Final Results from the Fluidized Bed Method

Evaluation of previous experiments with the new system

Objective

Unknown macro: {float}

The aerator at the beginning of Summer 2009

This set of experiments attempted to replicate the grain size research performed with the previous experimental setup, to assess both the functionality of the new system and the validity of the Spring 2009 results. Additionally, dissolved oxygen measurements were taken to evaluate the effectiveness of each of the components in the setup with respect to theoretical expectations. According to the theoretical model of the bubble formation potential, it is predicted that around 18 mL of bubbles will be formed for 1 L of water that has been previously exposed to 1 atm gage pressure at temperature of 25 C. See Figure 1. for the relationship between the theoretical bubble formation potential and initial air pressure with which the water reached equilibrium before returning to atmospheric pressure. For the current aerator, it was assumed for the sake of calculation that the dissolved gas concentration would reach equilibrium with the pressure in the aerator, resulting in 18 mg/L of dissolved gas in the water flowing into the sand filter. While a theoretical model of gas removal by the sand filter has not been developed, the team believed that the abundant surface area provided by the sand would remove gas by providing ample nucleation sites for bubbles, and sites at which bubbles could adhere to a surface and aggregate.

General Procedure

For the two experiments listed below, the same procedure was used with a different size of sand grain used in each. Sand 40 (0.49 mm - 0.57 mm) and Sand 30 (0.59 mm - 0.84 mm) were used for Experiments 1 and 2, respectively. The details of the procedure are available here.

Results and Discussion

Experiments 1 and 2 were performed to assess whether the new system collects consistent data and to ensure that previous sand grain experiments results are replicable, and thus are valid. We performed the control experiment (with no sand) after we observed that the measured rate gas removal in the sand filter was less than 18 mg/L, the theoretical rate of gas removal. When we realized that gas removal was less than expected, we took the dissolved oxygen measurements to determine which component of the system was not functioning effectively.

Reruns of the Previous Fluidized Bed Experiments

- Experiment 1 was performed shortly after the new setup was installed. Sand 40 was used to evaluate previous grain size results.
- Experiment 2 was performed after the system was modified to account for problems that arose in Experiment 1. Sand 30 was used with the purpose of testing the functionality again and evaluating previous results.
- A control Experiment (i.e., one with no sand) was performed to evaluate the sand filter's effectiveness by measuring gas removal in the absence of sand.

Dissolved Oxygen Measurements

- When we had confirmed that the measured gas removal values were less than theoretical values, we measured the concentrations of dissolved oxygen at various points in the experimental apparatus. We found that the measurements taken at a point just past the sand filter showed dissolved oxygen concentrations that were higher than that of water going into the sand filter. This suggested a problem with either the setup or the fluidized bed mechanism. Pressure through the sand filter was calculated to explain that large head loss through the system in combination with pressure build up in the filter was not resulting in tiny bubbles being reincorporated into solution. The results of the headloss calculations can be found here. With the control experiment, we confirmed that the sand filter was not suitable for gas removal because the material properties of the sand are not conducive for removing gas.

General Conclusions

Unknown macro: {float}

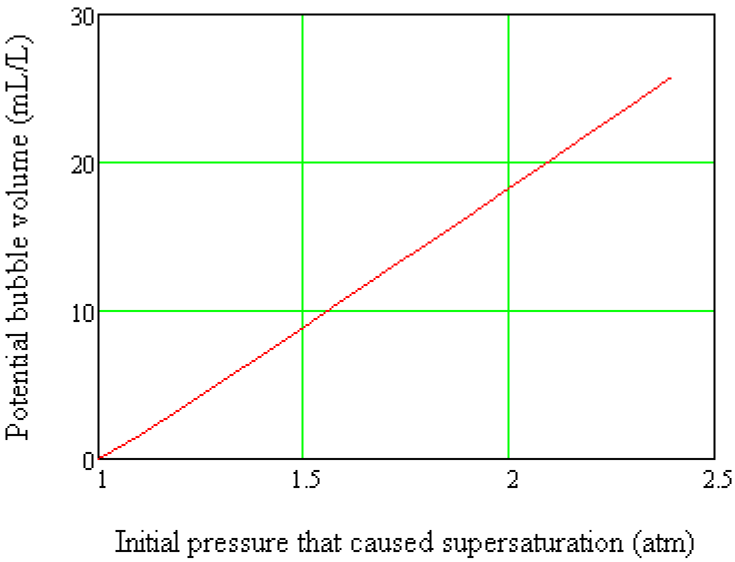
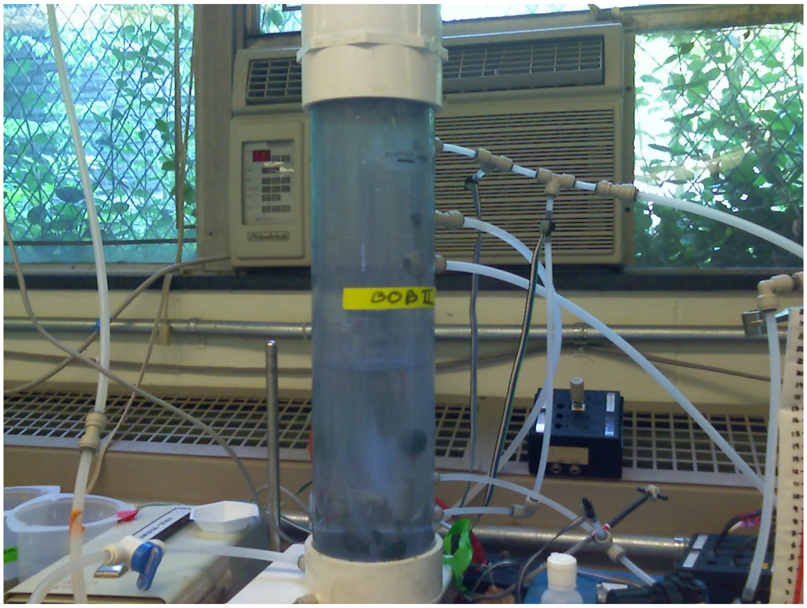


Figure 1: Theoretical bubble formation potential

Experiments using Sand 40 and Sand 30 showed rates of gas removal rates of about 5.09 mL/L and 2.01 mL/L, respectively, while the control experiment showed a rate of 7.47 mL/L. These results suggest that the sand inhibits gas removal, rather than facilitating it. In addition, the concentration of dissolved oxygen measured at each of the four ports in the system (tabulated below) support the notion that the sand filter did not provide a suitable mechanism of gas removal, as the measurements indicated higher oxygen concentrations in the water at points past the sand filter.

Literature concerning bubble formation and behavior indicate that rough, hydrophobic surfaces are most suitable for bubble formation. (See "Fundamentals of Bubble Formation during Coagulation and Sedimentation Processes" by P. Scardina and M. Edwards on the Floating Floc Annotated Bibliography page.) The sand filter may be unsuitable because sand is not hydrophobic.

Unknown macro: {float}



The aerator with four aeration stones

Concerning, the dissolved oxygen measurements, the results indicate that the aerator is able to supersaturate the water with 15.5 mg/L of dissolved oxygen. This is less than the theoretical rate 18 mg/L. Please see the Table 1. below for the dissolved oxygen concentrations and click here for more details and subsequent DO measurements in the absence of sand. Also, further measurements at that port reveal inconsistent levels of gas supersaturation. This inability to regulate the amount of dissolved gas in the influent water to the sand filter may have a significant impact on our ability to run controlled experiments. In order to address this issue, the team has altered the pressurized aerator by replacing the single aeration stone with a junction of four cylindrical aeration stones that would displace gas into the water in finer bubbles, which would be incorporated into solution more easily.

Table 1: Dissolved Oxygen Concentrations (DO) at sampling ports in the experimental setup with a sand bed.

Sampling Port	DO (mL/L), Probe 1, Trial 1	DO (mg/L), Probe 1, Trial 2	DO (mg/L), Probe 2, Trial 1	DO (mL/L), Probe 2, Trial 2
Water Source	9.8	10.2	8.7	12.1
Beyond Aerator	15.5	14.2	11.8	15.2
Beyond Sand Filter	17	16.3	11.9	15.3
Beyond Bubble Collector	17.8	16.2	12.3	15.7

It is also possible that the bubble collector, which is used to measure gas removal, may not be effective at capturing small bubbles. Although we had initially suspected that the small bubbles traveling through the system originated in the sand filter, we are now unsure whether small bubbles formed in the sand filter itself. During the controlled experiment, we observed that small bubbles were present throughout the system. Because of this, we suspect that the source of the small bubbles is a component other than the sand filter--perhaps the aerator. Before the team redesigns the bubble collector, we plan to modify the flow accumulator so that any small bubbles coming from the aerator will be collected so that water entering the sand filter is free of bubbles. If small bubbles are formed in the filter and the bubble collector must be redesigned to capture these bubbles, a new design for the bubble collector will be developed.