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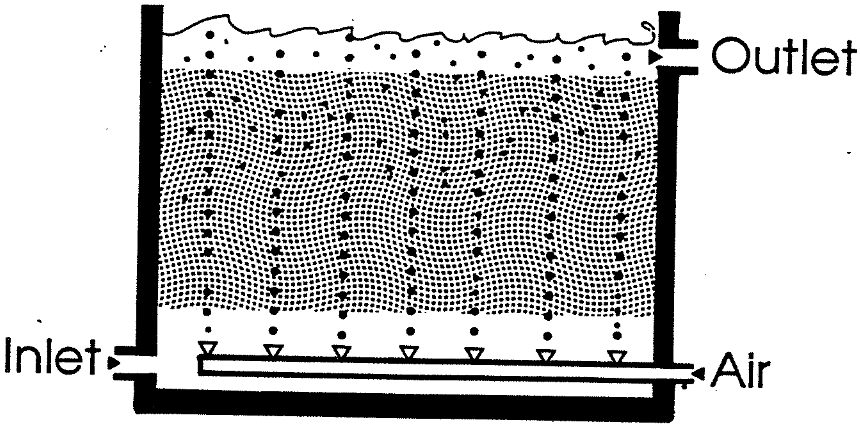
NIVAREPORT

Sewage treatment

O-89213

Nitrification with submerged filters

Air supply and consumption at the pilot-plant at Bekkelaget treatment plant



NIVA - REPORT

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Report No.: 0-89213
Sub-No.:
Serial No.: 2447
Limited distribution:

Report Title:
Nitrification with submerged filters.
Air supply and consumption at the pilot-plant at the Bekkelaget treatment plant.

Date: June 1990
0-89213
Topic group: Sewage treatment
Geographical area: Oslo
Number of pages (incl. app.)

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Contractor: State Pollution Control Authority (SFT)
Norwegian Institute for Water Research (NIVA)
Oslo Water and Sewage Works (OVA)

Contractors ref. (or NTNF-No): SFT nr. 445/89

Abstract:

During the three months research period (October 1989 - January 1990) the average nitrification efficiencies for municipal sewage were 48 % and 61 % for respectively one-step and two-step biological submerged filters placed after chemical precipitation. Corresponding nitrification rates were 0.69 and 0.56 g NH4-N/m2 d. The air/liquid ratio (m3/m3) varied from 18 - 35 for the diffused aeration, giving high O2-concentrations, but indicating an inefficient aeration system. No clogging problems occured with the backwashing routines used.

4 keywords, Norwegian
1. Nitrifikasjon
2. Dykket filter
3. Oksygen-forsyning
4. Oksygen-forbruk

4 keywords, English
1. Nitrification
2. Submerged filter
3. Oxygen supply
4. Oxygen consumption

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ISBN 82-577-1756-8

NORWEGIAN INSTITUTE FOR WATER RESEARCH (NIVA)

REPORT

Nitrification with submerged filters.
Air supply and consumption at the pilot-plant
at the Bekkelaget treatment plant.

1 October 1989 - 15 January 1990

(regarded as a partial report nr. 5)

as cooperation-project of

NIVA, OVA and Aquateam

Grazyna Englund

Oslo, June 1990

(jan)gen-pilot-rapp

LIST OF CONTENT

SUMMARY

During October 1989 to January 1990, pilot-plant research with two biological lines (one and two-step aerated submerged biological filters) for nitrification process and air supply and consumption with respect to this was performed. Chemical pre-precipitation was applied.

Plastic media with specific areas of 140 m^2/m^3 and 230 m^2/m^3, were used. Hydraulic rate was about 5 m^3/h in both lines, ammonia average surface load was 1.46 and 1.11 g NH_4-N/m^2d, for one and two-step biological nitrification, respectively. Submerged filters are aerated by means of air compressor. Three different aeration rates were performed; 324.5, 185.6 and 220.8 m^3/h on the total plant, at working conditions. Temperatures of wastewater varied from 6 to 13^{0}C.

Within research period following observations were made:

at one-step filtration:

- averaged COD load in: 7.6 g COD/m^2 d
- averaged ammonia load in: 1.5 g NH_4-N/m^2 d
- hydraulic load: 0.09 m^3/m^2 d
- averaged nitrification efficiency: 48 %
- averaged nitrification rate: 0.69 g NH_4-N oxidized/m^2 d
  nitrification rate varied from 1.38 in October to almost "0" in the end of November and then increased gradually

at two-step filtration:

- averaged COD load in: 6.3 g COD/m^2 d
- averaged ammonia load in: 1.1 g NH_4-N/m^2 d
- hydraulic load: 0.07 m^3/m^2 d
- averaged nitrification effeciency: 61 %
- averaged nitrification rate: 0.56 g NH_4-N oxidized/m^2 d
  nitrification rate varied from 1.18 in October to 0.34 in the end of November and then increased

Generally:

- Comparisons of dissolved oxygen supplied and consumed for carbonaceous and ammonia oxidation were performed and has shown that efficiency of the existing aeration system is very low. The majority of air supplied escape into air.

- There are difficulties to measure the rate of aeration.

- During the research period no problems with clogging of the filters occured. Filters were scoured once just before changing the rate of aeration from the first to the second.

- The last, third rate of aeration was set-up on higher level then the second because of bad nitrification process performance. Judgement for to do so was based on daily results, without having the COD results (analysing takes longer time) and not knowing that the organic load was higher (caused by raw sewage input from the Yeast Factory).

- Dissolved oxygen concentration was kept above 2 mg O_2/l.

- Two-step filtration perform better than on-step filtration.

- Changes of water temperature caused by rainfalls and snow melting periods influence the nitrification rate, but research period was too short to draw conclusions to which extent.

1. GOAL OF RESEARCH

Scope of this work was to:

- determine necessary air supply for maintaining dissolved oxygen at the levels needed for running the optimal biological nitrification at the aerated submerged filter

and

- to observe potential operational problems due to clogging.

Among important parameters influencing proper performance of biological nitrification process are:

- the first two stoichiometric parameters - oxygen requirement and alcalinity destruction - are important in the design of nitrifying treatment systems

- the third stoichiometric parameter, biomass production, is important to the understandig of microbial population dynamics

- temperature

Oxygen is essential for the growth of nitrifiers and alcalinity consumption is important because nitrifying organisms are efficient only over a relatively narrow pH range.

Compared to heterotrophic oxidation of carbonaceous waste material, nitrification generate relatively little biomass. This low cell production frequently causes wash-out of nitrifiers from conventional systems.

A parameter as temperature can hardly be manipulated in wastewater treatment, but has a great influence on the nitrification process. Biomass production can be increased by increasing the retention time (use of plastic media) as a supporting material.

Assurance of the optimal conditions of aeration (dissolved oxygen) and proper alcalinity levels belong to decisive.

INTRODUCTION

2.1. Generally

Pilot-scale research, treating municipal wastewater of the Bekkelaget treatment plant (OVA) in aerated submerged biological filters with high surface area filter media was performed in this research project. Oxygen demands with respect to nitrification process and effects of clogging was followed up in the period from October 1989 to approximately middle of January 1990.

Recently, much attention has been focused on the use of biological fixed-film reactors for wastewater treatment. This is primarily because of their simple operation, and reduced reactor volume and land area requirements. Submerged, fixed-film packed-bed reactor designs have recently been developed using different plastic media to further reduce reactor volume. Such reactors require air sparging to supply sufficient oxygen for relatively high substrate removal rates associated with the high biomass concentration per unit reactor volume and to avoid clogging. A typical example is the biological aerated filter, where air (oxygen) is continuously supplied and used. Oxygen consumption and supply is an important design consideration for such filters.

2.2. Nitrogen removal

The removal of nitrogen and nitrogen compounds from wastewater is receiving wide attention because:

a) the discharge of these contaminants (and phosphorus) manifested in the growth of algea and aquatic plants.
b) ammonia is toxic to aquatic organisms, especially fish, at concentrations as low as 0,5 mg/l;
c) nitrification, the biological oxidation of ammonium to nitrate ions, can exert a significant oxygen demand on the receiving waters
d) ammonium ions in waters used for water supply require an increased chlorine dosage to achive a free chlorine residual in desinfection.

Wastewater treatment plants facilities are already being designed for nitrogen control in other parts of the world.

The effluent standards for municipal wastewater plants in Denmark, for example are set-up to 8 mg N/l or 50 % reduction (BOD < 15 mg O/l) (annual average) for all plants greater than 15 000 person-equivalents (p.e.) and phosphorus removal to 1,5 mg P/l or 80 % removal (annual average) for all plants greater than 5 000 p.e.[3]

All problems connected to nitrogen removal can be solved by nitrification, i.e. biological oxidation from ammonium ions to nitrate ions and denitrification, i.e. biological reduction of nitrate ions to molecular nitrogen.

Nitrification can, in principle, be achived in any aerobic biological process. The key-requirements for nitrification to occur is that the process should be so controlled that the specific growth rate of the biomass as a whole is smaller then that of the nitrifying bacteria. If specific biomass growth rate exceeds specific nitrifier growth rate, the latter are gradually washed out of the bioreactor until nitrification is lost entirely.
A rational approach to prevent wash-out without excessively increasing the size of the bioreactor is immobilization of the nitrifying bacteria. Trickling filters, rotating-disc filters, fluidized-beds or submerged filters are established biofilm system with natural immobilization (high biomass concentration)[4].

3. THEORETICAL DEMANDS FOR OXYGEN AND ALCALINITY DURING THE NITRIFICATION PROCESS

3.1. Nitrification

Dissolved oxygen is an essential requirement for growth of both Nitrosomonas europea and Nitrobacter agilis, responsible for nitrification process. Other species have been also recognized but are of less importance[19].

During the nitrification process organic nitrogen and ammonia nitrogen are converted first to nitrite and then to nitrate, according to the following stoichiometry:

$$NH_4^+ + \frac{3}{2} O_2 \xrightarrow{\text{Nitrosomonas}} NO_2^- + 2H^+ + H_2O + \text{energy} \quad (1)$$

$$NO_2^- + \frac{1}{2} O_2 \xrightarrow{\text{Nitrobacter}} NO_3^- + \text{energy} \quad (2)$$

The overall reaction is:

$$NH_4^+ + 2O_2 \longrightarrow NO_3^- + H_2O + 2H^+ \quad (3)$$

For this reaction to go to completion, 4,57 g of O_2 are required per g of ammonia nitrogen. This oxygen demand is often identified as the nitrogenous oxygen demand (NOD)[4,5,21].

The energy produced by the oxidation of NH_4^+ and NO_2^- is used by nitrifying organisms primarily to produce new biomass (bacterial cells).
These bacterial cells can be represented by the approximate chemical formulation, $C_5H_7O_2N$. The biomass synthesis reaction for Nitrosomonas and Nitrobacter is given by Equation 4[8]:

$$NH_4^+ + HCO_3^- + 4\ CO_2 + H_2O \longrightarrow C_5H_7O_2N + 5O_2 \quad (4)$$

This synthesis reaction requires an impact of energy to proceed. During nitrification, this energy is obtained from NH_4^+ and NO_2^- oxidation (Equations 1 and 2). Reactions shown in Equation 1, 2, and 4, therefore, usually occur simultaneously. The energy yielded from the oxidation of one mole of NH_4^+ or NO_2^- is much less than energy required to produce one "mole" of bacterial cells ($C_5H_7O_2N$). Equations 1, 2 and 4 then must be proportioned so that after energy transfer efficiencees are taken into account, energy use equals energy production.

Biological nitrification can be expressed by Equation 5[8]:

$$NH_4^+ + 1.83\ O_2 + 1.98\ HCO_3 \longrightarrow 0.021\ C_5H_7O_2N + 0.98\ NO_3^- + 1.041\ H_2O + 1.88\ H_2CO_3 \qquad (5)$$

This Equation can be used to estimate the three important stoichiometric parameters associated with the nitrification process: oxygen requirements, alcalinity consumption, and nitrifier biomass production. Equation 5 predicts that 1.83 moles of oxygen are required to convert one mole of ammonium into nitrate and new biomass. This is equivalent to 4.2 g of O_2 per g of NH_4-N converted. The overall equation predicts that 1.98 mole or equivalents of H^+ are produced per mole of ammonium converted, or 7.07 g of alcalinity (as $CaCO_3$) is destroyed per g of NH_4-N converted. Other values as 7.1[1], 7.13[5], 7.14[8] are also reported. Finally the equation also predicts that 0,17 g (0.021 "moles") of cells are produced per mg of NH_4-N converted.

The first two stoichiometric parameters - oxygen requirement and alcalinity destruction are important in the design of nitrifying treatment system.
Oxygen is essential for growth of nitrifiers and nitrifying organisms are efficient only over a relatively narrow pH range (7.0-8.5)[11,12,13,14,21,22].

In a fixed-film process oxygen has to diffuse into the biofilm. The biofilm consumes oxygen and may become oxygen limited even though oxygen is present in the bulk liquid. Based on literature information [2,7,8,20], dissolved oxygen concentration in the bulk liquid should always be kept above 2 mg/l in order to perform properly.
Extra high air flowrates can reduce the efficiency of oxygen transfer[1].
Oxygen demand in the submerged filters in many cases is met by air sparging[18].
The turbulence created by rising diffused-air bubbles would control the overgrowth of biofilm by removing excess solids from the biofilm through shearing forces[23].

In the plant with nitrification process alcalinity consumption can be considerable. Low pH values will reduce the growth rate of nitrifiers, and they will be washed out of the system.
Carbon dioxide is produced at the rate of approximately 1.4 g for each g of oxygen used for the oxidation of BOD_5 and NOD (oxygen required to oxidized Total Kjeldahl Nitrogen (TKN))[8]. If then not enough alcalinity is present the microbial conversion causes a drop in pH what implies deterioration of the efficiency.

In order to avoid that kind of problems, waste water treatment must be operated with so high alcalinity that stable pH-values are obtained. According to (5) and (10) alcalinity should be at least 10 to 20 mg/l as $CaCO_3$ greater than the stoichiometric requirements for neutralization. This is to assure that pH does not limit the rate of nitrification.

3.2. Other remarks

Importance of oxygen transfer characteristics for sparged fixed-film systems is indicated and models are used to describe dissolution of oxygen from the gas phase to the liquid phase and then interfacial oxygen transfer (diffusion of oxygen from the bulk liquid into the biological floc or biofilm). This complicated question is still under investigations.

Several authors have published different results on the influence of temperature on oxygen transfer. These data have been plotted in Fig. 1 [18]. For comparison purposes the relative oxygen transfer was taken to be 1.0 at 10°C.

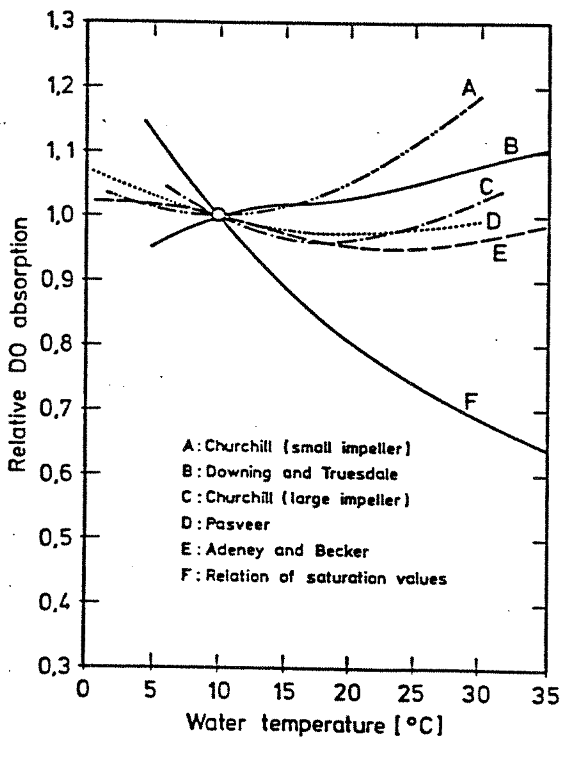

Fig. 1. Relative DO absorption as a function of water temperature by the results of several investigators. K.R. Imhoff and D. Albrecht (18)

For comparison purpose Fig. 1 also depicts curve F, which is obtained by converting the oxygen transfer with respect to the saturation values.

When calculating the oxygen deficit it must also be remembered that the oxygen saturation values of the water increases with falling temperature and rising pressure.
Nearly all conversion of the transfer rate, however, neglect the well-known influence of water turbulence. Water turbulence is important for the movement of oxygen, because after a very rapid oxygenation of the boundary layer in the absence of turbulence, a slow diffusion process must take place, which is also dependent on temperature [18].

Effect of dissolved oxygen on nitrification process is given in table below, after B. Sharma and R.C. Ahlert (20).

Table 1. Effect of dissolved oxygen.

Dissolved Oxygen Concentration, $mg\,l^{-1}$	Observation	Circumstance/Method of Observation	Reference
<0.5	O_2 uptake by nitrifiers occurs	Dropping-mercury electrode method used to measure oxygen uptake	Painter & Jones (1963)
Below 2	Limiting* for *Nitrosomonas* growth	10-l batches; water from Thames Estuary, England; determination made from a model	Knowles, Downing & Barrett (1965)
Below 4	Limiting for *Nitrobacter* growth		
2, 4, 8	Degree of nitrification same: rate about 10% lower at $2\,mg\,l^{-1}$	Small-scale plant	British Ministry of Technology (1965; cited in Painter, 1970)
Below 3	Limiting	Activated sludge	Downing & Knowles (1966; cited in Eckenfelder, 1967a)
0.08	Critical†	Pure culture of *Nitrosocystis oceanus* (marine species)	Gunderson (1966)
>7.5	Inhibiting		
Below 1–1.5	Limiting for growth	Activated sludge	Wuhrmann (1968)
0.1	Nitrification occurs	Pure culture of *Nitrosocystis oceanus*	Carlucci & McNally (1969)
0.5–0.7	Critical	Activated sludge	Downing, Boon & Bayley (1962; cited in Huang, 1973)
<20% saturation	Limiting	Batch tests with activated sludge	Kiff (1972)
1	Limiting	Pilot plant; activated sludge	Metcalf & Eddy (1973)
0.6–0.7	Limiting	Percolating filter; receiving seawater; marine nitrifiers	Forster (1974)
Up to 60	No inhibition; no increase rate of ammonia oxidation	Submerged filter; receiving pre-oxygenated feed	Haug & McCarty (1972)

* Rate of nitrification is concentration dependent below this value. † Minimum concentration necessary for nitrification to occur.

In our research we have not considered parameters mentioned above for the reasons of great difficulties of making any observations and analysis within submerged filters and short research period. Neither dissolved oxygen concentration was on the limiting side.

4. SHORT DESCRIPTION OF THE PLANT

4.1. General information

One of the main goals of the pilot-plant is to gain the knowledge required to provide better chemical pretreatment, as well as an investigation of the performance of some new chemicals. Improved chemical pretreatment will increase phosphorus removal hence, less eutrophication of the Oslo fjord. More important there will be increased organics removal which must be optimized to have nitrification in the following biological process.

Another main goal of the pilot-plant is to achieve and optimize nitrification in submerged, aerated biofilters so it may be adapted efficiently on a large scale to the main plant at Bekkelaget, where activated sludge is the main biological prosess today.

In the summer of 1988, operation of the Bekkelaget pilot wastewater treatment plant began. It was designed for experimentation with chemical pretreatment and nitrification in biological filters. With respect to the processes involved, the pilot plant is a complete wastewater treatment facility, but the effluent and sludge produced are recycled back to the income canal of the main wastewater treatment plant at Bekkelaget. Bekkelaget is treating the municipal wastewater from about 350 000 p.e.

The pilot plant is operated by Oslo Water and Sewage Works (OVA), the water and wastewater division of the Oslo city works. Although operated by OVA, the pilot-plant is actually owned by the Norwegian Institute for Water Research (NIVA).

4.2. Operation of the pilot-plant

The pilot-plant (fig. 2 and fig. 3) consist of two identical chemical pretreatment lines, with different biological treatment lines. Each line is designed for a maximum flow rate of about 8 and 5 m^3/h, for chemical and biological lines, respectively. Wastewater is received from the income canal of the main plant at Bekkelaget and is pumped through a screen before entering the pilot-plant.

4.2.1. Chemical treatment

Two parallel chemical lines (K1 and K2) with flocculation and sedimentation processes are fed by two submerged pumps. Chlorated ferric sulphate (JKL), lime, polymer and sea water (3 % of the flow rate) are added. Doses are shown in tables in appendix 1. After sedimentation wastewater proceeds into the biological step.

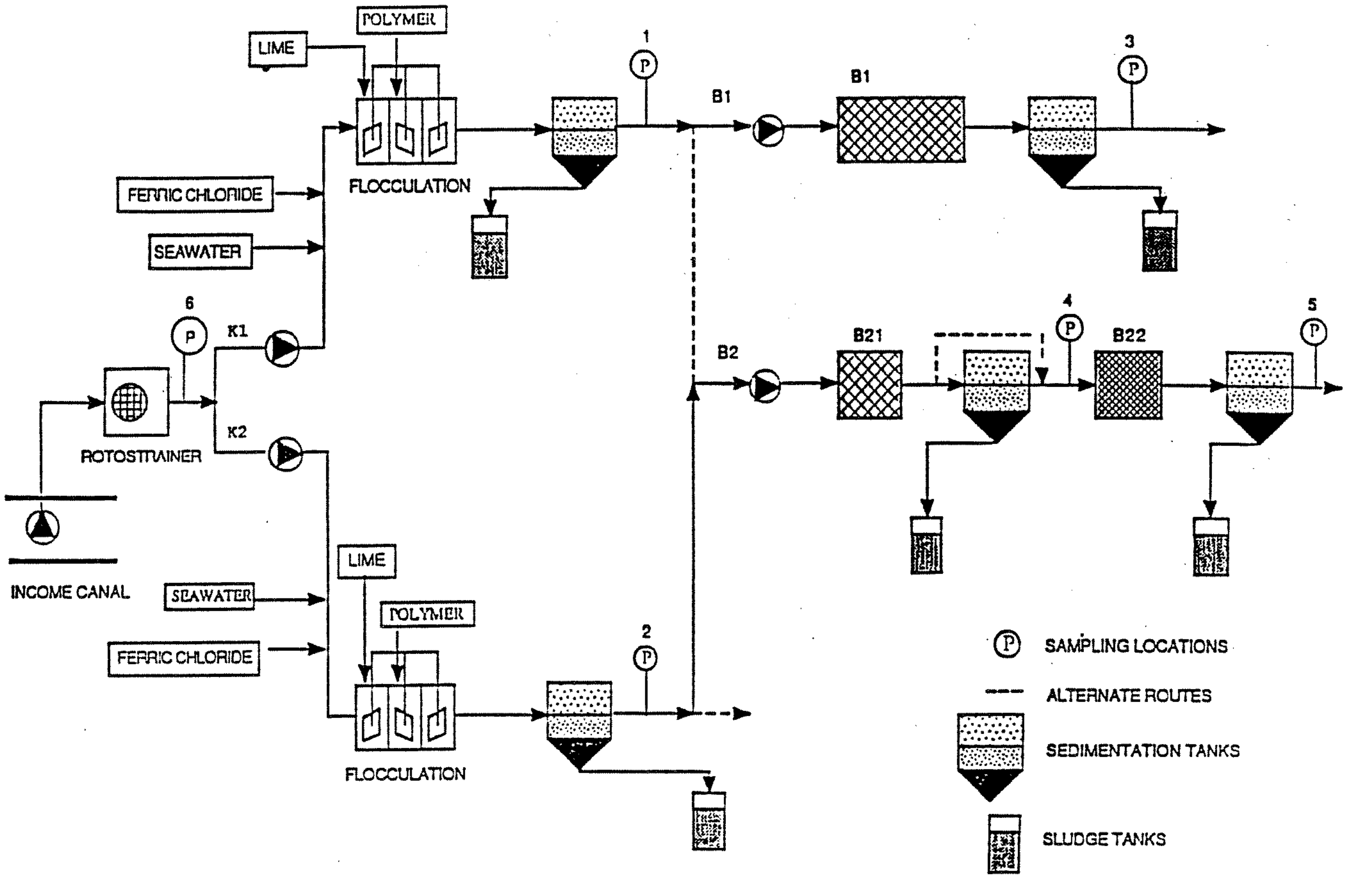

Figure 2. Flow scheme of the pilot-plant.

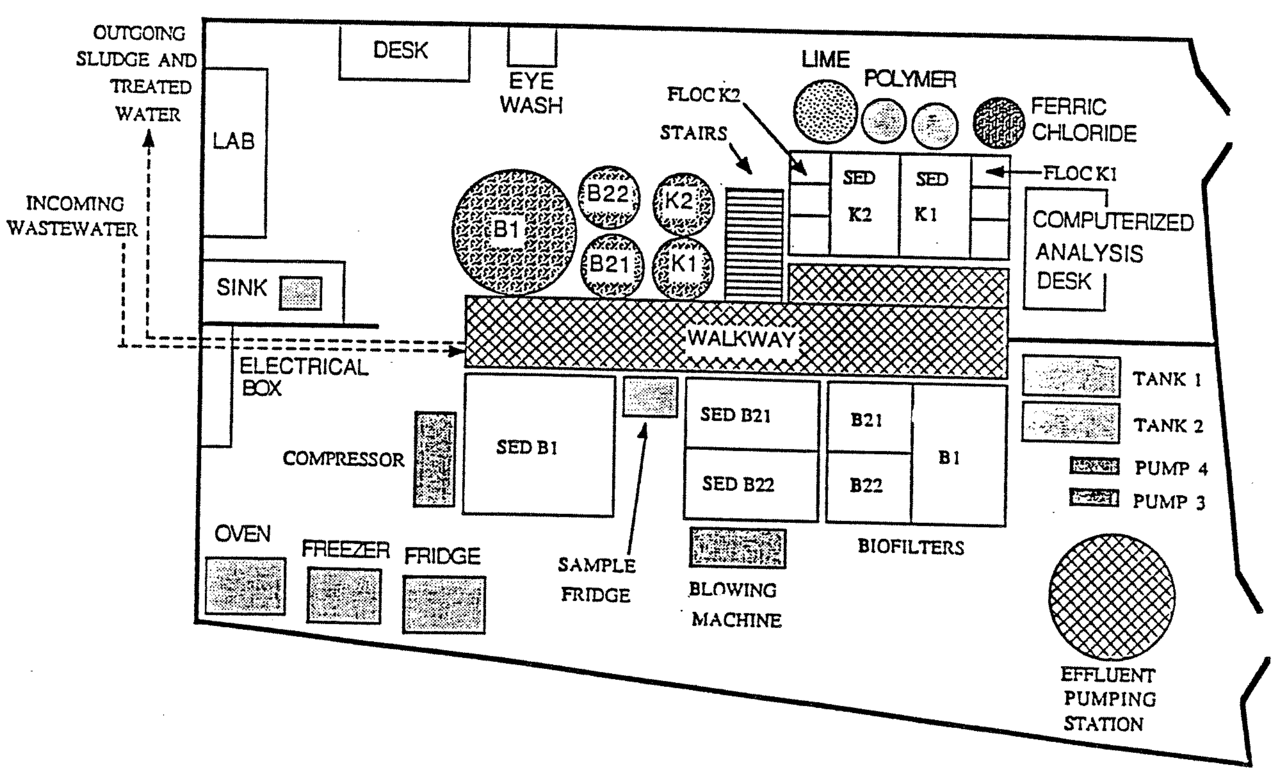

Figure 3. Crossectional view of the pilot-plant.

4.2.2. Biological treatment

Biological treatment involves aerobic attached growth on a plastic media in the aerated submerged filters.

Two parallel lines (B1 and B2) are implemented to perform nitrification process with one- (B1) and two-step (B2 splitted in B2/1 and B2/2) biological treatment. Each step is followed by sedimentation process. The filter medium has a specific surface area of 140 m^2/m^3 (B1) and (B2/1) and 230 m^2/m^3 (B2/2). Distribution of medium is shown on fig. 4, 5 and 6. Filter volume are: 9.6, 4.8 and 4.8 m^3, respectively. Hydraulic flow rate was kept on the level of 5 m^3/h to each line, thus retention time of treated wastewater was approximately 143, 76, 70 min., respectively, (based on the tank volume). For furhter information about operation of the plant see[6].

4.2.3. Aeration system at the pilot-plant

With help of one compressor air is supplied through the 9 lines with total 48 fine-bubble dome diffusors (fig. 7) at the bottom of the filters, at the submerged depth of 3 m. Aeration rates are controlled by 9 rotameters of different types:

A) 3 Rota G4 10.000 (capacity 10 - 100 m^3/h)
B) 1 Rota G4 6.300 (capacity 6.3 - 63 m^3/h)
C) 5 Rota G4 2.500 (capacity 4 - 40 m^3/h)

There is such a variety in types because these rotameters were taken from other places.

Installed blowing machine is operated with constant air flow rate and can not be regulated.

The excess pressed air from the blowing machine is escaping into air by the safety valve installed.

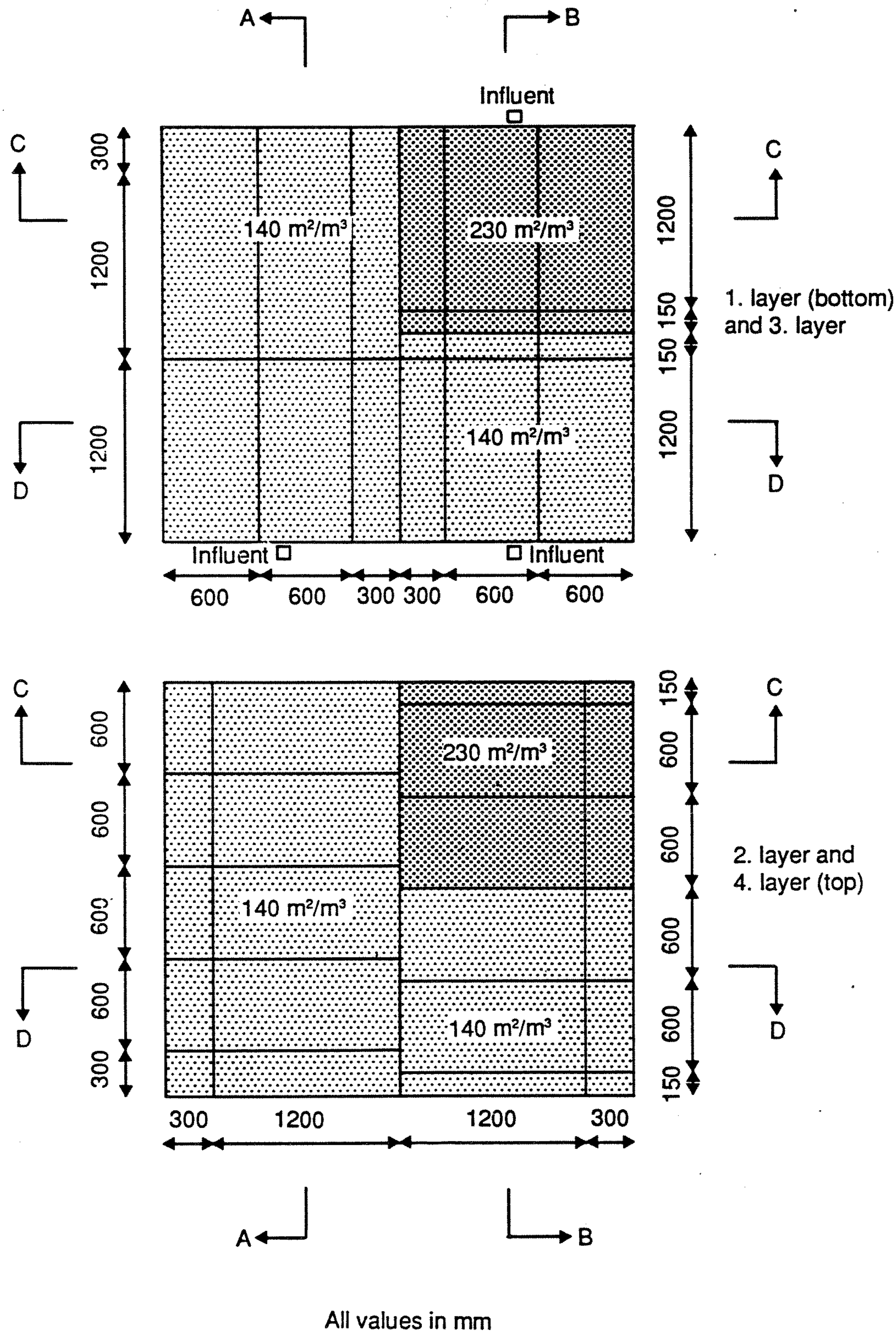

Figure 4. Distribution of the filter media (top view).

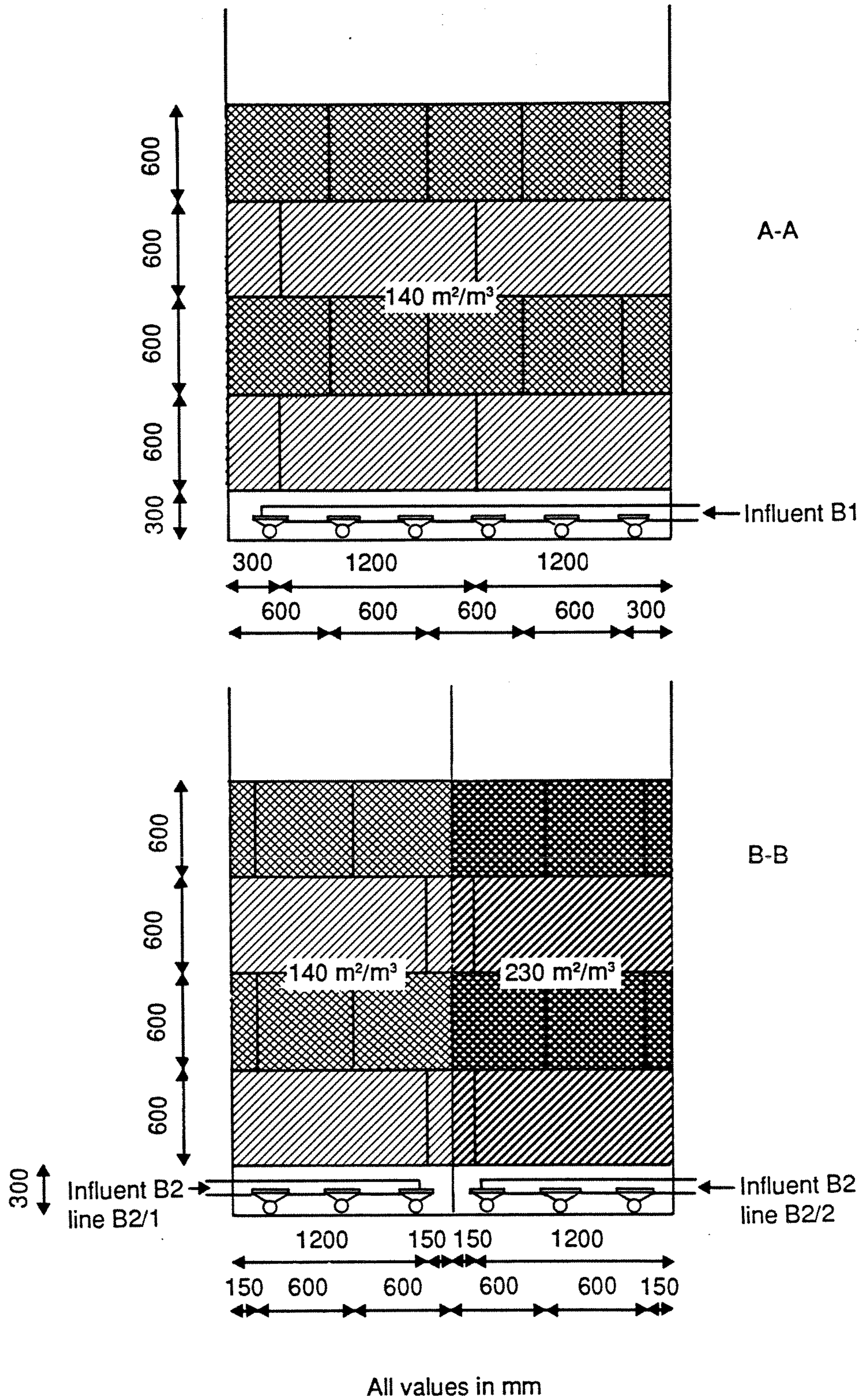

Figure 5. Distribution of the filter media (vertical crossections A-A and B-B).

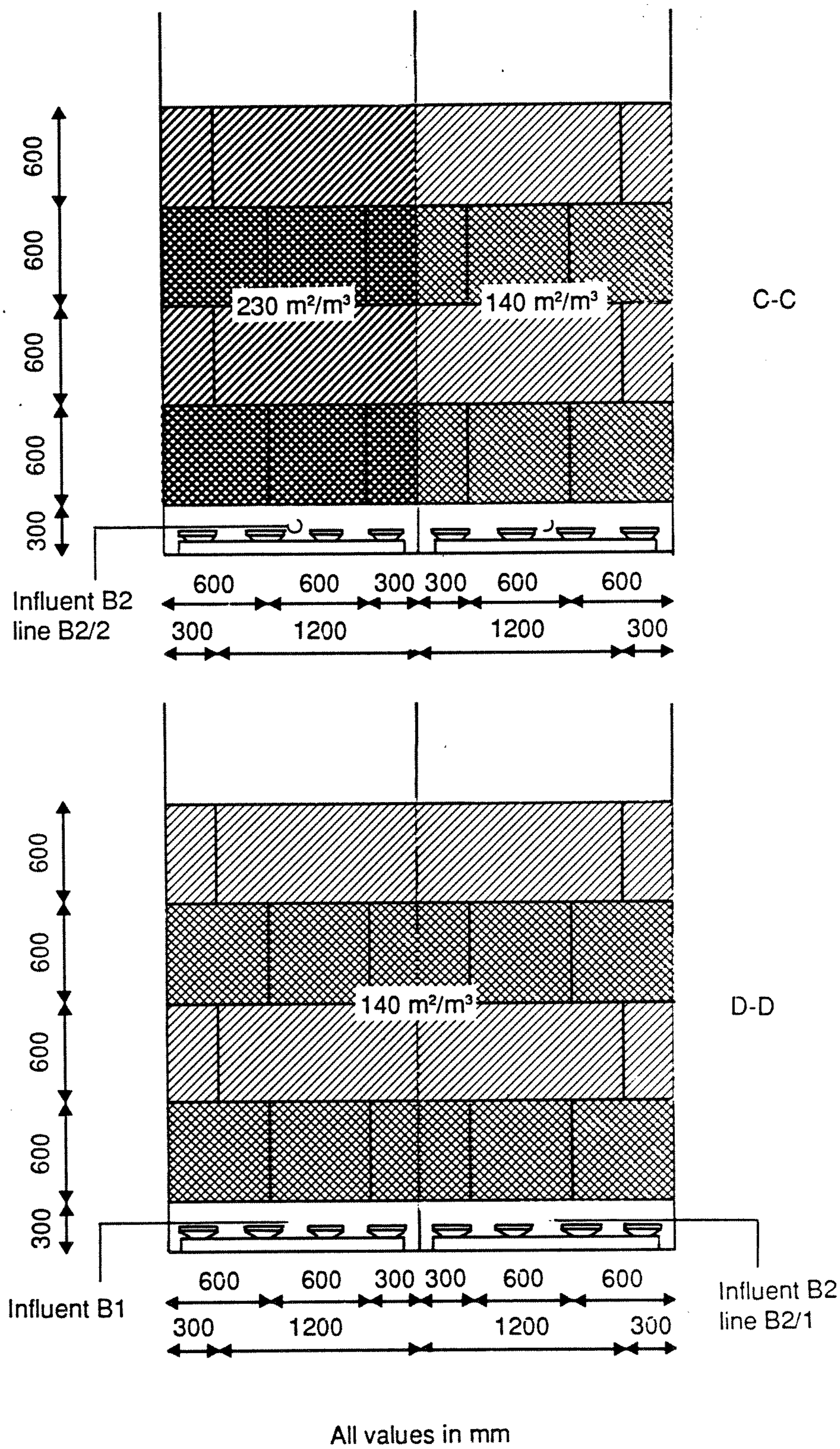

Figure 6. Distribution of the filter media (vertical crossections C-C and D-D).

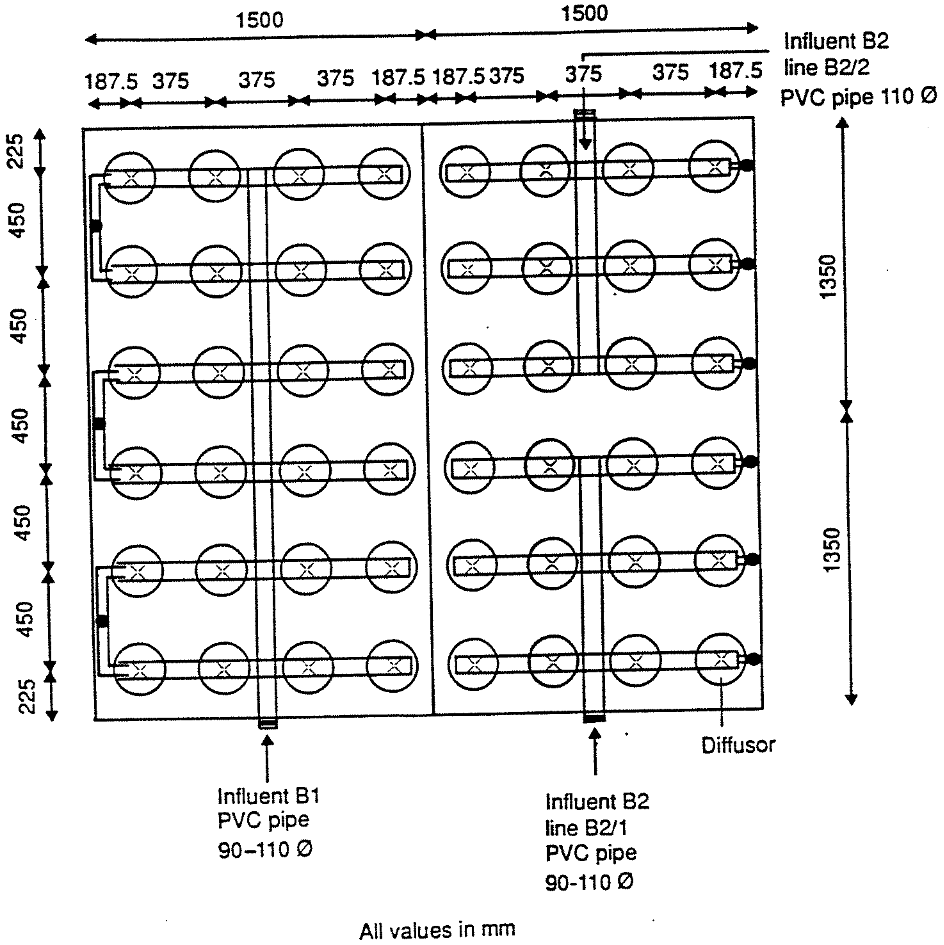

Figure 7. Top view of the aeration system.

Rotameters are installed as shown below on the scheme:

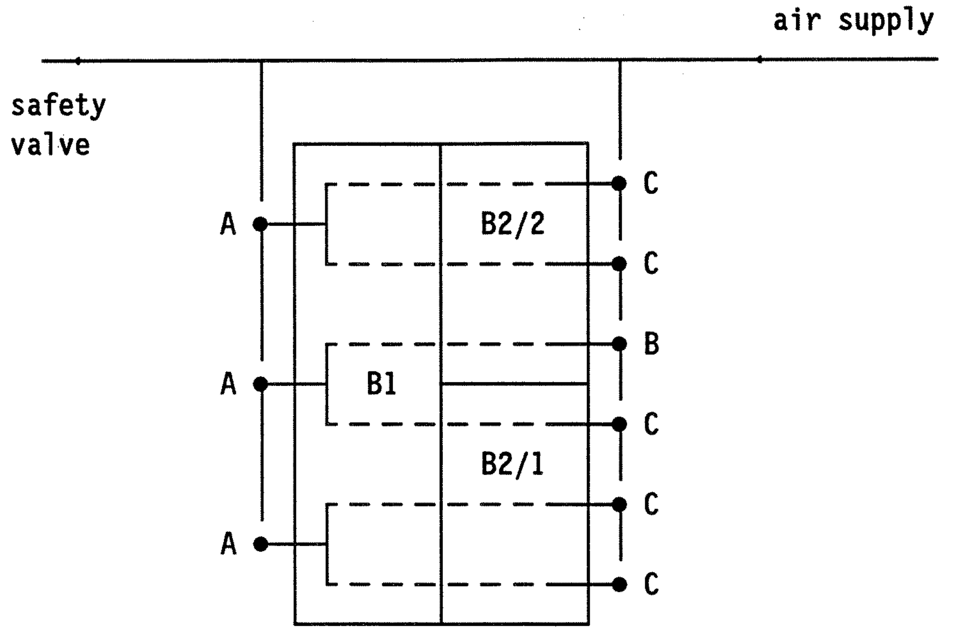

Fig. 8. Aeration system installed at the pilot-plant.

Wastewater is distributed through a perforated pipe directly above diffusers (see fig. 5 and 6).

5. PERFORMANCE

5.1. General

As mentioned previously air supply and demands were followed from October 1. 1989 to January 15. 1990. Average content (based on daily samples) of NH_4-N in the influent to the biological step in the period was 16.1 g/m^3 and COD 88.3 g/m^3, what corresponds to the load of ammonia of 1.44 and 1.09 g NH_4-N/m^2d and of COD of 7.9 and 6.0 g COD/m^2d, for one- and two-step filtration respectively. Lower value of a load at two-step treatment is caused by higher specific area.
Water temperatures varied from 6 to 13^{0}C and pH from 7.2 to 9.0.

Tables in appendix 2 show the results from measurements and analysis made for influent (nr.6), and samples after lines K1 (no. 1), K2 (no. 2), B1 (no. 3), B2/1 (no. 4) and B2/2 (no. 5) (see fig. 2 - sampling points) for pH, temperature, alcalinity, based on samples taken each day.
Ammonia, nitrite and nitrate were analysed mostly every 6-th day. Only after change of the aeration rates ammonia was checked daily.
These data were used for further evaluation with respect to nitrification performance related to oxygen and alcalinity use.

Tables in appendix 3 contain the samples gathered proportionally during the week, and were analysed for NH_4-N, NO_2-N, NO_3-N, total N, total P, dissolved and total COD for the same points as mentioned previously.
These data were used further for determination of general information, as efficiency (%) of the plant with respect to nitrification and nitrification rate (g NH_4-N oxidized/m^2d). (appendix 6).

Till the end of October both filters (B1 and B2/1) were fed from separate basins, each after separate flocculation and sedimentation lines. Since obtained influent parameters differed (ammonia concentration and COD concentration, alcalinity) it was difficult to directly compare results. Differences appeared mainly because of ununiform working conditions of pumps supplying chemicals into the flocculation step at both lines. From the beginning of November wastewater after chemical pretreatment was mixed and equalized before pumping to the biological step to improve data evaluation. This assured uniform starting conditions on both biological lines.

Performance of all the processes at the pilot plant have many disturbances caused by regular pumps breaks, starting from small parts (pumps for JKL, lime, polymer) to bigger as, main pumps supplying wastewater. It does not cause any problem for aeration system, since blower works constantly.

5.2. Aeration part

5.2.1. Aeration rate

As indicated before air was supplied into the biological treatment part by means of diffusors placed at the bottom of the filters. Amount of air supplied was measured by rotameters.

During the period of research three different aeration rate were applied, namely 324.5, 185.6 and 220.8 m^3/h in total, at working conditions. This corresponds to:

a) 15.7, 17.4 and 18.8 m^3 air per m^3 filter volume and hour for B1, B2/1, B2/2, respectively at the first aeration rate (assumed as maximum values).

b) 10.0, 8.7 and 10.0 m^3/m^3h for B1 B2/1 and B2/2, respectively at the second aeration rate (ca. 30% related to the first rate).

c) 12.0, 10.0 and 12.0 m^3/m^2h for B1, B2/1 and B2/2, respectively at the third aeration rate (adjusted such-that the air rate was approximately equal for all pipes).

Periods of runs were:

run 1 from 1 October 1989 to 21 November.
run 2 from 21 November to 21 December.
run 3 from 21 December to 15 January 1990.

Experiments started with the aeration rate already being used from the beginning of the running of the pilot-plant. It was set-up on the maximum level to assure always enough dissolved oxygen. In reality it was not stated before how much of air in m^3/h each filter obtained.

We could only read values of centimeters on the scales of each rotameter but we could not express it further in m^3/h. Reason for it was lacking of the characteristics of the rotameters.

Also variety in types used and daily unstability of air supplied made it initially impossible to predict the correct values of amount of air pressed.

This was the reason for the unregulary distribution of air in the first two runs and that the second run was delayed with respect to the program where aeration rate was lowered by the same value of approximate 30% of the previous values by all the rotameters.
Amount of air supplied were determined after obtaining the characteristics of the equipment.
Also the last run could be adjusted more accurate in such a way that almost the same amounts of air could be assured to each pipe, providing more equal air/oxygen distribution in the filter.
This implements that the aeration rate was changed by different values at each rotameters. Amount of air into the first step filter (B2/1) of the two steps was set-up on lower level because previous runs values have shown that DO content in the effluent from B2/1 was always higher then 2 mg/l demanded.

The last run aeration rate was set-up higher then previous because of bad nitrification performance during the run no. 2, although as we learned afterwards other reasons then aeration explained this phenomenon (see discussion of results).
Figure 9 presents the air supply condition for the 3 runs as averaged value and ranges of daily variations.

During time of experiments filter in the blowing machine was changed twice, based on observation of deterioration of pressing capacity.

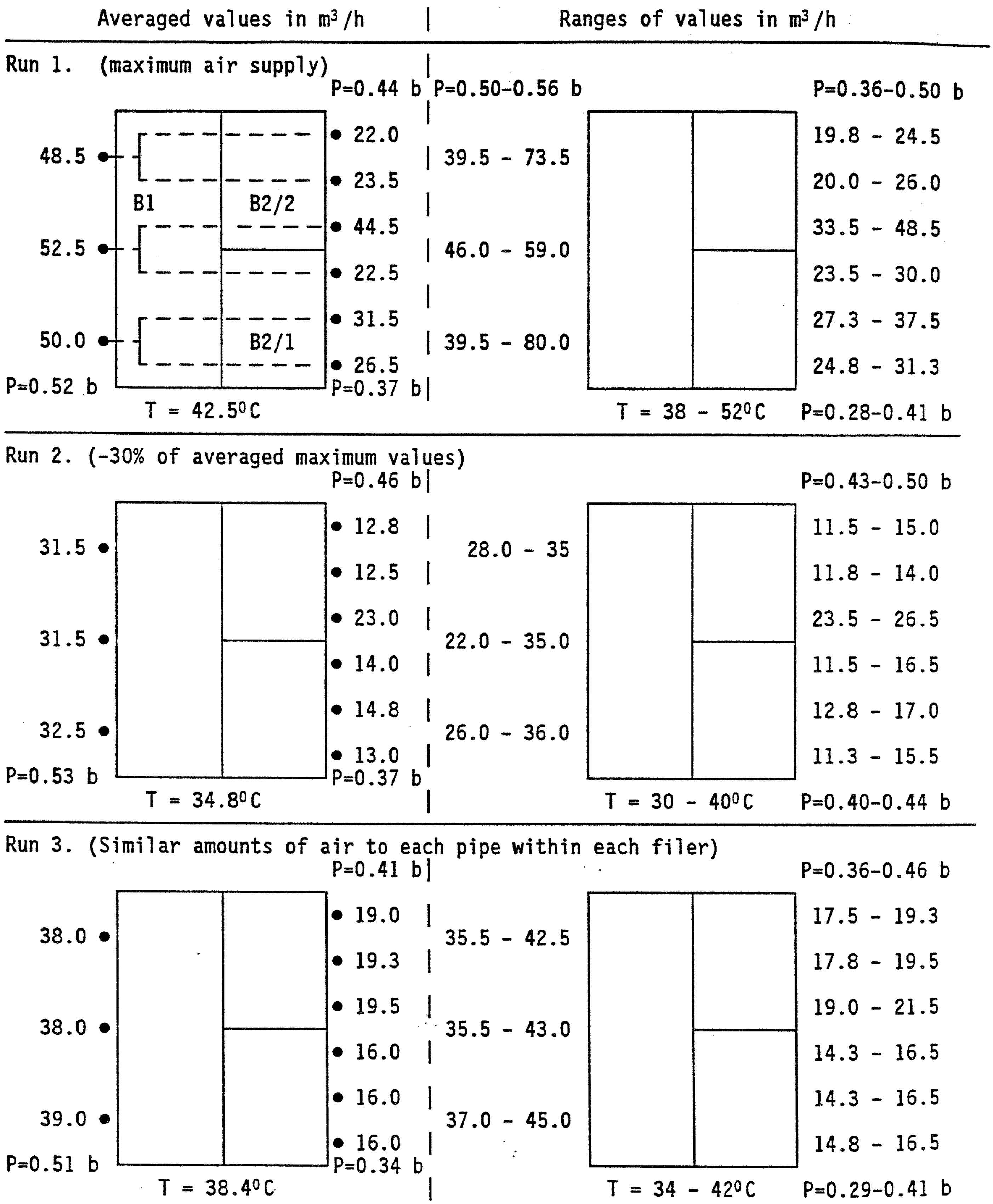

Figure 9. Air supply conditions during research period.

5.2.2. Dissolved oxygen

Parallel with air supply measurements dissolved oxygen (D.O.) levels before and after the filters were continously recorded by means of continous monitoring system. Electrodes for dissolved oxygen measurements were placed in 4 measuring points as shown on the scheme below:

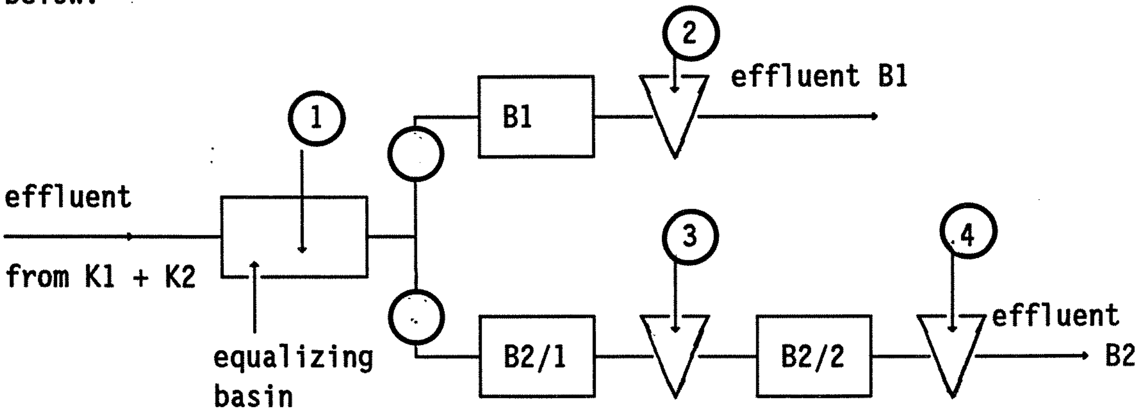

Fig. 10. Measuring points for dissolved oxygen.

Since there is no space and possibility of placing electrodes in the filters itself, they had to be placed in the inner pipe of the sedimentation tanks assuming the same D.O. as in the outlet of the filter. Such assumptions is reasonable because of minimal distances between the basins.

Electrodes were cleaned daily to prevent bacterial growing on it and showing misleading values of D.O. levels in the basins. Also changes of membranes on the electrodes and calibration of the system as well as bateries check on the monitors were performed regulary.

5.3. Backwashing of the filters

Traditional nomenclature of backwashing is used here for in fact scouring or stripping of the filters with air only.

Since there are not yet special criteria for backwashing of the filters, existing decisions to do so is based on visual observations of the working system. Both, when the pressure (on the manometers) is increasing and/or when the air flow (through the rotameters) is decreasing. After OVA's personnel information backwashing is performed since about one year ago and repeated occassionally for 4 or 5 times a year.

Compressed air is used allowing maximum air pass through each pipe, one after another. While one pipe is opened totaly others are closed completely. Balancing of air supplied into the system takes place by regulation of the safety value for excess air.

During the period of research, filters were backwashed just before changing the aeration rate from run 1 to run 2 (the 21th of November) This action could also influenced the stability of nitrification process afterwords (see results discussion).

As indicated in the literature reference (8) the frequency of backwashing, which is required to reduce clogging and build-up of pressure losses, will vary, depending on influent quality and flow rate. To avoid short-circulating, good hydraulic distribution of the influent is necessary along with the ability to backflush the media when plugging occurs. With the plastic media the frequence can be reduced considerably because of the high void volume. In most cases excess solids in the higher void space media (80 to 95%) can be withdrawn simply by draining the units on a monthly or less frequent schedule. For comparison, with gravel media, standard practice is to backwash the reactor at approximately 17 l/m^2s at least three times per week and, in some cases, daily[8].

In studies performed by Haug and McCarty[5] with submerged filters filled with stones periodic backwashing at about 2-week intervals was effective in removing solids held loosely between the media voids and in preventing the build-up of excess solids. The backflushing was accomplished by partially draining the filter from the bottom. If the influent to the filter contained any appreciable suspended material, the period between backwashing would undoubtedly have to be shortened.

6. RESULTS AND DISCUSSION

6.1. General

Detailed data for the results obtained during research are presented in tables in Appendixes 1 - 6.

Actual information about nitrification performance is:

a) NH_4-N in the influent and effluent and efficiency of the process based on daily samples,
b) alcalinity measured (influent, effluent),
c) measured dissolved oxygen values (influent, effluent),
d) calculated theoretical values of dissolved oxygen,
e) calculated alcalinity.
f) dissolved oxygen supplied.

Information for a) and b) are taken from Appendix 2. Values for c) are taken form Appendixes 4 and 5. Values for d) and e) are calculated for nitrification performance as obtained in practical conditions using the stoichiometric values of 4.2 g O_2 and 7.13 g $CaCO_3$ per g NH_4-N oxidized. These last values are compared with measured. Values for f) are taken from observations of air flow rates on the rotameters.

6.1.1. Temperature

Appendix 6 presents temperatures measured during the experiments. When started daily measurements of temperature (d.d. 7th of November) water temperature of incoming water was about + 12^{0}C.
The coldest period was reached around the 10th of December and lasted for about a week with air temperature down even to - 15^{0}C during the nights (see also tables with air temperatures obtained from the Norwegian Meteorological Institute). Afterwards weather conditions became milder reaching plus temperature and staying so till the end of the research period. As a matter of fact water temperatures have not followed the changes of air temperatures.

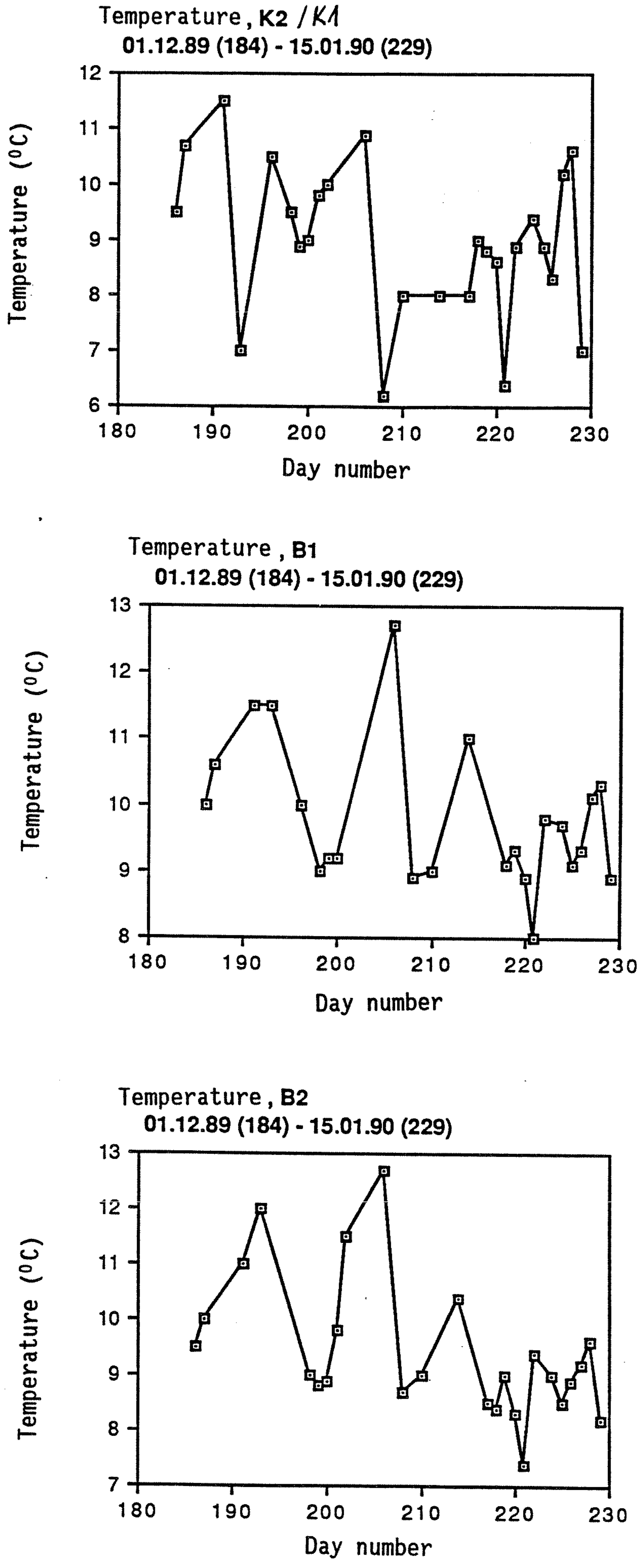

Figure 11. Temperature measured during the research time.

It is observed that the most pronounce influence on water temperature changes have: 1) rain and snow melting periods causing lowering of temperature, and 2) a fact that compressed air distributed into the filters has a temperature of app. $40^{0}C$ and cause usually an increase of temperature by approximately $1^{0}C$.

6.2. Nitrification-aeration

All results are presented in appendix and summarized in figures 12-22. In the following comments are made to each run.

6.2.1. Run one (1. October 1989 - 21. November 1989)

This run represents the maximum applied aeration rate at the filters, which was performed already for a long period proceeding this research. This is also why the most information are available for this run.

As explained in 5.2.1. aeration rate was initially set-up at the optional value, at the maximum rate, to prevent oxygen limitation (without possibilities of determination of the amount supplied) Therefore values calculated afterwards show that aeration rates vary from one filter to the other. Applied averaged aeration rate were: 15.7, 17.4 and 18.8 m^3 air per m^3 filter volume and hour, at the B1, B2/1 and B2/2, respectively. This higher amount of air in the B2/2 filter was caused by the relative large amount of air passing through the rotameter G4 6300.

Nitrification process was performed in general without problems. Averaged efficiency for the process from daily sampling was 52 % for one-step filtration and ca. 75 % for two-step filtration.

Averaged nitrification rate was 0.96 and 0.86 g NH-N oxidized/m^2d, for one- and two-step filtration, respectively.

Dissolved oxygen levels in the filters were above 2 mg/l required. Influent (K1 + K2) consisted generally D.O. above 4 mg/l (averaged value 5.1) although these values varied from almost "0" (when pumps failures occured) to above 9 mg D.O. /l.
Effluent after the one-step filtration (B1) consisted averaged D.O. of 8 mg/l. Effluent after the first-step (B2/1) of two-step filtration (B2) had D.O. above 4 mg/l, and effluent after the second-step (B2/2) had D.O. above 7 mg/l.

Since aeration rate was at the maximum, question of optimizing the system has arisen what has led to determination of the proper values of the air supplied (in m^3/h).

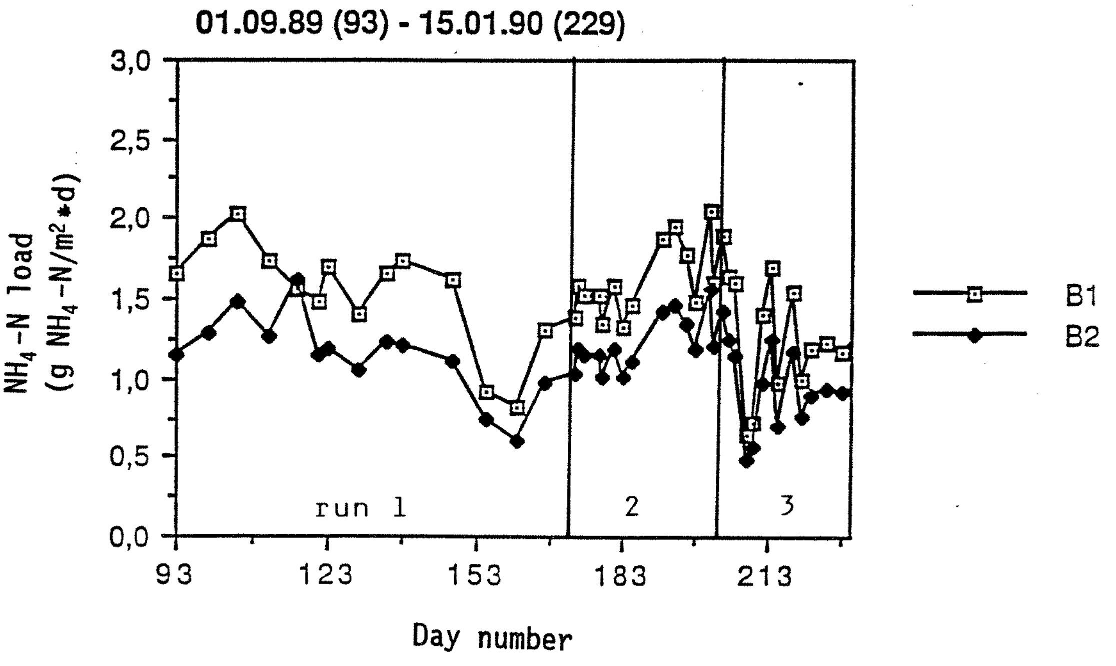

Figure 12. Ammonia load in the lines B1 and B2

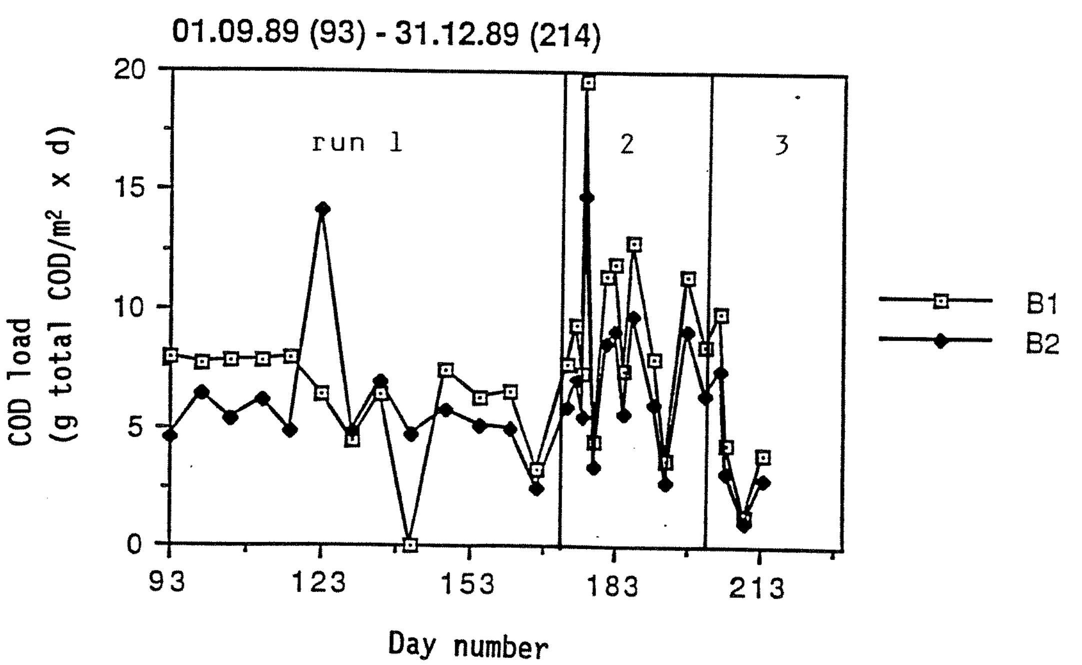

Figure 13. COD load in the lines B1 and B2.

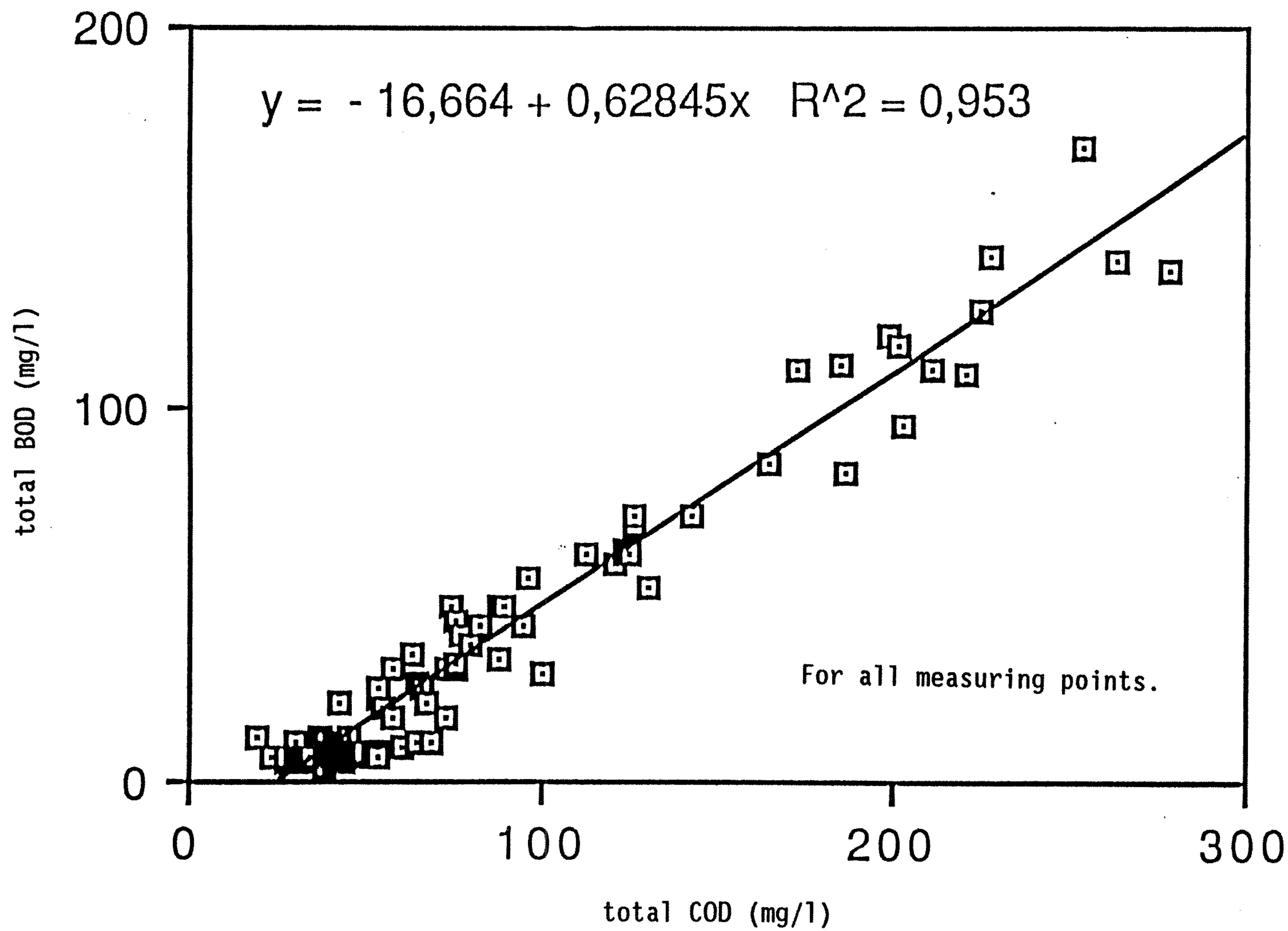

Figure 14. Relation between total COD and total BOD at the pilot-plant, weeks 20-35/89.

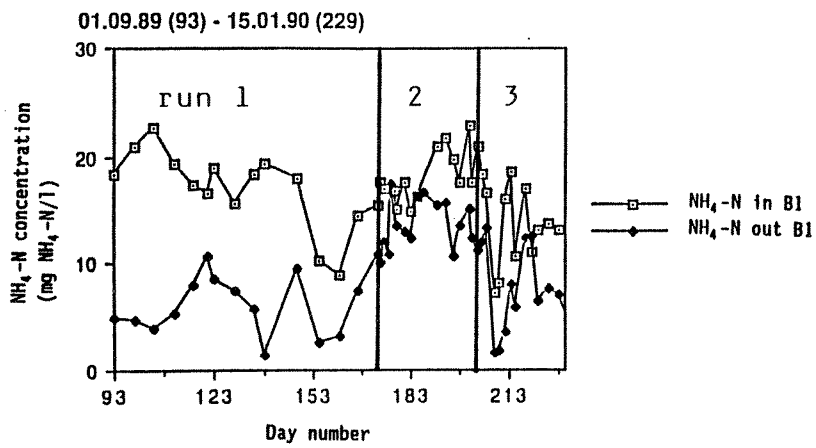

Figure 15. Ammonia concentration in the influent and effluent for B1.

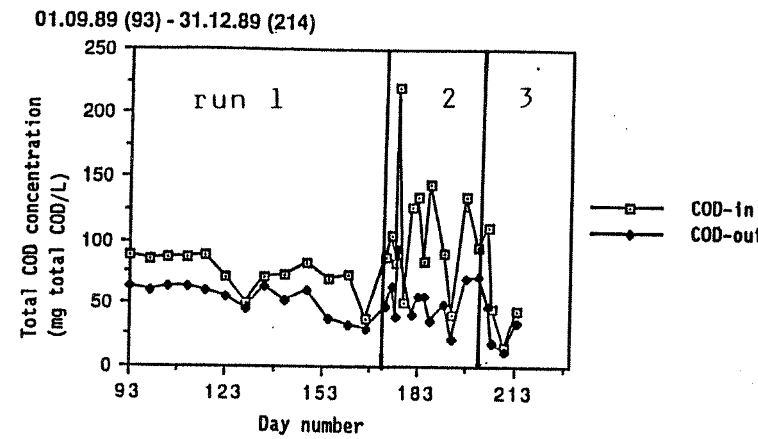

Figure 17. COD concentration in the influent and effluent for B1.

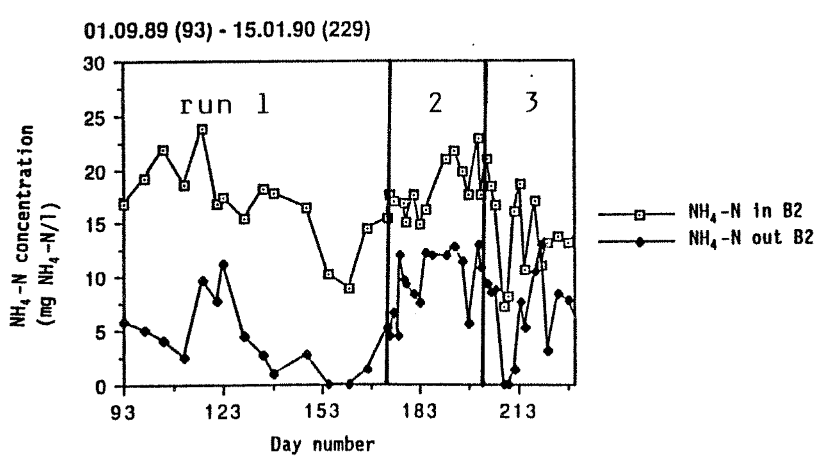

Figure 16. Ammonia concentration in the influent and effluent for B2.

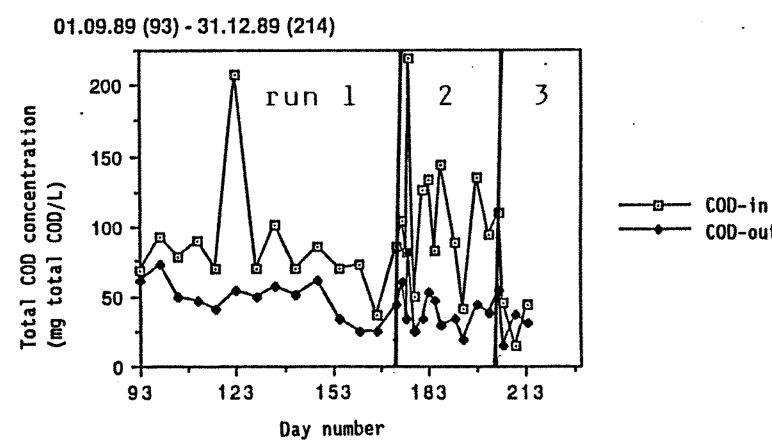

Figure 18. COD concentration in the influent and effluent for B2.

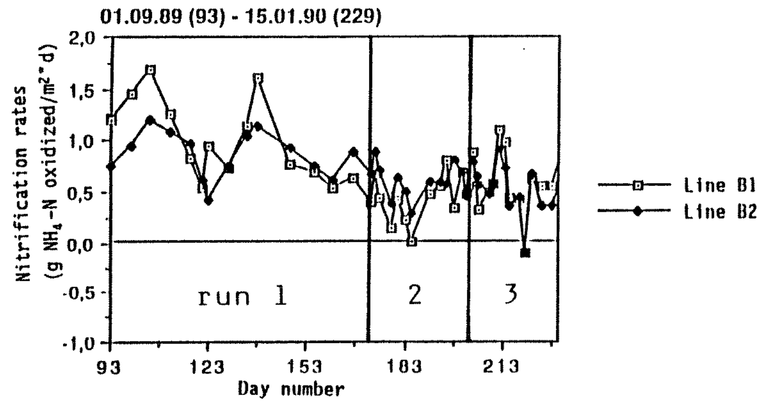

Figure 19. Nitrification rate as a function of research time, for B1 and B2.

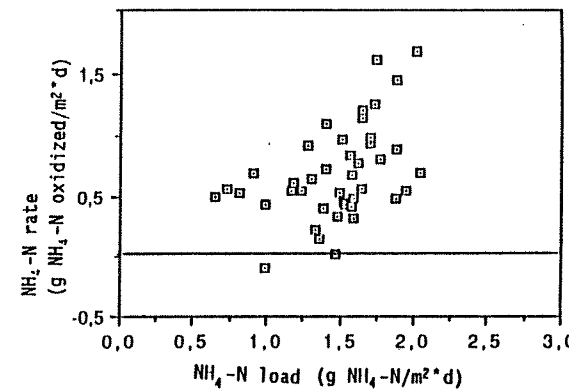

Figure 20. Ammonia load versus nitrificaion rate for B1.

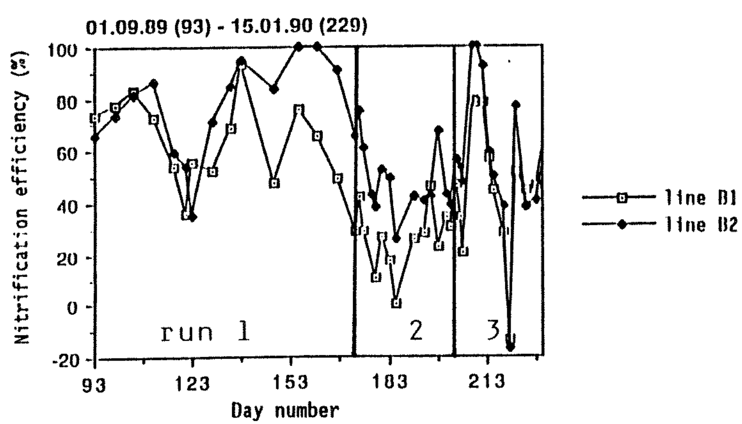

Figure 22. Nitrification efficiency during the research time.

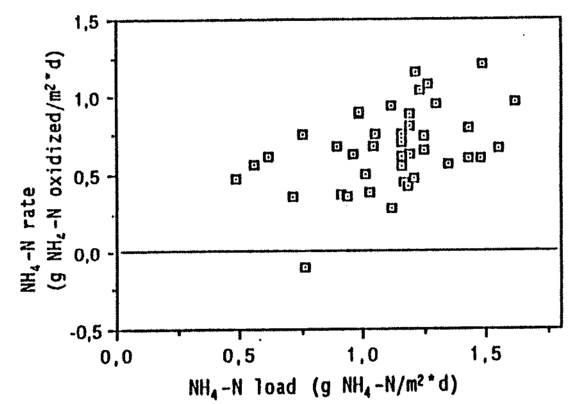

Figure 21. Ammonia load versus nitrificaion rate for B2

6.2.2. Run two (21. November 1989 - 21. December 1989)

The aeration rate was lowered by 30%, based on averaged values from run 1 obtained from the scales of the rotameters read in cm. From calculation backwards (when characteristics of the rotameters were available) changes by 30, 22.5 and 22.0% appeared to be applied for B1, B2/1 and B2/2, respectively.

After lowering the aeration rate nitrification process performed badly. Unstable nitrification has caused a big variation in the effluent quality. Although D.O. levels in the effluents were higher then 2 mg/l, efficiency of filters with respect to nitrification was very low. "Production" of NH_4-N in the first-step of the two-step filtration was observed caused by ammonification (the biodegredable portion of the organic nitrogen is decomposed by many bacteria releasing ammonium)[14]. Such increase of ammonium was observed also previously.

The main reason for bad nitrification performance was the high organic load on the filters (Yeast Factory which usually discharge equilized wastewater has discharged raw, concentrated sewage with a frequence of 4 days/week 6 hours/day in the period from 23 November till 6 December [15]).

Other events could also give explanation to this phenomenon, as:

- proceeding the lowering of the aeration rate all the filters were scoured with air (what could cause wash-out of a fraction of an active nitrifiers),

- this was the coldest period during the research time (although the air temperature has not noticable direct influence on water temperature, see 6.1.1).

Averaged efficiency for the process from daily samples was app. 26 % and app. 48 %, after one- and two-step filtration, respectively.

Averaged nitrification rate was 0.45 and 0.60 g NH_4-N oxidized/$m^2 \cdot d$ for one- and two-step filtration, respectively.

Dissolved oxygen levels were registrated mostly above 2 mg/l required.
Influent (K1 + K2) consisted D.O. above 6 mg/l.

Effluent B1	7	mg O_2/l
Effluent B2/1	5.6	mg O_2/l
Effluent B2/2	6.6	mg O_2/l

All values are averaged.

There was no danger that the dissolved oxygen is a limiting factor, but because of bad performance of nitrification process in this run it was decided (on request of OVA-personnel) not to lower further the aeration rate. If we knew about high organic load at that time we might have lowered aeration rate even more.

Since nitrification rates were very low, in order to avoid unfavorable conditions "meeting" at the same time (causing in worse case wash-out of nitrifiers) the next aeration rate was chosen to be in between the maximum and the low one.

6.2.3 Run three (21. December 1989 - 15. January 1990)

Because of the possibility to calculate the aeration rate properly, these values were adjusted such a way, that comparable amounts of air were supplied into the filters, which resulted in 65.5, 74 and 74 % of the maximum air supply (12.0, 10.0 and 12.0 m^3/m^2h) for B1, B2/1 and B2/2, respectively.

This run performed satisfactory, with an average efficiency for nitrification of app. 56 % and app. 61 % for one- and two-step filtration, respectively.

Also organic load conditions and water temperatures and quite diluted incoming wastewater (rainfalls) did not cause any extreems.

Averaged nitrification rate was 0.65 and 0.52 g NH_4-N oxidized/$m^2 \cdot d$ for one- and two step filtration, respectively.

Dissolved oxygen levels were recorded to be (averaged values):

incoming water	-	8.7	mg O_2/l
effluent B1	-	8.3	mg O_2/l
effluent B2/1	-	7.4	mg O_2/l
effluent B2/2	-	8.3	mg O_2/l

6.2.4 General remarks

Figure 23 shows averaged D.O. levels as a function of ammonia oxidized. There is hardly to see any relationship. Results for this period of research confirm that two-step filtration perform better then one-step.

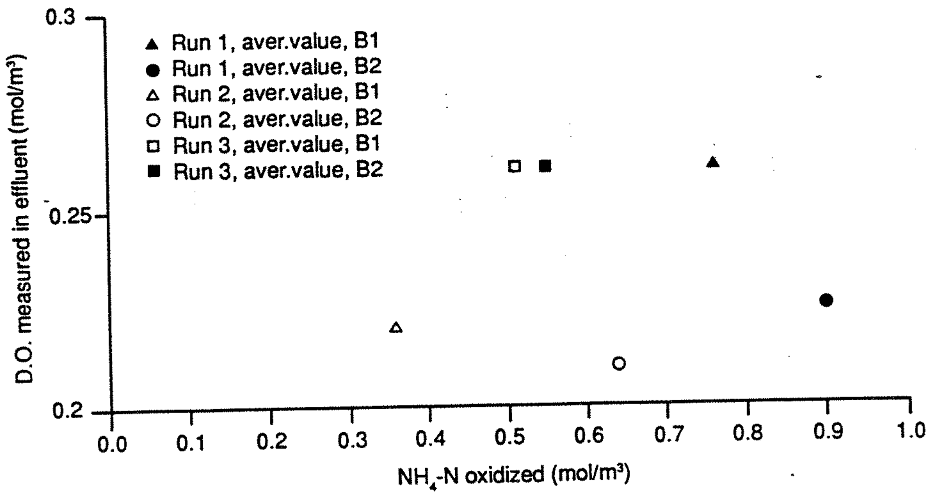

Figure 23. NH_4-N oxidized versus D.O. measured for B1 and B2, run 1, 2 and 3.

Appendix 5 includes also tables A 5.3 and A 5.4 where information are given how much oxygen was consumed for COD removal averaged values and table A 5.5 where D.O. supplied is compared with that consumed for carbonaceous and ammonia oxidation.

There are two general conclusions to be drawn out of these information:

1. the efficiency of the aeration system is very low. Taking into account the requirements for oxygen for ammonia oxidation, carbonaceous removal, build-up of biomass and preventing from clogging figurs indicate that only a very few percent of air pressed in is utilized in the system itself. Most of it escapes into air (table A 5.5).

   Literature (1) indicates that, in general the efficiency of porous diffuses varies from 4 to 30 percent or more, depending on the type and porosity of the diffuser, the size of the bubbles produced, the depth of submersion, the strenght of the wastewater ect. Extra high air flowrates may reduce the efficiency of oxygen transfer.

2. the air/liquid ratio (m^3/m^3) varies from 18 to 35. This surpass a lot the recommended values for diffused - air aeration, where the amount of air used has commonly ranged from 3.75 to 15.0 m^3/m^3 [1].

Foaming above the filters could also indicate that too much air is supplied, but this question should be checked before taking a final conclusion.

During the research period it happened to measure D.O. levels below 2 mg/l in the measuring points, especially during longer pumps breaks. These values, however, are not representative for a D.O. levels in the submerged filters itself, where air is supplied continuously, even while the liquid pumps failured. For mentioned before reasons it was not possible to constitute correct D.O. values inside the filter. Neither it was possible to capture air above the filter and to make any comparisons with D.O. in air and water. Such observations could help to constituate whether there are or not oxygen transfer problems.

6.3. Nitrification - alcalinity

Figures 24a-c and 25a-c show plots of the calculated effluent alcalinity versus the measured. They are based on results shown in appendix 4.

Figures 24a, b and c represent results obtained for one-step filtration, figure 25a, b and c - for two-step filtration, all for runs at the different aeration rate.

For run 2, when the aeration rate is lower then in run 1, smaller alcalinity values indicate that the nitrification rate was also smaller. Although values are shiffed down they appear to be less spreaded then in case of the higher aeration rate.

All results are laying in the ± 10 % interval of line x=y. A single overall relationship does not apply. Inaccuracy in analysis or/and the process disturbances could be the explanation for this phenomena.

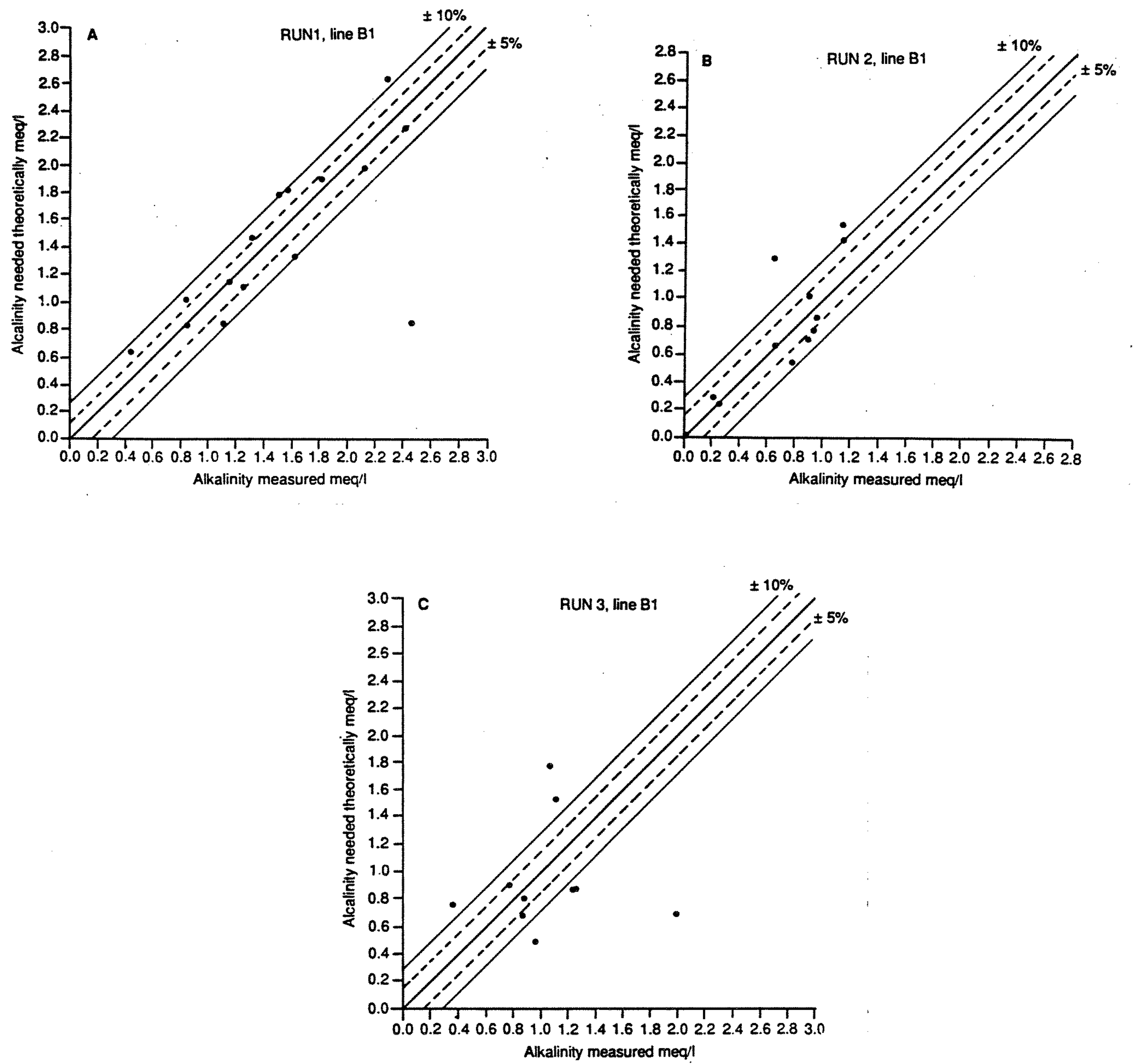

Figure 24. Alcalinity measured versus theoretical needed for ammonia oxidation, one-step filtration (B1).
a - run 1, b - run 2, c - run 3

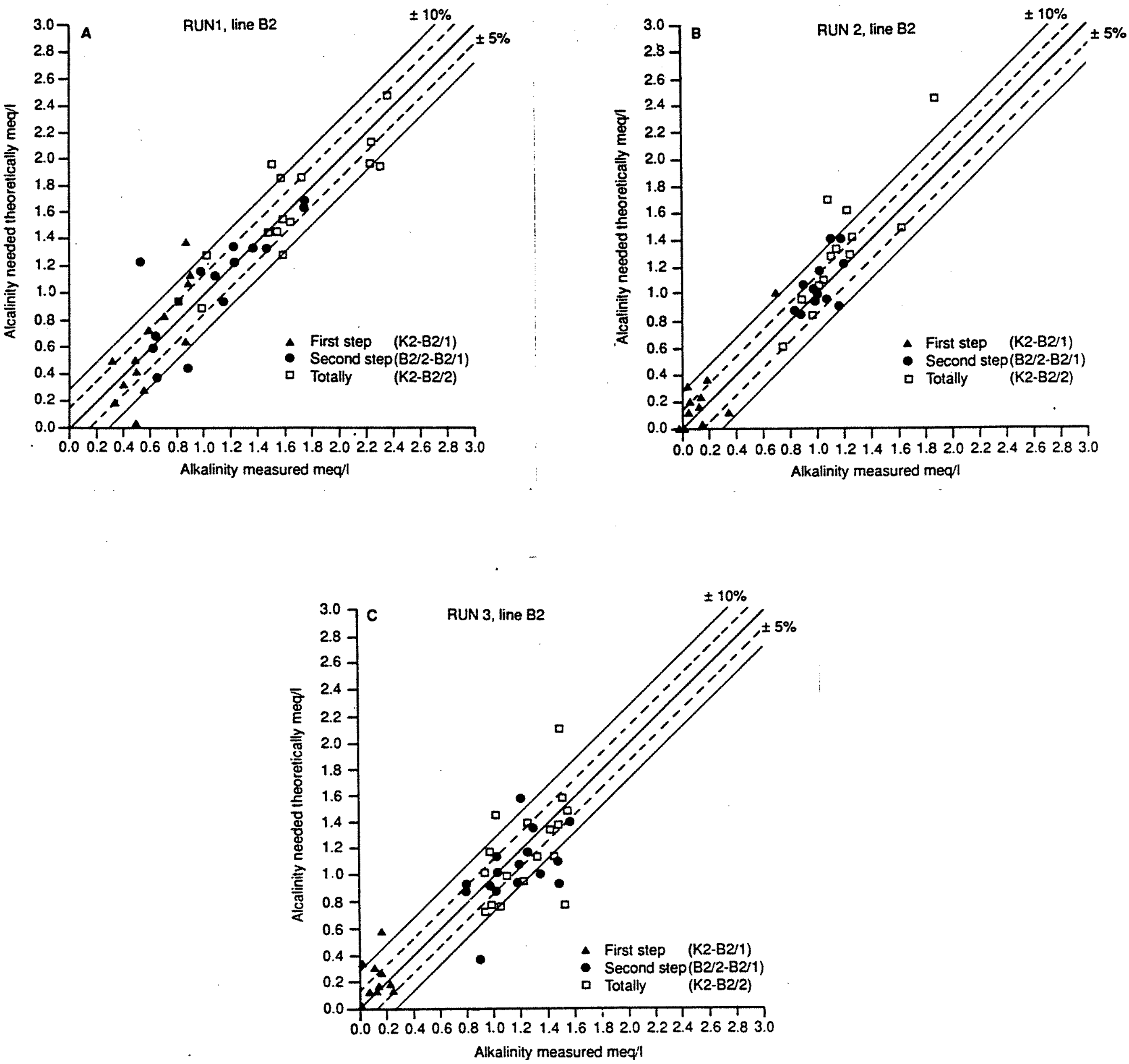

Figure 25. Alcalinity measured versus theoretical needed for ammonia oxidation, two-step filtration (B2).
a - run 1, b - run 2, c - run 3.

7. CONCLUSIONS

General conclusions for this research should include:

- giving suggestions for full-scale design criteria with respect to air supply and consumption for nitrification process and to prevent from clogging with use of the aerated submerged biological filters.

- conclude about performance of the existing pilot-plant for the same marks of reference as above.

For the first point answers are not given from the practical point of view: all the difficulties which we met during the measurements, and short time of the research period.
Unfortunate discharge of concentrated wastewater by the Yeast Factory during this period prevented us from further lowering the rate of aeration, thus it is impossible to state how far aeration rate could be lowered.

With regard to the pilot-plant following conclusions are drawn:

7.1. Aeration system

- The main conclusion from this research is that existing aeration system at the pilot-plant is very inefficient.

- Optimizing of aeration system, thus costs saving, is necessary.

- Better arrangement of the whole aeration system could be reached by:
  - not allowing such a big air losses, thus step-wise aeration by means of regulatory compressor and adjustment of air-needs to wastewater strenght and to prevent clogging,
  - uniform system for measurements of air would suit better (the same types of rotameters at one filter),
  - alternatively using of pure oxygen with recirculation could be considered.

- Study on the oxygen diffusion, turbulence and transfer conditions within the filters could be performed to choose the best aeration method.

- Other aeration rates performance and best optimal conditions for different seasons of the year could be found.

7.2. Submerged filters

7.2.1. Generally

- At present there is not possibility to perform any observations in the filters itself.

- For to understand biomass build-up on the support media and to be able to determinate oxygen, ammonia and other parameters distribution within the filters building-up of the measuring-taps along the filter walls is advisable.

- Plexiglass wall or windows could be placed for visual observations.

- When too high organic/ammonia-loads or other unfavourable conditions of incoming water appears to take place dilution by recirculation of effluent should be considered.

7.2.2. Alcalinity

- automatic control of pH adjustment (alcalinity) is advisably. At the moment alcalinity is adjusted manually by correcting alcalinity of effluent after biological step. This gives at least one day too late information. Alcalinity values vary from day to day even up to 1 meq/l (see appendix).
- Since the chemical dosage required for pH adjustment depends on alcalinity, loss of alcalinity can be regained by using denitrification process.

7.2.3. Backwashing

With respect to clogging phenomenon further study should be performed to set-up proper criteria for backwashing conditions. Suspended solids concentration and flow rate (hydraulic loading) should be watched. (see 5.3).

7.3. General remarks

During the research period nitrification performed satisfactory with an average efficiency around 65 % (lowest: 1 % run 2)
(highest: 100 % run 1.3)

and average nitrification rate of : 0.67 g NH_4-N oxidized/m^2d.

As mentioned previously the reasons for bad performance in run 2 was mainly the high organic load.

Generally 2-step attached-growth nitrification perform better then single step, where the 1st-step is used in general for degredation of the organic matter performed by heterotrophic bacteria (carbonaceous oxidation) and the 2nd-step is used mostly for nitrification process performance.

LIST OF DEFINITIONS, SYMBOLS AND ABBREVIATIONS;:

pH	= $-\log [H^+]$
Alcalinity	= meq H^+/l required to reach pH = 4.5 (methyl orange alcalinity)
1 eqv alcalinity/cm^3	= 50 mg/l alcalinity as $CaCO_3$
eqv	= equivalents
TN	= total nitrogen
TKN	= total Kjeldahl nitrogen
BOD	= biological oxygen demand
COD	= chemical oxygen demand
NH_4^+-N	= ammonia nitrogen
NO_2^--N	= nitrite nitrogen
NO_3^--N	= nitrate nitrogen
D.O.	= dissolved oxygen
p.e.	= person equivalent

ACKNOWLEDGEMENTS

Credits: This work was completed as a fulfillment of the Statens Forurensningstilsyn (SFT) contract nr. 445/89 within, the norwegian national FAN (Nitrogen removal) program and support of the Norwegian Institute for Water Research (NIVA) and Oslo Water and Sewage Works (OVA).

Work: All research was performed in close cooperation with OVA personnel (Anna Göhlman, Toril Hofshagen, Steinar Amlo), Knut Arne Pettersen from NIVA who has controlled instrumentation part and Ingar Næss (OVA) and Helge Liltved (NIVA) who have supported with discussions and advice. I thank also Jane Lilletvedt for typing the tekst. Special gratitude is given to Kjell Øren, research-leader at the Department of Environmental Technology at NIVA, for correcting the manuscript, valuable discussions and support.

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APPENDIX

Appendix 1: Hydraulic loads and doses of chemicals.

Appendix 2: Daily samples (influent, effluent) pH, alcalinity, NH_4-N, NO_2-N, NO_3-N, temperature

Appendix 3: Weekly samples (influent, effluent) Tot-N, Tot-P, COD dissolved & total.

Appendix 4: Results for nitrification - oxygen consumption and alcalinity, 1-step and 2-step filtration from daily samples.

Appendix 5: Averaged values of D.O., NH_4-N; BOD/COD measured for each run. Comparison of D.O. supplied and consumed.

Appendix 6: Nitrification rate (g NH_4-N removed/m^2.d) Temperature data.

APPENDIX 1

FORSØKSANLEGGET, BEKKELAGET. BELASTNINGER OG DOSERINGER.

sep-89

Kalk doseres som 5% løsning, polymer som 0.1% løsning, jernklorid som 20% løsning.

Av sjøvann doseres ca. 3% av vannmengdene.

Dato	Belastninger (m3/h)				Doseringer (g/m3)							Kommentarer
					Jernklorid		Kalk		Polymer		Sjøvann	
	K1	K2	B1	B2	K1	K2	K1	K2	K1	K2		
1	5,5	5,5	4,9	5,0	208	218	59	63	0,45	0,44	Kun K2	Pumpestopp P1/P2 (ca. 4 timer) og P6
2	5,5	5,5	5,0	5,0	215	218	62	0	0,00	0,00	Kun K2	Pumpestopp P6
3	5,5	5,5	4,9	5,0	215	225	85	218	0,56	0,55	Kun K2	Pumpestopp P6
4	5,5	5,5	5,0	5,0	196	221	93	32	0,59	0,50	x	
5	5,5	5,5	5,0	5,0	208	199	74	74	0,44	0,44	x	
6	5,5	5,5	5,0	5,0	205	205	82	33	0,44	0,55	x	Pumpestopp P1/P2 (ca. 2,5 timer)
7	5,5	5,5	5,0	5,0	208	202	90	34	0,49	0,52	x	
8	5,5	5,5	5,0	5,0	202	205	49	55	0,43	0,44	x	
9	5,5	5,5	4,9	5,0	218	221	51	60	0,40	0,51	x	
10	5,5	5,5	5,0	5,0	208	215	67	68	0,45	0,50	x	
11	5,5	5,5	5,0	5,0	192	205	76	77	0,33	0,37	x	
12	5,5	5,5	5,0	5,0	215	208	93	73	0,49	0,36	x	
13	5,5	5,5	5,0	5,0	192	208	84	86	0,46	0,40	x	Satte P1/P2 på rist
14	5,5	5,5	5,0	4,9	208	212	70	82	0,45	0,56	x	
15	5,5	5,5	5,0	5,0	199	189	82	74	0,36	0,32	x	Pumpestopp P8
16	5,5	5,5	5,0	4,9	212	208	95	68	0,37	0,69	x	
17	5,5	5,5	4,8	5,0	218	212	0	62	0,48	0,38	x	Tett kalkpumpe K1
18	5,5	5,5	5,0	5,0	205	208	74	71	0,46	0,37	x	
19	5,5	5,5									x	
20	5,5	5,5	5,0	5,0	208	208	87	87	0,60	0,44	x	P.st. P8 (ca. 3,5 timer), byttet kalktank
21	5,5	5,5	4,9	4,9	199	199	0	327	0,32	0,50	x	P.st. P8, tett kalkp. K1, strippet biofilter
22	5,5	5,5			205	215	29	49	0,29	0,48	x	
23	5,5	5,5	5,0	5,0	144	208	41	68	0,55	0,44	x	
24	5,5	5,5	5,0	5,0	192	0	68	70	0,44	0,44	x	Pumpestopp P8 (ca. 5 timer)
25	5,5	5,5	5,0	5,0	202	192	136	73	0,33	0,41	x	
26	5,5	5,5	5,0	5,0	160	241	74	112	0,44	0,47	Kun K2	Pumpestopp P8 (ca. 9 timer) og P6
27	5,5	5,5	5,0	5,0	244	225	51	76	0,44	0,39	Kun K2	
28	5,5	5,5	4,9	4,9	257	218	106	51	0,40	0,43	Kun K2	
29	5,5	5,5	5,0	5,0	186	218	68	90	0,43	0,47	x	
30	5,5	5,5	5,0	4,9	164	202	69	73	0,58	0,61	Kun K2	Pumpestopp P6

NBI Hydraulisk belastning for K1 og K2 har variert mye over døgnet. En midlere belastning kan anslås til 5,5 m3/h.

FORSØKSANLEGGET, BEKKELAGET. BELASTNINGER OG DOSERINGER.

okt-89

Kalk doseres som 5% løsning, polymer som 0.1% løsning, jernklorid som 20% løsning.

Av sjøvann doseres ca. 3% av vannmengdene.

Dato	Belastninger (m3/h)				Doseringer (g/m3)							Kommentarer
					Jernklorid		Kalk		Polymer		Sjøvann	
	K1	K2	B1	B2	K1	K2	K1	K2	K1	K2		
1	5,5	5,5	5,0	4,9	225	228	74	82	0,44	0,43	x	P6 i ustand, P7 leverer til både K1/K2
2	5,5	5,5	5,0	5,0	208	218	69	71	0,49	0,51	x	
3	5,5	5,5	5,0	5,0	205	212	65	74	0,38	0,44	x	
4	5,5	5,5	5,0	5,0	225	208	74	71	0,44	0,41	x	
5	5,5	5,5	4,8	5,1	231	228	94	77	0,49	0,46	x	
6	5,5	5,5	5,0	5,0	234	202	82	109	0,58	0,58	x	
7	5,5	5,5	5,0	5,0	208	215	74	55	0,59	0,43	x	
8	5,5	5,5	4,9	4,8	218	157	74	58	0,35	0,55	x	
9	5,5	5,5	5,0	5,0	208	64	95	90	0,36	0,47	x	
10	5,5	5,5	4,6	4,9	196	234	60	70	0,60	0,60	x	Pumpestopp P1/P2 (ca. 4 timer)
11	5,5	5,5	5,0	5,4	189	231	87	63	0,44	0,39	x	
12	5,5	5,5	5,0	5,0	128	205	74	65	0,39	0,40	x	Ny vannmåler P2
13	5,5	5,5	5,0	5,0		0	82	68	0,35	0,41	x	
14	5,5	5,5	4,9	5,4	228	0	80	69	0,39	0,46	x	
15	5,5	5,5	4,9	5,0	225	228	78	77	0,61	0,49	x	
16	5,5	5,5	5,0	5,0	225	228	76	60	0,40	0,44	x	
17	5,5	5,5	4,9	4,9	218	225	80	21	0,49	0,48	x	Alt stod pga. P5 (ca. 5 timer), ny midl. P5
18	5,5	5,5	5,0	5,0	218	225	82	41	0,34	0,37	x	
19	5,5	5,5	0,0	4,9	218	228	71	65	0,46	0,49	x	Pumpestopp P3 (minst 4 timer)
20	5,5	5,5	5,2	5,0	205	218	82	49	0,38	0,55	Kun K1	
21	5,5	5,5	5,0	5,0	221	225	71	89	0,40	0,44	Kun K2	
22	5,5	5,5	5,0	5,0	225	225	74	76	0,43	0,43	Kun K2	
23	5,5	5,5	5,0	5,0	208	144	86	88	0,41	0,49	Kun K2	
24	5,5	5,5	5,0	5,0	215	0	75	82	0,55	0,44	Kun K2	
25	5,5	5,5	5,0	5,0	215	0	87	85	0,65	0,59	Kun K2	
26	5,5	5,5	5,0	5,0	208	257	59	63	0,48	0,40	Kun K2	Pumpestopp P1/P2 (ca. 1 time)
27	5,5	5,5	5,0	5,0	218	205	60	104	0,48	0,44	Kun K2	
28	5,5	5,5	5,0	5,0	231	192	98	67	0,00	0,41	Kun K1	
29	5,5	5,5	5,0	4,9	241	237	68	87	0,46	0,49	Kun K1	Utløp K1/K2 blandes før pumping til B1/B2
30	5,5	5,5	5,0	5,0	192	192	75	94	0,37	0,49	Kun K1	Flokk.omr. K1 stoppet
31	5,5	5,5	4,9	4,8	192	176	85	76	0,65	0,38	-	Stopp i sjøvannsinntaket til Bekkelaget

NB! Hydraulisk belastning for K1 og K2 har variert mye over døgnet. En midlere belastning kan anslås til 5,5 m3/h.

FORSØKSANLEGGET, BEKKELAGET. BELASTNINGER OG DOSERINGER.

nov-89

Kalk doseres som 5% løsning, polymer som 0.1% løsning, jernklorid som 20% løsning.

Av sjøvann doseres ca. 3% av vannmengdene.

Dato	Belastninger (m3/h)				Doseringer (g/m3)							Kommentarer
					Jernklorid		Kalk		Polymer		Sjøvann	
	K1	K2	B1	B2	K1	K2	K1	K2	K1	K2		
1	5,5	5,5	5,0	5,0	192	199	80	83	0,47	0,48	-	Pumpestopp P8 (nesten ett døgn)
2	5,5	5,5	5,1	5,4	205	192	81	82	0,48	0,51	-	
3	5,5	5,5	5,0	5,0	202	186	60	81	0,46	0,47	-	Pumpestopp P1/P2
4	5,5	5,5	4,8	5,0	202	212	103	81	0,41	0,45	-	
5	5,5	5,5	5,0	5,2	202	164	58	82	0,45	0,58	-	
6	5,5	5,5	5,0	5,0	202	186	83	88	0,34	0,45	-	
7	5,5	5,5	5,0	5,0	199	208	86	76	0,44	0,44	-	Koblet til regulatorer for P1/P2
8	5,4	5,4	5,0	5,0	199	196	89	86	0,32	0,45	-	
9	5,3	7,6	5,0	5,0	223	162	80	58	0,37	0,24	-	
10	5,4	5,5	5,0	5,0	196	221	72	79	0,40	0,44	-	
11	5,3	5,4	5,0	5,0	200	180	85	83	0,45	0,44	-	
12	5,4	5,4	5,0	5,0	196	212	67	72	0,39	0,41	-	
13	5,4	8,0	5,0	5,0	196	154	80	57	0,48	0,32	-	
14	5,6	4,9	5,0	5,0	189	216	75	89	0,43	0,49	-	
15	5,5	5,2	5,0	5,0	192	210	68	77	0,55	0,51	-	
16	5,4	6,2	5,0	5,0	196	196	77	81	0,39	0,44	-	Pumpestopp P1/P2
17	5,5	5,5	5,0	5,0	189	225	25	79	0,33	0,46	-	
18	5,4	5,8	5,0	5,0	212	198	81	88	0,43	0,52	-	
19	5,1	5,4	5,3	5,0	232	196	74	78	0,59	0,47	-	
20	5,5	5,5	5,0	5,0	190	190	85	68	0,39	0,41	-	
21	5,7	5,7	5,0	5,0	179	186	82	74	0,38	0,40	-	Silbl. bøyd, alt st. (ca. 12 t.), strippet biof.
22	5,5	4,9	5,0	5,0	199	227	85	43	0,40	0,47	-	Pumpestopp P8 (ca. 2 timer)
23	5,8	5,8	5,0	5,0	201	195	81	66	0,62	0,66	-	Pumpestopp P1/P2
24	5,7	5,3	5,0	5,0	186	200	66	76	0,37	0,43	-	
25	5,5	6,2	5,0	5,0	167	185	70	89	0,36	0,32	-	
26	5,4	5,8	5,0	5,0	216	186	96	72	0,56	0,32	-	
27	5,7	5,7	5,0	5,0	204	214	78	79	0,42	0,41	-	P.st. P8 (ca. 2 timer), flokk.omr. K1 stoppet
28	5,7	5,7	5,0	5,0	201		74	79	0,37	0,37	-	Pumpestopp P1/P2
29	5,5	5,7	5,0	5,0	215	195	76	79	0,37	0,44	-	P.st. P1/P2 (ca. 5 t.), flokk.omr. K1 stoppet
30	5,7	5,8	5,0	5,0	217	195	74	81	0,35	0,36	-	

NBI Midlere hydraulisk belastning for K1 og K2 anslått til 5,5 m3/h t.o.m. 7. nov. F.o.m. 7. nov. styres frekvensen til P1/P2 av regulatorer.

FORSØKSANLEGGET, BEKKELAGET. BELASTNINGER OG DOSERINGER.

des-89

Kalk doseres som 5% løsning, polymer som 0.1% løsning, jernklorid som 20% løsning.

Av sjøvann doseres ca. 3% av vannmengdene.

Dato	Belastninger (m3/h)				Doseringer (g/m3)							Kommentarer
					Jernklorid		Kalk		Polymer		Sjøvann	
	K1	K2	B1	B2	K1	K2	K1	K2	K1	K2		
1	5,5	6,3	5,0	5,0	208	168	68	63	0,37	0,32	-	
2	5,7	6,1	5,0	5,0	201	174	64	79	0,32	0,30	-	
3	5,7	5,7	5,0	5,0	198	189	65	83	0,42	0,40	-	
4	5,7	5,7	5,0	5,0	207	176	47	79	0,42	0,37	-	
5	5,5	5,0	5,0	5,0	221	219	0	66	0,48	0,49	-	Tett kalkpumpe K1
6											-	Pumpestopp P5 (nesten ett døgn)
7	5,5	5,5	5,0	5,0	208	208	71	71	0,39	0,41	-	Pumpestopp P5 (nesten ett døgn)
8	5,5	5,5	5,0	5,0	225	135	55	73	0,37	0,39	-	Pumpestopp P1/P2 (ca. 2 timer)
9	5,6	5,6	5,0	5,0	221	243	72	27	0,32	0,33	-	
10	5,6	5,6	5,0	5,0	221	221	107	54	0,40	0,41	-	Tett sil, alt st. (ca 7 t.), flokk.omr. K1 st.
11	5,4	5,4	5,0	5,0	245	229	44	122	0,44	0,44	-	
12	5,5	5,5	5,0	5,0	225	225	75	109	0,44	0,44	-	
13	5,4	5,6	5,0	5,0	229	227	58	80	0,48	0,39	-	
14	5,5	6,0	5,0	5,0	231	232	68	53	0,57	0,57	-	
15	5,5	6,1	4,7	5,0	202	194	63	69	0,39	0,30	-	
16	5,1	5,2	4,9	5,1	235	244	64	57	0,33	0,47	-	
17	5,5	5,8	4,9	5,0	215	207	65	36	0,36	0,63	-	
18	5,5	5,0	5,0	5,0	205	226	82	117	0,51	0,26	-	Flokk.omr. K1 stoppet
19	5,4	5,4	5,0	5,0	206	212	74	93	0,47	0,33	-	Pumpestopp P8 (ca. 5 timer)
20	5,5	5,5	5,0	5,0	212	218	94	85	0,57	0,36	-	
21	5,5	5,5	5,0	5,0	205	205	57	60	0,40	0,40	-	
22	5,5	5,5	5,0	5,0	208	208	49	71	0,44	0,44	-	Flokk.omr. K1 stoppet
23	5,3	5,1	5,3	5,1	216	246	95	81	0,37	0,45	-	P.st. P1/P2 (ca. 15 t.), flokk.omr. K1 st.
24	5,3	5,5	5,0	5,0	230	80	78	71	0,36	0,41	-	
25	5,4	5,3	5,1	5,1	225	143	74	66	0,34	0,61	-	Pumpestopp P1/P2 (ca. 10 timer)
26	5,2	5,2	5,0	5,0	241	153	78	92	0,58	0,48	-	Pumpestopp P1/P2 (ca. 7 timer)
27	5,4	5,4	5,0	5,0	232	206	58	72	0,44	0,44	-	
28											-	Pumpestopp P8 (ca. 9 timer)
29	5,4	5,6	4,9	4,5	219	195	60	65	0,34	0,41	-	Pumpestopp P1/P2
30	5,4	5,8	5,0	5,1	216	228	91	103	0,37	0,38	-	
31	5,6	7,0	5,1	4,9	208	242	72	61	0,43	0,35	-	P.st. P8 (ca. 16 timer), flokk.omr. K1 st.

FORSØKSANLEGGET, BEKKELAGET. BELASTNINGER OG DOSERINGER.

jan-90

Kalk doseres som 5% løsning, polymer som 0.1% løsning, jernklorid som 20% løsning.

Av sjøvann doseres ca. 3% av vannmengdene.

Dato	Belastninger (m3/h)				Doseringer (g/m3)							Kommentarer
					Jernklorid		Kalk		Polymer		Sjøvann	
	K1	K2	B1	B2	K1	K2	K1	K2	K1	K2		
1	5,4	5,5	5,1	4,9	219	170	82	83	0,42	0,44	-	Pumpestopp P1/P2 (ca. 13 timer)
2	5,4	4,8	5,0	5,0	216	301	77	96	0,40	0,74	-	Pumpestopp P1/P2 (ca. 5 timer)
3	5,4	5,3	5,0	5,0	209	173	78	83	0,54	0,44	-	
4	5,5		5,0	5,0	218		60		0,37		-	P.st. P2 pga. korrodert flens (ca. 5 timer)
5	5,5	5,6	5,0	5,0	199	167	82	79	0,49	0,43	-	
6	5,3	5,9	5,0	5,1	210	144	76	63	0,48	0,37	-	
7	5,4	5,3	5,1	5,0	219	200	88	97	0,52	0,55	-	Silblad bøyd, alt stoppet (ca. 3 timer)
8											-	Pumpestopp P8 (ca. 8 timer)
9	5,6	5,6	5,0	5,0	211	205	77	78	0,47	0,44	-	Pumpestopp P1/P2
10	5,5	5,4	5,0	5,0	212	209	79	88	0,39	0,40	-	
11	5,5	6,0	5,0	5,0	215	182	85	70	0,48	0,42	-	
12	5,5	5,8	5,0	5,1	212	189	82	75	0,47	0,37	-	
13	5,0	4,8	5,1	5,1	229	224	86	76	0,54	0,65	-	
14	5,5	5,0	5,0	5,1	208	215	64	75	0,57	0,43	-	Pumpestopp P8 (ca. 1 time)
15	5,5	5,4	5,0	5,0	202	212	92	53	0,43	0,41	-	Pumpestopp P8 (ca. 1 time)
16	5,4	5,3	5,0	5,0	212	213	78	76	0,44	0,40	-	
17	5,5	5,3	4,8	5,0	196	216	82	79	0,33	0,36	-	P.st. P8 (ca. 18 timer), strippet biofilter
18	5,5	5,5	5,0	5,0	208	208	79	68	0,47	0,52	-	
19												
20	5,6	5,1	5,0	5,0	211	235	64	71	0,40	0,47	-	
21	5,6	5,6	5,0	5,0	211	217	65	67	0,43	0,45	-	
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												

APPENDIX 2

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: SEPTEMBER 1989 (1)

	pH						Temperatur (oC)						Alkalitet (mval/l)						Kommentar
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	7,7	7,3	7,2	7,4	6,5	7							2,97	1,89	1,15	1,4	0,32	2,58	
2	8,7	7,2	7,4	7,3	5,9	7,3							3,32	2,02	1,73	1,68	0,16	3,06	
3	8,6	8,2	7,4	7,7		7,3							3,04	2,83	1,47	2,01		2,78	
4	8,8	7,8	7,2	7,5		7,4							2,91	2,4	1,22	2,07		2,9	
5	8,7	8	7,1	7,5	7,9	7,2							3,27	3,02	1,1	3,12	2,01	2,7	Stikk 5
6	8,3	7,8	7,4	7,6	7	7,3							3,57	3,03	1,15	2,33	0,46	2,99	
7	7,8	7,5	7,1	7,5	6,8	7,3							3,58	2,61	1	2,04	0,3	3,39	
8	7,8	7,4	7,1	7,4	6,8	7,2							3,45	2,49	1,07	2	0,37	3,05	
9	8	7,6	7,3	7,6	7,1	7,3							3,48	3,03	1,27	2,52	0,64	3,05	
10	7,6	8	6,9	7,6	7,3	7,2							3,06	3,22	0,62	2,55	0,89	2,81	
11	7,8	7,8	6,9	7,6	7,2	7,3							3,03	2,88	0,57	2,17	0,65	2,83	
12	7,6	8	6,8	7,6	7,5	7,3							3	3,32	0,6	2,45	1	2,89	
13	7,7	7,9	7	7,6	7,3	7,2							3,21	3,38	0,9	2,48	1,03	3,12	
14	7,7	7,8	6,9	7,5	7,3	7,2							3,13	3,23	0,82	2,46	1,05	2,85	
15	8	7,4	7,3	7,4	7,4	7							3,32	2,64	1,46	1,92	0,91	2,66	
16	9,1	8,1	7,7	7,8	7,3	7,6							3,62	2,91	1,98	2,52	1,3	3,22	Stikk 5
17	7,4	7,8	7,1	7,7	7,2	7,4							2,62	2,58	0,79	2,02	1,05	2,61	
18	8,4		7,5	7,8									3,42		1,29	2,16			
19																			
20	8,6	7,7	7,5	7,6	7,6	7,1							3	2,7	1,84	2,52	1,48	2,78	
21	7,2	9,1	7,2	8,1	7,5	6,9							2,64	8,51	1,58	2,31	1,67	2,68	
22	7,1	7,5	7,1	7,4	7,2	7							2,7	2,81	1,47	2,57	2,21	3,25	Stikk 5
23	7,5	7,7	7,4	7,6	7,6	7,5							2,54	2,59	1,62	2,1	1,41	2,59	Stikk 5+6
24	8,8	7,8	7,7	7,6	7,6	7,2							2,98	2,38	2,02	1,88	1,4	2,7	
25	9,1	8,6	7,7	7,8	7,8	7,3							3,51	3,23	1,89	2,36	1,73	2,8	
26	8,8	7,8	7,7	7,7	7,8	7,3							3,78	3,11	2,46	2,48	1,76	3,08	
27	8,5	7,7	7,4	7,6	7,6	7,3							3,49	3,04	1,65	2,27	1,27	3,15	
28	8,7	8	7,3	7,7	7,6	7							2,87	3,44	2,01	3,07	2,14	2,62	
29	7,9	7,8	7,6	7,7	7,8	7,3	14,6	14,6					4,66	3,52	2,2	3,03	2,5	3,36	
30	7,5	7,5	7,2	7,6	7,4	7,4							2,2	1,7	1,28	2,4	1,06	2,87	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: SEPTEMBER 1989 (2)

	NH4-N (mg/l)						NO2-N (mg/l)						NO3-N (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	18,4	16,9	4,9	14	5,8	15,7	0,1	0,1	8,4	0,4	3,3	0,1	0,3	0,5	11,1	3,2	13,9	0,3	
2																			
3																			
4																			
5																			
6																			
7	20,9	19,1	4,7	17,1	5,1	20,8	0,1	0,1	7	0,4	1,2		0,6	0,7	16,4	5,7	16,7	1,2	
8																			
9																			
10																			
11																			
12																			
13	22,6	21,8	3,8	13,7	4,1	23	0,2	0,1	0,9	0,4	0,6	0	1,1	0,9	16,9	6,5	17,2	1,1	NH4-Dr L
14																			
15																			
16																			
17																			
18																			
19	19,3	18,6	5,2	13,3	2,6	16	0,1	0,1	0,6	0,3	0,3	0	0,6	0,5	13,6	4,3	10,2	0,7	NH4-Dr L
20																			
21																			
22																			
23																			
24																			
25	17,4	23,8	8	13,9	9,7	23,9	0,2	0,1		0,4	0,2	0	0	0	8,1	5	8,2	0	NH4,NO3-DrL
26																			
27																			
28																			
29	16,6	16,9	10,6	16,6	7,8	17,6													
30																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: SEPTEMBER 1989 (3)																		
	Tot-N (mg/l)						PO4-P (mg/l)						Tot-P (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	19,3	20,4	18,7	19,2	21,1	26,1	0	0				1,5	0,87	0,29	0,42	0,12	0,18	2,95	
2																			
3																			
4																			
5																			
6																			
7	27,5	27	25,3	22,9	24,9	30,9	0,04	0,08				1,9	0,75	0,64	0,46	0,28	0,26	2,8	
8																			
9																			
10																			
11																			
12																			
13	22,3	26,9	24,5	23,9	24,5	35,8	0	0				1,8	0,48	0,35	0,34	0,14	0,17	3,42	
14																			
15																			
16																			
17																			
18																			
19	18	19,7	19,1	19,9	15,7	26,3	0	0				1,9	0,07	0,13	0,07	0,06	0,04	3,3	5-Stikk
20																			
21																			
22																			
23																			
24																			
25	22,9	22,2	22,1	23,8	19,2	31,1	0,07	0,06	0,13	0,6	0,3	2	0,47	0,44	0,41	0,29	0,21	3,24	
26																			
27																			
28																			
29																			
30																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: SEPTEMBER 1989 (4)

	KOF, filtrert (mg O/l)						KOF, ufiltrert (mg O/l)						SS (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	60	67	36	42	77	80	88	68	62	44	61	233	38	17	23	7,5	15	179	
2																			
3																			
4																			
5																			
6																			
7	61	71	42	39	43	232	85	93	60	50	73	170	45	35	26	16	19	56	
8																			
9																			
10																			
11																			
12																			
13	69	64	54	62	41		87	79	62	40	49	289	31	24	22	13	10	184	
14																			
15																			
16																			
17																			
18																			
19	84	67	44	58	39	108	87	90	63	45	46	269							5-Stikk
20																			
21																			
22																			
23																			
24																			
25	71	59	45	48	39	82	88	70	60	62	41	221	27	31	24	21	18	141	
26																			
27																			
28																			
29																			
30																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: OKTOBER 1989 (1)

	pH						Temperatur (oC)						Alkalitet (mval/l)						Kommentar
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	8	7,2	7,7	7,5	7,4	7,2	13,1	13,1					3,07	1,95	1,75	1,61	0,97	2,54	
2	7,8	7,5	7,4	7,6	7,5	7,5							3,19	2,89	1,54	2,38	1,5		
3	8	7,5	7,4	7,7	7,5	7,7							3,28	2,99	1,59	2,6	1,56	3,52	
4	8,1	7,7	7,3	7,7	7,4	7,3							3,45	3,31	1,8	3,05	1,74	2,98	
5	8,3	7,4	7,5	7,4	7,4	7,5							3,49	2,95	2,51	2,79	1,38	2,87	
6	8	7,4	7,5		7,5	7,2							3,29	3,01	2,16		1,35	2,94	
7	8,1	7,6	7,5	7,6	7,4	7,3							3,27	2,98	2,11	2,58	1,35	2,59	
8	9,1	8,6	7,6	7,9	7,3	7,3							2,98	2,58	1,78	2,24	0,96	2,54	
9	9	7,4	7,7	7,7	7,1	7,5							3,6	2,3	2,1	1,7	0,7	2,86	
10	8,8	7,2	7,6	7,5	7,1	7,4							3,7	2,21	2,01	1,64	0,74	3,02	
11	8,8	8,2	7,4	7,8	7,3	7,3							3,42	3,12	1,4	2,18	0,83	2,65	
12	8,9	7,6	7,6	7,6	6,9	7,3							3,8	2,69	2,05	2,22	0,73	3,25	
13	9	9	7,7	8	7,4	7,4	13,5	13,5	14,5	14	14,5		3,55	3,61	2,05	3,12	1,38	2,72	
14	9	9,4	7,5	8	7,7	7,5							3,21	4,04	1,57	3,2	1,86	2,85	
15	8,8	8,5	7,1	7,5	7,1	7,4							3,13	3,11	1,62	1,97	0,67	2,63	
16	8,5	8,3	7	7,2	6,8	7,2							2,98	3,18	0,73	1,6	0,45	2,81	
17	8,7	7,4	7,1	6,8	6,2	7,4							3,15	1,95	0,77	0,62	0,13	2,76	
18	8,4	7,5	7,3	7,3	7	7,1							3,23	2,56	1,22	1,46	0,55	2,9	
19	8,5	8,1	7,4	7,5	7,2	7,3	14,5	14,5	15,1	14,6	14,7		3,23	3,14	1,66	2,28	0,92	3	
20	8,4	7,3	7,5	7,2	6,7	7,4							3,28	2,19	1,94	1,37	0,3	2,98	
21	8,9	8,5	7,5	7,8	7,1	7,5							2,99	2,73	2,15	2,23	0,63	2,77	
22	8,7	8,7	7,5	7,9	7,3	7,4							2,83	2,89	1,9	2,36	1,03	2,61	
23	8,8	8	7,8	7,8	7,1	7,5							3,18	2,75	2,32	2,13	0,7	2,91	
24	8,9	7,4	7,8	7,6	7	7,4							3,8	2,87	2,69	1,91	0,52	3,28	
25			7,8	8,2	7,5	7,3									2,56	3,4	1,7	2,85	
26	7,9	8	7,4	7,8	7,3	7,4							3	3,19	1,87	2,58	1,1	2,83	
27	8,2	8,3	7,6	7,9	7,4	7,3	14,5	14,5	14	14	14		3,35	3,28	1,87	2,54	0,97	2,93	Temp-?
28	8,9	7,8	7,9	7,8	7,1	7,4							3,47	2,84	2,3	2,24	0,68	3	
29	7,8	8	7,6	7,8	7,3	7,4							3,29	3,44	1,96	2,89	1,21	2,94	
30			7,6	7,7		7,2									1,05	1,75		2,42	
31			7,5	7,7		7,5									1,32	1,86		2,95	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: OKTOBER 1989 (2)

	NH4-N (mg/l)						NO2-N (mg/l)						NO3-N (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	19	17,4	8,5	16,1	11,2	17,5	0,3	0,1	1	0,3	0,2	0,1	0,6	0,1	10,6	2,8	9,1	0,6	Dr L-NH4
2																			
3																			
4																			
5																			
6																			
7	15,6	15,5	7,4	13,2	4,5	16,1	0,2	0,3	0,4	0,4	0,3	0	0	0	8,5	2,9	11	0	?
8																			
9																			
10																			
11																			
12																			
13	18,4	18,1	5,7	14,5	2,8	20,9	0,1	0,1	1,2	0,8	0,5	0	0	0	10	4	12,7	0	Dr Lange-alle
14																			
15																			
16	19,4	17,8	1,4	8	0,9	19,5													
17																			
18																			
19	18,8	15,4	5,9	10,9	1,3	21,6	0,1	0,1	0,6	0,5	0,4	0	0,1	0,2	13,5	6,9	16,7	0,5	Dr Lange-alle
20																			
21																			
22																			
23																			
24																			
25																			
26	18	16,4	9,4	12,5	2,7	18,4	0,1	0,1	0,9	0,3	0,6	0	0,1	0,1	10,6	4,9	15,9	0,5	Dr Lange-NH4
27																			
28																			
29																			
30																			
31																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: OKTOBER 1989 (3)

	Tot-N (mg/l)						PO4-P (mg/l)						Tot-P (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	19,3	18	23,3	17,4	21,4	25,2	0,03	0				1,3	0,55	2	0,47	0,38	0,24	3,08	
2																			
3																			
4																			
5																			
6																			
7	17,7	16,2	19,7	19,1	19,2	19,3	0,09	0,15				1,6	0,44	0,52	0,47	0,31	0,27	2,45	
8																			
9																			
10																			
11																			
12																			
13	21,6	22,6	21,7	23,8	22,5	29	0,08	0,53				2,2	0,27	0,93	0,31	0,66	0,41	3,65	
14																			
15																			
16																			
17																			
18																			
19	24	23,5	26,1	23	23,6	20,1	0	0,03				2,3	0,23	0,29	0,23	0,83	0,17	3,65	
20																			
21																			
22																			
23																			
24																			
25																			
26	22,6	21	22,7	22,7	21,3	27,8	0,06	0,05				2	0,66	0,31	0,65	0,17	0,15	3,15	
27																			
28																			
29																			
30																			
31																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: OKTOBER 1989 (4)

	KOF, filtrert (mg O/l)						KOF, ufiltrert (mg O/l)						SS (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1	51	61	53	42	37	84	71	208	55	65	53	215	31	244	22	35	25	123	
2																			
3																			
4																			
5																			
6																			
7	37	53	30	37	33	55	50	70	45	51	49	109	16	35	27	34	18	43	
8																			
9																			
10																			
11																			
12																			
13	61	63	61	45	34	90	71	101	63	66	56	272	19	33	18	28	23	166	
14																			
15																			
16																			
17																			
18																			
19	61	60	42	51	43	153	72	70	51	53	51	227	19	22	15	17	12	87	
20																			
21																			
22																			
23																			
24																			
25																			
26	58	72	40	51	41	107	82	85	60	55	61	211	34	18	26	14	17	96	
27																			
28																			
29																			
30																			
31																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: NOVEMBER 1989 (1)

	pH						Temperatur (oC)						Alkalitet (mval/l)						Kommentar
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			OBS OBS OBS
2		7,5	7,5	7,5	7,3	7,3		13,8	14,2	14	14			2,31	1,06	1,43	0,78	2,27	P1 og P2 er
3		7,6	7,6	7,6	7,3	7,2								1,98	3,01	2,19	0,9	2,84	slått sammen
4		8,5	7,5	7,5	7,3	7,2								2,25	1,48	1,68	0,97	2,22	til P2.
5		8,6	7,5	7,5	7,4	7								1,7	1,32	1,46	1,23	1,75	
6		8,3	7,5	7,5	7,4	7,2								2,4	1,42	1,68	1,11	2,35	Dag 3: Prøve
7		7,7	7,3	7,4	7,1	7,1								2,19	1,18	1,5	0,76	2,41	2 og 3 trulig
8		8,2	7,6	7,7	7,4	7,2		12	13	12,7	13			2,79	1,68	2,09	1,21	2,54	feil.
9		8,2	7,6	7,7	7,4	7,2								2,67	1,96	2,27	1,36	2,46	
10		8	7,5	7,7	7,4	7,2								2,44	1,47	2,11	1,12	2,46	
11		7,3	7,3	7,4	7,1	7,1								1,09	1,17	1,53	0,82	2,11	
12		8,4	7,6	7,7	7,6	7								2,04	1,5	1,76	1,33	2	
13		8,3	7,6	7,7	7,4	7,3		11,3	12,7	12,2	12,5			2,51	1,86	2,11	1,45	2,4	T-Grazyna
14		7,7	7,6	7,6	7,3	7,3								2,67	1,84	2,07	1,1	2,82	
15		7,9	7,6	7,7	7,4	7,4								2,71	1,6	1,41	0,78	2,81	
16		7,6	7,6	7,7	7,3	7,1								2,91	2,11	2,31	1,08	2,56	
17		7,5	7,7	7,7	7,4	7,4								2,67	2,04	2,28	1,12	3,03	
18		7,6	7,6	7,7	7,4	7,3								2,66	2,11	2,21	1,17	2,55	
19		8,4	7,9	7,8	7,6	7,7								2,84	2,34	2,57	1,51	3,08	
20		8,9	8	8	7,6	7,4		12,1	12,1	12,1	11,5			3,4	2,97	3,08	1,95	3	T-Grazyna
21		7,8	7,8	7,7	7,4	7,3								3,03	2,47	2,54	1,32	3,34	
22		7,9	7,8	7,8	7,4	7,2		11,5	13	12,8	13			3,11	2,22	2,65	1,49	2,93	
23		8,6	7,5	7,5	7,1	7,1		11,5	11,9	11,7	11,4			3,06	1,92	2,37	1,19	2,81	T-Grazyna
24		8,1	7,7	7,6	7,5	7,2								3,69	3,22	3,56	2,47	3,47	
25		8	7,5	7,5	7,4	7,6								2,91	2,82	2,98	2,22	3,06	
26		8,8	7,7	7,7	7,4	7,2		10,5	10,8	10,5	10,2			2,72	2,46	2,76	1,76	2,54	T-Grazyna
27		8,1	7,6	7,6	7,1	7,1								2,41	2,08	2,29	1,28	2,58	
28		8,4	7,5	7,6	7,2	7		10,5	11	10,9	10,4			2,89	2,23	2,83	1,6	2,56	T-Grazyna
29		8,5	7,8	7,8	7,6	7,4								3,22	3,11	3,19	2,21	2,65	
30		8,3	7,7	7,7	7,5			11	10,9	11	10,2			2,93					T-Grazyna

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: NOVEMBER 1989 (2)

	NH4-N (mg/l)						NO2-N (mg/l)						NO3-N (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	PT 1 og PT 2
1																			er slått
2		10,2	2,5	2,6	0	11,3		0,2	0,6	0,5	0,3	0,1		0,8	12,6	9,7	14,1	0,3	sammen til
3																			PT 2.
4																			
5																			NH4-L A
6																			NO3-Chalmer
7																			
8		9	3,1	3,1	0	12,3								1,1	8,6	6,4	12,3	0,2	
9																			
10																			
11																			
12																			
13																			
14		14,5	7,3	9,4	1,3	14,2								1	8,1	6,2	13,3	0,6	
15																			
16																			
17																			
18																			
19																			
20		15,4	10,9	11,9	5,3	18,6								1,1	5,8	4,4	12,9	0,9	
21		17,6	10,1	13,7	4,4	20,8													
22		17	12	12,9	6,6	17,2								0,7	6,7	3,1	11,7	0,1	
23			10,8	14,4	4,5	13,7								0,7	7,5	4,2	11,8	0,1	
24			17,4	21,8	12	23,3											11,5		
25		16,9			9,6														
26		15,1	13,5	16,2	9,3	12,6													
27																			
28		17,6	12,9	16,4	8,3	20,5		0,2	>0,6	0,2	0,6	0,4							
29																			
30		14,9	12,3	14,1	7,5			0,2	0,6	0,2	0,6			1,7	4,4	1,5	8,4		

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: NOVEMBER 1989 (3)

	Tot-N (mg/l)						PO4-P (mg/l)						Tot-P (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			OBS OBS OBS
2		15,5	17,9	17,3	16,9	17,2		0				1		0,65	0,48	0,39	0,44	1,8	P1 og P2 er
3																			slått sammen
4																			til P2.
5																			
6																			
7																			
8		16,4	17,3	17,3	14,3	16,6		0				1,11		0,31	0,29	0,16	0,17	1,7	
9																			
10																			
11																			
12																			
13																			
14		19,3	18,1	17,8	18	19,2		0				1,2		0,23	0,26	0,19	0,16	2,1	
15																			
16																			
17																			
18																			
19																			
20		24,8	24,2	23,9	23,3	26,9		0,08				1,3		0,75	0,44	0,72	0,27	2,9	
21																			
22		24,6	24	21,3	20,8	28,4		0,05				1,5		0,6	0,44	0,35	0,24	3,6	
23		24,4	19,6					0,18				1,33		0,39	0,15	0,25	0,14	3	2-Stikk
24					39,6			0,1				0,85		1,1	0,56	0,61	0,45	3,15	
25																			
26		19,7	22	21	20,6	23,5		0,06				1,41		0,33	0,11	0,16	0,07	2,3	
27																			
28		22,9	20,9	20,9	19,3	28,9								0,6	0,2	0,3	0,16	3,75	
29																			
30		25,7	21,2	21,2	19,2									0,85	0,22	0,37	0,2		6-prøve savn

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: NOVEMBER 1989 (4)

	KOF, filtrert (mg O/l)						KOF, ufiltrert (mg O/l)						SS (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			PT 1 og PT 2=
2		48	29	124	21	53		69	37	39	34	100		41	22	20	20	47	PT 2
3																			
4																			
5																			
6																			
7																			
8		39	23	30	25	54		72	32	27	24	91		21	21	10	10	38	
9																			
10																			
11																			
12																			
13																			
14		36	16	24	20	58		37	29	31	25	108		12	12	11	7	48	
15																			
16																			
17																			
18																			
19																			
20		55	35	39	43	79		86	46	51	43	242		39	22	18	13	152	
21																			
22		80	47	50	47	150		104	62	64	59	350		33	19	16	11	193	
23		69	34	40	33	92		81	38	45	33	246		21	6	11	6	134	
24		133	71	77	70	139		219	93	104	82	340		64	31	34	22	178	
25																			
26		45	27	27	30	91		49		31	24	115		18	6	7	4	42	
27																			
28		95	38	44	29	145		127	40	56	34	312		26	9	15	8	151	
29																			
30		99	53	63	52			134	55	70	52			35	5	11	17		

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: DESEMBER 1989 (1)																			
	pH						Temperatur (oC)						Alkalitet (mval/l)						Kommentar
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1		8,2	7,9	8	7,5	7,3								3,1	2,94	3,23	2,13	2,61	
2		8	7,7	7,7	7,5	7,6								2,8	2,79	2,89	2,06	2,77	
3		7,8	7,5	7,6	7,4	7,4		9,5	10	10	9,5			2,58	2,22	2,41	1,56	2,49	
4		9,4	7,7	7,7	7,5	7,4		10,7	10,6	10,6	10			3,6	2,35	2,65	1,68	2,56	
5			7,6	7,5	7,4	7,5									2,03	2,34	1,29	2,49	
6																			
7																			
8		7,7	7,5	7,5	7,4	7,1		11,5	11,5	11,5	11			2,89	1,95	2,55	1,6	2,57	
9		7,6	7,6	7,5	7,4	7,3								2,82	2,21	2,66	1,87	2,83	
10		7,9	7,6	7,6	7,4	7,2		7	11,5	12	12			2,82	2,06	2,6	1,7	2,71	temp 2-?
11		8,3	7,6	7,7	7,5	7,2								2,91	2,16	2,88	1,81	2,55	
12		8,3	7,8	7,7	7,6	7,3								3,25	2,61	3,16	2,21	2,74	
13		7,5	7,5	7,5	7,4	7,5		10,5	10					2,59	1,95	2,41	1,56	2,66	
14		7,4	7,4	7,4	7,3	7,6								2,64	1,7	2,39	1,4	2,92	
15		7,2	7,3	7,4	7,3			9,5	9		9			2,28	1,5	2,27	1,21	2,8	
16		7,5	7,5	7,4	7,5	7,6		8,9	9,2	9	8,8			2,76	2,16	2,85	1,83	2,63	
17		8	7,5	7,7	7,3	7,6		9	9,2	9	8,9			2,11	1,49	2,3	1,05	2,35	
18		8,5	7,6	7,8	7,5	7,5		9,8			9,8			2,69	1,79	2,64	1,44	2,8	
19		8,5	7,6	7,7	7,5	7,4		10			11,5			2,83	2	2,88	1,72	2,86	
20		7,8	7,5	7,7	7,4	7,4								2,37	1,49	2,43	1,21	2,51	
21		7,8	7,2	7,4	7,2	7,3								2,34	1,34	2,3	1,08	2,5	
22		7,8	7,4	7,4	7,2	7,2								2,58	1,8	2,52	1,32	2,5	
23		7,8	7,5	7,6	7,4	7,3		10,9	12,7		12,7			3,13	2,17	3,16	1,68	2,65	
24		7,5	7,4	7,5	7,2	7,3								2,27	1,49	2,26	1	2,43	
25		7,5	7,5	7,6	7,3	7,4		6,2	8,9		8,7			2,63	1,68	2,84	1,4	1,95	
26		7,8	7,2	7,5	6,9	7								1,58	0,7	1,45	0,65	1,32	
27		7,6	7,1	7,4	6,9	7		8	9	9	9			1,6	0,73	1,43	0,63	1,33	
28		7,8	7,5	7,5	7,2	7,7								2,42	1,46	2,17	1,21	2,6	
29		7,2	7,2	7,4	6,9	7,5								2,17	1,12	2,25	0,68	2,57	
30		8	7,5	7,6	7,1	7,7								2,89	1,66	2,76	1,29	2,79	
31		7,5	7,5	7,4	7,2	7,4	8,5	8	11	9,7	10,4			2,79	1,68	2,62	1,28	2,19	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: DESEMBER 1989 (2)																			
	NH4-N (mg/l)						NO2-N (mg/l)						NO3-N (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			NH4-L A
2		16,3	16,2	18,2	12,1	17,8		0,1	0,3	0,1	0,4	0,1		0,7	1,9	0,7	6,7	0,3	NO3-Chalmer
3																			
4			16,7	19,2	12	18,7			0,5	0,2	0,6	0,1			3,1	1	7,8	0,3	2-stikk
5																			
6																			
7																			
8		20,9	15,4	20,1	12	21		0,1	>0,6	0,3	0,4	0		1,1	8,6	3,2	9,6	0,2	
9																			
10																			
11		21,7	15,6	19,5	12,8	21,2		0,1	0,5	0,2	0,5	0,1		0,6	7	1,7	8,7	0,3	
12																			
13		19,8	10,7	17,3	11,4	18,3													
14																			
15		17,6	13,6	17,7	5,7	19,2		0,1	0,3	0,1	0,3	0,1		0	4,4	0	6,4	0,1	
16																			
17																			
18		22,8	15	21,5	12,9	23,2													
19		17,7	12,3	18,9	10,8	20,7		0,2	0,3	0,1	0,4	0,2		0	5,3	0	7,6	0	
20																			
21		21	11,2	17,4	9,2	21													
22		18,3	12	19,6	8,6	19,6		0,1	0,2	0,1	0,4	0,1		0	4,1	0,1	8	0	
23		16,7	13,3	16,4	8,7	18,4		0,1	0,2	0,1	0,5	0,1		0,1	4,6	0	8,2	0,5	
24																			
25																			
26		7,1	1,5	6,2	0	7													
27		8,2	1,8	6,4	0	5,2		0,2	0,2	0,2	0,3	0,1		2,2	9,7	4,2	9,9	0,7	
28																			
29		16	3,5	11,1	1,3	16,2													
30																			
31		18,6	7,9	14,5	7,5	13,6		0,1	0,3	0,2	1,1	0,1		0	8,5	1,4	12,1	0	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: DESEMBER 1989 (3)																			
	Tot-N (mg/l)						PO4-P (mg/l)						Tot-P (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			
2		21,5	24,7	22,9	21,7	25,7		0,05	0,06	0,06	0,08	1,9		0,82	0,23	0,35	0,22	3,45	
3																			
4		35,1	21,2	24,1	20,8	26,3		0,36	0	0	0	>1,6		1,28	0,29	0,37	0,2	2,7	stikk 2
5																			
6																			
7																			
8		23,9	25,3	25,5	25,6	31,2		0,03	0	0,04	0,04	1,9		0,8	0,27	0,71	1,6	3,1	
9																			
10																			
11		24,1	24,1	23,5	23,2	28,3		0,03	0	0	0	1,9		0,57	0,12	0,24	0,17	3,35	
12																			
13																			
14																			
15		24,8	23,3	23,5	24,1	33,5		0,05				2		1,02	0,23	0,41	0,22	3,8	
16																			
17																			
18																			
19		28,8	26,2	22,9	23,1	35		0,03				1,8		0,51	0,18	0,33	0,18	3,85	
20																			
21																			
22		22,9	18,9	20,9	20	26,4		0,06	0	0,03	0	1,8		1,15	0,45	0,61	0,44	3	
23		19,5	21,9	21,9	20,9	24,5		0,03				2,2		0,63	0,21	0,46	0,27	3,1	
24																			
25																			
26																			
27		12,3	14,3	12,8	13,2	9,3		0	0	0	0	0,41		0,26	0,19	0,17	0,59	1,05	
28																			
29																			
30																			
31		19,9	19,7	19,4	20,8	21,7		0,03				1,51		0,18	0,25	0,3	0,17	2,25	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: DESEMBER 1989 (4)

	KOF, filtrert (mg O/l)						KOF, ufiltrert (mg O/l)						SS (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			
2		51	76	44	42	96		83	55	92	46	289		36	6	16	4	163	
3																			
4		103	26	23	26	83		144	35	35	29	170		43	13	20	12	64	Stikk-2
5																			
6																			
7																			
8		41	32	38	20	68		89	48	59	34	126		37	12	32	20	58	
9																			
10																			
11		28	15	16	16	110		40	21	21	19	158		34	6	12	6	143	
12																			
13																			
14																			
15		86	44	47	43	190		135	69	59	43	360		54	9	18	9	170	
16																			
17																			
18																			
19		76	46	43	33	140		94	70	53	38	360		21	4	12	5	211	
20																			
21																			
22		70	46	50	42	60		110	46	83	53	110		52	12	26	18	84	
23		25	12	14	10	45		45	17	29	14	45		55	22	48	27	90	
24																			
25																			
26																			
27		12	9	20	17	30		15	11	28	37	78		30	9	12	31	72	
28																			
29																			
30																			
31		34	27	30	22	82		43	34	37	30	130		45	19	31	11	47	

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: JANUAR 1990 (1)																			
	pH						Temperatur (oC)						Alkalitet (mval/l)						Kommentar
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1		7,6	7	7,6	7	7,6								2,39	0,62	2,34	0,86	2,72	
2		7,8	7,3	7,6	7,2	7,5								2,75	1,35	2,65	1,16	2,64	
3		8,7	7,4	7,8	7,3	7,4		8			8,5			2,67	1,49	2,63	1,33	2,54	
4		8,7	7,5	7,8	7,4	7,6		9	9,1	9	8,4			3,07	2,2	3,05	1,86	2,88	temp-Graz
5		8,8	7,7	7,9	7,5	7,4		8,8	9,3	9,1	9			3,23	2,84	3,28	2,17	2,85	temp-Graz
6		8,6	7,7	7,8	7,5	7,5		8,6	8,9	8,8	8,3			3,1	2,74	3,05	2,16	2,77	temp-Graz
7		8,6	7,6	7,9	7,5	7,3		6,4	8	7,4	7,4			2,59	1,98	2,7	1,73	2,45	temp-Graz
8		8,2	7,4	7,7	7,3	7,2		8,9	9,8	9,5	9,4			2,38	1,4	2,28	1,26	2,19	temp-Graz
9		8,2	7,4	7,7	7,4	7,3								2,87	1,45	2,69	1,49	2,67	*prøve fra kl
10		8,2	7,5	7,8	7,5	7,5		9,4	9,7	9,5	9			2,93	1,74	2,89	1,71	2,95	16 dagen før
11		7,8	7,5	7,8	7,5	7,4		8,9	9,1	9	8,5			2,65	1,5	2,58	1,6	2,89	temp-Graz
12		8,2	7,5	7,8	7,4	7,4		8,3	9,3	8,7	8,9			3,04	2,15	2,92	2,07	1,91	stikk 6 t-G
13		8	7,5	7,7	7,4	7,4		10,2	10,1	8	9,2			2,45	1,61	2,53	1,55	2,46	temp-Graz
14		8,7	7,5	7,9	7,4	7,4		10,6	10,3	11	9,6			2,48	1,35	2,52	1,49	2,43	
15		8,6	7,4	7,9	7,5	7,4		7	8,9		8,2			2,64	1,44	2,57	1,54	2,63	temp-Graz
16		8,4	7,2	7,7	7,4	7,3								2,22	0,91	2,12	1,03	2,19	
17		8,3	7,1	7,8	7,2	7,3		9	12		12,1			2,76	0,93	2,42	1,1	2,68	temp-Graz
18		8,1	7,3	7,8	7,3	7,4								2,65	1,1	2,58	1,24	2,6	
19		7,7	7,1	7,7	7,3	7,3								2,46	0,92	2,22	0,97	2,78	
20		8,3	7,1	7,7	7,2	7,3								2,94	1,33	2,69	1,4	2,75	
21		8,1	7	7,6	7,1	7,2								2,75	1	2,47	1,08	2,63	
22		8	7,1	7,7	7,2	7,4								2,87	1,09	2,56	1,21	2,79	
23		8,5	7,2	7,7	7,1	7,2								2,68	1,14	2,45	1,2	2,39	
24		9	7,4	8	7,4	7,3		5,8	5,9	5,8				1,97	0,95	1,54	1,01	1,41	
25		8,7	7,3	7,7	7,5			7,4	8	7,9				1,87	0,93	1,62	0,89		
26		8,8	7,4	7,9	7,3	7,8		8,1	8,9	9,2	7,8			2,3	1,04	2,16	0,98	2,31	
27		8,5	7,5	7,8	7,5	8		10,1	11	11,1	10,6			2,58	1,71	2,47	1,5	2,54	
28		8,1	7,2	7,7	7,1	7,6		7,8	8,7	8,6	8,6			2,22	0,9	2	0,79	2,31	
29		8,7	7,2	7,7	7,2	7,6		5,9	7,1	6,5	7,1			1,97	0,85	1,89	0,87	1,95	
30		8,1	7,1	7,6	7,1	7,6		6	7,9	7,3	8,1			1,74	0,67	1,48	0,62	2,05	
31		8,6	7,2	7,4	7,2			4,1	5,1	4,8	5,1			1,15	0,62	1	0,66		

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: JANUAR 1990 (2)

	NH4-N (mg/l)						NO2-N (mg/l)						NO3-N (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1		10,7	5,9	11,9	5,3	17,2													
2																			
3																			
4		17,1	12,3	18	10,5	19,6		0,1	0,2	0,1	0,4	0,1		0,7	5,7	0	8,5	0,1	
5																			
6		11	12,5	15,5	12,9	17,9													
7																			
8		13,2	6,4	11,1	3,1	10,8		0,2	0,2	0,1	0,3	0,1		0,7	8,4	0,9	8,5	0	
9																			
10																			
11		13,7	7,6	14,8	8,4	11,3													
12																			
13																			
14		13,1	7	14,9	7,8	14,4		0,1	0,3	0,1	0,4	0,1		0,6	8,5	0,5	7,8	0	
15																			
16																			
17																			
18		14,2	3,9	5,3	4,9	14,8													stopp 10 tim
19																			
20		16,9	6,2	16,1	6,6	16,8		0,1	0,4	0,1	>0,6	0,1		0,7	11,6	2,1	11	0,1	
21																			
22																			
23		13,2	3,3	11,9	3,7	12,8													
24																			
25																			
26		9,2	1,2	8	1,3	10,2		0,2	0,3	0,2	0,4	0,1		1,1	10,1	2	10,1	0,9	
27																			
28																			
29		9,6	2,8	8,8	2,7	10,2													
30																			
31																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: JANUAR 1990 (3)

	Tot-N (mg/l)						PO4-P (mg/l)						Tot-P (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			
2																			
3																			
4		28,6	24,2	25,4	22,7	34,1		0,13	0	0,03	0,03	1,8		1,2	0,3	0,53	0,37	3,05	
5																			
6																			
7																			
8		18,2	16,9	17,6	18	23,3		0,03				1,3		0,39	0,26	0,29	0,26	2,85	
9																			
10																			
11																			
12																			
13																			
14		19,1	18,2	19,4	18,7	23,3		0,07				1,56		0,47	0,24	0,29	0,3	2,65	
15																			
16																			
17																			
18																			
19																			
20		29,3	27,6	27,6	26,6	30,7		0,03	0	0	0	1,47		0,43	0,27	0,21	0,2	2,5	
21																			
22																			
23																			
24																			
25																			
26		22	19,6	19,6	18,8	23,8		0,03				1,25		0,23	0,18	0,15	0,13	1,95	
27																			
28																			
29																			
30																			
31																			

FORSØKSANLEGGET, BEKKELAGET ANALYSERESULTAT: JANUAR 1990 (4)

	KOF, filtrert (mg O/l)						KOF, ufiltrert (mg O/l)						SS (mg/l)						Kommentarer
DATO	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1																			
2																			
3																			
4		90	43	56	43	140		140	57	77	56	300		53	12	25	14	155	
5																			
6																			
7																			
8		41	19	25	25	71		66	29	36	25	210		21	15	15	14	146	
9																			
10																			
11																			
12																			
13																			
14		75	35	37	33	90		75	42	49	43	180		23	10	13	13	83	
15																			
16																			
17																			
18																			
19																			
20		53	24	33	28	80		77	44	45	36	170		56	23	45	15	100	
21																			
22																			
23																			
24																			
25																			
26		47	20	26	14	84		53	23	32	42	120		11	8	8	4	41	
27																			
28																			
29																			
30																			
31																			

APPENDIX 3

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 34-38/89. (2)

Uke	Prøve-punkt	Antall dager	Løst KOF mg O/l	Tot KOF mg O/l	Løst BOF mg O/l	Tot BOF mg O/l	Tot P mg P/l	Tot N mg N/l	SS mg SS/l	Kommentarer
89/34	1	5	67	87	25	32	0,51	19,8		
21.08-	2	5	55	72	25	30	0,37	20,1		
27.08	3	5	40	44	7	9	0,21	17,9		
	4	5	34	44	5	6	0,13	20,1		
	5	5	29	32	6	6	0,08	15,5		
	6	4	67	120	35	58	2,05	21,1		
89/35	1	7	50	80	23	36	0,79	23,3		
28.08-	2	7	56	63	29	33	0,32	21,7		
03.09	3	7	32	41	7	9	0,29	20,2		
	4	7		33	4	5	0,13	21,3		KOF filtrert: feil analyse
	5	5	21	23	5	7	0,14	18,3		
	6	7	67	185	59	112	3,00	27,6		
89/36	1	7	48	75			0,64	23,4		BOF tas fra nå av sjelden
04.09-	2	7	50	71			0,43	24,1		
10.09	3	7	42	54			0,33	23,3		
	4	7	35	40			0,39	21,9		
	5	5	45	42			0,13	23,7		
	6	7	89	263			3,30	26,4		
89/37	1	7	60	81			0,49	21,6		
11.09-	2	7	58	70			0,42	23,1		
17.09	3	7	36	41			0,28	21,2		
	4	7	40	40			0,12	19,7		
	5	5	39	40			0,14	18,9		
	6	7	88	231			4,91	28,3		
89/38	1	7	62	68			0,51	22,9		
18.09-	2	6	57	82			0,76	22,5		
24.09	3	7	52	46			0,26	21,4		
	4	7	56	46			0,19	18,7		
	5	3	32	34			0,12	19,7		
	6	6	93	199			3,34	27,8		

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 34-38/89. (1)

Uke	Prøve-punkt	Antall dager	NH4-N mg/l (1)	NO2-N mg/l (2)	NO3-N mg/l (3)	1(+2)+3				Kommentarer
89/34	1	5	15,8		0,7	16,5				
21.08-	2	5	14,7		0,6	15,3				
27.08	3	5	7,7		6,5	14,2				
	4	5	13,3		1,7	15,0				
	5	5	5,4		8,8	14,2				
	6	4	14,7		0,1	14,8				
89/35	1	7	19,3	0,2	0,6	20,1				NO2-N-verdiene har økt
28.08-	2	7	16,5	0,1	0,7	17,3				betraktelig og bør tas hver
03.09	3	7	5,7	7,8	10,8	24,3				uke fra nå av.
	4	7	15,0	0,5	3,7	19,2				
	5	5	4,0	5,5	14,2	23,7				
	6	7	16,5	0,1	0,3	16,9				
89/36	1	7	28,0	0,2	1,0	29,2				NH4-N:Dr.Lange-lasa aqua
04.09-	2	7	31,3	0,2	0,5	32,0				
10.09	3	7	2,9	7,0	8,8	18,7				NO3-N-verdi trolig feil
	4	7	29,2	0,6	5,3	35,1				
	5	5	5,9	2,4	15,2	23,5				
	6	7	26,5	0,1	0,7	27,3				
89/37	1	7	21,6	0,2	0,7	22,5				
11.09-	2	7	20,9	0,1	0,9	21,9				
17.09	3	7	3,7	0,8	14,7	19,2				
	4	7	13,0	0,4	7,2	20,6				
	5	5	2,2	0,8	17,3	20,3				
	6	7	20,6	0,1	0,6	21,3				
89/38	1	7	17,9	0,1	0,0	18,0				NO3-N:Dr.Lange-lasa aqua
18.09-	2	6	16,8	0,1	0,0	16,9				
24.09	3	7	6,8	0,4	5,2	12,4				
	4	7	15,8	0,3	3,9	20,0				
	5	3	7,9	0,2	6,8	14,9				
	6	6	18,6	0,1	0,0	18,7				

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 39-43/89. (2)

Uke	Prøve-punkt	Antall dager	Løst KOF mg O/l	Tot KOF mg O/l	Løst BOF mg O/l	Tot BOF mg O/l	Tot P mg P/l	Tot N mg N/l	SS mg SS/l	Kommentarer
89/39	1	7	60	81			0,46	17,7		
25.09-	2	7	56	90			0,47	19,9		
01.10	3	7	43	53			0,26	22,1		
	4	7	41	61			0,21	21,0		
	5	7	40	40			0,18	20,4		
	6	7	95	195			3,45	27,1		
89/40	1	7	55	62			0,39	10,8		
02.10-	2	7	57	63			0,33	11,4		
08.10	3	7	32	45			0,26	10,7		
	4	6	36	38			0,21	12,2		
	5	7	41	51			0,54	12,9		
	6	7	88	170			4,50	18,3		
89/41	1	7	61	74			0,79	24,2		
09.10-	2	7	80	114			1,22			prøveflaske tot-N knust
15.10	3	7	39	52			0,40	24,1		
	4	7	47	54			0,65	24,2		
	5	7	50	48			0,39	23,9		
	6	7	107	246			3,30	29,3		
89/42	1	7	51	67	17	22	0,26	21,7		
16.10-	2	7	59	109	17	19	0,28	21,5		
22.10	3	7	34	45	5	7	0,29	23,0		
	4	7	39	49	5	7	0,23	21,5		
	5	7	36	46	6	6	0,27	20,6		
	6	7	82	186	39	75	3,18	24,5		
89/43	1	6	61	85			0,52	24,6		
23.10-	2	6	62	103			0,83	24,0		
29.10	3	7	42	66			0,43	19,1		
	4	7	45	56			0,25	21,8		
	5	7	40	50			0,17	21,8		
	6	7	91	205			3,15	27,7		

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 39-43/89. (1)

Uke	Prøve-punkt	Antall dager	NH4-N mg/l (1)	NO2-N mg/l (2)	NO3-N mg/l (3)	1 (+2) +3				Kommentarer
89/39	1	7	16,0	0,1	0,6	16,7				NO3-N:Dr.Lange-labinett
25.09-	2	7	18,4	0,1	0,3	18,8				
01.10	3	7	8,5	1,1	10,2	19,8				
	4	7	15,6	0,3	4,0	19,9				
	5	7	9,3	0,2	9,1	18,6				
	6	7		0,1	0,7					analysefeil
89/40	1	7	23,7	0,2	0,0	23,9				NO3-N:Dr.Lange-lasa aqua
02.10-	2	7	22,8	0,2	0,0	23,0				
08.10	3	7	8,3	0,8	10,7	19,8				
	4	6	14,4	0,5	3,4	18,3				
	5	7	7,4	0,4	12,7	20,5				
	6	7	19,7	0,1	0,0	19,8				
89/41	1	7	18,7	0,2	0,0	18,9				
09.10-	2	7	21,0	0,2	0,0	21,2				
15.10	3	7	5,8	1,3	11,2	18,3				
	4	7	4,4	0,9	4,3	9,6				NH4-N:analysefeil
	5	7	3,6	0,5	11,9	16,0				
	6	7	18,4	0,1	0,0	18,5				
89/42	1	7	16,0	0,2	0,6	16,8				NO3-N:Dr.Lange-labinett
16.10-	2	7	16,7	0,2	0,5	17,4				
22.10	3	7	5,1	0,5	13,7	19,3				
	4	7	8,0	0,8	8,1	16,9				
	5	7	3,0	0,4	16,1	19,5				
	6	7	17,4	0,1	0,5	18,0				
89/43	1	6	17,7	0,2	1,3	19,2				
23.10-	2	6	18,8	0,1	0,6	19,5				
29.10	3	7	10,5	0,8	10,5	21,8				
	4	7	12,8	0,4	5,8	19,0				
	5	7	2,2	0,6	16,3	19,1				
	6	7	21,1	0,1	0,6	21,8				

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 44-48/89. (2)

Uke	Prøve-punkt	Antall dager	Løst KOF mg O/l	Tot KOF mg O/l	Løst BOF mg O/l	Tot BOF mg O/l	Tot P mg P/l	Tot N mg N/l	SS mg SS/l	Kommentarer
89/44	1									Prøvepunkt 2 i kar I (vann
30.10-	2	4	33	46			0,33	14,0		fra både K1 og K2)
05.11	3	6	32	43			0,37	18,0		
	4	6	28	34			0,29	16,8		
	5	4	24	28			0,21	15,5		
	6	6	63	119			1,90	20,0		
89/45	1									
06.11-	2	7	35	45			0,22	13,7		
12.11	3	7	21	25			0,17	14,8		
	4	7	15	22			0,12	14,6		
	5	7	15				0,11	14,4		
	6	7	38	36			1,30	15,1		
89/46	1									
13.11-	2	7	39	70			0,34	19,3		
19.11	3	7	28	32			0,22	19,8		
	4	7	27	34			0,18	19,0		
	5	7	23	29			0,15	19,4		
	6	7	69	133			2,30	22,6		
89/47	1									
20.11-	2	6	75	109			0,73	25,7		
26.11	3	7	43	54			0,31	24,6		
	4	7	51	52			0,32	24,0		
	5	7	59	47			0,22	23,5		
	6	6	99	259			3,50	29,6		
89/48	1									
27.11-	2	7	77	104			0,76	23,8		
03.12	3	7	41	47			0,22	21,4		
	4	7	50	57			0,32	22,1		
	5	7	40	54			0,23	21,6		
	6	6	114	244			3,05	27,2		

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 44-48/89. (1)

Uke	Prøve-punkt	Antall dager	NH4-N mg/l (1)	NO2-N mg/l (2)	NO3-N mg/l (3)	1 (+2) + 3				Kommentarer
89/44	1									Prøvepunkt 2 i kar I (vann
30.10-	2	4	7,4		3,8	11,2				fra både K1 og K2)
05.11	3	6	3,3		9,1	12,4				
	4	6	6,0		7,6	13,6				
	5	4	0,0		12,9	12,9				
	6	6	11,7		0,7	12,4				
89/45	1									
06.11-	2	7	7,7		1,0	8,7				
12.11	3	7	2,8		8,4	11,2				
	4	7	5,0		5,2	10,2				
	5	7	0,0		11,1	11,1				
	6	7	9,5		0,3	9,8				
89/46	1									
13.11-	2	7	13,9		0,7	14,6				
19.11	3	7	8,8		6,7	15,5				
	4	7	11,5		5,8	17,3				
	5	7	3,0		13,5	16,5				
	6	7	11,3		0,7	12,0				
89/47	1									
20.11-	2	6	19,4	0,2	0,6	20,2				
26.11	3	7	13,8	0,4	5,2	19,4				
	4	7	16,2	0,2	2,9	19,3				
	5	7	7,8	0,5	10,2	18,5				
	6	6	18,1	0,1	0,2	18,4				
89/48	1									
27.11-	2	7	15,0	0,2	0,1	15,3				
03.12	3	7	15,3	0,5	2,8	18,6				
	4	7	14,9	0,2	0,3	15,4				
	5	7	10,0	0,5	7,3	17,8				
	6	6	12,0	0,2	0,0	12,2				

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 49/89-01/90. (2)

Uke	Prøve-punkt	Antall dager	Løst KOF mg O/l	Tot KOF mg O/l	Løst BOF mg O/l	Tot BOF mg O/l	Tot P mg P/l	Tot N mg N/l	SS mg SS/l	Kommentarer
89/49	1									Uke 49 og 50 samlet i en
04.12-	2	3								ukeblandprøve
10.12	3	5								
	4	5								
	5	5								
	6	5								
89/50	1									
11.12-	2	7			24	34	0,64	23,4		løst og tot KOF:
17.12	3	7			5	7	0,26	23,4		prøveflasker ombyttet
	4	7			8	11	0,29	23,2		
	5	7			5	6	0,16	22,9		
	6	7		230	63	119	3,50	28,6		
89/51	1									
18.12-	2	7	26	45			0,64	23,0		
24.12	3	7	8	14			0,20	20,9		
	4	7	13	17			0,35	22,1		
	5	7	7	11			0,25	21,3		
	6	7	52	130			3,50	27,8		
89/52	1									
25.12-	2	7	52	57			0,35	19,7		
31.12	3	7	31	31			0,16	22,4		
	4	7	27	41			0,22	22,4		
	5	7	19	33			0,22	21,6		
	6	6	69	85			1,75	21,4		
90/01	1									
01.01-	2	7					0,80			
07.01	3	7					0,24			
	4	7					0,40			
	5	7					0,24			
	6	7					2,80			

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 49/89-01/90. (1)

Uke	Prøve-punkt	Antall dager	NH4-N mg/l (1)	NO2-N mg/l (2)	NO3-N mg/l (3)	1(+2)+3				Kommentarer
89/49	1									Uke 49 og 50 samlet i en
04.12-	2	3								ukeblandprøve
10.12	3	5								
	4	5								
	5	5								
	6	5								
89/50	1									
11.12-	2	7	19,1	0,1	0,1	19,3				
17.12	3	7	14,3	0,4	3,9	18,6				
	4	7	13,2	0,2	0,1	13,5				
	5	7	11,2	0,4	6,2	17,8				
	6	7	18,5	0,1	0,0	18,6				
89/51	1									
18.12-	2	7	19,8	0,1	0,1	20,0				
24.12	3	7	10,6	0,2	5,7	16,5				
	4	7	12,7	0,1	1,6	14,4				
	5	7	8,7	0,5	10,6	19,8				
	6	7	17,5	0,1	0,1	17,7				
89/52	1									
25.12-	2	7	14,8	0,2	0,0	15,0				
31.12	3	7	4,2	0,3	7,7	12,2				
	4	7	5,2	0,2	1,7	7,1				
	5	7	4,0	1,2	8,9	14,1				
	6	6	11,1	0,1	0,0	11,2				
90/01	1									
01.01-	2	7	15,8		0,2	16,0				
07.01	3	7	8,5		7,6	16,1				
	4	7	12,4		0,5	12,9				
	5	7	9,4		8,8	18,2				
	6	7	16,0		0,0	16,0				

FORSØKSANLEGGET, BEKKELAGET. ANALYSERESULTAT FOR UKEBLANDPRØVER. UKE 02-06/90. (1)

Uke	Prøve-punkt	Antall dager	NH4-N mg/l (1)	NO2-N mg/l (2)	NO3-N mg/l (3)	1 (+2)+3				Kommentarer
90/02	1									
08.01-	2	7	16,1	0,1	0,9	17,1				
14.01	3	7	8,4	0,3	7,8	16,5				
	4	7	16,2	0,1	0,7	17,0				
	5	7	8,4	0,4	8,1	16,9				
	6	6	16,9	0,1	0,0	17,0				
90/03	1									
15.01-	2	5	15,8	0,1	0,3	16,2				
21.01	3	5	5,8	0,4	10,2	16,4				
	4	5	14,8	0,1	1,3	16,2				
	5	5	6,4	0,6	9,7	16,7				
	6	5	16,3	0,1	0,0	16,4				
90/04	1									
22.01-	2	7	11,5	0,1	0,7	12,3				
28.01	3	7	3,0	0,3	9,8	13,1				
	4	7	9,9	0,2	2,4	12,5				
	5	7	3,0	0,5	9,7	13,2				
	6	6	14,3	0,1	0,0	14,4				
90/05	1									
20.01-	2									
04.02	3									
	4									
	5									
	6									
90/06	1									
05.02-	2									
11.02	3									
	4									
	5									
	6									

APPENDIX 4

Table A 4.1 Results obtained at two-step filtration (B2)

Date	NH_4-N (mg/l)			Alcalinity (meq/l)				D.O. (mg/l)				D.O. (gO_2/h)	
	K2 in	B2 out	K2-B2	measured K2	measured B2	measured K2-B2	needed theoretic.	measured K2	measured B2/1	measured B2/2	needed theoretic.	needed theoretic. for nitrific.	applied in the system
RUN 1													
1.10.89	17.4	11.2	6.2	1.95	0.97	0.98	0.88	----	-----	----	26.0	130.2	average
7.10.89	15.5	4.5	11.0	2.98	1.35	1.63	1.57	4.23	5.29	6.36	46.2	231.0	value
13.10.89	18.1	2.8	15.3	3.61	1.38	2.23	2.18	3.88	2.29	6.16	64.3	321.3	for
19.10.89	15.4	1.3	14.1	3.14	0.92	2.22	2.01	5.94	2.89	3.79	59.2	296.1	RUN 1
26.10.89	16.4	2.7	13.7	3.19	1.10	2.09	1.95	2.84	3.45	8.77	57.5	287.7	B2/1 =
2.11.89	10.2	0.0	10.2	2.31	0.78	1.53	1.46	7.38	6.77	7.78	42.8	214.2	25.050
8.11.89	9.0	0.0	9.0	2.79	1.21	1.58	1.28	6.15	5.19	7.49	37.8	189.0	B2/2 =
14.11.89	14.5	1.3	13.2	2.67	1.10	1.57	1.88	4.65	3.31	6.08	55.4	277.2	27.000
20.11.89	15.4	5.3	10.1	3.40	1.95	1.45	1.44	4.81	5.67	6.62	42.4	212.1	
21.11.89	17.6	4.4	13.2	3.03	1.32	1.71	1.88	5.25	4.50	6.16	55.4	277.2	
RUN 2													
22.11.89	17.0	6.6	10.4	3.11	1.49	1.62	1.48	3.68	4.80	6.62	43.7	218.4	average
23.11.89	(13.7)	4.5	9.2	3.06	1.19	1.87	1.31	3.32	3.98	5.94	38.6	193.2	value
24.11.89	(23.3)	12.0	11.3	3.69	2.47	1.22	1.61	2.88	2.26	4.93	47.5	237.3	for
25.11.89	16.9	9.6	7.3	2.91	2.22	0.69	1.04	4.39	4.40	4.61	30.7	153.3	RUN 2
26.11.89	15.1	9.3	5.8	2.72	1.76	0.96	0.83	5.01	4.33	4.06	24.4	121.8	B2/1 =
28.11.89	17.6	8.3	9.3	2.41	1.28	1.13	1.33	5.46	5.23	5.32	39.1	195.3	12.540
30.11.89	14.9	7.5	7.4	2.93	----	----	1.05	5.47	5.37	6.09	31.1	155.4	B2/2 =
2.12.89	16.3	12.1	4.2	2.80	2.06	0.74	0.60	5.92	6.43	6.61	17.6	88.2	14.490
4.12.89	(18.7)	12.0	6.7	(2.56)	1.68	0.88	0.96	7.26	5.34	7.15	28.1	140.7	
8.12.89	20.9	12.0	8.9	2.89	1.66	1.23	1.27	6.24	6.23	5.74	37.4	186.9	
11.12.89	21.7	12.8	8.9	2.91	1.81	1.10	1.27	----	2.80	4.88	37.4	186.9	
13.12.89	19.8	11.4	8.4	2.59	1.56	1.03	1.19	6.82	6.83	8.34	35.3	176.4	
15.12.89	17.6	5.7	11.9	2.28	1.21	1.07	1.70	6.91	6.60	8.62	45.0	249.9	
18.12.89	22.8	12.9	9.9	2.69	1.44	1.25	1.41	8.47	6.32	8.03	41.6	207.9	
19.12.89	17.7	10.8	6.9	2.83	1.72	1.11	0.98	----	7.29	7.09	29.0	144.9	
21.12.89	21.0	9.2	11.8	2.34	1.08	1.26	1.68	8.39	6.40	7.05	49.6	247.8	
RUN 3													
22.12.89	18.3	8.6	9.7	2.58	1.32	1.26	1.38	8.91	6.30	5.76	40.7	203.7	average
23.12.89	16.7	8.7	8.0	3.13	1.68	1.45	1.14	7.98	6.92	7.13	33.6	168.0	value
26.12.89	7.1	0	7.1	1.58	0.65	0.93	1.01	8.55	9.06	9.48	29.8	149.1	for
27.12.89	8.2	0	8.2	1.60	0.63	0.97	1.17	9.66	9.44	9.45	34.4	172.2	RUN 3
29.12.89	16.0	1.3	14.7	2.17	0.68	1.49	2.10	10.14	8.81	9.88	61.7	308.7	B2/1 =
31.12.89	18.6	7.5	11.1	2.79	1.28	1.51	1.58	10.07	8.94	9.74	46.6	233.1	14.400
1.01.90	10.7	5.3	5.4	2.39	0.86	1.53	0.77	10.18	8.86	9.87	22.7	113.4	B2/2 =
4.01.90	17.1	10.5	6.6	3.07	1.86	1.21	0.94	8.45	5.16	8.06	27.7	138.6	17.340
6.01.90	(17.9)	12.9	5.0	3.10	2.16	0.94	0.71	7.77	7.17	7.09	21.0	105.0	
8.01.90	13.2	3.1	10.1	2.38	1.26	1.12	1.44	7.96	7.00	7.40	42.4	212.1	
11.01.90	13.7	8.4	5.3	2.65	1.60	1.05	0.76	6.89	6.30	7.88	22.3	111.3	
14.01.90	13.1	7.8	5.3	2.48	1.49	0.99	0.76	8.33	7.72	7.68	22.3	111.3	

* values in the brackets represent NH_4-N concentration/alcalinity in wastewater before K2.

Table A 4.2 Results obtained at one-step filtration (B1)

	NH_4-N (mg/l)			Alcalinity (meq/l)				D.O. (mg/l)			D.O. (gO_2/h)	
				measured			needed theo-retic.	measured		needed theo-retic.	needed theore-tic. for nitrific.	applied in the system
Date	K1 in	B1 out	K1-B1	K1	B1	K1-B1		K1	B1/1			
RUN 1												
1.10.89	19.0	8.5	10.5	3.07	1.75	1.32	1.50	----	----	44.1	220.5	average
7.10.89	15.6	7.4	8.2	3.27	2.11	1.16	1.17	4.23	9.02	34.4	172.5	value
13.10.89	18.4	5.7	12.7	3.55	2.05	1.50	1.81	3.88	8.77	53.3	266.5	for
19.10.89	18.8	5.9	12.9	3.23	1.66	1.57	1.84	5.94	5.94	54.2	271.0	RUN 1
26.10.89	18.0	9.4	8.6	3.00	1.87	1.13	1.23	2.84	8.26	36.1	180.6	45.300
2.11.89	10.2	2.5	7.7	2.31	1.06	1.25	1.10	7.38	8.50	31.5	157.5	
8.11.89	9.0	3.1	5.9	2.79	1.68	1.11	0.84	6.15	8.08	24.8	123.9	
14.11.89	14.5	7.3	7.2	2.67	1.84	0.83	1.03	4.65	5.02	30.2	151.2	
20.11.89	15.4	10.9	4.5	3.40	2.97	0.43	0.64	4.81	4.90	18.9	94.5	
21.11.89	17.6	10.1	7.5	3.03	2.47	0.56	1.07	5.25	5.76	31.5	157.5	
RUN 2												
22.11.89	17.0	12.0	5.0	3.11	2.22	0.89	0.71	3.68	6.06	21.0	105.0	average
23.11.89	(13.7)	10.8	2.9	3.06	1.92	1.14	1.55	3.32	5.98	12.2	60.9	value
24.11.89	(23.3)	17.4	5.9	3.69	3.22	0.47	0.84	2.88	5.46	24.8	123.9	for
25.11.89	16.9	----	----	2.91	2.82	0.09	----	4.39	5.54	----	-----	RUN 2
26.11.89	15.1	13.5	1.6	2.72	2.42	0.26	0.23	5.01	5.07	6.7	33.6	28.650
28.11.89	17.6	12.9	4.7	2.89	2.23	0.66	0.67	5.46	8.33	19.7	98.7	
30.11.89	14.9	12.3	2.6	----	----	----	0.37	5.47	7.57	10.9	54.6	
2.12.89	16.3	16.2	0.1	2.80	2.79	0.01	0.01	5.91	5.98	0.4	2.1	
4.12.89	(18.7)	16.7	2.0	(2.56)	2.35	0.21	0.29	7.26	5.27	8.4	42.0	
8.12.89	20.9	15.4	5.5	2.89	1.95	0.94	0.78	6.24	7.98	23.1	115.5	
11.12.89	21.7	15.6	6.1	2.91	2.16	0.75	0.87	----	6.35	25.6	128.1	
13.12.89	19.8	10.7	9.1	2.59	1.95	0.64	1.30	6.82	9.04	38.2	191.1	
15.12.89	17.6	13.6	4.0	2.28	1.50	0.78	0.57	6.91	8.01	16.8	84.0	
18.12.89	22.8	15.0	7.8	2.69	1.79	0.90	1.11	8.47	8.29	32.8	163.8	
19.12.89	17.7	12.3	5.4	2.83	2.00	0.83	0.77	----	6.89	22.7	113.4	
21.12.89	21.0	11.2	9.8	2.34	1.34	1.00	0.82	8.39	5.53	41.2	205.8	
RUN 3												
22.12.89	18.3	12.0	6.3	2.58	1.80	0.78	0.90	8.91	4.83	26.5	132.3	average
23.12.89	16.7	13.3	3.4	3.13	2.17	0.96	0.49	7.98	9.83	14.3	71.4	value
26.12.89	7.1	1.5	5.6	1.58	0.70	0.88	0.80	8.55	9.58	23.5	117.6	for
29.12.89	16.0	3.5	12.5	2.17	1.12	1.05	1.78	10.14	9.98	52.5	262.5	RUN 3
31.12.89	18.6	7.9	10.7	2.79	1.68	1.11	1.53	10.07	6.37	44.9	224.7	34.500
1.01.90	10.7	5.9	4.8	2.39	0.62	1.77	0.69	10.18	9.54	20.2	100.8	
4.01.90	17.1	12.3	4.8	3.07	2.20	0.87	0.69	8.45	5.63	20.2	100.8	
6.01.90	(17.9)	12.5	5.4	3.10	2.74	0.36	0.77	7.77	4.69	22.7	113.4	
8.01.90	13.2	6.4	6.8	2.38	1.40	0.98	0.97	7.96	7.33	28.6	142.8	
11.01.90	13.7	7.6	6.1	2.65	1.50	1.15	0.87	6.89	9.45	25.6	128.1	
14.01.90	13.1	7.0	6.1	2.48	1.35	1.13	0.87	8.33	7.93	25.6	128.1	

* values in the brackets represent NH_4-N concentration/alcalinity in wastewater before K1.

APPENDIX 5

Table A 5.1

Amount of D.O. (mg/l) measured.
Range and average value for each run are given.

Run	Measured D.O. (mg/l)				Air supplied m³/h		
	K1/K2	B1	B2/1	B2/2	B1	B2/1	B2/2
1	1.5 - 9.2 5.1	4.9 - 13.2 8.3	0.7 - 7.8 4.1	3.8 - 10.0 7.2	150	83.5	90.0
2	2.9 - 8.6 6.0	3.1 - 9.3 7.0	2.3 - 7.5 5.6	4.1 - 8.7 6.6	95.5	41.8	48.3
3	6.8 - 10.5 8.7	4.7 - 11.6 8.3	5.2 - 9.7 7.4	5.8 - 10.3 8.3	115	48.0	57.8

Table A 5.2

Amount of NH_4-N (mg/l) measured
Range and average value for each run are given.

Run	NH_4-N (mg/l)				
	K1	B1	K2	B2/1	B2/2
1	9.0 - 22.6 17.1	1.4 - 10.9 6.4	9.0 - 23.8 16.7	2.6 - 17.1 12.0	0 - 11.2 4.1
2	13.7 - 23.3 18.7	10.7 - 17.4 13.7	13.7 - 23.3 18.7	12.9 - 21.8 17.8	4.5 - 12.9 9.8
3	7.1 - 18.6 12.8	1.2 - 12.5 5.6	7.1 - 18.6 12.8	5.3 - 18.0 11.6	0 - 12.9 5.1

Table A 5.3

Amount of total COD (mg/l) measured. Range and avarage value for each run are given

COD (mg/l)

RUN	K1	B1	K2	B2/1	B2/1
1	37 - 86 67.8	27 - 63 45.9	37 - 208 88.7	27 - 65 48.7	24 - 61 44.0
2	40 - 219 108.3	21 - 93 53.3	40 - 219 108.3	21 - 104 57.4	19 - 82 41.1
3	15 - 140 70.6	11 - 57 33.7	15 - 140 70.6	28 - 83 48.4	14 - 56 36.9

Table A 5.4

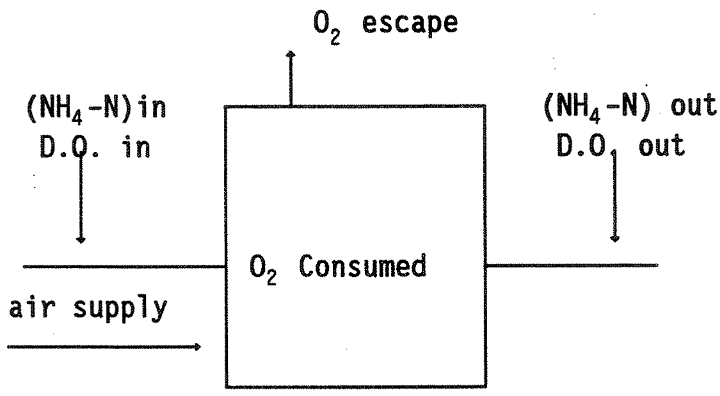
Amount of total BOD_5 (mg/l) recalculated from COD analysis. Average value for each run are given using BOD_5/COD ratio 0.63 (based on analysis from OVA, figure 28).

RUN	total BOD_5 (mg/l)				
	K1	B1	K2	B2/1	B2/2
1	42.7	28.9	55.9	49.6	27.7
2	68.2	33.6	68.2	36.2	25.9
3	44.5	21.2	44.5	30.5	23.3

Table A 5.5 Comparison of D.O. supplied and consumed for carbonaceous and ammonia oxidation.

		D.O. ($g\ O_2/h$)			
	Line	Consumed for			Supplied
		BOD_5	NOD	BOD_5 + NOD	
1	B1	176.5	224.7		45.300
	B2	86.5	273.0		52.050
	B1 + B2	263.0	497.7	760.7	97.350
2	B1	216.5	105.0		28.650
	B2	264.5	189.9		27.030
	B1 + B2	481.0	291.9	772.9	55.680
3	B1	145.5	151.2		34.500
	B2	132.5	161.7		31.740
	B1 + B2	278.0	312.9	590.9	66.240

-Considerations on air supply and consumptions



Consumed: for NH_4-N oxidation + biomass build up + carbonaceous reduction.

RUN 1

B1)

Average $(NH_4\text{-}N)$in - average $(NH_4\text{-}N)$out is 17.4 - 16.4 = 10.79 g NH_4-N/m^3 is oxidezed.
This means that 10.7 g NH_4-N/m^3 x 4.2 O_2 g needed to oxidized 1 g of NH_4-N = 44.9 g O_2 needed/m^3 x 5 m^3 of wastewater/h = 224.7 g O_2/h is theoretically needed to oxidize 10.7 g NH_4-N/m^3

air pressed: 151 m^3 air/h, what corresponds to 45.300 g O_2/h (1 m^3 of air contains 0.21 m^3 of oxygen, what corresponds to ca. 300 g O_2)
air liquid ratio: 151/5 ≈ 30 m^3 air/m^3 liquid.

B2)

Average $(NH_4\text{-}N)$in - average $(NH_4\text{-}N)$out is 17.1 -4.1 = 13 g/m^3 is oxidized.
This means that; 13 g NH_4-N/m^3 x 4.2 g O_2/g NH_4-N = 54.6 g O_2/m^3 x 5 m^3 of wastewater/h = 273 g O_2/h is theoretically needed to oxidize 13 g NH_4-N/m^3.

air pressed: (83.5 + 90)= 173.5 m^3 air/h, what corresponds to 52050 g O_2/h
air liquid ratio: 173/5 ≈ 35 $\left\{ \begin{vmatrix} 17 - B2/1 \\ 18 - B2/2 \end{vmatrix} \right\}$

RUN 2

B1)

Average $(\overset{in}{18.7} - \overset{out}{13.7})$ = 5 g NH_4-N/m^3 x 4.2 g O_2/g NH_4-N =
21.0 g O_2/m^3 x 5 m^3/h => 105 g O_2/h
theoretical needed to oxidize 5 g NH_4-N

air pressed: 95.5 m^3 air/h => what corresponds to: 28.650 g O_2/h
air/liquid ratio: 95.5/5 ≈ 19 m^3 air/m^3 liquid

B2)

Average $(\overset{in}{18.7} - \overset{out}{9.8})$= 8.9 g NH_4-N/m^3 x 4.2 g O_2/g NH_4-N =
37, 4 g O_2/m^3 x 5 m^3/h = 186.9 g O_2/h
theoreticaly needed to oxidize
8.9 g NH_4-N/m^3

air pressed: (41.8 + 48.3) = 90.1 m^3/h, what corresponds to:
27.030 g O_2/h
air liquid ratio: 90.1/5 ≈ 18 m^3/m^3 $\left\{\begin{array}{l} 8 - B2/1 \\ 10 - B2/2 \end{array}\right\}$

RUN 3

B1)

Average $(\overset{in}{12.8} - \overset{out}{5.6})$ = 7.2 g NH_4-N/m^3 x 4.2 g O_2/g NH_4-N =
30.2 g O_2/m^3 x 5 m^3/h => 151.2 g O_2/h
theoretically needed to oxidize
7.2 g NH_4-N/m^3

air pressed: 115 m^3/h => what corresponds to: 34.500 g O_2/h
air/liquid ratio: 115/5 ≈ 23 m^3/m^3

B2)

Average $(\overset{in}{12.8} - \overset{out}{5.1})$ = 7.7 g NH_4-N/m^3 x 4.2 g O_2/g NH_4-N =
32.3 g O_2/m^3 x 5 m^3/h => 161.7 g O_2/h
theoretically needed to oxidize
7.7 g NH_4-N/m^3

air presed: (48.0 + 57.8) = 105.8 m^3/h, what corresponds to:
31.740 g O_2/h
air/liquid ratio: 105.8/5 = 21 $\left\{\begin{array}{l} 9.5 - B2/1 \\ 11.5 - B2/2 \end{array}\right\}$

Based on averaged BOD_5 values D.O. requirements for carbonaceous oxidation was:

RUN 1

B1)

averaged BOD in - averaged BOD out = 42.7 - 28.9 = 13.8 gO_2/m^3 was removed
This means 13.8 g/m^3 x 1.25 (after[8]) = 17.3 gO_2/m^3 x 5 m^3/h ==> 86.5 gO_2/h for BOD removal.

B2)

averaged BOD in - averaged BOD out = 55.9 - 27.7 = 28.2 gO_2/m^3 was removed.
This means 22.8 g/m^3 x 1.25 = 35.3 gO_2/m^3 x 5 m^3/h ==> 176.5 gO_2/h

RUN 2

B1)

averaged (68.2 -33.6) = 34.6 gO_2/m^3 x 1.25 = 43.3 gO_2/m^3 x 5 m^3/h ==> 216.5 gO_2/h

B2)

averaged (68.2 -25.9) = 42.3 gO_2/m^3 x 1.25 = 52.9 gO_2/m^3 x 5 m^3/h ==> 264.5 gO_2/h

RUN 3

B1)

averaged (44.5 -21.2) = 23.3 gO_2/m^3 x 1.25 = 29.1 gO_2/m^3 x 5 m^3/h ==> 145.5 gO_2/h

B2)

averaged (44.5 -23.3) = 21.2 gO_2/m^3 x 1.25 = 26.5 gO_2/m^3 x 5 m^3/h ==> 132.5 gO_2/h

APPENDIX 6

NH4-ukebland

uke	belastning (m3/h)		NH4 (mg NH4-N/l)					NH4-belastning (g NH4-N/m2*d)				nitrifisering (% NH4-N fjernet)				nitrifikasjonshastighet (g NH4-N fjernet/m2*d)			
	B1	B2	1	2	3	4	5	1,3	2,4	2,5	4,5	1,3	2,4	2,5	4,5	1,3	2,4	2,5	4,5
89/30	5,0	5,0	13,6	15,2	3,1	13,5	9,4	1,22	2,72	1,03	1,47	77,2	11,2	38,2	30,4	0,94	0,30	0,39	0,45
89/31	5,0	5,0	7,7	7,6	1,7	6,9	3,9	0,69	1,36	0,52	0,75	77,9	9,2	48,7	43,5	0,54	0,13	0,25	0,33
89/32	5,0	5,0	12,1	11,0	2,9	10,1	9,1	1,08	1,97	0,75	1,10	76,0	8,2	17,3	9,9	0,82	0,16	0,13	0,11
89/33	5,0	5,0	8,3	7,0	1,5	7,5	6,2	0,74	1,25	0,47	0,82	81,9	-7,1	11,4	17,3	0,61	# # #	0,05	0,14
89/34	5,0	5,0	15,8	14,7	7,7	13,3	5,4	1,41	2,63	1,00	1,45	51,3	9,5	63,3	59,4	0,73	0,25	0,63	0,86
89/35	5,0	5,0	19,3	16,5	5,7	15,0	4,0	1,73	2,96	1,12	1,64	70,5	9,1	75,8	73,3	1,22	0,27	0,85	1,20
89/36	5,0	5,0	28,0	31,3	2,9	29,2	5,9	2,51	5,61	2,12	3,19	89,6	6,7	81,2	79,8	2,25	0,38	1,72	2,54
89/37	5,0	5,0	21,6	20,9	3,7	13,0	2,2	1,93	3,74	1,42	1,42	82,9	37,8	89,5	83,1	1,60	1,41	1,27	1,18
89/38	5,0	5,0	17,9	16,8	6,8	15,8	7,9	1,60	3,01	1,14	1,72	62,0	6,0	53,0	50,0	0,99	0,18	0,60	0,86
89/39	5,0	5,0	16,0	18,4	8,5	15,6	9,3	1,43	3,30	1,25	1,70	46,9	15,2	49,5	40,4	0,67	0,50	0,62	0,69
89/40	5,0	5,0	23,7	22,8	8,3	14,4	7,4	2,12	4,08	1,55	1,57	65,0	36,8	67,5	48,6	1,38	1,50	1,04	0,76
89/41	5,0	5,0	18,7	21,0	5,8		3,6	1,67	3,76	1,42		69,0		82,9		1,16		1,18	
89/42	5,0	5,0	16,0	16,7	5,1	8,0	3,0	1,43	2,99	1,13	0,87	68,1	52,1	82,0	62,5	0,98	1,56	0,93	0,55

side 4

NH4-ukebland

uke	belastning (m3/h)		NH4 (mg NH4-N/l)					NH4-belastning (g NH4-N/m2*d)				nitrifisering (% NH4-N fjernet)				nitrifikasjonshastighet (g NH4-N fjernet/m2*d)			
	B1	B2	1	2	3	4	5	1,3	2,4	2,5	4,5	1,3	2,4	2,5	4,5	1,3	2,4	2,5	4,5
89/43	5,0	5,0	17,7	18,8	10,5	12,8	2,2	1,59	3,37	1,27	1,40	40,7	31,9	88,3	82,8	0,64	1,07	1,13	1,16
89/44	5,0	5,0	7,4	7,4	3,3	6,0	0,0	0,66	1,33	0,50	0,65	55,4	18,9	# # #	# # #	0,37	0,25	0,50	0,65
89/45	5,0	5,0	7,7	7,7	2,8	5,0	0,0	0,69	1,38	0,52	0,55	63,6	35,1	# # #	# # #	0,44	0,48	0,52	0,55
89/46	5,0	5,0	13,9	13,9	8,8	11,5	3,0	1,24	2,49	0,94	1,25	36,7	17,3	78,4	73,9	0,46	0,43	0,74	0,93
89/47	5,0	5,0	19,4	19,4	13,8	16,2	7,8	1,74	3,47	1,32	1,77	28,9	16,5	59,8	51,9	0,50	0,57	0,79	0,92
89/48	5,0	5,0	15,0	15,0	15,3	14,9	10,0	1,34	2,69	1,02	1,63	0,0	0,7	33,3	32,9	0,00	0,02	0,34	0,53
89/49	5,0	5,0	19,1	19,1	14,3	13,2	11,2	1,71	3,42	1,29	1,44	25,1	30,9	41,4	15,2	0,43	1,06	0,54	0,22
89/50	5,0	5,0	19,1	19,1	14,3	13,2	11,2	1,71	3,42	1,29	1,44	25,1	30,9	41,4	15,2	0,43	1,06	0,54	0,22
89/51	5,0	5,0	19,8	19,8	10,6	12,7	8,7	1,77	3,55	1,34	1,39	46,5	35,9	56,1	31,5	0,82	1,27	0,75	0,44
89/52	5,0	5,0	14,8	14,8	4,2	5,2	4,0	1,33	2,65	1,00	0,57	71,6	64,9	73,0	23,1	0,95	1,72	0,73	0,13
90/01	5,0	5,0	15,8	15,8	8,5	12,4	9,4	1,41	2,83	1,07	1,35	46,2	21,5	40,5	24,2	0,65	0,61	0,43	0,33
90/02	5,0	5,0	16,1	16,1	8,4	16,2	8,4	1,44	2,88	1,09	1,77	47,8	0,0	47,8	48,1	0,69	0,00	0,52	0,85
90/03	5,0	5,0	15,8	15,8	5,8	14,8	6,4	1,41	2,83	1,07	1,61	63,3	6,3	59,5	56,8	0,90	0,18	0,64	0,92

TEMPERATURE (^0C)

Day	Air	Air inside		Water				Remarks
	outside	down	up	K1+ K2	B1	B2/1	B2/2	
26.09.89		18.0	19.5	----	----	15.5	----	
28.09.89	---	15.3	19.3	14.4	----	13.4	----	
RUN 1								
02.10		16.2	20.0	14.6	----	----	----	
10.10		14.1	18.5	15.0	14.9	15.0	15.0	
12.10		11.0	16.8	14.1	----	----	----	cooler
16.10		13.7	19.6	----	----	12.4	----	
17.10		11.1	19.6	----	----	12.7	----	
23.10		13.1	16.6	----	----	12.9	----	
24.10		13.1	16.1	13.9	----	14.1	----	
31.10		----	16.2	----	----	13.0	----	
02.11			18.0	----	----	13.4	----	cooler, 30.10.rainy
07.11	6-7	13	17.9	11.7	12.7	12.6	12.8	rainy
13.11		13.1	----	11.3	12.7	12.2	12.5	Sat. 11-11 rainy
16.11		6.3	----	12.2	12.8	12.8	12.7	cooler
17.11	8	8.2	13.5	12.2	12.2	12.4	11.9	sunny, cold
18.11				12.0	12.0	11.8	11.3	
19.11				12.5	12.1	12.2	11.7	
20.11	8	8.0	12.3	12.1	12.1	12.1	11.5	
21.11	7	10.0	12.6	12.0	14.5	13.8	13.9	foggy
RUN 2								
22.11	5	6.5	11.2	11.5	13.0	12.8	13.0	
23.11	0-3	9		11.5	11.9	11.7	11.4	dry, cold
25.11				12.1	11.9	----	11.2	dry, cold
26.11	0-1	8.6		10.5	10.8	10.5	10.2	dry, warmer
27.11		12.3	16.5	11.7	12.1	12.2	11.8	dry, warmer
28.11	-5	10.3	11.6	10.5	11.0	10.9	10.4	dry, cold
29.11	-5	5.3		11.2	13.0	12.2	12.5	dry, cold
30.11	-5	4.7	14.8	11.0	10.9	11.0	10.2	dry, cold
04.12	+0	11.9	16.6	10.7	10.6	10.6	10.0	dry, warmer
05.12	-1	12.0	16.5	10.8	10.6	10.9	10.2	
6&7.12	Whole plant stopped							
8.12	0	11.8	17.8	10.2	11.4	11.1	11.3	
14.12	-5	10		10.2	10.3	10.2	9.8	cold
15.12	-10	8.0		----	10.0	9.9	9.2	very cold
16.12				----	9.2	9.0	8.8	
17.12	-5			----	9.2	9.0	8.9	cold snow
18.12		10.4	17.8	----	9.9	9.9	9.2	warmer

continue

Day	Air	Air inside		Water				Remarks
	outside	down	up	K1+ K2	B1	B2/1	B2/2	
20.12	0	11.2		----	10.3	10.5	10.0	warmer
21.12	0	16.6		9.8	10.2	10.1	9.8	
RUN 3								
23.12	-1	19.7	23.8	10.9	12.7	11.7	12.7	snow
24.12	-2	17.0	28.0	10.5	10.4	10.2	9.8	
25.12	+3	17.3	29.2	----	8.9	7.7	8.7	rain
28.12	0/+2	12.4	22	9.3	9.8	9.8	9.3	
29.12	-3	12.2	21.2	8.0	10.3	9.7	10.3	dry, cloudy
30.12	-2	12.1	21.3	7.8	8.9	8.9	8.4	dry, cloudy
31.12	-3	13.9	27.0	8.0	11.0	9.7	9.4	dry, cloudy
01.01.90	-4	9.6	20.3	9.0	11.2	10.7	11.3	dry, cloudy
02.01	-4	9.2		9.0	10.2	9.8	9.8	dry, cloudy
03.01	-3	2.5		8.4	8.8	8.5	8.2	dry, cold
04.01	-2	2		9.0	9.1	9.0	8.4	dry, cold
05.01		6.0	24.0	8.8	9.3	9.1	9.0	dry, cold
06.01	+1	10.0	24.2	8.6	8.9	8.8	8.3	dry
07.01	+2	11.4	25.5	6.4	8.0	7.4	7.4	rain in the night
08.01	+2	10.0	23.8	8.9	9.8	9.5	9.4	
		Pumps stopped						
10.01	0	12.0		9.4	9.7	9.5	9.0	dry
11.01	0	9.0	17.0	8.9	9.1	9.0	8.5	dry
12.01	+3	12.5	20.5	8.3	9.3	8.7	8.9	foogy
13.01	0	13	22.5	10.2	10.1	8.0	9.2	dry
14.01	+1	12.9	27.6	10.5	10.3	11.0	9.6	dry
15.01	0	13.0	27.5	----	8.9	----	8.2	rain

1570 OSLO - BLINDERN   Kommune: OSLO   94 moh

LUFTTEMPERATUR DT	01	07	13	19	Tm	Tx	Tn	SKY-DEKKE	NEDBØR i mm R07	R19	R
1		3.0	12.6	12.2	8.4	15.2	3.0	111			
2		11.0	13.7	10.2	10.2	14.0	5.7	132		0.0	
3		2.0	11.6	6.6	5.9	13.5	1.5	131			0.0
4		1.0	10.9	8.4	5.9	13.4	0.9	223			
5		7.9	10.8	9.8	9.1	11.8	6.9	687	0.0		0.0
6		8.8	9.8	8.6	9.1	10.4	8.6	788		3.5	
7		7.8	7.5	6.3	7.2	9.2	5.6	786	3.0	3.5	6.5
8		1.0	5.3	2.9	2.8	6.7	0.5	625			3.5
9		5.3	6.7	5.4	5.2	7.3	2.9	886	1.1	0.7	1.1
10		0.1	7.6	5.6	3.4	7.9	0.0	167		0.0	0.7
11		2.2	7.2	4.3	4.0	8.1	1.5	131	4.3		4.3
12		-2.2	3.4	5.8	1.9	6.0	-2.2	387		0.0	
13		1.4	11.2	7.0	5.1	11.2	0.7	123			0.0
14		0.8	8.7	5.2	4.0	9.5	0.4	338		3.0	
15		-1.4	7.2	3.2	2.5	9.7	-1.7	112			3.0
16		2.6	4.6	4.2	3.2	5.3	0.7	887	3.0	4.0	3.0
17		3.4	5.5	4.4	4.0	6.5	1.7	985	0.3		4.3
18		3.8	7.2	6.6	5.7	9.0	3.5	575			
19		6.4	8.3	9.2	7.7	9.2	6.0	788	1.0	0.4	1.0
20		9.5	10.2	10.7	9.9	10.8	8.5	898	0.1	5.5	0.5
21		7.8	8.9	9.9	9.3	11.9	7.5	481	5.0	3.5	10.5
22		7.0	13.3	11.1	9.7	14.2	6.3	227			3.5
23		6.2	11.5	9.4	8.6	12.5	6.2	643	2.2		2.2
24		2.2	9.0	8.5	5.9	10.9	1.9	215			
25		6.1	12.3	9.0	8.3	12.9	5.0	111			
26		3.7	10.9	7.2	6.4	11.4	3.4	111			
27		0.1	7.4	4.6	3.2	8.2	-0.2	127			
28		4.7	5.3	6.1	5.2	6.4	3.5	787	0.5	0.1	0.5
29		5.8	7.2	8.0	6.9	8.2	5.6	888	1.7	7.6	1.8
30		7.2	6.9	7.2	7.3	8.0	6.9	788	2.7	2.5	10.3
31		6.2	6.5	6.2	6.4	7.2	6.0	787			2.5
MIDDEL:		4.2	8.7	7.2	6.4	9.9	3.4		SUM:		59.2

Max døgntemp	10.2	dato	2.	Max pos. endring av Tm	3.2	dato	4.
Min døgntemp	1.9	dato	12.	Max neg. endring av Tm	-4.4	dato	7.
Abs. maxtemp	15.2	dato	1.	Max døgnamplitude	12.5	dato	4.
Abs. mintemp	-2.2	dato	12.	Max døgnnedbør	10.5	dato	21.
Tm-avvik av normalen:	0.5			Nedbørsum i % av normalen:	78		

Døgn med:

Tm<0	Tn<-10	Tn<0	Tx<0	Tx>=20	Tx>=25	R>=0.1	R>=1.0	R>=10.0	R>=25.0
0	0	3	0	0	0	17	14	2	0

Stasjoner som ikke observerer kl 01, har tom 01-kolonne

TEMPERATUR 01,07,13,19: temperatur ved respektive tidspunkt

Tm: døgnmiddel Tx: maksimum Tn: minimum

SKYDEKKE skydekke målt i åttendedeler kl 01,07,13,19 eller 07,13,19
0=skyfritt og 8=overskyet, 9=himmel ikke synlig

NEDBØR R07: nedbør kl 19-07 R19: nedbør 07-19 R: nedbør fra kl 07 foregående døgn til kl 07 dette døgn. Noen stasjoner har ikke R19.

1870 OSLO - BLINDERN   Kommune: OSLO   94 moh

LUFTTEMPERATUR								SKY-	NEDBØR i mm		
DT	01	07	13	19	Tm	Tx	Tn	DEKKE	R07	R19	R
1		5.9	6.6	6.5	6.3	7.4	5.4	887	2.6	6.9	2.6
2		4.5	4.6	4.6	4.9	6.5	4.1	768		1.2	6.9
3		6.7	7.5	7.6	6.7	7.7	4.6	788	2.3	7.0	3.5
4		8.5	7.6	7.0	7.8	8.7	7.0	787	3.0	13.9	10.0
5		7.6	6.6	6.4	7.0	7.7	6.4	787	3.5		17.4
6		6.4	7.6	6.6	6.7	8.0	5.9	757	1.4	2.0	1.4
7		5.8	6.4	2.8	4.8	7.6	2.8	872	3.1	0.1	5.1
8		3.6	5.6	7.8	5.1	8.0	1.1	887	0.1	5.8	0.2
9		5.2	6.8	8.9	6.8	9.0	4.0	788	0.0	3.0	5.8
10		5.5	5.8	6.8	6.5	8.9	4.6	388	5.3	4.0	8.3
11		8.6	10.8	10.6	9.3	11.3	6.7	887	5.5	2.2	9.5
12		3.9	6.4	6.2	6.0	11.1	2.7	178	0.2		2.4
13		2.2	5.5	2.0	3.1	6.2	1.8	245			
14		5.3	7.4	8.1	6.2	9.7	1.6	811			
15		5.7	6.7	2.1	4.8	9.4	2.1	031			
16		-1.2	1.9	0.2	0.2	3.7	-1.8	111			
17		-1.4	2.6	-0.4	-0.1	3.2	-1.8	111			
18		0.7	2.3	3.1	1.1	3.1	-2.5	888		0.0	
19		1.5	1.5	2.5	2.0	3.1	0.7	888			0.0
20		2.6	2.8	2.4	2.6	3.0	2.4	877		0.0	
21		1.8	2.4	-1.0	0.6	2.6	-1.0	871	0.0	0.0	0.0
22		1.6	2.4	1.0	1.0	2.5	-1.0	110			0.0
23		-1.6	0.0	-2.8	-1.5	1.1	-2.8	766			
24		-6.7	-3.0	-6.7	-5.8	-2.7	-7.3	112	0.2		0.2
25		-6.6	-3.8	-4.1	-5.3	-2.6	-8.1	887		0.0	
26		-2.5	0.7	-0.9	-1.2	2.7	-4.3	152			0.0
27		-4.7	3.1	4.4	-0.3	4.7	-5.6	111		0.2	
28		-3.3	-1.8	-5.4	-2.3	5.0	-5.5	153			0.2
29		-5.9	-2.7	-3.8	-4.4	-1.2	-6.6	311			
30		-5.2	-1.2	-4.4	-4.0	-1.0	-5.4	142			
MIDDEL:		1.8	3.6	2.6	2.5	5.1	0.3			SUM:	73.5

Max døgntemp 9.3 dato 11.   Max pos. endring av Tm 4.1 dato 25.
Min døgntemp -5.8 dato 24.   Max neg. endring av Tm -4.6 dato 15.
Abs. maxtemp 11.3 dato 11.   Max døgnamplitude 10.5 dato 28.
Abs. mintemp -8.1 dato 25.   Max døgnnedbør 17.4 dato 5.
Tm-avvik av normalen: 1.4   Nedbørsum i % av normalen: 107

Døgn med:

Tm<0	Tn<-10	Tn<0	Tx<0	Tx>=20	Tx>=25	R>=0.1	R>=1.0	R>=10.0	R>=25.0
9	0	13	4	0	0	14	11	2	0

Stasjoner som ikke observerer kl 01, har tom 01-kolonne
TEMPERATUR 01,07,13,19: temperatur ved respektive tidspunkt
Tm: døgnmiddel   Tx: maksimum   Tn: minimum
SKYDEKKE skydekke målt i åttendedeler kl 01,07,13,19 eller 07,13,19
0=skyfritt og 8=overskyet, 9=himmel ikke synlig
NEDBØR R07: nedbør kl 19-07 R19: nedbør 07-19 R: nedbør fra kl 07 foregående døgn til kl 07 dette døgn. Noen stasjoner har ikke R19.

1870 OSLO - BLINDERN   Kommune: OSLO   94 moh

LUFTTEMPERATUR

DT	01	07	13	19	Tm	Tx	Tn	SKY-DEKKE	NEDBØR i mm R07	R19	R
1		-6.5	-2.3	-3.3	-4.5	-1.4	-7.0	141			
2		-4.1	-4.8	-4.0	-4.3	-2.6	-6.5	979			
3		-4.3	-0.6	1.5	-1.6	1.5	-5.0	463			
4		5.0	5.7	0.6	2.9	5.9	0.1	310			
5		-6.0	-2.5	-2.0	-3.4	0.6	-6.2	355			
6		-2.2	8.6	6.7	2.0	9.0	-5.6	611			
7		0.0	-0.2	-3.1	0.1	6.7	-3.1	331			
8		0.6	0.3	-0.7	-0.7	1.0	-3.8	788		0.1	
9		-5.1	-4.5	-5.2	-4.4	-0.3	-7.0	117			0.1
10		-2.4	-2.0	-3.4	-3.1	-1.1	-5.4	771			
11		-0.5	-2.2	-4.5	-1.9	2.8	-5.4	117			
12		-4.2	-1.1	-4.9	-3.5	0.2	-5.0	731			
13		-7.6	-7.3	-11.0	-8.7	-4.9	-11.2	116			
14		-9.1	-10.1	-13.4	-11.2	-8.3	-14.0	777		0.0	
15		-16.4	-14.2	-11.3	-14.0	-11.0	-17.5	777	0.0	0.3	0.0
16		-8.2	-6.8	-7.2	-8.9	-6.5	-13.6	788	0.0	0.0	0.3
17		-5.2	-4.1	-3.8	-4.9	-3.5	-7.2	888	2.0	1.0	2.0
18		1.4	0.7	5.2	2.1	5.5	-3.8	875	7.0	0.3	8.0
19		0.8	3.1	-2.6	0.3	5.5	-2.6	522			0.3
20		0.6	-1.3	-4.4	-1.7	1.5	-4.4	232			
21		-2.4	-0.9	-1.0	-2.3	-0.3	-5.5	887	0.5	0.6	0.5
22		-3.3	-0.9	-0.6	-2.0	0.0	-4.0	688		1.6	0.6
23		-0.7	-2.0	-2.3	-1.7	-0.4	-3.6	717	14.5		16.1
24		-3.3	-2.9	0.2	-1.7	0.2	-4.1	989		0.3	
25		5.2	6.7	6.3	4.7	7.0	0.2	887	4.5	0.0	4.8
26		6.7	5.8	4.4	5.6	6.8	4.4	867	0.4		0.4
27		2.2	0.5	-1.1	1.0	4.4	-1.6	997			
28		-4.8	-3.9	-5.9	-4.4	-1.0	-5.9	131			
29		-8.3	-5.8	-4.1	-6.2	-3.8	-8.6	188			
30		-3.5	-2.9	-3.1	-3.3	-2.7	-4.1	888			
31		-4.9	-6.6	-9.7	-6.8	-3.1	-9.7	851	0.0		0.0
MIDDEL:		-2.9	-1.9	-2.8	-2.7	0.2	-5.7			SUM:	33.1

Max døgntemp 5.6 dato 26.   Max pos. endring av Tm 7.0 dato 17.
Min døgntemp -14.0 dato 15.   Max neg. endring av Tm -6.3 dato 4.
Abs. maxtemp 9.0 dato 6.   Max døgnamplitude 14.6 dato 6.
Abs. mintemp -17.5 dato 15.   Max døgnnedbør 16.1 dato 23.
Tm-avvik av normalen: -0.7   Nedbørsum i % av normalen: 52

Døgn med:

Tm<0	Tn<-10	Tn<0	Tx<0	Tx>=20	Tx>=25	R>=0.1	R>=1.0	R>=10.0	R>=25.0
23	4	28	15	0	0	10	4	1	0

Stasjoner som ikke observerer kl 01, har tom 01-kolonne

TEMPERATUR 01,07,13,19: temperatur ved respektive tidspunkt
Tm: døgnmiddel Tx: maksimum Tn: minimum

SKYDEKKE skydekke målt i åttendedeler kl 01,07,13,19 eller 07,13,19
0=skyfritt og 8=overskyet, 9=himmel ikke synlig

NEDBØR R07: nedbør kl 19-07 R19: nedbør 07-19 R: nedbør fra kl 07 foregående døgn til kl 07 dette døgn. Noen stasjoner har ikke R19.

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187) OSLO - BLINDERN Kommune: OSLO 94 moh

LUFTTEMPERATUR								SKY-	NEDBØR i mm		
DT	01	07	13	19	Tm	Tx	Tn	DEKKE	R07	R19	R
1		-8.4	-6.2	-4.5	-7.2	-4.2	-11.9	787			
2		-6.2	-5.4	-5.9	-5.6	-4.3	-6.2	887			
3		-7.9	-7.6	-7.1	-7.2	-5.9	-8.0	788		0.0	
4		-3.4	-1.3	-0.6	-2.9	-0.6	-7.1	888	0.3	1.0	0.3
5		-1.2	-0.8	-0.4	-0.8	-0.3	-1.2	887		0.1	1.0
6		-3.7	-2.5	-0.4	-2.0	-0.2	-3.7	889		0.5	0.1
7		1.9	2.3	0.9	1.3	2.6	-0.4	889	6.0	0.5	6.5
8		3.0	3.9	-0.1	1.8	4.2	-0.1	713			0.5
9		2.3	4.2	2.5	2.6	5.8	-0.2	310			
10		0.0	2.6	2.0	1.3	3.3	0.0	788		4.0	
11		1.8	4.9	1.2	2.2	5.2	0.6	444			4.0
12		2.6	3.0	3.9	2.7	4.0	0.3	898			
13		2.6	2.1	0.1	1.9	5.2	-0.2	121			
14		1.1	0.1	1.0	0.8	2.3	-1.4	178			
15		4.2	6.1	5.7	4.6	7.6	1.0	811	1.6	0.3	1.6
16		0.2	3.6	3.3	2.5	7.0	-0.5	111			0.3
17		4.3	5.1	4.8	4.5	7.0	2.0	161	2.5		2.5
18		5.9	5.3	1.8	4.3	7.7	1.8	276			
19		-1.6	-0.6	4.5	1.1	4.5	-3.0	288		0.6	
20		0.0	2.7	3.4	1.9	4.5	-0.4	637			0.6
21		1.8	2.9	2.2	2.6	4.7	1.6	757			
22		2.1	5.8	5.4	3.4	6.0	-0.1	898	0.7	4.3	0.7
23		0.6	4.4	5.3	3.1	5.8	0.5	488		8.7	4.3
24		1.6	1.4	-0.5	1.5	5.4	-0.5	763	3.0		11.7
25		-3.6	-0.5	0.7	-1.5	0.9	-4.1	126		0.1	
26		0.2	0.7	0.9	0.6	1.3	-0.2	888	4.5	1.7	4.6
27		-2.5	-1.8	-1.3	-1.3	0.9	-2.5	888	0.2	0.0	1.9
28		-1.3	1.1	1.2	0.0	1.3	-1.4	888	0.0	12.0	0.0
29		1.1	2.1	-0.9	0.5	2.5	-0.9	226	9.9		21.9
30		3.8	3.3	2.1	2.1	4.0	-1.5	888	5.4	3.6	5.4
31		5.0	5.6	6.1	4.8	6.4	1.7	888	5.7	9.0	9.3
MIDDEL:		0.2	1.5	1.2	0.8	3.1	-1.5			SUM:	77.2

Max døgntemp 4.8 dato 31. Max pos. endring av Tm 4.3 dato 3.
Min døgntemp -7.2 dato 1. Max neg. endring av Tm -3.2 dato 18.
Abs. maxtemp 7.7 dato 18. Max døgnamplitude 7.7 dato 1.
Abs. mintemp -11.9 dato 1. Max døgnnedbør 21.9 dato 29.
Tm-avvik av normalen: 5.5 Nedbørsum i % av normalen: 157

Døgn med:

Tm<0	Tn<-10	Tn<0	Tx<0	Tx>=20	Tx>=25	R>=0.1	R>=1.0	R>=10.0	R>=25.0
8	1	22	6	0	0	18	12	2	0

Stasjoner som ikke observerer kl 01, har tom 01-kolonne
TEMPERATUR 01,07,13,19: temperatur ved respektive tidspunkt
Tm: døgnmiddel Tx: maksimum Tn: minimum
SKYDEKKE skydekke målt i åttendedeler kl 01,07,13,19 eller 07,13,19
0=skyfritt og 8=overskyet, 9=himmel ikke synlig
NEDBØR R07: nedbør kl 19-07 R19: nedbør 07-19 R: nedbør fra kl 07 foregående døgn til kl 07 dette døgn. Noen stasjoner har ikke R19.