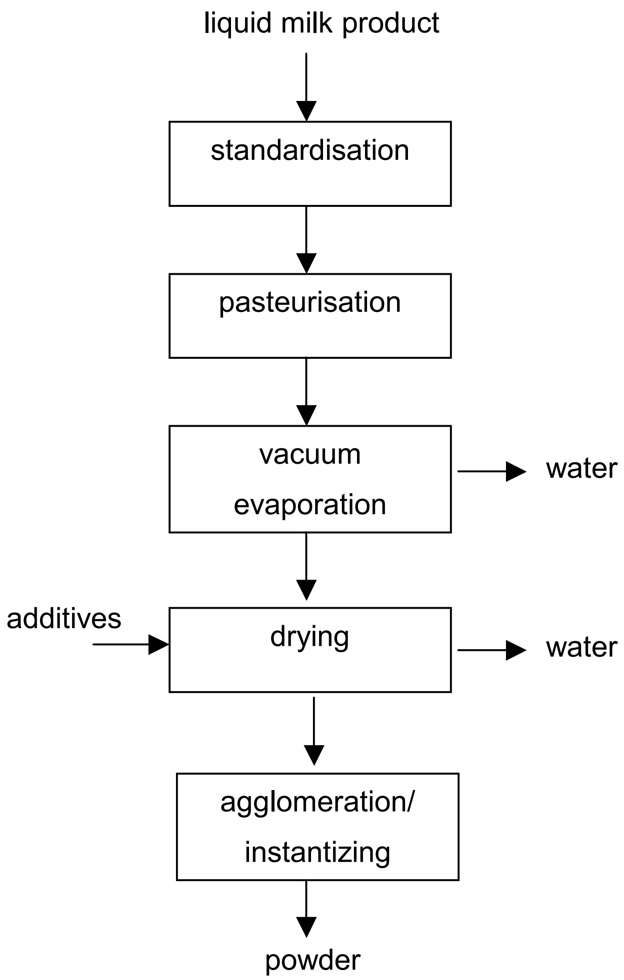


Figure 8-2: Production process for milk powder products

Depending on the product in a first step the fat content of the milk has to be adjusted by adding cream to the skimmed milk before the liquid product has to be pasteurised. After the pasteurisation the liquid product is concentrated with an evaporator and finally dried to produce powder.

The most common evaporator in the food industry is the falling film evaporator. The evaporation of milk has to take place under vacuum to avoid heat damage During the vacuum evaporation the water content is reduced approx. 30-40%.

After the pre-concentration the still remaining water has to be removed to a level less than 5% by the means of a drier. Following drying processes are possible:

spray drying

drum drying

spray-belt drying

vacuum belt drying

Spray-drying is the principal method used for drying milk in the dairy industry. By the spray-drying process the concentrate is introduced as a fine spray or mist into a tower or chamber with heated air. As the small droplets make intimate contact with the heated air, they flash off their moisture, become small particles, and drop to the bottom of the tower and are removed. The advantages of spray drying include a low heat and short time combination which leads to a better quality product.

Most skim milk powders used as ingredients are spray dried and are manufactured in two basic varieties: instant (agglomerated) and non-instant (regular). The instantized spray-drying process gives the powder a larger grain size than regular spray dried powder and renders it instantly soluble when reconstituted in cold water. Furthermore, the heat treatment applied during the manufacture of specific spray dried skim milk powders will, to a certain extent, affect the denaturation of the milk proteins, and consequently, their solubility and functionality as milk ingredients.

By the drum drying process the drying is realized by indirect heating as the metal drums have internal steam heating. The product dries to a thin film on the drum surface. Both low- and high-viscosity products can be dried on the drums

The main application of the vacuum belt dryer is to dry viscous products with a high solids content. Liquid and powder components are continuously mixed to a paste, then gently dried under vacuum with controlled heating. Lightweight porous products are obtained; after drying, these are ground to the desired grain size.

The combined spray/belt dryer is a combination of the conventional spray tower and the belt dryer. It is designed to handle products that formerly posed major drying problems. Fats and other components can be applied to a variety of substrates (milk solids, starches, vegetable proteins, maltodextrins, etc.).

The following figure illustrates the relevant production processes:

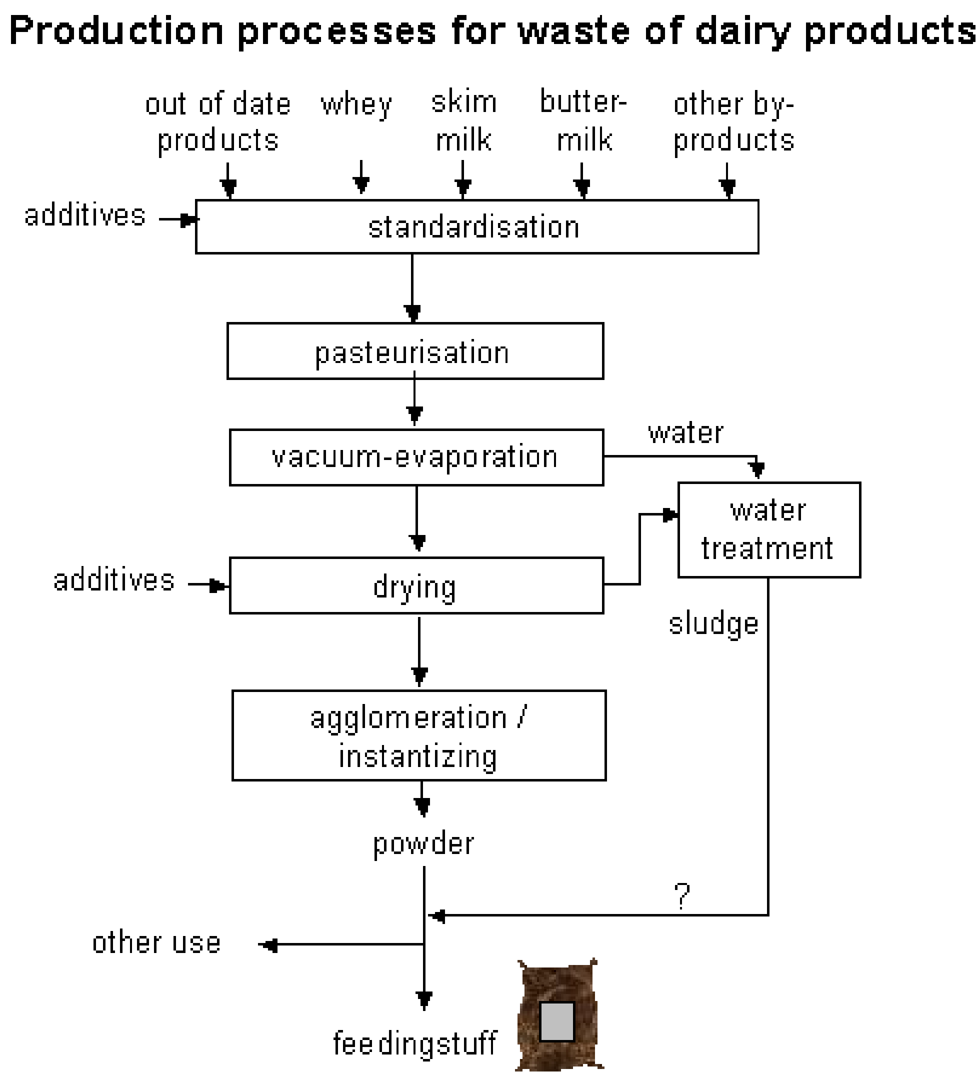


Figure 8-3: Production processes for waste of dairy products

8.5 Contamination theses

The following figure shows the production processes for waste of dairy products against the background of contamination theses and the consequences for sampling points.

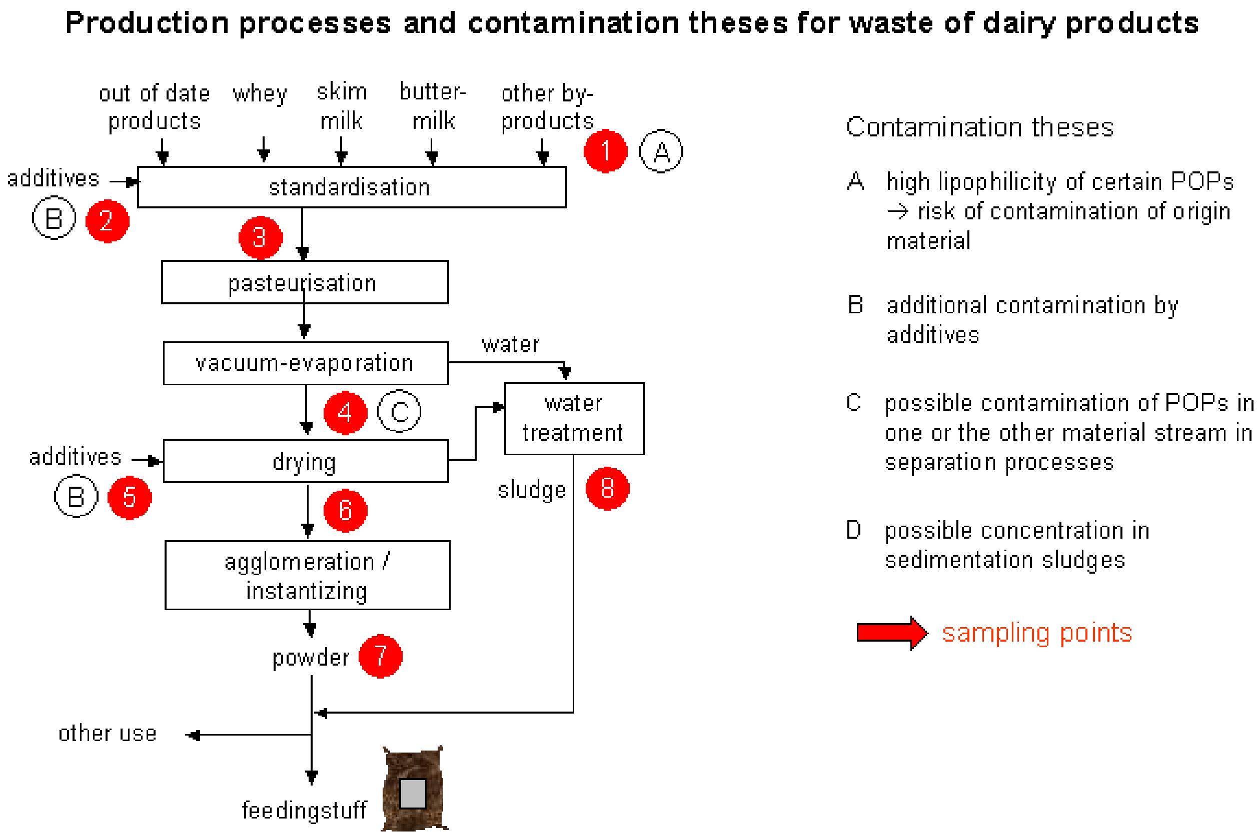


Figure 8-4: Production processes and contamination theses for waste of dairy products

As explained above certain POPs accumulate in livestock animals including milk cows. Approximately 1/3 of the most toxic PCDD/F congeners taken up by a cow are excreted via milk [Fiedler 2000]. The excretion of dioxin-like PCBs may be similar. Consequently the input material "cow's mild" into dairy products is considerably contaminated.

Additional contaminations may occur during processing e.g. by additives that are used for various process steps.

Finally concentration effects of POPs may occur in separation steps such as evaporation, drying and water treatment. Of special interest in this context are the contaminations of sludges that are recovered for feedingstuff materials.

The consequences that are resulting from the production process analysis and the contamination theses are shown in the following table:

Dairy wastes:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1a	out of date products	before processing	1
1b	whey	before processing	1
1c	skim milk	before processing	1
1d	buttermilk	before processing	1
1e	other by-products	before processing	1
2	additives	before standardisation	1
3	mixture	after standardisation	1
4	dried material	after vacuum evaporation	1
5	additives	before drying	1
6	mixture, dried material	after drying	1
7	powder	after agglomeration / instantizing	1
8	sludge	after waster treatment	1
			12

Table 8-5: Consequences of production processes and contamination theses for dairy products

8.6 Requirements for decision-making

The low contamination volume category indicates that there is no need for a broad data base. At present there is no or little need for action in the field "Components from dairy products". However, total used amounts are quite high and there might be some accidental contaminations. Thus the different processes and the contamination theses to the process steps lead to the necessity to examine the relevance of single process steps. This knowledge would enable to describe possible technical measures that could lower the POPs contamination in inputs to feedingstuff industry.

8.7 Data and sampling strategy

As a consequence of the data requirements it is suggest to have a 2 step procedure with a low important second step. The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Dairy wastes:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1a	out of date products	before processing	1
1b	whey	before processing	1
1c	skim milk	before processing	1
1d	buttermilk	before processing	1
1e	other by-products	before processing	1
2	additives	before standardisation	1
3	mixture	after standardisation	1
4	dried material	after vacuum evaporation	1
5	additives	before drying	1
6	mixture, dried material	after drying	1
7	powder	after agglomeration / instantizing	1
8	sludge	after waster treatment	1
			12

Table 8-6: Consequences of production processes and contamination theses for dairy products

Existing data cover already 4 of these sampling points (milk and dairy products for out of date products, whey, skim milk, other by-products; see annex 1). Consequently data are needed for the remaining 9 sampling points. For reasons of consistency it may however be appropriate to investigate one coherent process and to correlate the results with the already available data.

The second step of the data and sampling strategy meets output based samples.

For this step only few data are necessary due to the low contamination-volume-category. Only contamination levels due to accidents following the precautionary principle are of interest. This would result in 5 mixed samples from dairy products. Each mixed sample should consist of 30 individual samples.

Sampling plan			
step 1:	required:	12	process specific samples
	available:	- 3	covered by existing data
	remaining:	= 9	process specific data
step 2:	required:	1	mixed samples of 30 individual samples for whey
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for whey
step 2:	required:	1	mixed samples of 30 individual samples for skim milk
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for skim milk
step 2:	required:	1	mixed samples of 30 individual samples for buttermilk
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for buttermilk

step 2:	required:	1	mixed samples of 30 individual samples for other milk by-products
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for other milk by-products
step 2:	required:	1	mixed samples of 30 individual samples for out of date products
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples for out of date products
total necessary individual samples:			**158 (8 + 30 + 30 + 30 + 30 + 30)**
necessary measurements:			**13 (8 + 1 + 1 + 1 + 1 + 1)**

Table 8-7: Components from dairy products: sampling plan

9 Components from agriculture and industry with a high fibre content

9.1 Existing contamination data

In the European Union huge amounts of grain and pulses are processed. Relevant wastes, by-products and recyclates of the processing like harvest residues from cereal cultivation (straw) or from pulse cultivation and from corresponding cleaning processes (e.g. aspiration dust from cereal cleaning) are used for feedingstuff. Furthermore, by-products or wastes from the processing of wood, paper or textiles with a high fibre content might be used as raw material in the feeding stuff industry.

Related to these items only few specific contamination data are currently available. Average contamination levels have to be assessed on the basis of existing contamination data that allow estimations for the relevant materials. Existing contamination data (see annex II), not published measurements of industrial companies and assumptions on comparable contamiantions indicate the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
straw from grain	d.m.	~ 0.12[1)]	~ 0.25[2)]
harvest residues from pulse cultivation	d.m.	no data available (~ 0.12)[3)]	no data available (~ 0.25)[3)]
aspiration dust from cereal cleaning	d.m.	~ 0.11[1)]	~ 0.66[1)]
wood, sawdust, wood shavings, paper, pulp waste	d.m.	~ 1 (very variable)[2)]	~ 1[2)]
waste from processes or unprocessed textile fibres		no data available	no data available

1) see annex II
2) unpublished measurements of industrial companies
3) assumption: comparable contamination as straw from grains

Table 9-1: Components from agriculture and industry with a high fibre content: approximate WHO-TEQ levels on the basis of available data

The values for straw mainly derive from information on grass. Recent data on rice leaves and rice straw indicate somewhat higher levels for rice straw (~ 1 pg/g d.m. total WHO-TEQ). As there are no data available on harvest residues from pulse cultivation a comparable contamination as in the case of straw from grains has been assumed. The contamination levels for aspiration dust from cereal cleaning are the outcome of a recent study including for the first time dioxin and PCB levels. The dioxin levels are below former findings [BMVEL 2002], consequently the contamination volume category had to be readjusted with regard to the workshop results.

For wood and paper by-products the high variability of contamination levels makes it difficult to indicate an average contamination level. High reported contamination levels are usually related to specific sources (e.g. treated wood) or recycled paper. Those values can not be considered to be representative for materials used in compound feedingstuffs but the fact that those materials exist increase the possibility, that those materials are illegally or accidentally used.

Precise data are required for several materials at the relevant process steps that means for

- the over ground plant parts of cereals, grains, straw, cleaned grains and aspiration dust
- the over ground plant parts of pulses, cleaned pulses and harvest residues from pulses
- wood or wood by-products (cuttings, saw meal, dust from grinding, etc.)

Several data are available on contamination levels for 3 relevant process steps (on straw, cleaned grains and aspiration dust). These can be directly used for a decision base and are documented in annex 1.

9.2 Material flow

Harvest residues like straw from grain and pulse cultivation are used as feedingstuffs mainly due to their high content of fibres. As explained in the previous project there were some indications that these components may be significantly contaminated with dioxins and PCBs. The following agricultural and industrial wastes with high fibre content have been investigated:

- straw from grain
- harvest residues from pulse cultivation
- aspiration dust from cereal cleaning/processing
- wood, sawdust, wood shavings
- paper pulp and paper pulp waste
- waste from processed or unprocessed textile fibres

A bottom up approach is difficult as there are various types of wastes with high fibre content and the share of these components varies significantly within different types of feed. Following expert interviews in pig feed shares up to 25% of high fibre material can be estimated, in cattle feed up to 60% is possible.

In any way it therefore can be stated that the amount of components from agriculture and industry with a high fibre content exceeds 5 million tons. The most important components are straw from grain and rice straw and harvest residues from pulse cultivation.

Having in mind that about 4 million tons of pulses are used for feed harvest residues might count for more than a million tons. Straw from grain and rice straw definitely also exceed 1 million (lower estimation), an amount of about 4 million tons is expected .

Experts of the feedstuff industry explained that for pelleted feedingstuffs about 0.5% of components with high fibre content resulting of paper/pulp waste and waste from wood processing are used. This means a volume of more than 100 kt for wood, sawdust, wood shavings and paper/pulp waste.

Aspiration dusts form another input to feedingstuffs however, this use is forbidden in some Member States (for example Germany). Following discussions with the feedingstuff industry a volume of more than 100 kt seems a reasonable European dimension for this material flow.

As a last type of material with a high fibre content wastes from processed and unprocessed textile fibres has been investigated. Indications for relevant volumes used in compound feedingstuffs have not been found.

The following illustration shows the estimated amounts of the selected streams that are used in feedingstuffs:

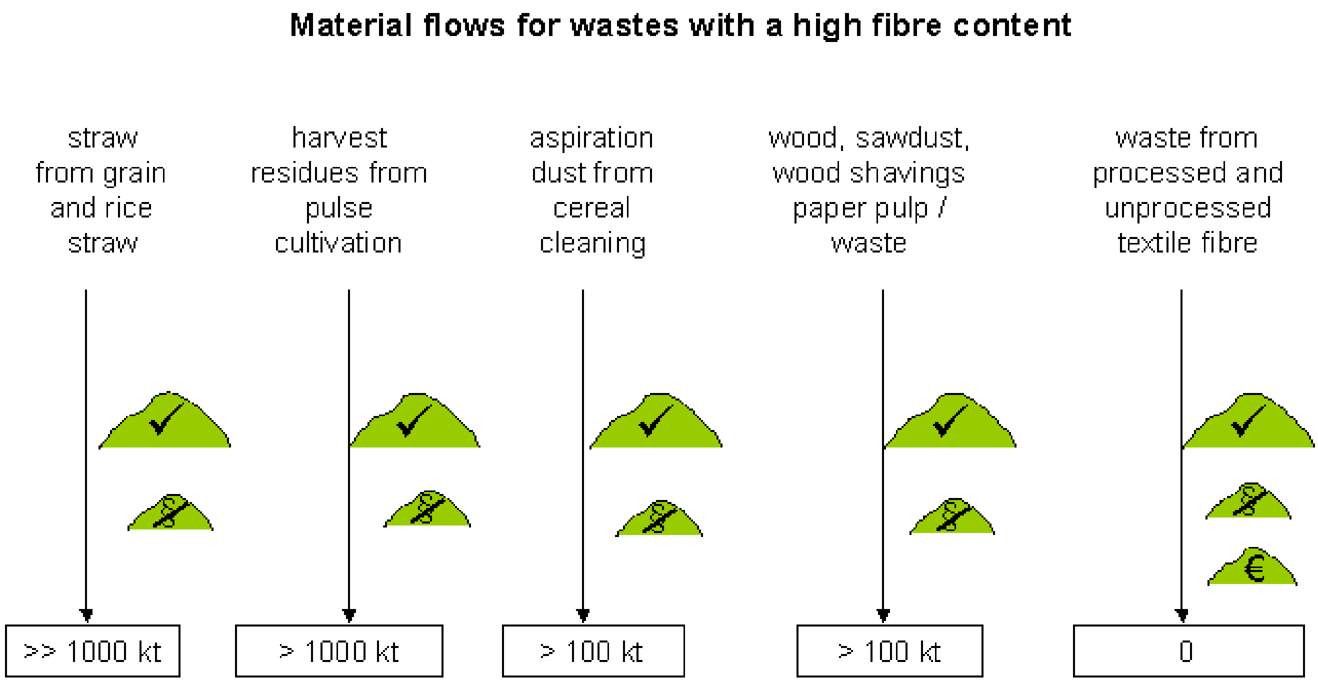


Figure 9-1: Material flow for wastes with a high fibre content

9.3 Contamination volume categories

Combing the existing contamination data with the results of the material flow the following WHO-TEQ freights result:

straw from grain (upper estimation)	1.48 g
harvest residues from pulse cultivation	0.37 g
aspiration dust from cereal cleaning	0.077 g
wood, saw dust, wood shavings, paper pulp waste	0.1 g

This leads to the following contamination volume categories:

material flow	contamination volume category
straw from grain	**high (> 1 g)**
harvest residues from pulse cultivation	**medium (> 0.1 g)**
aspiration dust from cereal cleaning	**low (< 0.1 g)**
wood, saw dust, wood shavings, paper pulp waste	**medium (> 0.1 g)**

9.4 Description of the process

For the processing of high fibre content feed materials a multitude of processing techniques exist. Selected processes for high fibre content materials (hot air drying, cereal cleaning) have been described in stage I of the project [Fiedler et al 2000]. Related to the selected feed materials the following process steps have to be taken into consideration:

(A) Cereal processing

From cereal processing the relevant material flows "straw from grains" and "aspiration dust" originate. The following figure gives an overview on the relevant production processes:

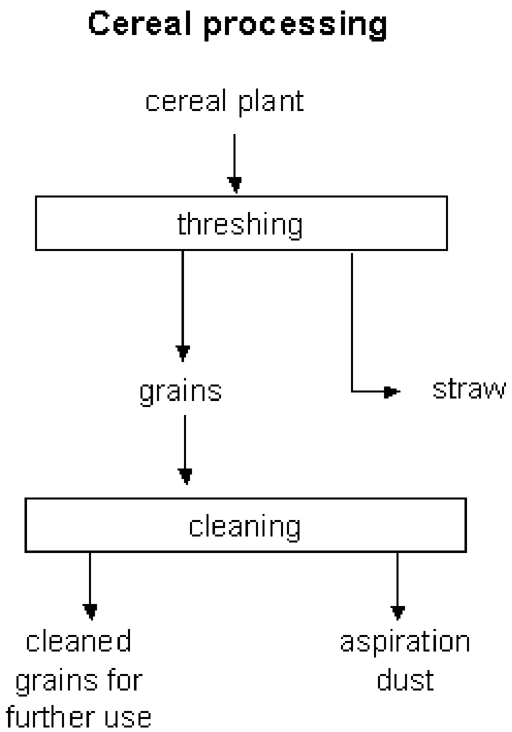


Figure 9-2: Production processes cereal processing

Grain processing is complex. The above illustrated figure shows the relevant process steps for possible input to compound feedingstuffs. During threshing the grains are separated from the rest of the plant (straw). Before the grain can be applied for further uses it undergoes several cleaning steps. Several dust fractions are separated. The separation is carried out according to weight differences in a jet of air and through shaking sieves according to different particle sizes. The general term for this separated material is "aspiration dust". It consists of dust, chaff and other superficial material.

(B) Processing of pulses

As the following figure shows, there is no principal difference between the relevant process steps in pulse harvesting and cereal processing:

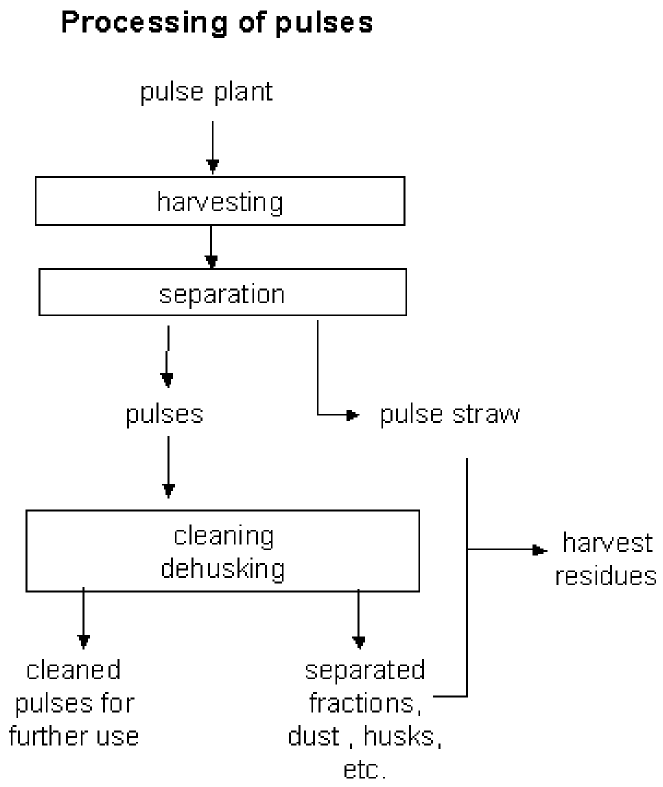


Figure 9-3: Production processes pulse processing

Even if pulses undergo a number of different process steps, the relevant steps are comparatively simple and quite similar to those in cereal processing. After harvesting the overground parts of the plant the pulses are separated from the other plant parts (pulse straw). Basic processes are cleaning and dehusking. The separated fractions together with the pulse straw can be considered as harvest residues from pulse.

(C) Processing of wood

From wood processing result the relevant material flows wood shavings, cuttings sawdust, dust form grinding and fibres from paper pulp production. The relevant process steps are part of the main procedures

- sawing/cutting
- grinding
- paper and pulp production

The following figure gives an overview on the relevant processes:

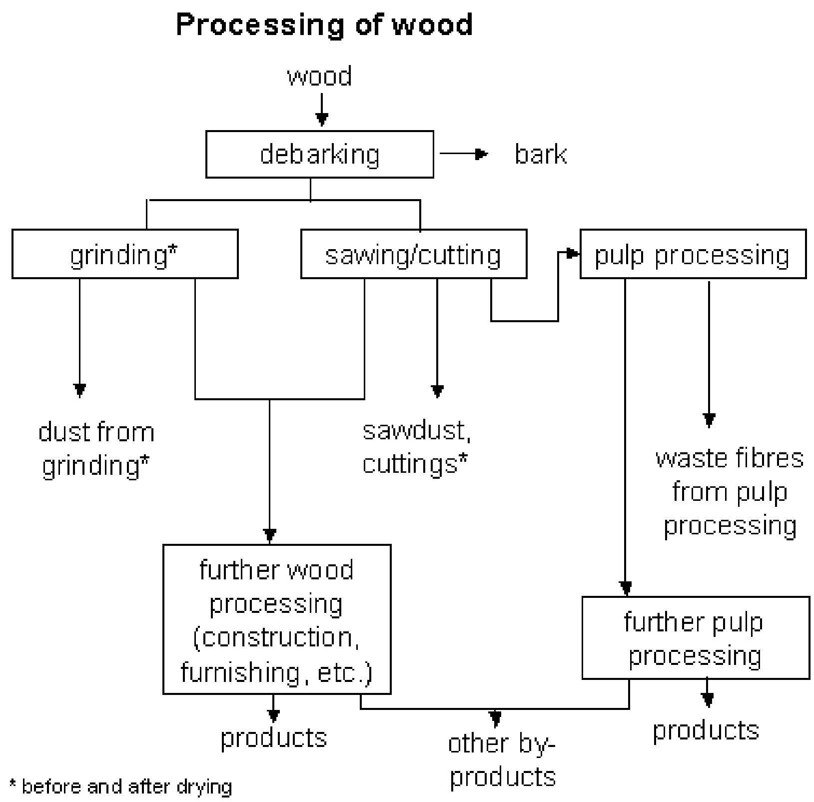


Figure 9-4: Production processes wood processing

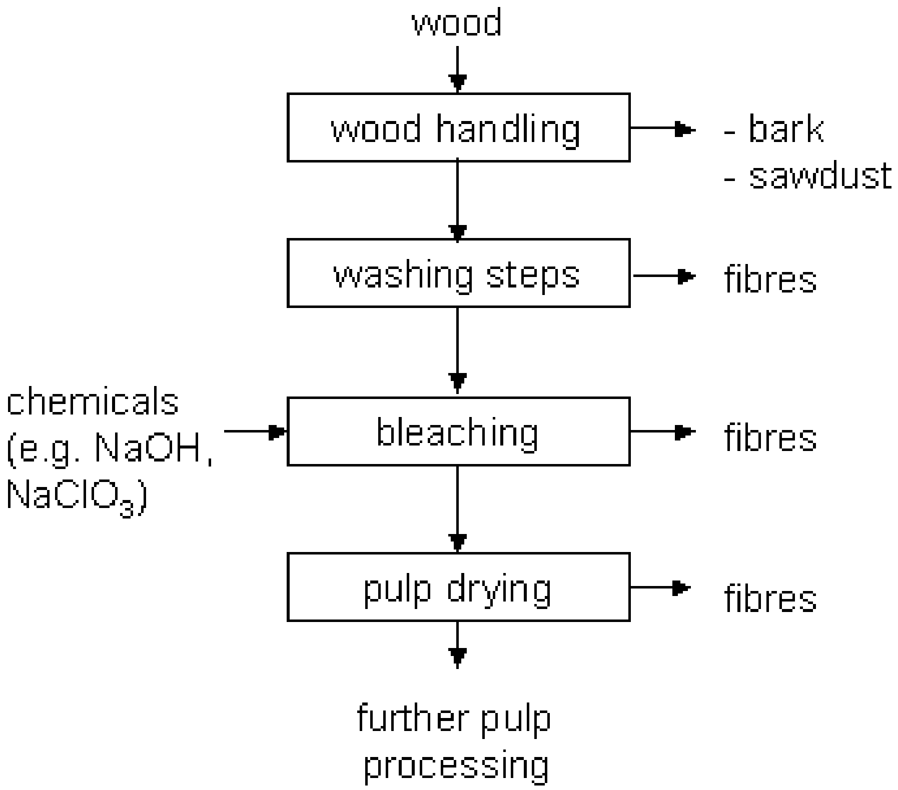
Sawing, cutting and grinding are simple mechanical steps that need no further description. These process steps may be performed before and after drying of the wood.

Paper pulp production is a complex process that can be differentiated in

- sulphate (kraft) pulping
- sulphite pulping

- mechanical pulping
- recovered paper processing

Pulp processing is described in detail in the BAT document for the pulp and paper industry (IPPCB 2001). The fibres from pulp processing result from the following steps:



At several process steps following the initial wood handling chemicals are added. No indications have been found that fibres resulting from process steps after addition of chemicals are used in compound feedingstuff production. Consequently these waste streams are not relevant for the project aims. The only legally relevant process step is sawing during wood handling and the resulting sawdust as input as high fibre material into compound feedingstuff.

9.5 Contamination theses

The background contamination enters the process mainly via superficial contamination of the processed material (grains, straw, harvest residues) or via contamination due to previous processing (e.g. treated wood or paper pulp materials).

During processing several separation steps may result in POP concentration effects (e.g. cleaning or mechanical treatment may lead to concentration of surface particles in aspiration dust from cleaning, rejects and waste from sieving or sludges from process water treatment).

In biological or chemical treatment POPs may enter the process (e.g. via used chemicals) or be generated (e.g. due to appliance of strong alkali). Finally thermal processes are well known for the generation of dioxins and furans. They may cause additional contamination in processes such as direct heating.

(A) Cereal processing

The following picture shows the relevant process steps in cereal processing against the background of contamination theses and the consequences for sampling points.

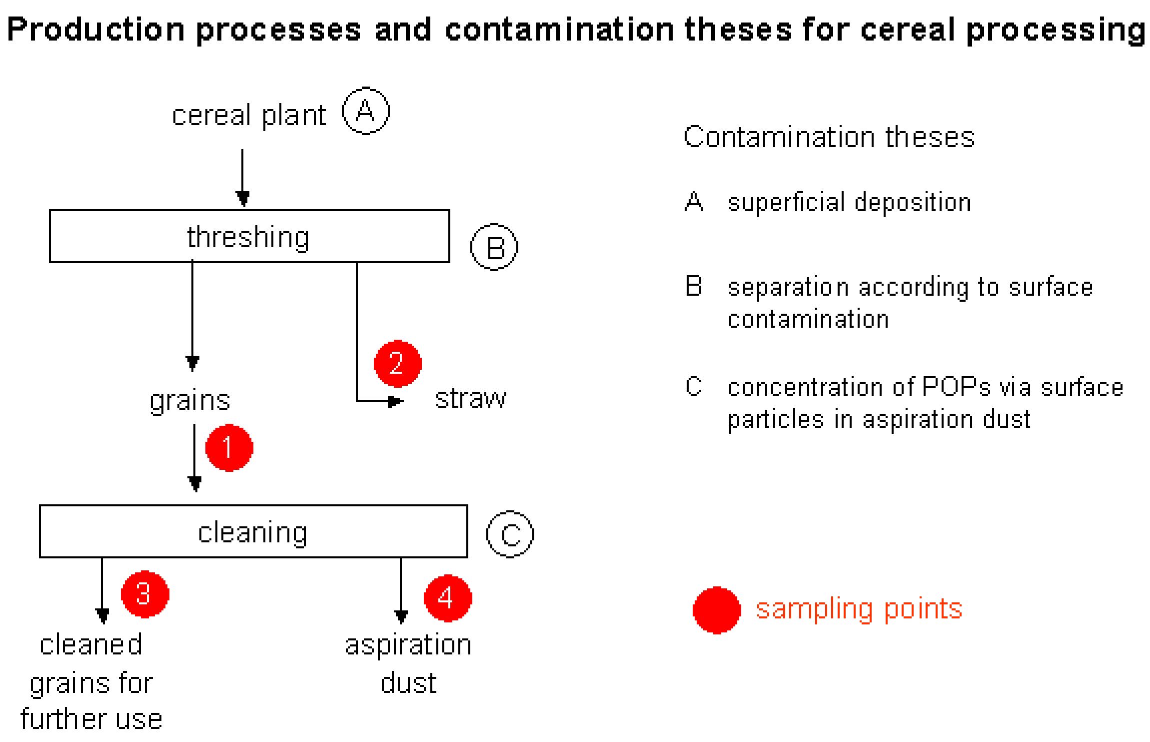


Figure 9-5: Cereal processing: production processes and contamination theses

Dioxins and PCBs are transported via air and deposited on the surface of the cereal plant. Additional contamination is due to soil splash leading to soil particles that pollute predominantly the lower parts of the plants close to the soil. A simple measure to reduce the contamination of straw might be to cut the cereal plants during harvesting a little bit higher above the ground in order to reduce the pollution of the straw with soil particles.

During the threshing process the grains are separated from the steam and leaves and other plant parts. The contamination rests in surface related particles and plant tissues. According to the bigger surface of the straw, the major share of the contamination is expected to result in the straw fraction. Another share should be in the outer parts of the grains (surface particles, chaff).

According to the thesis that the contamination is mainly related to the surface, the dioxins and PCBs can be assumed to accumulate in the separated aspiration dust fractions. This has been shown in recent investigations (see annex 1, data sets 1348-1356) and even if the importance of the TEQ flow is less important than former findings indicated, it might be a possible measure to eliminate the input of around 0.08 g WHO-TEQ by the exclusion of aspiration dust from compound feedingstuff production.

The consequences that are resulting from the production process analysis and the contamination theses are shown in the following table:

Wastes with high fibre content from cereal processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	grains	after threshing	1
2	straw	after threshing	1
3	grains	after cleaning	1
4	aspiration dust fractions	after cleaning	1
			4

Table 9-2: Consequences of production processes and contamination theses for wastes from cereal processing

(B) Processing of pulses

The following picture shows the relevant process steps in pulse processing against the background of contamination theses and the consequences for sampling points.

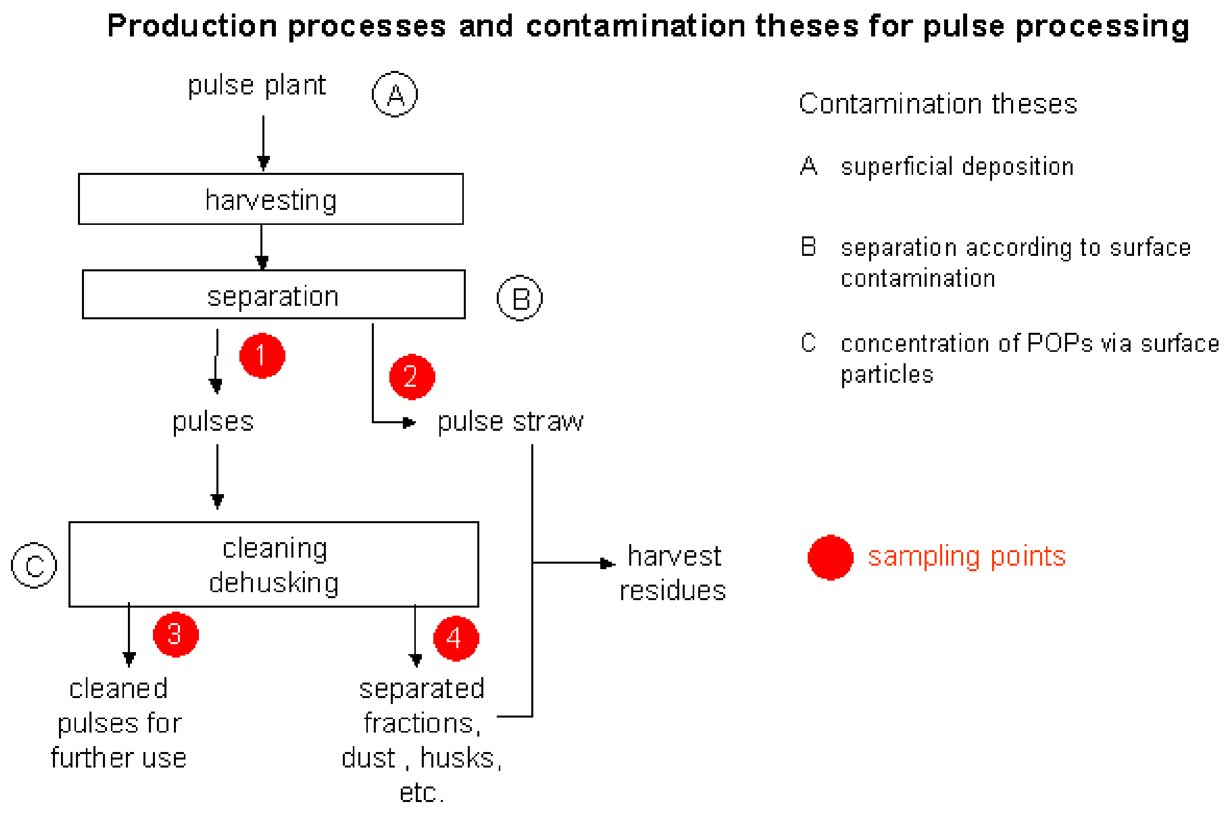


Figure 9-6: Pulse processing: production processes and contamination theses

The contamination theses for pulses are valid and analogous to those in cereal processing. To summarise it can be assumed that the major share of dioxin and PCB contamination can be found in the surface particles and outer plant tissues and thus finally in the harvest residues.

The consequences that are resulting from the production process analysis and the contamination theses are shown in the following table:

Wastes with high fibre content from pulse processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	pulses	after separation	1
2	pulse straw	after separation	1
3	pulses	after cleaning	1
4	separated fractions (dust, husks)	after cleaning	1
			4

Table 9-3: Consequences of production processes and contamination theses for wastes from pulse processing

(C) Wood processing

The following picture shows the relevant process steps in wood processing against the background of contamination theses and the consequences for sampling points.

Production processes and contamination theses for wood processing

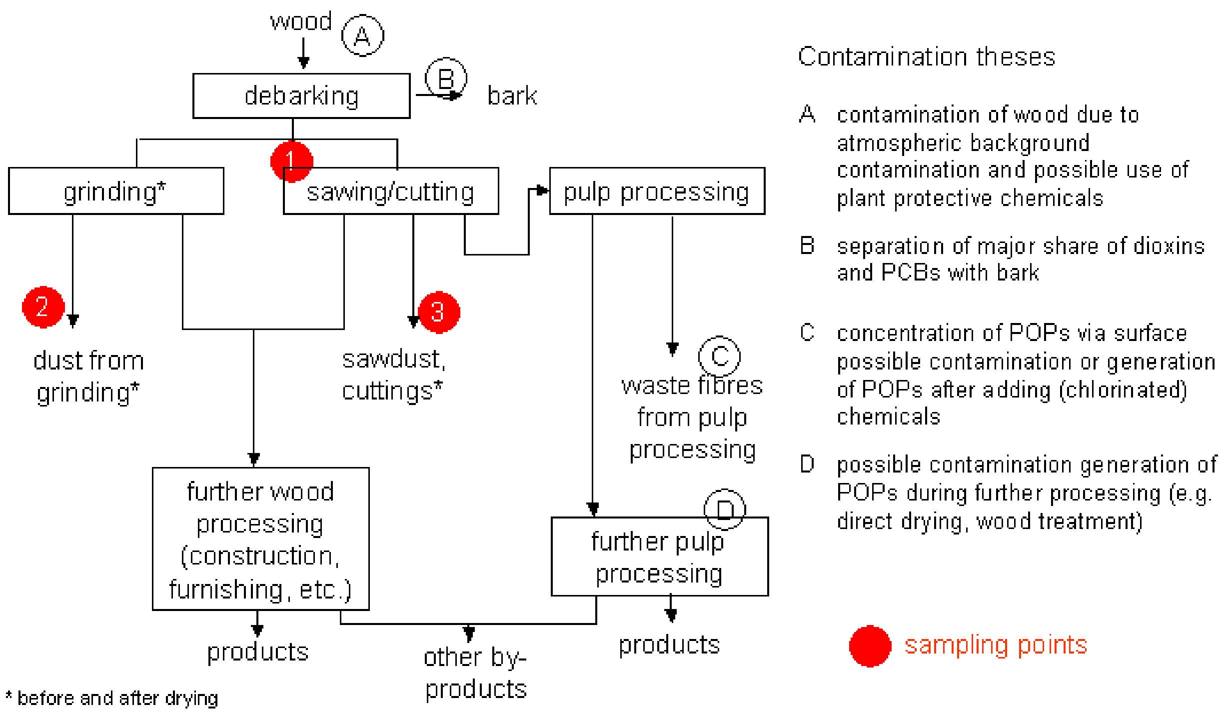


Figure 9-7: Wood processing: production processes and contamination theses

The contamination of wood is related to atmospheric background contamination and the use of pesticides in forestry.

The wood itself has no contact with the atmosphere during the growth of a tree and due to the contamination mechanisms (atmospheric deposition, no or low transport inside plants, no or low root uptake) the major contamination can be assumed to be found in the outer parts of trees (leaves, bark). Consequently the main part of the contamination of a tree is removed with the bark. There are no indications that bark is included in compound feedingstuffs (high content of tannin and polyphenols) and does not reach the food chain via feedingstuffs.

During pulp processing several chemicals are added according to the process requirements. Among these chemicals there are alkalines and chlorinated chemicals (e.g. NaOH and $NaClO_3$) that might lead to generation of chlorinated POPs.

Also further treatment of wood with protective chemicals may lead to further contamination. Such chemically treated wood or wood by-products are not allowed to be used in feedingstuffs.

The sampling plan focuses on the use of non-treated wood by-products. The consequences for the sampling plan against the background of the contamination theses and the production process analysis are shown in the following table:

Wastes with high fibre content from wood processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	wood	raw material, untreated, without bark	1
2	dust	from grinding	1
3	sawdust	from sawing	1
			3

Table 9-4: Consequences of production processes and contamination theses for wastes from wood processing

9.6 Requirements for decision-making

The high contamination volume category for straw from grain indicates a strong need for a broad data base. Need for action might exist due to the large material flows even if maximum limits and action values for PCDD/Fs are already available and there are only few, simple relevant process steps. The contamination theses on the process steps should be investigated to see whether there is a special relevance of single process steps that is at present not known.

Harvest residues from pulse cultivation show a medium contamination volume category. Again the process steps need to be investigated to see whether there is a special relevance of single steps. Like for straw better data on material flows are necessary and sufficient output based contamination information should be available.

For aspiration dust there are no requirements for process specific information as this is already covered with the examination of the process steps leading to straw from grains. Few output based data are necessary to see whether the expected contamination levels can be proved even in cases of illegal use.

Wood, saw dust, wood shavings and paper pulp waste shows a medium contamination volume category. The relevant processes are quite complex and consist of many process steps, however, only few steps are relevant for feedingstuffs and should be examined. Due to the broad variability of output data a representative data base should be established.

It has to be added that there is a risk of accidental or illegal mixture of untreated wood with treated wood. In case treated wood is used for feedingstuff there can exist a significant risk of high contamination.

9.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to have a 2 step procedure with an important second step that might be also done simultaneously to the first step.

The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Wastes with high fibre content from cereal processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	grains	after threshing	1
2	straw	after threshing	1
3	grains	after cleaning	1
4	aspiration dust fractions	after cleaning	1
			4

Table 9-5: Consequences of production processes and contamination theses for wastes from cereal processing

Wastes with high fibre content from pulse processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	pulses	after separation	1
2	pulse straw	after separation	1
3	pulses	after cleaning	1
4	separated fractions (dust, husks)	after cleaning	1
			4

Table 9-6: Consequences of production processes and contamination theses for wastes from pulse processing

Wastes with high fibre content from wood processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	wood	raw material, untreated, without bark	1
2	dust	from grinding	1
3	sawdust	from sawing	1
			3

Table 9-7: Consequences of production processes and contamination theses for wastes from wood processing

Existing data towards the processing of cereals cover already 3 of the 4 necessary sampling points (straw, cleaned grains, aspiration dust).

Existing data towards the processing of pulses cover already 1 sampling point (cleaned pulses).

Process specific data for wood, grinding dust and sawdust do not exist.

For reasons of consistency it may be appropriate to investigate one coherent process for each of the three types mentioned above and to correlate the results with the already available data.

Due to the developed methodology for output based samples the following samples are necessary:

straw from grains:	15 mixed samples each with 20 individual samples
harvest residues from pulse cultivation:	7 mixed samples each with 15 individual samples 1 mixed samples with 30 individual samples
aspiration dusts from cereal cleaning:	1 mixed samples each with 30 individual samples
wood, sawdust, wood shavings, paper pulp waste:	7 mixed samples each with 15 individual samples 1 mixed samples with 30 individual samples

Thus the following sampling plan results:

Sampling plan			
step 1:	required:	4	process specific samples cereal processing
	available:	- 3	covered by existing data
	remaining:	= 1	process specific data
step 1:	required:	4	process specific samples pulse processing
	available:	- 1	covered by existing data
	remaining:	= 3	process specific data
step 1:	required:	3	process specific samples wood processing
	available:	- 0	covered by existing data
	remaining:	= 3	process specific data
step 2:	required:	15	mixed samples of 20 individual samples of straw from grain
	available:	- 0	covered by existing data sets
	remaining:	= 15	mixed samples of 20 individual samples of straw from grain

step 2:	required:	7	mixed samples of 15 individual samples of harvest residues from pulse cultivation
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 15 individual samples of harvest residues from pulse cultivation
step 2:	required:	1	mixed samples of 30 individual samples of harvest residues from pulse cultivation
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples of harvest residues from pulse cultivation
step 2:	required:	1	mixed samples of 30 individual samples of aspiration dusts from cereal cleaning
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples of aspiration dusts from cereal cleaning
step 2:	required:	7	mixed samples of 15 individual samples of wood, sawdust, wood shavings, paper pulp waste
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 15 individual samples of wood, sawdust, wood shavings, paper pulp waste

step 2:	required:	1	mixed samples of 30 individual samples of wood, sawdust, wood shavings, paper pulp waste
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed samples of 30 individual samples of wood, sawdust, wood shavings, paper pulp waste
total necessary individual samples:		**607**	**(7+(15*20)+(7*15)+30+(7*15) +30 + 30)**
necessary measurements:		**39**	**(7 + 15 + 7 + 1 + 7 + 1 + 1)**

Table 9-8: Components from agriculture and industry with a high fibre content: sampling plan

10 Components from further wastes, by-products and recyclates

10.1 Existing contamination data

10.1.1 Catering wastes

In the European Union about 1700 kt tons of catering waste arise. Thereof approximately 1,000 kt are used as input in the feedingstuff industry. Due to EU legislation future use of catering wastes for feedingstuff might be restricted. An estimation based on existing contamination data indicates the following contamination levels:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
catering waste	fat	~ 0.7	~ 0.7

Table 10-1: Catering wastes: approximate WHO-TEQ levels on the basis of available data

The estimation is based on dioxin contamination levels in canteen food, food surveys and levels in diverse foodstuffs. The average adult TEQ-intake from dioxin-like PCBs (57-110 pg/d PCB-TEQ) is approximately comparable or even higher than that from dioxins (29-97 pg/d PCDD/F-TEQ) [SCOOP 2000]. Thus as long as no specific data are available it can be assumed that the contribution from dioxin-like PCBs to the total WHO-TEQ in catering waste is at least the same as that from dioxins.

Specific data are required for catering waste from the process input (industrial kitchens, restaurants and catering facilities and households) and the resulting swill itself. At present no data are available that could be directly used as an input to the decision basis.

10.1.2 Components of vegetable oil refining

In the European Union the vegetable oil supply amounts to appr. 10 million tons every year. By-products from vegetable oil extraction and refining steps are used as input in the feedingstuff industry. An estimation based on existing contamination data indicates the following contamination level:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
by-products from refining of vegetable oils	fat	~ 0.26	~ 0.13

Table 10-2: By-products from refining of vegetable oils: approximate WHO-TEQ levels on the basis of available data

This estimation is based on data on vegetable oils and connected with considerable uncertainties. A conservative behaviour of the dioxins and PCBs has been assumed and thus a comparable contamination for vegetable oils and the corresponding by-products from refining of vegetable oils. This assessment has to be seen in the light of some information on non-refined oils that indicate elevated levels for raw oils before refining and lower levels in refined oils. Consequently significantly higher levels in the outputs from the refining steps are probable. Considering a lowering of the TEQ in vegetable oil refining of about 50% and the concentration of the other 50 % in the by-products from refining (3-5% of the oil amount) a 20 fold contamination levels compared to raw oils might result in the refining by-products. This uncertainty is in particular important having in mind that in feedingstuff production usually non-refined oils and by-products from refining are used and underlines an urgent need for investigations in this field.

Available information concerning vegetable oils can be directly used as an input to the decision base (data on oil seeds, oil cakes, refined vegetable oils and on non-refined vegetable (olive) oil).

10.1.3 Components from fruit and vegetable processing

In the European Union huge amounts are processed every year. Various by-products from different processing steps are used in feedingstuffs. An estimation based on existing contamination data indicates the following contamination level:

item	basis	WHO-TEQ [pg/g]	
		PCDD/Fs	DLPCBs
fruits and vegetables	product	~ 0.024	~ 0.012

Table 10-3: Wastes from fruit and vegetable processing: approximate WHO-TEQ levels on the basis of available data

The estimation is based on data on fruits and vegetables. The contamination with dioxin-like PCBs seems to be comparable in fruits and vegetables at a comparatively low level.

The information on the contamination of fruits and vegetables can be directly used as an input to the decision base (fruit and vegetable raw material input). These data are documented in annex 1.

10.1.4 Components from other processes

Solid residues from bio-gas plants, components from the leather and fur industry and from organic chemical processing have been investigated as well. As others, these waste types have been selected from the EC-waste catalogue as being suspicious to contribute to the input of POPs into the feed chain. However, no indications have been found that the corresponding by-products or wastes are used in compound feed production.

10.2 Material flows

10.2.1 Catering wastes

Catering waste is defined as waste from restaurants, catering facilities or kitchens, including industrial kitchens from that point on when it is no longer intended for human consumption.

Only licensed companies (or farmers) are allowed to collect catering wastes and cook swill in several countries (e.g. Germany, the UK and Austria).

Considerable uncertainties have to be taken into consideration w.r.t. statistical data on catering wastes, as they are frequently reported together with other compostable waste or slaughterhouse wastes.

Based on statistical data [BayForrest], [ÖWAV 2002], [OÖ 2000], [ÖKO 2000] and [MAFF 2001] the following estimations could be developed:

1) A range of ~25% - 30% of the total amount of catering waste is collected and recycled to swill.
2) The collected amount in Europe is ~ 3 – 4.5 kg/yr and citizen leading to a range of 1 – 1.7 mio. t within the EU.
3) The lower boundary of this estimate fits relatively well with the percentage of 1,4 of all pigs fed with swill in the UK considering at total amount of more than 50 mio. tons of pig feed which is consumed in the EC.

On the basis of these estimations a material flow can be established:

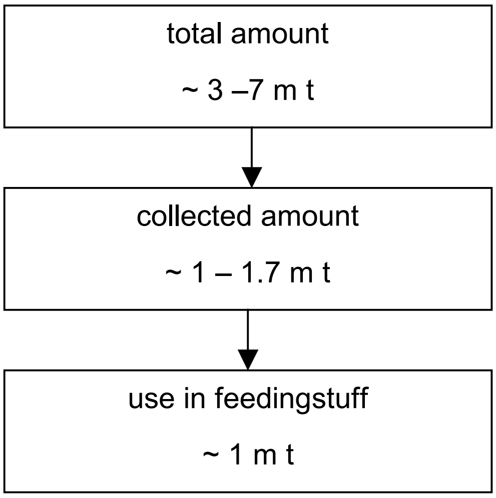
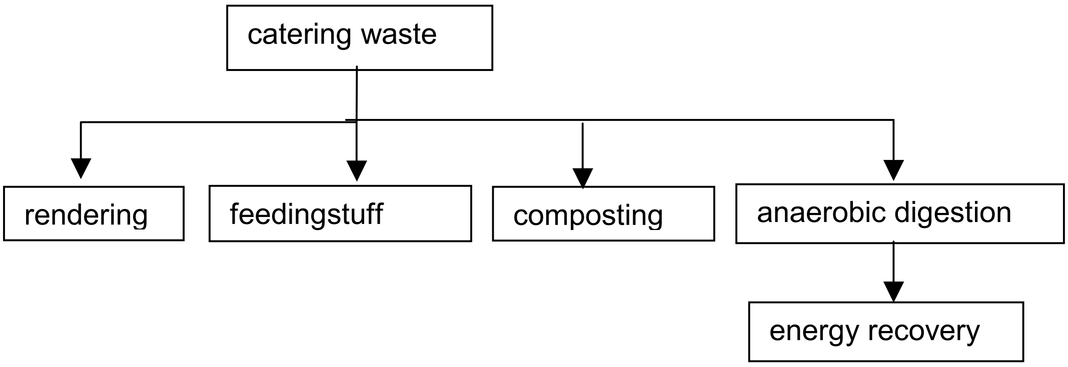


Figure 10-1: Estimated material flow for catering waste

Catering wastes may also be used for other purposes than feedingstuff.



10.2.2 Components of vegetable oil refining

The total amount of vegetable oil production is connected to 3 to 5 % of by-products resulting from extraction and refining steps. Considering a total amount of vegetable oil supply from soybeans, rape, sunflower and olives of about 10 million tons per year [FAO data], vegetable by products amount between 300 to 500 kt per year. Refined oils are usually not used in feedingstuff production, whereas most of the by-products are used for feedingstuffs (legal restrictions e.g. in the Netherlands). Some feedingstuff producers use exclusively these by-products as vegetable oil components (especially in pig diets, species dependent differentiation).

10.2.3 Components from fruit and vegetable processing

In the EU fruits, vegetables and starchy roots are processed in huge amounts (> 40 million t). Various by-products in particular from vegetables are used in feedingstuffs. By-products from fruit processing are less appropriate due to problems related to their high acidity. However they are used in considerable amounts. It can be assumed that by far more than 1 million ton (upper estimation 5 million tons) of by-products from fruits and vegetables is used in feedingstuffs.

The following chart gives an overview on estimated material flows of selected further wastes:

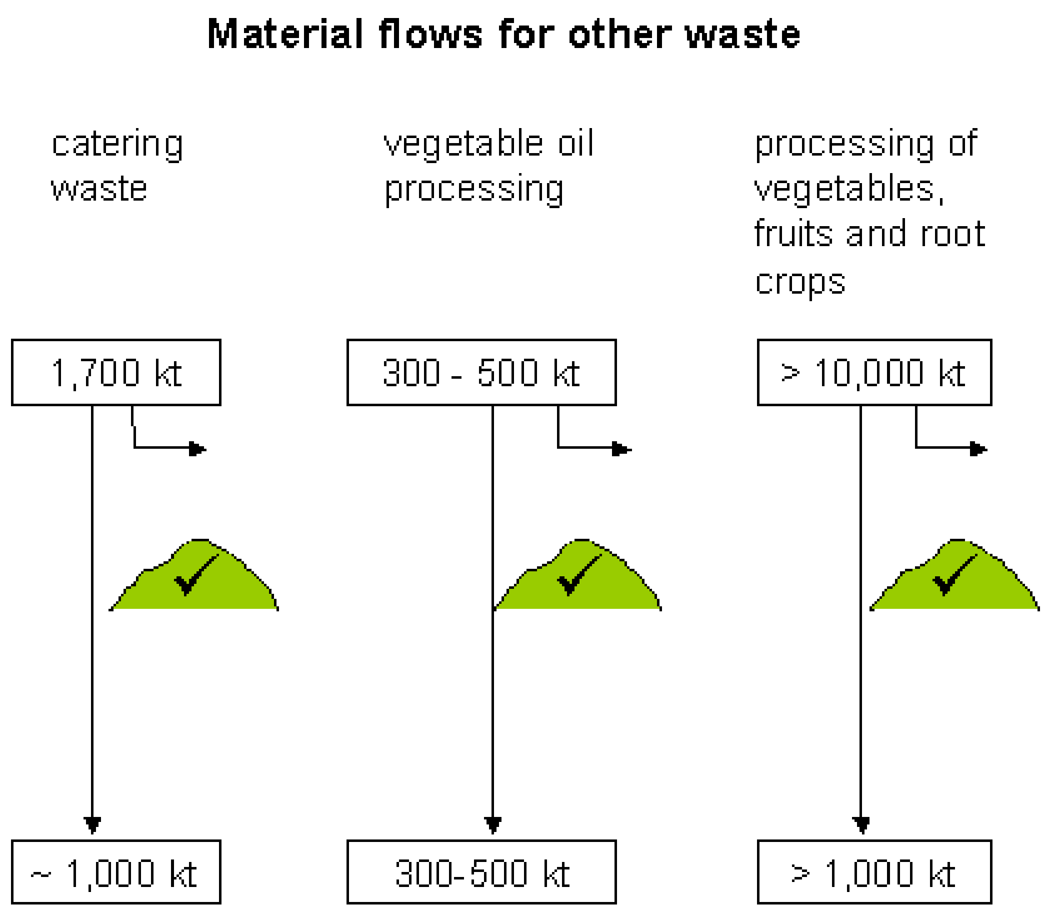


Figure 10-2: Material flow for other wastes

Data in the upper row stand for volumes of wastes, by-products and recyclates, data in the lower row stand for volumes used in the feedingstuff industry. For some amounts estimations have been discussed with industry experts to identify the ranges of the volumes.

10.3 Contamination volume categories

10.3.1 Catering wastes

Available contamination data lead to the following estimations for average TEQ levels:

	average WHO-TEQ level
swill (liquid feed) from catering waste	~ 1.4 pg/g fat

Information on the fat content of catering waste varies from 3.5 to 10%. Combined with the results of the material flow the following WHO-TEQ freight results for an upper estimation

swill (liquid feed) from catering waste	0.14 g

This leads to the **medium contamination volume category** (0.1 – 1 g WHO-TEQ).

10.3.2 Components of vegetable oil refining

Available contamination data lead to the following estimations for average TEQ levels

	average WHO-TEQ level
components from extraction and refining steps in vegetable oil production	0.39 pg/g fat

Combining the contamination estimation with the results of the material flow the following WHO-TEQ freight results for an upper estimation

components from extraction and refining steps in vegetable oil production	~ 0.2 g

Having in mind the uncertainties related to the contamination estimation the freight from by-products from vegetable oil refining might be considerable higher.

This leads to the **medium contamination volume category** (0.1 – 1 g WHO-TEQ).

10.3.3 Components from fruit and vegetable processing

Available contamination data lead to the following estimations for average TEQ levels

	average WHO-TEQ level
components from processing of fruits, vegetables and root crops	0.036 pg/g fat

Combining the contamination estimation with the results of the material flow the following WHO-TEQ freight results for an upper estimation

components from processing of fruits, vegetables and root crops	0.18 g	[0.036*5000*0.001]

This leads to the **medium contamination volume category** (0.1 – 1 g WHO-TEQ).

10.4 Description of the processes

10.4.1 Catering wastes

Catering waste that is used for feeding pigs or poultry has to be treated. Several country specific laws define that catering waste has to be cooked by > 95 °C (Austria) up to 100°C (Great Britain) for a minimum of 35 min (Austria) resp. up to 1 hour (Great Britain). Only after treatment by licensed enterprises the now so-called swill is authorised to be used for pig or poultry feedingstuff. The following chart illustrates the rather simple production processes for catering waste:

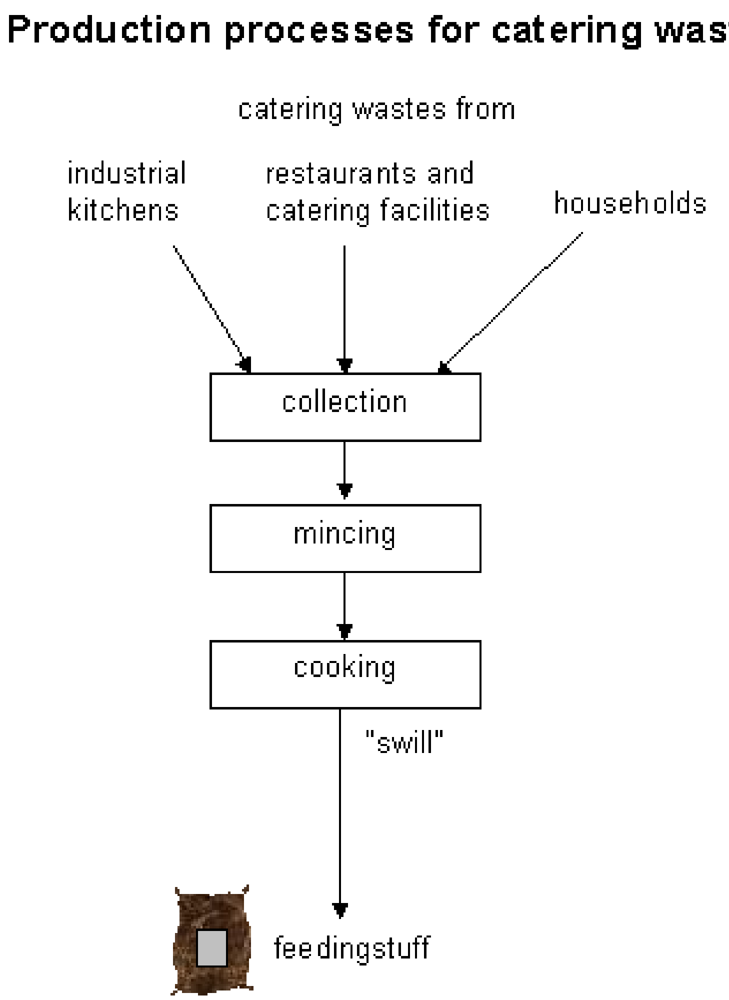


Figure 10-3: Production processes for catering waste

10.4.2 Components of vegetable oil refining

In contrast to cereal processing where aspiration dust is a feed relevant material flow, there are no comparable process steps in oil seed processing. Cleaning is effected by sieving and the sieving fractions (usually < 1%) are disposed off in other pathways than the feed chain (e.g. combustion).

The following chart illustrates the production steps in vegetable oil processing:

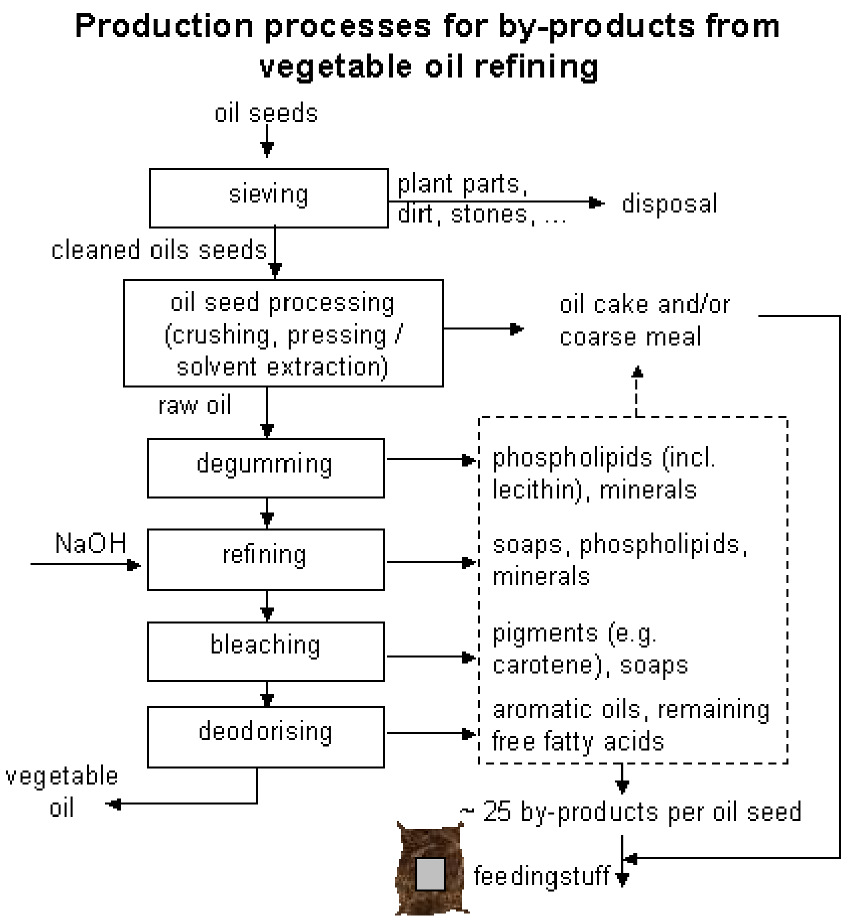


Figure 10-4: Production processes for by-products form vegetable oil production

The focus of the chart are the refining steps from raw oil to the end product vegetable oil. The production of vegetable oil from oil seeds, in particular the refining steps from raw oil to the end product involves approx. 25 by-products (per oil seed!). Several substances which are eliminated from the oil in the form of 25 resulting by-products are used in compound feedingstuffs, via addition to oil cakes or coarse oil meal, via direct input into feedingstuff or finally mixed together with other feedingstuff compounds.

10.4.3 Components from fruit and vegetable processing

The following chart gives an overview on general production processes in fruit and vegetable processing:

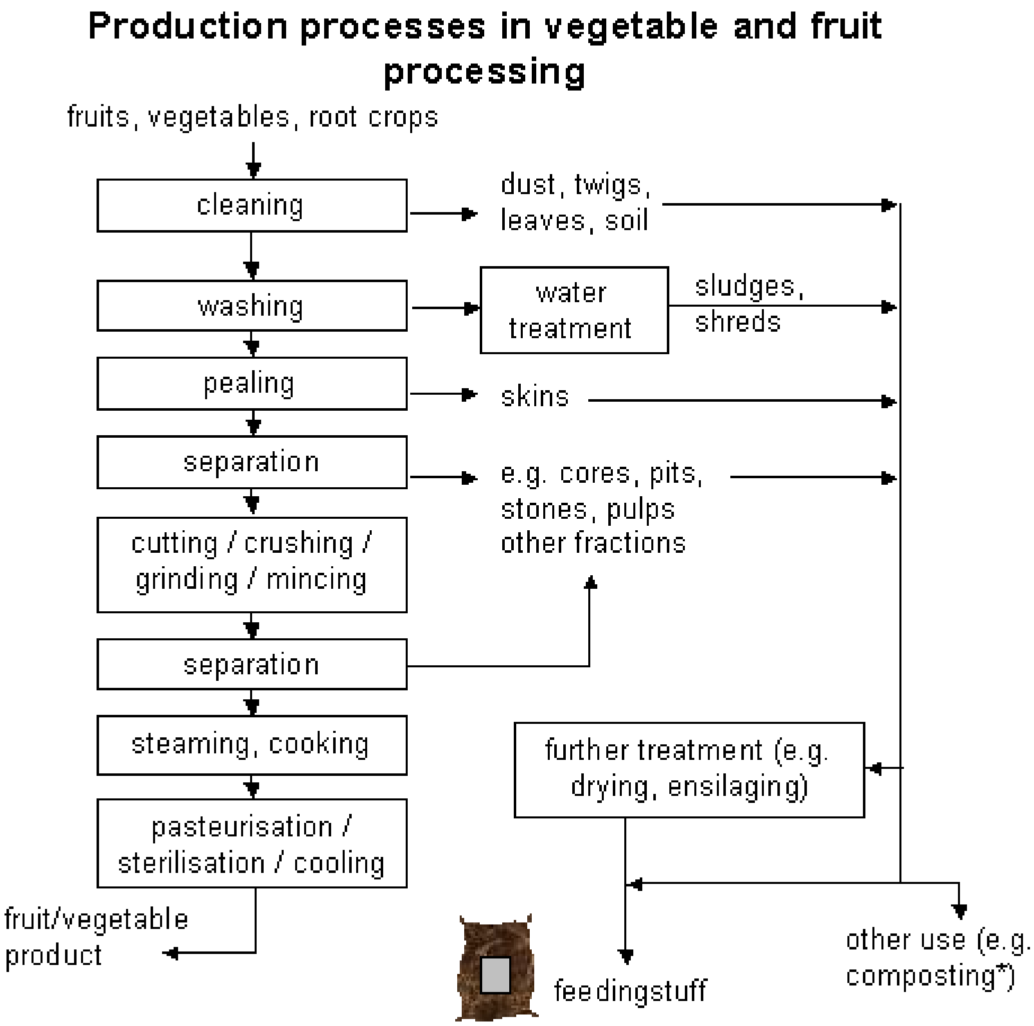


Figure 10-5: Production processes in vegetable and fruit processing

The process realisation generates several outputs that are relevant for the production of compound feedingstuffs such as beet shreds, potato skins or fruit trester. The above chart focuses in a schematic way on the process steps where these outputs are generated such as pealing, separation of cores, pits, pulps etc.

10.5 Contamination theses

10.5.1 Catering wastes

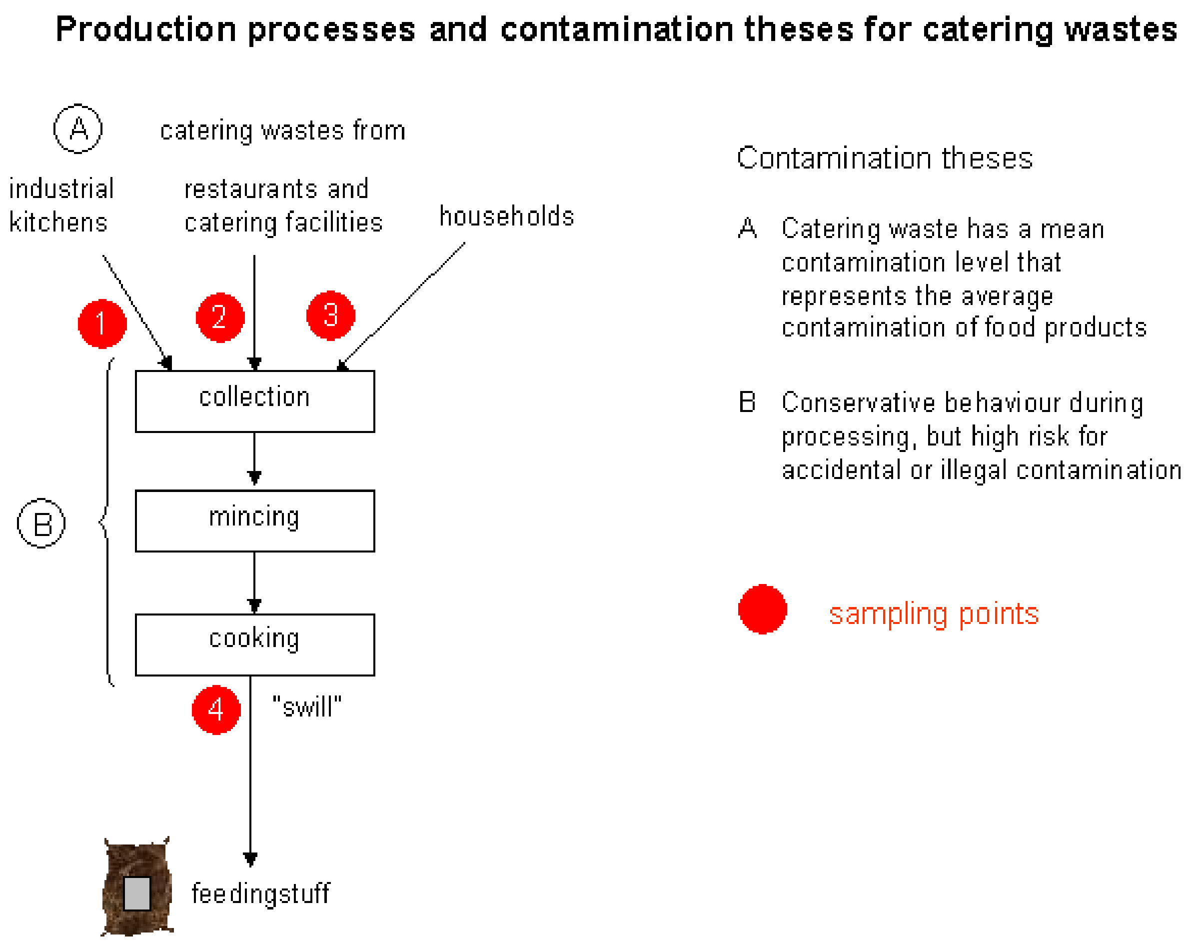


Figure 10-6: Production process and contamination theses for catering waste

According to its nature, catering waste usually has approximately a mean contamination level that represents the average contamination of processed food.

During processing a conservative behaviour of the dioxins and PCBs can be assumed even if it has to be taken into consideration, that the processing of the catering waste may have a lowering effect on TEQ-levels.

For catering waste a certain risk for accidental or illegal contamination has to be assumed during storage and transport (e.g. not cleaned transport containers, open containers that may facilitate illegal or accidental addition of contaminated fats or oils).

The consequences that result from the processing step analysis and the contamination theses are shown in the following table:

Catering waste:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	catering waste from industrial kitchens	before processing	1
2	catering waste from restaurants and catering facilities	before processing	1
3	catering waste from households	before processing	1
4	swill	after processing	1
			4

Table 10-4: Consequences of production processes and contamination theses for catering waste

10.5.2 Components of vegetable oil refining

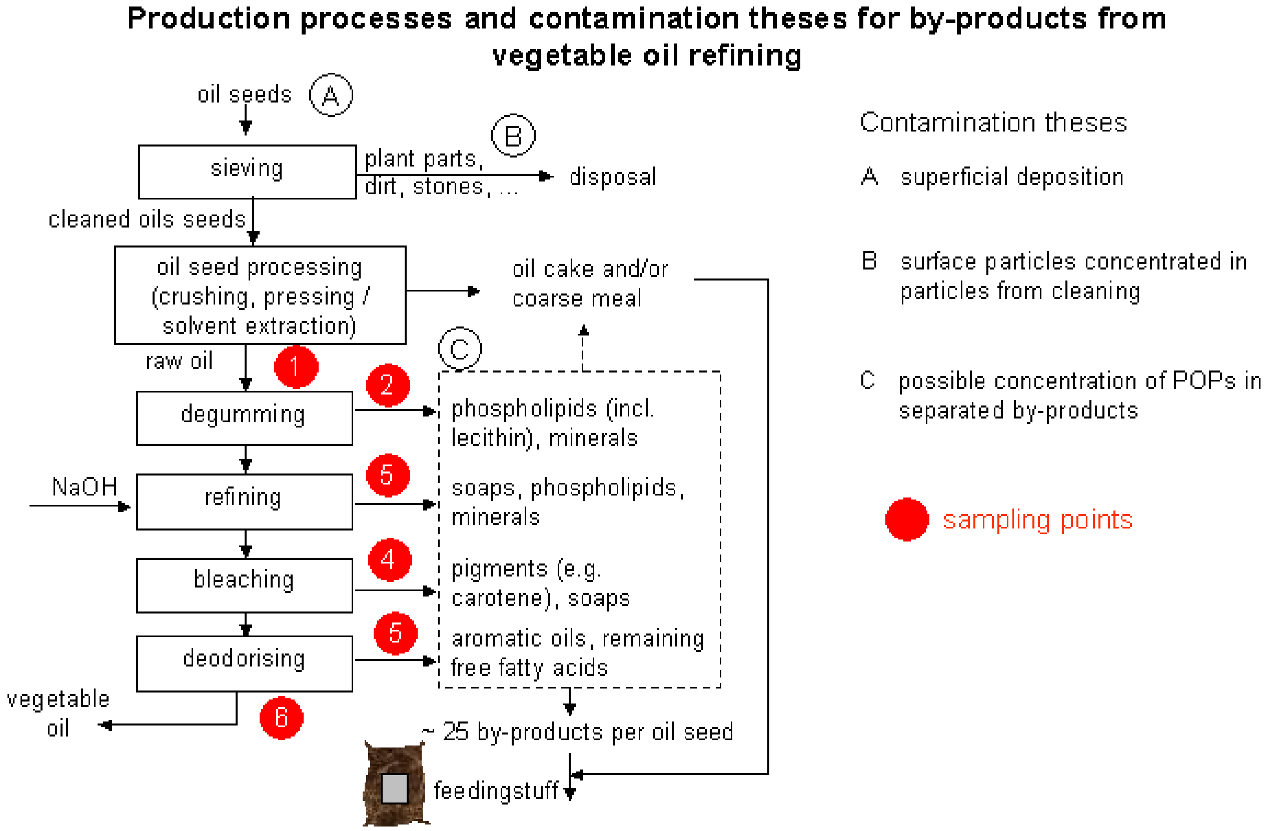


Figure 10-7: Production processes and contamination theses for by-products from vegetable oil refining

Contamination mainly takes place via superficial contamination on the oil seed plant surface. A share of the contamination will be removed from the seed in mechanical cleaning processes (mainly sieving) and will be removed with the separated particles (plant parts, stones, dirt, metal) which are disposed off (e.g. by combustion) outside the feed chain.

Due to the high lipophilicity of dioxins and PCBs it can be expected that the major share of the contamination can be found in the raw oil fraction. The other share remains in the oil cakes and the coarse oil meal.

Concentration of POPs may be effected during the following four refining steps in raw oil processing (degumming, refining, bleaching, deodorizing) in the resulting by-products. This thesis is supported by information on comparatively high levels that have been reported for non refined solvent extracted olive oils and comparatively low levels for refined solvent extracted olive oils (from different batches; data sets 1329A and 1329D). The thesis is furthermore supported by the fact that refining steps are known to reduce the contamination in the end product [Hilbert 1998]. By-products from vegetable oil refining are used as components in compound feedingstuff production and may thus significantly contribute to feedingstuff contamination. Having in mind the importance of PCDD/F fluxes into compound feedingstuffs via oil cakes and oil meal (approx. 1/3 of the total flux [Fiedler 2000]) it might be an important option to prevent the relevant material flows from entering the food chain.

Against the background of about 25 by-products per oil seed from vegetable oil refining a reasonable approach to close the knowledge gaps is to focus on the four material flows of by-products that result from the 4 main process steps in one representative process. The consequences that result from the process step analysis and the contamination theses are shown in the following table:

Components from vegetable oil refining:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	raw oil	after oil extraction	1
2	by-products	from degumming	1
3	by-products	from refining	1
4	by-products	from bleaching	1
5	by-products	from deodorising	1
6	refined oil	after refining	1
			6

Table 10-5: Consequences of production processes and contamination theses for by-products from vegetable oil refining

10.5.3 Components from fruit and vegetable processing

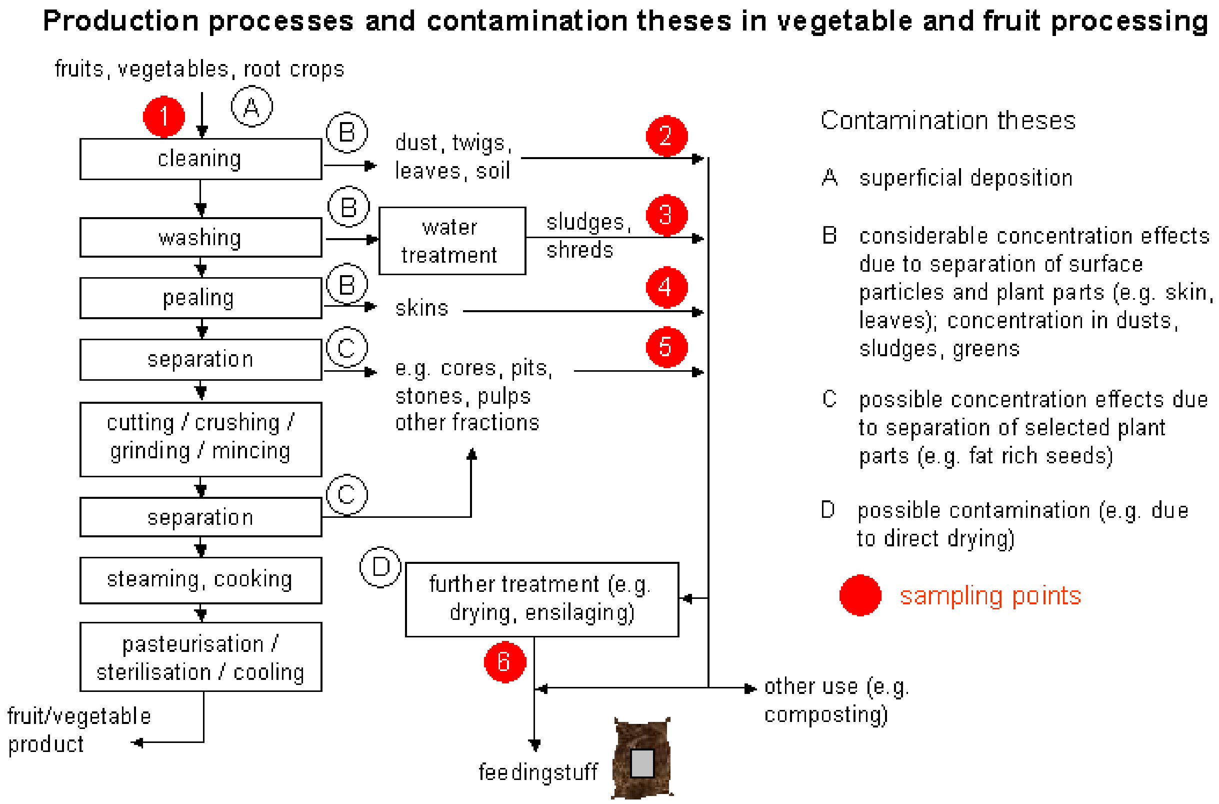


Figure 10-8: Production processes and contamination theses in vegetable and fruit processing

Contamination of fruits, vegetables and starchy roots is effected via superficial pollution on plant surfaces (atmospheric deposition, soil splash, direct soil contact). During processing several considerable POP concentration effects can be expected when surface particles (dust, soil, ..) or surface plant tissue (leaves, skins, …) is separated. Furthermore concentration effects are possible due to separation of selected plant parts (cores, pits, …) or fractions (pulps). If the separated material flow is further heated other contamination effects may occur (e.g. direct drying of beet shreds).

The consequences that result from the process step analysis and the contamination theses are shown in the following table:

Vegetable and fruit processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	fruit/vegetable	before processing	1
2	separated material	from cleaning	1
3	sludge	from process water treatment	1
4	skins	from pearling	1
5	cores, pits, pulps, stones, ...	from separation	1
6	input to feedingstuff	after further treatment	1
			6

Table 10-6: Consequences of production processes and contamination theses for by-products from fruit and vegetable processing

It seems to be reasonable to focus on important material flows that are relevant for compound feedingstuffs such as fruit trester from juice production, (sugar) beet shreds or potato skins.

10.6 Requirements for decision-making

All examined three types of further wastes, by-products and recyclates show a medium contamination volume category. This indicates that there is need for a broad data base, however, filling data gaps does not define the highest priority. At present there is no urgent need for actions in the fields "catering wastes", "components from vegetable oil refining" and "components from fruit and vegetable processing".

However, estimated amounts of POPs incorporated in feedingstuffs are not negligible and there are considerable uncertainties to process specific and output based data that should be clarified to be able to initiate efficient future measures.

10.7 Data and sampling strategy

As a consequence of the data requirements it is suggested to realise a 2 step procedure.

The first step of the data and sampling strategy meets process specific samples. Due to the results of the process step analysis and the contamination theses the following data requirements result:

Catering waste:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	catering waste from industrial kitchens	before processing	1
2	catering waste from restaurants and catering facilities	before processing	1
3	catering waste from households	before processing	1
4	swill	after processing	1
			4

Table 10-7: Consequences of production processes and contamination theses for catering waste

Existing data cover no sampling points, consequently data are needed for all 4 sampling points.

Components from vegetable oil refining:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	raw oil	after oil extraction	1
2	by-products	from degumming	1
3	by-products	from refining	1
4	by-products	from bleaching	1
5	by-products	from deodorising	1
6	refined oil	after refining	1
			6

Table 10-8: Consequences of production processes and contamination theses for components from vegetable oil refining

Existing data cover 2 sampling points (raw oil, refined oil), see annex 1. Consequently data are needed for the remaining 4 sampling points. However, for reasons of consistency it would be appropriate to investigate one coherent process and to correlate the results with the already available data.

Vegetable and fruit processing:
Consequences of production processes and contamination theses

	sample type	sampling point	min. sample amount
1	fruit/vegetable	before processing	1
2	separated material	from cleaning	1
3	sludge	from process water treatment	1
4	skins	from pearling	1
5	cores, pits, pulps, stones, ...	from separation	1
6	input to feedingstuff	after further treatment	1
			6

Table 10-9: Consequences of production processes and contamination theses for components from vegetable and fruit processing

Existing data cover 1 sampling point (fruit, vegetables before processing), see annex 1. Consequently data are needed for the remaining 5 sampling points. For reason of consistency it may be appropriate to investigate one coherent process and to correlate the results with the already available data.

The second step of the data and sampling strategy meets output based samples.

For this step in all 3 categories of further wastes, by-products and recyclates 7 mixed samples each with 15 individual samples for catering wastes, components from vegetable oil refining and components from vegetable and fruit processing.

Sampling plan			
step 1:	required:	4	process specific samples "catering waste"
	available:	- 0	covered by existing data
	remaining:	= 4	process specific data "catering waste"
step 1:	required:	6	process specific samples "components from vegetable oil refining"
	available:	- 2	covered by existing data
	remaining:	= 4	process specific data "components from vegetable oil refining"
step 1:	required:	6	process specific samples "components from vegetable and fruit processing"
	available:	- 1	covered by existing data
	remaining:	= 5	process specific data "components from vegetable and fruit processing "
step 2:	required:	7	mixed samples of 15 individual samples of catering waste
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 15 individual samples of catering waste

step 2:	required:	1	mixed sample of 30 individual samples of catering waste
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual samples of catering waste
step 2:	required:	7	mixed samples of 15 individual samples of by-products from vegetable oil refining
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 15 individual samples of by-products from vegetable oil refining
step 2:	required:	1	mixed sample of 30 individual samples of by-products from vegetable oil refining
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual samples of catering waste
step 2:	required:	7	mixed samples of 15 individual samples of by-products from vegetable and fruit processing
	available:	- 0	covered by existing data sets
	remaining:	= 7	mixed samples of 15 individual samples of by-products from vegetable and fruit processing

step 2:	required:	1	mixed sample of 30 individual samples of by-products from vegetable and fruit processing
	available:	- 0	covered by existing data sets
	remaining:	= 1	mixed sample of 30 individual samples of by-products from vegetable and fruit processing
total necessary individual samples:		**418**	**(13 + 7*15 + 1*30 7*15 + 1*30 + 7*15 + 1*30)**
necessary measurements:		**37**	**(13 + 7 + 1 + 7 + 1 + 7 + 1)**

Table 10-10: Further wastes: sampling plan

11 Composition and contamination of compound feedingstuffs

11.1 Raw materials for compound feedingstuffs

Feeding studies are conducted to determine the requirements of fat, protein, carbohydrate, vitamins, minerals, etc. of production animals at different ages. The manufacturers of compound feedingstuffs choose among a variety of raw materials to meet these requirements.

Information on formulae of compound feedingstuff mixtures is normally not available. As a further complication, it is often difficult to identify quantity, quality and origin of ingredients used in compound feedingstuffs.

Council Directive 79/373/EEC of April, 2 1979 on the marketing on compound feedingstuffs requires “to provide the user with accurate and meaningful information on the compound feedingstuffs at his disposal”, and “at least the levels of analytical constituents having a direct effect on the quality of the feedingstuff should be declared”. Thus, declarations by compound feedingstuff producers are normally restricted to the contents of crude protein, crude oils and fats, crude fibre, crude ash, various vitamins, amino-acids, trace elements, and to categories of ingredients (according to *Commission Directive 91/357/EE*C), which may be indicated instead of individual components.

For the identification and evaluation of POP fluxes within the feedingstuff industry and feedingstuff users, such declarations are of limited help. More useful for this purpose would be the composition of feed materials with respect to the nature and the origin of the raw materials used.

Another approach to classify feed components has been made by the Scientific Committee on Animal Nutrition (SCAN) in it’s report on the dioxin contamination of feedingstuffs [SCAN 2000, p.27].

Feed materials have been grouped into three main categories. Each category has been further divided into a limited number of sub-groups (for instance, data concerning wheat, barley and corn appear under “vegetable feed materials” and “cereals”). The SCAN has established the following classification:

A Vegetable feed materials	B. Feed materials of animal origin	C Other feed materials
A1 Roughages	B1 Fish oil, fish meal	C1 Binders and anticaking agents
A2 Roots and tubers	B2 Animal fats, meat and bone meal	C2 Trace elements
A3 Cereals and seeds	B3 Milk products	C3 Macrominerals

A4 By-products of plant origin		
A5 Vegetable oils		

Table 11-1: Classification of feed components according to SCAN

These established classifications will also be used in this report.

According to the identified relevant material flows, the following volumes have been used in feed in 2000.

category	Volumes [kt]
compound feedingstuffs[10]	124,403
cattle feed	33,001
pig feed	43,771
poultry feed	38,036
milk substitutes	1,711
other animals (including fish feed)	7,884
thereof fish feed	ca. 600
individual feed materials (SCAN categories)[11]	
A vegetable feed materials	92,000
A1 roughages	2,500
A2 roots and tubers	2,800
A3 cereals and seeds	51,000
A4 by-products of plant origin	34,600
A5 vegetable oils	~ 1,000
B feed materials of animal origin	4,750
B1 fish oil, fish meal	150
B2 animal fat, meat and bone meal	~ 3,000
B3 milk products	1,600
C other feed materials	3,500
D other feed materials (unidentified origin)	25,300

Table 11-2: Amounts of compound feedingstuffs and individual feed materials in 2000 [thousand tons]

[10] according to FEFAC 2000

[11] estimations based on different sources

The following amounts (upper bound estimation)have been investigated with respect to by-products, recyclates and wastes:

selected materials	volumes [kt]
	use[12]
components from olive processing	
olive pulp	50
non-edible solvent extracted olive oil	50
sludge from olive processing water	1
components from used oils and fats	
waste oils and fats collected from hot use in industry	600
waste oils and fats collected from hot use in restaurants	
waste oils and fats collected from hot use in households	
waste oils and fats directly from industry	
components from agricultural and industrial waste with high fibre content	
aspiration dust[13] from cereal, oil seed and pulse cleaning	100
harvest residues from pulse cultivation	1,000
straw	4,000
wood, sawdust, wood shavings	100
paper pulp waste	
components from animal wastes	
meat and bone meal	0
blood meal	0
feather meal	0
poultry meal	0
animal fats from rendering processes	1,000
fish meal from fish waste	100
fish oil from fish waste	50
fish silage[14] from fish waste	100
whey	1.600
skim milk	
butter milk	
other milk by-products or wastes	
out of date products	

[12] upper estimation

[13] consisting mainly of dust, chaff and weeds from cereal cleaning

[14] also “fish protein concentrate"

components from further wastes	
swill (liquid feed) from catering waste	1,000
components from extraction and refining steps in vegetable oil production	500
components from processing of fruits, vegetables and root crops	1,000

Table 11-3: Volumes of selected by-products, recyclates and wastes that are potentially important in feedingstuff production

11.2 Material flow for compound feedingstuffs

Components of feedingstuff can be of vegetable, animal or other (e.g. mineral) origin. They can be directly used for the feeding of livestock animals or indirectly via compound feedingstuffs as "natural" ingredients or as products (e.g. fish meal) or by-products (e.g. maize gluten) resp. waste from other industries (usually from the feed and food processing industry) processing appropriate raw materials. These secondary resources can contribute significantly to the components of compound feedingstuffs. The schematic material flow is demonstrated in the following figure:

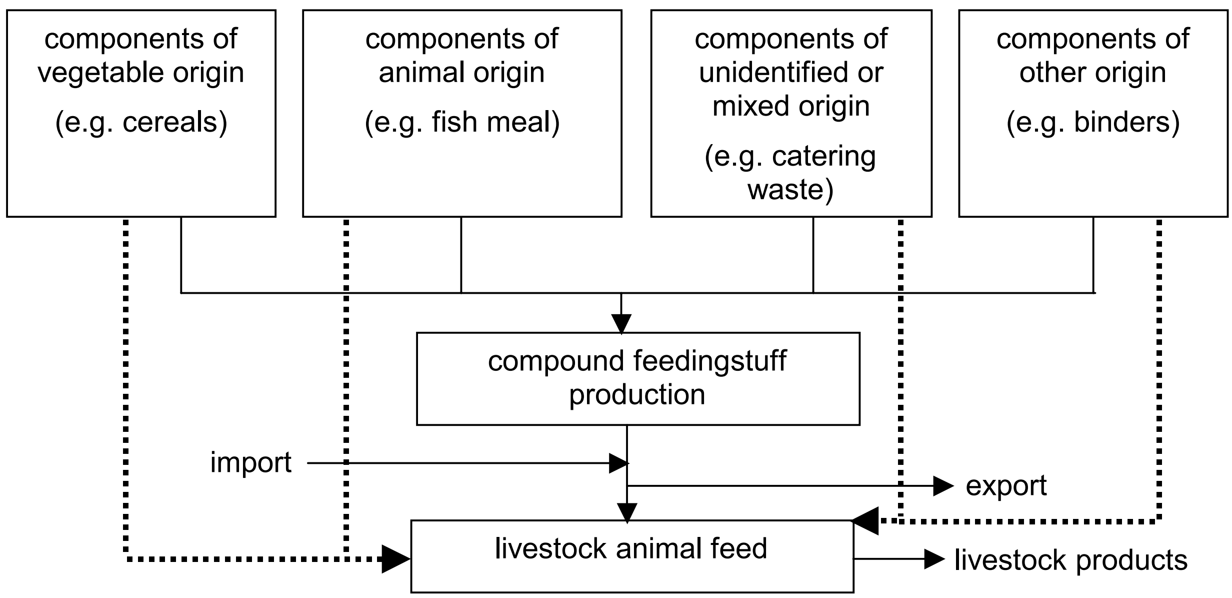


Figure 11-1: Schematic material flow for feedingstuff components

FEFAC Data show that the main components are grains with approx. 40% and oil cakes and coarse oil meal with approx. 25% of the total amount of about 125 million tons of raw materials processed. Remarkable is, that by-products from the food industry play an important role contributing approx. 15% to the input of raw materials in compound feedingstuff production.

The following table shows consumption data for European compound feedingstuff producers from the year 2000:

Raw Material	Amount in thousand tons	relative share [%]	origin*[15]	attribution[16]**
Grains	49.880	40.1	v	A3
Oil-cakes and meals	32.163	25.8	v	A4
Pulses	4.130	3.3	v	A4
Tapioca	3.790	3.0	v	A2
Dried forages	1.839	1.5	v	A1
By-products of food industry	17.840	14.3	v or a	A4 or B
Oils and fats	2.144	1.7	v or a	A4 or B
Animal meals	1.986	1.6	a	B2
Dairy products	1.624	1.3	a	B3
Other raw materials	5.440	4.4	other	C
Minerals and vitamins	3.603	2.9	other	C2/3
Total	124.439	100.0	n.a.	n.a.

Table 11-4: Consumption of raw materials by European compound feedingstuff producers in 2000 (estimate) [FEFAC 2002] and attribution to SCAN categories according to the nature or origin of the components

The raw materials can be attributed to the SCAN categories. The following figure illustrates the origin of feed materials manufactured in compound feedingstuffs. 73.3% of the components can be attributed to vegetable origin (SCAN category A), 3.6% to animal origin (SCAN category B) and 6.8 to other (e.g. inorganic) origin (SCAN category C). By-products from the food industry as well as oils and fats can not be attributed unambiguously. The origin may be from animals and/or plants (16.3% category A or B).

[15] v = vegetable origin, a = animal origin

[16] attribution according to SCAN classification of feed materials (see above)

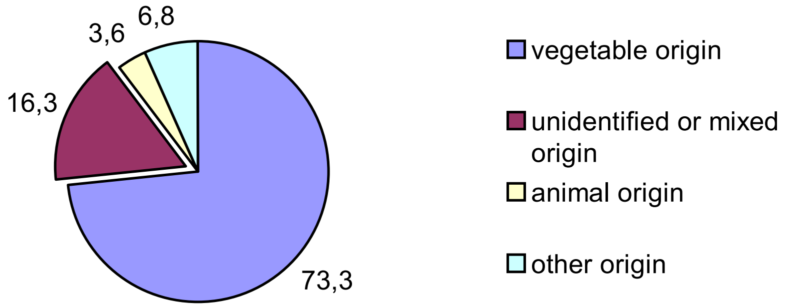


Figure 11-2: Origin of feed materials manufactured in compound feedingstuffs

Figure 11-3 on the following page demonstrates where and in which amounts the relevant materials originate and where they enter compound feedingstuff production. The volumes for the selected materials are based on the material flow analysis (see subchapters x.1 of chapters 3 to 10). The volumes for raw materials are mainly based on data for the year 2000 as shown in Table 11-4 [FEFAC 2002]. The present use of animal meals is legally restricted except of fish meal. Consequently the amount of animal meal has been estimated to be approximately 1000 kt per year, the amount of fish meal annually consumed by farm animals in Europe [IFOMA 1999]. The volumes for vegetable oils (~450 kt) and animal fats (~1700 kt) are based on the FEFAC data for oils and fats (~2150 kt) data on rendered fats (~1000 kt), fish oil (~400 kt) and the estimation that approximately 50% of used oils and fats used in feedingstuff are of animal origin (~300 kt used animal fats).

Selected material	Feed relevant amount	Vegetable origin: Grains	Oil-cakes and meals	Pulses	Tapioca	Dried forages	Vegetable oils	Animal origin: Animal fats	Animal meals	Dairy products	Other or mixed origin: Other raw materials	Minerals and vitamins	By-products food
olive processing	100												100
used oils and fats	600						300	300					
waste with high fibre content	5,200										5,200		
land animal meals	0												
rendered fats	1,500							1,500					
fish meal from fish waste	100								100				
fish oil from fish waste	50							50					
fish silage from fish waste	100												100
dairy by-products and waste	1600									1600			
swill	1000												1000
vegetable oil processing	500												500
processing of fruits and vegetables	500												5,000
Input from wastes, by-products and recyclates		*0*	*0*	*0*	*0*	*0*	*300*	*1,850*[17]	*100*	*1,600*	*5,200*	*0*	*6,700*
total input into feedingstuff		**50,000**	**32,000**	**4,100**	**3,800**	**1,800**	**450**	**1,700**	**1,000**	**1,600**	**5,500**	**3,600**	**18,000**

Figure 11-3: Complemented schematic material flow for feedingstuff components (upper estimation) showing the contribution of the selected material flows to raw materials for feedingstuffs [in kt/year]

[17] Due to upper estimations the amount of wastes exceeds the total input.

11.3 Average composition of compound feedingstuffs

The average composition of compound feedingstuffs can be derived from the consumption of raw materials by feedingstuff producers. Consequently the relative shares of raw materials consumed for the production reflect the average composition of compound feedingstuffs. In addition estimated average contaminations allow to conclude on the share of TEQ contamination from the different raw materials and on an average TEQ contamination of feedingstuff per gram product. The following figure illustrates the share of raw materials.

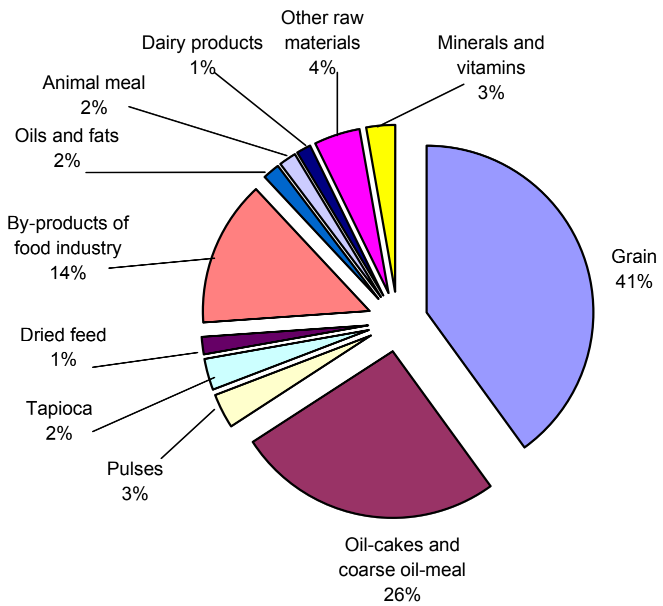


Figure 11-4: Average composition of feed materials from European manufacturers in 2000 [FEFAC 2002]

The SCAN report gives examples for typical animal diets based on the above explained SCAN categories for ruminants, pigs, poultry, rabbits and fish. Typical possible compositions for corresponding compound feedingstuffs are shown in the following figures. The SCAN categories and subgroups (see Table 11-1) for vegetable feed materials (A), feed materials of animal origin (B) and other feed materials (C) are indicated:

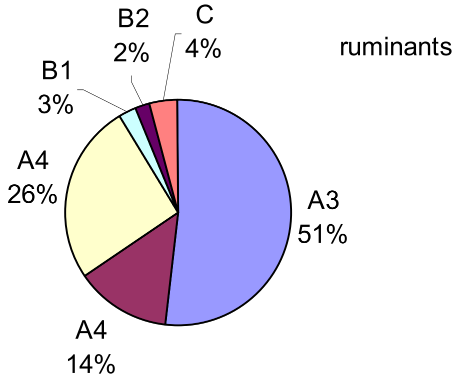


Figure 11-5: Average composition of compound feedingstuffs for ruminants [based on SCAN 2000, p. 28]

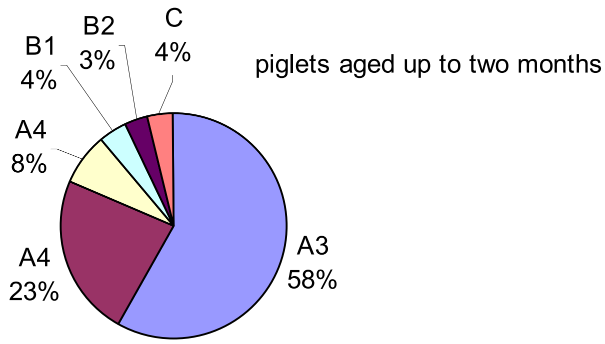


Figure 11-6: Average composition of compound feedingstuffs for piglets aged up to two months [based on SCAN 2000, p. 34]

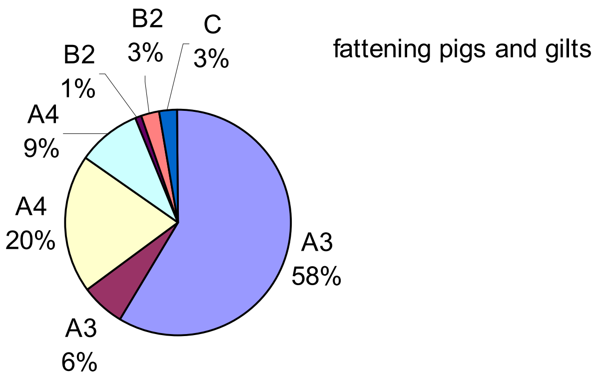


Figure 11-7: Average composition of compound feedingstuffs for fattening pigs and gilts [based on SCAN 2000, p. 34]

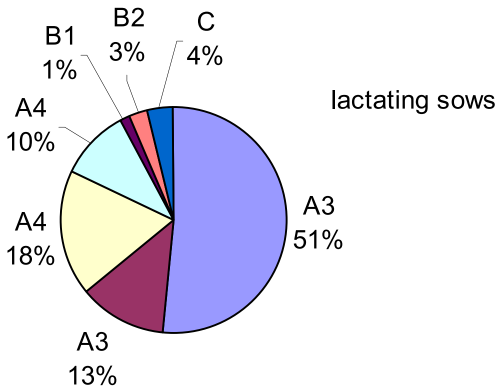


Figure 11-8: Average composition of compound feedingstuffs for lactating sows [based on SCAN 2000, p. 35]

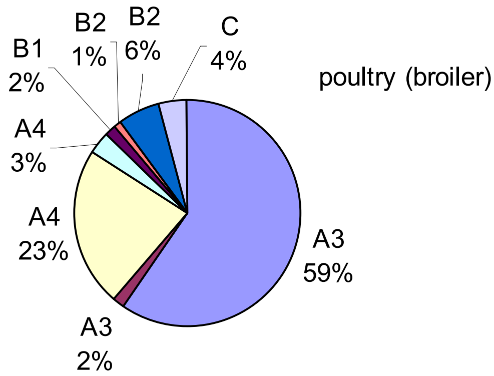


Figure 11-9: Average composition of compound feedingstuffs for poultry (broiler) [based on SCAN 2000, p. 36]

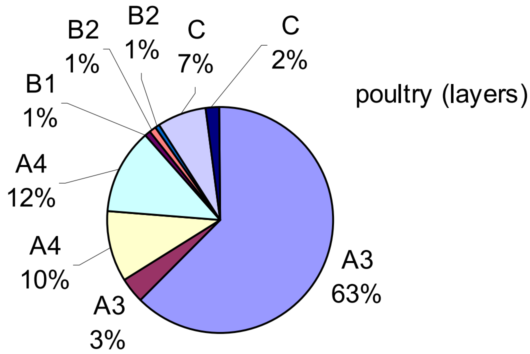


Figure 11-10: Average composition of compound feedingstuffs for poultry (layers) [based on SCAN 2000, p. 36]

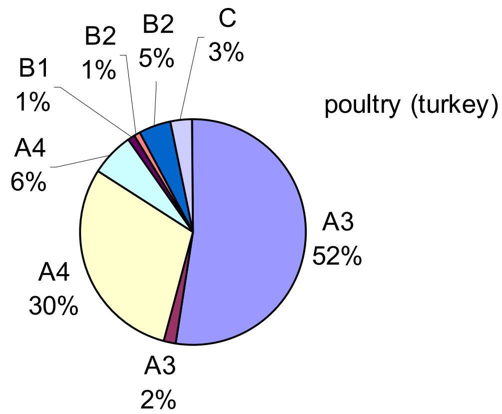


Figure 11-11: Average composition of compound feedingstuffs for poultry (turkey) [based on SCAN 2000, p. 36]

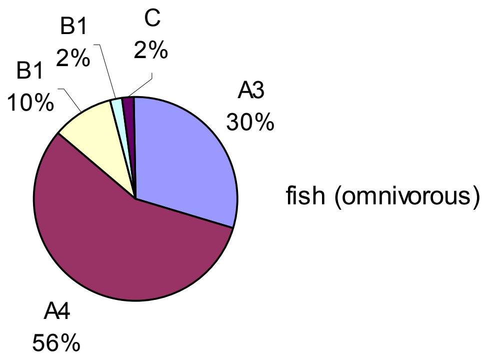


Figure 11-12: Average composition of compound feedingstuffs for fish (omnivorous) [based on SCAN 2000, p. 38]

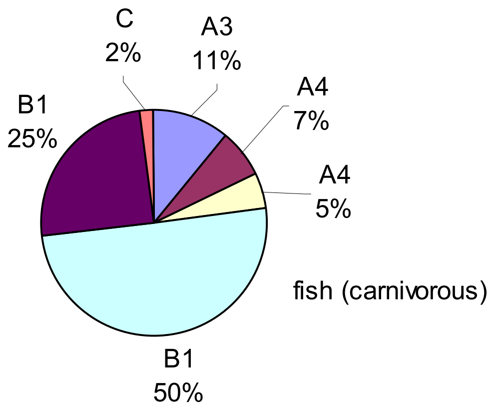


Figure 11-13: Average composition of compound feedingstuffs for fish (carnivorous) [based on SCAN 2000, p. 38]

11.4 Contribution of wastes and by-products to contamination of compound feedingstuffs and to human intake

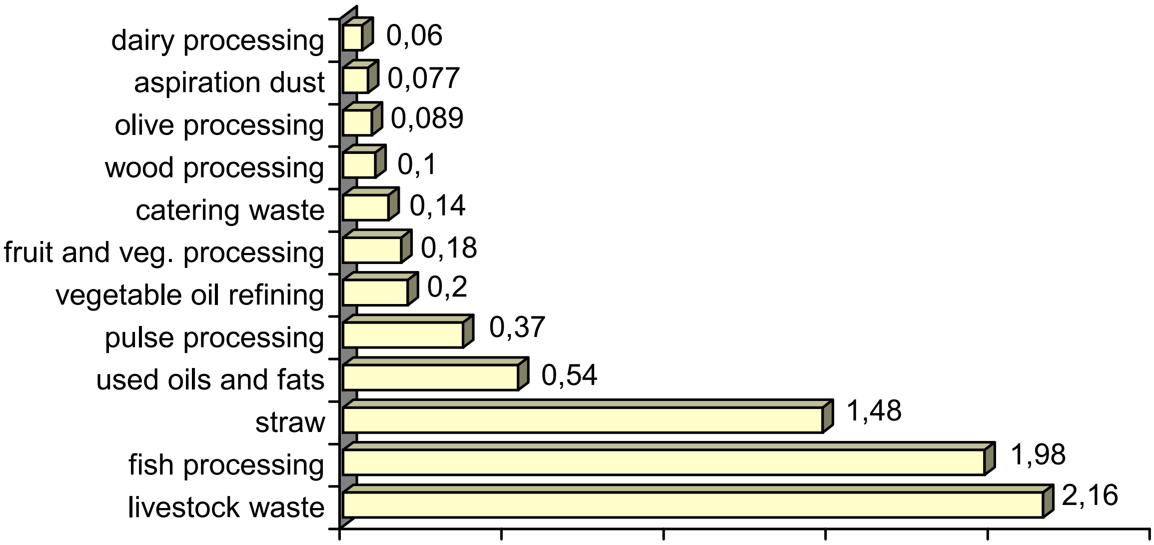


Figure 11-14: Upper bound estimations for TEQ inputs via the investigated wastes and by-products [g WHO-TEQ]

The figure above illustrates the upper bound estimations of WHO-TEQ freights from the investigated material flows of by-products, recyclates and wastes entering compound feedingstuffs in the Member States each year. This results in a total annual input into feedingstuffs of more than 7 g WHO-TEQ from these wastes and by-products.

This upper bound estimation allows to conclude to what degree the corresponding material flows contribute to the average human TEQ intake and consequently to which extent the elimination or substitution of certain material might reduce the intake. The estimation is based on typical contamination levels and does not take into account additional freights that are due to accidental or illegal aspects.

The following illustration shows a rough estimation to which degree the wastes and by-products contribute to the human intake:

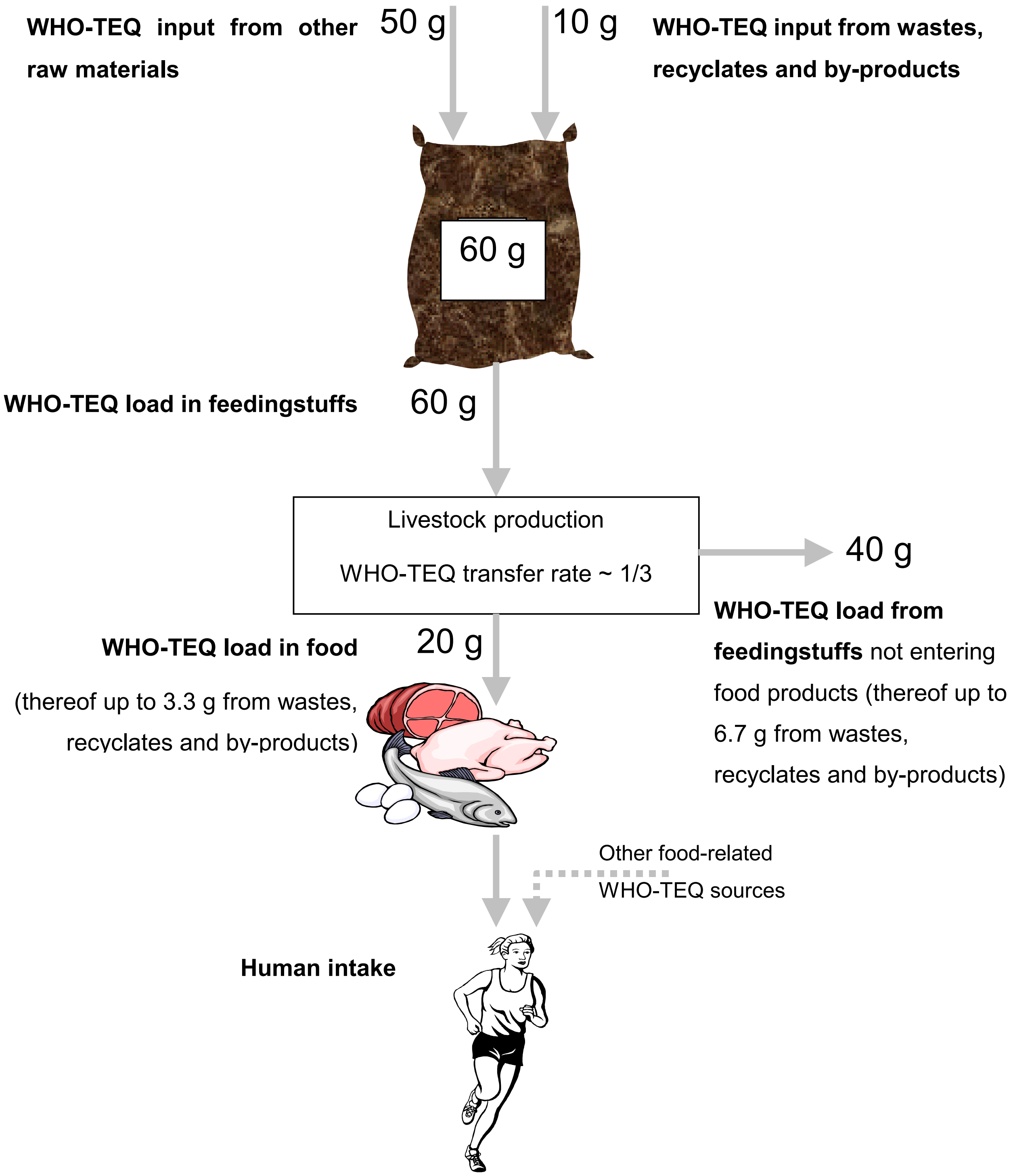


Figure 11-15: Upper bound estimation on the contribution to the human WHO-TEQ intake from wastes, recyclates and by-products used for compound feedingstuff production

As Figure 11-15 shows, up to 3.3 g WHO-TEQ from wastes and by-products may enter the food chain via food and thus contribute up to 1/6 to the human intake. A reduction of the freight from a certain waste stream of 1 g would reduce the human intake about 0,17 g per year.

This rough estimation is connected with considerable uncertainties and is based on the following assumptions:

The annual human TEQ intake is assumed to be 63 pg/d from PCDD/Fs plus 83 pg/d from dioxin-like PCBs. This results in a WHO-TEQ of 146 pg/d (arithmetic mean of SCOOP data) or an annual intake of the total EU Member State population of roughly 20 g WHO-TEQ intake.

The input from wastes into compound feedingstuffs of up to 10 g is the summarised result from chapters 3 to 9.

Comparatively little is known about transfer rates of WHO-TEQs from feed to food (i.e. milk, meat, eggs, fish). Relevant information is summarised in chapter 7 of stage I of the present project [Fiedler 2000]. Carry over rates from feed to milk are about one third for PCDD/Fs. For PCBs they seem to be higher. There is only little knowledge on WHO-TEQ carry over rates to meat, eggs and fish. Based on the limited knowledge a rough estimation for an overall WHO-TEQ transfer rate from feed to food of 1/3 has been assumed.

Another conclusion from Figure 11-15 is that the contribution to the contamination of compound feedingstuffs is up to 1/6 of the total contamination. The average contamination of compound feedingstuffs has been assessed to be around 0.2 pg/g PCDD/F-TEQ [SCAN 2000] or slightly above (0.266 pg/g; see chapter 9 of stage one of the present project). Assuming a comparable contribution from dioxin-like PCBs, a total WHO-TEQ load of 60 g TEQ in feedingstuffs is a reasonable estimation (corresponding to 0.48 pg WHO-TEQ average contamination of feedingstuffs).

12 Legislation, enforcement and control

As a detailed analysis of the legal situation related to wastes, recyclates and by-products and their potential to enter the feed and food chain was not a main objective of the project a brief overview is given in this chapter regarding:

- the different roles of and the expectations on the stakeholders in legislation, enforcement and control
- the current legal situation at EU level
- weaknesses and deficiencies of the current control system, legislation and enforcement
- approaches for possible improvements and recommendations for decision-making with a view of better control and enforcement

According to the project aims, the overview focuses on issues related to "dioxins and PCBs". The results with respect to deficiencies in legislation, enforcement and control are primarily based on expert interviews and on considerations of the project team. They do not necessarily reflect the views of Commission services.

Different roles of and expectations on the stakeholders in legislation, enforcement and control

For the stakeholders a differentiation of three major groups has been performed:

1. European Commission and European institutions
2. Member States and national authorities
3. Operators

With regard to legislation the **European institutions** are expected to establish a consistent and harmonised legal framework that is focused on lowering the contamination of human and animal intake of dioxins, PCBs and other POPs. As it is shown by the project results (see material flows) the goal of lowering the POP-contamination can be tackled from various perspectives such as feed and food legislation, waste legislation, air quality legislation and technology based legislation (IPPC approach).

Expectations on the European institutions and on Member States with regard to enforcement and control are focused on:

- the establishment of co-ordinated inspection programmes for feedingstuffs
- the establishment of harmonised methods for sampling and analysis

- a clear communication strategy including a support of communication between Member States and Candidate Countries

Member States must transpose Community legislation into national legislation and fully implement it in time. It is the responsibility of member states to carry out the necessary controls and inspections.

Further expectations can be seen in

- control of conformity of feed materials and foods with prescriptions
- measures to ensure that undesirable components are not used in materials for animal nutrition
- measures and penalties applicable to infringements
- carry out co-ordinated inspection programmes and report to the European Commission
- publish related research reports and results of measurements.

Expectations and obligations on **feedingstuff producers** and **producers of feedingstuff input** materials regarding enforcement and control measures can be summarised as follows:

- establishment of legally complying production, processing and distribution procedures
- Quality assurance (QA) and Quality standard (QS) measures
- analysis and improvement of production processes in line with producer responsibility?.

Overview on the current legal situation at EU level

The legal framework related to dioxins and PCBs is set by several EU directives, regulations, communications etc. … (for details see Community strategy for dioxins, furans and PCBs [COM(2001)593 final]) on

- air protection (emission limit values for waste incineration)
- water protection (against pollution with dangerous substances)
- integrated pollution prevention and control
- restrictions on the marketing and use of certain dangerous chemicals
- major accident hazards (of certain substances and activities)
- waste and waste treatment and disposal
- feed and food safety (on undesirable substances and limit, action and target values)
- a general strategy for Dioxins, Furans and Polychlorinated Biphenyls

According to the focus of the project the situation in the field of feed (and food) safety is described in more detail:

The measures addressed in feed and food consist of a combination of maximum limits, action and target levels as explained in the Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls [COM(2001)593 final]. At present only PCDD/Fs are covered but the inclusion of dioxin-like PCBs is foreseen until the end of 2004. To this end a database of dioxin-like PCBs shall be established.

The relevant directive related to feed materials and compound feedingstuffs (Directive 2001/102/EC) fixes maximum limits and Commission recommendation 2002/201/EC sets corresponding action levels at around 2/3 of the above maximum limits and foresees the setting of target levels by the end of 2004 simultaneously with the first revision of the action levels with a view on the inclusion of dioxin-like PCBs in the levels.

The following overview summarises these maximum limits and action levels (ng PCDD/F-TEQ/kg product weight relative to a feedingstuff with a moisture content of 12%):

	feed material	maximum limit	(action level)
▪	feed materials of plant origin - including vegetable oils and fats - including roughages	0.75	(0.50)
▪	minerals	1.00	(0.50)
▪	animal fat	2.00	(1.20)
▪	meat and bone meal	0.75	
▪	fish oil	6.00	(4.50)
▪	fish meal	1.25	(1.00)
▪	compound feedingstuffs - except fish feed - except feedingstuffs for fur animals - except feedingstuffs for pet animals	0.75	(0.40)
▪	feedingstuffs for fish and feedingstuffs for pet animals	2.25	(1.50)

Furthermore the Commission recommends random monitoring of the presence of dioxins and dioxin-like PCBs in feed materials and feedingstuffs in accordance with guidelines set up by the Standing Committee on the Food Chain and Animal Health.

Several wastes are excluded from the use in compound feedingstuffs by the means of a negative list that enumerates prohibited ingredients in the compound feedingstuffs (Commission Decision 91/516/EEC):

1. Faeces, urine as well as separated digestive tract content resulting from the emptying or removal of the digestive tract, irrespective of any form of treatment or admixture.
2. Hide treated with tanning substances, including its waste.
3. Seeds and other plant propagating materials which, after harvest, have undergone specific treatment with plant protection products for their intended use (propagation), and any derived by-products.
4. Wood, sawdust and other materials derived from wood treated with wood protection products.
5. All wastes obtained from the various phases of the urban, domestic and industrial waste water[18] treatment process, irrespective of any further processing of these wastes and irrespective also of the origin of the waste waters. The term 'waste water' does not refer to 'process water', i.e. water from independent conduits integrated in food or feed industries; where these conduits are supplied with water, this must be wholesome and clean water[19]. In the case of fish industries, the conduits concerned might be also supplied with clean sea water[20]. Process water shall only carry feedingstuffs or foodstuffs material and shall be technically free from cleaning agents, disinfectants or other substances not authorised by the animal nutrition legislation. Materials of animal origin in the process water shall be treated in accordance with Council Directive 90/667/EEC.
6. Solid urban waste, such as household waste.
7. Untreated waste from eating places, excluding foodstuffs of vegetable origin considered unsuitable for human consumption for reasons of freshness.
8. The packaging and parts of packaging from the use of products from the agri-food industry.

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[18] As defined in Article 2 of Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment

[19] As specified in Article 4 of Council Directive 98/83/EC of 3 November 1998 concerning the quality of water intended for human consumption.

[20] As defined in Article 2 of Council Directive 91/493/EEC of 22 July 1991 laying down the health conditions for the production and the placing on the market of fishery products

9. Protein derived from mammalian tissue as an ingredient in compound feedingstuffs for ruminants, excluding:

- milk and milk products,

- gelatine,

- hydrolysed proteins with a molecular weight below 10 000 daltons which have been:

  (i) derived from hides and skins obtained from animals which have been slaughtered in a slaughterhouse and have undergone an *ante mortem* inspection by an official veterinarian in accordance with Chapter VI of Annex I to Directive 64/433/EEC and passed fit, as a result of such inspection, for slaughter for the purpose of that Directive;

  and

  (ii) produced by a production process which involves appropriate measures to minimise contamination of hides and skins, preparation of the hides and skins by brining, liming and intensive washing followed by exposure of the material to a pH of > 11 for > three hours at temperature > 80 ºC and followed by heat treatment at > 140 ºC for 30 minutes at > 3,6 bar or by an equivalent production process approved by the Commission after consultation of the appropriate Scientific Committee;

  and

  (iii) come from establishments which carry out an own checks programme(HACCP),

- dicalcium phosphate derived from defatted bones, and

- dried plasma and other blood products.

Community legislation on animal nutirition provides the legal basis to extend this negative list in order to prohibit the use of feed materials that are consistently highly contaminated with POPs for the production of compound feedingstuffs.

At present there is a controversial discussion ongoing on the establishment of a European positive list that contains all feed materials that may be used in compound feedingstuffs.

Weakness and deficiencies of the current legislation, control system and enforcement

The obligations of waste producers and all companies which are involved in the handling of waste to store and handle waste without any risk to human or animal health and the environment (Art. 4 75/442 EWG) is an obligation which is formulated in very general terms. Based on discussions of the project team it can be stated that these general terms might not be efficient enough and therefore might define some "weakness" of the current legislation looking at the materials investigated in this report. Wastes

which are dedicated to be used in feed materials and

which can cause an accumulation of POPs in feed and food and

which contain very small amounts of dangerous substances far below those limit values which indicate use of the term “hazardous waste”

might need a more specific legislation on European level than it is given by Directive 75/442. This general background should be seen as a basis for the following points:

1. Current legislation includes a definition of waste (Directive 75/443 EWG) to which the European Court of Justice has provided some interpretations. However, it is not homogeneously applied by economic operators and in particular by the agro-food industry, which in some cases differentiates between waste, by-products and recyclates, which is a demarcation that does not exist in Community legislation. Consequently waste legislation is sometimes not applied when it should and only veterinary legislation is respected which in some cases might be insufficient to prevent the contamination of feedingstuff. To ensure even further that critical materials are not used as input to feedingstuffs there should be two efficient regulative barriers:

   a) an output specific regulation with respect to the waste generating process and
   b) an input specific regulation with respect to the feedingstuff.

2. Use of waste as input for feedingstuffs or food industry requires special declaration in order to follow the objectives of lowering POPs contamination in human intake. Such declaration does typically not take place at the output side and it is not generally done at the input side. The current legislation (Art. 11 Directive 75/442 EWG) allows not authorized companies to recover wastes if there is no danger for health and environment. Due to the fact that there is no “obvious” danger during handling the materials described in this report it can be expected that in most member states no

approval by the competent authorities for the recovery of wastes as raw materials for feedingstuff is required.

3. Measures to avoid accidental or fraudulent contaminations seem to be capable of improvement. Collection, transportation and distribution of wastes, by-products and recyclates that are destined to be used in feedingstuffs should be strictly separated from the handling of hazardous or potential POP-containing wastes (e.g. used mineral oil). Existing legislation bans the mixing of hazardous with non hazardous wastes and the mixing of different types of hazardous waste, however, **specific** regulations for separate handling (for example with regard to storage) of waste which will enter the food chain do not exist.

4. The input of wastes, by-products and recyclates to feedingstuffs requires special care in handling the relevant processes which generate the feeding materials. For these processes waste-specific, suitable measures regarding internal monitoring and control, quality assurance/quality standard (QA/QS) measures and measures for legal compliance at operators levels would improve the situation and reduce risks of unwanted contaminations. These measures should include storage and handling regulations and documentation requirements.

5. A weakness of control can be seen in the fact that a legally binding coordinated inspection programme does not exist. In addition collected data are not always reported to national authorities or to the European Commission.

6. At present there is a controversial discussion ongoing on the establishment of a positive list that contains all feed materials that may be used in compound feedingstuffs. Against the background of the project results a missing positive list for all feedingstuff inputs does not indicate a weakness on an European scale. However, a positive list for wastes used in feedingstuffs should be seen different from a general positive list. For the project team a positive list of wastes that can be used for feedingstuffs seems to be a measure to improve the contamination situation, to strengthen enforcement and to avoid high efforts that will probably occur with a general positive list.

Possible improvements including proposals for policy conclusions with a view of better control and enforcement

A) feedingstuff related measures: establishment of a positive list of wastes (not including products, by-products or recyclates) that are used in feedingstuffs.

As there are a lot of difficulties with a general positive list it might be helpful to have such a positive list only for wastes (not including products, by-products or recyclates) to be used in feedingstuffs. This would not mean a high effort as the number of relevant wastes, which are clearly accepted as wastes by all stakeholders (e.g. aspiration dust from cereal cleaning, out of date dairy products, used oils and fats) is quite small.

B) waste related measures: declaration necessity for wastes used for feedingstuffs

Implementation of specific documentation duties for wastes (e.g. mentioned in A) that are used in feedingstuffs seems to be another measure to improve enforcement and control towards unwanted "recycling" activities. In order to improve the traceability of the waste and subsequently of the feedingstuff ingredients the accompanying documentation should indicate type of waste, producer of waste, waste generating process and volume used for feedingstuff production. The documentation should be available at the producer of waste, at all stations in the distribution chain, at the producer of compound feedingstuff to the relevant authority.

C) waste related measures: waste identification procedure for feedingstuff inputs

A crucial problem is the non-classification of many agro-food industry residues as waste. It seems to be a promising measure to develop a procedure for process outputs that are used for feedingstuffs to specify under which conditions these outputs have to be regarded as waste and when not

D) waste related measures: separation of handling for materials destined for feedingstuffs and hazardous waste or potential POP-containing waste.

A policy approach might be the establishment of specific requirements for the handling of waste, by-products and recyclates that are foreseen to be used in feedingstuffs. This handling regulations should ensure that there is a strict separation of these materials from hazardous products or hazardous wastes. Such a regulation should be controlled by local authorities. If the regulation is not followed by an operator it should not be possible for this operator to deliver further material to feedingstuff producers.

E) Feedingstuff related measures: licence and quality assurance for suppliers to feedingstuff industry

Companies that supply the feedingstuff industry with wastes, by-products and recyclates should have internal monitoring and control procedures, quality assurance/ quality standard (QA/QS) systems and a system to ensure legal compliance. A specific regulation might establish that a licence is necessary to deliver waste for feedingstuff production and these systems have to exist to get one.

F) Data related measures: Coordinated inspection programme

It might be helpful to establish a legally binding coordinated inspection programme with national quotes for controls and requirements for feed controllers.

With the design of such a programme further measures to support coordinated research and development activities and know how transfer can be stated in order to support the information flow and communication between stakeholders.

It is expected that the measures and policy approach discussed above will intensify their effect if not only a single measure is implemented but there is an integrated system of measures within the already existing and quite well working legal framework.

13 Conclusions and recommendations

General conclusion

- With the results of the study it could be calculated that an annual input of up to 10 g WHO-TEQ to European feedingstuffs due to the recovery of wastes, by-products and recyclates might exist. This means a share of about 15% of the TEQ freight of 60 g WHO-TEQ which enters feedingstuffs with all raw materials. This freight leads to a WHO-TEQ load of about 20 g in animal based food and consequently effects human intake as an important part of the total intake. These facts underline the demand for further actions in the field of the recovery of wastes, by-products and recyclates to reach the general objective of lowering daily intake of POPs for humans.

Further research and data collection

- With the results of this study a lot of data are available for material flows and the importance of waste generating processes. This data cover all Member States and can be used as a basis for decisions. Further research and data collection on material flows is necessary with a view to Candidate Countries.
- Contamination data have been collected and summarised systematically. Available data show significant deficits in some areas (like processing of high fibre materials) some other areas are quite well analysed (like fish and fish products). However, PCB and dioxin contamination for the same sample are seldom available, in most cases only one contamination value is existing and estimations for a WHO-TEQ have to be made. In addition, process specific contamination data always show some data gaps on relevant process steps. Furthermore for no category of feedingstuff inputs representative contamination data on an European scale do exist. Following these facts it has to be concluded that with respect to contamination data a sufficient decision basis for specific and effective political measures does hardly exist and consequently further research and data collection is necessary.
- With available data contamination volume categories have been calculated in this study and thus the importance of various categories of wastes, by-products and recyclates could be shown. These results enable an efficient collection of contamination data. It can be concluded that a general research and data collection programme for all feedingstuff inputs is not necessary, it is much more efficient to collect data through a step by step procedure.

The following list of priorities – starting with the highest priority – for the execution of the sampling strategy and the collection of further contamination data is recommended:

- components from agriculture and industry with a high fibre content
- livestock wastes
- by-products and wastes from the fish processing industry
- components from processing of used oils and fats
- components from further wastes, by-products and recyclates
- components from dairy products
- components form olive oil processing

➢ Integration of unpublished contamination data to an European database:

Experiences of the project team with the collection of available data show that there is a broad communication with data resulting of scientific based approaches. However, far more data are available in the hand of industry and local authorities. Following some particular interests these data are not published or communicated in a broader way. Due to intensive contacts some of these data could be integrated in this report, but still many data are kept by their owners. It is therefore suggested to use the existing structure of the data basis generated by this study – which is compatible to the structure of SCAN – and SCOOP data – and put it on the web site of the European Commission with an invitation for everyone to include existing, but not yet available data by a special organised data input procedure. This procedure should be designed to provide advantages with regard to the information flow to those who submit their data to the European Commission.

Sampling programme and sampling strategy

- The information and sampling strategy applied in this study shows clearly that it is useful to integrate all existing and reliable data in a sampling programme. The material flow analysis shows further, that it is appropriate to start sampling with process specific samples, to check established contamination theses and to define afterwards the type of output based samples to be collected.
- For process specific samples existing data can save a lot of sampling and analysis effort so it is suggested to keep the developed sampling plan updated with new upcoming data and calculate the necessary samples with the calculation programme.
- Output based samples have to be representative on an European scale. This is enabled with the developed sampling plan. The project team recommends to use a mixed samples approach that significantly lowers measurement costs and guarantees representative results.
- Furthermore it is recommended to have different types of mixed samples for typical contamination and for accidental contamination. For accidental contamination more individual samples should be put together to one mixed sample. It is not necessary that accidental oriented samples are representative on a country-specific scale.
- As a result of the present data availability the following sampling plan is suggested:

	STEP 1	STEP 2	Mixed Samples
Components from olive oil processing	9	90	12
Components from processing of used oils and fats	8	135	16
Livestock wastes and dead animals	5	420	24
By-products and waste from the fish processing industry	10	655	44
Components from dairy products	9	150	14
Components from agriculture and industry with a high fibre content	1 3 3	600	39
Components from further wastes, by-products and recyclates	4 4 5	315	34
Sum	**61**	**2,365**	**183**

Table 13-1: Summarised sampling plan

"Step 1" means process specific samples, "Step 2" means output based individual samples, "Mixed samples" stands for measurements of output based samples.

The sampling plan relies on a computer based program in which the parameter can be adopted to special Commission needs. Also via the computer program new and upcoming data can be integrated and a systematic structure of old and new data sets is available. The program is a voluntary contribution of the project team and it is designed as a working tool for internal purposes.

Reduction of human exposure

The following measures and recommendations have been developed in discussion with experts and stakeholders. The project team sees these proposals as a contribution to further discussion and political activities, however, pros and cons of the suggestions could not be checked in detail within the project scope.

A) feedingstuff related measures: establishment of a positive list of wastes that are used in feedingstuffs.

B) waste related measures: declaration necessity for wastes used for feedingstuffs

C) waste related measures: waste identification procedure for feedingstuff inputs

D) waste related measures: separation of handling for materials destined for feedingstuffs and hazardous waste or potential POP-containing waste.

E) Feedingstuff related measures: licence and quality assurance for suppliers to feedingstuff industry

F) Data related measures: Coordinated inspection programme

A more detailed description of these suggestions is available in chapter 12.

14 List of Tables

15 Table of Figures

16 References

Abad 2002
A. Abad, J.J. Llerena, J. Saulo, J. Caixach, J. Rivera (2002): Study on PCDDs/PCDFs and co-PCBs content in food samples from Catalonia (Spain). Chemosphere 46 (9-19) 1435-1441

ADEF 2001
Administration des Eaux et Forets Luxembourg, Contamination des Poissons du systeme Alzette-Sûre-Mosell par les dioxines et les PCB, Luxembourg, Fevrier 2001

APPUHN 2000
Appuhn, H. et al, Dioxine in Futtermitteln, Kraftfutter 7-8, 275-278

ATUMA 1998
Atuma, S.S. et al., PCBs in Salmon (Salmo salar) from the Swedish East Coast, Organohalogen Compounds Volume 39, 1998

Austria 1999
Results from "Österreichisches Dioxin Untersuchungsraster 1999"

BayForrest
BayForrest Forschungsvorhaben 149 Speiseresteverwertung – Erfassung und Verwertung von Speiseresten unter Berücksichtigung von Seuchenhygiene und Verwertungsalternativen

BECHER 1998
Becher et al., Dioxins and non-ortho PCBs on Atlantic salmon, Salmo salar, from major Norwegian and Russian salmon rivers, Organohalogen Compounds Volume 39, 1998

BJERSELIUS 2002 b
Rickard Bjerselius, Swedish National Food Administration, personal communication August 2002

BLAG 2002 a
Daten zur Dioxinbelastung der Umwelt, 3. Bericht der Bund Länder AG Dioxine, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn, 2002

BLAG 2002 b
Dioxin-Referenzmessprogramm, 4. Bericht der Bund Länder AG Dioxine, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn, 2002

BMVEL 2001
Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft, Germany, www.verbraucherministerium.de

BMVEL 2002
personal communication on a recent study including data on cereal processing; authors cited related to PCB levels: K.H.Schwind, W.Jira and H.Hecht; author cited related to PCDD/F levels: U. Ruoff

BORDAJANDI 2002
Bordajandi et al, Presence of Polychlorinated Dibenzo-p-Dioxins (PCDDs), Dibenzofurans (PCDFs) and Biphenyls (PCBs) in selected food samples from Huelva, Spain. Organohalogen Compounds, Vol 57 p 69, 2002

BROOKS 2000
Paul Brooks et al., PCDD/F analysis in Brazil; case studies part 1, continuous monitoring program of food in Brazil, Organohalogen Compounds Volume 47, 2000

CHOI 2000
Dongmi Choi et al., Levels of dioxins like compounds in Korean Food, Dioxin 2000 – Organohalogen Compounds Volume 47, 2000

COM(2001)593 final
Communication from the Commission to the council, the European Parliament and the Economic and Social Committee; Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls, COM (2001) 593 final, Brussels, 24.10.2001

CORSOLINI 2000
Simonetta Corsolini et al., PCBs in arctic and antarctic organisms: polar bear, Krill, Fish, Weddel Seal and Skua, Dioxin 2000 – Organohalogen Compounds Volume 46, 2000

EC 2001 a
European Commission, Green paper on the future of the common fisheries policy, Brussels, 20.03.2001

EC 2001 b
European Commission DG Environment, Survey of wastes spread on land, final report, Brussels, July 2001

EC 2001 c
European Commission Press Release, Commission services paper on the processing, disposal and uses of animal by-products in Member States, Memo 01/378, 20. November 2001

EFPRA 2002
personal communication, July 2002

ELJARRAT 2000
Eljarrat, et. al. Determination of PCDDs and PCDFs in Different Animal feed Ingredients, Organohalogen Compd. Volume 47, p. 330-33

EPET 2002
European POPs Expert Team, Preparatory Actions in the Field of Dioxins and PCBs, Brussels, April 2002

Falk 2001
O.Falk, Sutor G., Wiegland S., Altspeisefette: Aufkommen und Verwertung, TU München, Lehrstuhl für Energie und Umwelttechnik der Lebensmittelindustrie, München 2001

FERRARIO 2002
Joseph Ferrario et.al., Analysis of Animal- and Plant-derived Feed Ingredients for dioxin-like Compounds, Organohalogen Compounds, Vol 57, p 85

Fiedler 2000
Fiedler, H., Hutzinger, O., Welsch-Pausch, K., Schmiedinger, A., Evaluation of the occurrence of PCDD/PCDF and POPs in wastes and their potential to enter the food chain, on behalf of the European Commission, DG Environment, September 2000

Finnish Environment Institute 2001
personal communication from the Finish Environment Institute 2001

FOCANT 2000
Jean-Francois Focant et al., Contribution and importance of non-ortho (coplanar) PCBs for the I-TEQ evaluation in Dioxins Analysis in biological Matrices, Dioxin 2000 – Organohalogen Compounds Volume 48, 2000

FOCANT 2001
Jean-Francois Focant et al., Comparison of PCDD/Fs and cPCBs Levels in Commercial pasteurised cow's milk in Wallonia (Belgium) – Organohalogen Compounds 2001, V51, p 340

FÜRST 2001
Fürst et al, Contribution of dioxin-like PCB to total toxic equivalents of dairy products, Organohalogen Compounds 2001, V. 51 p. 279

Gehrer 1991
Gehrer, TH. Hübner, R. und Wachmann, H.-P., Rekollektion gebrauchter Speiseöle und –fette in Haushalten und Gewerbe, Fachverband der Nahrungs- und Genussmittelindustrie Österreichs, Wien 1991

German compound feed manufacturers 1999
Monitoring zur Belastung von Einzelfuttermitteln und Zusatzstoffen mit polychlorierten Dibenzodioxinen und –furanen, Dezember 1999

GROCHOWALSKI 2000
Adam Grochowalski et al., The result of a large scale determination of PCDDs, PCDFs and coplanar PCBs in polish food product samples using GC-MS/MS, Organohalogen Compounds Volume 47, 2000

Hilbert 1998
Gudrun Hilbert, Lone Lillemark, Stehen Balchen and Carsten Schriver Højskov, Reduction of organochlorine contaminants from fish oil during refining, Chemosphere, Vol. 37 no 7, p. 1241, Great Britain, 1998

HOCHDORF 2002
Hochdorf Nutritec Ltd., www.hochdorf.com, 2002

IFOMA 1999
International Fishmeal & Oil Manufacturers Association, Fish meal and fish oil dioxin levels, Research report number 1999-4, U.K., September 1999

Improlive 2000
"Improvements of Treatments and Validation of the Liquid-Solid Waste from the Two-Phases Olive Oil Extraction", CT 96-1420, FAIR-programme of the European Commission, www.fiw.rwth-aachen.de/improlive

IOOC 2001
International Olive Oil Council, www.internationaloliveoil.org

IPPCB 2001
European Commission, IPPCB, Integrated Pollution Prevention Council, Reference Document on Best Available Technologies in Pulp and Paper Industry, Brussels/Seville, December 2001

JACOBS 2000
Miriam Jacobs et al., Investigation of PCDDs, PCDFs and selected coplanar PCBs in Scottish farmed atlantic Salmon, Dioxin 2000 – Organohalogen Compounds Volume 47, 2000

Jong-Guk Kim 2000
Jong-Guk Kim et al., Exposure of PCDD/Fs via air and food in Koreans, Organohalogen Compounds Volume 47, 2000

JRC 2002
Personal Communication from Dr. Umlauf, JRC, Ispra, August 2002

KAMEDA 2002
Kameda et al, Historical trend of dioxin and agrochemicals in rice straw and their impact on meat and dairy products, Organohalogen Compounds 2002, Vol 56, p 477

KANG 2000
Youn-Seok Kang et al., Temporal trends of PCDD/Fs and dioxin-like PCBs in preserved fish samples from 1953 to 1999; Dioxin 2000 – Organohalogen Compounds Volume 46, 2000

KARL1999
H. Karl, A. Blüthgen, U. Ruoff, Polychlorierte Dibenzodioxine und –furane in Fisch und Fischerzeugnissen, Hamburg und Kiel, July 1999

KIM 2000
Yunje Kim et al., The Levels of PCDD/Fs and in the 5 Kinds of fishes in Korea; Dioxin 2000 – Organohalogen Compounds Volume 47, 2000

KOLIC 2000
T.M. Kolic et al., A comparison of the TEQ Contributions from PCDD/Fs and dioxin-like PCBs in great lake fishes, Dioxin 2000 – Organohalogen Compounds Volume 46, 2000

LC 1972
London Convention 1972, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, WASTE-SPECIFIC GUIDELINES FOR FISH OFFAL & RELATED MATERIAL

LINDSTRÖM 2002
Gunilla Lindström et al, Levels of PCDD, PCDF, non-ortho PCB and mono-ortho PCB in chicken, butter, beef, human milk, salmon and cod liver from Northern Europe compared to the current EU limit values for these types of foods, Organohalogen Compounds, Vol. 57 (2002), p. 89

LLOBET 2002
Llobet et al, Levels of PCDD/PCDFs in Food Samples from Catalonia, Spain, Organohalogen Compounds 2002, V. 57p 105

MAFF 1999
MAFF 1999, Dioxins and PCBs in UK and imported marine fish, MAFF info sheet 184, 1999

MAFF 2001
Letter to the MAFF; Feeding to livestock of by-products from the food-industry: ban on swill-feeding, March 2001

MALISCH 2002
Malisch et al, PCDDs/PCDFs and Dioxin-like PCBs in feedingstuffs for Fish, Organohalogen Compounds V 51 p. 287

MALISCH FÜRST 2000
Malisch, R. FÜrst, P., Background Contamination of Feedstuff with Dioxins, Organohalogen Compounds 47, p. 322-325

MAYER 2002
Richard Mayer, PCDD/PCDF Levels in Freshwater Fish from Southern Germany, Organohalogen Compounds 2002, V 57, p 181

MAYER 1999
Richard Mayer, PCDD/PCDF Levels in Germany Canteen Food, Organohalogen Compounds 44, p 189

MCLACHLAN 1996
McLachlan, M.S., Bioaccumulation of Hydrophobic Chemicals in Agricultural Food Chains, Environ. Sci. Technol. 30, 252-258

NFA SWEDEN 2001a
Swedish National Food Administration: Interim Report 1 – Study of dioxin levels in fatty fish from Sweden 2000 – 2001

NFA SWEDEN 2001b
Swedish National Food Administration: Interim Report 2 – Study of dioxin levels in fatty fish from Sweden 2000 – 2001

NFA SWEDEN 2002
Swedish National Food Administration: Interim Report 3 – Study of dioxin levels in fatty fish from Sweden 2000 – 2002

NOBUYASU 2002
Nobuyasu et al, Time Trend of PCDD/Fs and CO-PCBs Concentration and Compositions in Rice leaves, Organohalogen Compounds 2002, Vol 57, p 97

NUTRECO 2002
Nutreco Aquaculture Research Centre, Contaminant Monitoring Programme, Stavanger February 2002

ÖKO 2000
Biogene Abfälle aus der Lebensmittelindustrie und dem Gewerbe, Ökosoziales Forum Wien, Vienna, March 2000

OÖ 2000
Umweltbericht 2000 des Landes OÖ, Austria, 2000

ÖWAV 2002
ÖWAV Stellungnahme zu: Verordnung des EU Parlaments und Rates für nicht für den menschlichen Verzehr bestimmte tierische Nebenprodukte (COM (2000) 574 und 2000/0259/COD) und deren Auswirkungen für die Bioabfallwirtschaft; January 2002

REICHLE 1997
Reichle, E. et.al., Investigation of used wood for contents on PCP, Lindane, PCDD/F, PCB and PAH, Organohalogen Compound Vol. 32, P. 178-183

RIVERA 2000 a
Josep Rivera et al. 2000 a, PCDDs and PCDFs in different animal feed ingredients; Organohalogen Compounds Volume 47, 2000

RIVERA 2000 b
Josep Rivera et al. 2000 b, PCDD/Fs and co-planar Biphenyls in foodstuff samples from Catalonia (Spain), Organohalogen Compounds Volume 47, 2000

Sang-Jo KIM 2002
Sang-Jo KIM et al., Polychlorinated Dibenzo-p-Dioxins and polychlorinated Dibenzo Furans in raw and cooked fisheries products, Organohalogen Compounds, Vol. 57 (2002), p. 169

SCAN 2000
European Commission, DG Health and Consumer Protection: Opinion of the Scientific Committee on Animal Nutrition on the dioxin contamination of feedingstuffs and their contribution to the contamination of food of animal origin, adopted on 06.11.2000

SCF 2000
European Commission, DG Health and Consumer Protection: Opinion of the Scientific Committee on Food on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food, adopted on 22.11.2000, p.19

SCF 2001
European Commission, DG Health and Consumer Protection: Opinion of the Scientific Committee on Food on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food, update based on new scientific information available since the adoption of the SCF opinion of 22nd November 2000, adopted on 30 May 2001.

Schlabach 2001
Schlabach et al., *PBDEs and other POPs in Norwegian freshwater fish*, The second international workshop on brominated flame retardants, p 371, Stockholm 2001

SCHÖPPE 1996
Schöppe, G.; C. Kube-Schwickardi; H. Bendig; J. Schram; M. Schulte, G. Reinders (1996), Untersuchungen zum Eintrag von PCDD und PCDF über Tierkraftfutter in die menschliche Nahrungskette, UBA-Forschungsvorhaben 106 01 073

SCHREY 1995
Schrey, P. et al., Dietary intake of PCDD/F measured by the duplicate method, Organohalogen Compound 26, 147-150

SCHREY 1996
Schrey, P. et al., Dietary intake of PCDD/F by small children measured by the duplicate method, Organohalogen Compound 30, 166-171

SCHUHMACHER 1997
Schuhmacher M. et.al., Dietary Intake of PCDD/Fs from Food in Catalonia, Spain, Organohalogen Compounds 33, P. 431-435

SCHWINDT 2000
Schwindt, K.-H.; H. Hecht, Keine Dioxinbelastung durch Frittieren, Untersuchungen zum Vorkommen von Dioxin in frischen und gebrauchten Frittierfetten, Mitteilungsblatt der Bundesanstalt für Fleischforschung Kulmbach 39,Nr. 149, 803, 2000

SCORTICHINI 2001
Scortichini et.al., Food and Animal Feeds contamination by PCDDs-PCDFs in Italy in Years 1999 and 2000: Incidence and TEQ Congeners Patterns, Organohalogen Compounds, Vol. 51 (2001), p. 400

S:P:J: van LEEUWEN 2002
S:P:J: van Leeuwen 2002, Dioxins, Furans and Dioxin-like PCBs in wild, farmed, imported and smoked eel from the Netherlands, Organohalogen Compounds Vol. 57 (2002), p. 217

WELSCH-PAUSCH 1998
Welsch-Pausch K., Atmosphärische Deposition polychlorierter Dibenzo-p-dioxine and Dibenzofurane auf Futterpflanzen, Doctoral thesis, University Bayreuth

[79/373/EEC]
Council Directive 79/373/EEC of 2 April 1979 on the marketing of compound feedingstuffs