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BIOSYSTEMS ENGINEERING

Lab 2: Solids Determination of Waste Samples
BSEN 5230 Laboratory Assignment
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Objective:

To learn the procedure for determining total, volatile, fixed, and settleable solids in a wastewater sample.

Methods:

In part one of this lab, a total solids analysis of the wastewater sample was completed. The total solids analysis included the determination of total solids, total volatile solids, and total fixed solids. To determine the number of total solids in the waste water sample, aluminum evaporation dishes were used for three trials. The weight of each aluminum evaporation dish was recorded through the use of a scale as W_1. Tongs were used in the process of handling the aluminum evaporation dishes to reduce the influence of oil from our hands. Samples measured at 25 mL were poured into each dish and placed in the 103°C oven overnight. The next day the dishes were cooled for 30 minutes then weighed and recorded as W_2. The total volatile solids were measured by placing the same dishes in the muffle furnace of 550°C for 15 minutes. The dishes were cooled for 30 minutes and weighed as W_3. The total fixed solids were determined by the subtraction of weight of the volatile solids from the total solids.

In part two of the lab, a suspended solids analysis of the sample wastewater sample was completed. The suspended solids analysis included the determination of suspended solids, volatile suspended solids, and suspended fixed solids. Group 5 obtained three clean aluminum dishes and three Whatman GF/C glass microfiber filter circles for each wastewater sample. The weight of the dishes and microfiber filters were weighed as W_4. Each of the three trials filtered 50 mL of the well mixed wastewater sample through the filtering apparatus. The filters were put back into the appropriate dish and dried at 103°C overnight. The next day, each dish was taken out of the oven and cooled for 30 minutes. The samples were then weighed and recorded as W_5. The volatile suspended solids were measured by placing the same dishes in the muffle furnace of 550°C for 15 minutes. The dishes were cooled for 30 minutes and weighed as W_6. The suspended fixed solids were determined by the subtraction of weight of the volatile suspended solids from the suspended solids.

In part three of the lab, a settleable solids analysis of the wastewater sample was completed. An Imhoff Cone was filled with 1 L of the collected well-mixed raw wastewater. This volume was allowed to settle for 45 minutes. The contents of the Imhoff Cone were stirred gently with a rod to dislodge any air bubbles and solids attached to the walls then allowed to settle for another 15 minutes. The volume of settled solids was recorded and reported in mL/L.

Diagrams:

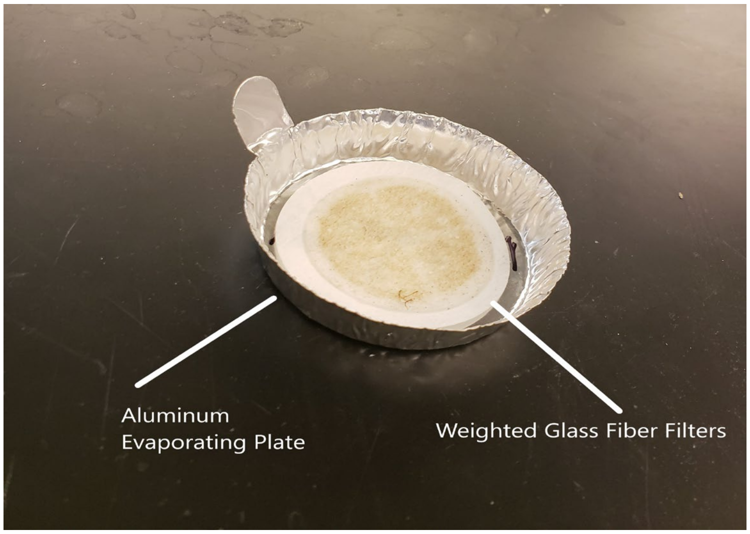

Image 1- labeled picture of an aluminum evaporating plate and fiberglass filter after filtration

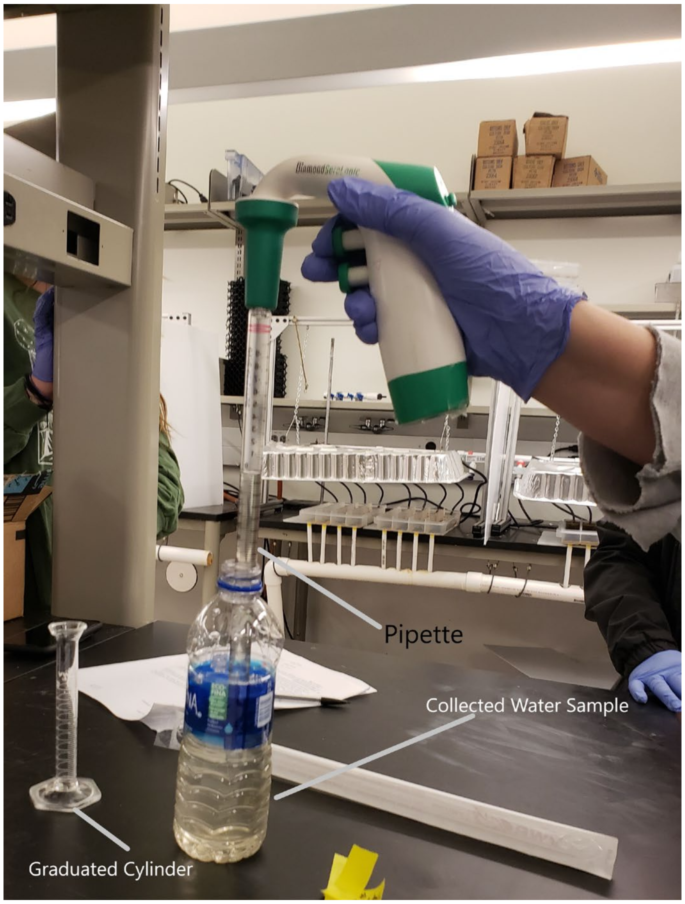

Image 2- Transfer of collected water sample to the filtering apparatus via a pipette.

Image 3- demonstrates transfer of collected water sample to the filtering apparatus

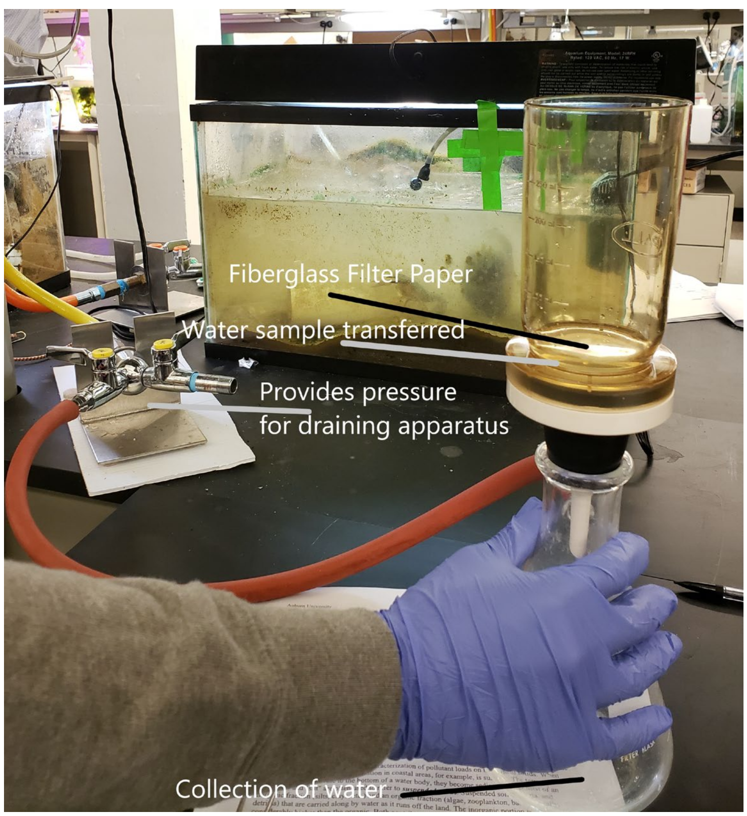

Image 4- Setup of filtering apparatus after transference of water

Image 5- example of Imhoff Cones used in Part III of laboratory assignment

Results:

Table 1 – Procedural data from total solids analysis.

Tray	**W_1 (g)**	**W_2 (g)**	**W_3 (g)**
1	1.0503	1.1860	1.0528
2	1.0425	1.1318	1.0503
3	1.0524	1.1785	1.0549

Table 2 – Procedural data from suspended solids analysis.

Tray	**W_1 (g)**	**W_2 (g)**	**W_3 (g)**
1	1.1831	1.1832	1.1807
2	1.1673	1.1673	1.1647
3	1.1911	1.1915	1.1891

Volume of settled solids = 1 mL of solids/1 L of well-mixed raw water sample

Calculations:

Part 1 – Total Solids

A.

$$Total\ Solids\ \left(\frac{mg}{L}\right) = \frac{(W_2 - W_1)\ g}{mL\ of\ sample} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L}$$

$$Tray\ 1\ Total\ Solids = \frac{(1.1860 - 1.0503)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 5428\ \frac{mg}{L}$$

$$Tray\ 2\ Total\ Solids = \frac{(1.1318 - 1.0425)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 3572\ \frac{mg}{L}$$

$$Tray\ 3\ Total\ Solids = \frac{(1.1785 - 1.0524)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 5044\ \frac{mg}{L}$$

B.

$$Total\ Volatile\ Solids\ \left(\frac{mg}{L}\right) = \frac{(W_2 - W_3)\ g}{mL\ of\ sample} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L}$$

$$Tray\ 1\ Total\ Volatile\ Solids = \frac{(1.1860 - 1.0528)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 5328\ \frac{mg}{L}$$

$$Tray\ 2\ Total\ Volatile\ Solids = \frac{(1.1318 - 1.0503)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 3260\ \frac{mg}{L}$$

$$Tray\ 3\ Total\ Volatile\ Solids = \frac{(1.1785 - 1.0549)\ g}{25\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 4944\ \frac{mg}{L}$$

C.

$$Total\ Fixed\ Solids\ \left(\frac{mg}{L}\right) = Total\ Solids\ \left(\frac{mg}{L}\right) - Total\ Volatile\ Solids\ \left(\frac{mg}{L}\right)$$

$$Tray\ 1\ Total\ Fixed\ Solids = 5428\ \frac{mg}{L} - 5328\ \frac{mg}{L} = 100\ \frac{mg}{L}$$

$$Tray\ 2\ Total\ Fixed\ Solids = 3572\ \frac{mg}{L} - 3260\ \frac{mg}{L} = 312\ \frac{mg}{L}$$

$$Tray\ 3\ Total\ Fixed\ Solids = 5044\ \frac{mg}{L} - 4944\ \frac{mg}{L} = 100\ \frac{mg}{L}$$

Part 2 – Suspended Solids

A.

$$Suspended\ Solids\ \left(\frac{mg}{L}\right) = \frac{(W_5 - W_4)\ g}{mL\ of\ sample} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L}$$

$$Tray\ 1\ Suspended\ Solids = \frac{(1.1835 - 1.1801)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 68\ \frac{mg}{L}$$

$$Tray\ 2\ Suspended\ Solids = \frac{(1.1678 - 1.1640)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 76\ \frac{mg}{L}$$

$$Tray\ 3\ Suspended\ Solids = \frac{(1.1915 - 1.1882)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 66\ \frac{mg}{L}$$

B.

$$Volatile\ Suspended\ Solids\ \left(\frac{mg}{L}\right) = \frac{(W_5 - W_6)\ g}{mL\ of\ sample} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L}$$

$$Tray\ 1\ Volatile\ Suspended\ Solids = \frac{(1.1835 - 1.1807)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 56\ \frac{mg}{L}$$

$$Tray\ 2\ Volatile\ Suspended\ Solids = \frac{(1.1678 - 1.1647)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 62\ \frac{mg}{L}$$

$$Tray\ 3\ Volatile\ Suspended\ Solids = \frac{(1.1915 - 1.1891)\ g}{50\ mL} * \frac{1000\ mg}{1\ g} * \frac{1000\ mL}{1\ L} = 48\ \frac{mg}{L}$$

C.

$$Suspended\ Fixed\ Solids\ \left(\frac{mg}{L}\right) = Total\ Solids\ \left(\frac{mg}{L}\right) - Volatile\ Suspended\ Solids\ \left(\frac{mg}{L}\right)$$

$$Tray\ 1\ Suspended\ Fixed\ Solids = 68\ \frac{mg}{L} - 56\ \frac{mg}{L} = 12\ \frac{mg}{L}$$

$$Tray\ 2\ Suspended\ Fixed\ Solids = 76\ \frac{mg}{L} - 62\ \frac{mg}{L} = 14\ \frac{mg}{L}$$

$$Tray\ 3\ Suspended\ Fixed\ Solids = 66\ \frac{mg}{L} - 48\ \frac{mg}{L} = 18\ \frac{mg}{L}$$

Precautions:

The minimum temperature that can cause a burn in a finite amount of time is 44ºC; contact with a surface at this temperature could cause first-degree burns. Second-degree burns can be sustained with surface contact at approximately 55ºC. Human skin is destroyed at contact with a surface that is approximately 72ºC. During this experiment, extra care should be taken when transferring the aluminum evaporating dishes into and out of the 103ºC oven and the 550ºC oven. Gloves should be worn at all times when handling the aluminum evaporating dishes to avoid influencing the weight measurements with oils present on skin.

Sources of Error:

Some sources of error could have negatively influenced the resulting data collected during the course of the experiment. The scale used to measure the weights of the samples before and after heating could have been calibrated incorrectly. The measured weight also fluctuated slightly if left to sit for too long on the scale before recording a weight. Errors could have been encountered when measuring out the volumes of wastewater for each solids analysis technique; this potential discrepancy could have influenced the results of the data calculations.

Discussion:

Total Dissolved Solids (TDS) would be more appropriate as a parameter for natural waters rather than wastewater samples as natural water properties align with the operational definition of how to measure dissolved solids. Natural waters, unlike wastewater, contains molecular, ionized or micro-granular suspended particles which are detected through filtration. As for wastewater, total suspended solids that are floating in the sample cannot pass through a two-micrometer sieve; a primary requirement of measuring total dissolved solids. TDS would more likely apply to natural waters as opposed to wastewater samples as testing wastewater is associated with determining health effects and less towards the aesthetic characteristics of drinking water.

There are various removal technologies employed for different solids fractions of waste and/ or wastewater. Filtering caters to dilute samples, such as samples that are extracted from natural bodies of water; but for waste or wastewater, the preferred method involves placing a measured subsample into an already weighed crucible and drying the samples for the purpose to be reweighed. Processes to reduce floating and suspended solids done by mechanical means or gravity results in 50% -70% removal of solids while other technologies including oil separators and the coagulation/flocculation methods can achieve greater than 95% solids removal. Once these methods are implicated, the amount of removal should range from about 50%-90% on average.

The organic content of the suspended solids in the various samples is equal to the volatile weight lost after the samples were heated at 550°C. Within the organic content, common components found in the samples: algae, zooplankton, bacteria and detritus are homogenously mixed into the water. For the suspended solids analysis, this organic content for each of the three samples was calculated as 56 mg/L, 62 mg/L, and 48 mg/L.

Conclusion:

Solids are separated into several groups based on particle size and characterization. During the course of this experiment, analysis of total, volatile, fixed, and settleable solids was investigated in order to become familiar with the procedure. Total solids are the amount of the suspended and dissolved solids in water; suspended solids can be captured on a filter. Volatile solids are those that are lost after the completion of a heating process at 550°C. Fixed solids are those left in the vessel after a sample is heated to dryness at 550°C. Settleable solids are those which will not remain suspended or dissolve after a given time period. A total of three results were collected for each section of the lab procedure. The calculated averages of each group of results was as follows: total solids = 4681.33 mg/L, total volatile solids = 4510.67 mg/L, total fixed solids = 170.67 mg/L, suspended solids = 70.00 mg/L, volatile suspended solids = 55.33 mg/L, and fixed suspended solids = 14.67 mg/L. Analysis of solids in municipal wastewaters helps system operators to determine the efficiency of treatment processes to maintain compliance with standards set by regulatory agencies.

References

Burn Exposure Chart, antiscald.com/index.phproute=information%2Finformation&information_id=15.

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