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# Effects of Wastewater Quality and Quantity Fluctuations in Selecting the Wastewater Treatment Plant: a Case Study of Surabaya's Mall

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**Abstract:** The contamination of Surabaya's water river, one of the reasons, is caused by the lack functioning of Wastewater Treatment Plant (WWTP). If the WWTP can be designed properly and in accordance with wastewater flow and characteristics, then the operation of WWTP is expectedly able to overcome or to reduce the water river contamination. Effects of wastewater quality and quantity fluctuations are considered as highly influential in the selection ofthe WWTP. The fluctuations are measured by wastewater sampling on H-Mall, with the flow measurement and laboratory analysis of COD, BOD, TSS, NH3, PO4, and O&G parameters. Wastewater quality and quantity in H-Mall of Surabaya are fluctuating hourly in a day, daily in a week, and the control chart analysis found that the parameters of TSS, NH3 and PO4 exceeds the 3 standard deviation. The design of the equalization basin for WWTP is considerably needed, not only due to the existence of quality and quantity fluctuations, but also due to the Malls in Surabaya city are commonly have only 12 hours operation a day. The calculation of anaerobic filter WWTP, with the 90% removal efficiency, produces the effluent WWTP that meets the current quality standards. With the size of 295 $m^2$, it is possible to be built in the parking area of H-Mall.
**Keywords** : BOD, COD, TSS, anaerobic filter.

## Introduction

The contamination of water river in cities is becoming an important issue in many cities all over the world[1,2,3]. In Indonesia, the contamination of water river in cities is occurring because the untreated load of pollution has fused to the river[4]. Specifically, for Surabaya City, the research study reveals that the load of Surabaya's water pollution is contributed from domestic waste and agriculturalwaste (non industrial waste) as shown in Table 1[5]. This domestic waste contains the waste from Mall as regulated by the Governor of East Java of Indonesia[6].

**Table 1. Inflow load on Surabaya's river contamination from non industrial waste**

| Reach | Location (KM) | TSS (kg/day) | BOD (kg/day) | COD (kg/day) | NH4-N (kg/day) | NO3-N (kg/day) | PO4-P (kg/day) |
|---|---|---|---|---|---|---|---|
| 1 | 36.90 | 43933.97 | 4371.93 | 12301.80 | 550.66 | 262.65 | 293.44 |
| 2 | 31.60 | 479472.49 | 37911.78 | 98891.48 | 325.84 | 1563.03 | 0.99 |
| 3 | 21.70 | 933.53 | 279.21 | 617.40 | 4.17 | 1.67 | 1.67 |
| 4 | 12.00 | 1156.50 | 305.40 | 1138.08 | 334.42 | 2.47 | 6.96 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 5.60 | 76220.64 | 10435.27 | 34449.98 | 1241.97 | 491.01 | 77.61 |
| 6 | 2.60 | 2536.15 | 1343.36 | 2473.94 | 178.85 | 5.18 | 36.29 |
| 7 | 0.00 | 21821.01 | 10849.75 | 20205.21 | 1695.86 | 48.01 | 351.94 |
| Total | | 626074.29 | 65496.69 | 170077.89 | 4331.77 | 2374.03 | 768.90 |

From several results of research studies in many countries, it shows the existence of river contamination in almost every part of the world. This indicates on how the ineffective function of Wastewater Treatment Plant (WWTP), which caused the wastewater contaminate many rivers. If the WWTP can be designed properly, in accordance with the characteristics and flow of wastewater, then the operation of WWTP is expectedly able to overcome or to reduce the water river contamination. Therefore, the existence of WWTP as the prevention of river contamination is essentially needed. Various types of WWTP with anaerobic in suspended growth form, or in attached growth media have been studied and published[6,7,8,9].

## Experimental

### Quality and quantity fluctuations of wastewater H-Mall in each hour

To observe the magnitude on quality and quantity fluctuations of wastewater H-Mall in each hour for 24 hours, the wastewater sampling and flow measurement in H-Mall were performed. The measured parameters of wastewater, analyzed in the laboratory, are consisted of COD, BOD, TSS, NH3, PO4 and O&G (Oil & Grease). The result of laboratory analysis and flow measurement of wastewater is displayed in Table 2.

**Table2. Concentration of fluctuation and flowrate of waste in H-Mall**

| Time (hour) | COD (mg/l) | BOD (mg/l) | TSS (mg/l) | NH3 (mg/l) | PO4 (mg/l) | O& G (mg/l) | Flowrate (l/second) |
|---|---|---|---|---|---|---|---|
| 11 | 371 | 218 | 474 | 101,28 | 4,55 | 42 | 3,5 |
| 12 | 415 | 240 | 534 | 97,45 | 3,86 | 46 | 3,69 |
| 13 | 472 | 278 | 570 | 95,53 | 4,9 | 54 | 4,27 |
| 14 | 460 | 262 | 510 | 107,97 | 5,21 | 53 | 1,94 |
| 15 | 393 | 220 | 528 | 117,41 | 5,48 | 44 | 5,64 |
| 16 | 370 | 224 | 480 | 105,79 | 5,71 | 40 | 4,67 |
| 17 | 337 | 202 | 436 | 109,31 | 5,1 | 38 | 5,44 |
| 18 | 348 | 206 | 466 | 115,36 | 5,48 | 39 | 6,03 |
| 19 | 326 | 198 | 440 | 126,98 | 4,9 | 36 | 2,92 |
| 20 | 404 | 246 | 416 | 119,46 | 4,67 | 46 | 4,08 |
| 21 | 393 | 236 | 396 | 131,08 | 5,21 | 42 | 6,42 |
| 22 | 393 | 230 | 420 | 125,06 | 5,44 | 43 | 2,72 |
| 23 | 472 | 288 | 428 | 112,08 | 4,82 | 52 | 2,33 |
| 24 | 415 | 256 | 504 | 112,21 | 5,71 | 47 | 1,36 |
| 1 | 382 | 236 | 340 | 117,54 | 5,25 | 43 | 0,39 |
| 2 | 213 | 132 | 284 | 103,74 | 6,84 | 24 | 0,19 |
| 3 | 225 | 138 | 138 | 126,98 | 6,87 | 26 | 0,39 |
| 4 | 180 | 112 | 72 | 238,92 | 10,84 | 20 | 0,39 |
| 5 | 213 | 136 | 72 | 198,72 | 11,01 | 24 | 0,39 |
| 6 | 326 | 190 | 420 | 170,29 | 8,65 | 37 | 0,19 |
| 7 | 360 | 208 | 466 | 130,91 | 8,15 | 40 | 0,78 |
| 8 | 326 | 192 | 558 | 103,33 | 5,83 | 34 | 2,72 |
| 9 | 314 | 188 | 510 | 118,09 | 6,02 | 32 | 1,56 |
| 10 | 303 | 178 | 620 | 105,92 | 6,25 | 33 | 0,77 |

From Table 2., an assessment was performed by the control chart to observe the deviation of data with 3 standard deviation as shown in the following figures.

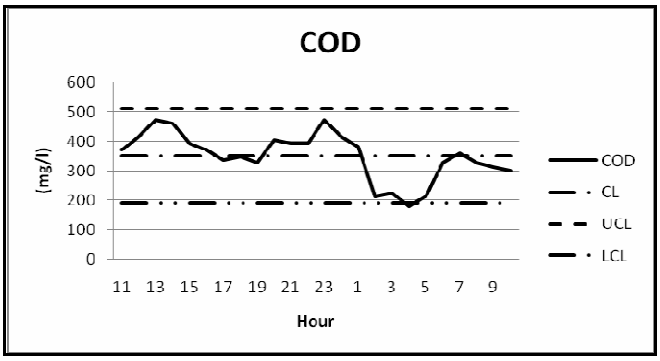


**Figure1. Control chart for COD parameter of H-Mall**

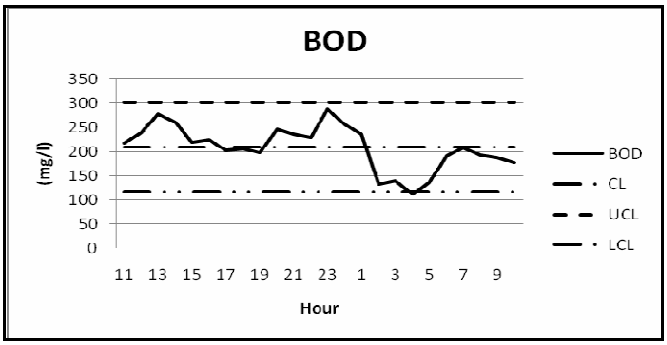


**Figure 2. Control chart for BOD parameter of H-Mall**

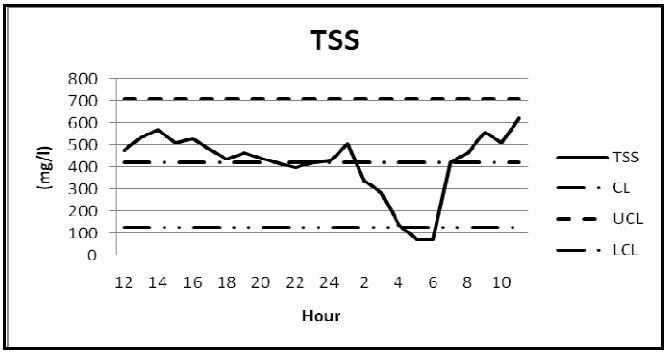


**Figure 3. Control chart for TSS parameter of H-Mall**

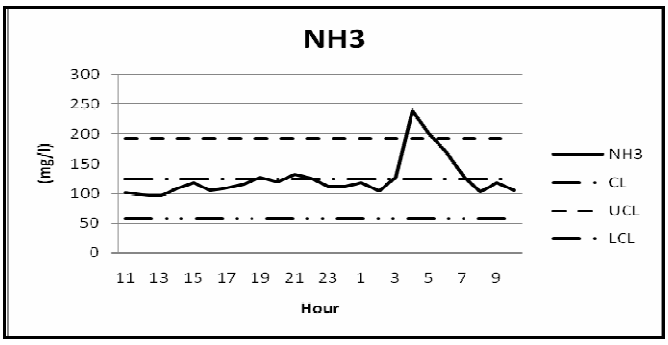


**Figure 4. Control chart for NH3 parameter of H-Mall**

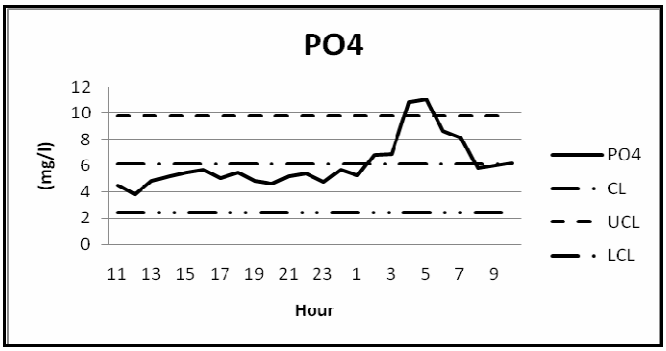


**Figure 5. Control chart for PO4 parameter of H-Mall**

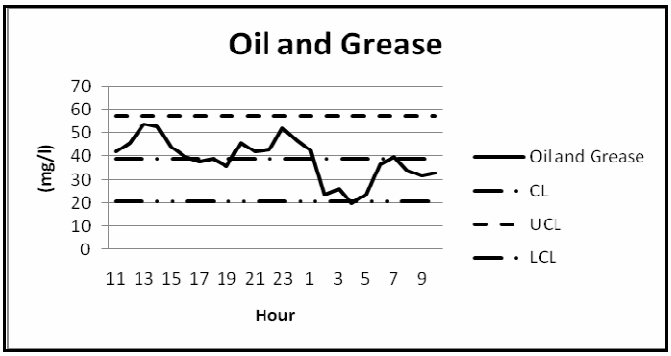


**Figure 6. Control chart for O&G parameter of H-Mall**

**Quality and quantity fluctuations of wastewater H-Mall in each day**

To observe the daily fluctuation, a wastewater sampling of H-Mall was performed in 7-sequence days. The laboratory result is shown in Table 3.

**Table3.Daily observation of H-Mall wastewater concentration**

| Days | COD (mg/l) | BOD (mg/l) | TSS (mg/l) | NH3 (mg/l) | PO4 (mg/l) | O &G (mg/l) |
|---|---|---|---|---|---|---|
| Monday | 359 | 212 | 396 | 91,87 | 4,56 | 26 |
| Tuesday | 393 | 236 | 396 | 131,08 | 5,21 | 42 |
| Wednesday | 450 | 266 | 410 | 118,2 | 3,58 | 28 |
| Thursday | 685 | 404 | 828 | 87,03 | 2,09 | 56 |
| Friday | 292 | 178 | 258 | 100,41 | 4,13 | 32 |
| Saturday | 427 | 260 | 406 | 132,3 | 6,33 | 36 |
| Sunday | 292 | 178 | 216 | 147,08 | 6,91 | 28 |
| Average | 414 | 248 | 416 | 115 | 5 | 35 |

**WWTP DED Plan**

From Table 2, it can be seen that the wastewater flow has a fluctuation. Therefore, to gather the average flowrate that will be used for WWTP DED, a 70% water supply approach was performed. From the usage record of clean water in 2013, the average of H-Mall wastewater flowrate can be calculated and shown on Table 4.

**Table 4.Calculation of average wastewater in H-Mall**

| Month | Water Supply (m3) | Wastewater (m3) |
|---|---|---|
| Jan | 14718 | 10302.6 |
| Feb | 15642 | 10949.4 |
| Mar | 14271 | 9989.7 |
| Apr | 13951 | 9765.7 |
| May | 18309 | 12816.3 |
| June | 17035 | 11924.5 |
| July | 11770 | 8239 |
| Aug | 12753 | 8927.1 |
| Sep | 15995 | 11196.5 |
| Oct | 15323 | 10726.1 |
| Nov | 14322 | 10025.4 |
| Dec | 18694 | 13085.8 |
| Total | 182783 | 127948.1 |
| Avarege ($m^3$/month) | 15231.9 | 10662.3 |
| Average ($m^3$/day) | 507.73 | 355.41 |

By using the average flow rate of H-Mall that are 355,41 $m^3$/day and the average of BOD on wastewater quality = 76 mg/l and COD = 122 mg/l, a DED calculation for WWTP by using Dewats[9] method was performed. The results of DED figures are presented in Figure 7-9. In addition of an anaerobic filter, this method also equips the anaerobic filter with a septic tank that has a function as a settler. The current DED surely has been equipped with the equalization basin.

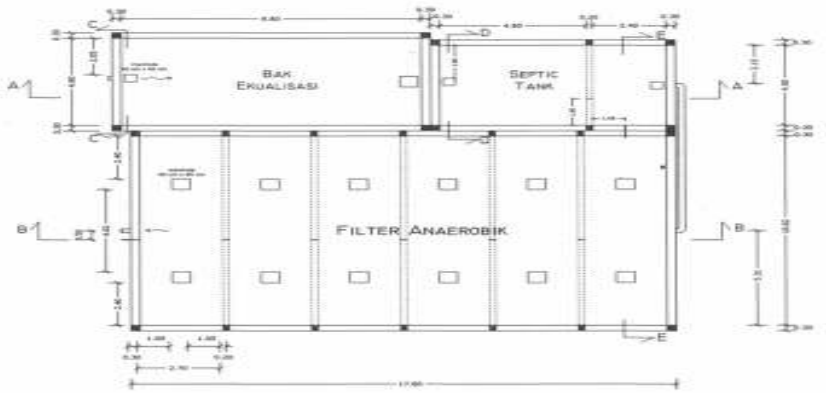


**Figure 7. WWTP layout of H-Mall**

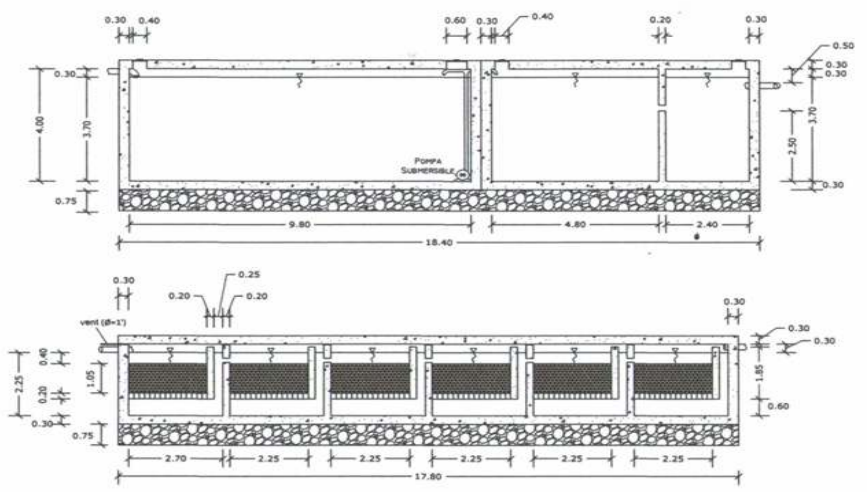


**Figure 8.Lengthwise WWTP layout of H-Mall**

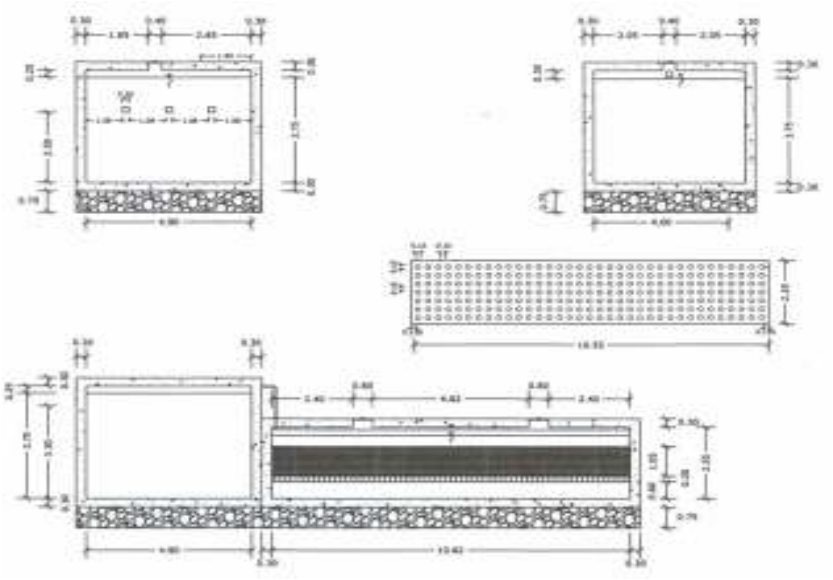

**Figure 9. Crosswise WWTP layout of H-Mall**

## Results and Discussion

From the control charts, showed in Figure 1-6., the illustrations related to 3 standard deviation on average were captured, where the COD, BOD, and O&G parameters have no dot that exceeds the 3 standard deviation. As for TSS parameter, the dots that exceed the lower side of 3 standard deviation are at 4p.m. and 5 p.m. For NH3 parameter, the dot that exceeds the upper side of 3 standard deviation is in 4 p.m. For PO4, the dots that exceeds the upper side of 3 standard deviation are in 4 p.m. and 5 p.m. Table 2 and Table 3 show the wastewater from H-Mall in Surabaya City having a fluctuation on quality and quantity, hourly a day and daily a week. The existence of wastewater concentration every hour and every day caused the need of an equalization basin plan before it is treated in WWTP. Not only has the function to equalize the wastewater concentration, equalization basin also has the function to equalize the wastewater flow since the operation of the H-Mall is not 24-hours (commonly it operates 12 hours). The existence of NH3, PO4, O& G, which relatively small as shown in Figure 4-6., will not disturb if the WWTP with attached growth like anaerobic filter is selected. Anaerobic filter of WWTP is also frequently studied and been applied because not only having the advantages of handling the wastewater quality and quality, but also having a high removal efficiency[10,11,12,13]. The high removal is needed to help the treated wastewater in WWTP to produce effluent that meet the current quality standards. If the anaerobic filter of WWTP can be operated with 90% removal efficiency, then the calculation of effluent concentration by using the average concentration data from Table 3 is shown in Table 5.

**Table 5. WWTP effluent concentration calculation on H-Mall in Surabaya City**

| Parameter | COD (mg/l) | BOD (mg/l) | TSS (mg/l) | NH3 (mg/l) | PO4 (mg/l) | O&G (mg/l) |
|---|---|---|---|---|---|---|
| WWTP influent | 414 | 248 | 416 | 115 | 5 | 35 |
| Removal 90 % | 372.6 | 223.2 | 374.4 | 103.5 | 4.5 | 31.5 |
| WWTP Effluent | 41.4 | 24.8 | 41.6 | 11.5 | 0.5 | 3.5 |
| Effluent quality standard[6] | 50 | 30 | 50 | - | - | 10 |

The calculation result from Table 5 shows the WWTP effluent concentration on H-Mall meet the current quality standard[6]. From Figure 7-9, the 295 $m^2$ size area of WWTP was collected and it is highly possible to be constructed in the parking area of H-Mall. If the average flow rate of H-Mall 355.41 $m^3$/day and removal COD = 372.6 mg/l and removal BOD = 223.2 mg/l from Table 4 were used, then the values of removal load contamination COD =355.41 $m^3$/day x 372.6 mg/l = 132 kg/day and removal load contamination BOD = 355.41 $m^3$/day x 223.2 mg/l = 79 kg/day. Removal load contamination for 1 Mall is surely insignificant

compared to the contamination load on Surabaya's river as shown in Table 1. However, if these values are multiplied with the total of 34 Malls that currently operated in Surabaya City, then it surely gathered the removal load contamination of the Malls that are significant to the river in Surabaya City.

## Conclusion

1. Wastewater quality and quantity of H-Mall in Surabaya City fluctuates hourly in a day and daily in a week. The control chart analysis found that the TSS, NH3, and PO4 have exceeded the 3 standard deviation.
2. Design of equalization basin for WWTP is needed because not only for the wastewater quality and quantity, but also because commonly Malls in Surabaya only operates 12 hours a day.
3. A calculation with 90% removal efficiency for anaerobic filter WWTP resulted the effluent WWTP that meets the current quality standards. By the size of 295 $m^2$, it is possible to be built in the parking area of H-Mall

## References

1. Lin, C. E., Kao, C. M., Jou, C. J., Lai, Y. C., Wu, C. Y., & Liang, S. H. Preliminary identification of watershed management strategies for the Houjing river in Taiwan. *Water science and technology : a journal of the International Association on Water Pollution Research, 62*(7), 1667-1675. 2010. doi:http://dx.doi.org/10.2166/wst.2010.460
2. Burroughs, R. *Coastal Governance*, Foundations of Contemporary Environmental Studies. 2011. doi : http://dx.doi.org/10.5822/978-1-61091-016-3_3
3. Morihama, A.C.D., Amaro, C., Tominaga, E.N.S., Yazaki, R.F.O.L., Pereira, M.C.S., Porto, M.F.A., Mukas, P & Lucci, R.M. Integrated solutions for urban runoff pollution control in Brazilian metropolitan regions. *Water science and technology : a journal of the International Association on Water Pollution Research, 66*(4), 704-711. 2012. doi: http://dx.doi.org/10.2166/wst.2012.215
4. Fulazzaky, M. A. Water quality evaluation system to assess the status and the suitability of the Citarum river water to different uses. *Environmental Monitoring and Assessment, 168*(1-4), 669-684. 2010. doi: 10.1007/s10661-009-1142-z
5. Anonymous. East Java Governor Decree No. 72 of 2013 on Water Quality Standard Industrial Waste and Other Business Activities in East Java . 2013. www.blh.jatimprov.go.id/index.php
6. Said, N.I. Treatment of Domestic Wastewater in Jakarta City : Problem, Strategy and Treatment Technology. 2008 http://ejurnal.bppt.go.id/index.php/JTL/article/viewFile/159/167
7. Tcobanoglous, G. Burton, F.L., Stensel, H.D. *Wastewater Engineering : treatment and reuse*, Metcalf & Eddy, Inc., McGraw Hill, 4th ed, 1819 p. 2003
8. Sasse. L. Decentralised Wastewater Treatment in Developing Countries (Dewats). Borda (Bremen Overseas Research and Development Association), Bremen. 2009.
9. Shammas, N., & Wang, L. Aerobic and Anaerobic Attached Growth Biotechnologies. In L. K. Wang, V. Ivanov & J.-H. Tay (Eds.), *Environmental Biotechnology* (Vol. 10, pp. 671-720): Humana Press. 2010. doi: http://dx.doi.org/10.1007/978-1-60327-140-0_14
10. Show, K.Y, & Tay, J.H. Influence of support media on biomass growth and retention in anaerobic filters. *Water Research, 33*(6), 1471-1481. 1999. doi: http://dx.doi.org/10.1016/S0043-1354(98)00352-2
11. Puñal, A., Trevisan, M., Rozzi, A., & Lema, J. M. Influence of C:N ratio on the start-up of up-flow anaerobic filter reactors. *Water Research, 34*(9), 2614-2619. 2000. doi: http://dx.doi.org/10.1016/S0043-1354(00)00161-5
12. Bodík, Igor, Herdová, Bronislava, & Drtil, Miloslav. The use of upflow anaerobic filter and AnSBR for wastewater treatment at ambient temperature. *Water Research, 36*(4), 1084-1088. 2002. doi: http://dx.doi.org/10.1016/S0043-1354(01)00308-6
13. Omil, Francisco, Garrido, Juan M., Arrojo, Belén, & Méndez, Ramón. Anaerobic filter reactor performance for the treatment of complex dairy wastewater at industrial scale. *Water Research, 37*(17), 4099-4108. 2003. doi: http://dx.doi.org/10.1016/S0043-1354(03)00346-4

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