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# Lessons Learned Regarding Spent Hop Material Recovered from Wastewater Stream and the Final Composting Solution

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**ABSTRACT**

In 2013, the Matt Brewing Company needed to find a solution for an excessive amount of suspended solids that created performance issues for its anaerobic digester. Removing those solids upstream of the digester feed created an additional byproduct stream that resulted in a cooperative arrangement between the brewery and the regional municipal waste authority. The effort led to a unique composting solution that saved the brewery disposal fees, kept the waste out of the landfill, and generated a supply of quality compost for landscaping projects at the brewery and local charities.

## Introduction

In 2006, the Matt Brewing Company investigated the feasibility of installing an anaerobic digestion system to pretreat the brewery's wastewater that flowed into the Oneida County (New York) sanitary sewer system. The study included the State of New York and technology suppliers. This investigation was motivated by a desire to enhance the brewery's efforts toward sustainability, co-generate power and heat from the biogas, and take advantage of incentives to encourage the adoption of new green technologies. Cost reduction, in the form of sewage fee reductions, was not a big player in this scenario. The project was delayed by circumstance until 2011, with construction commencing in 2012 and commissioning occurring in the fall of 2012 and early 2013.

A key input to the system's design and sizing was a wastewater flow study completed in the project's early stages. It was impossible to determine the total quantity and characteristics of the wastewater flow due to the facility's age, expansions over the years, and multiple connections to the sewer system. Therefore, a study of incoming water flows and multiple grab samples of wastewater from several locations took place. After much discussion and observation, we extrapolated the data into approximate wastewater flow and strength. This approximation turned out to be flawed in a few ways, the most immediate of which was a dramatic underestimation of the suspended solids from hops.

## The Plan

One of the first efforts involved identifying and redirecting all process wastewater drains to a series of two new lift stations. Lift station 1 would collect all of the wastewater from the brewhouse and pump it to the second lift station. Lift station 2 would manage the flows from the upper cellars plus lift station 1 and pump it through a strainer to the equalization tank.

Lift station 1's dual pumps were sized at 450 gallons per minute each and programed in a lead and lag manner. Lift station 2's dual pumps were similarly programmed but sized at 900 gallons per minute each. The equalization tank's design included a top feed and bottom gravity discharge feeding the digester feed pumps located in the adjacent mechanical building. The pumps and the equalization tanks worked well throughout the timeframe of this paper.

The chosen treatment design, an anaerobic fluidized bed digester, requires having minimal suspended solids to maximize its effectiveness. An in-line, self-flushing strainer was selected to reduce the suspended solids and installed downstream of lift station 2. The strainer chosen was an automatic screen filter, 24 inches long by 6 inches in diameter with an 0.03 inch (800 µm) screen. The filter was designed to auto-flush when the pressure drop across the strainer exceeded the set point.

## Opportunity for Improvement

It quickly became evident that we did not size this strainer adequately, because it would plug solid with spent hops several times per day. Each time it plugged, it would take two people to disassemble, clean, and replace. It was clear that we had overlooked the enormity of the hop load—an understatement if there ever was one.

We began to quantify the theoretical loading of hops using three factors: first, the quantity of hops used in the process areas that fed the system; second, the mass that these hops represented once saturated with liquid; and third, the peak flow rates at which these would hit the system given normal production modes at the brewery.

The first was a straightforward calculation based on production records and the bills of material.

The second took a little work in the lab. On several occasions, we measured a mass of hop pellets and allowed them to hydrate in a quantity of water proportional to their various use rates in the brewery. After decanting off the liquid, we found typical val-

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ues of 92% moisture and a density of 52 to 53 pounds per cubic foot.

As a sidebar to this, we found that for every 20 kg of hop pellets used, they bound up 1.4 to 1.5 barrels of liquid. This value was verified through other measures in the brewery and became the basis for factors used to estimate yields and losses.

The third and most challenging estimate to make was the rate at which these wet hop solids would hit the system. Through many observations, calculations, and conversations, we decided to size a new system to handle a steady flow of 39 pounds of wet solids per minute with some reserve capacity to handle temporary peak flows.

## Exploring Options

A couple of people on the team had experience using a unit referred to as a "microcut" unit that acted like an industrial-sized food processor. The thought was that if we reduced the particle size sufficiently, they would flow through the screen. The concept and capacities made this seem possible. However, the digester experts rejected this option because the suspended solids would still affect the digester's performance and potentially affect treatment fees.

The next option to consider was a side-hill screen, a cost-effective, straightforward, static unit commonly used in the wastewater treatment industry. They are ideal where an open-air installation is possible and where sufficient vertical space exists to capture the solids in a hopper or receptacle placed below the screen. Side-hill screens use wedge wire as the screening medium. Water is distributed evenly over the width of the infeed at the top of the unit. As it cascades down the inclined screen, the liquid passes through the wedge wire, and the solids roll down the screen to the receptacle below. Access is needed to clean the screen, and the units are not enclosed, so wastewater and the solids are exposed, making them best used outside or in an area separated from other processing equipment.

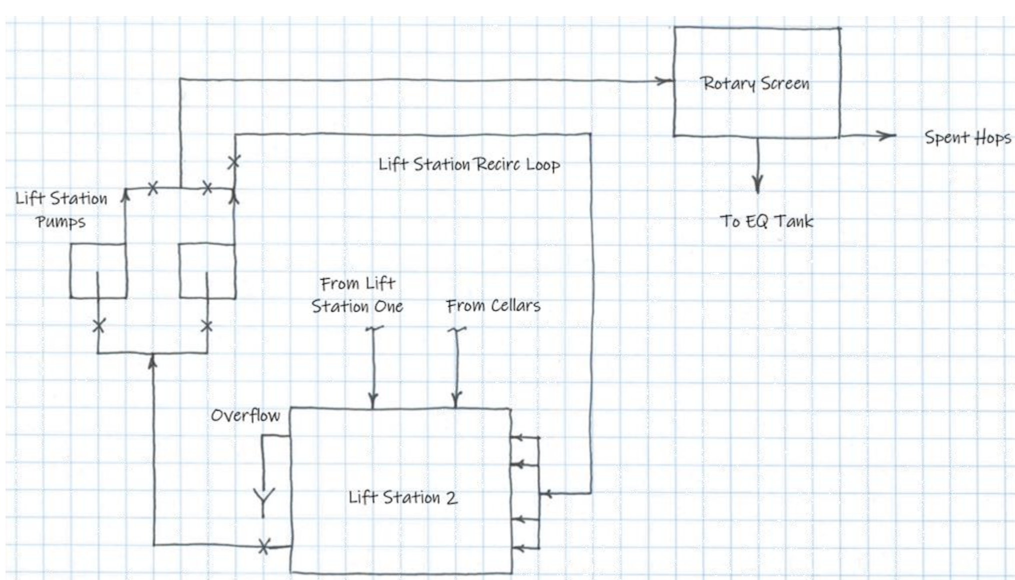
Our testing showed that a wedge wire screen with 0.02 inch (500 µm) openings gave the best throughput and solids retention performance.

The space designated for this screening step is adjacent to a production area with limited access. Given the open nature and limited access, we continued to explore alternatives.

We found a third option, a rotating drum screen. These utilize the same wedge wire and have enclosed cases, making them more suitable for production areas. The wastewater feeds into a weir that distributes it onto the inside of the drum's upwardly rotating side. The water flows through the screen to a catch basin below. Internal flights on the rotating drum convey the solids to the end where they discharge.

We decided to proceed with a rotary drum unit that was 48 inches in diameter and 72 inches long. We reengineered lift station 2's pumps to reduce the likelihood that we would overload the screen with slugs of spent hops during a tank clean. The lag pump rarely, if ever, came on, so we repiped it to provide a recirculation loop in lift station 2's reservoir, drastically in-

Top: screened spent hops inside of rotary drum. Bottom: spent hops after being dewatered.




System diagram.

creasing the homogenization of the wastewater solids. This redesign had the added benefit of virtually eliminating the solids building up in the bottom of the tank.

The rotary screen system created another unexpected challenge for the project. We were presented with a solid waste byproduct that was previously washed away with the wastewater. To minimize the disposal cost of this waste and maximize the liquid fed to the digester, we installed a dewatering screw on the discharge of the screen. The dewatering screw reduced the moisture contented from ~92% moisture to ~70% and directed the liquid back into the digester feed. The dewatered spent hops collected in hoppers with no excess moisture spilling in the area, which eased the movement of those hoppers to the bulk collection site.

## Disposal Dilemma

The going rate for solid waste disposal at the time was $72 per ton, and the thought of sending it to the landfill was a nonstarter.

We explored the path of sending the material out with our spent grains by working with our spent grain broker. Test results confirmed that we could mix the material with spent grains, but we would have to mix them homogeneously. The cost of conveyance and controls to ensure a homogenous mix made that path uneconomical for us.

We ended up working with the Oneida-Herkimer Solid Waste Authority (OHSWA), who operated a modern composting facility for municipal yard waste from curbside pickup. With an initial estimate of $15 to $35 per ton plus transportation, this seemed like a more palatable option. Initial thoughts were that the finished compost could be worked back into the soil of the regional commercial hop fields and sold to the region's consumers and landscapers—it would be compost with an interesting story.

Rows of in-process composting spent hops and yard waste.

Finished composted spent hops and yard waste.

## Success

By the fall of 2013 the rotary drum screen and related modifications were in place. With few exceptions, the screening system worked beautifully and handled everything we could throw at it. With a few tweaks here and there, the unit hasn't missed a beat in over 7 years of service.

We contracted with a local waste hauler who positioned a 20 cubic yard dumpster on our property dedicated to the spent hops. The dewatered spent hops collect in 2 cubic yard tipping hoppers that get regularly dumped into the dedicated dumpster. The dumpster is emptied weekly at the OHSWA composting facility and returned to the brewery.

OHSWA knew from the start that the spent hop material would have to be blended with drier organic material from their curbside pickup green waste stream. They started their trials with a 1:4 ratio of yard waste to spent hops, but this blend failed to become active enough to raise the bed temperature into the 120 to 140°F range for thorough seed and pathogen destruction. They revised their blend to 1:2 and successfully hit their targets.

Testing of the final compost showed that it was virtually identical to the compost from their 100% yard waste compost and met every standard required for sale to the public. However, their permits forbid them from selling material from commercial sources, so the material is available to the brewery as needed for landscaping and local charitable organizations for their use. There is even a plan to use this material as a significant component of the topsoil for the finished grading around Matt Brewing's new fermentation and aging cellar, scheduled for completion in 2020.

The properties of the finished product are as follows:

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|---|---|
| Moisture @ 70°C | 57.47% |
| Solids | 42.53% |
| Total nitrogen (N) | 0.52% |
| Phosphorus (P) | 0.07% |
| Phosphate ($P_2O_5$) | 0.17% |
| Potassium (K) | 0.17% |
| Potash ($K_2O$) | 0.20% |
| Magnesium (Mg) | 0.28% |
| Calcium (Ca) | 3.19% |

Interestingly, a reference I found on the subject of spent hops' nutrient values was from a November 16, 1925, publication of the United States Golf Association (USGA). They used non-composted spent hops to amend the soils of fairways built on clay with good success. You can find this reference here: https://gsr.lib.msu.edu/1920s/1925/2511257.pdf. Their analysis showed the following:

> An analysis of spent hops thus treated made by the Bureau of Plant Industry, United States Department of Agriculture, is as follows: Potash ($K_2O$), trace; phosphoric acid ($P_2O_5$), .34 per cent; nitrogen, (N) 5.55 per cent.

> The material is however quite acid (technically expressed as hydrogen-ion exponent 4.7 per cent). The total amount of acidity calculated as lactic acid is .4 per cent.

A final note on the composting process. Both the experience with our spent hops and a comment made in the USGA article showed that the hops seem to take longer to break down than might be expected. One speculation on a possible cause of this is the anti-microbial properties of the hops themselves. Perhaps they inhibit the growth rates of the beneficial microflora responsible for decomposition.

## Economics

I have yet to hear of a wastewater project that becomes a profitable venture, and this one is no exception. In addition to the initial cost of the anaerobic system and initial wastewater collection design, the additional cost of the screening and solids disposal system, and the composting service's ongoing expense ($15 per ton, plus transportation) make the economics even more difficult. However, with a steady flow of wastewater, the system has proven itself to be a reliable pretreatment facility with plenty of growth capacity. In addition to pretreating the wastewater, the system generates biogas. The brewery collects and blends the biogas with natural gas to feed a generator that produces up to 400 kW on-site. This electricity feeds back into the brewery's switchgear, and it both offsets the brewery's electricity purchases and increases the site's electrical supply capacity by 16%.

## Summary

If you are separating your spent hops, we have found that they are compostable if a complementary and compatible dryer material is available for blending. Our experience indicates that the resultant compost meets the standards required for landscape use and perhaps consumer use if permitted.

I would make a few points. First, if you are fortunate enough to be building a new brewery, be sure to design your wastewater streams so that you can easily measure its quantity and characteristics and accommodate the side-streaming of byproducts should the need arise. Second, before undertaking a major project outside of your area of expertise, get a few experts to review and challenge your project, its assumptions, and initial designs—it might save you a great deal of money and heartache down the road. And lastly, don't settle for directing any waste stream to the landfill until you have exhausted every conceivable alternative. If the landfill is the ultimate path, revisit options regularly because the science, technology, and economics of alternatives are everchanging.

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