Assessment of a Minnesota Residential Septic System Affected by Home Hemodialysis

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Abstract

The University of Minnesota Onsite Sewage Treatment Program assessed a residential septic system in Minnesota owned by a patient undergoing home hemodialysis treatment for kidney failure to evaluate the wastewater being generated by the household and determine whether the composition of this wastewater has the potential to affect the function of the septic system. A site assessment and sampling for general wastewater constituents was done and showed higher than normal concentrations of Total Suspended Solids (TSS) at 142 mg/L, Total Kjeldahl Nitrogen (TKN) at 132 mg/L and Biochemical Oxygen Demand (BOD) at 198 mg/L. Chloride and Sodium were also found to be at higher than normal levels; 1,250 mg/L and 742 mg/L respectively. However, it is suggested that more data must be collected on this subject to observe any trends and further this research.

Introduction

The University of Minnesota Onsite Sewage Treatment Program conducted an assessment of a residential septic system owned by a patient undergoing home hemodialysis treatment for kidney failure. The purpose of this study was to evaluate the wastewater being generated by the household and determine whether the composition of this wastewater has the potential to affect the functioning of the septic system. Hemodialysis is one of two treatments used for kidney failure. It is a process that uses a dialyzer that functions as an artificial kidney to clean and clear extra fluid from the patient's blood. Plastic tubing transports blood from the patient's body, through the dialyzer where it passes through a filter and back into the body. The function of the filter is dependent upon a dialysis solution that also moves through the filter, removing waste products from the blood as it does so, leaving the filtered blood behind to be transported back to the body, see Figure 1 (NIDDKD, 2018). Each dialysis solution is formulated differently to meet the needs of each patient.

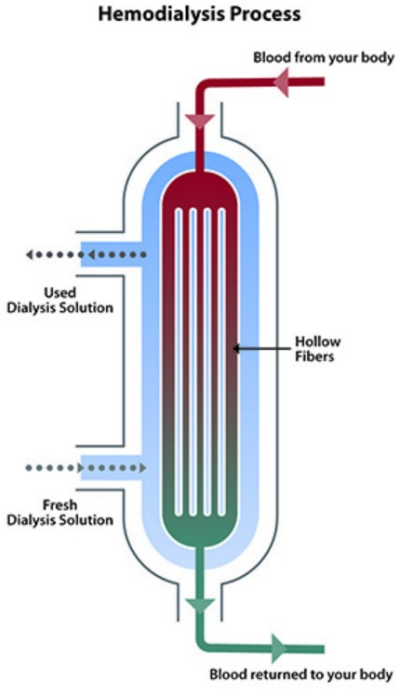

Figure 1 Hemodialysis Filter (NIDDKD, 2018)

The two wastewater streams produced by home hemodialysis are reverse osmosis reject water and a post-dialysis effluent called dialysate, in this system the two streams are combined at the output point Fresh dialysis solution has a high concentration of sodium and chloride and because of this, the dialysate dialysis solution is also high in sodium and chloride. If a patient is discharging this waste to their septic system, these high concentrations have the potential to negatively affect the function of the system. The reverse osmosis water is not harmful to a septic system because it is considered clean. The

only concern would be that, depending on a patient's treatment plan and schedule, a septic system may not be designed for the additional flow.

Many patients plumb their dialyzer directly into their home plumbing. Wastewater is usually discarded directly into the toilet and flushed. There is no published documentation about this issue but the general recommendation by septic professionals is that hemodialysis patients who are living in residences served by soil based wastewater treatment systems should be separately capturing the dialysate solution and discharging it into a below ground rock pit as to ensure there is no extra strain on their system (Heger, 2017).

Site Information

The homeowners involved in this project volunteered their septic system for assessment and testing. The site is a residence near the Snake River in Pine City, MN. There is a 1,500 gallon septic tank from which the wastewater flows via gravity to rock trenches. In the drainfield there is 15 inches of soil on top of the rock distribution media and a total of 12 inches of rock. The system is sized appropriately for the number of bedrooms and soil conditions. There is a demand-based water softener and at the time of this assessment, the water softener was in operation.

When the system was last inspected in 2017 there was 36 inches to the limiting condition according to the Minnesota state code. The system froze in January of 2018 likely due to a very shallow septic tank depth. The shallow depth of this tank in cold Minnesota temperatures can be unfavorable for fostering natural bacteria growth. It was estimated that in early April of 2018 the septic tank was cleaned.

Figure 2 Patient's Home Hemodialysis Station

The dialysis patient living in the home began home hemodialysis in May of 2018. He undergoes hemodialysis about five times per week with a treatment time of approximately three hours per treatment. Thirty liters (8 gallons) of dialysate are used per treatment. The hemodialysis machine gets cleaned about two or three times per month. The homeowner uses one hundred and twenty milliliters (0.03 gallons) bleach water solution to clean the plastic dialysis lines. This particular dialysis machine is plumbed into the home's water supply and discharges into the toilet.

Figure 3 The homeowner's hemodialyzer is plumed directly into the toilet

The homeowner mentioned that the patient is taking a calcium supplement as a facet of their treatment. Other than that vitamin regimen, there are no other types of medications being used.

The dialysate that that homeowner is using for each hemodialysis treatment is from Nx Stage Medical and include the following chemical compounds found in Table 1.

Table 1. Compounds Included in Homeowner's Dialysate Prescription

Compound	Name	g/L
NaC3H5O3	Sodium Lactate	156.88
CaCl2 + 2H2O	Calcium Chloride Dihydrate	4.63
MgCl2 + 6H2O	Magnesium Chloride Hexahydrate	2.13
KCl	Potassium Chloride	1.57
NaCl	Sodium Chloride	122.64
C6H12O6 + H2O	Glucose solution	23.1
1:20 (60L)		mE q/L
C3H5O3	Lactate	40.0
Ca++	Calcium ion	3.0
Mg++	Magnesium ion	1.0
K+	Potassium ion	1.0
Na+	Sodium ion	140.0
Cl-	Chloride ion	105.0
C6H12O6	Glucose	100.0 mg/dL
mS/cm	-	13.3
pH	-	6.0 – 7.6

Methods

Because this was a volunteer site, the only factor in the site selection process was that there was hemodialysis taking place onsite. During the visit the site characteristics were evaluated and samples were taken out of the outlet of the septic tank. The site evaluation included understanding the septic system, how the homeowner had set up the dialyzer, and looking at other site characteristics such as presence of a water softener and an irrigation system. See Appendix A for a map of the site. A sludge judge was used in the septic tank to measure the depth of water and how much sludge and scum were present in order to make a recommendation of whether the tank needed to be pumped or not. A soil boring was taken near the east end of the drainfield to look at the soil in the treatment area and obtain an understanding of separation to a limiting condition. Wastewater samples were taken from inspection pipe over the outlet baffle using a vacuum pump water sampler. Samples were brought to Pace Analytical where they were analyzed using various methods (see Table 2). Inside the house, the homeowner showed and explained the process of using and maintaining the hemodialysis machine.

Results and Discussion

Septic System

Using a sludge judge to measure, the depth of the water in the septic tank was about 48 inches and there was about 8 inches of sludge on the bottom of the tank and minimal scum. The MN rule states that the sludge and scum value must not exceed 25% of the tank's liquid capacity. For this tank, 25% would be 12 inches of sludge and scum, so at 8 inches this tank does not need to be pumped at this time. The inspection caps in the drainfield were removed from all visible inspection pipes and were all observed to

be dry. The drainfield was located near the home under turf grass. The soil boring was dug directly off the east side of the drainfield, on a < 1% slope between the far and middle trenches. The soil was observed to 60 inches. Digging was stopped after evidence to periodically saturated soil (limiting condition) was observed between 53 and 60 inches. Soil textures were generally sandy.

Wastewater

Table 2. Wastewater Parameters of Septic Tank Effluent at Hemodialysis Site

Wastewater Parameters	Site Septic Tank Effluent	Typical Septic Tank Effluent	Analytical Method
Total Kjeldahl Nitrogen (TKN)	132 mg/L	40-100 mg/L *	EPA 351.2 rev.2
Biochemical Oxygen Demand (BOD)	198 mg/L	140-200 mg/L*	Hach 10360 Rev.1
Total Suspended Solids (TSS)	142 mg/L	50-100 mg/L*	SM 2540D
Fecal Coliform	Too numerous to count	1000000 – 100000000 MPN per 100ml**	SM 9222D
Sodium	742 mg/L	50 mg/L***	EPA 200.7
Chloride	1,250 mg/L	18 mg/L***	SM 4500-Cl E
Phosphorus	7.3 mg/L	6 - 12 mg/L**	SM 4500-P F

*EPA (2002) ** Siegrist (2017) ***Lowe (2009)

TKN

Total Kjeldahl Nitrogen is the combination of organic nitrogen, ammonia and ammonium- nitrogen. The primary source of nitrogen in septic system wastewater is urine. The other sources of nitrogen are digested and undigested food and commercial cleaners. TKN concentrations at this site were 132 mg/L, which is high for typical domestic wastewater which averages 40-100 mg/L.

BOD

Biochemical oxygen demand is the amount of dissolved oxygen consumed by microorganisms that are breaking down organic matter in wastewater. This was measured in the study because it is an indicator of waste strength. Typical strength for domestic wastewater in a septic tank is 140-200 mg/L of BOD. BOD concentrations were above expected at 198 mg/L with two people residing in the home and a 1,500-gallon septic tank. This could be a result of higher levels of glucose due to the dialysate entering the system but is not high enough to be of concern.

TSS

Total suspended solids are a measure of the solids that remain in the wastewater after settling has occurred in the septic tank. TSS is also a measure of waste strength. Typical TSS for residential septic tank effluent is 50-100 mg/L. TSS concentrations were high for this site at 142 mg/L, particularly with two people residing in the home and a 1,500-gallon septic tank

Fecal Coliform

Fecal coliform bacteria is an indicator bacteria common to the digestive systems of warm-blooded mammals. This analysis was performed to determine the overall bacterial count in the wastewater. The

fecal coliform concentrations were reported from this sampling event as too numerus to count (TNTC). This indicates the laboratory did not sufficiently dilute the wastewater prior to analysis, but that overall the bacteria count was numerous.

Sodium and Chloride
Sodium concentrations at this site were 742 mg/L and chloride concentrations were 1,250 mg/L, both are higher than normal. These high concentrations could be caused by the composition of the dialysate solution and running the water softener.

Total Phosphorus
Phosphorus in wastewater comes from feces, detergents and other household cleaning supplies. Total phosphorus concentrations at this site were 7.3 mg/L. To show comparison, a normal range of total phosphorus in septic effluent reported by the Environmental Protection Agency in 2002 is 6-12 mg/L.

Recommendations

As a result of the higher than normal TKN concentrations, it is recommended that the homeowner not dispose of any undigested food into the system, evaluate all cleaners and remove those that contain ammonia or nitrogen. It could also be helpful, because of the higher than normal levels of BOD and TSS, to evaluate if there are any sources of organic material that can be reduced such as a garbage disposal. Overtime, if the levels stay high, it could plug up the soil treatment area. It would also be helpful, in order to reduce TSS, to add an effluent screen on the outlet of the septic tank.

High sodium and chloride concentrations can affect the function of the septic system by potentially killing or changing the organisms that the system needs to function properly. The septic system can also be affected negatively by these high levels because they could potentially foster organism overgrowth either in the tank or downstream. (Heger, 2017). To help minimize the potential effect of the water softener it is recommended to either have it adjusted to regenerate less frequently, not run the discharge to the septic system, or discontinue use.

The general recommendation for home hemodialysis patients is to not discharge post-dialyzer effluent to the septic system because the high saline content of the fluid could affect proper wastewater treatment. For this specific site there were no signs of impact in the drainfield but with continued use it is possible. Due to the elevated wastewater constituents resulting from this sampling event, more sampling is needed to determine if these results are consistent.

Future Research

Further research of this kind should continue at this site. There needs to be more data collected to observe contaminant concentration trends. The University of Minnesota Onsite Sewage Treatment Program has sent out a communication to septic system maintainers for more homeowner volunteers such as this one in hopes of collecting more data to further this research. Contact the program at sheger@umn.edu of you are interested in participating.

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