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BIOMETRICS AND PROCESS CONTROL

Technical report:

Stability analysis of a synthetic municipal wastewater

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1. Introduction

The main goal of the SBR under study was to breed an activated sludge as stable as possible in terms of (1) effluent and activated sludge characteristics and (2) microbial community. An important fact regarding this “stability” is the variability of environmental parameters and not in the least the variability of the influent composition. The latter will be investigated in this report.

2. Influent composition

As influent of the SBR a synthetic sewage called Syntho is used, which aims to mimic a real domestic wastewater.

2.1. What is Syntho ?

Syntho was designed to mimic pre-settled domestic wastewater (Boeije, 1998). As it was intended to be used as a standard influent, its components should be commonly available and at a relatively low cost. In addition the feed should be easy to prepare and dose.

Syntho is conceived as a mixture of synthetic wastewater and a minor fraction (10% v/v) of presettled real domestic wastewater. The selection of ingredients for the synthetic part is based on the expected composition of domestic sewage.

Syntho therefore differs considerably from the classical bacterial growth media. It is based on the average composition and quality of sanitary wastewater, i.e. the combination of urine and feces (e.g. Hendericks, 1991; Isselbacher et al., 1994). The household fraction (gray water) was harder to define given its variability. A typical trait is that it contains biodegradable surface-active agents.

The synthetic part also contains lyophilized sludge, mainly to act as a starter for floc formation. Real sewage contains a particulate fraction which is inert or mineral. This fraction is simulated by diatomaceous earth, which helps to increase sludge floc density. The type and concentration of trace metals added to the medium is based on typical concentrations found in sewage (Kempton et al., 1987; Stephenson and Lester, 1987). An overview of the synthetic fraction (90%) of the Syntho medium is given in ***Table 1***.

Domestic sewage provides a constant influx of bacteria and spores which act as an inoculum for the activated sludge plant (Mara, 1974; Curds, 1975). The broad range of substrates in real sewage will also ensure a diverse microbial population and enzymatic activity.

The total calculated and measured COD of the medium (without the domestic sewage) is approximately 470 and 508 mg/l, respectively. The alkalinity of the synthetic sewage was determined by titration with 0.01 N HCl. At a set pH of 7.25, the alkalinity was 3.5 meq HCO_3^-/l.

The cost of Syntho in terms of chemical ingredients is low, ca. 0.03 Euro per liter.

Table 1 -*Syntho medium composition (mg/l)*

C-source		**N-source**		**P-source**		**Sewage simulation**	
Peptone	15	Urea	75	$MgHPO_4.3H_2O$	25	LAS[*]	10
Na-acetate[**]	120	NH_4Cl	11	$K_3PO_4.H_2O$	20	AE[*]	10
Dry meat extract	15	Uric acid	9			Lyophilized act. Sludge	50
Glycerol	40					Diatom. Earth	10
Potato starch	50					Diet fibers	80
Milk powder	120						
Minerals & trace metals[***]							

[*] C12-C14 Linear Alkylbenzene Sulphonate (LAS) and Alcohol Ethoxylate or any other readily biodegradable surface active agents.

[**] Na-acetate can be varied to adjust the C/N/P ratio, to fine-tune N/P removal

[***] $CaCl_2$, 5 mg/l; $NaHCO_3$, 25 mg/l; $FeSO_4.7H_2O$, 10 mg/l; trace metals: $CuCl_2{\cdot}2H_2O$, 480 µg/l; $Cr(NO_3)_3{\cdot}9H_2O$, 680 µg/l; $MnSO_4{\cdot}H_2O$, 100 µg/l; $NiSO_4{\cdot}6H_2O$, 300 µg/l; $CoCl_2{\cdot}6H_2O$, 50 µg/l; $ZnCl_2$, 180 µg/l; K_2MoO_4, 20 µg/l; EDTA, 0.22 µg/l.

2.2. *Influent modifications*

For cost reduction, the synthetic influent was slightly modified according to Boeije (1999). Its final composition is presented in ***Table 2***:

Table 2 - *Synthetic influent composition*

	mg/l	COD mg/l	N mg/l	P mg/l
Chemical compounds				
Urea	91.74	23.22	42.81	0
NH_4Cl	12.75	0	3.52	0
Na-acetate o $Na\text{-}acetate.3H_2O$	79.37 131.64	79.37 79.37	0 0	0 0
Peptone	17.41	17.41	0.67	0
$MgHPO_4.3H_2O$	29.02	0	0	5.14
KH_2PO4	23.4	0	0	3.14
$FeSO_4.7H_2O$	5.80	0	0	0
Food ingredients				
Starch	122.00	122.00	0	0
Milk powder	116.19	116.19	6.95	1.14
Yeast	52.24	52.24	6.28	0
Soy oil	29.02	29.02	0	0
Total		**439.47**	**60.23**	**9.42**

Trace metals		
	mg/l	mg metal /l
$Cr(NO3)3.9H_2O$	0.770	0.100
$CuCl_2.2H_2O$	0.536	0.200
$MnSO4.H_2O$	0.108	0.035
$NiSO_4.6H_2O$	0.336	0.075
$PbCl_2$	0.100	0.075
$ZnCl_2$	0.208	0.100

The calculations of the previous table are approximate. For some proteins and sugars, it was assumed that 1 mg/l of product equals 1 mg/l of COD. This was verified by comparing the calculated and the measured total COD of the influent (Boeije, 1996).

The calculated COD/N/P ratio of the synthetic sewage is 439,47:60,23:9,42 or 100:13,7:2,14. The theoretical BOD, assuming a COD to BOD conversion factor of 0.65, is 285 mg/l.

Daily, there are 4 cycles in which 40 liters of influent need to be added. This implies that 160 liters should be stored. To reduce the volume of the influent it was decided to prepare it as a concentrated liquid and to dilute it just before entering the reactor. To reduce the preparation labour it was decided to prepare concentrated influent once a week. During one week 1120 liters of influent is needed. A dilution ratio of 1:16,23 was used. The composition of the concentrated influent is presented in ***Table 3***.

The dosing system is described in the section 3.

Table 3 - *Concentrated synthetic influent composition*

	mg/l	COD mg/l	N mg/l	P mg/l
Chemical compounds				
Urea	1581	400	738	0
NH_4Cl	220	0	61	0
Na-acetate o Na-acetate.3H_2O	1368 2268	1368 1368	0 0	0 0
Peptone	300	300	12	0
$MgHPO_4.3H_2O$	500	0	0	89
KH_2PO4	403	0	0	54
$FeSO_4.7H_2O$	100	0	0	0
Food ingredients				
Starch	2102	2102	0	0
Milk powder	2002	2002	120	20
Yeast	900	900	108	0
Soy oil	500	500	0	0
Total		**7572**	**1039**	**163**

Trace metals		
	mg/l	mg metal /l
$Cr(NO_3)_3.9H_2O$	13.27	1.7
$CuCl_2.2H_2O$	9.24	3.4
$MnSO_4.H_2O$	1.86	0.6
$NiSO_4.6H_2O$	5.79	1.3
$PbCl_2$	1.72	1.3
$ZnCl_2$	3.58	1.7

3. Influent dosing system

As mentioned before, the effort of preparing influent was minimised by preparing it as a concentrated liquid and to dilute it on-line with tap water prior to addition to the SBR setup. A computer-controlled pump (Watson Marlow 505U; Q=667 ml.min^{-1}) is used to generate the influent flow. The influent enters the SBR at a height of 62 cm. Water is added by using a computer-controlled two-way pinch valve (Sirai S307 02, with silicone tubing of 10/12 mm internal/external diameter). A constant supply of tap water was provided in a reservoir, which is kept at a constant level using a level switch (cfr. toilet system). An overview of the system is shown in Figure 1.

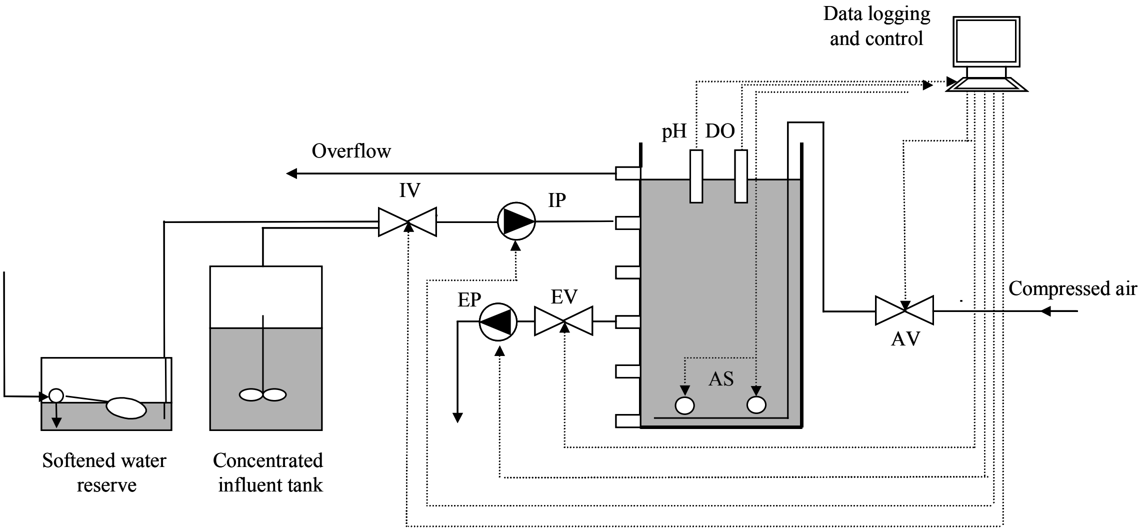


Figure 1 - *Schematic overview of the SBR pilot-plant (IV = influent valve; IP = influent pump; EP = effluent pump; EV = effluent valve; AS = aeration system; pH = pH probe; DO = DO probe; AV = air valve)*

4. Influent "pre-screening"

To minimize labor the objective was to prepare 75 liters of concentrated synthetic influent every week and store it for one week. The storage conditions are, however, of major importance with regard to the stability of the influent. The most important "threat" for deterioration of the influent is microbial growth. The following paragraphs are therefore related to the possible storage methods available to keep the influent quality as constant as possible in order to avoid microbial growth. In order to achieve this stability, one should create conditions that are not favoured by the microorganisms. These conditions can be met by means of:

- Sterilization (autoclavation)
- Refrigeration (4°C or lower)
- Create alkalic (pH>11) or acidic (pH<3) conditions

These methods should at least be able to avoid microbial growth during 7 days.

In order to choose the most appropriate method (in terms of feasibility and implementation labor) some experiments were carried out. Sterilization was not taken into account since the needed equipment was not available.

4.1. Refrigeration

Since temperature has a big influence on the metabolic activity of the microbial population, maintaining the temperature of the concentrated influent below 4°C will bring microbial growth to a standstill. The effect of temperature on the reaction rate of a biological process is usually expressed as:

$$r_t = r_{20}\theta^{(T-20)}$$

Where: r_t = reaction rate at temperature T (°C) ($Kg \cdot m^{-3} \cdot s$)

r_{20} = reaction rate at 20°C ($Kg \cdot m^{-3} \cdot s$)

θ = temperature-activity coefficient

T = temperature (°C)

Typical values of the temperature-activity coefficient are shown in ***Table 4***.

Table 4 - *Typical value for temperature-activity coefficient*

		Θ value
Process	Range	Typical
Activated sludge	1.00 – 1.08	1.04
Aerated lagoons	1.04 – 1.10	1.08
Trickling filters	1.02 – 1.08	1.035

To test the efficiency of the cooling system used for this purpose (Lauda, VK 1400) some experiments were performed:

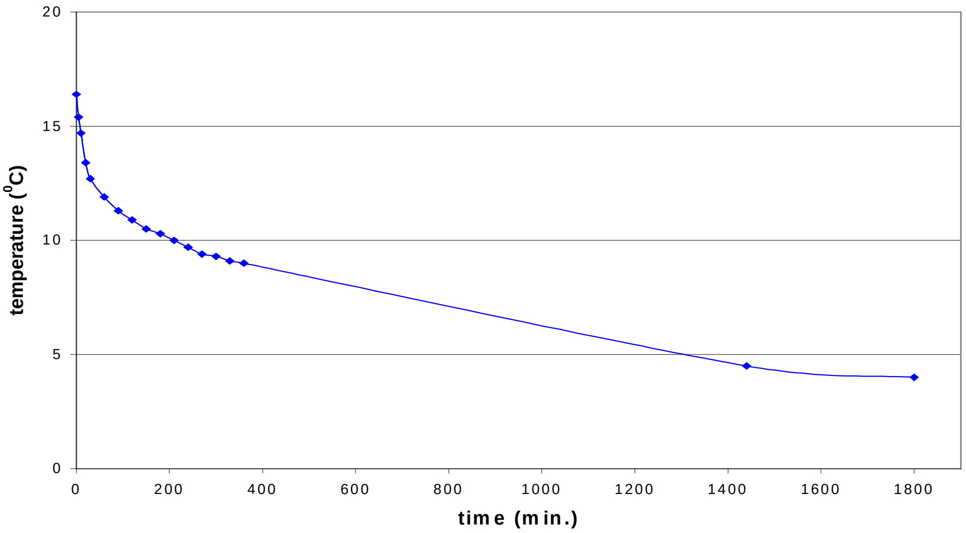
- Experiment 1: cooling of internal liquid to 4°C
- Experiment 2: cooling of 50 liters external water to 4°C
- Experiment 3: maintain pre-cooled water at 4°C

4.1.1. Experiment 1: cooling of internal liquid to 4°C

To check the time needed to cool the cooling liquid inside the cooling system to 4°C, 20 liters of softened water was added to the cooling system (max capacity is 23 liters) at a temperature of 17°C; the cooling system set point was set to 4°C. The temperature of the cooling liquid (internal water) was followed in time with the system bypass closed. The experiment was repeated with a solution

(3/1) of water and monoethyleneglycol (MEG). With such solution the set point of the cooling system can even be set at -15^{o}C.

The results are shown in ***Figure 2***:



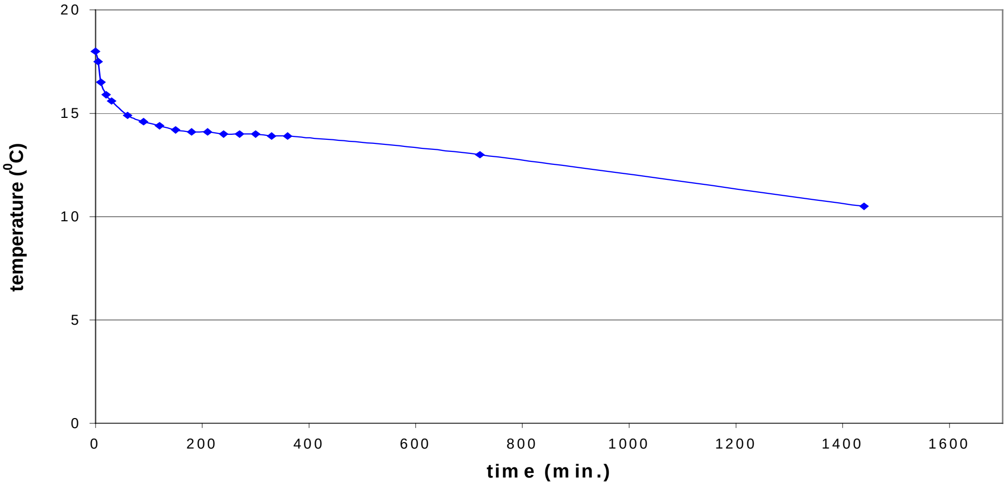


Figure 2 - *Cooling liquid temperature profiles for water (top) and monoethyleneglycol solution (bottom)*

In both cases the cooling system process takes a long time (> 1 day). The difference between the two graphs is due to the lab temperature during the experiments rather than the different liquids added to the cooling system. During the first experiment, in fact the lab temperature was 15.5°C, while during the second experiment it was 19.5°C.

It is therefore concluded that it is impossible to cool the cooling water to 4°C in a short time especially when the ambient (lab) temperature is higher. The experiments were conducted during winter time. In summer this would even be a bigger problem.

4.1.2. Experiment 2: cooling of 50 liters external water to 4^{0}C

Further experiments were carried out to check if the cooling system was able to cool 50 liters of water from 17.8°C to 4°C (initially the internal water was at 17°C). The water was stored in a vessel that was thermo-isolated with polystyrene. The lab temperature during this experiment was 19°C. The temperature was monitored in time. Results are shown in ***Figure 3***.

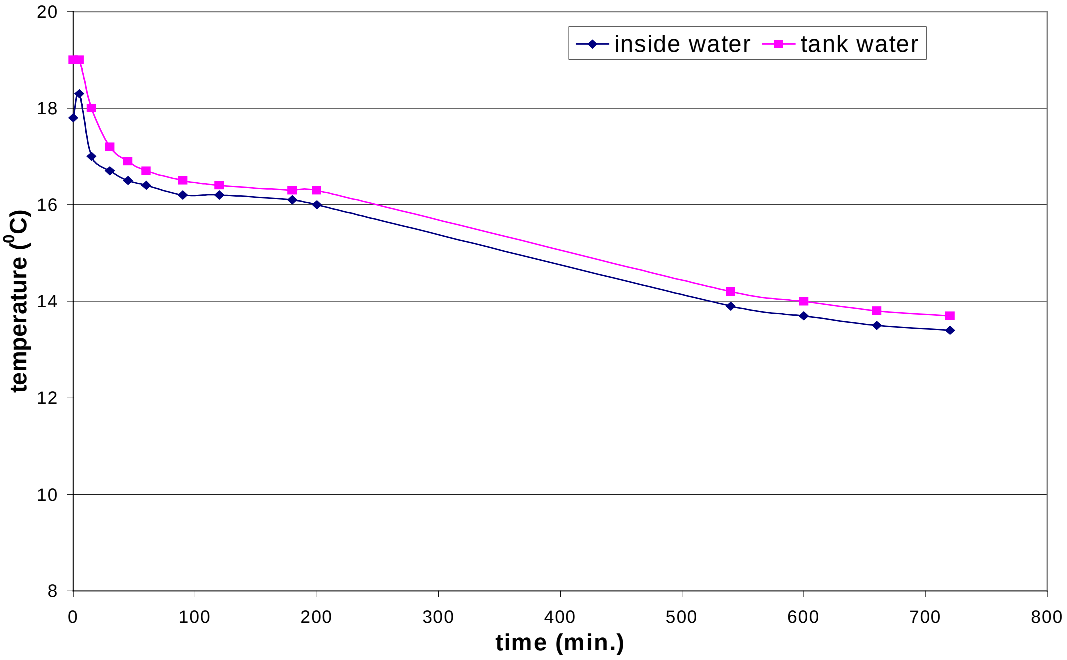


Figure 3 - *Cooling liquid and cooled water temperature profiles*

From ***Figure 3***, it can be concluded that the cooling system is unable to reach the set point of 4°C. The change of slope during night is present also in this graph and shows that the water temperature is much influenced by the lab temperature that drops at night.

4.1.3. Experiment 3: maintain pre-cooled water at 4^{0}C

Since it is difficult to get the internal water to 4°C, 50 liters of tap water was stored in a fridge for 24 hours. Then the water was added to the cooling system after which it was tried to maintain it at 4°C using the cooling system.

The temperature of the cooling water and of the water in the tank were monitored in time.

The results shown in ***Figure 4*** shows that with this setup it is possible to maintain a temperature between 4.5°C and 6.5°C according to the lab temperature. In this way the desired temperature was reached after 7 hours and maintained for 4 hours. An increase of the lab temperature caused a temperature increase from 4 to 6.5°C. Hence, the desired temperature could not be maintained. In summer this could become problematic.

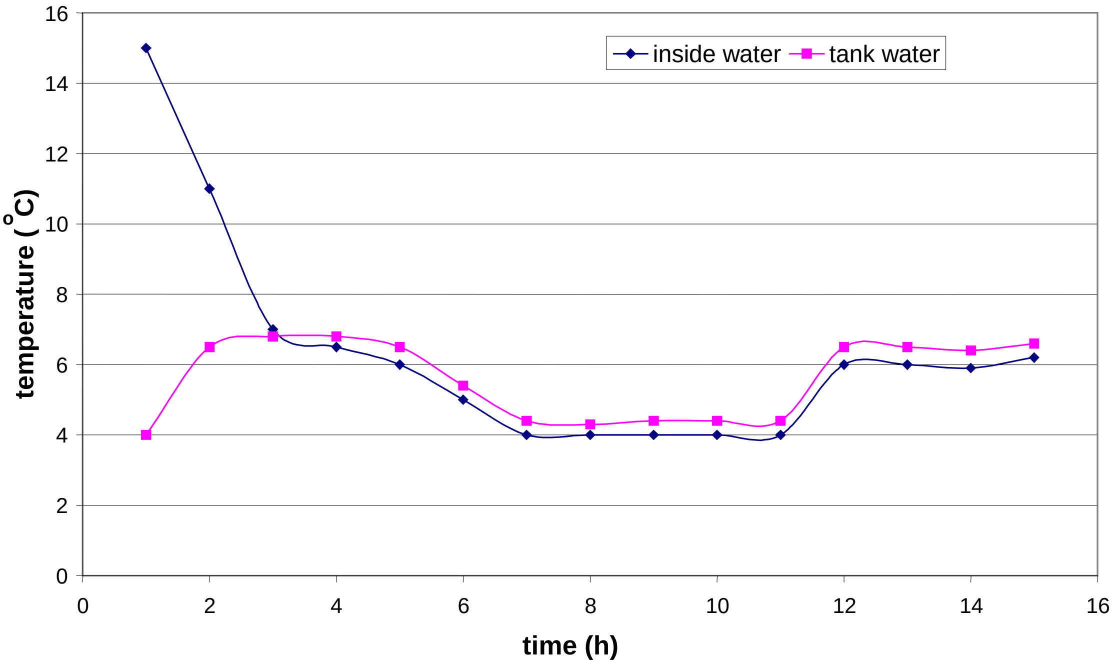


Figure 4 - *Temperature of the cooling liquid and of the outside water using pre-cooled water*

CONCLUSION:

According to these results, even if pre-cooled water is used, it is not possible to reach and maintain the concentrated synthetic wastewater at the temperature of 4°C, with the cooling system available, especially if the lab temperature is too high (e.g.. in summer).

4.2. Maintain influent pH at resp. 3 and 11

To avoid microbial growth an acidic or alkalic environment can be created in the influent tank. In this kind of situation the bacteria should not be able to grow. Moreover, adaptation should not occur within 7 days.

When doing this, the following needs to be considered:

- Does the pH-change affect the influent composition (e.g. precipitation, volatilization)?
- What is the quantity of acid/base that needs to be added?
- Does the diluted influent cause a pH shock when added to the SBR?

The first aspect can be evaluated visually. The latter 2 can be checked using titration curves of both the concentrated influent and the dilution water. The following experiments were carried out:

Experiment 1: Visual changes in the influent characteristics

Experiment 2: Titration curve of concentrated influent / feasibility of pH change

Experiment 3: Stability of influent in terms of pH, COD, soluble COD and TSS

Experiment 4: pH of diluted influent

Experiment 5: Stability of the influent stored at pH 11 in terms of total Nitrogen

4.2.1. Experiment 1: Visual changes in the influent characteristics

There are no evident changes in the influent characteristics: no precipitation is observed. A little change in the color of the influent stored at pH 11 is observed (from white to light brown).

4.2.2. Experiment 2: Titration curve of concentrated influent / feasibility of pH change

The titration curve of the concentrated influent (three samples of 150 ml each) is shown in ***Figure 5***.

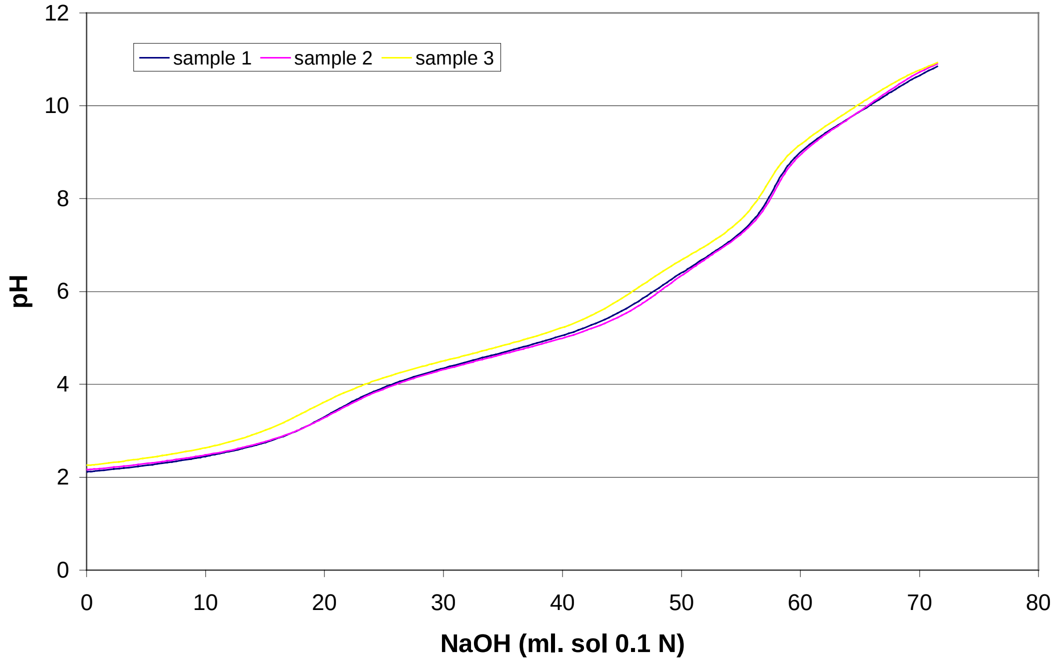


Figure 5 - *Titration curve of synthetic wastewater (three samples)*

The titration curve is obtained by adding small amounts of a strong base (0.1N NaOH) to a weak acid solution and measuring the pH after each addition. The curve has an “S-shape”, which suggests that the pH does not change at a constant rate with the addition of strong base. When a lot of acid is added without causing a pH-change, the solution is buffered. From ***Figure 5*** it is possible to differentiate 3 buffering zones (pH = 2,5; pH = 5; pH = 7).

From the titration curve it is possible to know how much acid or base is needed to reach pH 3 or 11. In fact, to move from pH 6.8 to 3, approx. 40 ml of a solution 0.1 N of HCl is needed, while approx

20 ml of a solution 0.1 N of NaOH is needed to bring 150 ml of concentrated wastewater to pH 11. That means 20 l and 10 l of HCl (0.1 N) and NaOH (0.1N) are needed for this purpose in 75 l.

In order to not influence the volume of the concentrated influent and hence the dilution, more concentrated acidic or basic solutions should be used.

CONCLUSION:

From this experiment it seems better to increase pH above 11, since less NaOH is needed compared to HCl (1/2).

4.2.3. Experiment 3: Stability of influent in terms of pH, COD, soluble COD and TSS

In this experiment three vessels were filled with 1 liter of concentrated synthetic wastewater and were continuously mixed using a magnetic stirrer. Acid (0.1 N HCl) and base (0.1 N NaOH) were added to the first and to the second vessel until pH 3 and 11 respectively were reached. A third vessel was left at normal pH (pH = 6.8). A schematic overview of the setup is presented in Figure 6.

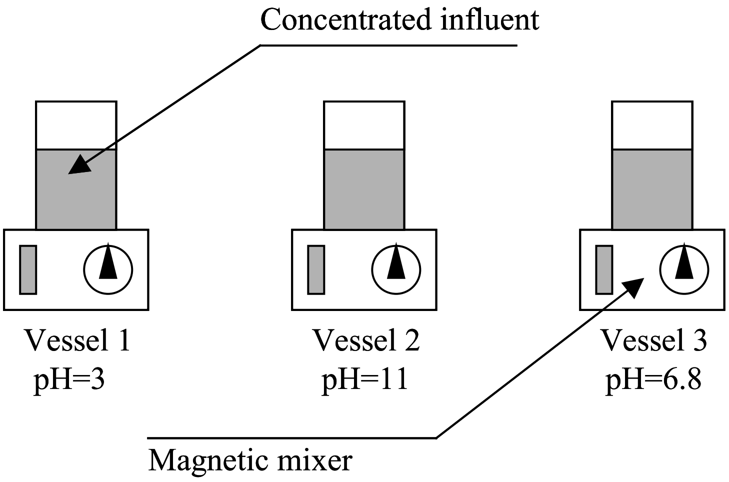


Figure 6 - *Schematic overview of the influent pre-screening setup*

The values of pH, COD, soluble COD and TSS were followed in time (one week) in order to check for the presence of bacterial activity and, if present, to what extent this affects the stability of their characteristics. Each day a sample of 140 ml was taken from each vessel by means of a pump (Watson Marlow 505U, Q=667 ml.min^{-1}) and analyzed.

The results of this measuring campaign with regard to pH, COD, soluble COD and TSS are shown in Figure 7, Figure 8 and Figure 9. Soluble COD was measured after filtering (Schleicher&Schuell 597 folded filters). COD and soluble COD were measured using a spectrophotometric method (Dr. Lange).

The pH profiles show that while the concentrated influent kept at pH 3 and the one at normal pH maintained a quite stable pH (a small increase after day 4), it is impossible to keep pH constant for the influent at pH 11 for which NaOH had to be added daily. This is due to the carbonate system equilibrium.

The explanation of this behavior lies in the slow (relatively to other deprotonation reactions) rate of hydration of aqueous CO_2. The hydratation of $CO_{2(aq)}$ leads to H_2CO_3:

$$CO_{2(aq)} + H_2O \leftrightarrow H_2CO_3$$

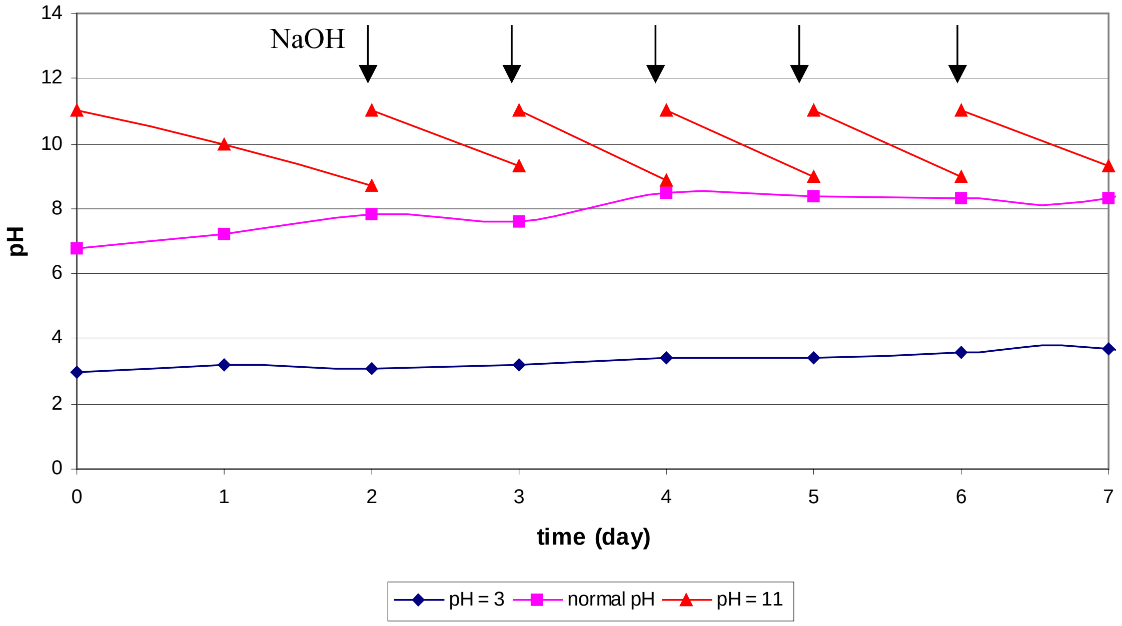


Figure 7 - *pH profiles*

The formation of H_2CO_3 will disturb the carbonate equilibrium. The individual rate constants cannot be experimentally resolved and are reported simply as k_{CO2} and k_{H2CO3} corresponding to the simplified scheme:

$$CO_{2(aq)} + H_2O \leftrightarrow H_2CO_3 \overset{\text{Very fast}}{\leftrightarrow} H^+ + HCO_3^-$$

From this scheme it can be concluded that protons will be produced when CO_2 dissolves, leading to a decreasing pH. The vessel at pH=3 seems to be the most stable throughout a week.

The COD of the three liquids remained quite constant in time with a small decrease for the soluble COD. The quite large variations of the COD values are due to measurement inaccuracies. In fact, the presence of suspended solids in the influent, can influence the Dr. Lange measurements that only use small sample sizes. The soluble COD presents a more constant value (there are no big particles) and the small decrease (especially for the normal pH influent) of the COD shows that while there is only a small biological activity at high or low pH, the biological activity for the raw influent is high (the final soluble COD is only half of the initial soluble COD). The influent at pH 3 has the most constant soluble COD value.

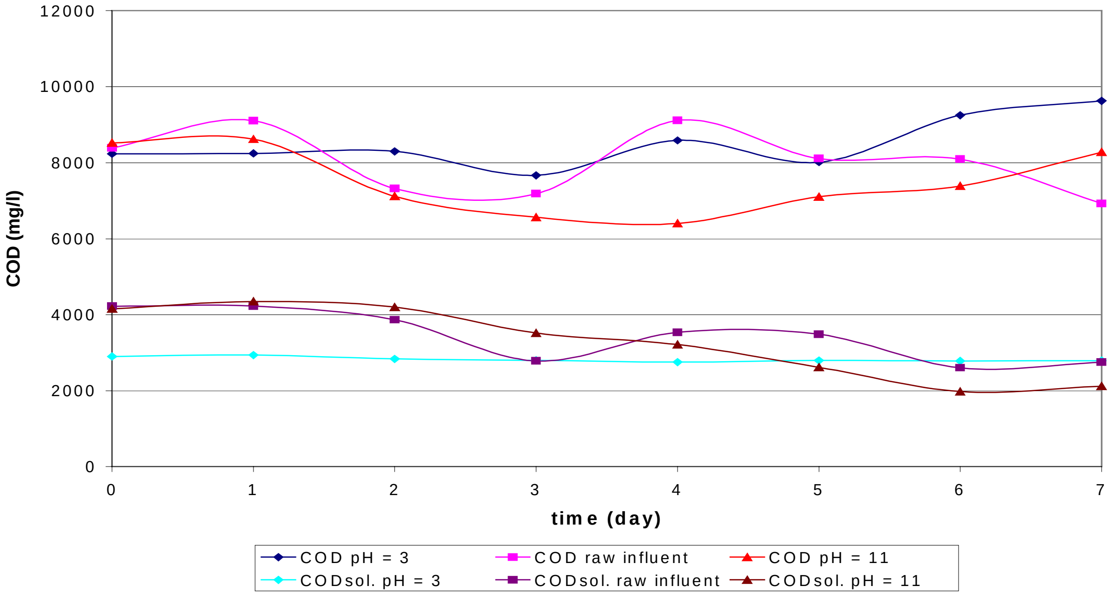


Figure 8 - *COD and soluble COD profiles*

The total suspended solids for the three liquids present a quite constant value over the first 4 days (***Figure 9***). Then the TSS for the liquid at pH 3 increases, while it slightly decreases for the other two liquids. The increase of the TSS at the end of the experiment is probably due to the accumulation of big particles that are not sucked out from the vessel by the pump. They accumulate in the vessel and their concentration increases. However, their amount is negligible.

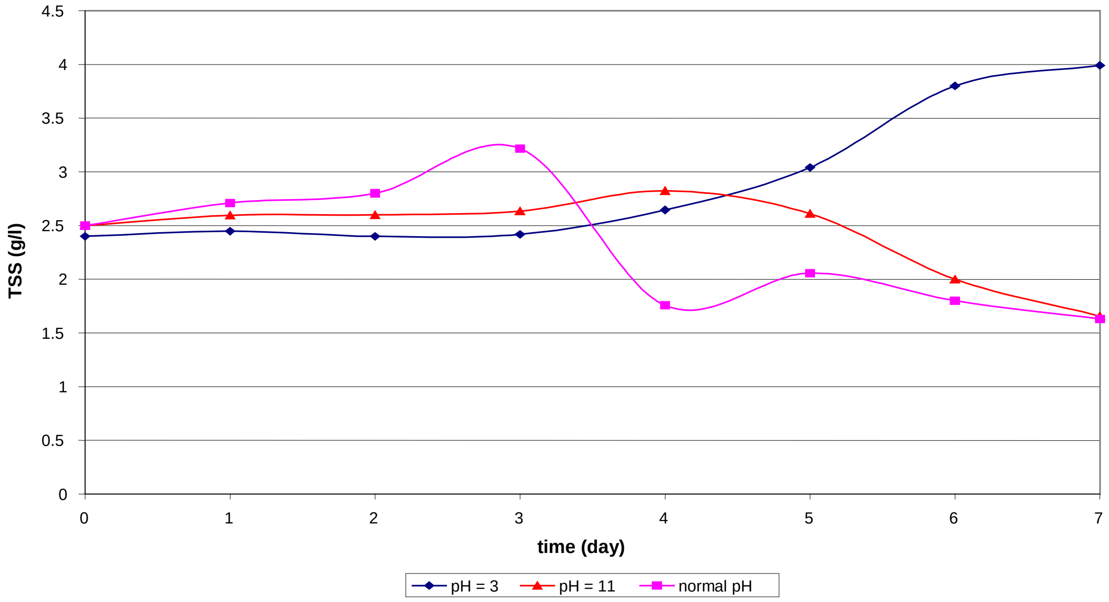
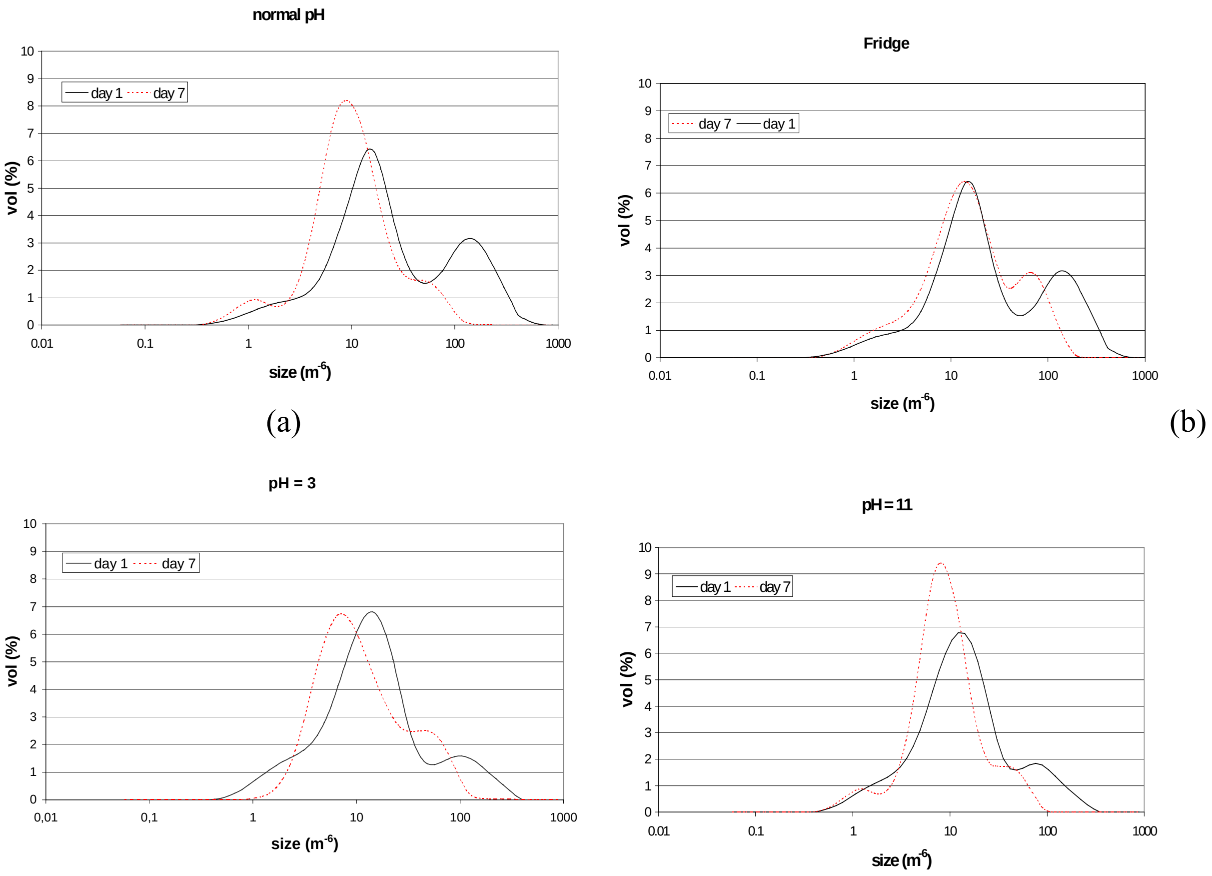


Figure 9 - *TSS profiles*

In order to evaluate flocculation effects taking place during the experiments, the particle size distribution of the samples was analyzed with the Malvern Mastersizer on the first and the last day. Results are shown in Figure 10.

In all vessels the particle size distribution shifts to the left showing a slight size decrease of the majority of the particles. The peak of the distribution changes from around 10 µm to 8 µm. The big particles peak present around 100 µm (especially in the tank kept at normal pH), also shifts to smaller diameters at day 7th. This is probably due to the solubilization of the particles in time. As a result it is possible to conclude that the increase of the TSS concentration for vessel one (pH=3) is not due to flocculation that occurred in the vessels (the particles size becomes smaller), but as discussed before, to particles accumulating in the vessel. Probably more intensive mixing could minimize this problem.



(a) (b)

(c) (d)

Figure 10 - *Particle size distribution at day 1 and 7 for the influent kept at normal pH (a), in the fridge at 4°C (b), at pH = 3 (c) and at pH = 11 (d).*

CONCLUSION:

On the basis of the results of this experiment it was opted to work at pH=3, especially because the daily addition of base could be eliminated.

4.2.4. Experiment 4: pH of diluted influent

To check the buffer capacity of the SBR influent (after dilution with tap water) and its pH, some further experiments were performed. 50 ml of concentrated influent was put in a vessel (pH = 6.8). The pH was set to 3 using 0.1 N HCl-solution (13.2 ml). The pH-evolution is shown in ***Figure 11***. 12.32 ml of the acidic influent was then mixed with 200 ml of tap water (this was the dilution of the influent that was finally used to feed the SBR). The pH of the diluted influent was 6.72 due to the alkalinity of the tap water. The latter was then titrated with HCl (0.1 N). The pH-evolution is shown in ***Figure 12***.

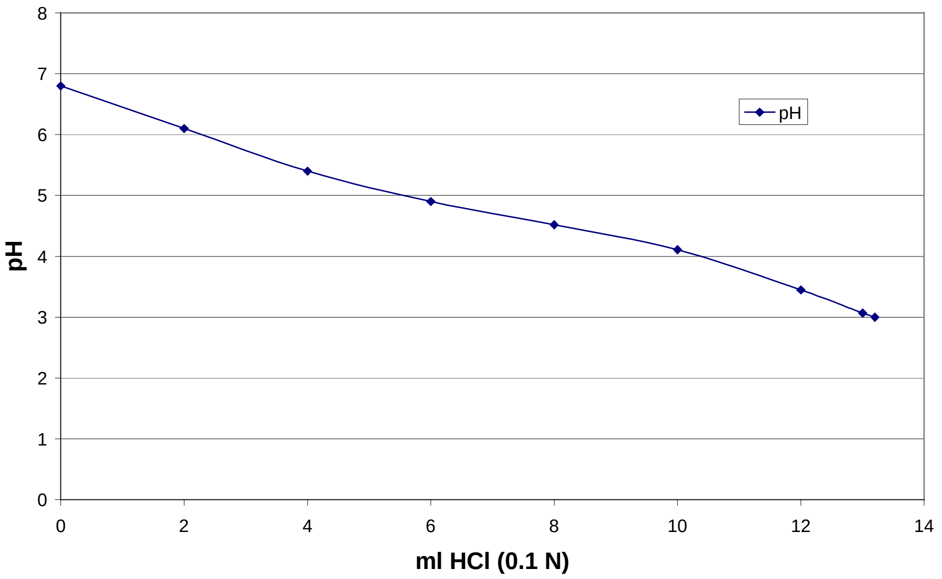


Figure 11 - *pH profile of the concentrated wastewater when a solution of HCl (0.1 N) is added to a 50 ml sample*

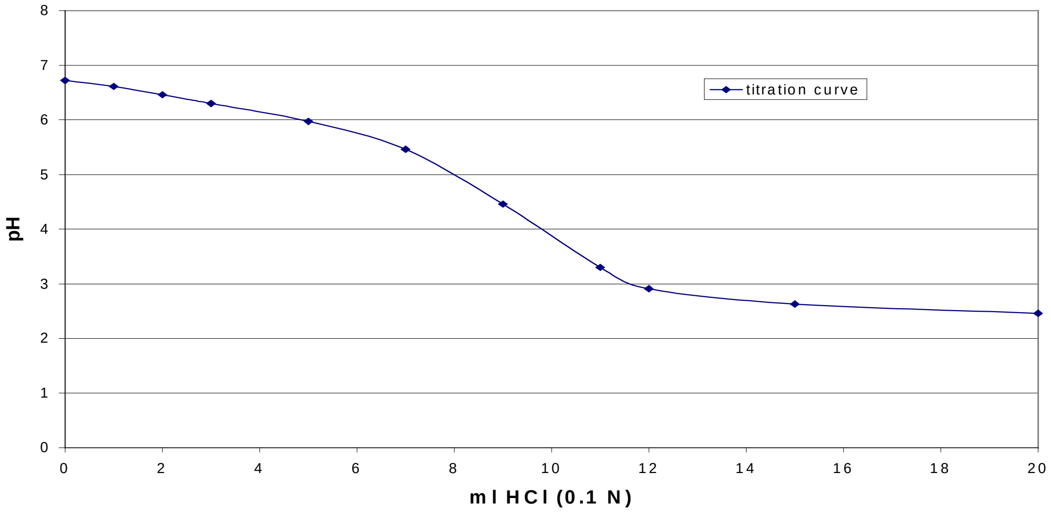


Figure 12 - *Titration curve of 50 ml of diluted influent*

Since the influent pH is 6.72 after the dilution, it is possible to use it as influent of the SBR without danger for a pH shock to the sludge. As ***Figure 12*** shows some buffer capacity of the influent is left between pH 6-7, probably due to the bicarbonate system of the tap water.

4.2.5. Experiment 5: Stability of the influent stored at pH 11 in terms of Total Nitrogen

A vessel was filled with 1 liter of diluted influent and was continuously mixed using a magnetic stirrer. Base (NaOH solution 0.1 N) was added to the vessel until pH 11 was reached. The values of Total Nitrogen were followed in time (2 days). The results are shown in ***Table 5***.

Table 5 - *Influent screening results (total Nitrogen)*

	After preparation	After 1 day	After 2 days
Total Nitrogen (mg/l)	62.3	51.0	39.5

After only two days the total Nitrogen concentration decreased from the initial value of 62.3 mg/l to the final value of 39.5 mg/l. According to the following equilibrium (Tchobanoglous and Burton, 1991)

$$NH_4^+ + OH^- \leftrightarrow NH_3 + H_2O$$

the gaseous form of nitrogen is present in large quantities if the pH of the influent is high as, then, this equilibrium is moved to the right. In that way a significant amount of nitrogen may be lost from the influent and, hence, its characteristics will change.

CONCLUSION:

According to the results presented in this paragraph the method chosen to keep the concentrated influent characteristics as constant as possible was to store it at pH = 3. The method to keep the influent at high pH is not applicable mainly for the following reasons:

It is difficult to maintain the pH at high value, i.e. every day NaOH has to be added to the vessel.

It is impossible to maintain the composition of the influent stable (loss of nitrogen from the influent).

4.3. Conclusion

Because the first method (cooling system) is not applicable due to the inefficiency of the cooling system (albeit a quite powerful one) and the method to keep the influent at high pH is problematic due to the difficulty to maintain high pH and to achieve constant characteristics of the influent (nitrogen loss), the best method to keep the influent characteristics as constant as possible seems to be to store the concentrated influent at pH=3.

In order to better check if that method is applicable, further experiments were carried out (influent screening), as reported in the next section.

5. Acidic concentrated influent “screening” results

Seventy liters of concentrated synthetic influent were prepared in order to monitor its stability in time (one week). The influent vessel was filled with the liquid and it was continuously stirred by means of a mixer (IKA labortechnik, RW 28W, Germany). 170 ml of concentrated HCl (37%) were added to the vessel in order to set the pH to 3.

The pH, COD, soluble COD, total N, ammonia, phosphorus and TSS were followed in time (one week) in order to point out the presence of microbial activity in the vessel and the stability of the influent composition. Each day a sample was taken from the vessel by means of the SBR setup influent system (pump: Watson Marlow, 505U) and analyzed.

The influent pump and the influent valve were controlled by a PC with DAQ card (AT-MIO-16XE-50; National Instruments) using LabView (NI). The pump speed was set at 65 rpm (667 ml/min). The concentrated wastewater was diluted by means of a two-way pinch influent valve (Sirai S307 02), which alternated between concentrated influent and tap water (cycle: 10.7 / 169.3 seconds) to achieve the correct dilution. Each sample (approx. 3.7 liters) was taken over two cycles. After each sampling approx. 9.4 liters of concentrated feed were wasted in order to simulate the real consumption of feed in the SBR setup during one day. At the same time (as in the actual SBR operation that was planned) the mixing speed was gradually decreased in order to have the same mixing energy per volume (from 800 rpm the first day to 240 rpm the last day).

The concentrated influent pH values, measured directly in the vessel for 1 week, are shown in ***Figure 13***.

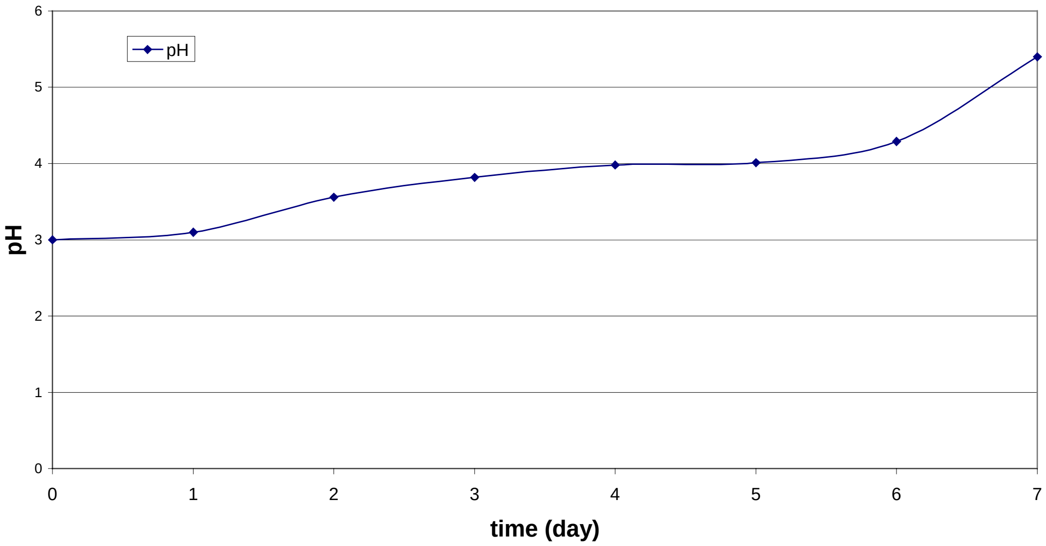


Figure 13 - *pH profile in acidic concentrated influent*

The pH profile shows a quite large increase, especially after day 5. This increase of pH was not found at all or it was smaller during the monitoring of the influent in later experiments done with the operational SBR. It was decided to use somewhat smaller pH values (pH = 2.8). This resulted in a stable pH during one week.

Three samples of 100 ml were taken from the 3.7 l sample and analyzed with Dr. Lange kits. The COD, soluble COD, total-N, ammonia and PO_4-P during 7 days are shown in ***Figure 14*** and ***Figure 15***. The TSS data are given in ***Figure 16***. The data are summarized in ***Table 6***.

Table 6 - *Influent screening results (7 days)*

Day	COD (mg/l)	CODsol (mg/l)	%	Ntot (mg/l)	NH_4-N (mg/l)	1.1.1.1. PO_4-P (mg/l)	TSS (mg/l)
0	431.5	224.3	52%	52.7	6.9	11.2	170
1	471.1	226.0	48%	66.7	6.3	10.8	160
2	407.7	202.4	50%	60.0	6.7	9.6	170
3	378.2	210.8	56%	56.2	6.1	9.9	150
4	460.8	251.6	55%	63.1	5.8	11.1	170
5	431.2	232.5	54%	68.3	6.8	10.7	200
6	468.3	226.4	48%	68.4	6.1	9.2	210
7	446.7	220.3	49%	63.2	5.9	9.8	190
Average	436.9 ±32	224.3 ±14.6	51%	62.3 ±5.7	6.3 ±0.42	10.3 ±0.75	180 ±20
Th. values	439.47	-	-	60.23	-	9.42	-

The COD:N:P ratio during the measurement campaign are presented in ***Table 7***.

Table 7 - *Influent COD:N:P ratio*

Day	COD	Ntot	PO_4-P
0	100	12.2	2.6
1	100	14.2	2.3
2	100	14.7	2.4
3	100	14.9	2.6
4	100	13.7	2.4
5	100	15.8	2.5
6	100	14.6	2.0
7	100	14.1	2.2
Average	100	14.3	2.4
Th. values	100	13.7	2.1

The COD of the diluted influent fluctuated between 378.2 (3rd day) and 471.1 mg/l (1st day) with an average of 436.9 ±32 mg/l. This value lies very close to the theoretical synthetic influent COD concentration (439.47 mg/l). The profile shows that there was no visible organic matter consumption during the week: no trend appears in the profile. The COD fluctuation is due to measurement errors caused by bigger particles present in the synthetic wastewater. The soluble

COD, the measurement of which is not affected by particles, presents, in fact, a more stable profile. The values fluctuated between 202.4 (2nd day) and 251.6 mg/l (4th day). The average for the 7 days is 224.3 ±14.6 mg/l, that means that 51% of the influent COD is soluble.

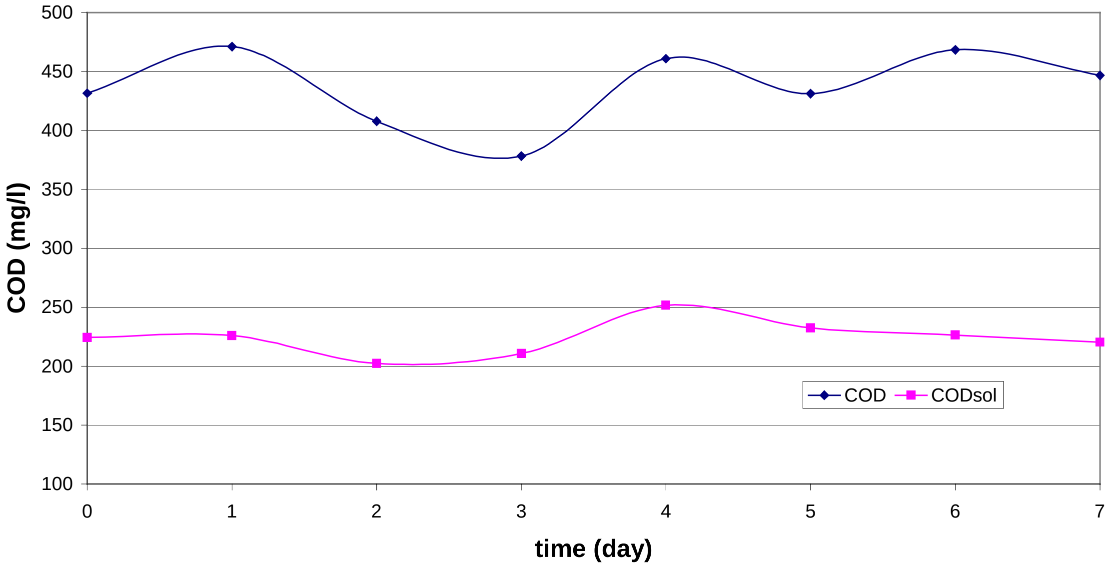


Figure 14 - *COD and soluble COD profiles in diluted influent*

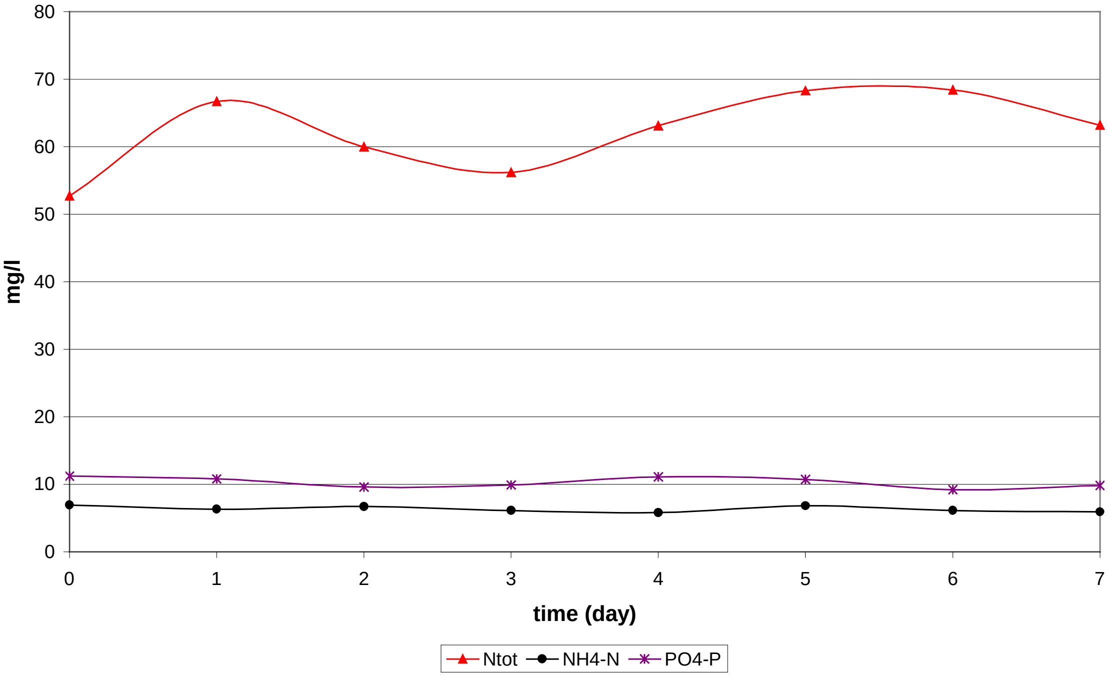


Figure 15 – *Tot-N, NH_4-N and PO_4-P profiles in diluted influent*

The average concentrations of total nitrogen and of ammonia nitrogen are respectively 62.3 and 6.3 mg N/l, with quite stable profiles. The total nitrogen concentration is quite close to the theoretical value (60.23 mg N/l). The influent concentration of ammonia nitrogen is quite low (10%). In general 35% of the total nitrogen is present in the form of ammonium (Tchobanoglous and Burton, 1991). This means that the organic nitrogen present in the synthetic wastewater represents the largest fraction of the total nitrogen and it is not hydrolyzed into ammonia in the influent tank.

The PO_4-P profile presents a quite stable trend, with an insignificant decrease. The average concentration is 10.3 mg P/l, which is a little larger than the theoretical value (9.42 mg P/l)

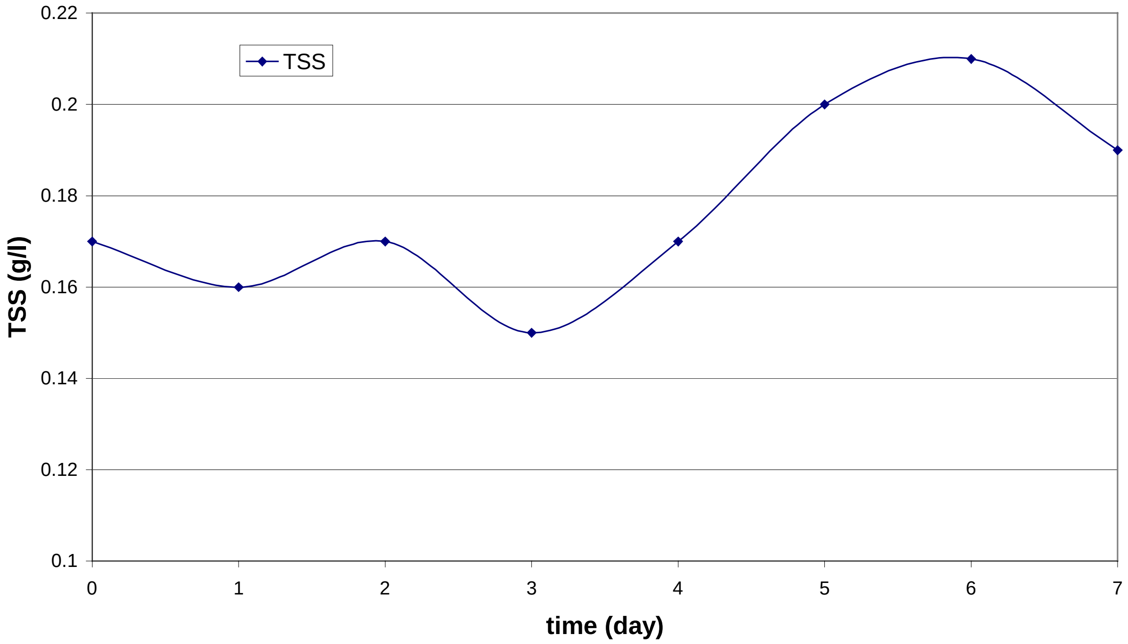


Figure 16 - *TSS profile*

The diluted wastewater TSS concentration presents a slight increase after day 4. As discussed in the influent prescreening, while the particles size distribution shows that there is no flocculation in the wastewater, the increase of the TSS is probably due to big particles that cannot be sucked from the vessel by the pump. They accumulate in the vessel and their concentration increases.

CONCLUSION

From the results shown in the previous paragraphs it can be concluded that the method chosen to store the concentrated influent is good enough to avoid bacterial activity in the tank and to preserve the influent composition. The measured parameters remain stable and are close to the theoretical values.

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