FACTSHEET

January 2015 # 002

IMPACT OF MUCK SOILS ON WATER TREATMENT SYSTEMS

Bridget Visser

Characteristics of Muck Soils

Muck soils differ from mineral soils in several key aspects. Muck is comprised of between 20 and 80% organic matter (OM), compared to less than 10% in mineral soils, and the most common parent material is peat. It is found in low-lying areas like bogs that have been drained, leaving highly productive soil behind. There is a naturally-occurring subsidence associated with these soils as the breakdown of the organic matter is a natural source of many nutrients required for plant growth. Muck soils are more reactive than mineral soils with more opportunities for cation exchange. While muck has a similar particle size to that of clay and silt, the specific gravity is less than half (Table 1). Water has a specific gravity of 1; any particle with a higher specific gravity will sink whereas an object with a lower specific gravity will remain suspended. They can be easily identified by their distinctive dark colour. These unique aspects of muck soils present challenges when treating vegetable wash water containing muck particles.

Water Treatment Systems

There are several water treatment systems impacted by the presence of muck in washwater. Sedimentation and reverse osmosis are particle removing systems that can be affected. Disinfection systems, like chlorine and UV sterilization, can have their efficiency reduced. The order of treatment systems is an additional consideration that can impact the efficiency of the overall operation.

Table 1: Size and specific gravity of sand, silt, clay, and organic-based soils

	Size		Specific Gravity
	Microns	mm	
Sand	50-2,000	0.05-2	2.64-2.68[a]
Silt	2-50	0.05-0.002	2.68-2.72[a]
Clay	<2	<0.002	2.44-2.92[a]
Peat	0-40,000	0-40	1.26-1.90[a]
Muck	<74[b]	<0.074[b]	1.002[c]

[a] Source: Ou (2006); Venkatramaiah (2006)
[b] Fratta et al. (2010); 91% of the muck soil passed through a #200 wet sieve
[c] Source: Privately completed study

Sedimentation

The process of sedimentation removes suspended particles from water using gravity. Water is pumped into tanks, ponds, or basins where it remains for a time allowing the particles to sink. Once the particles have settled out, treated water exits the system leaving a build-up of sediments behind at the bottom of the tanks. The required holding time is based on the size and specific gravity of the particles with heavier particles requiring less time to settle. The treatment system is suggested for sand and silt, but the finer particles of clay and muck require additional time that may make this system impractical (Haman & Zazueta, 2014). The time required to

Table 2: Estimated settling velocity and the time required to settle 1 inch of different sized particles of muck and mineral (clay and silt) soils calculated from Equation 1.

	Muck		Mineral	
Specific Gravity	1.002 [a]		2.6 [b]	
Particle Size (microns)	Settling velocity (inches/minute)	Time to settle 1"	Settling velocity (inches/minute)	Time to settle 1"
1	2.7×10^{-6}	257 days	0.0022	7.7 hours
13	0.00046	37 hours	0.37	2.7 minutes
25	0.0017	10 hours	1.35	0.7 minutes
38	0.0039	4 hours	3.12	0.3 minutes
50	0.0068	2 hours	5.40	0.2 minutes

[a] Source: Privately completed studies
[b] Source: Haman & Zazueta (2014)

settle particles out of water can be determined using the following equation which is based on Stokes' law, assuming that the particle is spherical, smooth, and rigid:

$$V_p = 0.00135 \times d^2 \times (SG - 1) \qquad [1]$$

where V_p is the settling velocity of particles in water (inches/minute), d is the particle diameter (microns), and SG is the specific gravity of the particles (Haman & Zazueta, 2014).

Privately completed studies of four settling ponds treating washwater containing muck soil found that 90% of the particles were less than 50 microns in size. Washwater containing muck soils analyzed through the HMGA Water Project found that 87% of the particles were 5 microns and less in size, which was averaged across 6 sites ranging from 81 to 94% of total suspended solids. The results of this equation when applied to muck and mineral, specifically clay and silt particles, soils of this particle size are shown in Table 2. Muck soil particles have a specific gravity so close to that of water that they essentially float, therefore the time needed for the particles to settle is longer than for mineral soils. Sedimentation systems can be a viable treatment option for water with muck and clay soil particles, but they must be built larger than for water with silt and sand particles in order to handle the increased time required to settle out the particles.

Reverse Osmosis

Osmosis dictates that under normal conditions water travels through a membrane from areas of low to high concentrations in order to create an equal concentration on both sides of the membrane. Reverse Osmosis (RO) applies pressure to force the water to move from the side of the membrane with the high concentration of solids to the side with the lower concentration. The membrane does not allow the particulates to move with the water, and thus, the one side of the membrane becomes increasingly concentrated throughout the process. The water from the clean side of the membrane can be discharged. Water containing OM from muck soils has a lot of small-sized particulates. This causes the membrane to become clogged quicker and therefore filters must be replaced more often; this creates an increased work load and higher operating cost.

Chlorine Disinfection

The presence of organic matter (OM), which can be plant material and juices, microbes, and soil, deteriorates the quality of wash water (Gil et al., 2009; Pirovani et al., 2004). Chlorine can be added to wash water as a disinfecting treatment to manage human and plant pathogens. The chlorine, however, will react with OM and deplete the amount of available chlorine (Gil et al., 2009; Pirovani et al., 2004). When the available chlorine is decreased, the efficiency of the sanitization process and pathogen reduction is also decreased (Luo, 2007). The amount of chlorine that has reacted with organic matter can be measured as the difference between total chlorine and available, or free, chlorine (Pirovani et al., 2004). The degree by which chlorine reacts is directly related to the amount of product being washed in relation to the amount of wash water (Luo, 2007). While this relationship can be an issue when working with product from mineral soils, it becomes a larger problem with muck soils due to the increased amount of OM associated with this soil type. Costs are increased as more chlorine is required when treating water with this soil profile. Treatment systems working with both kinds of soils will need to be calibrated differently and monitored in order to be as efficient as possible.

Ultraviolet Sterilization

Ultraviolet (UV) sterilization is a point disinfection technique that only impacts the water quality at one time and has no residual effects. It works by damaging the DNA of microorganisms which prevents them from reproducing. Nothing is removed from the water but it is considered disinfected as the organisms cannot reproduce (Edstrom Industries, Inc.). The most common UV lamps used for disinfecting produce UV sterilization at 254 nm (Edstrom Industries, Inc.; Korshin et al., 1997). UV sterilization efficiency is impacted by the quality of the water, especially the amount and type of solids in the water (Gil et al., 2009). It is important for the user to test their washwater before choosing this system. Particulates that are suspended in the water cause problems as they can block the radiation from reaching the microorganisms (Edstrom Industries, Inc.). The same lamps used for disinfection are also used in another capacity to monitor the concentration of OM present to

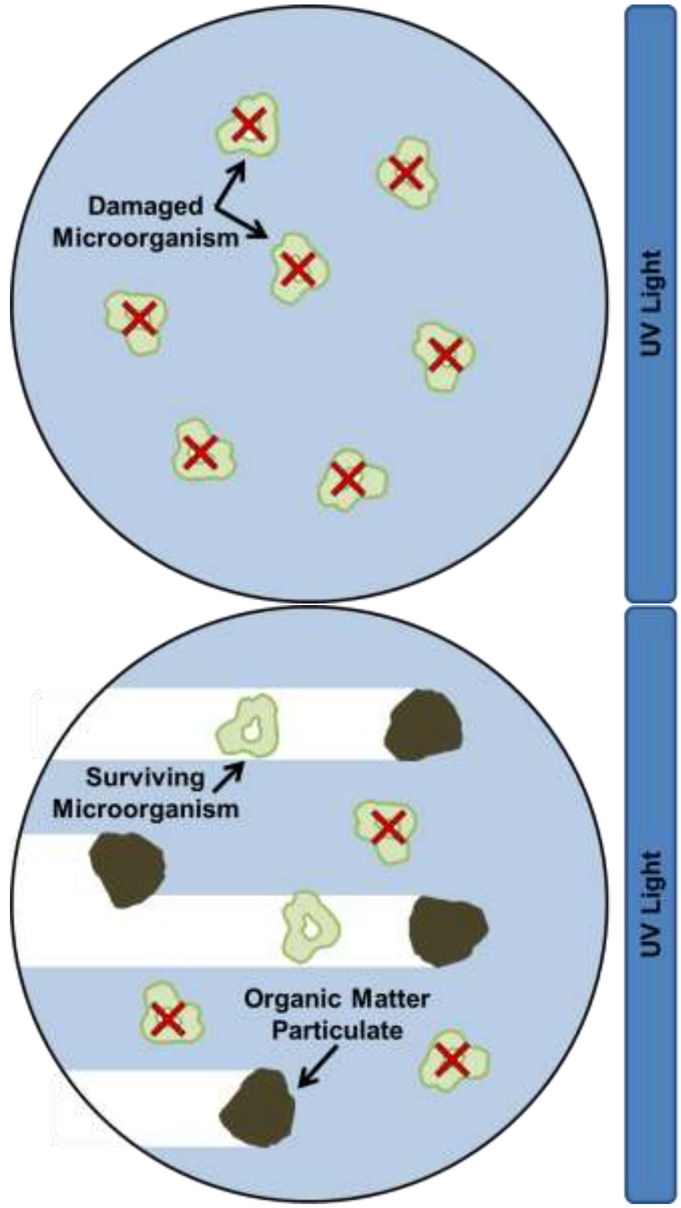

Figure 1: UV sterilization system with no organic matter particulates (top) and the same system with organic matter particulates and surviving microorganisms (bottom).

test water quality (Edstrom Industries, Inc.; Korshin et al., 1997). OM will absorb wavelengths from 200 to 400 nm, rendering the light ineffective as it does not penetrate through to the targeted organisms (Gil et al., 2009; Korshin et al., 1997). The organisms that are shielded from the light can travel through undamaged and continue to reduce the water quality as shown in Figure 1 (Edstrom

Industries, Inc.). The presence of solids in water can be quantified by turbidity which measures the lack of clarity as caused by suspended or dissolved solids (Canadian Council of Ministers of the Environment, 2002). The impact of organic matter on the efficacy of UV sterilization can be reduced by increasing the amount of water that passes close to the lamp and contact time thereby limiting shielding by OM (Gil et al., 2009).

Conclusion

Muck soils can have a detrimental effect on the efficiency and efficacy of several washwater treatment systems due to its unique characteristics. These impacts must be considered when designing systems that will handle this type of water as additional systems or considerations may be required to achieve the desired result.

References

Canadian Council of Ministers of the Environment. (2002). Total Particulate Matter. In *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

Edstrom Industries, Inc. (n.d.). Ultraviolet Disinfection. In *Water Research Center*. Retrieved October 22, 2014, from http://www.water-research.net /Waterlibrary/privatewell/UVradiation.pdf

Fratta, D. O., Puppala, A. J., & Muhunthan, B. (2010). *GeoFlorida 2010: Advances in analysis, modeling & design* (p. 2753). N.p.: ASCE Publications.

Gil, M. I., Selma, M. V., López-Gálvez, F., & Allende, A. (2009). Fresh-cut product sanitation and wash water disinfection: Problems and solutions. *International Journal of Food Microbiology*.

Haman, D. Z., & Zazueta, F. S. (2014, October). Settling basins for trickle irrigation in Florida. In *University of Florida IFAS Extension*. Retrieved from http://edis.ifas.ufl.edu/pdffiles/WI/WI01000.pdf

Luo, Y. (2007). Fresh-cut produce wash water reuse affects water quality and packaged product quality and microbial growth in romaine lettuce. *Hort Science*, *42*(6), 1413-1419.

Korshin, G. V., Li, C., & Benjamin, M. M. (1997). Monitoring the properties of natural organic matter through UV spectroscopy: A consistent theory. *Water Research*, *31*(7), 1787-1795.

Ou, C.-Y. (2006). *Deep excavation: Theory and practice* (p. 8). London, UK: CRC Press.

Pirovani, M., Piagentini, A., Güemes, D., & Arkwright, S. (2004). Reduction of chlorine concentration and microbial load during washing-disinfection of shredded lettuce. *International Journal of Food Science and Technology*, *39*, 341-347.

Venkatramaiah, C. (2006). *Geotechnical Engineering* (3rd ed., p. 32). New Delhi, India: New Age International.

This factsheet was prepared by Bridget Visser on behalf of the Holland Marsh Growers Association Water Project. This project was undertaken with the financial support of the Government of Canada through the federal Department of the Environment. Ce projet a été réalisé avec l'appui financier du gouvernement du Canada agissant par l'entremise du ministère fédéral de l'Environnement.