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UPGRADING OF EXISTING SEWAGE TREATMENT PLANTS

Th. Muller and J. M. Janus

DHV Consulting Engineers, P.O. Box 85, 3800 AB Amersfoort, The Netherlands

I. THE INCORPORATION OF PRIMARY SEDIMENTATION IN CARROUSEL PLANTS

INTRODUCTION

In sewage treatment plants of the Carrousel type the raw influent is treated by an activated sludge system at an ultra-low sludge load (F/M-ratio) of about 0.05 kg BOD/(kg MLSS.day). The sludge age of the activated sludge is sufficient to produce stabilized surplus sludge (20 to 30 days). The biological capacity of the plant can be enlarged by incorporating a primary sedimentation tank. The F/M-ratio in the Carrousel can be raised to 0.1-0.15 kg BOD/(kg MLSS.day). As there is no primary sludge, the sludge yield is lowered to such an extent, that the sludge age will be sufficient to allow simultaneous stabilization of the biological surplus sludge and also nitrification of the TKN. In this way the capacity of the plant can be more than doubled. Anaerobic stabilization of the primary sludge and usage of the digester gas for power generation will decrease the net energy consumption.

In this paper a cost comparison is presented for the extension of a carrousel plant (50.000 p.e.) by:

I Additional carrousel (55.000 p.e.).
II Additional primary sedimentation (total capacity 105.000 p.e.).

DESCRIPTION OF THE EXISTING SEWAGE TREATMENT PLANT

The existing sewage treatment plant contains the following units:

grit removal	:	1600 m^3/h
carrousel	:	12.500 m^3
		F/M 0.054 kg BOD/(kg.MLSS.d)
final clarifier	:	diam. 45 m
returned sludge	:	840/1120 m^3/h
sludge thickener	:	diam. 10 m
sludge lagoons	:	16.000 m^2
sludge dewatering	:	5 tons/h (belt filter press)

CAPACITY

	Actual	Future
Biological capacity	50.000 p.e.	105.000 p.e.
Hydraulic capacity	1.600 m^3/h	3.070 m^3/h

EFFLUENT REQUIREMENTS

Settlements	≤	0.3 ml/l
susp. solids	≤	30 mg/l
BOD	≤	20 mg/l
TKN	≤	20 mg/l (in summer)

DESCRIPTION OF THE ADDITIONAL UNITS

Alternative I (Fig. I-3) (carrousel) mainly	Alternative II (Fig. I-4) (primary sedimentation) mainly
grit removal	grit removal
-	primary clarifier Ø 39.6 m
contact tank	contact tank
carrousel 13.750 m^3	-
final clarifier (Ø 40.8 m)	final clarifier (Ø 39 m)
return sludge pumps	return sludge pumps
sludge thickener Ø 14.9 m	-
-	sludge digestion tanks (5260 m^3)
	gas holder (525 m^3)
	sludge thickener Ø 14.9 m
sludge lagoons	sludge lagoons
belt filterpress 19 tons/h	belt filterpress 12 tons/h

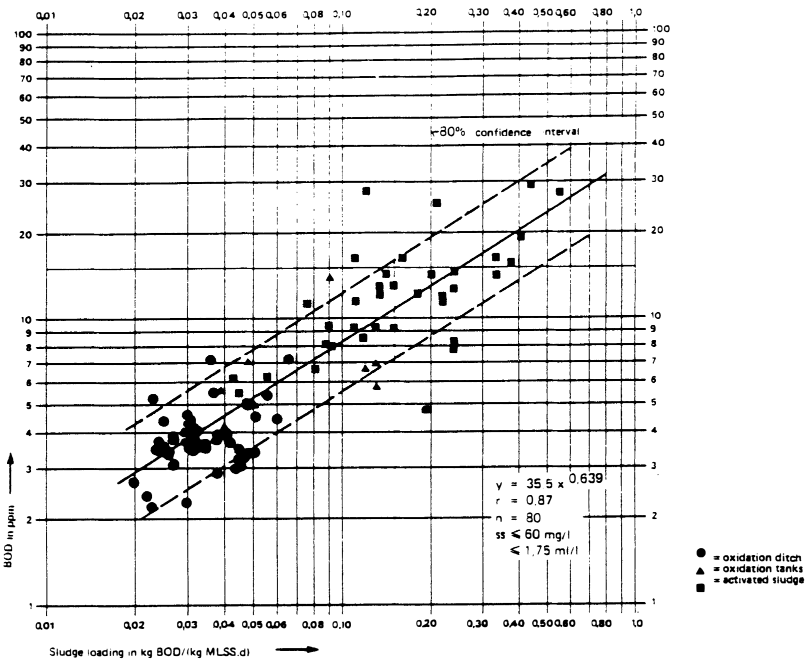


Fig.I-1. The average yearly BOD_5 concentration as a function of the BOD-loading of activated sludge treatment plants

EFFLUENT COMPOSITION

In Alternative I the F/M ratio of the activated sludge amounts to 0.054 kg BOD/(kg MLSS.day). In this situation the expected effluent composition is:

BOD	:	5 ppm (average)
TKN	:	7 ppm (summer)

(see Figs I-1 and I-2).

In Alternative II the F/M ratio amounts to 0.1 kg BOD/(kg MLSS.day). The expected effluent composition is:

BOD	:	8 ppm (average)
TKN	:	12 ppm (summer)

In both alternatives the effluent requirements are met.

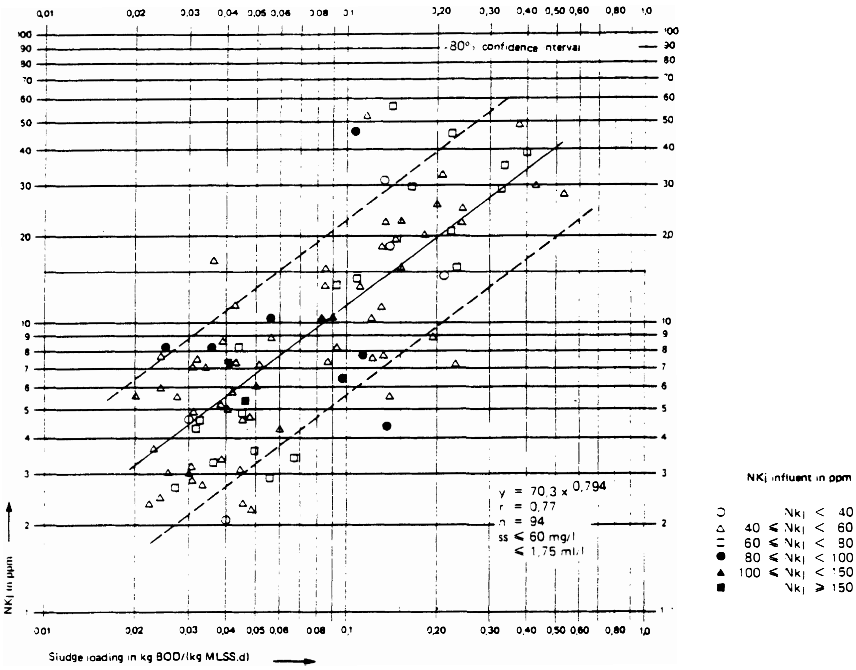


Fig. I-2. The average NKj concentration in the effluent of activated sludge treatment plants as a function of the BOD-loading, during the months May-October

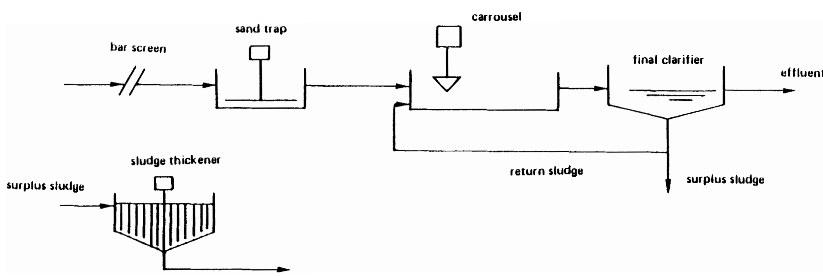


Fig. I-3. Extended aeration type carrousel

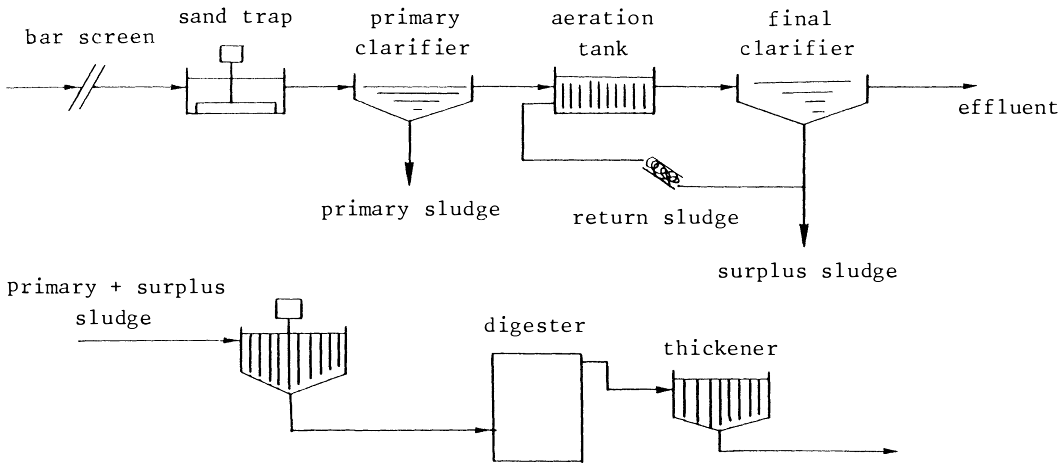


Fig. I-4. Incorporated primary sedimentation

COMPARISON

A comparison of investment and yearly cost is presented in the following survey:

	Alternative	
	I (Carrousel)	II (Primary Sedimentation)
Investment	US \$ 3.4	US \$ 4.1
Yearly cost		
Capital cost	US \$ 0.5 x 10^6	US \$ 0.6 x 10^6
Exploitation	US \$ 0.4 x 10^6	US \$ 0.4 x 10^6
Energy	US \$ 0.2 x 10^6	US \$ 0.1 x 10^6
Total	US \$ 1.1 x 10^6	US \$ 1.1 x 10^6

As indicated the investment of Alternative II (primary sedimentation and sludge digestion) is 18% higher than the investment of Alternative I.

The yearly costs of both alternatives are equal.

If the energy cost will increase 6% per year the present value of the alternatives are:

I US \$ 11.1 x 10^6
II US \$ 10.9 x 10^6

If energy cost will increase 10% per year the present value of the alternatives are:

I US \$ 12.2 x 10^6
II US \$ 11.4 x 10^6

SYSTEM SELECTION

Based on the expected increasing energy costs the extension of the sewage treatment plant by incorporation of primary sedimentation was recommended. The extension is now under construction.

II. INTEGRATION OF EQUALIZATION TANKS IN THE ACTIVATED SLUDGE SYSTEM OF A SEASONAL FACTORY

INTRODUCTION

The wastewater of the fruit and vegetables canning industry is very well biodegradable, but the seasonal BOD-load varies substantially. As a result of these seasonal fluctuations the sewage treatment plant must be able to handle a high loading in summer periods and a low loading in winter periods.

A wastewater treatment plant designed for average loading conditions will be overloaded in summer periods. A wastewater treatment plant designed for the seasonal peak loading will be underloaded in the winter periods, which can give operational problems.

A seasonal factory with a wastewater treatment plant of 12.500 p.e. was confronted with a seasonal peak loading of appr. 40.000 to 50.000 p.e., resulting in overloading, poor effluent quality and the impossibility of re-using the effluent in the factory.

To increase the capacity of the plant an economic solution was found in the integration of the existing equalization tanks in the activated sludge system and in additional treatment of the excess sludge during the summer periods.

DESCRIPTION OF THE EXISTING SEWAGE TREATMENT PLANT

The following units were in operation before upgrading:

screens
pumping station (80 m^3/h)
sieve (3 mm)
grit trap
2 equalization tanks (also for settling)
aeration tank 2100 m^3
MLSS 6 kg/m^3
F/M 0.08 kg BOD/kg (MLSS day) design
OC 105 kg O_2/h
final clarifier: 0.5 $m^3/(m^2.h)$
return sludge pump
sludge thickener
sludge lagoons

The effluent composition was during winter periods: BOD < 20 ppm
SS < 20 ppm

during summer periods: BOD > 200 ppm
SS > 100 ppm

EXTENSION OF THE SEWAGE TREATMENT PLANT

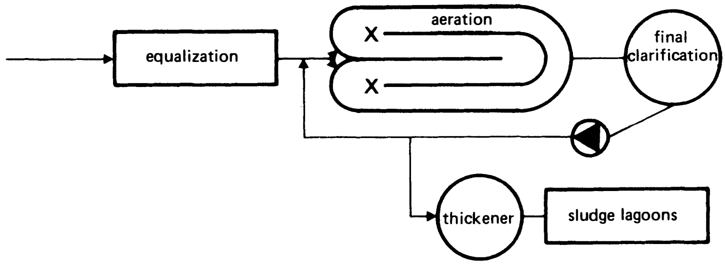
a) Upgrading of Biological Treatment

As described, the functions of the existing equalization tanks were equalization, removal of fine grit and sludge. During the campaign (preserving and canning of fruits mainly) the quantities of grit and sludge are negligible, resulting in the possibility to integrate the equalization tanks in the biological process. For this purpose floating surface aerators were installed in the equalization tanks (additional OC: 221 kg O_2/h). The total aeration volume after extension was 3525 m^3. The returned sludge capacity was doubled. In the winter periods the surface aerators are removed; the equalization tanks are used then for equalization and removal of fine grit and primary sludge.

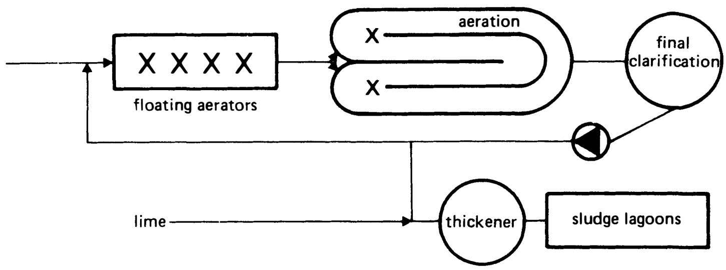
After the extension the capacity of the sewage treatment plant amounts to

55.000 p.e. (4.900 kg BOD/day). The F/M ratio is 0.35 kg BOD/(kg MLSS.day). At this F/M ratio the excess sludge is not completely stabilized, so additional measures for sludge treatment were necessary, see b).

During the winter periods the F/M ratio amounts to 0.08 kg/BOD/(kg MLSS. day). In this situation the excess sludge is stabilized (aerobic) and can be thickened and dewatered in the existing sludge lagoons without odour nuisance.



a) Operation during 5 months per year (12.500 p.e.)



b) Operation during campaign (45.500 p.e.)

Fig. II-1. Upgrading of existing industrial S.T.P. (seasonal factory). Type of industry: preserving (fruit and vegetables).
Advantages: - low additional investment
- small amounts of excess sludge
- excess sludge is odourless
- flexibility in operation

b) Upgrading of Sludge Treatment

In the summer periods (F/M 0.35 kg BOD/(kg MLSS.day) aerobic sludge stabilization is impossible, so additional sludge treatment is necessary.

A very cost-effective and reliable method has been selected as stabilization by adding lime to the thickened excess sludge. The quantity of dosed lime has to be controlled to maintain a pH in excess of 12 in the lime/sludge mixture.

This lime treatment system can be characterized as follows:

- low investment costs
- low operation costs (only during campaign)
- excellent dewatering characteristics
- no odour emission
- high dry solids % of dewatered sludge
- the sludge can be used as fertilizer
- favourable hygienic sludge conditions

The following equipment is installed:

1 lime silo 80 m^3
1 lime dosing screw + conveyor 0-100 kg/h
1 lime slurry pump 0.5 m^3/h.

The lime dosing rate is 0.2 kg lime per kg sludge (d.s.).

The yearly lime consumption was appr. 60 to 90 tons.

SUMMARY

The capacity of a wastewater treatment plant of a seasonal factory can be increased, if the existing equalization tank is integrated as a component of the activated sludge system. For this purpose floating aerators are installed in the equalization tank and this tank is integrated in the activated sludge system. In general, the surplus sludge produced during the season has not been stabilized simultaneously. It is possible to produce an odour-free stabilized surplus sludge by dosing of lime. Furthermore the dewatering characteristics of this product are excellent.

III. THE PROCESSING OF SEWAGE SLUDGE INTO A USEFUL PRODUCT

INTRODUCTION

The disposal of sewage sludge for agricultural uses may stagnate in several parts of the Netherlands in the near future, in particular after the Disposal of Manures Act becomes operative. This means that other means of sludge disposal will have to be found. The Veluwe Water Authority commissioned DHV Consulting Engineers to perform a study into the possibilities of treating the sewage sludge from the Harderwijk STP into a product with the following properties:

- dry solids content of approximately 40%;
- a consistency that facilitates dumping.

ALTERNATIVES

In the study the following alternatives were considered:

1. Dewatering with sieve belt-presses followed by mixing with sand to a dry solids content of 40%.
2. Dewatering with sieve belt-presses followed by mixing with quicklime to a dry solids content of 40%.
3. Dewatering with sieve belt-presses followed by mixing with sand and quicklime to a dry solids content of 40%.
4. Dewatering with membrane filter presses to a dry solids content of 40%.

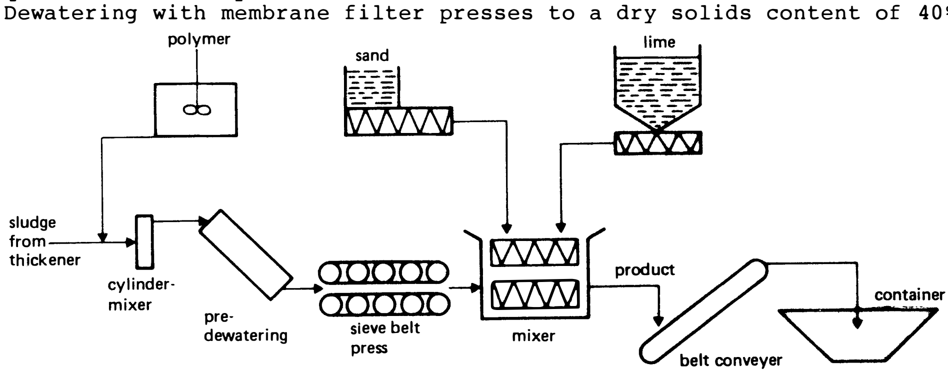


Fig. III-1. Process scheme

Based upon the system choice in the case of STP Harderwijk, the alternative of dewatering with sieve belt-presses followed by mixing with sand and lime to a dry solids content of 40% was chosen to be in operation for eight hours per working day. The decisive criteria for this choice were minimal operation costs and optimal usefulness of the end product. The process scheme is shown in Fig. III-1.

This alternative has been studied further in practice in order to optimize the process. The influence of the following parameters have been studied:

- mixing ratios of sludge, sand and lime;
- use of quicklime or hydrated lime;
- way of mixing;
- type of sand.

The main results of the experiments with mixing of sludge, sand and lime have been summarized in Table III-1.

CONCLUSIONS

The main conclusions are:

- hydrated lime is not suitable;
- the optimal mixing ratio sand/lime is 90/10 (weight %);
- premixing of sand and lime does not improve the results compared to instantaneous mixing of sludge, sand and lime;
- the product is well-mixed, friable and moderately kneadable and is very suitable for use as material in interlayers of waste disposal sites.

TABLE III-1 Results of the Experiments of Mixing Sludge, Sand and Lime

Feature*	Exp. nr.	Sludge cake		Sand		Lime		Sand: lime	product							r.p.m. mixer
											homogenity[1]	kneadability[2]	friability	diameter grain		
		%ds	kgds/h		kg/kgds		kg/kgds	kg/kg	%ds	% ash	-	-	-	cm	% > 1 cm	-/min
High sludge flow	A1	20,5	66	medium	1,74	CaO	0	100:0	39,5	79,7	-	-	-	2-5		30
	A2	20,6	66	medium	1,65	CaO	0,080	95:5	41,0	80,7	+/-	-	+/-	0,1-2	30	42
	A3	21,0	66	medium	1,58	CaO	0,17	89:11	46,9	86,7	+	+/-	+	0,2-1,5	10	25-42
	A4	21,9	66	medium	1,38	CaO	0,30	78:22	47,0	85,5	+	+/-	+	0,2-1,5	10	34-44
Low sludge flow	B1	21,1	58	medium	1,07	Cao	0	100:0	46,2	83,9	+	-	+/-	0,5-2	10	25-40
	B2	21,9	58	medium	1,75	CaO	0,086	95:5	47,7	83,9	+	+/-	+/-	0,2-3	30	30-32
	B3	22,7	58	medium	1,66	CaO	0,17	90:10	52,0	86,0	+	+/-	+	0,2-2	10	25
	B4	22,2	58	medium	1,47	CaO	0,31	79:21	48,7	86,1	+	+/-	+	0,2-1,5	10	25
Silversand	C3	21,2	58	silver	1,66	CaO	0,17	90:10	43,1	81,3	+	-	-	0,5-6		40
	C4	21,4	58	silver	1,47	CaO	0,31	79:21	47,1	85,1	+	-	-	0,2-1		27-40
Fine sand	D2	22,0	58	fine	1,79	CaO	0,086	95:5	48,0	83,6	+	-	+	0,2-4	30	31
	D3	22,7	58	fine	1,66	CaO	0,17	90:10	48,0	82,7	+/-	+/-	+	0,2-3	10	30-33
	D4	22,3	58	fine	1,50	CaO	0,31	79:21	50,5	83,7	+/-	+/-	+	0,2-3	10	30
Coarse sand	E2	22,6	58	coarse	1,78	CaO	0,086	95:5	56,3	87,9	+	+/-	+/-	0,2-3	30	28-40
	E3	22,9	58	coarse	1,66	CaO	0,17	90:10	42,0	85,6	+	+/-	+/-	0,2-1,5	10	25-40
	E4	22,8	58	coarse	1,47	CaO	0,31	79:21	49,7	85,7	+	+/-	+	0,2-3	10	32
Hydrated lime	F2	22,4	58	medium	1,78	$Ca(OH)_2$	0,11	94:6	47,6	83,0	+/-	-	+	0,5-2	10	36
	F3	22,8	58	medium	1,66	$Ca(OH)_2$	0,23	86:14	46,5	82,0	+/-	-	+	0,2-2	10	38
	F4	22,7	58	medium	1,47	$Ca(OH)_2$	0,41	83:27	50,0	84,8	+/-	-	+	0,2-1,5	10	40

* Sludge flux to sieve belt press exp. A 1,65 m^3/h; other experiments 1,44 m^3/h

1: + well mixed; +/- moderately mixed; - badly mixed

2: + not kneadable; +/- moderately kneadable; - very kneadable

3: + friable; +/- moderately friable; - sticky