EXAMINATION POSSIBILITIES OF WASTE WATER PURIFICATION ORIGINATE FROM ANIMAL WASTE PROCESS

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During my work I analyzed a wastewater purification plant, which clears mostly industrial wastewater. The experimental reactor I planed and created was similar to the purification plant regarding basic parameters and the wastewater I would clean regularly came from the purification plant. My purpose was to develop a purification process, achieving minimal pollution components in the wastewater.

Keywords: wastewater, sequencing batch reactor, active sludge, COD, nitrogen

Introduction

After joining the EU regulations on most economic areas have been tightened up. One of their most important purposes is to raise level of environmental protection as well as to improve human standard of living. In accordance with these regulations strict quality assurance and environmental protection rules have been introduced; their negligence or default in production and service branches are punished with serious fines or even closure by the authorities.

It certainly refers to the companies which deal with collecting and processing animal waste.

There are also tight regulations both for finished products quality and for treating waste coming from processing, and their making harmless, too.

In Hungary most people make a grimace when those cargos are mentioned which carry animal carcass. They are considered stinky and slow going vehicles and if you meet them you should take over or follow them far. Now give it a second thought. These vehicles serve to protect inhabitants and environment. Without them animal waste could not be placed and processed safely since carcass pits do not give proper and safe solution to the problem. Drivers of these vehicles are liable to the smell, moreover they have to pass special driving exams, and their duty is to collect and transport animal waste to a processing plant. During process of animal waste other harmful waste arise which needs special treatment.

In my study I am examining the waste water purification in laboratory, which originates from a Hungarian animal waste salvage unit. This waste water contains high amount of organic substance and nitrogen; their disposal is substantial for the recipients' interest. I examined the removal of these components at different temperatures in order to find the optimal condition which gives the best result in purification.

Experimental reactors

The system is built up of four, separated reactors (number 1, 2, 3, 4). Their construction is the same, the only one difference is the temperature inside the reactors.

These reactors are all SBR systems, so they function fractionally. Extraction of organic substances, nitrification and denitrification as well as remove of biological phosphorus is in progress in one space (but certainly not at the same time).

Intake waste water is in the vessel among the reactors, in which sample material is continuously stirred in order to keep it homogenous. Purification process in the reactors is controlled by a central unit, which changes intake, anoxic and oxic circumstances, decantation and pumping at preset times.

Figure 1: Purification reactors

The complete process does not only consist of one intake, stirring, airing, decantation and pumping. Each case after waste water intake there is a 30 minutes

stirring followed by 10 minutes airing. These three steps are repeated 3 times, followed by approximately 60 minutes decantation. It means that a complete purification process takes 8 hours including intake and pumping purified water. The suitable stirring and airing is provided by magnetic stirrers and air diffusers placed at the bottom of the reactors.

Waste water intake and purified water pumping is done by the pumps, their operation is also controlled by a central unit. Altogether there are 14 pumps, 4 of them are responsible for intake and pumping, also 1 pump by reactor feeds alkali. The other two pumps belong to reactors 2 and 3. At the beginning their task was to add needed amount of acid to keep optimal pH level. Later we took them out of the system.

Collecting purified water we have conical flasks with a cork.

Every reactor has its own pH level and temperature controlling system. Temperature is set 20 °C, 25 °C, 30 °C, 35 °C. In case of the first reactor we need cooling, as the laboratory temperature is higher than the set one in the reactor. In case of the other three reactors we need heating to reach the wanted temperature.

There are two controllers for the other 4 reactors. Each reactor has its own pH sensor, which sends signs to the controllers. According to the signs the pumps, taking the right amount of acid or alkali, is operated.

Remove organic substances from wastewater

It is essential to remove organic substances from waste water, otherwise they would cause lack of oxygen at the recepients' side and it could kill living organism.

Remove organic substances is shown in *Fig. 2*.

There were problems with the purification efficiency in reactor 1 due to technical faults, in most cases exchange of sludge was needed. The problem was caused by the starter inoculation sludge originated from Mátyás-domb wastewater purification plant, where the operational conditions are a bit different, so the sludge needed to adapt. After a while COD measure decreased because we repeated sludge exchange in the reactor. We decided on this action because the amount of organic substances did not decrease after a month of regular operation (30th, September). That is why I did not evaluate the performance in reactor 1 and it is not shown in Fig. 2. New sludge arrived, again from the above mentioned Mátyás-domb, some weeks later I still did not notice decrease in purification efficiency. It suggests that only the period after sludge exchange is interesting for us. After this action data give clear picture about the 20 °C reactor real purifying performance. The graphs show that after restore the reactor COD in let off water never went over 100 mg/l.
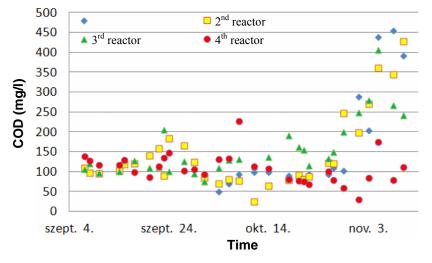

Figure 2: Chemical oxygen demand (COD) changes in pumped purified water

In contrast with reactor 1 the other three reactors operated properly both before and after the exchange. It can be seen that COD rate in purified water varies within a narrow range, there is no extreme case. The most stable and the least changing results are from reactors 3 and 4, while reactor 2 shows bigger fluctuation.

Only on the ground of measured rate it cannot be identified whether 20°C, 25°C, 30°C, 35°C gives higher level of organic substance remove as COD rates are rather close to each other.

Comparing the results we cannot find big differences in the efficiency of the reactors' organic substance remove performance depending on operational temperature.

On the base of my experiences I cannot make ranking since there were cases when one of the reactors purified better. However I have to note that it is possible to purify water under limit rate at any temperature, positive load and proper sludge.

On the score of bibliography we expected the highest performance from reactor 4 whereas the lowest one from reactor 1.

But at such low level load we had different result. Supposedly ~100mg/l COD amount is hard to split biologically, so it cannot be removed from waste water even longer period of time.

Changes of nitrogen forms concentrations

Waste water arriving at purification plant contains high amount of ammonium ions and organic nitrogen forms.

Fig. 3 shows measured ammonium concentration in purified water.

It can be seen that the most stable results are shown in reactors 3 and 4. It is interesting to observe that reactors operating at 20 °C and 25 °C temperature higher increase in let off ammonium concentration. Since all the circumstances, such intake water quality and quantity was the same, differences must be due to different temperatures. The higher the temperature is, the more intensive the functioning of the nitrificating microorganism

is. It makes their reproductive ability faster and their amount is more significant.

Their regular time of hydraulic stay in the system is 12.3 days (due to little intake water), that is why any changes in the system's operation or let off water quality develops later (2-3 days). Supposedly nitrification in reactor 1 capsiced due to increased load (rough waste water content changed) as ammonium concentration was 120 mg/l till then, after that it became more than double. Autotrophic volume in the reactor could not oxydate the whole amount of ammonium during time of stay. Because of this nitrification stopped after a while, let off water ammonium concentration level was almost the same as intake rough waste water's nitrate concentration content in purified water went down to zero as well.
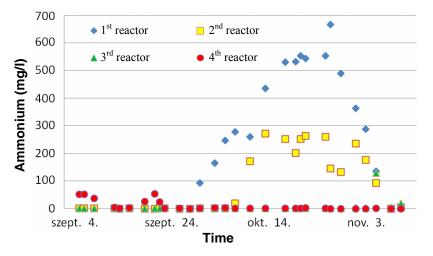

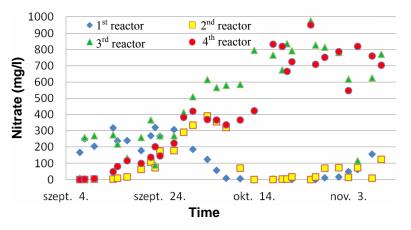*Figure 3:* Changes of ammonium concentration level in let off water

Figure 4: Changes of ammonium concentration level in let off water

Later I experienced the same situation in reactor 2 as well. Only the fall in performance happened later. Supposedly the cause is that the higher temperature may be more favourable for autotrophic, so proper rate nitrification went on and ammonium oxygenation stopped only after a while following ammonium load. Purifying goes on easier if more microorganisms meets the same amount of nutrients during the same purifying time. In an optimal case when part of nitrogen is taken out from waste water, nitrogen gas develops while the rest is concentrated in the sludge, because nitrogen has an essential role in building of cells. During nitrification

ammonium becomes nitrite, then nitrate; during denitrification nitrate develops into nitrogen gas. That explains why it is important to take nitrite and nitrate concentration in purified samples into consideration to evaluate rightly ammonium transformation.

Improper denitrification might have two causes. One of them is the too short time for anoxic process, the other is the lack of easily splitting nutrients.

As it was mentioned above, the optimal COD/TN rate is 10, here it is only 4-5. Besides long time of stay helps remove biologically splitting organic substances under oxic circumstances. Since organic components rate

is low comparing to nitrogen compounds and most of easily splitting organic substances are transformed during airing, denitrification would not happen because of missing nutrients. More load of rough waste water does not help either, since all happens during anoxic phase, in oxygen-free circumstances.

Except for reactor 3 let off nitrogen concentration from other reactors show the tendency which we could conclude from the amount of ammonium. That is, if ammonium concentration level decreases in purified water, the nitrate content grows. Reactor 3 showed the most stable nitrification. During the experiment this reactor let off purified water contained minimum amount of ammonium in each case, while its nitrate content moves within wide ranges. Its reason could be the different content COD and N of intake waste water.

In practice measuring nitrite concentration is given little interest. Although nitrite in purified water also gives important information.

Considering nitrite reactor 1 showed high rates. If we compare it with nitrogen results it can be seen that nitrification was limited at the beginning of examined period (from 7th to 30th, September), while ammonium was high. Nitrification was partial because let off water contained 200–300 mg NO_3^-–N. According to bibliography high nitrite concentration hinders nitrification so it could have happened so. If we examine let off water organic substance content we can see that filtered COD level was also high so we may suppose that high nitrite concentration strikes on the functioning of heterotrophic organic oxidants.

In the other reactors the nitrite concentration was not so high usually under 10-100mg/l. Further examination showed that nitrite concentration and COD are related in case nitrite concentration is over 50 mg/l. Certainly differences were not very big, they showed only some 10 mg/l COD increase. However, we measured filtered samples, that is why we cannot have false measure due to floating substances. Furthermore all 3 high nitrite concentration paralleled with high let off COD than before it suggests positive conclusion. It should be examined during further experiments.

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