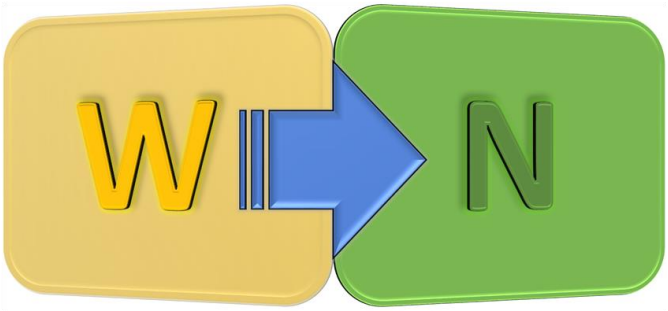
Project Purpose



Urine is an unsterile, nutrient-rich resource that can be used to fertilize plants. Human urine contains high quantities of nutrients such as nitrogen and phosphorous. Though urine is unsterile, it does not contain the same hazards, bacterial pathogens, which exist in the solid waste. Separating urine from solid waste is an effective approach to recover nutrients. Exploiting the benefits of urine is a good way of 'closing the cycle' in agriculture nutrient flows. This system could also possibly reduce sewage costs and ecological consequences, as well as improve sanitation in developing areas. This project focuses on the nitrogen recovery from liquid waste as a laboratory model intended for future applications implemented on a household scale.

Liquid waste is mostly in the form of ammonia species and must be oxidized to nitrate before plants can take it up through their root systems. Nitrogen compounds are reduced and are sequentially oxidized to nitrite and nitrate by nitrifying bacteria through the nitrification process. The main purpose of the nitrification column is to convert nitrogen compounds in urine (Ammonia) to a form that can be used by plants directly. The nitrification column provides suitable growth and living conditions for the bacteria involved in the process of nitrification. The systemwill also have a nitrate solution dispersal system to provide the ability to utilize the solution on plants.

Project Location

Waste to Nutrients is the name of the nitrification column design project. The design and construction of a laboratory model, intended for future applications implemented on a household scale, will be completed in the CENE laboratory located in room 245 of the NAU Engineering Building.

Project Constraints

The constrains of this project are limitations that the design work presents. This system only considers liquid waste influent. This system will not consider any solid waste influent, or the separation of the two types of waste. The only nutrient that this system is designed to collect and utilize is nitrate. The scale of this project is only four a household with home gardens. This excludes utility scale projects and mass agriculture. Though this project is a design for a household scale system, the design and construction of the laboratory model will be scaled.

Determination of Growth Media Characteristics and Selection of Bacterial Source

Three growth medias were tested under the same conditions. The medias tested were Pine Shaving, Cedar Shaving and Dry Straw. Showed in the figure below respectively. These medias were selected for their apparent Absorbability, Decomposability and Compressibility. Each of these medias were also tested with one of each type containing the natural sample and one of each with the "pure" sample (Quickstart TM).

Credit: Photo by Siwen Li

The samples were tested two days after urine addition. This was done to gauge the change in the system for each of the bacteria types. This data collected from these samples are found in the following table.

Growth Media Test #	Bacteria Sample	Growth Media Mass (g)	Tap Water Volume	Test Time	COD (mg/L)	NH_3 (mg/L NH_3-N)	NO_2^- (mg/L NO_2^--N)	NO_3^- (mg/L NO_3^--N)
Pine #1	Wildcat	15.02	240 mL	Oct 10	2145	5.9	0.15	9.22
				Oct 12	5320	12.3	0.63	16.5
Pine #2	Pure	15.02	240 mL	Oct 10	2144	6.1	0.10	9.79
				Oct 12	5400	10.6	0.54	15.3
Cedar #1	Wildcat	15.02	240 mL	Oct 10	2169	6.1	0.13	11.2
				Oct 12	2640	13.9	0.29	14.6
Cedar #2	Pure	15.04	240 mL	Oct 10	2131	6.3	0.12	10.0
				Oct 12	3170	17.2		20.5
~~Straw #1~~	~~Wildcat~~	~~15.03~~	~~240mL~~	~~Oct 10~~	~~3402~~	~~20.9~~	~~0.98~~	~~20.7~~
~~Straw #2~~	~~Pure~~	~~15.02~~	~~240mL~~	~~Oct 10~~	~~4459~~	~~18.7~~	~~1.19~~	~~24.2~~

The table above shows alternatives for growth medias and bacterial source. Though the Beaker 1 with eth WCH bacteria displayed the most effective nitrification, we selected the API bacteria to use in the final design because it has less interference from residual bacteria. The dry straw was not considered because of its foul odor and rapid decomposition. Pine was selected over cedar because it demonstrated the highest adorability and lowest decomposition. It should be noted that cedar dyed the effluent a reddish color, this was undesirable.

Determination of Column Cartridges

There were three main trials conducted. These are described by the following table.

Trial #1	**Trial #2**	**Trial #3**
Pre-saturated VS Start-up Fluid (40 cm columns)	40 cm Column VS. 60 cm Column	40 cm Column VS 80 cm Column

The influent and effluent total nitrogen in the system was measured for each test. However, there was only a plus or minus concentration of approximately 1%. Thus, we can conclude that there was no loss of nitrogen within the system.

The percent efficiency of trial 1 is described by the following table.

	Pre-Saturated	**Start-up Fluid**
Ammonia (%)	Increase 40%	Decrease 34%
Nitrate (%)	Increase 16.3%	Increase 24.5%

This trial seemed to result in some very odd data. It appears that for the pre-saturated column there was an increase in the initial ammonia concentration and a negative organic nitrogen concentration. This is not true. We believe the reason for this odd data is the residual nitrogen in the growth media that escaped out with the effluent.

The percent efficiency of trial 2 is described by the following table.

	40 (cm)	**60 (cm)**
Ammonia (%)	Decrease 32.96%	Decrease 45.04%
Nitrate (%)	Increase 19.12%	Increase 21.32%

This trial demonstrates that system efficiency increases with the column length. The 60cm cartridge test showed the greater decrease in ammonia and greater increase in nitrate.

The percent efficiency of trial 3 is described by the following table.

	40 (cm)	**60 (cm)**
Ammonia (%)	Decrease 53%	Decrease 75.6%
Nitrate (%)	Increase 7.6%	Increase 6.7%

This cartridge test has a significant reduction in nitrate being produced. We believe this is because of ammonia concentration entering the column was almost three times stronger. As can be expected the 80 cm column had the greatest system efficiency.

Final Design

We wanted a minimum of 80% efficiency in this column design. We previously found that 80cm had an efficiency of about 75%. For easy of construction a 120 cm Column height was selected with a 2 cm diameter. Increasing the diameter allowed for an increased loading rate. We hypothesized that this would grant us our desired 80% system efficiency. This system was design with the API system start-up fluid.

This design was constructed with 2 plastic cartridges, the housing unit, and miscellaneous purchases totaling about $135. This system was then constructed, drilling oxygen intake wholes within the column cartridges. This is illustrated by the figure on the left.

The percent efficiency of final design test is described by the following table.

	120 (cm)
Ammonia (%)	Decrease 80%
Nitrate (%)	Increase 61.5%

The final design was able to accomplish the goal of 80% efficiency. The final design also significant increased the nitrate production. The design team was expecting a nitrate increase in the 30% ‘s. The design team believes that the increased nitrate production was due to improved oxygen flow within the system.

List of Tasks and Working Hours

The table below represents the hour load for each completed task and sub task for each team member.

Task	**Planned Hours**	**Actual Hours**	**Emily**	**Adrian**	**Siwen**
1.0 Legality and Sanitation Aspects	**10**	**10**	**4**	**1**	**5**
1.1 State Local and Federal Regulations	*2.5*	*5*			*5*
1.2 Effluent Quality Regulations	4	1		1	
1.3 Hazards to Public Safety	3.5	4	4		
2.0 Preliminary Lab Work	**11.5**	**38**	**18**	**18**	**6**
2.1 List of Standard Methods	*4*	*30*	*15*	*15*	
2.2 Standard Method Access	*3.5*	*4*			*4*
2.3 Lab Access	*2*	*2*	*2*	*1*	*1*
2.4 Material and Equipment Accesses	*2*	*2*	*1*	*2*	*1*
3.0 Initial Lab Work Considerations	**82.5**	**199.5**	**66.5**	**75**	**58**
3.1 Urine Samples	*7.5*	*7.5*	*7.5*		
3.2 Urine Dilution	*15*	*45*	*10*	*25*	*10*
3.3 Bacteria Acquirement	*10*	*30*	*10*	*10*	*10*
3.4 Batch Sample Establishment	*25*	*90*	*30*	*30*	*30*
3.5 Growth Media Selections	*25*	*27*	*9*	*10*	*8*
4.0 Column Cartridge Lab Testing	**175**	**271**	**86**	**106**	**79**
4.1 Cartridge Testing Method	12.5	3	1	1	1
4.2 Cartridge Data Collection	55	210	70	75	65
4.3 Cartridge Analysis	57.5	43	10	25	8
4.4 Cartridge Conclusion	50	15	5	5	5
5.0 Final Design Considerations	**25**	**26**	**3**	**6**	**3**
5.1 Design Concept Generation	*11.5*	*8*	*2*	*4*	*2*
5.2 Design Concept Analysis	*11.5*	*3*	*1*	*1*	*1*
5.3 Design Concept Selection	*2*	*15*	*5*	*5*	*5*
6.0 Final Design Calculations	**7**	**40**	**17**	**16**	**7**
6.1 Determine Desired Efficiency	5	12	1	10	1
6.2 Determine Column Dimensions	5	25	15	5	5
6.3 Request Last Minute Feedback	*2*	*3*	*1*	*1*	*1*

7.0 Constructions of Final Design	**22.5**	**10**	**0**	**10**	**0**
8.0 Final Column Design Testing	**20**	**14**	**2**	**10**	**2**
8.1 Column Testing Method	*4*	*2*			*2*
8.2 Column Data Collection	*10*	*10*		*10*	
8.3 Column Analysis	*4*	*1*	*1*		
8.4 Column Conclusion	*2*	*1*	*1*		
9.0 Project Management	**25**	**120**	**55**	**25**	**40**
Total Hours	**378.5**	**728.5**	**251.5**	**267**	**205**