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# Real-scale comparison between simple and composite raw sewage sampling

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**Abstract:** The present study performed a qualitative and quantitative characterization of the raw sewage collected at the entrance of the sewage treatment station of the city of Itumbiara, state of Goiás. Samples were collected every two hours over a period of seven consecutive days. Characterization of both point samples and composite samples was performed. The parameters analyzed were: temperature, pH, alkalinity, chemical oxygen demand, oil and grease, electric conductivity, total phosphorus, settleable solids, ammoniacal nitrogen, total suspended solids, volatile suspended solids, fixed suspended solids and turbidity. These results allowed us to verify that it is possible to perform the collection and analysis of a point sample, instead of a composite sample, as a way of monitoring the efficiency of a sewage treatment plant.

**Keywords:** water quality, wastewater, flow variation, organic load

## 1 Introduction

The characterization of raw and treated sewage is of paramount importance for verifying the efficiency of the treatment used. However, there are several potentially influential variables from collection to the analytical procedures employed.

According to Leitão (2004), domestic sewage usually varies widely in flow due to the number of inhabitants and residences connected to the sewage network, the specific characteristics of the collection network (type, material, length, maintenance, infiltration and the use of lift stations), as well as climate, topography, domestic and industrial contributions and time. Francisqueto (2007) adds to this group; family income, cultural characteristics of the population and periods of festivals and vacations.

Sperling (1996), considered that between 60% and 100% of the water consumed returns in the form of sewage, and admits a usual coefficient of return of 80%, since part of the water consumed can be incorporated clandestinely into the rainwater network, used in green areas, or infiltrated, among other situations. Metcalf & Eddy (2003) affirm the existence of variation in hourly flow, with the maximum occurring between 7 a.m. and 3 p.m., and the minimum after midnight, inferring that in some cities mean flow values can oscillate between 50% and 200%. Tsutiya (2005) mentions that the volume of sewage produced can range from 50 $L.person^{-1}.day^{-1}$ to 600 $L.person^{-1}.day^{-1}$ and is directly related to the volume of water consumed by the population.

Facing this reality, Borges (2005) discusses variation in the organic and hydraulic loads of raw sewage that are sent to Upflow Anaerobic Sludge Blanket (UASB) reactors, because they are perturbation factors that result in the reduction of reactor performance or even in structural failures. Thus, in order to analyze raw sewage, care must be taken to consider the factors responsible for variation in the characteristics of this material, especially when performing composite sampling to represent a whole, further highlighting the use of automatic samplers (PETRIE et al., 2017). Baker & Kasprzyk-Hordern (2011) also point out that for some parameters this type of sampling with this type of sampler, is inadequate, and can influence the results.

The collection and analysis of a composite sample makes it possible to reduce the quantity of samples to be analyzed, since only one sample is needed instead of several simple/point samples collected throughout the period of monitoring. APHA, AWWA & WEF (2005) explain that composite samples should provide a repesentative sample of a group with greater heterogeneity in which the concentration of the analytes of interest can vary over short periods of time. Otherwise, composite camples can be obtained by combining multiple samples or by using automatic sampling devices. According to CETESB (2011), composite samples can not be used for assessing variables that change during aliquot manipulation, citing dissolved oxy-

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gen, pH, free carbon dioxide, microorganisms, dissolved metals, volatile compounds and oils and grease, which can be altered (transfer among bottles, volatilization, oxidation and reduction, loss of viability, etc.) during the composition process or during the time period required between collection and analysis. In their study, Hillebrand et al. (2013) concluded that if immediate analysis is not possible, storage time should be minimized. For these situations, simple/point samples can be used, but is of interest to know at what time of day the collection and analysis of simple/point samples would represent the result of the composite sample. According to Ort et al. (2010), a representative sample is a prerequisite for delivering significant analytical results and cannot be compensated for by a large number of samples, accurate chemical analysis or sophisticated statistical evaluation. Thus, the present study aims to characterize raw sewage over a period of seven consecutive days, determine the composite sample and discuss the best time of day for performing simple/punctual sampling aimed at the replacement of the composite sample.

## 2 Material and methods

The study took place in the municipality of Itumbiara, Goiás, Brazil, and according to data from the local operator, has 19,884 sewer connections, which reach the Estação de Tratamento de Esgoto [Sewage Treatment Station (STS)] - Itumbiara with an average daily flow of 287 L.s$^{-1}$. The system is composed of three sewage lift stations and a sewage treatment plant with four UASB reactors and five maturation ponds.

According to the characteristics of the system, the study was carried out at the sewage lift station SLS III (Point 2 in Figure 1), where practically all sewage from the city arrives by gravity.

In order to characterize the raw sewage affluent going to STS - Itumbiara, samples were collected over seven consecutive days at intervals of two hours, generating 84 samples from which the following parameters were analyzed: temperature, pH, alkalinity, chemical oxygen demand (COD), oils and greases (OG), electrical conductivity (EC), total phosphorus ($P_{total}$), settleable solids (SetS), ammoniacal nitrogen ($N_{ammoniacal}$), total suspended solids (TSS), volatile suspended solids (VSS), fixed suspended solids (FSS) and turbidity, according to *Standard Methods* (APHA; AWWA; WEF, 2005), with the exception of the parameter oils and greases (EPA, 1993). The parameter for biochemical oxygen demand (BOD) was not included in

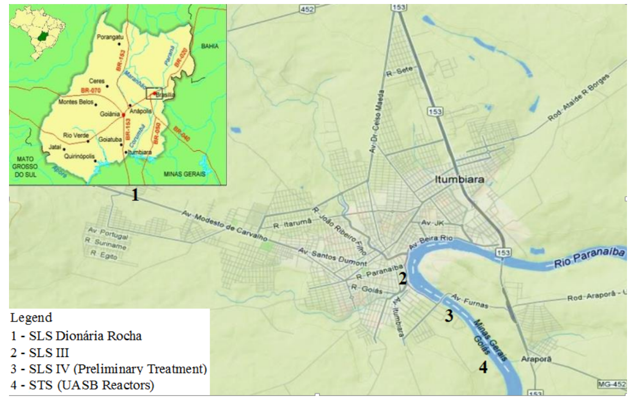


**Figure 1:** Location of the municipality of Itumbiara.
Source: Adapted from www.itumbiara.go.gov.br

the parameters due to the difficulty in carrying out the laboratory analysis within 24 hours. However, this parameter can be estimated as a function of COD as reported in some studies (ORSSATTO et al., 2009; SILVA E MENDONÇA, 2004 & SCALIZE et al., 2003).

Samples were acquired with a 3.5 L container, conditioned in two vials, one of plastic material and the other of amber glass with sulfuric acid (for preservation of the sample), and then packed in a thermal box for transportation to the Laboratório de Saneamento (Laboratory of Sanitation) of UFG, where the physico-chemical analyses were performed ($N_{ammoniacal}$, $P_{total}$, OG, COD, TSS, VSS and FSS). The parameters: temperature, alkalinity, SetS, pH, turbidity and EC were analyzed within 90-minutes of collection.

The collection site was at the outlet of the Parshall gutter installed in SLS III, thus the raw sewage was collected almost entirely by gravity, with the exception being that collectionat SLS Dionária Rochaarrived by pumping. At the moment of collection, the flow was recorded using an ultrasonic meter installed in the Parshall gutter in order to determine the composition of the organic load.

The data were collected at intervals of 2 hours (0 to 24 h), and a composite of the values was obtained to acquire a mean for each time interval using Equation 1, where, Q = flow rate (m$^3$.h$^{-1}$); C = concentration (g.m$^{-3}$) and M = mean mass of the analyzed parameter (kg.h$^{-1}$).

$$M_{\text{media}(0-2\text{h})} = (Q_{0h} \times C_{0h} + Q_{2h} \times C_{2h})/(2.1000) \quad (1)$$

This calculation was performed for the measurements made during the monitoring, from which 12 results were obtained daily for a total of 84 values at the end of the seventh day.

For each time interval (0-2 h; 2-4 h; 4-6 h; ...; 22-24 h) mean, minimum and maximum values were obtained analyzing the seven days of the week. The standard deviation and coefficient of variation were then calculated. With

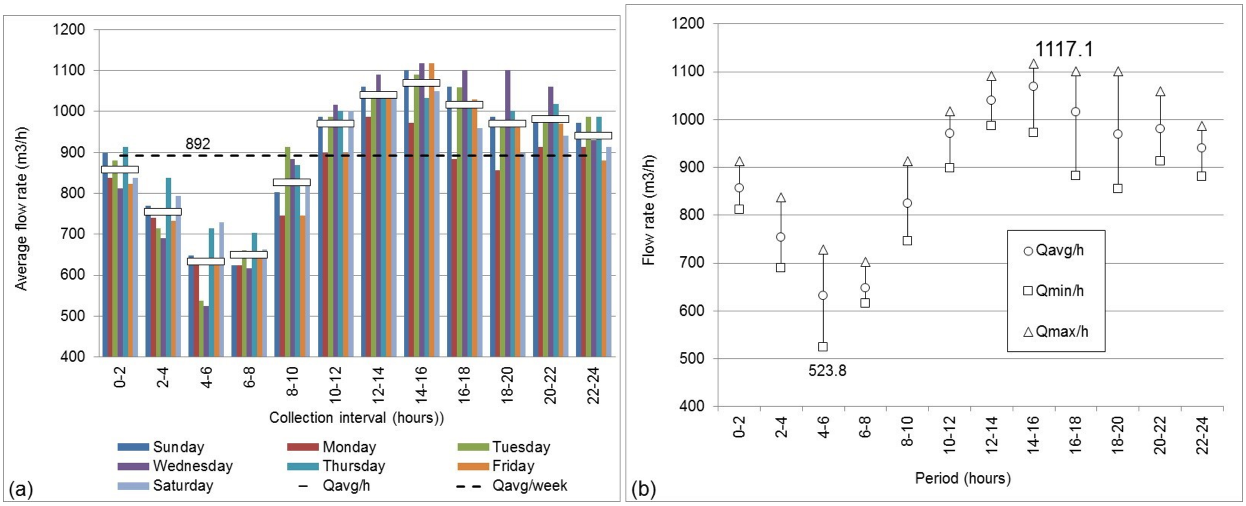


**Figure 2:** Variation in sewage flow rate during the study period of seven consecutive days, highlighting the average weekly flow and the average flow during the collection intervals (a), and variation of the sewage flow rate as a function of the monitoring schedule, showing the lowest and highest flow detected (b).

**Table 1:** Values of mean mass, standard deviation and coefficient of variation for the physico-chemical parameters investigated in raw sewage during the study period, highlighting the lower CV values between 8 h and 15 h.

| Time interval | Parameter | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N_{ammmoniacal}$ | | | COD | | | $P_{total}$ | | | Alkalinity | | | EC | | | Temperature | | |
| | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) |
| 0-2 | 27.9 | 5.3 | 19.1 | 244.0 | 34.3 | 14.1 | 0.3 | 5.3 | 26.7 | 1302.3 | 110.0 | 8.4 | 389.9 | 29.7 | 7.6 | 20.9 | 1.3 | 6.0 |
| 2-4 | 17.1 | 3.6 | 21.2 | 129.9 | 26.9 | 20.7 | 0.2 | 3.6 | 20.0 | 958.2 | 124.5 | 13.0 | 273.2 | 38.7 | 14.2 | 17.1 | 2.0 | 11.5 |
| 4-6 | 38.9 | 4.9 | 12.6 | 143.5 | 34.2 | 23.8 | 0.2 | 4.9 | 22.4 | 1057.2 | 216.6 | 20.5 | 292.9 | 48.6 | 16.6 | 17.5 | 0.7 | 3.8 |
| 6-8 | 82.6 | 9.7 | 11.8 | 321.4 | 139.3 | 43.4 | 0.5 | 9.7 | 18.3 | 1869.7 | 250.6 | 13.4 | 535.4 | 88.5 | 16.5 | 22.5 | 2.1 | 9.5 |
| 8-10 | 92.5 | 9.0 | **9.7** | 620.4 | 124.8 | 20.1 | 0.8 | 9.0 | 17.2 | 2508.0 | 210.0 | 8.4 | 755.3 | 63.4 | 8.4 | 26.9 | 1.6 | 6.0 |
| 10-12 | 81.2 | 11.6 | 14.3 | 867.3 | 80.6 | **9.3** | 0.9 | 11.6 | **7.0** | 2498.3 | 177.6 | **7.1** | 774.1 | 26.3 | **3.4** | 29.2 | 1.0 | **3.5** |
| 12-14 | 69.5 | 11.2 | 16.1 | 912.4 | 97.0 | 10.6 | 0.8 | 11.2 | 7.9 | 2304.0 | 175.9 | 7.6 | 717.2 | 41.8 | 5.8 | 30.2 | 1.5 | 5.1 |
| 14-16 | 55.5 | 7.7 | 13.8 | 759.2 | 149.9 | 19.7 | 0.6 | 7.7 | 16.8 | 1988.0 | 191.1 | 9.6 | 626.4 | 52.3 | 8.3 | 28.7 | 2.1 | 7.3 |
| 16-18 | 57.4 | 9.2 | 16.1 | 636.2 | 117.8 | 18.5 | 0.6 | 9.2 | 19.8 | 1793.5 | 129.8 | 7.2 | 576.1 | 29.5 | 5.1 | 27.4 | 2.2 | 8.2 |
| 18-20 | 61.9 | 8.5 | 13.7 | 631.9 | 66.3 | 10.5 | 0.6 | 8.5 | 11.9 | 1822.7 | 59.5 | 3.3 | 591.6 | 13.6 | 2.3 | 27.7 | 1.3 | 4.7 |
| 20-22 | 57.7 | 3.5 | 6.1 | 587.4 | 142.4 | 24.2 | 0.6 | 3.5 | 19.8 | 1725.2 | 165.7 | 9.6 | 556.0 | 35.1 | 6.3 | 26.5 | 1.2 | 4.7 |
| 22-24 | 45.6 | 4.1 | 8.9 | 434.3 | 97.8 | 22.5 | 0.4 | 4.1 | 26.0 | 1553.2 | 147.2 | 9.5 | 486.7 | 29.2 | 6.0 | 24.0 | 1.1 | 4.7 |

CV – coefficient of variation; σ - standard deviation.

these data, graphs were constructed showing the variation over the days of the week and the hours during the day.

## 3 Results and Discussion

Figure 2 shows that the mean flow rate for the study period was 891.7 $m^3.h^{-1}$ (247.7 $L.s^{-1}$), with the days of lowest and highest contribution being Monday and Thursday. Figure 2 also shows that the lowest recorded values occurred from 4 h to 6 h and the highest flow from 14 h to 16 h. The sewage flow ranged from 523.8 $m^3.h^{-1}$ to 1,117.1 $m^3.h^{-1}$ and the total volume recorded over the seven days of the study was 149,810 $m^3$.

The pH values of the 84 simple/point samples varied between 7.16 and 7.67, so that at any time of day the pH value varied little, as was also observed by Souza et al. (2015) in raw sewage from a refectory and toilets sent to a pilot STS.

Considering that the working hours for the majority of the employees of a sanitation company is between 8 h and 16 h, this would be the most suitable time for a possible simple/point sample collection instead of a composite sample. Tables 1 and 2 show the coefficient of variation (CV) for the parameters $N_{ammoniacal}$, COD, $P_{total}$, alkalinity,

**Table 2:** Values of mean mass, standard deviation and coefficient of variation for the physico-chemical parameters investigated in raw sewage during the study period, highlighting the lower CV values during the interval of 8 h to 15 h.

| Time interval | Parameter | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SetS | | | TSS | | | VSS | | | FSS | | | Oils and greases | | | Turbidity | | |
| | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) | Mean mass ($kg.h^{-1}$) | σ | CV (%) |
| 0-2 | 3.0 | 0.5 | 16.1 | 60.6 | 15.4 | 25.4 | 53.0 | 14.7 | 27.8 | 7.6 | 2.3 | 30.1 | 10.3 | 0.6 | 6.3 | 78.0 | 7.3 | 9.4 |
| 2-4 | 1.6 | 0.5 | 30.4 | 29.0 | 4.6 | 16.0 | 23.7 | 3.8 | 16.1 | 5.3 | 2.8 | 52.4 | 6.5 | 1.3 | 19.4 | 52.0 | 7.1 | 13.6 |
| 4-6 | 1.9 | 0.7 | 36.3 | 60.1 | 9.2 | 15.3 | 51.0 | 8.4 | 16.5 | 9.1 | 3.5 | 38.9 | 12.5 | 7.4 | 58.8 | 46.4 | 10.7 | 23.0 |
| 6-8 | 4.7 | 0.7 | 15.8 | 156.2 | 44.9 | 28.7 | 133.7 | 42.0 | 31.4 | 22.5 | 9.6 | 42.7 | 32.4 | 7.8 | 24.2 | 96.8 | 17.3 | 17.8 |
| 8-10 | 7.6 | 1.1 | 14.8 | 241.6 | 72.8 | 30.1 | 206.7 | 61.2 | 29.6 | 35.0 | 15.6 | 44.6 | 52.7 | 14.9 | 28.3 | 150.5 | 18.2 | 12.1 |
| 10-12 | 8.0 | 1.2 | **14.5** | 270.7 | 62.5 | 23.1 | 227.1 | 56.4 | 24.9 | 43.7 | 14.7 | 33.5 | 66.8 | 17.8 | 26.6 | 172.2 | 14.7 | 8.6 |
| 12-14 | 8.1 | 1.6 | 20.2 | 295.7 | 54.6 | **18.5** | 245.3 | 53.3 | **21.7** | 50.4 | 15.0 | 29.8 | 66.1 | 12.6 | 19.1 | 173.4 | 13.1 | **7.6** |
| 14-16 | 7.8 | 1.4 | 18.3 | 281.5 | 100.8 | 35.8 | 237.7 | 91.0 | 38.3 | 43.8 | 12.4 | **28.2** | 52.5 | 8.5 | **16.1** | 159.3 | 16.2 | 10.2 |
| 16-18 | 5.8 | 1.2 | 20.6 | 204.2 | 86.8 | 42.5 | 171.6 | 72.1 | 42.0 | 33.2 | 19.5 | 58.6 | 46.5 | 11.8 | 25.4 | 143.2 | 15.2 | 10.6 |
| 18-20 | 5.3 | 1.1 | 20.3 | 179.6 | 52.5 | 29.2 | 154.0 | 45.8 | 29.7 | 26.3 | 10.6 | 40.2 | 42.8 | 16.7 | 39.1 | 141.9 | 11.0 | 7.7 |
| 20-22 | 5.5 | 1.6 | 29.9 | 178.9 | 63.0 | 35.2 | 160.0 | 57.5 | 35.9 | 18.9 | 10.7 | 56.5 | 31.3 | 6.5 | 20.7 | 128.4 | 18.9 | 14.7 |
| 22-24 | 4.4 | 1.2 | 27.7 | 124.1 | 50.6 | 40.8 | 111.3 | 43.6 | 39.1 | 12.7 | 9.0 | 70.6 | 18.5 | 3.0 | 16.1 | 97.7 | 14.6 | 14.9 |

CV – coefficient of variation; σ - standard deviation.

**Table 3:** Comparison of the coefficients of variation obtained in the analyses of the physico-chemical parameters considering the time interval and days of the week.

| Parameter | Coefficient of variation obtained from the hourly analysis (from Tables 1 and 2) | Coefficient of variation obtained from the daily analysis (from Tables 4, 5 and 6) |
|---|---|---|
| Ammoniacal nitrogen | 9.7 | 9.1 |
| Chemical oxygen demand | 9.3 | 10.2 |
| Total phosphorus | 7.0 | 7.1 |
| Alkalinity | 7.1 | 3.5 |
| Electrical conductivity | 3.4 | 3.5 |
| Temperature | 3.5 | 3.5 |
| Settleable solids | 14.5 | 9.1 |
| Total suspended solids | 18.5 | 23.8 |
| Volatile suspended solids | 21.7 | 24.9 |
| Fixed suspended solids | 28.2 | 26.2 |
| Oils and greases | 16.1 | 8.9 |
| Turbidity | 7.6 | 7.1 |

EC, temperature and SetS, which were lower in the range of 8 h to 12 h, being below 10% (with the exception of SetS, which was 14.5%). We can also include in this group of parameters turbidity, which presented a CV of 8.6% within this time interval (8 h to 10 h and 10 h to 12 h). The parameters TSS, VSS, FSS, OG and turbidity had lower CV values between 12 h and 16 h, but the CV values of these parameters, with the exception of turbidity, were higher than 10%, reaching 28.2% in this time interval. For the latter parameters, CV values varied from 6.3% to 70.6%.

Tables 4 to 6 show the calculated values of the physico-chemical parameters studied. Mass values are also included for the time intervals during the seven consecutive days of monitoring. The standard deviation of the means obtained each day Values of CV, calculated by taking into account the weekly average of each parameter, varied between 3.5% and 26.2%. Thus, even if we collect? composite samples for 24 hours, we will have variation among the days of the week.

By analyzing the CV values obtained in the hourly and daily analyses (Table 3), it is evident that the variation is very small; that is, the error that may occur by collecting a composite sample on different days of the week is practically the same as that of collecting and analyzing in a determined interval of time.

**Table 4:** Mass of ammoniacal nitrogen, chemical oxygen demand, total phosphorus and alkalinity for the time intervals as a function of the days of the week, with the mean, minimum and maximum mass, plus the standard deviation and CV for the study period.

| Parameter | Time interval | Mass ($kg.h^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun | Mon | Tue | Wed | Thu | Fri | Sat | hourly average | hourly minimum | hourly maximum |
| Ammoniacal nitrogen Weekly mean = 57.3 $kg.h^{-1}$; σ= 5.2; CV = 9.1 % | 0-2 | 33.2 | 24.8 | 21.5 | 21.0 | 32.5 | 32.5 | 29.8 | 33.2 | 24.8 | 21.5 |
| | 2-4 | 20.0 | 18.4 | 11.0 | 12.9 | 19.7 | 18.8 | 18.8 | 20.0 | 18.4 | 11.0 |
| | 4-6 | 31.6 | 37.8 | 40.0 | 44.2 | 44.4 | 40.6 | 33.7 | 31.6 | 37.8 | 40.0 |
| | 6-8 | 74.7 | 70.6 | 84.5 | 99.4 | 89.6 | 77.4 | 82.2 | 74.7 | 70.6 | 84.5 |
| | 8-10 | 99.9 | 76.9 | 90.0 | 104.5 | 89.4 | 89.8 | 96.8 | 99.9 | 76.9 | 90.0 |
| | 10-12 | 98.6 | 66.0 | 72.2 | 88.3 | 71.3 | 86.0 | 86.3 | 98.6 | 66.0 | 72.2 |
| | 12-14 | 87.6 | 54.6 | 59.8 | 75.6 | 64.5 | 68.4 | 76.1 | 87.6 | 54.6 | 59.8 |
| | 14-16 | 68.4 | 43.8 | 53.4 | 61.1 | 54.5 | 52.2 | 54.9 | 68.4 | 43.8 | 53.4 |
| | 16-18 | 65.5 | 43.7 | 55.2 | 72.2 | 56.7 | 56.8 | 51.7 | 65.5 | 43.7 | 55.2 |
| | 18-20 | 67.0 | 47.4 | 61.2 | 74.9 | 63.6 | 61.6 | 57.4 | 67.0 | 47.4 | 61.2 |
| | 20-22 | 62.2 | 51.3 | 56.9 | 59.7 | 58.8 | 55.6 | 59.7 | 62.2 | 51.3 | 56.9 |
| | 22-24 | 51.4 | 43.1 | 41.1 | 40.5 | 47.3 | 47.7 | 48.1 | 51.4 | 43.1 | 41.1 |
| | Daily mean | 63.4 | 48.2 | 53.9 | 62.9 | 57.7 | 57.3 | 58 | - | - | - |
| Chemical oxygen demand Weekly mean = 524 $kg.h^{-1}$; σ= 53.6; CV = 10.2 % | 0-2 | 206 | 235 | 261 | 208 | 302 | 265 | 231 | 244 | 206 | 302 |
| | 2-4 | 86 | 151 | 131 | 114 | 158 | 113 | 155 | 130 | 86 | 158 |
| | 4-6 | 108 | 136 | 215 | 143 | 139 | 145 | 119 | 143 | 108 | 215 |
| | 6-8 | 418 | 326 | 486 | 469 | 161 | 214 | 176 | 321 | 161 | 486 |
| | 8-10 | 736 | 613 | 712 | 778 | 554 | 482 | 468 | 620 | 468 | 778 |
| | 10-12 | 800 | 807 | 879 | 930 | 1015 | 802 | 839 | 867 | 800 | 1015 |
| | 12-14 | 857 | 765 | 1008 | 980 | 1029 | 849 | 899 | 912 | 765 | 1029 |
| | 14-16 | 811 | 623 | 941 | 912 | 825 | 561 | 642 | 759 | 561 | 941 |
| | 16-18 | 738 | 606 | 684 | 756 | 706 | 443 | 522 | 636 | 443 | 756 |
| | 18-20 | 658 | 713 | 632 | 584 | 714 | 573 | 550 | 632 | 550 | 714 |
| | 20-22 | 602 | 865 | 593 | 454 | 640 | 486 | 471 | 587 | 454 | 865 |
| | 22-24 | 475 | 599 | 404 | 312 | 498 | 406 | 346 | 434 | 312 | 599 |
| | Daily mean | 541 | 537 | 579 | 553 | 562 | 445 | 451 | - | - | - |
| Total phosphorus Weekly mean = 0.53 $kg.h^{-1}$; σ= 0.04; CV = 7.1 % | 0-2 | 0.23 | 0.31 | 0.28 | 0.20 | 0.38 | 0.18 | 0.32 | 0.27 | 0.18 | 0.38 |
| | 2-4 | 0.13 | 0.21 | 0.17 | 0.13 | 0.22 | 0.18 | 0.19 | 0.18 | 0.13 | 0.22 |
| | 4-6 | 0.16 | 0.27 | 0.25 | 0.15 | 0.27 | 0.23 | 0.22 | 0.22 | 0.15 | 0.27 |
| | 6-8 | 0.31 | 0.53 | 0.53 | 0.58 | 0.43 | 0.47 | 0.50 | 0.48 | 0.31 | 0.58 |
| | 8-10 | 0.60 | 0.83 | 0.83 | 1.00 | 0.63 | 0.80 | 0.84 | 0.79 | 0.60 | 1.00 |
| | 10-12 | 0.83 | 0.85 | 0.99 | 0.94 | 0.82 | 0.88 | 0.93 | 0.89 | 0.82 | 0.99 |
| | 12-14 | 0.82 | 0.73 | 0.73 | 0.89 | 0.83 | 0.82 | 0.88 | 0.81 | 0.73 | 0.89 |
| | 14-16 | 0.60 | 0.61 | 0.52 | 0.83 | 0.67 | 0.53 | 0.68 | 0.64 | 0.52 | 0.83 |
| | 16-18 | 0.62 | 0.50 | 0.52 | 0.63 | 0.53 | 0.37 | 0.70 | 0.55 | 0.37 | 0.70 |
| | 18-20 | 0.47 | 0.66 | 0.63 | 0.58 | 0.55 | 0.59 | 0.67 | 0.59 | 0.47 | 0.67 |
| | 20-22 | 0.45 | 0.68 | 0.64 | 0.43 | 0.43 | 0.63 | 0.59 | 0.55 | 0.43 | 0.68 |
| | 22-24 | 0.53 | 0.47 | 0.40 | 0.24 | 0.38 | 0.40 | 0.58 | 0.43 | 0.24 | 0.58 |
| | Daily mean | 0.48 | 0.56 | 0.54 | 0.55 | 0.51 | 0.51 | 0.59 | - | - | - |
| Alkalinity Weekly mean = 1782 $kg.h^{-1}$; σ= 63.2; CV = 3.5 % | 0-2 | 1414 | 1308 | 1263 | 1131 | 1454 | 1227 | 1319 | 1302 | 1131 | 1454 |
| | 2-4 | 968 | 981 | 836 | 792 | 1100 | 907 | 1123 | 958 | 792 | 1123 |
| | 4-6 | 742 | 1236 | 1321 | 991 | 968 | 886 | 1255 | 1057 | 742 | 1321 |
| | 6-8 | 1776 | 1822 | 2274 | 2008 | 1790 | 1459 | 1958 | 1870 | 1459 | 2274 |
| | 8-10 | 2684 | 2271 | 2538 | 2812 | 2449 | 2231 | 2570 | 2508 | 2231 | 2812 |
| | 10-12 | 2587 | 2328 | 2349 | 2714 | 2291 | 2523 | 2697 | 2498 | 2291 | 2714 |
| | 12-14 | 2556 | 2020 | 2262 | 2347 | 2160 | 2359 | 2423 | 2304 | 2020 | 2556 |
| | 14-16 | 2285 | 1686 | 2096 | 1955 | 1936 | 2088 | 1869 | 1988 | 1686 | 2285 |
| | 16-18 | 1965 | 1636 | 1772 | 1746 | 1777 | 1973 | 1686 | 1793 | 1636 | 1973 |
| | 18-20 | 1820 | 1894 | 1829 | 1707 | 1873 | 1825 | 1810 | 1823 | 1707 | 1894 |
| | 20-22 | 1782 | 1828 | 1877 | 1454 | 1841 | 1528 | 1766 | 1725 | 1454 | 1877 |
| | 22-24 | 1707 | 1589 | 1648 | 1304 | 1659 | 1403 | 1561 | 1553 | 1304 | 1707 |
| | Daily mean | 1857 | 1717 | 1839 | 1747 | 1775 | 1701 | 1836 | - | - | - |

CV – coefficient of variation; σ - standard deviation.

**Table 5:** Mass of electrical conductivity, settleable solids, total suspended solids and volatile suspended solids for the time intervals as a function of the days of the week, with the mean, minimum and maximum mass, plus the standard deviation and CV for the study period.

| Parameter | Time interval | Mass ($kg.h^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun | Mon | Tue | Wed | Thu | Fri | Sat | hourly average | hourly minimum | hourly maximum |
| Electrical conductivity Weekly mean = 548 $kg.h^{-1}$; σ= 19.3; CV = 3.5 % | 0-2 | 401 | 387 | 380 | 344 | 441 | 374 | 401 | 390 | 344 | 441 |
| | 2-4 | 262 | 298 | 234 | 224 | 321 | 258 | 315 | 273 | 224 | 321 |
| | 4-6 | 225 | 337 | 369 | 278 | 303 | 255 | 284 | 293 | 225 | 369 |
| | 6-8 | 522 | 562 | 677 | 596 | 529 | 414 | 448 | 535 | 414 | 677 |
| | 8-10 | 787 | 759 | 815 | 827 | 748 | 648 | 703 | 755 | 648 | 827 |
| | 10-12 | 772 | 749 | 776 | 823 | 747 | 761 | 791 | 774 | 747 | 823 |
| | 12-14 | 750 | 638 | 727 | 764 | 692 | 733 | 715 | 717 | 638 | 764 |
| | 14-16 | 702 | 540 | 660 | 642 | 620 | 634 | 585 | 626 | 540 | 702 |
| | 16-18 | 616 | 537 | 581 | 593 | 575 | 593 | 537 | 576 | 537 | 616 |
| | 18-20 | 602 | 608 | 588 | 603 | 592 | 576 | 573 | 592 | 573 | 608 |
| | 20-22 | 594 | 584 | 566 | 527 | 572 | 493 | 555 | 556 | 493 | 594 |
| | 22-24 | 514 | 486 | 503 | 445 | 522 | 453 | 485 | 487 | 445 | 522 |
| | Daily mean | 562 | 541 | 573 | 556 | 555 | 516 | 533 | - | - | - |
| Settleable solids Weekly mean = 5.3 $kg.h^{-1}$; σ= 0.5; CV = 9.1 % | 0-2 | 3.6 | 2.9 | 2.2 | 2.8 | 3.4 | 3.2 | 2.7 | 3.0 | 2.2 | 3.6 |
| | 2-4 | 2.2 | 0.9 | 1.2 | 1.5 | 2.3 | 1.6 | 1.7 | 1.6 | 0.9 | 2.3 |
| | 4-6 | 1.8 | 1.4 | 3.3 | 2.0 | 1.8 | 1.1 | 1.8 | 1.9 | 1.1 | 3.3 |
| | 6-8 | 4.7 | 4.8 | 5.7 | 5.5 | 4.3 | 3.6 | 4.2 | 4.7 | 3.6 | 5.7 |
| | 8-10 | 8.4 | 8.8 | 7.2 | 8.9 | 7.5 | 6.1 | 6.5 | 7.6 | 6.1 | 8.9 |
| | 10-12 | 7.6 | 8.8 | 9.6 | 8.1 | 7.5 | 5.9 | 8.5 | 8.0 | 5.9 | 9.6 |
| | 12-14 | 7.2 | 8.0 | 10.9 | 6.1 | 8.6 | 6.7 | 9.2 | 8.1 | 6.1 | 10.9 |
| | 14-16 | 7.7 | 6.3 | 10.6 | 8.6 | 7.5 | 7.0 | 7.0 | 7.8 | 6.3 | 10.6 |
| | 16-18 | 6.0 | 3.8 | 7.3 | 7.3 | 5.3 | 5.6 | 5.6 | 5.8 | 3.8 | 7.3 |
| | 18-20 | 5.1 | 5.6 | 5.2 | 3.4 | 7.1 | 5.3 | 5.6 | 5.3 | 3.4 | 7.1 |
| | 20-22 | 5.3 | 8.2 | 5.2 | 3.5 | 7.2 | 4.3 | 4.8 | 5.5 | 3.5 | 8.2 |
| | 22-24 | 4.9 | 6.8 | 3.8 | 3.4 | 5.1 | 3.5 | 3.6 | 4.4 | 3.4 | 6.8 |
| | Daily mean | 5.4 | 5.5 | 6.0 | 5.1 | 5.6 | 4.5 | 5.1 | - | - | - |
| Total suspended solids Weekly mean = 174 $kg.h^{-1}$; σ= 41.3; CV = 23.8 % | 0-2 | 40 | 55 | 58 | 86 | 76 | 57 | 52 | 61 | 40 | 86 |
| | 2-4 | 27 | 27 | 23 | 33 | 37 | 25 | 30 | 29 | 23 | 37 |
| | 4-6 | 52 | 53 | 68 | 76 | 64 | 53 | 55 | 60 | 52 | 76 |
| | 6-8 | 133 | 145 | 179 | 246 | 136 | 146 | 109 | 156 | 109 | 246 |
| | 8-10 | 222 | 223 | 252 | 397 | 205 | 223 | 170 | 242 | 170 | 397 |
| | 10-12 | 254 | 223 | 227 | 402 | 269 | 287 | 233 | 271 | 223 | 402 |
| | 12-14 | 261 | 227 | 341 | 372 | 336 | 283 | 249 | 296 | 227 | 372 |
| | 14-16 | 254 | 195 | 400 | 437 | 289 | 209 | 186 | 282 | 186 | 437 |
| | 16-18 | 219 | 139 | 242 | 367 | 204 | 158 | 100 | 204 | 100 | 367 |
| | 18-20 | 217 | 132 | 251 | 219 | 181 | 151 | 106 | 180 | 106 | 251 |
| | 20-22 | 189 | 232 | 280 | 182 | 153 | 110 | 106 | 179 | 106 | 280 |
| | 22-24 | 99 | 206 | 160 | 143 | 126 | 66 | 69 | 124 | 66 | 206 |
| | Daily mean | 164 | 155 | 207 | 247 | 173 | 147 | 122 | - | - | - |
| Volatile suspended solids Weekly mean = 148 $kg.h^{-1}$; σ= 36.9; CV = 24.9 % | 0-2 | 30 | 51 | 51 | 76 | 66 | 49 | 47 | 53 | 30 | 76 |
| | 2-4 | 20 | 22 | 22 | 23 | 32 | 23 | 24 | 24 | 20 | 32 |
| | 4-6 | 39 | 46 | 58 | 65 | 50 | 49 | 49 | 51 | 39 | 65 |
| | 6-8 | 101 | 132 | 147 | 217 | 110 | 138 | 91 | 134 | 91 | 217 |
| | 8-10 | 177 | 205 | 207 | 338 | 170 | 199 | 152 | 207 | 152 | 338 |
| | 10-12 | 205 | 195 | 189 | 352 | 208 | 231 | 211 | 227 | 189 | 352 |
| | 12-14 | 212 | 184 | 284 | 340 | 258 | 231 | 210 | 245 | 184 | 340 |
| | 14-16 | 207 | 158 | 355 | 374 | 235 | 179 | 156 | 238 | 156 | 374 |
| | 16-18 | 169 | 116 | 227 | 302 | 162 | 134 | 91 | 172 | 91 | 302 |
| | 18-20 | 173 | 111 | 229 | 186 | 149 | 132 | 98 | 154 | 98 | 229 |
| | 20-22 | 165 | 192 | 264 | 164 | 139 | 99 | 97 | 160 | 97 | 264 |
| | 22-24 | 85 | 175 | 149 | 133 | 113 | 59 | 66 | 111 | 59 | 175 |
| | Daily mean | 132 | 132 | 182 | 214 | 141 | 127 | 108 | - | - | - |

CV – coefficient of variation; σ - standard deviation.

**Table 6:** Mass of fixed suspended solids, oils and greases, temperature and turbidity for the time intervals as a function of the days of the week, with the mean, minimum and maximum mass, plus the standard deviation and CV for the study period.

| Parameter | Time interval | Mass (kg.h$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun | Mon | Tue | Wed | Thu | Fri | Sat | hourly average | hourly minimum | hourly maximum |
| Fixed suspended solids Weekly mean = 26 kg.h$^{-1}$; σ= 6.7; CV = 26.2% | 0-2 | 10 | 5 | 7 | 10 | 9 | 7 | 4 | 8 | 4 | 10 |
| | 2-4 | 8 | 5 | 2 | 9 | 5 | 2 | 7 | 5 | 2 | 9 |
| | 4-6 | 13 | 6 | 9 | 10 | 14 | 4 | 7 | 9 | 4 | 14 |
| | 6-8 | 32 | 13 | 32 | 29 | 26 | 8 | 18 | 23 | 8 | 32 |
| | 8-10 | 45 | 18 | 45 | 59 | 34 | 24 | 19 | 35 | 18 | 59 |
| | 10-12 | 49 | 28 | 38 | 51 | 62 | 56 | 22 | 44 | 22 | 62 |
| | 12-14 | 50 | 43 | 58 | 32 | 78 | 53 | 39 | 50 | 32 | 78 |
| | 14-16 | 47 | 38 | 46 | 63 | 54 | 30 | 30 | 44 | 30 | 63 |
| | 16-18 | 50 | 23 | 14 | 65 | 42 | 23 | 14 | 33 | 14 | 65 |
| | 18-20 | 44 | 21 | 22 | 33 | 33 | 19 | 12 | 26 | 12 | 44 |
| | 20-22 | 24 | 40 | 16 | 18 | 14 | 11 | 8 | 19 | 8 | 40 |
| | 22-24 | 14 | 31 | 11 | 10 | 13 | 7 | 3 | 13 | 3 | 31 |
| | Daily mean | 32 | 23 | 25 | 32 | 32 | 21 | 15 | - | - | - |
| Oils and greases Weekly mean = 36.6 kg.h$^{-1}$; σ= 3.2; CV = 8.9 % | 0-2 | 10.6 | 11.3 | 10.0 | 10.3 | 9.4 | 10.7 | 9.7 | 10.3 | 9.4 | 11.3 |
| | 2-4 | 6.3 | 4.6 | 5.7 | 7.2 | 6.0 | 8.4 | 7.6 | 6.5 | 4.6 | 8.4 |
| | 4-6 | 3.9 | 5.6 | 14.8 | 23.8 | 7.8 | 19.4 | 12.3 | 12.5 | 3.9 | 23.8 |
| | 6-8 | 25.3 | 33.2 | 46.1 | 38.5 | 23.9 | 28.1 | 31.6 | 32.4 | 23.9 | 46.1 |
| | 8-10 | 59.5 | 64.5 | 72.0 | 39.6 | 44.2 | 30.5 | 58.5 | 52.7 | 30.5 | 72.0 |
| | 10-12 | 84.7 | 73.7 | 76.5 | 63.6 | 45.7 | 40.1 | 83.1 | 66.8 | 40.1 | 84.7 |
| | 12-14 | 82.0 | 65.5 | 71.3 | 58.7 | 48.8 | 55.7 | 80.5 | 66.1 | 48.8 | 82.0 |
| | 14-16 | 59.1 | 48.4 | 58.5 | 36.0 | 56.5 | 50.0 | 58.9 | 52.5 | 36.0 | 59.1 |
| | 16-18 | 42.7 | 49.4 | 36.4 | 55.6 | 64.0 | 28.6 | 49.0 | 46.5 | 28.6 | 64.0 |
| | 18-20 | 25.4 | 45.1 | 24.1 | 59.8 | 68.0 | 33.3 | 43.6 | 42.8 | 24.1 | 68.0 |
| | 20-22 | 22.7 | 29.7 | 25.8 | 29.8 | 42.4 | 35.3 | 33.4 | 31.3 | 22.7 | 42.4 |
| | 22-24 | 20.6 | 21.0 | 19.6 | 12.6 | 16.6 | 20.4 | 18.5 | 18.5 | 12.6 | 21.0 |
| | Daily mean | 36.9 | 37.7 | 38.4 | 36.3 | 36.1 | 30.0 | 40.6 | - | - | - |
| Temperature Weekly mean = 24.9 kg.h$^{-1}$; σ= 0.9; CV = 3.5% | 0-2 | 21.3 | 20.6 | 20.1 | 19.2 | 22.9 | 20.0 | 21.9 | 20.9 | 19.2 | 22.9 |
| | 2-4 | 17.7 | 17.4 | 14.8 | 14.3 | 19.0 | 17.1 | 19.5 | 17.1 | 14.3 | 19.5 |
| | 4-6 | 16.9 | 17.1 | 18.2 | 16.9 | 18.6 | 17.4 | 17.3 | 17.5 | 16.9 | 18.6 |
| | 6-8 | 22.0 | 20.3 | 25.6 | 24.8 | 23.3 | 20.0 | 21.8 | 22.5 | 20.0 | 25.6 |
| | 8-10 | 27.4 | 24.8 | 28.0 | 28.8 | 27.3 | 24.5 | 27.4 | 26.9 | 24.5 | 28.8 |
| | 10-12 | 29.7 | 27.9 | 29.6 | 31.1 | 28.5 | 29.0 | 28.8 | 29.2 | 27.9 | 31.1 |
| | 12-14 | 31.1 | 27.6 | 31.3 | 31.7 | 28.9 | 31.3 | 29.4 | 30.2 | 27.6 | 31.7 |
| | 14-16 | 30.0 | 25.1 | 30.3 | 31.1 | 28.6 | 28.9 | 27.0 | 28.7 | 25.1 | 31.1 |
| | 16-18 | 27.9 | 24.4 | 27.7 | 31.3 | 28.1 | 27.2 | 25.3 | 27.4 | 24.4 | 31.3 |
| | 18-20 | 27.4 | 26.1 | 28.1 | 29.9 | 28.6 | 27.3 | 26.5 | 27.7 | 26.1 | 29.9 |
| | 20-22 | 27.4 | 26.1 | 27.9 | 26.0 | 27.6 | 24.6 | 25.5 | 26.5 | 24.6 | 27.9 |
| | 22-24 | 25.2 | 23.7 | 24.9 | 22.8 | 25.3 | 22.7 | 23.3 | 24.0 | 22.7 | 25.3 |
| | Daily mean | 25.3 | 23.4 | 25.5 | 25.7 | 25.6 | 24.2 | 24.5 | - | - | - |
| Turbidity Weekly mean = 120 kg.h$^{-1}$; σ= 8.5; CV = 7.1 % | 0-2 | 83.4 | 80.2 | 72.3 | 66.0 | 88.1 | 79.8 | 76.2 | 78.0 | 66.0 | 88.1 |
| | 2-4 | 55.3 | 55.7 | 54.4 | 36.6 | 57.3 | 53.5 | 51.5 | 52.0 | 36.6 | 57.3 |
| | 4-6 | 32.9 | 40.1 | 65.8 | 47.0 | 52.1 | 39.4 | 47.4 | 46.4 | 32.9 | 65.8 |
| | 6-8 | 90.0 | 88.8 | 116.2 | 111.9 | 110.6 | 67.4 | 92.4 | 96.8 | 67.4 | 116.2 |
| | 8-10 | 151.4 | 142.3 | 155.1 | 181.6 | 158.9 | 122.1 | 142.5 | 150.5 | 122.1 | 181.6 |
| | 10-12 | 165.3 | 156.8 | 169.5 | 202.1 | 179.2 | 166.2 | 166.4 | 172.2 | 156.8 | 202.1 |
| | 12-14 | 172.4 | 150.1 | 178.5 | 183.3 | 190.4 | 174.2 | 164.7 | 173.4 | 150.1 | 190.4 |
| | 14-16 | 162.8 | 138.5 | 172.2 | 173.5 | 172.6 | 160.1 | 135.1 | 159.3 | 135.1 | 173.5 |
| | 16-18 | 152.4 | 132.6 | 148.6 | 155.3 | 154.7 | 145.0 | 113.6 | 143.2 | 113.6 | 155.3 |
| | 18-20 | 148.6 | 143.7 | 147.0 | 139.2 | 156.8 | 135.9 | 122.3 | 141.9 | 122.3 | 156.8 |
| | 20-22 | 139.5 | 148.5 | 134.1 | 113.8 | 149.3 | 104.8 | 108.8 | 128.4 | 104.8 | 149.3 |
| | 22-24 | 109.8 | 110.3 | 95.2 | 83.7 | 117.2 | 82.3 | 85.5 | 97.7 | 82.3 | 117.2 |
| | Daily mean | 122.0 | 115.6 | 125.8 | 124.5 | 132.3 | 110.9 | 108.9 | - | - | - |

CV – coefficient of variation; σ - standard deviation.

## 4 Conclusions

The conclusion of the present study is that the analysis of a composite sample should be performed within a period of at least seven consecutive days, since there is qualitative and quantitative variation among days of the week. In addition, it is possible to collect simple/point samples in substitution for a composite sample for determining the parameters of $N_{ammoniacal}$, COD, $P_{total}$, alkalinity, EC, turbidity and temperature with a CV lower than 10%. For the parameters of SetS, TSS, VSS, FSS and OG, the CV was higher than 14.5%, reaching almost 30%. The CV calculated for the different days of the week as a function of the composite samples collected at two-hour intervals is close to the CV obtained from the simple/point samples collected in the pre-established time intervals. The results obtained in this study support the collection and analysis of a simple/point sample in substitution for a composite sample for assessing the studied parameters.

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