

Pharmaceuticals in treated wastewater and streams draining the Sewanee Utility District watershed and the potential for water reuse in Sewanee, TN

I received the Environmental Mellon Internship to work at the Sewanee Utility District (SUD) to characterize the watersheds of Lakes Jackson and O'Donnell and to analyze the presence of pharmaceuticals in various stages of the wastewater treatment process. Professors Deborah McGrath of the Biology Department and Ken Smith of the Forestry Department were my advisors. Professor McGrath was my internship sponsor. I worked with Julie Bennett, also a Sewanee student, for the duration of the internship.

SUD is exploring treated wastewater reuse to meet both community water and waste treatment demands. Reusing waste water would allow a certain water supply in times of drought, such as the one that was experienced in 2007. Pumping the water back into Lakes Jackson and O'Donnell that supply the drinking water for the Sewanee community would help maintain the levels of these lakes during water stressed times. However, the concern with this option is whether the chemicals and other substances that are in waste water are completely removed from the water during the treatment process. This would determine whether the public supports or rejects reuse of the water in this manner even though these pharmaceuticals are not regulated by the EPA.

By conducting such a study, we wish to determine if pharmaceuticals in treated wastewater pose a hazard to wastewater reuse or if SUD can safely recycle wastewater through constructed wetlands back into the municipal water supply, increasing the sustainability of the Sewanee community. This study will also assist SUD in determining if there is a need to examine possibilities for investment in technology to remove the pharmaceuticals from the water. We hypothesized that (1) pharmaceutical concentrations will be lower in treated wastewater pre and post sprayfield application than in untreated sewage, and (2) that estrogens will occur in greater

concentrations during the academic year compared to the summer when very few students are present. The chemical analysis that we did over the summer at TN Tech only tells us qualitatively what pharmaceuticals are found in which location and will help us determine where we need to perform quantitative analysis. For example, if estrogen is not found in either lake then there is no need to perform more intensive analysis.

During June, Julie and I performed the watershed characterization in the mornings. In the afternoons, we entered our data and worked on our writing assignments given to us by Professor McGrath after removing countless ticks. This characterization will help to determine how the species composition of the forest could change and how well the soil and vegetation could adapt to an addition of water (e.g. constructed wetland). Using satellite imagery and the help of Nicole Nunley in the Forestry and Geology Department, thirty plots at each Lake Jackson and Lake O'Donnell were randomly selected and the coordinates were loaded to a handheld GPS device. At each plot, a 5.64 m radius circle was marked, and we determined the species and the diameter at breast height (DBH) of trees. We determined the percentage of understory cover in each category of grass, viburnum, smilax, vaccinium, and tree in a smaller circle with a radius of 1.78 m. Using a soil stick, we measured the depth of the soil at the center of the circle, three steps out from center, and 6 steps out from center. The weather was pretty nice, generally not too hot. It only sprinkled one day but we were in the woods and did not get too wet. We saw lots of interesting bugs and spiders. We even came across a baby deer sleeping in the understory and nearly stepped on it. It was so cute especially when it woke up, screamed, and ran away. Our hike was probably several miles each day. I learned quite a bit during this part of the internship. I learned how to identify some tree species (none of which I knew before), how to use a GPS, and that I really really really hate little ticks that crawl through my socks and attack themselves to my ankles. I spent most of

June itchy from little tick bites and came in from the field with an average of 20 or 30 each day. In spite of the ticks, it was so much fun.

During the second week in June, we installed the passive samplers with help from Nathan at SUD. To qualitatively determine the presence of pharmaceuticals for more intensive analysis, Polar Organic Chemical Integrative Samplers (POCIS) were installed in seven (7) locations: untreated sewage (sewage chamber), treated affluent before it is sprayed on the spray fields (chlorination chamber), three streams draining the spray fields, Lake Jackson, and Lake O'Donnell. Each POCIS was placed into a stainless steel vegetable steamer, which was wired closed with copper wire. Three (3) POCIS were placed at each location for approximately four (4) weeks; the three POCIS at a single location were combined to a single sample for analysis with the exception of the sewage chamber, in which each POCIS was analyzed separately. Four (4) POCIS were placed at each lake; three (3) were wired into cinderblocks for protection and one (1) was allowed to free-float. The free-floating POCIS were completely covered in sediment when we removed them. At each stream, the POCIS were secured to the weirs; to maintain the water level, a cinderblock was placed in the flume of each weir. The POCIS were lowered into the sewage and chlorination chambers and secured to the railing. Nathan again helped us when we were ready to remove the POCIS from their locations. After removal, we wrapped each POCIS/vegetable steamer in aluminum foil, double bagged in Ziploc bags, and put them on ice for transport.

Julie and I then traveled to Tennessee Tech in Cookeville, TN to learn the method for extraction and analysis of the POCIS membranes. During July at TN Tech we generally worked in the Chemistry Department lab from 8:30 am to 6 pm with a two hour lunch break. We were under the supervision of a PhD student, Vanaja, who taught us the POCIS cleaning, extraction, and

filtration method. She also showed us how to use a LC/MS/MS to determine what pharmaceuticals were present in the water.

Cleaning the POCIS was really easy, but when it came to removing the nuts and bolts on the metal rings, it was really difficult. This was because the bolts were really tight and to remove them, it was necessary to hold the nut still while turning the bolt. To make it even more difficult, the membrane could not be touched because if the membrane was punctured, it would be very bad. There was one close call where the wrench had slipped and hit the membrane, but it didn't completely puncture it; it just had a big dent in it. As a side experiment, when we finished with one of the membranes, we tried to gauge the force required to puncture the membrane. When Julie used her finger, a considerable amount of force was required to puncture the membrane. However, when I applied pressure with the copper wire we used to close the vegetable steamers, it required very little effort.

The extraction and filtration was not difficult but it was extremely tedious, taking from three or four hours to almost all day for one POCIS to be completely filtered. It was because we used Pasteur pipettes with filter paper stuffed down in them; the filtration was drop by drop. Once we got to this step, there was not really much to do besides wait and refill the pipettes as they filtered—drop by drop. Generally there was about 60 mL of extracted solution to filter, which took a long time—drop by drop. As a result, Julie and I did stuff on our laptops. I spent countless hours researching graduate programs and contacting potential graduate school advisors as well as watching a few movies. Despite the tedious nature of this part of the research, I enjoyed every minute. This internship solidified my interest in environmental sciences. It also firmed my desire to go to graduate school and pursue a career in research.

After we finished with our POCIS for the day, we ate dinner and went to the common room of our dorm to relax and watch some educational television, generally the History channel or Animal Planet. We made some new friends who were taking summer classes—a couple of them were engineering students; sometimes they talked about circuits and organic chemistry. Ugh. Huh? Once we decided to go to sleep, we had to fight with the door to let us in and then climb the Eifel Tower up to our room on the fifth floor. Sadly, there was no elevator. However, on the bright side, it was good exercise after sitting down all day. On our first night in our dorm, we found this huge 2 inch long cockroach with wings (at least that's what we thought it was) in the garbage can since the previous occupants failed to take out their garbage. It gives me the shivers just thinking about it. I also came across another one in the basement when I went to do my laundry. Ick!

This was by far the best summer I have had since coming to Sewanee, and I so glad I took the time to apply for internship funding. I learned to work with a variety of people, which helped me see the issue from a host of different perspectives that allowed me to more fully understand the issue. I have had so much fun doing this research that I will be continuing it until I graduate in May and possibly through the summer. We will hopefully be doing the analyses on the LC/MS/MS that our Chemistry Department just purchased once it is up and running.

I would advise future interns to do something they never thought they would be interested in; they just might find a new passion or solidify an old one while making themselves look good to potential graduate programs. Even if things go wrong or you hit a snag during your internship, do not give up or get upset, instead use it as a learning opportunity; this will help you grow as individual and show that you can deal with problems that arise and make the best of them. Most importantly, learn and have fun!