

THE DIAGNOSIS OF THE SEWAGE TREATMENT PLANT BY FACULTATIVE LAGOONS BASED IN A 24 HOURS MONITORING

T. Matsumoto*, I.A. Sánchez Ortiz**.

* Assistant Professor. Faculdade de Engenharia de Ilha Solteira - FEIS/UNESP - Departamento de Engenharia Civil - Alameda Bahia, 550 - Ilha Solteira - SP - CEP: 15385-000 - Brasil - Tel/Fax: (0xx18) 762-3121 - e-mail: tsunao@dec.feis.unesp.br

** Professor. Facultad de Ciencias Pecuarias - Universidad de Nariño. Departamento de Recursos Hidrobiológicos – Ciudad Universitaria, Torobajo - San Juan de Pasto - Nariño - Colombia - Tel: (572) 731-1449 - e-mail: iaso@udenar.edu.co

ABSTRACT

The diagnosis of a sewage treatment plant (WWTP) is necessary in order to know the variability of organic load and solids in the plant affluent, to verify the loading rate, variation of raw influent flow, remotion of the different control parameters and the concentration of discharges in recipient water bodies. The variation in the volume of flow found it follows the tendencies reported in the literature, and the estimated loading rate was 107kgDBO/Ha.d, below recommended for the cerrado region, dry and sunny climate. In relation to BOD treatment efficiency at outlet plant, there was estimated a mean removal of 78%, with mean concentration estimated of 51mg/l, showing that the WWTP needs appropriate operation and maintenance.

Keywords: Stabilization ponds, facultative lagoons, Treatment diagnosis, 24 hours monitoring.

INTRODUCTION

Waste stabilization ponds (WSP) are designed for wastewater treatment by biomass interaction (algae, bacterial, protozoarian, and others) like big reservoirs where inflow and outflow sewage is defined by a defined hydraulic detention time (HDT), involving only the natural biological purification processes which occur in any water body. None external energy, apart from the originated by solar radiation, is required for the operation (Kellner & Pires, 1998).

According to von Sperling (2006), facultative lagoons are the simplest variety in the WSP systems. Basically the process consists in the retention of sewage for a period of time long enough to the natural development of the organic matter stabilization processes. The main advantages of facultative lagoons are associated to the predominance of the natural phenomena.

von Sperling (2006), stated the HDT could vary according to local conditions, specially according to the local temperature. HDT are usually adopted from 15 to 45 days. The lower HDT can be used in regions where water temperature is higher, reaching with this a reduction in the required lagoon volume.

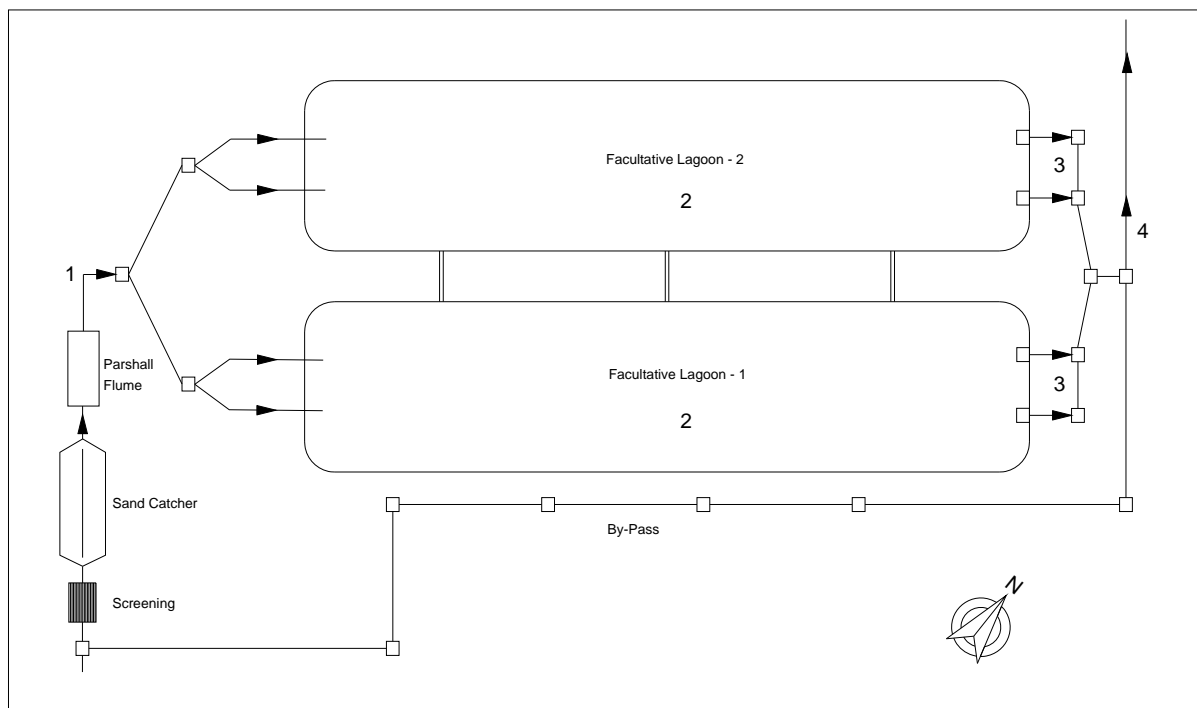
In this context, the usage of only facultative lagoons in sewage treatment has become uninteresting due to the need of large areas and limited performance related to the main control parameters to dealt in the current legislation. The city of Ilha Solteira – SP chose this treatment option motivated

by the available area and the construction executive in the period of implementation of the sewage treatment plant.

After the installation, sewage plants need constant control monitoring, and periodically need carry out 24 hours monitoring with the purpose to verify operational conditions and compare them with the design parameters.

METHODOLOGY

The WWTP was monitored during 24 hours with sample collection for each hour. The monitoring started at 10:30 on 10/01, 2002 and finished at 10:30 on 10/02, 2002, representing 25 samples every hour in 02 preestablished sampling points as indicated in Figure 1, for the determination of the next 15 controlling parameters: Flow rate (Q), Dissolved oxygen (DO), pH, Temperature, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BDO), Total Coliform (TC), Faecal Coliform (FC), Total Solids (TS), Total Fixed Solids (TFS) and Total Volatile Solids (TVS), Total Suspended Solids (TSS), Fixed (TFSS) and Volatile (TVSS) and Sedimentable Solids (SdS). Sample parameters were analyzed following the procedures determined by Standard Methods for the Examination of Water and Wastewater (1998).



- 1 – Raw sewage inlet (sampling point 1)
- 2 – Facultative Lagoons
- 3 – Outlet of treated sewage in each lagoon
- 4 – Joint of the treated sewage water to general outlet (sampling point 2)

Figure 1 – Lay-Out of Ilha Solteira's WWTP

RESULTS

Collecting samples for influent raw sewage and treated effluent characterization in the Ilha Solteira's WWTP starting at 10:30 on 10/01, 2002 and finishing at 10:30 on 10/02, 2002, representing 25 samples every hour in 02 preestablished sampling points.

Figure 2 shows the influent organic load variation, in terms of BOD and COD in the sewage plant of Ilha Solteira, as well as the influent flow variation during a 24 hour period. The average values of the results measured in the monitoring are presented in Table 1.

The curve of influent flow corresponds to the variation reported in the literature, with an average estimated flow of 49.26L/s, approximately 4,434m³/day. The flow during the monitored period had a variation from 7.2L/s (minimum) and 102.7L/s (maximum). Due to the volume of each lagoon is approximately of 55,200m³, thus a total volume of 110,400m³, consequently, the estimated HDT of the sewage treatment plant was 24.9 days, adequate to a plant with facultative lagoons, normally designed for HDT from 20 to 35 days.

Table 1 – Summary of average values of influent raw sewage characteristics in Ilha Solteira’s WWTP.

| Parameters | Average Values |
|----------------------------------------|----------------|
| Volume of flow (L/s) | 49,26 |
| Dissolved oxygen (mg/L) | 7,1 |
| pH | 7,35 |
| Temperature (°C) | 28,9 |
| Chemical Oxygen Demand (mg/L) | 424 |
| Biochemical Oxygen Demand (mg/L) | 235 |
| Total Coliform (NMP/100mL) | 5,06E+07 |
| Faecal Coliform (NMP/100mL) | 5,13E+06 |
| Total Solids (mg/L) | 409 |
| Total Fixed Solids (mg/L) | 176 |
| Total Volatile Solids (mg/L) | 232 |
| Total Suspended Solids (mg/L) | 169 |
| Total Suspended Fixed Solids (mg/L) | 60 |
| Total Suspended Volatile Solids (mg/L) | 109 |

The effluent BOD concentration presented variation between the maximum value of 469mg/L and the minimum value of 66mg/L with an average of 235mg/L, the COD concentration varied from a maximum value of 758mg/L and a minimum value of 148mg/L with an average of 424mg/L. There was determined the relation COD/BOD nearly to 2 as commented in the literature of the area (VON SPERLING, 1996; METCALF & EDDY, 1991; UEHARA & VIDAL, 1989).

Those results and the volume of flow data were estimated the input organic loading in the sewage treatment plant. The diary BOD loading was estimated as 1,043 kgBOD/day, and the diary organic load in terms of COD was estimated in 1,880 kgCOD/d.

The organic superficial loading of facultative stabilization lagoons, with a superficial area of 96.800m² (9,68hectares), it could be considered as a low superficial load, of approximately 107 kg/BOD/Ha.d., compared with the design parameters established for this region of São Paulo State; Kawai et al, (1981), recommended that facultative stabilization ponds could be designed with loadings up to 260kgBOD/Ha.d and, in northeastern brazilian, in semi arid climate, it could be up to 460 kg/DBO/Ha.d. according Silva & Mara (1976).

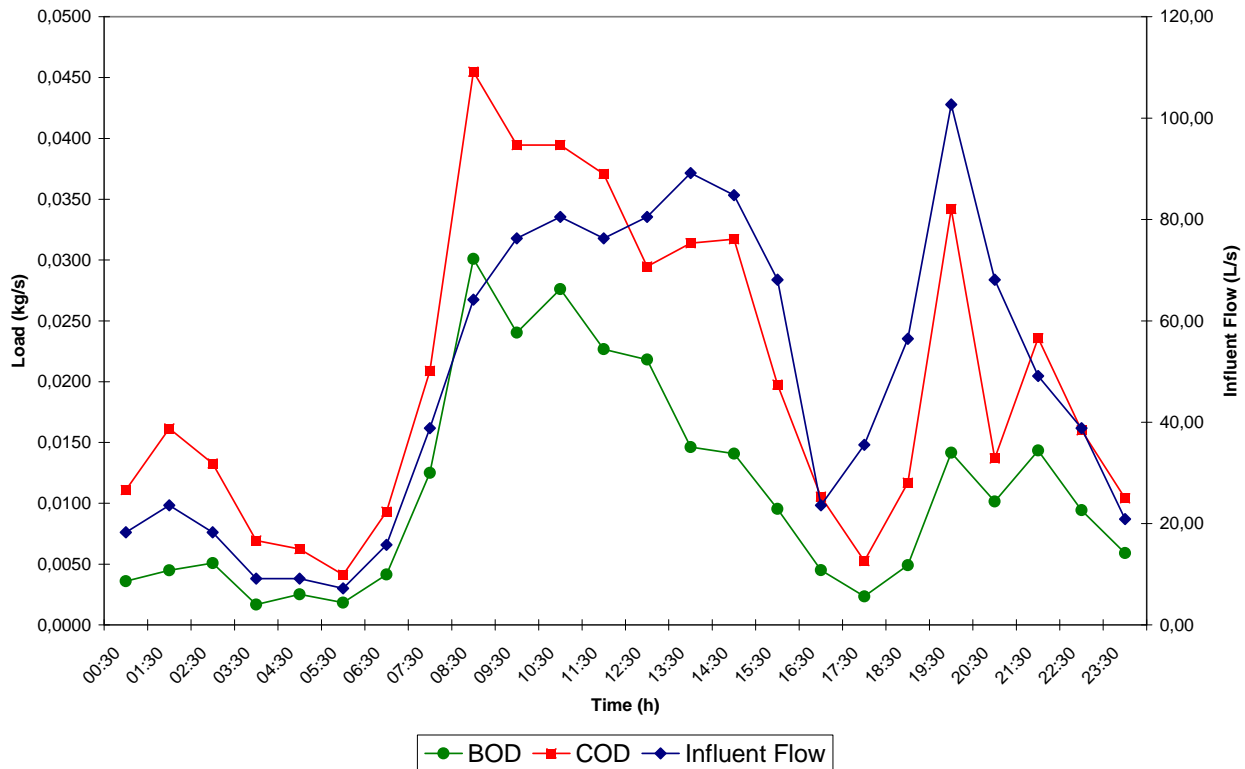


Figure 2 – Variation of Influent Flow, COD and BOD influent to the Ilha Solteira’s WWTP during 24h.

In more recent literature, von Sperling (2006) recommended for hot winter and high solar radiation region, application loading rate between 240 and 300kgBOD/ha.day. Thus, the lagoons in this case had a loading rate equivalent to the cold winter and low solar radiation region where the loading must be between 100 and 180kgBOD/ha.day.

In the WWTP final effluent the variation of the BOD was 21 to 158mg/L, with an estimated average of 51mg/L, reaching an estimated average to removal efficiency of 78%, lower to recommended removal percentual for legislation (Decreto 8464/76) and near to maximum of 60mg/L. This result indicates to special handling care must be adopted by WWTP operators.

The effluent COD varies between 100 and 501mg/L with an arithmetical average near to 245mg/L, as concern with results advocated by specialized literature.

Other parameters monitored during the preliminary phase were: DO, pH, Temperature, Total and Faecal Coliform, Total Solids, Fixed and Volatile, Total Suspended Solids, Fixed and Volatile and Sedimentable Solids. The parameters will be discussed in sequence.

The DO concentration varies in this monitoring of 1.2 to 14.8mg/L at inlet of the WWTP, this case, it can be occasioned by measurement probe, with instantaneous read, but normally the DO concentration for raw sewage varying between 0.0 and 1.0mg/L. Therefore, the effluent DO concentration varying from 7.4 to 18.7mg/L, showing high DO production inside the lagoon.

The influent pH was always were near to neutral value, varying from 7.2 to 7.8 and approximate average of 7.4. At effluent, the results indicated that the pH was alkaline, oscillated from 7.3 to 9.2, the average near to 8.3. The pH values founded were inside the pH range reported in literatures.

The sample temperature at inlet the WWTP oscillated between 27.5 to 29.9°C however at the effluent varying from 28.1 to 34.8°C by the high solar radiation characteristic for the region where the studied WWTP is located. In term of average temperature, the variation was only 0.3°C among the influent and the effluent, staying at 28.9 °C and 29.2°C, respectively. The registered temperatures in the preliminary study (sampling at spring) indicated that the samples were realized in weather condition varying the hot sun to cloud with fresh night, attested, in this way that the region is subject to highest temperature and long time the solar radiation.

In the bacteriological tests realized to the influent and the effluent, were determined the Total and Faecal Coliforms, that varying to MPN for $2.00 \times 10^6/100\text{mL}$ to $9.90 \times 10^8/100\text{mL}$ and from $1.00 \times 10^5/100\text{mL}$ to $8.70 \times 10^6/100\text{mL}$ of the Total Coliforms and from $1.77 \times 10^3/100\text{mL}$ to $2.00 \times 10^8/100\text{mL}$ and from $8.80 \times 10^4/100\text{mL}$ to $3.70 \times 10^6/100\text{mL}$ of the Faecal Coliforms to the influent and the effluent of the WWTP, respectively. Values of Faecal Coliforms could be considered high to discharge, because of the minimum is near to 04log that is recommended the MPN/100 mL is always under 03log.

About Total Solids (TS), the contribution of the TS oscillated between 140 and 580mg/L with average of 409mg/L, divided among 40 to 280mg/L of Total Fixed Solids (TFS) with average of 176mg/L and 80 to 440mg/L of Total Volatile Solids (TVS) with average of 232mg/L at the influent and, 110 to 460mg/L of TS with average of 311mg/L at the effluent, divided between 30 to 240mg/L of TFS (average of 115mg/L) and 80 to 420mg/L of TVS (average of 196mg/L). These results, in the solid mass balance of the lagoon indicated that it existed accumulated solids inside the lagoons, independent of the organic matter stabilization for the inlet to treatment systems, seeing that the concentration solids at the effluent is lower than at the influent.

About Total Suspended Solids (TSS), at the influent the oscillation was 80 to 280mg/L with average of 169mg/L, divided among FSS, 20 to 120mg/L (average of 60mg/L), and VSS of 40 to 220mg/L (average of 109mg/L). In the effluent, the oscillation of TSS was of 40 to 340mg/L, divided among FSS, 20 to 120mg/L (average of 40mg/L) and Volatile Suspended Solids (VSS) of 20 to 280mg/L (average of 99mg/L). The results showed that occur more discharge of TSS in the effluent to receive in the influent of the WWTP, this variation could be attributed to the microorganism cellular production in the facultative stabilization lagoons.

On the other hand, the normative control parameter looking for the Sedimentable Solids (SdS) presence at the WWTP effluent, which maximum limit is 1.0mL/L in Imhoff cone test. Perhaps the high concentration of TSS presented, the variation of SdS oscillated between >0.01 to 0.50mL/L, showing in this way, that in terms of SdS, the effluent of the WWTP was inside of recommended limit.

CONCLUSIONS

During the monitoring period, Ilha Solteira's WWTP reach an estimated BOD removal efficiency of 78%, slightly lower to the 80% recommended removal goal for current legislation (Decreto 8464/76).

Pathogen removal in the WWTP was low, Faecal Coliforms minimum values registered at final effluent were near to 04log and the recommended MPN/100 mL to discharge must be always under 03log.

Solid mass balance of the lagoons indicated that exist accumulated solids inside the ponds, independent of the organic matter stabilization for the inlet to treatment systems, because the concentration solids at the effluent is lower than at influent.

Ilha Solteira's WWTP need an urgent remotion of the accumulated sludge at third parts of facultative lagoons, where the detritus banks are visible and the scum thick layer had covered this area. This accumulated matter could restricted the superficial water layer circulation richer in DO, thus hindered the oxygen penetration in water mass.

Only the lagoons dragging could not resolve the problem to a new city planning (10 to 20 years), maybe in the near future, it could be necessary more drastic reforms, as introducing an anaerobic covered unit inside the facultative lagoon for gas retention or adopting an UASB reactor to solve it.

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