

# Environmental Handbook

Documentation on monitoring and evaluating environmental impacts

Environmental Brief

Dairies



Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung  
(BMZ)



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## Abbreviations

BOD <sub>5</sub>	Biochemical oxygen demand over 5 days
CIP	Clean in place (recirculation process for cleaning)
COD	Chemical oxygen demand
°C	Degrees Celsius
dB(A)	Sound pressure level in decibels
CFC	Chlorofluorocarbon
kW	Kilowatt
l	Litre
ml	Millilitre
m <sup>3</sup>	Cubic metre
N	Nitrogen
P	Phosphorus
PE	Polyethylene
pH	Logarithm of the reciprocal of the hydrogen-ion concentration (acid solution < pH 7 < alkaline solution)
t	Tonne
TrinkwV	German drinking water treatment ordinance
Ø	Mean value

## 1. Scope

Milk is a delicate food which needs careful treatment at all times to ensure that the final product reaching the customer is in perfect condition and suitable for human consumption.

The business of dairying therefore requires a high standard of know-how and hygiene awareness among producers, a certain level of infrastructure (roads, energy supplies, water supplies) for milk collection and processing, and a minimum standard of equipment (hygiene, refrigeration) in the sales outlets for dairy products.

The **dairy** project area covers three segments: the upstream segment of milk collection, the central segment of milk processing and the downstream segment of product marketing.

The dairies' processing capacity can vary from 10 to several 100 t of milk per day, depending on regional demand.

In developing countries a dairy industry cannot be established simply as a matter of course, because the majority of the world's population suffers from a congenital lactose intolerance (with the exception of people from cultures with a tradition of drinking milk, such as Europe, Nigeria etc.). The onset of congenital lactose intolerance is from 3 - 7 years of age, irrespective of the quantities of milk ingested in early childhood. Although it is possible for an adult person with congenital lactose intolerance to drink a certain amount of milk without developing symptoms (up to 250 ml of milk per meal in exceptional cases), most people experience the typical symptoms such as stomach ache, bloating and diarrhoea. In countries where the population is not used to milk consumption, immobilised  $\beta$ -galactosidase should be used to hydrolyse lactose. This procedure is economically viable even if applied to large amounts of milk.

### 1.1 Milk collection

#### 1.1.1 Milk production

Fresh (cow's) milk in its natural state contains  $10^1$  to  $10^4$  microorganisms per ml. This contamination causes untreated milk to go sour very quickly due to microbial production of glycolic acid. The accepted guideline is that at room temperature fresh milk goes sour within one day. If cows are milked by hand (the practice most common in developing countries), there is additional contamination of the milk through soiling (fur, teat surface, milking bucket, milk strainer, milker etc.).

At a temperature of 20°C the bacterial count in milk doubles every 20 minutes, whereas at a temperature of 4°C it only doubles every 4 hours. Because of this it is important to ensure continuous cooling of the milk as far as possible, from the producer through to processing (pasteurisation), to assure the quality of the product.

Any milk which does not satisfy the quality standards laid down in milk delivery regulations (see Section 1.2.1) cannot normally be processed in the dairy and has to be disposed of as a spoilt batch.

The quantity and quality of the milk depends on the particular livestock available. The average milk yield per year and the most important milk constituents as applicable to different livestock are listed in Table 8 in the Appendix.

There are no known differences in storage behaviour regarding milk from different livestock, although there are differences regarding the processing of different kinds of milk, especially in cheese-making (e.g. mozzarella cheese and buffalo milk).

### **1.1.2 Milk collection**

As a rule, small-scale producers do not transport their milk straight to the dairy, but to central collection points or to milk collecting stations. The milk is then collected from there by bulk-milk tankers (owned by the dairy). Large-scale producers are usually visited directly by the milk tankers.

At the central collection points, the driver of the bulk-milk tanker records the quantity of milk supplied by the producer. It is technically feasible to check the milk for contamination and watering down, and such checks should be carried out if necessary.

At milk collection stations which are mainly set up as central collection points for small-scale producers in catchment areas a relatively long way away from the dairy, the quantity of the milk is recorded on delivery, the milk is checked for contamination and watering down and then stored in refrigerated milk tanks until it is collected. If the milk is collected by the dairy every day, it should be cooled to 8°C, while if it is collected every other day it should be cooled to 4°C (to avoid spoilt batches due to bacterial fermentation).

Identifying the milk constituents which determine its quality is possible only at the dairy itself (see Section 2.3.1).

### **1.1.3 Milk transport**

During milk collection the raw milk is combined in individual batches. Because prices are determined by the quality of the whole batch (see Section 1.2.1), it is necessary for small-scale producers to join together in regional producers' associations. This is especially important in countries where a large number of very small-scale producers are part of the milk collection system.

The milk tankers should be specially equipped for collecting milk away from the dairy. The tank should consist of several (usually 3) chambers, so that the milk churn be assigned to individual producers' associations or groups.

In warmer countries milk tankers with insulated milk tanks are essential to avoid excessive warming of the milk during transport (spoilt batches).

## **1.2 Milk processing (dairies)**

### **1.2.1 Criteria for milk quality**

On delivery at the dairy, the quality of each batch of milk batch must be tested individually.

The price paid for the milk (to each producers' association) depends on the value-determining constituents of the milk (fat, protein) and other quality characteristics (bacterial count, somatic cells, inhibitors etc). The price paid for the milk is usually graded according to quality. The grades are laid down in milk delivery regulations negotiated by the dairy and the producers' associations.

The test methods for establishing the value-determining milk constituents and the other quality characteristics are usually also laid down in the milk delivery regulations. These tests should be carried out by an institution which is independent of the dairy and recognised by the producers' associations.

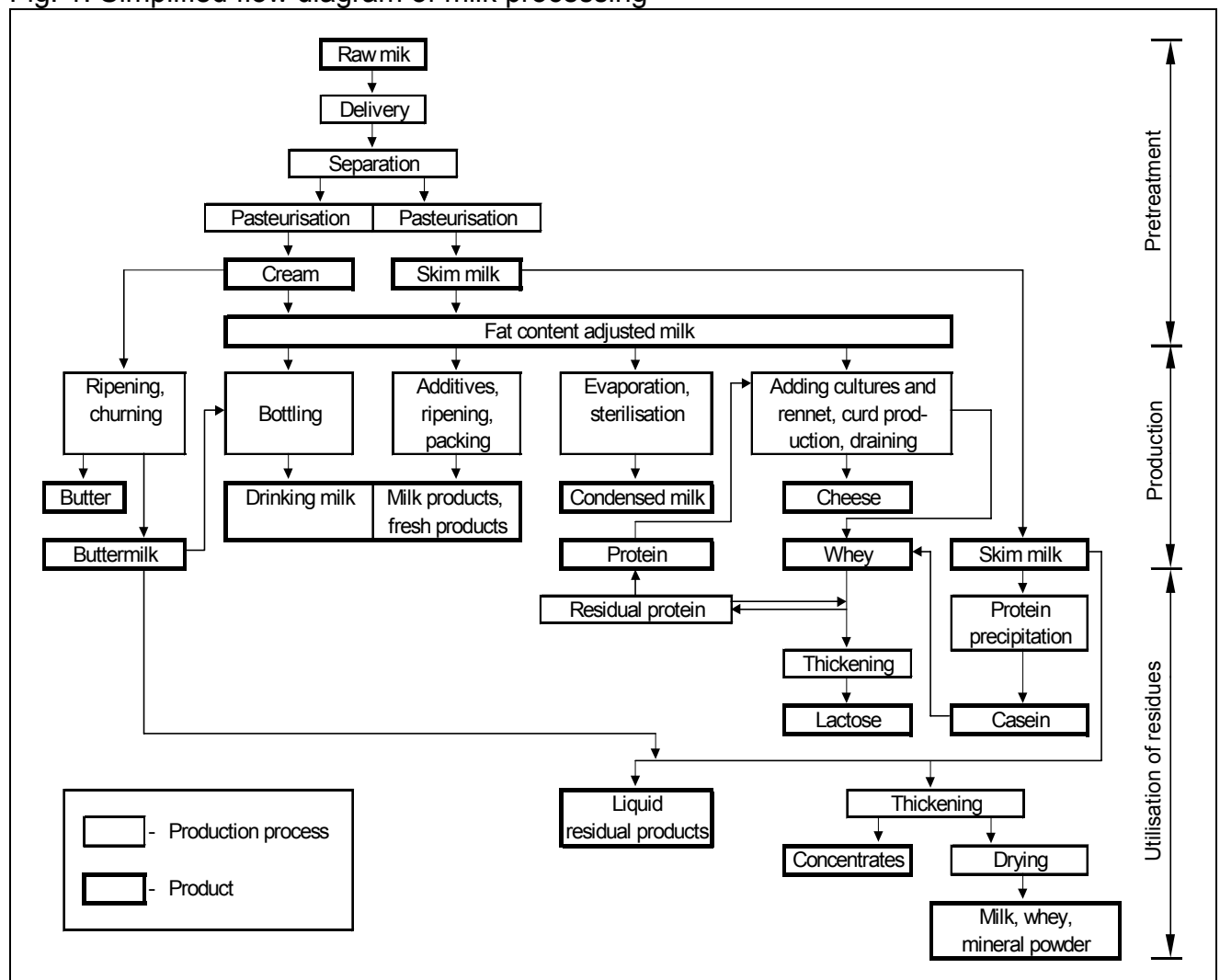
Likewise, the valuation of spoilt batches should be contractually stipulated in the milk delivery regulations.

### 1.2.2 Processing

In dairies, raw milk is treated for use as drinking milk (longer shelf life, homogenisation) or processed to produce other products. In addition to producing butter, cheese, fresh dairy produce, milk powder and other milk-based foods, dairies also isolate individual milk constituents such as casein or lactose for industrial and pharmaceutical purposes.

Figure 1 is a simplified flow diagram of some important production lines in milk processing.

Fig. 1: Simplified flow diagram of milk processing



Source: ATV Vol. V, 1985 (modified)

For most milk-based foods the milk is pretreated before processing to ensure longer shelf life:

- Filtering and cooling of the milk to 4°C - 6°C (milk collection)
- Pasteurisation of the milk at temperatures between approx. 63°C and 96°C
- Milk separation into skimmed milk and cream
- Adjustment of the milk's fat content to the desired level for further processing

Pasteurisation is an essential step which kills some of the microorganisms by thermal treatment. In this process, pathogenic bacteria that may be present in the milk are rendered innocuous and deterioration of the products is slowed down (for data on pasteurisation, see Appendix, Table 11).

The energy required for milk processing and also the undesirable by-products resulting from processing, such as exhaust gases, liquid effluent and other waste, are discussed in detail in Sections 2.3.4 to 2.3.10.

### 1.2.3 Packaging systems

Possible packaging systems for fresh milk are listed in Table 1. The same packaging can be used for fluid or semi-fluid milk products such as buttermilk, sour milk, drinking yoghurt and milk drinks.

Table 1: Packaging systems for fresh milk

Block packaging (cardboard PE composite), non-returnable
Tube packaging (PE), non-returnable
Tubs (PE), non-returnable
PE bottles, returnable
Glass bottles, returnable
Container distributors, 150-300 l. (+ milk churns/glass bottles)
PE tube distributors, 25-50 l. (+ milk churns/glass bottles)

The term 'block packaging' covers all forms of composite packaging, with a weight of approximately 25 g.

Returnable plastic bottles made from polyethylene (or polycarbonate) compete directly with returnable glass bottles. Their outstanding feature is their robustness (100 to 120 return cycles) combined with low net weight (80 g). Filling the bottles with household substances other than milk can cause problems, because organic molecules migrate into the bottle wall and can interfere with the milk's smell and taste after refilling.

Returnable glass bottles have high net weight (480 or 380 g). The average number of return cycles depends on the quality of the glass and the form of transport used (in Western Europe 25 - 30, in developing countries around 10). The efficiency of the deposit system is also important.

The choice of a packaging system for milk and milk products that is suitable for the project location, the region or the country concerned is dependent on several factors; of these, the ecological criteria discussed in more detail in Section 2.3.11 represent only certain aspects. The packaging manufacturing capacities available locally or regionally and the quality and cost of the product can also play a crucial part in the decision.

### 1.3 Product marketing and transport

With the exception of products for industrial or pharmaceutical purposes and also UHT milk and hard cheeses, the marketing of dairy products requires continuous refrigeration during transport and storage up until the time of sale, to ensure the quality of the products. If no official or other institutions are responsible for food inspection in general, the dairy should try to establish a supply contract in which certain minimal standards for the sales outlets are laid down. The same applies to the distributors (wholesalers, haulage firms).

## 2. Environmental impacts and protective measures

In the dairy industry, environmental impacts mainly result from

- hygienic requirements during milk production (cleaning of milk churns, strainers, milking installations, containers for intermediate storage, milk collection tankers),
- transport,
- disposal of spoilt batches,
- milk processing (energy consumption, water consumption, wastewater, disposal of coolants),
- cleaning of packaging materials (recyclable packaging),
- disposal of packaging and secondary packaging materials, and
- noise of dairy machinery.

Table 2: Environmental impacts in the dairy industry

	Water consumption	Energy consumption	Waste-water	Waste gases	Noise	Waste	Problem waste
Milk collection	X	(X)	X	X			(X)
Dairy	X	X	X		X	X	(X)
Product marketing		(X)		X		X	(X)

(x) = not always applicable

### 2.1 Risk potential during milking and milk collection

The hygienic measures and the refrigeration of the milk in all areas before the milk reaches the dairy serve to ensure quality and therefore to prevent spoilt batches that would require regulated disposal (see Section 1.2.1).

#### 2.1.1 Milking

Prior to milking the teats should be washed with hand-hot water. The first teat contents should be caught in a separate container and disposed of outside the cowshed because of the particularly high contamination of this milk.

Daily cleaning of the milking equipment (milking buckets, milk churns, strainers etc.) is imperative. As long as the milking equipment is of simple design and easily accessible, it may be cleaned by hand using a brush, hand-hot water, soda solution or lime milk. The environmental impact of this method of cleaning is negligibly small.

The milk should be cooled straight away at the farm itself. The milk is usually precooled with well water; by this means it is possible to cool the milk to no more than 3°C above the temperature of the water. The cooling process is faster if the milk churns are sprinkled with water rather than being immersed in a water-bath. If precooling is not possible, the milk must be taken to the nearest collecting station within a certain time dependent on the bacterial count and the outdoor temperature.

In countries where there is no (state) inspection of foodstuffs, milk adulteration (cream separation, thinning with water, improvement of storage stability by the addition of nitrates etc.) is widespread. The dairy must counteract this by performing appropriate quality tests, specifying regulations for quality grading and imposing contractually

defined sanctions (see Section 1.2.1). In particular it is important to draw attention to the risk to babies from the addition of nitrates (medical term: cyanosis).

### **2.1.2 Milk collecting stations**

Milk collecting stations where the regional milk producers usually deliver their milk twice a day should have refrigerated milk collecting tanks. In most cases the heat exchangers of older refrigeration units, like those of older domestic refrigerators, use cooling agents containing CFCs. CFCs are characterised by their low human toxicity, but damage the stratospheric ozone layer if they escape into the atmosphere through leaks or after the unit has been taken out of service. For this reason, all such units must be serviced regularly and have to be disposed of in a regulated way at the end of their service life. In accordance with the Montreal Protocol of 1988 and its London Amendment (1990) on the reduction of ozone-depleting halogenated compounds, modern refrigeration units should contain CFC-free cooling agents. When new milk collecting stations are built or old ones are refurbished, the equipment installed should always be CFC-free.

The milk collecting tanks should be cleaned every time after emptying. The cleansing agent used is a 0.2 to 2% sodium hydroxide solution (see Section 2.3.5). After the sodium hydroxide solution has been neutralised in a mixing tank, it is quite safe to discharge the wastewater diluted with the rinsing water into running water because of the small amounts involved. Alternatively the wastewater can be applied to agricultural land, discharged into wastewater lagoons or cleaned in purification systems using plants.

### **2.1.3 Transport**

The emissions caused by transporting milk in bulk-milk tankers (usually with diesel engines) are unavoidable. They can only be reduced by selecting appropriate sites for the dairies, optimising the collection route, and choosing suitable vehicles and servicing them in the proper way.

The milk tankers are cleaned every day immediately after the milk has been pumped off in the dairy, using acid cleansing agents. The rinsing water is discharged into the mixing and equalising tank of the dairy's wastewater treatment system (see Section 2.3.6).

## **2.2 Risk potential arising from building a dairy**

### **2.2.1 Site selection**

When selecting a site for a dairy the following points must be taken into consideration:

- The choice of site determines how much transportation is involved between the producers, the dairy and the markets.
- The choice of site has an effect on the consequences of water extraction and on environmentally friendly wastewater disposal.
- The choice of site can influence expenditure on the provision of the necessary energy sources (e.g. acquisition of process heat from other businesses).

### **2.2.2 Suitable building materials**

The building structures that are liable to come into contact with milk or lactic acid must be made of materials resistant to moisture, acid and corrosion. Surface materials to be used are acid-resistant earthenware tiles, moulded plastic flooring (= optimum solution)

and acid- and abrasion-resistant paints. Uncoated concrete flooring or pounded clay floors are totally unsuitable, because lactic acid and leftover milk damage their surface structure.

As far as possible, chrome-nickel steels (V2A) or chrome-molybdenum-nickel steels (V4A) in accordance with DIN 11851 should be used.

V2A steels are the standard materials for the construction of dairy units. However, they are not resistant to corrosion by chloride, which is why hydrochloric acid should not be used as a cleansing agent. One example of a suitable acid cleansing agent is phosphoric acid. V4A steels are used if high salt concentrations occur during production (for example brine baths during cheese making).

### 2.3 Risk potential during operation of a dairy

The residues arising during operation of a dairy and requiring disposal are listed in Table 3; they are discussed in more detail in the respective subsections below.

Table 3: Wastewater, waste material and waste air in milk processing

Process stage	Wastewater	Waste material	Waste air
Delivery of raw milk	Drip losses, tank residues, spoilt batches		
Separation		Separator sludge	
Churning	Butter washing water (buttermilk)		
Milk evaporation, skim milk, thickening of molasses		Molasses	Exhaust vapours (organically contaminated steam)
Cheese-making	Whey, brine baths, paraffin baths		
Protein precipitation		Permeate, whey protein	
Drying	Cleaning of spray dryers	Milk dust	
Cooling	Cooling water		
Packing products	Drip losses, cleaning water* (returnable packaging)	Secondary packaging rejected packaging (returnable container schemes)	
Cleaning of buildings	Water used for cleaning*	Packaging of cleansing agents and disinfectants	
Cleaning of facilities	Cleansing agents*	Packaging of cleansing agents and disinfectants	

\* - main contamination

### **2.3.1 Raw milk**

Spoilt batches, i.e. milk batches which do not comply with the contractually agreed quality standards (see Section 1.2.1) and which cannot be processed in the dairy, must be disposed of.

As in the case of other residues with high organic loading (sterilised separator sludge, unprocessed whey), they should be put to alternative use if at all possible, for example as feed in agricultural (fattening) units. If this is not feasible, the spoilt batches are discharged into the mixing and equalising tanks of the dairy's own wastewater treatment system (see Section 2.3.6), where they give rise to high levels of organic loading.

### **2.3.2 Cultures and adjuvants**

Bacterial and fungal cultures are sometimes used during further processing of the milk. Product-specific mixtures of these cultures can be bought throughout the world. The cultures in pellet form commonly available in industrial countries are less suitable for use in developing countries due to their special storage requirements (- 35°C); freeze dried (lyophilised) cultures can be stored in a refrigerator or even without any cooling if needs be. There are no known factors relevant to the environment or damaging to health.

Adjuvants such as pieces of different kinds of fruit, natural colourings, flavourings, starch, gelatine, pectin, carob meal, carrageen (seaweed extract), alginates, and extracts from coffee, tea, nuts, chocolate etc. are used in yoghurt production, in particular.

There are no known factors relevant to the environment or damaging to health.

### **2.3.3 Products**

With the exception of spoilt batches or returned products that are no longer suitable for human consumption( see Section 2.3.1), there are no known environmentally relevant impacts.

### **2.3.4 Water consumption**

Dairies need large amounts of water, on average 1 - 3 times the amount of milk processed (possible range 0.5 - 11). Water is mainly needed to clean the machinery, the production building and the transport vehicles, but also for cooling, steam generation and chilled water production.

The water used for cleaning the machinery must be in perfect condition in terms of hygiene (which should usually be the case with drinking water), because otherwise cleaning residues in the equipment would lead to contamination of the products. Where perfectly sanitary water is in short supply, the aim must be to minimise water consumption. At the same time this reduces the volume of wastewater (see Section 2.3.6).

### **2.3.5 Cleansing agents and disinfectants**

Dairy machinery is almost always cleaned and disinfected using the recirculation method (CIP method). This is a cleaning method where individual sections of the installation as a whole (piping systems including pumps, separators, heaters, tanks,

bottling lines etc.) are cut off by valves at appropriate points in the piping system and are cleaned and disinfected according to need. The stages in this cleaning method are as follows:

- Initial flushing with water
- Alkaline rinse (0.2 - 2% sodium hydroxide solution)
- Intermediate rinse with water
- Acid rinse (0.5 - 2% formic, citric or phosphoric acid)
- Final rinse with water

The cleansing agents and disinfectants are directed into the mixing and equalising tank of the dairy's own wastewater treatment system (see Section 2.3.6) together with the wastewater.

Relatively small dairies require up to 350 litres of sodium hydroxide solution and up to 170 litres of organic acids per year (both in concentrated form).

Where returnable glass bottles are used, the bottles are pre-rinsed, immersed in 1.5 - 2 % sodium hydroxide solution and then rinsed out again with running water or by spraying. The water consumption is approximately 0.25 – 0.4 litres per bottle.

Diluting the sodium hydroxide solution and the organic acids to concentrations ready for use is unproblematic, and the risk of an occupational accident is low.

The (concentrated) cleansing agents and disinfectants should be stored in a separate room which is lockable and marked clearly as a store for cleansing agents, has a separate catch pit and where an (eye) douche containing sodium carbonate solution or boric acid for the treatment of chemical burns caused by alkaline solutions is installed in case of emergencies.

### **2.3.6 Wastewater**

The wastewater from a dairy can be divided into the following fractions:

- Production wastewater
- Sewage from sanitary facilities
- Rain water (non-contaminated) from sealed surfaces

The production wastewater is mainly contaminated with dissolved organic compounds from production residues (cleaning, losses due to dripping, and residues without further use) and contains only 1 - 2 ml/l settleable substances. Further contamination of the wastewater results from inorganic constituents from cleansing agents, substances containing chlorine or quaternary ammonium compounds from disinfectants and possibly pathogenic bacteria from spoilt batches.

A characteristic feature of the wastewater produced by dairies is that the amount arising is distributed very unevenly over the course of a day. Characteristic data for wastewater from dairy production is summarised in Table 4, while specific data for individual production lines is given in Table 12 in the Appendix.

Table 4: Characteristic data of wastewater from dairy production

	Average amounts (daily average)		Possible range	
Volume of wastewater per 1000 kg milk	1 - 2	m <sup>3</sup>	0.5 – 4.0	m <sup>3</sup>
BOD <sub>5</sub>	800 - 2,500	mg/l	up to 50,000	mg/l
Settleable substances	1 - 2	ml/l	up to 250	ml/l
pH	9 - 10.5		1 - 13	
Temperature	25 - 35	°C	5 - 60	°C

The main determining factors for the organic loading of the production wastewater are the specific production line, the level of raw material and product losses, and the recycling of any resulting by-products. The broad spread of the possible ranges clearly indicates that the wastewater treatment system has to be designed individually to suit each dairy.

Untreated dairy wastewater causes a reduction of the oxygen content in the receiving water because of the breakdown of the organic constituents by microbes. Another effect is an accumulation of nutrients in the water caused by nitrogen and phosphorus from product residues and cleansing agents. If wastewater is discharged into stretches of standing water or if it is only slightly diluted in the receiving water, oxygen deficiency and eutrophication will result.

By way of comparison it should be noted that in dairy production wastewater the concentrations of organic constituents are usually more than double those in municipal wastewater, and that the proportion of settleable substances, roughly 1 - 2 ml/l, is well below that in municipal wastewater.

The high organic loading of the dairy wastewater makes it advisable or imperative to treat the wastewater before discharge into receiving water (the limit values permissible in Germany are listed in the Appendix, Table 13).

The wastewater is pretreated in mixing and equalising tanks. Their purpose is to intercept any shock loading in respect of volume and degree of contamination, and to adjust the wastewater pH to a tolerable level between pH 6.5 and pH 10 by mixing wastewater with different pH levels and by (residual) neutralisation through the addition of acid or alkaline solutions as appropriate.

The organic substances contaminating the wastewater mainly in dissolved form are the reason why solely physical-chemical techniques are insufficient to achieve wastewater purification. Because dairy wastewater generally meets the nutrient requirements of the microorganisms (BOD<sub>5</sub>:N:P = 100:18:1), several aerobic and also anaerobic procedures are available for complete biological purification of dairy wastewater (with required effluent values of max. 30 mg BOD<sub>5</sub>/l), depending on the daily BOD<sub>5</sub> contamination load and on the concentration of contaminating substances present in the wastewater. Table 5 shows procedures suitable for the purification of dairy wastewater. The assignment of the individual procedures to the daily BOD<sub>5</sub> load correlates with the dairy's processing capacity, but is dependent on the BOD<sub>5</sub> concentration of the wastewater (in mg/l) in each specific case.

Table 5: Suitable wastewater purification procedures for dairy wastewater

BOD <sub>5</sub> load	Suitable wastewater purification procedures
up to 200 kg BOD <sub>5</sub> /day	Oxidation ditch, aeration ditch, percolating filter
above 200 kg BOD <sub>5</sub> /day	Low contamination activated sludge processes with sludge stabilisation
approx. 1000 kg BOD <sub>5</sub> /day	Two-stage plants, plastic percolating filters in combination with activated sludge processes
above 1500 kg BOD <sub>5</sub> /day	Combined anaerobic / aerobic plant

To reduce the environmental impact caused by dairy wastewater, the aim must be to bring about an in-house reduction of the wastewater load in combination with subsequent purification of the unavoidable wastewater. In-house measures concentrate on the reduction of product losses as a main source of the contamination load. In addition, measures to capture the individual wastewater components separately are an important part of economical wastewater purification.

The following measures can lead to a reduction in water demand and, as a consequence, a reduction in the volume of wastewater (Table 6):

Table 6: Possible measures for in-house reduction of wastewater load

Leakages	<ul style="list-style-type: none"> <li>• Inspect piping regularly</li> <li>• Weld pipe joints rather than screw-connect them</li> </ul>
Spillages	<ul style="list-style-type: none"> <li>• Monitor the filling level in milk tanks in conjunction with automatic switching off of pumps</li> <li>• Install possible means of separating spoilt batches from production</li> <li>• Sweep up solid product components with a dry brush instead of flushing them out with water</li> <li>• Avoid foaming by filling the tanks from below</li> </ul>
Milk reception and milk storage	<ul style="list-style-type: none"> <li>• Allow sufficient time for the milk churns to be drained</li> <li>• Collect highly contaminated water used for pre-rinsing separately</li> <li>• Empty and clean all containers without delay, to avoid creaming and adhesion</li> </ul>
Processing	<ul style="list-style-type: none"> <li>• Pre-rinse highly viscous products with small amounts of water and reintroduce them into the production line</li> <li>• Collect separator sludge separately (accounts for some 2 - 10% of the entire contamination load)</li> <li>• Cheese-making: reclaim whey where possible, discharge highly contaminated brine baths only in small portions and together with buffering production wastewater containing protein</li> </ul>

Cleaning	<ul style="list-style-type: none"> <li>• Empty the installation prior to cleaning as completely as possible, pipes may be blown clean with air (pipes or tanks which do not drain completely because of deficient installation result in extremely high concentrations of contamination)</li> <li>• Pre-rinse with as little water as possible</li> <li>• Collect final rinsing water to be used for the next pre-rinsing</li> <li>• Use decentralised cleaning (CIP) to enable alkaline and acid solutions to be dosed according to need</li> <li>• Optimise recirculation cleaning procedures</li> </ul>
Water-consumption	<ul style="list-style-type: none"> <li>• Use closed-loop chilled water circulation cooling rather than cooling with well or tap water</li> <li>• Use air cooling for cooling milk after pasteurisation if the energy required is below <math>4 \times 10^5</math> kJ/h</li> <li>• Limit the nominal width of water hoses for cleaning to 1/2 to 3/4 inch, and use self-closing spray attachments</li> <li>• Use high-pressure sprayers for floor cleaning</li> </ul>

To ensure lasting reduction of the consumption of (drinking) water within the company, staff should be alerted to environmental issues and it should be ensured that appropriately skilled staff are available to maintain the machinery.

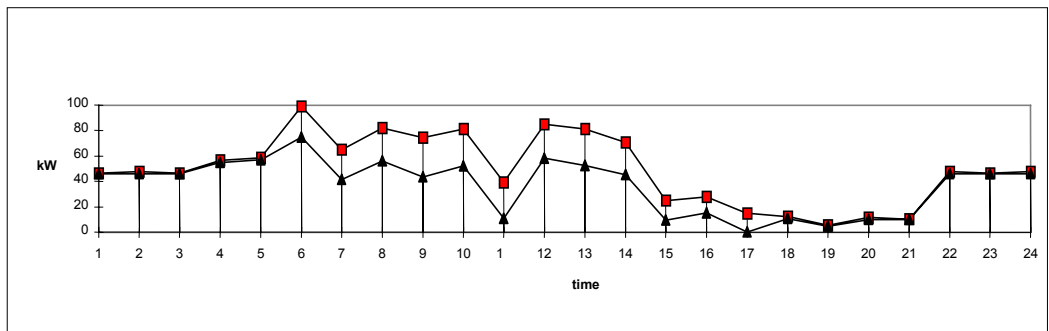
### 2.3.7 Energy consumption, primary energy sources

The amount of energy consumed by dairies is relatively high because the milk needs to be cooled on delivery, then heated briefly for pasteurisation and subsequently cooled again continuously for further processing (chilled-water processing). In more recent plants, process energy consumption is reduced by using efficient heat exchangers (efficiency > 90 %).

As an example, Table 7 shows the electricity consumption of a (modern) dairy with a processing capacity of roughly 15 t milk per day. The energy necessary for emergency operation is shown separately because the capacity of the emergency electricity supply must be designed according to this figure.

Table 7: Energy consumption of a dairy with a capacity of approximately 15 t milk per day (in kW)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
<b>Milk delivery</b>																									
Milk pump	x				1	1	1	1	1																
<b>Raw milk storage</b>																									
Raw milk tanks								1,1		1,1		1,1													
Triblender									2	2															
Milk pump									2	2															
Raw cream tank										1,1		1,1		1,1		1,1									
Milk feed pump						1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1											
<b>Milk pasteurisation</b>																									
Milk pump						3	3	3	3	3	3	3	3	3	3	3									
Hot-water pump						1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1									
Separator						7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5										
Homogenisator						22	22	22	22	22	22	22	22	22	22										
<b>Past. Milchlager</b>																									
3 milk storage tanks		1,1		1,1		1,1		1,1		1,1		1,1		1,1		1,1		1,1		1,1		1,1		1,1	
<b>Bottling/filling</b>																									
Milk pump								1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1									
2 filling machines								4	4	4	4	4	4	4	4	4									
Hot-stamping unit																									
Container washing machine						13	13	13	13	13	13	13	13	13	13										
<b>Butter-making</b>																									
2 cream tanks																									
Circulation pump																									
Cream pump								1,1		1,1															
1 cream tank					1,1		1,1		1,1																
1 butter chum								4		4															
<b>CIP-Station</b>																									
Feed pump									3		3		3		3		3		3		3		3		
Return pump									2		2		2		2		2		2		2		2		
<b>Compressed air supply</b>																									
Compr. Air piston compr.						5,5		5,5		5,5		5,5		5,5		5,5		5,5		5,5		5,5		5,5	
Compr. Air refrig. drier						0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	
<b>Steam supply</b>																									
Steam boiler				From power plant																					
Hing-press. Centrif. pump burner																									
Water heater 2000 ltr.			alternative			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	
<b>Water supply</b>																									
Circulation pumps																									
Softening unit																									
Metering unit																									
Oil storage																									
<b>Cooling system</b>																									
Chilled-water agitators	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	
Refrigeration equipment	x	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	
Evaporator for cold stores	x																								
Chilled-water pump. set					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
<b>Lighting</b>	x	1	1	1	10	10	10	5	5										5	5	10	10	1	1	1
<b>Electrical energy (kW)</b>	47	48	47	57	59	99	65	82	74	81	39	85	81	71	25	28	15	13	5,5	12	11	48	47	48	
Essential electrical energy	46	46	46	55	57	75	42	56	44	52	11	58	53	45	9,7	15	0,5	11	5	10	10	46	46	46	



### **2.3.8 Waste air**

The waste air from the processing operations of dairies contains no air pollutants. Odour emissions are mainly caused by waste air from the areas of processing, wastewater purification and steam generation.

These emissions can be reduced by a number of measures, starting from the use of covered, odour-sealed sewers in the production building, through appropriate air purification in the exhaust vent installation (for example by adsorption (biological filters, biological air scrubbing) or absorption processes (physical-chemical processes)) to the selection of the site for wastewater treatment and covering the activated sludge tank used in the activated sludge process.

With regard to the combustion of fossil fuel in combined heat and power stations, the aim should be to limit emissions. When burning low quality heavy oils, in particular, increased quantities of pollutants are released, among them relatively large amounts of health-threatening heavy metals such as nickel and vanadium. Appropriate waste gas treatment should therefore be implemented, and facilities that are untenable from the standpoint of protecting the environment should be replaced by more modern ones.

In older chilled-water systems operating with ammonia as the coolant, leaking ammonia can endanger the health of staff because of its powerfully corroding effect on mucous membranes. For this reason, more modern, CFC- and ammonia-free chilled water systems should be employed if at all possible. Otherwise adequate maintenance of the equipment must be ensured.

### **2.3.9 Waste heat**

In dairies waste heat is mainly generated by the following:

- Milk pasteurisation
- Heat exchangers in the chilled-water system
- Superheated steam power plant

Waste heat is dissipated via the waste air and wastewater. In terms of its environmental impact, the heating of waste air can be considered to have little detrimental effect. In contrast, the raised temperature of the wastewater may conceivably have a significant effect on conditions in the receiving water if there is insufficient cooling during the wastewater purification phase.

The temperature of the wastewater can range from 5°C to 60°C depending on local climatic conditions. Daily mean values are stated as being 25°C to 35°C. Modern facilities have heat recovery systems, which result in a considerable decrease in wastewater temperatures. When older dairy facilities are renovated this has to be taken into account if anaerobic wastewater treatment is considered as an option (because of the higher wastewater temperatures during the production process).

### **2.3.10 Waste material**

The separator sludge produced during milk processing is an organic residue, and if possible should be put to alternative use (see Section 2.3.1).

The bulk of the waste material arising in a dairy is made up of the packaging for the cleaning agents and disinfectants, the overwrap of the product packaging and, if

returnable systems are used, the product packaging (bottles) rejected as unsuitable for further use.

These waste materials should be disposed of or recycled according to existing regulations (see Section 2.3.11).

### **2.3.11 Product packaging**

In the following an example is used to illustrate some important aspects of potential endangering of the environment caused by the different forms of packaging for fresh milk and fresh milk products (see Section 1.2.3).

The life-cycle assessment (LCA) for fresh milk packaging drawn up under the auspices of the German Federal Environmental Agency (Umweltbundesamt; 1995) is based on the typical scenarios in Europe regarding the distance from the packaging manufacturer to the packaging user, distribution distances, number of return cycles for returnable packaging, and disposal situations (1-litre containers, 1000 litres milk, transport distance 100 km, returnable glass bottles with 25 return cycles, usual overwrap).

The terms defined in Section 1.2.3 are used in abbreviated form (block, tube, ret. glass) to identify the individual kinds of packaging. An overview of the market share of the individual kinds of packaging in Germany is given in the Appendix, Table 14.

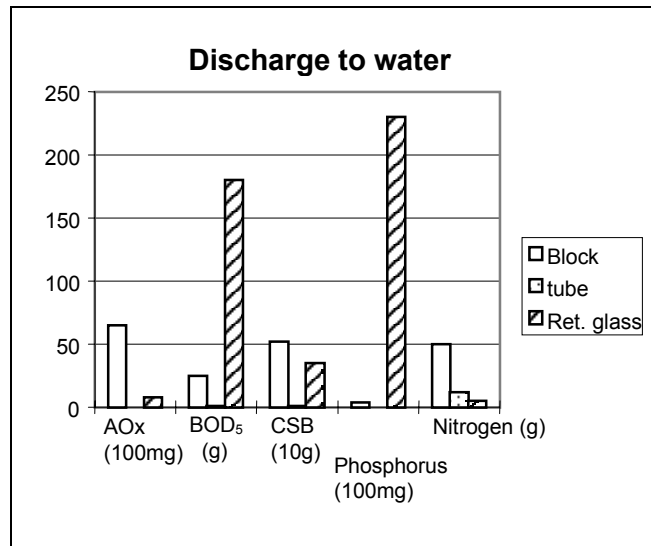
The main contributory factors to the water consumption inventory (Fig. 3) are consumption during manufacturing of the packaging and consumption during washing of the returnable glass bottles. The frequency of washing has relatively little effect on the overall inventory compared to water consumption during manufacturing.

In the water pollution inventory (Fig. 2) the repeated washing of returnable glass bottles leads to high BOD<sub>5</sub> and COD loading of local stretches of water. In the case of disposable packaging, water pollution only arises locally where the packaging is manufactured.

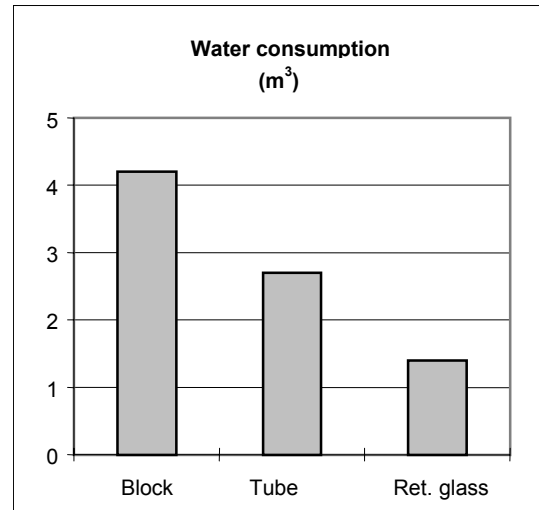
The atmospheric emissions inventory (Fig. 4) is affected not only by the manufacturing materials balance but also the high net weight of the returnable glass bottles in the form of transport energy (exhaust emissions). As the number of return cycles increases, the balance shifts in favour of returnable glass bottles.

The inventory of occupied volume in landfill sites (Fig. 5) clearly mirrors the high return rate of the returnable glass bottles. As the number of return cycles increases, the balance will continue to shift in favour of returnable glass bottles.

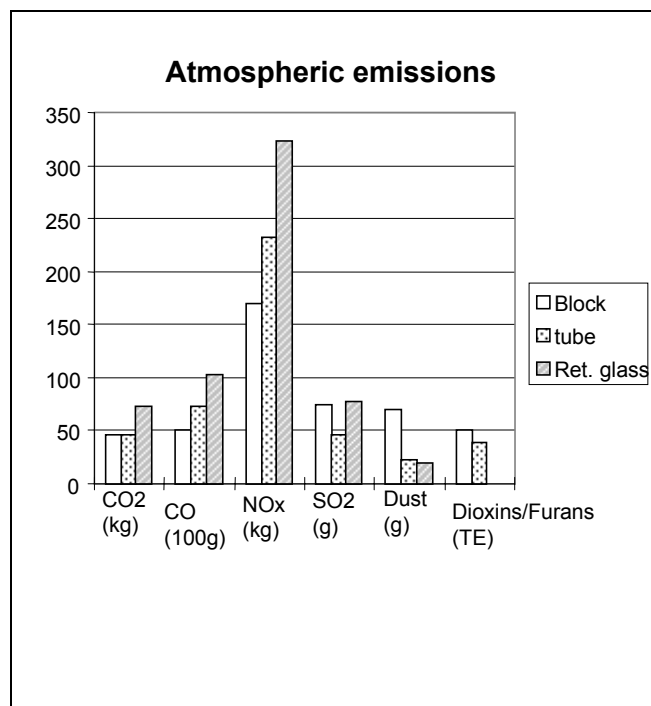
**Fig. 2: Water pollution**



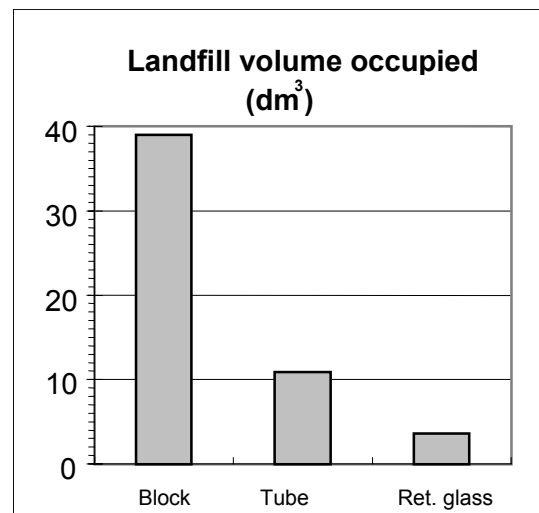
**Fig. 3: Water consumption**



**Fig. 4: Atmospheric emissions**



**Fig. 5: Landfill volume occupied**



The preparation of a life-cycle assessment largely depends upon the given basic conditions, such as production conditions, distribution conditions, energy supply, water supply, wastewater treatment systems, waste disposal and recycling schemes, capacities of landfill sites, climatic conditions etc. Being based on European conditions, therefore, this LCA cannot simply be applied to developing countries without suitable adjustments.

To assist in the assessment of the potential environmental impact from (fresh milk) packaging, basic data on the consumption of raw material, water and energy as well as on water and air pollution caused by returnable glass bottles and block packaging are

shown in the Appendix, Table 15. The data on the distribution of returnable glass bottles has been adjusted to a more realistic number of 10 return cycles (transport conditions) for developing countries.

Before a certain kind of packaging is introduced, it is necessary to clarify certain other parameters on location.

For the introduction of a disposable packaging scheme (block, gabled or tube packaging):

- Acceptance of the packaging material among the local population
- Potential for further use or for regulated disposal of the packaging

For the introduction of a returnable packaging scheme (glass or PE bottles)

- Financing of the higher investment costs on the part of the dairy, distribution business and trade (ratio of disposable to returnable scheme approx. 1 : 1.5)
- Acceptance of the higher price of milk caused by the higher costs of the scheme
- Acceptance of a deposit system
- Possible number of lost bottles and bottle crates due to alternative use (can be influenced by amount of deposit payable)
- Expected rate of breakage as a consequence of the local infrastructure (roads, means of transport)
- Expected number of return cycles according to the quality of the packaging

In developing countries with a shortage of foreign currency, the variable ongoing requirement for foreign currency should be taken into consideration as a selection criterion for the different kinds of packaging.

### **2.3.12 Noise**

Potentially considerable noise sources in dairies are as follows:

- Production machinery, in particular heavy-duty pumps (sometimes > 90 dB(A)), separators (80 - 85 dB(A)) and spray dryers for powdered milk production
- Bottle cleaning and bottle filling equipment
- Milk collection and product loading stations

Certain areas of dairy plants must be regarded as noise-intensive facilities. A reduction in noise pollution for staff and neighbouring homes can be achieved in the following ways:

- Planning the establishment to be a certain minimum distance from residential buildings and taking into account the main wind direction towards those buildings
- Encapsulation of machinery
- Keeping windows and doors of the production building shut
- Integration of sound-insulating walls (bottling)

In respect of the noise-intensive areas of a dairy, in-house regulations should provide for and ensure the use of ear protectors.

### **2.3.13 Accident hazards**

The workplaces in a dairy do not represent a source of extreme risk of accidents for staff. One main cause of accidents is wet and therefore slippery floors. Appropriate non-slip shoes should be provided. Other potential sources of accidents are the handling of chemicals in the laboratory and the preparation of diluted acids for cleaning

purposes. All regulations in force must be observed; if necessary, relevant regulations should be drawn up within the company (see Section 2.3.5).

In Germany the general regulations for accident prevention in food-processing enterprises apply; there are no special accident prevention regulations for dairy businesses.

#### **2.4 Risk potential arising from product marketing**

In this area as in the area of milk collection, the factors relevant to the environment are transport and cooling. The same comments apply as in sections 2.1.2 and 2.1.3.

### **3. Notes on the analysis and evaluation of environmental impacts**

If there are no regulations at the national level regarding evaluation of the quality of the raw milk delivered to the dairy, limit values and reference values should be laid down in delivery regulations agreed between the dairy and the producers' associations. In Germany these values are specified in the milk quality ordinance (see Appendix, Table 9).

As of a pH value < 6.3, the (raw) milk coagulates during heating (pasteurisation) and can therefore not be processed any further; if necessary the pH can be raised by mixing the milk with another batch.

The delivery regulations should stipulate the price of the milk in relation to its quality (grading) as well as the analytical techniques for assessing the quality of the (raw) milk. A suggestion for the implementation of quality testing is included in the Appendix, Table 10.

Limit values and reference values for wastewater contamination should be specified. In Germany these are laid down in the Water Resources Act, § 7a, Appendix 3 (Milk Processing).

If there are no regulations at the national level, an analysis should be conducted to determine the prerequisites under which the dairy wastewater can be discharged to a municipal wastewater treatment plant or how the local population can be safeguarded in general from the impacts caused by pollution of the groundwater and eutrophication of surface waters. In this connection, external factors such as the degree of dilution of the wastewater and contamination of the water by other dischargers etc. must also be taken into consideration.

The level of water consumption by a dairy should be within the bounds of the reference value of 1-3 t water per t milk. With regard to hygiene requirements, the national drinking water standards should be observed. In Germany the water must meet the requirements for drinking water according to § 1 - 4 of the Ordinance on Drinking Water and Water for the Food Industry (TrinkwV).

In countries where (drinking) water is in short supply, the possible means of reducing water consumption pointed out in Section 2.3.4 should be implemented as far as possible.

According to the 1988 Montreal Protocol and its 1990 London Amendment on the reduction of ozone-depleting halogenated compounds, cooling units with CFC-free coolants must be installed when a new dairy is built.

If older dairies are renovated, it is recommended that refrigeration units containing CFCs or ammonia should be replaced. The old units must be disposed of as hazardous waste.

The energy consumption of a dairy should be optimised by using more modern installations with heat exchangers to make use of the waste heat. Reference value: 4 - 7 kWh per t milk.

With regard to the burning of fossil fuels in combined heat and power plants, the aim should be to limit emissions and not to transfer problems elsewhere through a policy of building high chimneys. Generally speaking, the limit values determining the point from which odour-active aerosols constitute a nuisance must be brought in line with the tolerance thresholds in the population, which vary locally. In Germany the limit values for tolerable air pollution are laid down in the technical directive on air quality control (TA-Luft).

The different degrees of potential hazard from the various types of packaging for fresh milk and fresh milk products are still the subject of controversial discussion in Germany today; it is therefore difficult to make any general comments on the advantages and disadvantages of individual kinds of packaging.

From the observations in Section 2.3.11 the trend can be deduced that lightweight packaging with a low transport volume has distinct advantages in economic and environmental terms if the packaging is delivered from far away (or if the packaging is imported).

The same applies if the fresh milk or fresh milk products are distributed over great distances (more than 50 - 100 km) or if the prevailing transport conditions make it likely that there will be a high rate of glass breakage.

DIN 18005 can be used as an aid to forecasting the noise pollution affecting neighbouring areas (although the reference values in this DIN standard are not necessarily suitable for making practical assessments).

For noise protection within the dairy, the German ordinance on places of employment and the accident prevention regulation on noise (a regulation drawn up by the employers' liability insurance associations) allow maximal levels of 85 dB(A) (equivalent continuous sound levels over 8 hours). At levels above this threshold, personal noise protection devices must be provided, and they must be worn at levels above 90 dB(A).

The site analysis for a dairy should not only examine the economical and ecological aspects discussed above but also socio-economic factors (issues regarding employment opportunities, gender-specific division of labour, working conditions, income conditions etc.).

#### **4. Interaction with other sectors**

Further information on the identification, assessment and reduction of environmental impacts caused by the circumstances surrounding milk production can be found in the following environmental briefs:

- Plant production (forage growing and cereal growing)
- Livestock farming
- Veterinary services

Further information on the identification, assessment and reduction of environmental impacts caused by milk processing can be found in the following environmental briefs:

- Planning of locations for trade and industry
- Water supply
- Wastewater disposal
- Solid waste disposal

Further information on the identification, assessment and reduction of environmental impacts caused by the manufacturing of packaging can be found in the following environmental briefs:

- Glass
- Pulp and paper

Further information on the identification, assessment and reduction of environmental impacts caused by the disposal of cooling equipment containing CFCs and ammonia can be found in the following environmental briefs:

- Disposal of hazardous waste

## **5. Summary assessment of environmental relevance**

The main environmental impacts caused by the running of a dairy are the result of:

- Spoilt batches
- Transport energy (exhaust emissions)
- High water and energy consumption
- Wastewater with high organic loadings
- Noise
- Manufacture and disposal of product packaging

In the field of milk collection, potential hazards can be largely reduced by avoiding spoilt batches. This can be achieved by providing appropriate training in milk hygiene and animal care for the (small-scale) producers involved, by ensuring contractually agreed quality control in coordination with the producers' associations, and by establishing a milk pricing arrangement dependent on quality (grading).

The potential hazards deriving from refrigeration equipment in milk collection stations can be eliminated by using CFC-free equipment.

The environmental pollution caused by the exhaust emissions of the transport vehicles is unavoidable, but relatively insignificant in relation to traffic as a whole.

Depending on the processing capacity of the dairy, the field of milk processing (in dairies themselves) may be a source of considerable environmental impacts. These can be reduced in the following ways:

- Installing appropriately designed technical equipment in the dairy
- Having technical staff available who are adequately trained and aware of environmental issues (socio-economic factors may be of considerable importance in this respect)
- Optimising the use of primary energy sources (heat exchangers, waste heat from other plants)

- Optimising consumption of (drinking) water
- Maintaining the machinery
- Ensuring an adequate supply of spare parts
- Using an appropriately designed in-house wastewater treatment system
- Implementing in-house measures to reduce contaminant loading
- Implementing in-house measures to reduce noise emissions
- Introducing a packaging system that is also acceptable from an ecological standpoint
- Making use of the available opportunities for the controlled landfilling or recycling of waste substances

In the field of product marketing the potential danger caused by cooling equipment in sales outlets can be eliminated by using CFC-free units. With regard to the environmental impact caused by the exhaust emissions of transport vehicles, the same comments apply as to the field of milk collection.

## 6. References

Authors	Title	
ATV (Edit.)	Lehr- und Handbuch der Abwassertechnik, 3rd revised Edition, Vol. IV + Vol. V	Ernst & Sohn, Berlin 1985
Bertsch	Wasserverwendung in Molkereien – Verbrauchsdaten, Kosten und Einsparmöglichkeiten	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Bertsch	Molkereiabwasser als Kostenfaktor – Bestandsaufnahme	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Bischoff, E.	Ökobilanz oder Umweltchimäre Kommentar zur Untersuchung des Deutschen Umweltbundesamtes	Getränkeindustrie 10/1994, Year 48, pp. 788 - 793
Bojkow, E.	Umweltfragen der Getränkeverpackung – Aktueller Wissensstand	ZFL 41/1990 No. 5, pp. 274 - 288
Doedens, H.	Problematik der Starkverschmutzerzuschläge	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Goldbach, H	Berücksichtigung der Umweltverträglichkeit bei der Planung und Sanierung lebensmittelverarbeitender Betriebe am Beispiel des albanischen Molkereisektors	Master Thesis, Faculty of Civil Engineering and Surveying, University of Karlsruhe 1993
Grundke, G.	Recycling und Ökobilanzen von Packmitteln aus Kunststoffen	ZFL 43/1992, No. 1/2, pp. 50 - 53
GTZ (Ed.)	Abwassertechnologie: Entstehung, Ableitung, Behandlung, Analytik der Abwässer	Springer Verlag, Berlin 1988
Güngerich,	Membrantechnik in der Wasser-/Abwasseraufbereitung in Molkereien (Brüdenwasser - Aufbereitung, Wiederverwendung)	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Hiddink, J.	Overview from a processor's perspective	Internationaler Milchwirtschaftskongress, New Delhi, 23, Montreal, 8.-12.10.1990, Vol. 2, page 803 ff
Hui, Y.H. (Ed.)	Dairy science and technology handbook, Vol. 1, 2, 3	VCH Verlagsgesell. New York, Weinheim 1992
Immerz, J.	Molkereiabwässer - Möglichkeiten und	dmz deutsche molkerei-zeitung

<b>Authors</b>	<b>Title</b>	
Guthy, K.	Grenzen der Beseitigung. Eine Literaturübersicht	34/35/45/49, 1987
Klöpfer, W.	Ökobilanzen als Instrument der Produktbewertung	Chem.-Ing-Tech. 65/1993, No. 11, pp. 1313 - 1317
Kielwein, G.	Leitfaden der Milchkunde und Milchhygiene	Verlag Paul Parey, Berlin-Hamburg 1985, 2nd Edition
Lammers, W. Frerich-Sagurna, r.	Transporte in der Ökobilanz	p&t, interpack Messe 1990 Schnelldienst 4, pp. 18 – 21
Mann, E.J.	Molkereiabwasser - Behandlung und Verwertung	Welt der Milch, 47, 1993, p. 509 ff
Mosthaf, H.	Wie erstellt man eine Ökobilanz?	neue verpackung 8/1990, pp. 80 - 82
N.N.	Mindestanforderungen an das Einleiten von Abwasser in Gewässern - §7a Wasserhaushaltsgesetz- Milchverarbeitung -	Bundesanzeiger (Federal Gazette) 1994
N.N.	Tetra Brik Umweltprofil	dmz deutsche molkerei-zeitung 13/1987, pp. 399 - 402
N.N.	Und es geht doch - Polycarbonat-Mehrwegflaschen	ZFL 45/1994, No. 1/2, pp. 42 - 43
N.N.	Methode für Lebenswegbilanzen von Verpackungssystemen	Fraunhofer Institut für Lebensmitteltechnologie, Munich; Institut für Energie und Umweltforschung, Heidelberg; Gesellschaft für Verpackungsmarktforschung, Wiesbaden, 1992
N.N.	Ökobilanz für Getränkeverpackungen (Vorabauszug)	Umweltbundesamt, Press Release 52/93
N.N.	Ökobilanz für Getränkeverpackungen	Umweltbundesamt, Texte 52/95
N.N.	Molkereitechnik, Band 64, Die neuen Richtlinien für Molkereiabwässer	Schriftenreihe des Verlages Th. Mann, Gelsenkirchen 1984
Noda, N.	Molkereiabwasser - Eigenschaften, Reinigung, Schlammbehandlung	Dissertation TU Hannover 1980
Nyhuis, G.	Biologische Abwasseraufbereitung	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Ohst, S.	Polycarbonatflaschen für Milchprodukte	ZFL 45/1994, No. 11, pp. 50 - 53
Schließer, Th. Strauch, D.	Desinfektion in Tierhaltung, Fleisch- und Milchwirtschaft	Enke Verlag, Stuttgart 1981
Schonert, M.	Ökobilanzen - was wird hier eigentlich bilanziert?	ZFL 43/1992, No. 1/2, pp. 42 - 49
Schricker, G.	Die Verpackung zwischen Ökonomie und Ökologie	ZFL 8/1988 pp. 655 - 658
Stehle, G.	Alles Öko - oder was? (Verpackung)	Deutsche Milchwirtschaft 24/1994, Year 45, p. 1201
Strecker, A.	Ökobilanzen - Sinn und Unsinn	Verpackungs-Rundschau 3/1992 Year 43, pp. 26 - 31
Tharun, G. Thanh, N.C. Bidwell, R.	Environmental Management for Developing Countries: Vol. I + III	Asian Institute of Technology, Carl Duisberg Gesellschaft, Enviromental Resources Ltd Bangkok 1983
Traxdorf,	Rechtsgrundlagen und deren Bedeutung für die Praxis	Seminar "Wasseraufbereitung und Abwasser in Molkereien", Ulm, November 1993
Wietbrauk, H.	Milchverpackung: Einweg oder Mehrweg?	Forschungsreport Nr. 3, 1988 Bmf. Ernährung, Landwirtschaft und Forsten (Fed. Ministry of Food,

---

<b>Authors</b>	<b>Title</b>	
		Agriculture and Forestry)
Wildbrett, G., Böhner, B.	Phosphor u. Stickstoffbelastungen in Abwässern aus milchverarbeitenden Betrieben	dmz, Lebensmittelindustrie und Milchwirtschaft, Part 1: 37, 1990; Part 2: 39, 1990;
World Bank (Hrg)	Environmental Assessment Sourcebook Vol. II	World Bank Technical Paper Number 140 (1991)
World Bank (Hrg)	Environmental Assessment Sourcebook Vol. III	World Bank Technical Paper Number 154 (1991)

## 7. Appendix

### re 1.1.2 Milk yields

Table 8: Average milk yield and composition of milk from different species of domestic animals

Species	Milk yield kg milk/year	Lactation days/year	Milk constituents in %					
			Fat	Protein	Casein	Lactose	Mineral elements	Dry matter
Cow	900 - 8,000	up to 300	4.0	3.2	2.5	4.7	0.7	12.7
Sheep*	400 - 500	200	7.2	6.5	4.5	4.3	0.8	18.5
Sheep	120 - 150	120	7.2	6.5	4.5	4.3	0.8	18.5
Goat	500 - 600	200 - 250	4.9	4.3	3.3	3.9	0.8	14.2
Buffalo			7.7	4.1	3.5	4.8	0.7	17.6
Camel	500 - 3,600	up to 300	3.9	2.9				
Horse			1.6	2.0	1.2	6.4	0.4	10.5
Donkey			1.4	1.9	1.0	6.2	0.5	9.9
Rein- deer			19.7	10.9	8.7	3.6	1.4	35.7

\* - Dairy breeds

### re 1.2.1 Milk grading criteria

Table 9: Limit values for milk grading according to the milk quality ordinance in the Federal Republic of Germany (cows' milk)

Grading characteristics	Grade*)	Number of bacteria (per ml)		
		before 1986 (FRG)	1994 (FRG)	from 1.1.1998 (EU)
Bacteria (per ml)	1	up to 500 000	up to 100 000	up to 100 000
	2	up to 2.5 mill.	up to 400 000	more than 100 000
	3	up to 4 mill.	more than 400 000	not marketable
	4	more than 4 mill.	not marketable	
Somatic cells (per ml)		more than 750 000 milk price deduction	below 400 000 milk price deduction	more than 400 000 not marketable
Freezing point		above -0.515°C not marketable	above -0.515°C not marketable	above -0.515°C not marketable
Inhibitors detectable		not marketable	not marketable	not marketable

\*) Grade 1, no deduction; Grades 2 to 4 increasing deductions in milk price or milk no longer marketable.

It must be pointed out that the high demands on the quality of milk (FRG 1994, EU 1998) can only be met if good hygienic standards are observed during milking and if the milk is cooled immediately and kept cool continuously (4°C - 8°C).

From the standpoint of processability, the values in force in Germany until 1986 are sufficient.

Table 10: Suggestion for the implementation of quality testing

Quality characteristics	Test method	Frequency
Smell and appearance of the milk		2 x per month
Fat content		2 x per month
Density and fat-free dry weight		2 x per month
Dilution	Alcohol test	daily, on site
Number of bacteria	Laboratory	
Number of somatic cells		
pH value	pH meter	daily, on site
Acidity (SH value)	Soxhlet - Henkel	
Freezing point		
Inhibitors	Delvotest	1 x per month.

### re 1.2.2 Processing

Table 11: Time - temperature combinations for milk pasteurisation [Lewis, 1986].

Country/region	Pasteurisation	
	Temperature	Duration
Central Europe	74 °C	30-40 s
GB	62.8-65.6 °C	at least 30min
	71.7 °C	at least 15 s
USA	63 °C	30 min
	77 °C	15 s
	89 °C	1 s
	94 °C	0.1 s
	96 °C	0.05 s

## re 2.3.6 Wastewater

Table 12: Dairy wastewater – typical characteristic data and characteristic data according to production line, with reference to 1000 litres raw milk

	Specific wastewater volume (m <sup>3</sup> )			BOD <sub>5</sub> kg			COD kg			Settleable mat. kg/m <sup>3</sup>		
	min.	max.	Ø	min.	max.	Ø	min.	max.	Ø	min.	max.	Ø
<b>Typical data for dairy wastewater</b>												
And possible ranges	0,50	4,00	1,50	0,30	5,00	1,60				1,00	13,00	10,20
pH	9,0	10,5	9,7									
Temperature (°C)	5,0	60,0	30,0									
<b>Type of production</b>												
<b>Group</b>												
1: Consumer-ready milk and Fresh milk products	0,90	4,20	2,84	1,04	4,16	2,42	1,59	6,24	3,21		1,10	0,90
2: Butter												
Batch method	16,00	44,50	25,00	12,50	50,20	13,60	14,80	73,60	18,20	0,10	1,00	0,90
Continous method	10,50	1,00	20,60	20,60	7,20	18,50	10,10	53,40	30,60	0,30	7,80	4,90
3: Cheese without whey draining												
Uncured cheese	1,93	3,50	2,20	1,25	4,25	1,80	1,53	8,10	2,29	3,00	5,40	5,00
Soft cheese	3,10	3,12	3,11	1,67	3,45	2,14	2,02	4,27	2,98	0,04	2,30	0,80
Semi-hard cheese	0,61	3,86	1,52	0,81	3,43	1,32	1,15	6,05	2,72	0,40	1,90	0,90
Hard cheese	0,85	4,01	1,74	1,38	2,19	1,54	2,00	2,96	2,23			1,30
Processed cheese	3,25	8,00	4,70				2,81	4,47	3,46	0,12	0,20	0,20
4: Cheese with whey draining	Ø group 3 + 0,85, respectively					37,50			58,00			
5: Condensed milk			0,80 *)				0,41	0,53	0,44	0,05	0,20	0,20
6: Powdered milk												
Spray-drying process	0,32	0,68	0,46 *)	0,20	0,60	0,40	0,40	0,81	0,60	1,30	4,60	2,80
Milling process			0,50 *)			0,30			0,61			5,80
7: Whey products												
Powdered whey	0,13	1,36	0,53 *)			0,45	0,72	0,88	0,75	8,80	30,00	23,40
Lactose	0,13	0,52	0,33 *)	0,27	0,68	0,48	0,60	1,52	1,07	1,40	4,10	2,80
8: Casein												
Acid casein			0,84 *)	0,84		1,14			2,57			1,50
Rennet casein			0,80 *)	0,80		3,89			8,18			3,20

\*) Not including vapour condensates

### re 2.3.6 Wastewater

Untreated dairy wastewater exceeds the (German) limit values for discharge into receiving water and the values for discharge into public wastewater treatment plants.

In Germany, according to ATV Work Sheet (Arbeitsblatt) A115 commercial and industrial wastewater can only be discharged into **public wastewater treatment plants** if it does not exceed the following limit values:

- Maximum temperature 35 °C
- pH value between pH 6.5 and pH 10
- Saponifiable fats and oils no more than 200 mg/l

Similarly there are also minimum requirements for the discharge of dairy wastewater into **receiving water** [Appendix 3 of the Rahmen-AbwVwV (Framework Administrative Provisions on Wastewater) according to § 7a WHG (Water Resources Act), 1993].

Table 13: Minimum requirements on the discharge of dairy wastewater into receiving water

	Settleable substances	COD (mg/l)	BOD <sub>5</sub> (mg/l)
Random sample	0.5 (ml/l)		
2-hour mixed sample		110	25
24-hour mixed sample		125	30

### re 2.3.11 Product packaging

Table 14: Packaging systems for fresh milk and their market share in the Federal Republic of Germany

<b>Market shares in FRG</b>	1985	1987	1989	1990	1991
Block packaging (composite cardboard)	91,8%	88,0%	82,3%	75,5%	71,1%
Tube packaging (PE)	4,5%	3,8%	2,4%	1,9%	1,6%
Tubs (PE)	0,2%	0,2%	0,2%	0,1%	0,1%
PE bottles (returnable)	3,3%	2,7%	2,5%	2,4%	2,3%
Glass bottles (returnable)	0,2%	5,3%	12,6%	20,1%	24,8%
Container-distributors, 150-300 l. (+ milk churns/glass bottles)					
PE-tube-distributors, 25-50 l. (+milk churns/glass bottles)					

Table 15: Materials balance between returnable glass bottles and block packaging (with reference to 1000 l fresh milk in 1-litre packs)

<b>Raw mat. consumption</b> kg/1000 l	25 gr <b>Block</b>	480 gr <b>Glass ret. 10</b>	<b>Energy consumption</b> MJ/1000 l	25 gr <b>Block</b>	480 gr <b>Glass ret. 10</b>
Wood	38,18	0,75	Board manufacture	790	
Pyrite	1,09		LDPE	490	20
Oil	0,48		Coating	100	
Chemicals	3,55		Glass manufacture		530
Bauxite		0,14	Paper manufacture		20
Sand		27,15	Cleaning		290
Limestone		13,45	Filling	150	200
Dolomite		3,12	Distribution	430	620
Feldspar		1,91	Retail trade	310	460
Salt		10,57	Waste transport	0	10
<b>Total</b>	<b>43,30</b>	<b>57,10</b>	Heat recovery <sup>1)</sup>	-430,00	-10,00
			<b>Total</b>	<b>1.840,00</b>	<b>2.140,00</b>
<b>Water consumption</b> m <sup>3</sup> /1000 l			<b>Water pollution</b> kg/1000 l		
Paper manufacture	2,31		Salt (manufacture)		2,82
Glass manufacture		0,52	Suspended substances	0,07	0,78
Bottle washing		11,50	BOD <sub>5</sub>	0,06	0,25
<b>Total</b>	<b>2,31</b>	<b>12,02</b>	COD	0,34	
			<b>Total</b>	<b>0,46</b>	<b>1,03</b>
<b>Air pollution</b> kg/1000 l			<b>Amount of solid waste</b> kg/1000 l	<b>25</b>	<b>48</b>
Oxides of nitrogen	0,72	1,06			
Hydrocarbons	0,19	0,17			
Carbon monoxide	0,19	0,17			
Oxides of sulphur	0,84	1,21			
Miscellaneous					
Organic compounds	0,17	0,03			
<b>Total</b>	<b>0,17</b>	<b>0,03</b>			

1) in waste incineration plants or from recycling of waste glass