Considerations for Optimization of Biological Treatment Process for Small Wastewater Treatment Plant

CRISTIAN STANILOIU*, CONSTANTIN FLORESCU
[1] Politehnica University of Timisoara, 2 Victoriei Sq., 300223, Timisoara, Romania

Wastewater treatment is particularly important to maintain a clean and healthy living environment. Through wastewater understood in this context, the dirty water from household activities, industry, public institutions or to other uses, i.e. waters whose characteristics have been changed after using. Stormwater too, under certain conditions, will not be considered conventional clean water and will be subject to treatment prior to its infiltration into the ground or discharge a receiving water. Protecting existing water resources requires quality and quantity controlling of discharges both high flow and low flow rates. Small wastewater flows, seemingly insignificant, produce little local pollution, which must be removed before they can grow. If big cities already have modern sewage treatment plants with a treatment technology well developed, small consumers raises specific issues. Therefore it is not possible direct application of treatment technologies by simply sizing for smaller capacities. In this paper the authors present some aspects of wastewater treatment from small households or from other consumers, which in terms of discharge water quality can be compared with those.

Keywords: wastewater treatment, small wastewater treatment plants, biological wastewater treatment process

The problem of small customers who do not have a centralized system for the collection, transport, treatment and discharge of wastewater is topical in our country, trying to implement rapid solutions but also technically and economically efficient. It was followed by the creation and development of rural infrastructure appropriate current standards of comfort and hygiene.

In the study was analyzed the possibility of optimizing the biological treatment process at a small wastewater treatment plant by adjusting the period of the aeration sequences of the activation basin. The experiments were performed on a pilot reactor, which is actually an industrial small wastewater treatment plant, approved in our country.

Specific requirements for wastewater treatment plants of small capacity

Classification of wastewater treatment plants based on the capacity

Classification of wastewater treatment plants, depending on their capacity, results from technological and structural differences but also from the specific operating conditions. Thus, a general classification of wastewater treatment plants based on wastewater flow is, [5]:

- Very small wastewater treatment plants
  $Q_{d.max} \leq 5 l/s$;
- Small wastewater treatment plants
  $5 l/s \leq Q_{d.max} \leq 50 l/s$;
- Medium wastewater treatment plants
  $50 l/s \leq Q_{d.max} \leq 250 l/s$;
- Large wastewater treatment plants
  $Q_{d.max} \geq 250 l/s$.

This classification is, however, difficult to use in the current continuous decrease of water demand due to its rational use and metering.

So, it must be proposed such a classification of wastewater treatment plants that takes into account the technological and constructive differences given by the treated wastewater flow, but also by the number of the equivalent users.

A general classification of wastewater treatment plants, depending on the number of the equivalent users, according to ATV and ONORM is [6, 7]:

- Very small wastewater treatment plants 5-50 PT;
- Small wastewater treatment plants 50-500 PT;
- Medium wastewater treatment plants 500-5000 PT;
- Large wastewater treatment plants 5000-50000 PT;
- Very large wastewater treatment plants >50000 PT.

Specific problems and requirements of low capacity wastewater treatment plants

Specific problems of low capacity wastewater treatment plants

Household wastewater treatment from the small communities or isolated households raises specific problems both in design and in implementation and operation. So can be mentioned the following particular aspects, [2-4, 6].

- the low value of the circulated flows (for sizing and cheking), flows for which the self cleaning speed on the pipelines is not usually reached;
- hourly flow variation, $q_{h.max}/q_{h.min}$, is very high;
- plants are intermittently in operation, (at night or even in some hours of the day inflow may be zero);
- application of monoblock solutions, classical solutions are too expensive;
- operation without continuous supervision by individual, qualified personnel performing periodic inspection and maintenance of the stations;
- providing water of small capacity or even nonexistent;
- providing water of high quality, for example the case of stations located near the mountain tourist resorts;

* email: c_staniloiu@web.de

- providing the financing of the works design, construction and maintenance these works often being not payed from the country budget funds.

Specific requirements of low capacity wastewater treatment plants

Requirements for the efficiency of wastewater treatment plants of low capacity is also in accordance with their goal, [1-4, 6];

- investment and operating costs to be minimal;
- availability of machines, equipment and installations robust, reliable and simple to operate;
- a complex automation of systems for remote data transmission;
- low energy consumption and a reliable system of power supply (for greater security can be provided a backup generator set);
- materials used in construction to be durable and anticorrosive;
- to be able to take the eventual knocks of flow;
- to be compact and occupy an area as small as possible;
- if it is required a physico-chemical step, to be developed in such a way that the consumption of chemical reagents to be minimal;
- be so located for the community users as not to create deficiencies by producing odor, noise or vibration, generally not a source of pollution to water, air and soil;
- to avoid shocks flow and pollutant load by providing the resources necessary for continuous operation of the biological treatment step, steady flow as much as possible, (equalization tank).

Optimization of biological wastewater treatment process

Description of the experimental facility

Small wastewater treatment plant is an industrial plant with constant flow, consisting of a tank divided into four compartments. In these compartments the following mechanical and biochemical processes of treatment, occur [4].

Compartment 1, acts as a catchment, of primary sedimentation tank and pumping station, Br, Dp, Sp, taking wastewater inflow. Through a distribution and pump system accumulated water is transferred at a constant rate to the second section. Excess flow is recirculated, thus ensuring proper mixing of the accumulated water. In the compartment is submerged a submersible pump, protected by a grill to retain rough and coarse material.

It is very important to achieve in this compartment a proper mixing of wastewater. Coarse materials will be deposited in the dead zones of compartment 1 from where they will be periodically removed.

Compartments 2 and 3, Ba1 and Ba2, constitute the activation basin of the small plant. The compartments are physically separated by a dividing wall, which is open at the bottom. Each compartment is equipped with one aeration plate.

Recirculation activated sludge from the secondary sedimentation tank is made in compartment 1, and the link between activation and secondary sedimentation tank is carried out by gravity from compartment 2.

Compartment 4, Ds, is the secondary sedimentation tank, (being the smallest compartment). In this compartment secondary sludge sedimentation occurs . A part of this sludge will be recirculated and another part is retained in the sludge storage tank. Sludge recirculation is done through a gas-lift system, operating on the whole duration of aeration. Sampling of treated water is made through an immersed tube with holes.

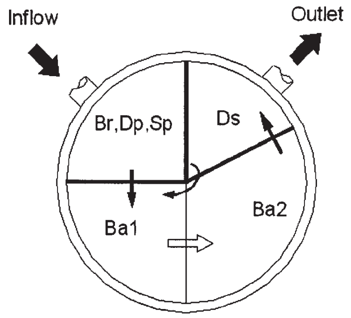

Fig. 1 A plan view of the experimental facility, subdivision and the water circuit

Aeration is achieved through a compressor whose operation is controlled by a timer and three aeration pads. Aeration pads are mounted in those two activation compartments. Details of the facility are shown in figure 1. It is noted that this facility is actually a miniature wastewater treatment plant. It consists of a mechanical stage and a biological stage (functioning based on the activated sludge).

Small wastewater treatment plant was designed for a number of five equivalent inhabitants and has a total volume of 1.85 m, from which the activation basin, composed of compartments Ba1 and Ba2, occupy 1.10 cubic meters.

Optimization of biological treatment process by adjusting the aeration sequences

Unlike a municipal wastewater treatment plant, at this small plant, aeration of activation basin is discontinuous. An intense aeration lead to a too high concentration of dissolved oxygen and large breaks between aeration sequences leading to the settling of the activated sludge. This sedimentation it is not beneficial, activation basin becoming virtually a sedimentation tank. Activated sludge would depreciate very quickly, and its density would decrease. We have to mentioned that, the treatment facility does not have mechanical agitation of water-sludge mixture. Manufacturer aimed to achieve a simple installation, reliable and easy to operate.

The authors summarizing in this paper, how the aeration sequences were adjusted and conclusions which have resulted. Note that adjusting the aeration sequences is only one aspect in optimizing the operation of such facilities. The experiments described are part of a broader cycle of exploitation scenarios which were analyzed.

Small wastewater treatment plant was put into operation on 24th of May, the power being made twice daily (morning at 8.00 and afternoon at 16.00), the total amount of wastewater inflow being of 800l. The wastewater was collected from the wastewater treatment plant of Timisoara, after the separation of sand and fats.

This rough water can be considered as an *extreme* water for the experiments that will be described. This is due primarily to inhibitors coming from industrial wastewater and depreciates more the biological step activity, but also of residual fat loading.

Proper functioning, given first by reactor stability, is directly dependent on the intensity and duration of aeration applied.

Starting from the consideration that self priming installation has been proposed, first it was tried a very intense aeration.

Sequences of aeration for 60 minutes with breaks for 30 minutes.

1) 30min 30min 30min 30min 30min 30min..... total aeration time 2/3 from 24h

1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0

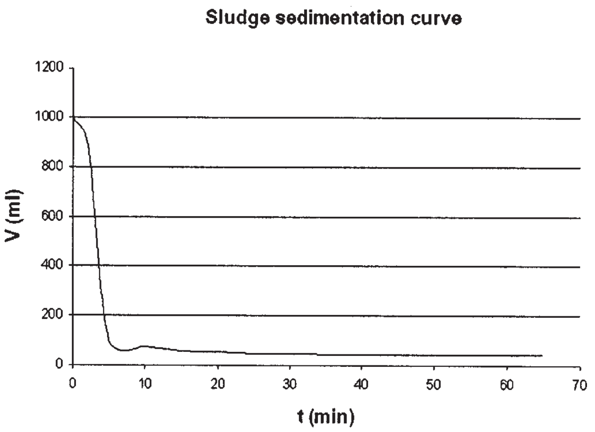

Fig. 2. Sludge sedimentation curve

These aeration sequences were maintained for nine days, during which time the dissolved oxygen content was very high, close to saturation. It still managed good results of the physical characteristics of the effluent.

The first reduction of the aeration duration meant to halve the time of airing. Sequences were for 30 min with breaks of 30 min.

2) 30min 30min 30min 30min 30min 30min..... total aeration time 1/2 from 24h

1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

These sequence of aeration have been maintained for three days, during which time the dissolved oxygen content from the activation basin recorded higher values of 7mgO_2/L.

It was further reduced the aeration period, settling time of airing for 30 min followed by a break of 60 min.

3) 30min 30min 30min 30min 30min 30min..... total aeration time 1/3 from 24h

1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0

Those sequences of the aeration were kept for three days, without being a significant reduction in the amount of dissolved oxygen in the aeration tank.

Due to the fact that from technical conditions point of view aeration time of 30 min cannot be reduced, we increased the pause between two aeration, to 90 min.

4) 30min 30min 30min 30min..... total aeration time 1/4 from 24h

1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0

This working regime was maintained for 41 days of operation. During this period, the amount of dissolved oxygen was reduced to 3.40 - 6.20 mgO_2/L. This amount is still very high compared to the limit of 2.00 mgO_2/L given in the literature.

By replacing the original developer, it was possible to reduce the sequences of 30 min to 15 min. Also it was introduced a break night, between 0 and 8.00 a.m., during which aeration is done only once between 4.00 and 4.15 h it results:

5) 15 min aeration, 45 min break, the total aeration time being 4.5 h from 24 h.

Underlying this decision was also the establishment, that after stopping aeration and hence the agitation of water-sludge mixture from activation basin, sludge sedimentation is almost entirely produced in the first 15 min. (fig.2).

It follows basically a *dead time*, in which the biological activity takes place almost only at the base of the basin, on the height of the sludge deposited. This is evident also from the variation of the concentration of dissolved oxygen in time, at different depths.

The variations of the sludge index and of dissolved oxygen from activation basin are shown in figures 3 a, 3 b.

The sludge volume index (SVI) is the volume in milliliters occupied by 1 g of a suspension after 30 min settling.

Calculations:

$$SVI = \frac{settled\_sludge\_volume\_(mL/L)\cdot 1000}{suspended\_solids\_(mg/L)} \quad (1)$$

It is noted that a good stabilization of the sludge, with an index greater than 70 mL/g, occurs in the second part of the period, when the dissolved oxygen is less than 5 mg/L.

Other indicators followed:

Biochemical oxygen demand, BOD_5 (mg/L), (fig. 4).

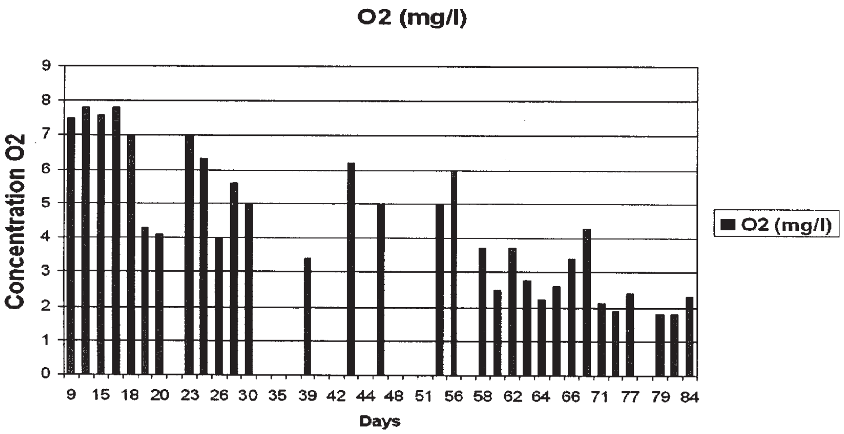

Fig. 3a. The concentration of oxygen from the aeration basin

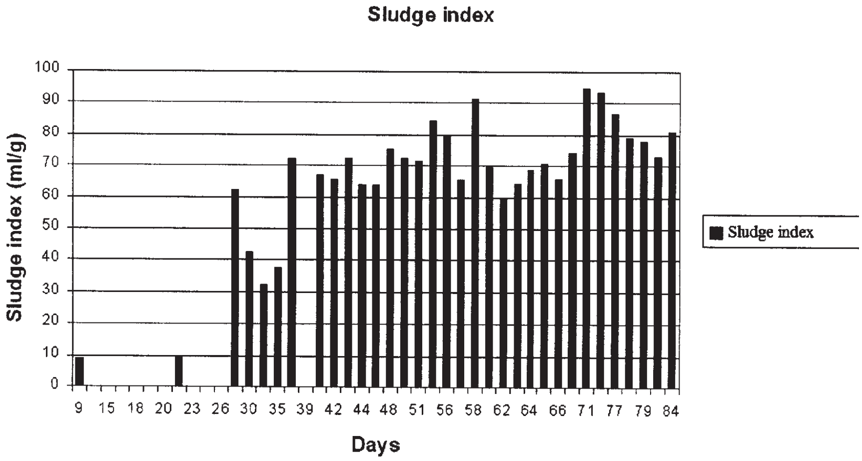

Fig. 3b. The sludge index

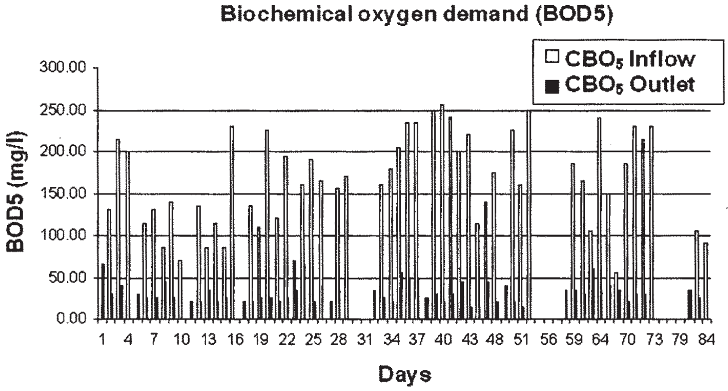

Fig. 4. Biochemical oxygen demand in the inflow and outlet of the plant

Conclusions

For the optimum aeration, both in intensity and duration, it is obtained a good quality activated sludge, which provides a stable facility operation.

Setting sequences and the intensity of aeration should take into account the following::

- constructive particularities of the installation (from those presented above appears very significant contribution made to aeration, by the power supply system of the activation basin);

-the time of the sedimentation, aiming to avoid a complete sedimentation of sludge in the tank;

- the concentration limits of the dissolved oxygen, which are recommended in the literature between 2-4 mgO_2/L;

- the inflow average amount in the installation and time periods where there exist effluent flow, resulting sequences of aeration customization depending on the mode of use of the water over a period of 24 h.

Due to the simplicity of installations of small and very small capacity, the possibility of adjusting the intensity of aeration can be done only by discharge into the atmosphere a part of the flow of air pumped by the compressor. As a rule, these installations are equipped with a single compressor, with no air storage tank, (compressor with diaphragm). Choosing a compressor with smaller power, will reduce the intensity of aeration, but may not be able to achieve a satisfactory water-sludge mixture and to provide the necessary air flow and pressure of gas-lift installations.

An optimization proposal would be to introduce an air distributor controlled by electrovalves. Thus, it can be accessed separate and different times, the aeration circuits and those of gaz-lift. The disadvantage consist in the fact that it requires more air circuits (the placing of the distribution with electrovalves in the basin of the small wasteater treatment is not recommended because of the wet environment) and a more compplex developer.

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