Pure & Appl. Chem., Vol.52, pp.2005-2015. 0033-4545/80/0801-2005$02.00/0
Pergamon Press Ltd. 1980. Printed in Great Britain.

LOW WASTE TECHNOLOGY IN FOOD INDUSTRIES

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Abstract - There is presented a brief survey discussing additional methods and possibilities for reducing the amount of waste and load in the food processing industries. There are emphasized methologies and technologies, which can be employed in factory production to bring about a reduction in waste amounts. Representative examples of applications as applied to the vegetable, food, canning, the starch, and beverage industries are presented. Specific processes such as dry peeling, modern blanching, vacuum filling, residue recovery etc. are also discussed. In addition there are described 3 examples of water reuse duel recycling in the starch, sugar, and vegetable industries, which reduce the amount of waste.

In conclusion the author contends that as result of his experiences proper organisation of the production process, and technical training of operating personal in the arts water saving can lead to meaningfull savings within the food preparation industry.

INTRODUCTION

A major portion of production costs in the food processing industry is caused by costly input water supply and the subsequent waste water discharge. Anticipated costs for discharged waste water conveyance in the Federal Republic of Germany will rise from DM 12.00 in 1981 to DM 40.00 in 1986, in accordance with the provisions of the Waste Levy Law enacted 13. Sept. 1976 (termed Abwasserabgabengesetz). Since also food processing firms discharging their waste water into municipal sewer systems are presumably charged for it by local communities, it becomes increasingly necessary for food processing plants to reduce quantities of discharged waste substances, and especially so in order to minimize waste water disposal costs as unit costs of disposal increase. Most residue substances resulting from food processing are easily biodegradable.

The several possible methods for reducing the waste load during the plant preparation processes may be broadly categorised by two different methods:

a. Either the application of production methods and procedures with minimal or no waste water to include methods for regaining stuffs from the water, or;
b. application of water cycles.

Most of the following descriptive processes will deal with new production methods now employed in the vegetable and fruit canning industry, the starch, the beverage, and the sugar industry for example. Due to space limitations, water cycles and other paliative measures for saving water in affected factories will be discussed only briefly.

ALTERNATIVES FOR REDUCTION OF WASTE WATER IN THE FOOD PROCESSING INDUSTRY

Application of Production Methods and Measures with Minimal or the total absence of Waste Water and additionally Procedures for Regaining Stuffs from Resulting Wastes

Vegetable and Fruit Canneries

In the following sub-sections, some representative new production methods, which result in a lower specific waste water load, will be presented. These methods are particularly applicable in the peeling, blanching, and container filling and packing operations of vegetable and fruit canneries.

In these canneries peeling is normally accomplished through the use of either steam or lye. The waste residue producing portion of both peeling methods lies in the final water rinsing. However unlike the steam peeling method, the lye peeling method produces an inorganic load in addition to the organic load as a consequence of the necessity for neutralisation. As a result the lye peeling method is increasingly supplanted by the steam peeling method in plant operations.

The further development of a dry peeling process for such edibles as carrots and potatoes has resulted in an additional and substantial reduction in the quantity and the load of waste water. In this dry peeling process, the raw food stuffs are briefly heated by steam under a pressure of 16 bar. Only the outer thin layer is boiled and thus it is easily removed resulting in a marked reduction of product loss.

Although there are several different types of dry peeling machines in use, they are apparently still in the development prototype stage. The preferent machines in general use today are machines with processing cylinders aligned or straightened to conform to transport flow direction. Fig. 1 shows a cross section of this type machine.

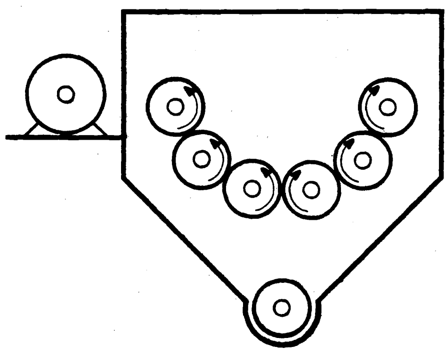

Fig. 1. Cross section of a cylindrical dry peeling machine according to Steverding (Ref. 21).

The length of the cylinders is about 4 m and the diameter about 0,2 m. The cylinders are built as cage-type cylinders containing iron ribs. Thus peels an other waste materials are permitted to fall through the aperture between the ribs. In the final quarter of the machine the potatoes or carrots are rinsed by water sprinklers.

Factories using this method report over a two thirds reduction in waste water quantity and over a three quarter reduction of the waste load mass (Ref. 27 & 22), see table 1.

TABLE 1. Comparison of water consumption and waste water load of a pommes-frites factory using the lye-method and the dry-peeling method (Ref. 22)

	dimension	lye-peeling	dry peeling
water consumption per t potatoes	m^3/t	5,7	1,9
p.e. per t potatoes	p.e./t	503	112

The waste of a pommes-frites production line using the dry-peeling method is approximately 150 kg per t of potatoes; of this quantity 13% is dry matter (d.m.). The final rinsing process results in approximately 206 kg/t of which 3.3% is d.m.. In the final phase diluted sludges are centrifuged and the final product is used as fodder.

Newly developped machines are the brush-cylinder type, which are aligned 90 degrees to the flow-direction. Because these cylinders are much shorter than the rib-cage cylinders they do not bend as readily. As a result the loss of small potatoes falling through or between the cylinders is reduced below the levels lost using rib-cages. The capacity of these machines is 12-20 t potatoes per hour. Fig. 2 shows a longitudinal section. The belt located above the brush cylinder prevents potatoes and peelings from being thrown up and additionally forces the peelings to the lower parts of the machine. The slope of the machine is variable to accomodate changing production flows.

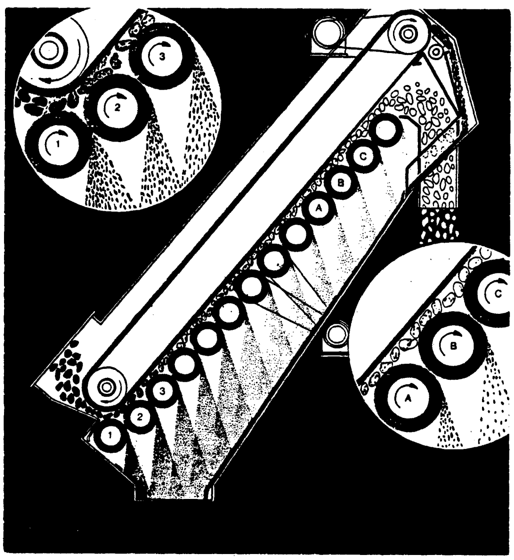

Fig. 2. Longitudinal section of a dry-peeling machine with brushes 90 degrees to the flow direction (photo by Gouda, Ref. 5).

Manufacturers report that in the final rinse the quantity of the waste-water is about 0,3-0,5 m^3/t of potatoes; additionally the load is reported to be only 10% of that of other common methods. After the preboiling and subsequent dry peeling the resulting potatoe peel slurry can be used fo fodder (Ref. 5).

In addition to the process described above it is also possible to reduce the waste produced in the vegetable and food canning industries. This is especially true in the blanching process. By changing from the hot water method to the steam blanching method the quantity of resulting condensate is so minimal that it need not be recovered from the product. Since there is no cleaning effect this method is not applicable in any case. In development stages are newer methods for blanching utilizing such methods as hot air jets, IR-rays, microwaves exposure, and a steam-air-mixture. A quick hot water method is also reported, which requires only 30 seconds. Employing this method the load of the blanching water is diminished to 50%.

The operation of filling cans and preservative jars in the vegetable and fruit industry leads itself to waste product reduction by employing alternative methods. E.g. cleaning cans and glass jars by compressed air eliminates the use of water entirely. Using older methods to fill the cans and jars leads to product losses due to overflow which leads to an increase of the waste water load. Depending upon the properties (for example viscosity) of the product it is often possible to use the vacuum principle in the packing/filling operation. The containers are evacuated to 99,6% and atmospheric pressure forces the product into the container resulting in no loss of product and no contamination of the outer glass surfaces (Ref. 4, 9, 12, 16 & 17).

Starch industry

From 1962 through 1975 waste water effluent in the maize-starch industry was reduced by approximately 50% of the present levels of 0,8-1,4 m^3/t of maize. This resulted chiefly from the adapting water cycles which will be discussed behind.

However there are additional and new methods currently in the laboratory stage which promise additional reduction in the waste amount. It can be demonstrated that mechanical bruising of the maize-kernel shell reduces the mash-time by 40% and also reduces the amount of waste (Ref. 28). Also in the experimental stage are methods to collect production waste concentrate from the water of the starch industry utilising an evaporative process of reverse osmosis and ultrafiltration.

Centrifuges are already employed in factories for dewatering gluten through several stages with a resulting decrease in the amount of waste water.

Between the years 1962 and 1978 the amount of waste water in the potatoe-starch-production industry was reduced from 4-10 m^3/t to 2-4 m^3/t of potatoes chiefly through the use of water cycles. The specific load was also reduced from 22-56 kg BOD/t to 7,5-10,7 kg BOD/t of potatoes. At this point it should be noted that there are two additional methods which help to decrease the amount of waste: One process utilises stone flotation for separation and the other method uses the potatoe cell-water (fruit-water) for starch separation. The stone flotation technique for separating small stones from the potatoes uses a heavy sludge of water and soil with a density of 1,15-1,20 kg/l. The potatoes float in the sludge and the stones sink to the bottom of the mass. Employing this method of separation reduces the amount of waste-water by 80-90%. The other method of separation is the fruit-water-process. Cell-water content of potatoes is about 75% of the total weight. It contains highly concentrated organic substances resulting in a BOD of approximately 60.000 mg/l. It is possible to recover protein from this cell-water. In addition it can be used for starch separation, further reducing the amount of waste water. Häusler and Malcher (Ref. 10) report a protein recovery method, which reduces the BOD to 44% and the total N to 40%. Heisles (Ref. 11) describes an ion-exchange process to retrieve fertilizers from cell-water with a composition of 32-42% K_2SO_4, 53-56% $(NH_4)_2SO_4$ and 1% amino acids.

Using fruit-water for the starch separation process is a highly efficient method. However a problem arises in controlling foam, which develops easily. Two systems are reported to overcome the foaming difficulty: Bode (Ref. 8) recommends the use of a jet separator in conjunction with equipment for separating air from the influent, and recycling the cell-water by use of a foamless pump. The wash station for starch separation consists of four rotating screening drums at which point the washed pulp still contains 24% cell-water and 1% starch. Fig. 3 shows a simplified flow chart for separating and recycling the cell-water.

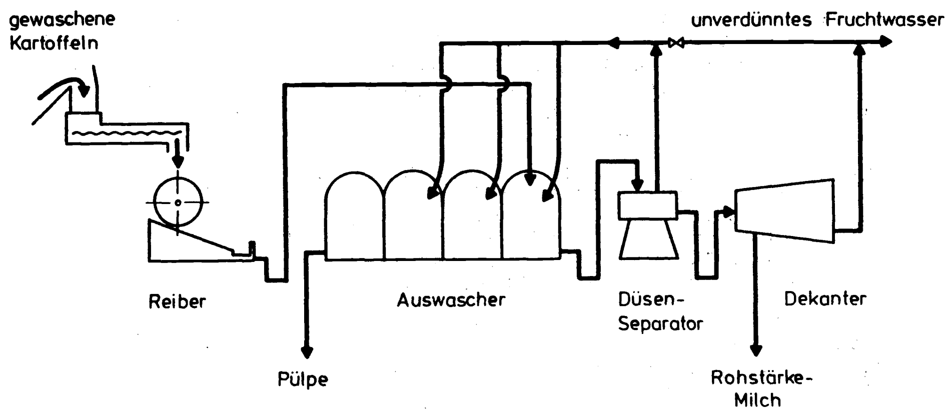

Fig. 3. Flow chart for separating and recycling the cell-water of potatoes, according to Bode (Ref. 8).

Verberne (Ref. 27) reports using hydrocyclones combining 240 smaller cyclones within a mulicyclone with a flow capacity of 72 m^3/h starchmilk. In this process the separated cell-water is recovered and recycled to the forgoing cyclone. Fig. 4 shows an individual hydrocyclone as it relates to a multi-hydrocyclone-system.

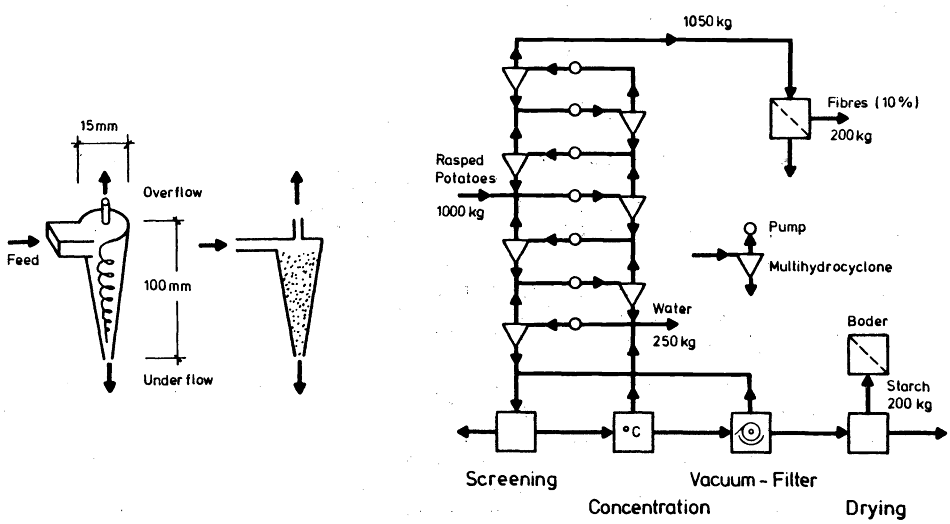

Fig. 4. A hydrocyclone and the flow chart of a multi-hydrocyclone-system according to Verberne (Ref. 27).

In the cell-water washing process foam formation is prevented by using a closed flow system without the usual balance tank and additionally employes direct pulp injection without screening. Fresh water is used only in the last multihydrocyclones (counter current method). The amount of fresh water used is reported to be only 0,25 m^3/t of potatoes instead of the usual 1,0-1,3 m^3/t when fruit-water is used instead of clean water.

In wheat-starch-production from 1962 to 1968 waste amounts have been reduced from 8-9 m^3/t of flour to 3-6 m^3/t by employment of waste water recycling. However waste load has not been reduced in the same proportion because of the increased concentration.

Meuser and Smolnik (Ref. 14) report success in experiments for the concentration of the waste by ultrafiltration and evaporation. An additional technique, which brings about a real water savings is the mechanical separation of the gluten and the starch out of the highly concentrated paste. The "Westfalia Weipro-Process" uses a centrifuge with a force of 3000-4000 g. The input influent consists of a dough of water: flour in a ratio of 1:1. The protein amounts to 40% of the gluten fraction. Total fresh water consumption can be reduced to 2-3 m^3/t of flour.

A similar method of gluten/starch separation is the "Raisio-Process" using Alfa-Laval-centrifuges (Ref. 14 & 19).

The process recommended by Verberne uses multihydrocyclones as described above in the potatoe starch fabrication-process. The amount of resulting wastes is reduced to about 2 m^3/t of flour.

The major portion of the waste load in the beverage industry is a result of product losses at the filling stations, glass breakage, and the cleaning process. The products of the beverage industry are highly concentrated with organics. Table 2 illustrates some BOD-values.

TABLE 2. BOD and p.e. values of some beverages (Ref. 20, 25 & 26)

Beverage	BOD_5 (mg/l)	(p.e./l)
milk	110 000	2,8
buttermilk	60 000	1,5
juice (orange)	60 000	1,5
wine	120 000	3,0
must	155 000	3,9
beer	80 000	2,0

There are different methods to minimize product losses in the production process. To accomplish this it is necessary to equip production tanks with equipment to preclude overflow. And in addition to the forgoing it is vitally important to clean pipes with compressed air before rinsing the pipes with water.

The use of reverse osmosis or ultrafiltration to recover proteins from rinsing water, f.e. in dairies, is already widely used. Table 3 shows the results of reverse osmosis recovery from the waste load in food industries.

TABLE 3. The effect of reverse osmosis in reducing the waste load in food industries (Ref. 24)

	Influent mg/l	permeate mg/l	Concentrate mg/l
BOD_5	18 250	56	85 500
COD	40 000	170	177 000
Organic Nitrogen (N)	1 092	0	5 712
total solids	3,5%	0,05%	20,0%

Wastes containing suspended matter are usually highly concentrated with organics. Table 4 shows some representative concentrations.

TABLE 4. Amount of turbid wastes and BOD-load of beverage industries (Ref. 1 & 25)

beverage	turbid waste water			load	
(-)	(-)	l/hl**	(mgBOD_5/l)	gBOD_5/m^3	p.e.
wine	from desliming	1.0	110 000	1100	2
wine	yeast slurry fresh	3.7	170 000	6290	10.5
wine	yeast slurry stale	3.7	500 000	18500	31
wine	from polishing	1.2	100 000	1200	2
beer	draff			2440	6.1*
beer	draff + yeast			920	2.3*

* settled = 40 g BOD/p.e. ** hl = 100 l

Alternative methods of separating the suspended matter are screening, filtration, centrifuging, and in some cases flocculation. The separated and residual matter can be used as compost.

A new but obvious method to reduce waste load in wine production is to rinse the yeast and the other solids from the centrifuge using wine instead of water. In this process particular care must be observed to ensure separation of the filter cake from Kieselgurfilters f.e. in a dry condition. Table 5 shows the BOD-load of the waste of a winery before and after the application of these measures.

TABLE 5. Efficiency of different methods (M) to reduce waste loads of a winery with $4 \cdot 10^6$ l must/a (Ref. 30)

turbid waste	quantity		load		
water	without M.	M.applied	without M.	M.applied	M.
(-)	(l/d)	(l/d)	(kgBOD_5/d)	(kgBOD_5/d)	(-)
must desliming	2 100	360	94.5	16.2	rinsing with wine
yeast slurry	1 380	240	113.8	19.8	rinsing with wine
polishing	4 500	3.000	47.3	18.0	dry filter cake

The separation of solids from the apparatus of other beverage factories could be employed to the same advantage as application in wine production.

Another process to reduce the waste amount is by the use of larger vessels in place of smaller ones. By reducing the specific surface a reduced waste load is generated during the cleaning process (table 6).

TABLE 6. The waste load from tank cleaning as related to the tank size

beverage	tank	volume of the tank	spec. load from tank cleaning
(-)	(-)	(m^3)	gBOD/m^3(settled)
beer	fermentation tank	45.5	0.57
beer	"	200.0	0.53
beer	"	610.0	0.127
wine	cask	1.0	5.21 *
wine	cask	30.0	1.70 *
wine	cask	100.0	1.15 *
wine	cask	300.0	0.80 *

* specific load after the first decantation

Another source of waste water is the bottle cleaning equipment. It will be noted that the BOD of rinse water from this stage of a brewery operation is approximately 180 g/hl beer (1,8 g/l), but of this quantity up to 85,3 % (136,5 g BOD) were found to be a result of the size and type of paper used in labeling. The 1 % solution of potassium hydroxide (NaOH) used in cleaning the bottles dissolves a remarkable part of the paper. Using pure water instead of NaOH for delabeling reduces the waste load by as much as 33 % in the brewery industry and 56 % in the juice industry (Ref. 20).

Application of production water cycles

Citing three examples the following should be a short survey of possible methods of water recycling in the food industry.

In the counter current technique fresh water is introduced in a pea cannery at the end of the production line. The now highly polluted water is used for precleaning incoming raw materials. Reclaimed produktion water must be disinfected by chlorine or other means to forstall bacterial and mucic growth and to achieve desodorisation. Seventy % of the water can be recovered. Fig. 5 shows the water recycling scheme of such a process.

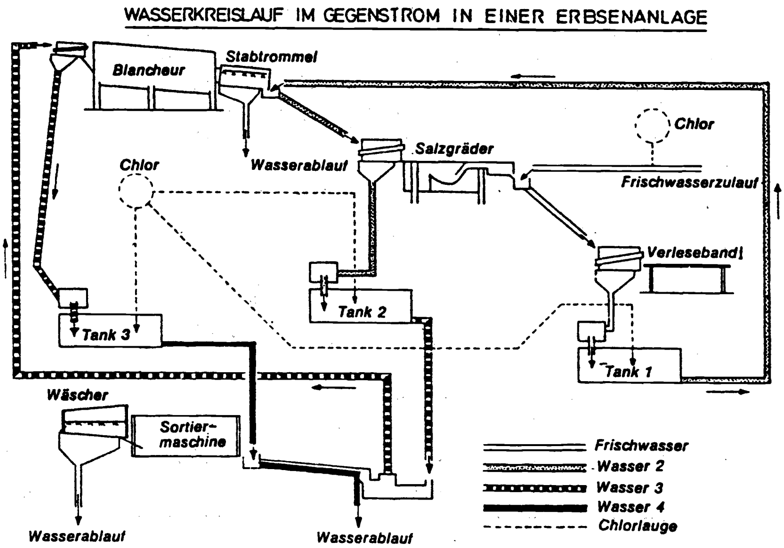

Fig. 5. Example of a counter current water cycle in a pea-cannery, according to Nehring (Ref. 17).

To supplement the above process it is advisable to separate the suspended solids in the recycled water by the use of settling tanks, centrifuges or filters.

Fig. 6 illustrates the simplified flow chart scheme of a beet sugar factory. Note that there is a separate cycle for washing water including the use of a settling tank.

Another separate cycle is used to cool the water from vacuum pump, containing the condensate, (Fallwasser).
In its functional use the water undergoes a heat build up, which must be disappated through the use of cooling towers or cooling basins. Due to evaporation a portion of this water must be replaced by fresh water.

Fig. 7 illustrates a flow chart scheme of a wheat starch factory with a high percentage of water recycling. In this instance water consumption is about 2 - 6,5 m^3/t instead of the usual 8 - 9 m^3/t of flour.

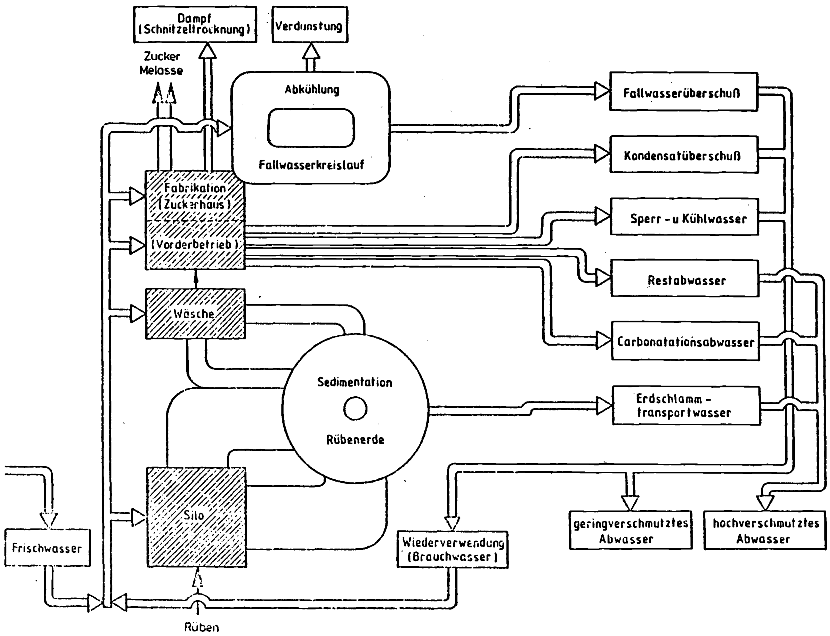

Fig. 6. Simplified example of a flow chart scheme of a beet sugar factory (Ref. 1).

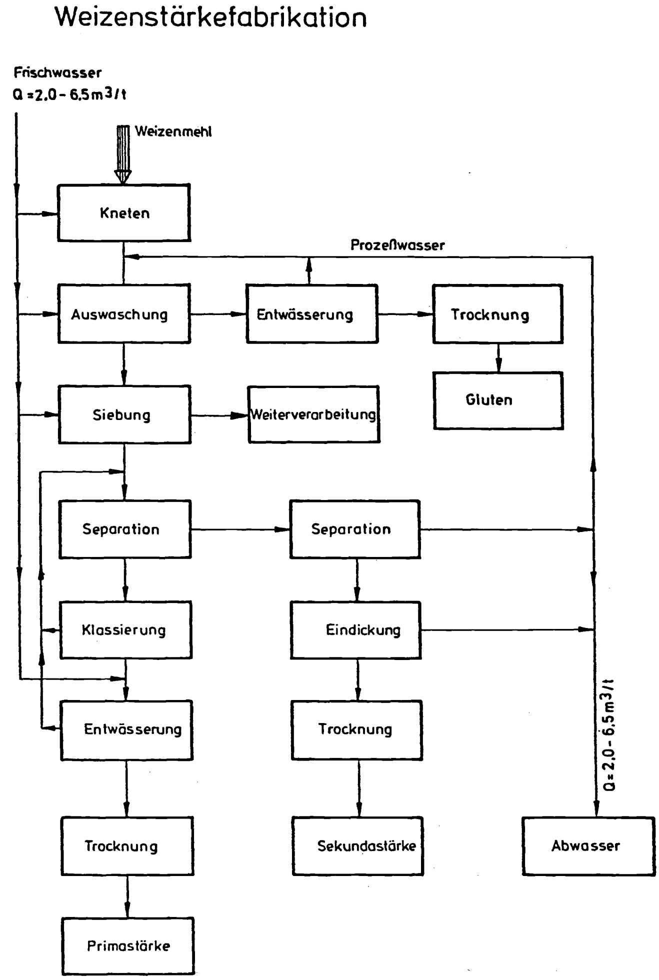

Fig. 7. Flow chart scheme of a wheat starch factory utilizing water recycling.

One should take in account that employment of either Westfalia - Weipro or Raisio - Process would additionally reduce the amount of waste.

Acknowledgement - The work for this paper was partly supported by grants from the KfW, and UBA, FRG. The author wishes to express his thanks to D.I. Rosenwinkel, Institut für Siedlungswasserwirtschaft (Universität Hannover, FRG), for his kind help.

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