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# Use of Membrane Filtration Techniques to Recover Nutrient from Environmental Waste

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***Abstract*— Among Environmental waste Urine is the most nutrient-dense household waste product produced by humans and cows. Urine separation has been suggested as a way to maximize nutrient recovery and recirculation in the environment. Environmental Nutrient pollution impairs water and environmental quality. The combination of multiple stages of recovery options in this paper leads to the development of a dependable, yet straightforward prototype. This is achieved through a series of experiments on the prototype with corresponding recovery percentages of potassium, nitrogen, and total solid from both synthetic urine and cow urine using membrane techniques. On top of that, the proposed prototype may help adjusting the choice of potassium, nitrogen, total solid recovery according to the concerned use of product.**

***This paper examines the industrial and cost-effective feasibility of membrane filtration technology in the potassium, nitrogen, and total solid recovery process. Specifically, it aims to reduce bulk and increase potassium, nitrogen, and total solid concentration through the application of membrane filtration techniques, namely ultra filtration membrane and reverse osmosis membrane.***

***Index Terms*— Nutrient Recovery, Phosphate Recovery, Ammonia Recovery, Membrane-Based Process**

## I. INTRODUCTION

In the domain of environment waste urine is currently undergoing a paradigm shift from a mindset that views it as a waste that has to be treated to one that is proactive in trying to recover elements and energy from these streams. This work focuses on the creation and implementation of a methodical, prototype-based approach for creating sustainable and commercially viable membrane-based nutrient recovery systems.

Urine is recognized as a source for nutrient recovery for reasons:

- There exists a huge concentration of nutrients;
- This is available in large quantities.

Because the membrane can enrich nutrients, it is a promising method of recovering nutrients from urine. It may eventually improve the nutrient retrieval process's technical and economic feasibility. Phosphorus and nitrogen are main nutrients for the organism growth.

But these nutrients can also cause eutrophication, which can seriously deteriorate the quality of the water and possibly even cause aquatic life to perish. As a result, the release of nutrients needs to be properly controlled. Urine nutrient removal and nutrient release concentrations of less than 1-6 mg N/L and 0.4 mg P/L, respectively, are required for this purpose. The primary current forms of N and P are ammonium and phosphate ions in urine, respectively. (Amanda et al., 2015).

The presence of heavy metals and other impurities has detrimental effects on the formation of nutrients throughout the regeneration phase, including lowering the quality of restored nourishment. The retrieved struvite crystals were found to contain hazardous heavy metals, with an even higher concentration of arsenic than 497 mg/kg, it was decided. Because of its poor quality and purity, the use of such recovered struvite in agriculture may be prohibited as a result.

The goal of the current work is to recover nutrients (N, P, and K) from synthetic pee and cow urine using membrane filtering techniques. This will allow the nutrients to be separated from undesirable or hazardous elements, increasing the nutrients' potential for usage. Since the membrane system may enhance the nutrient within the shell with few or no undesirable components, it is more in demand for nutrient recovery.

## II. MATERIALS AND METHODS

UF Membrane

Sponge Filter

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Pump

RO membrane

**Basic Process Configuration**

The test was performed on the following setup using cow urine:

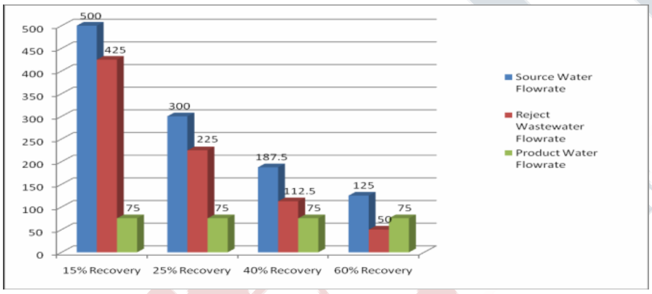
*One Stage R.O Recovery System*


Permeate & Reject Volume in 1 st Trial

1 stage R.O System

| Sl. No. | Parameter | Raw | | Reject | | Permeate | | % Recovery |
|---|---|---|---|---|---|---|---|---|
| | | Conc. | Total(g) | Conc. | Total(g) | Conc. | Total(g) | |
| 1 | Volume (L) | 8 | | 6.2 | | 1.6 | | |
| 2 | Total Solids (mg/L) | 2539.2 | 203.136 | 30981.2 | 192.083 | 5888.125 | 9.421 | **94.56** |
| 3 | Urea (mg/L) | 1800.1 | 144.008 | 20976.78 | 130.056 | 3001.2 | 4.802 | **90.31** |
| 4 | Phosphorous(mg/L) | 1550 | 12.400 | 1822.24 | 11.298 | 33.75 | 0.054 | **91.11** |
| 5 | TKN (mg/L) | 4282.2 | 34.258 | 4991.1 | 30.945 | 59.5 | 0.095 | **90.33** |

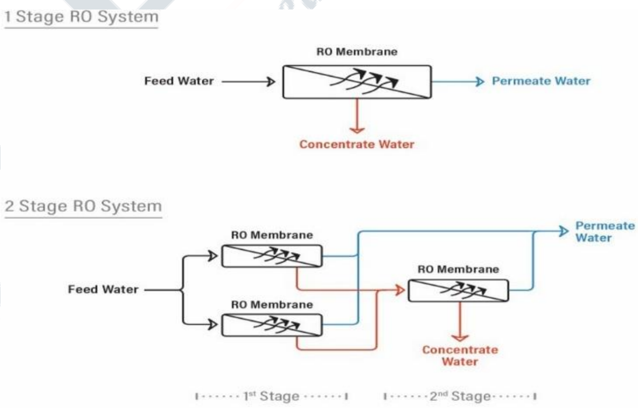
Here, while the amount of the recovered nutrients was also quite high, the recovery % was high, defeating the entire purpose of the R.O Membrane's ability to recover and concentrate the nutrients. (Sendrowski and Boyer, 2013).




According to Lalit Mohan Sharma's paper, "Reverse osmosis is not a viable option for water purification in water stressed regions of India," we found that R.O. performance varies between 15 and 60 percent, and that the nutrient recovery percentage is highest when the reject volume is significantly lower than the permeate volume.

This statistic helps us understand that in order to increase the percentage recovery, we must set up the reject volume to either decrease or be substantially less than the permeate volume.

In a two-stage design, the focus (or dismissal) from the first step becomes the feed water for the second phase. The permeate water from the first stage is collected with the permeate water from the second stage. Phases two and three enhance system recuperation.




(https://puretecwater.com/reverseosmosis/what-is-reverse-osmosis)

*Two Stage R.O Recovery System*

Permeate & Reject Volume in 1st Trial
2 stage R.O System

Permeate & Reject Volume in 1st Trial
2 stage R.O System

Permeate & Reject Volume in 1st Trial
1 stage R.O System

| Sl. No. | Parameter | Raw | | Reject | | Permeate | | % Recovery |
|---|---|---|---|---|---|---|---|---|
| | | Conc. | Total (g) | Conc. | Total (g) | Conc. | Total (g) | |
| 1 | Volume (L) | 8 | | 4.38 | | 3.23 | | |
| 2 | Total Solids (mg/L) | 2539.2 | 203.136 | 34367.25 | 150.529 | 15475.24 | 49.985 | 74.10 |
| 3 | Urea Nitrogen (mg/L) | 1800.1 | 144.008 | 25401.35 | 111.258 | 9238.64 | 29.841 | 77.26 |
| 4 | Phosphate (mg/L) | 1550 | 12.400 | 2087.1 | 9.141 | 999.97 | 3.230 | 73.72 |
| 5 | TKN (mg/L) | 4282.2 | 34.258 | 5869.02 | 25.706 | 2447.67 | 7.906 | 75.04 |
| 6 | pH | 7.92 | | 7.98 | | 7.12 | | |

After reading through a number of publications, we discovered that Lennetch RO Water Chemistry states that high TDS levels cause significant osmotic pressure. In order to counteract this osmotic pressure, the RO feed pump must provide sufficient pressure. As a general guideline, saltwater with 36789 parts per thousand TDS generates an osmotic pressure of 383 psi. (Peavy et al., 1985).

Consequently, we created a high-pressure stage that produced an output pressure of 200 psi with this in mind. To manage or regulate the pressure inside the RO, a valve was also included in the design of the system at the reject exit.

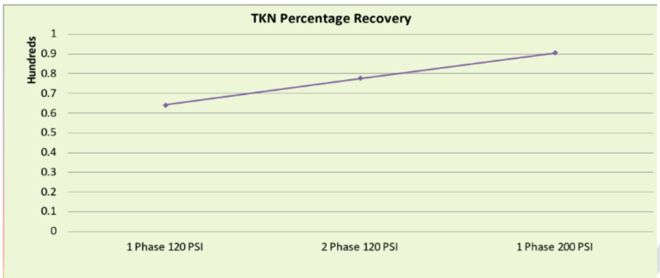
*High Pressure Stage R.O Recovery System*

**Table 3:** Results of high pressure stage

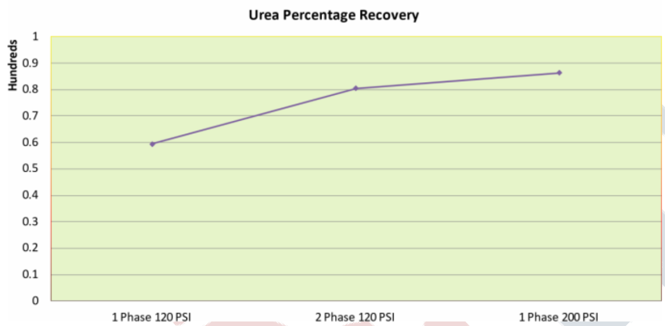
| Sl. No. | Parameter | Raw | | Reject | | Permeate | | %Recovery |
|---|---|---|---|---|---|---|---|---|
| | | Conc. | Total (g) | Conc. | Total(g) | Conc. | Total(g) | |
| 1 | Volume (L) | 8 | | 4.1 | | 3.4 | | |
| 2 | Total Solids (mg/L) | 2539.2 | 203.136 | 42536.69 | 174.400 | 7451.76 | 25.336 | **85.85** |
| 3 | UreaNitrogen (mg/L) | 1800.1 | 144.008 | 28925.2 | 118.593 | 5269 | 17.915 | **82.35** |
| 4 | Phosphate (mg/L) | 1550 | 12.400 | 2461.9 | 10.094 | 551.8 | 1.876 | **81.40** |
| 5 | TKN (mg/L) | 4282.2 | 34.258 | 6991.01 | 28.663 | 1545.58 | 5.255 | **83.67** |
| 6 | pH | 7.92 | | 7.98 | | 7.12 | | |

## III. RESULTS

Percentage Recovery Variation of TKN with Pressure

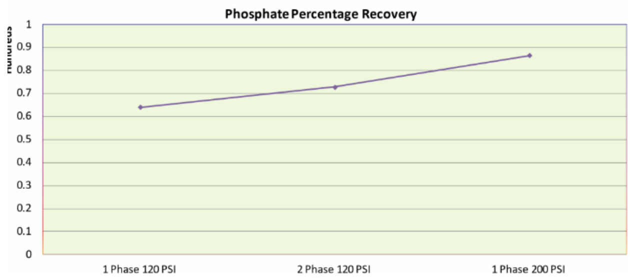



Percentage Recovery Variation of Urea with Pressure




**Comparison of 4 Stages**

Percentage Recovery Variation of Phosphate withPressure




## IV. CONCLUSIONS

At the moment, nutrient recovery is more crucial than nutrient removal. Since it is known that the pore size of a membrane affects the membrane filtering method and that water in the feed will pass through the membrane under the necessary pressure, membrane technology is useful in recovering nutrients. Chemicals and energy are not used in the membrane separation process because it is a simple physical process. Because of its related feasibility, the membrane separation process is therefore more recommended than any other separation method in terms of operating and maintenance costs. It can concentrate the nutrient with higher purity, which can improve the financial viability of the nutrient retrieval process. The analysis of the first, second, and high stress phases revealed that a rise in output recovery percentage and a sufficient reduction in volume result in a large increase in the nutrient retrieval proportion. Finally, but just as importantly, nutrient recovery can reduce the harsh effects of sewage therapy and save expenses. The main issue it raises, though, is the requirement for energy and membrane fouling, which must be sufficiently handled by fusing biological processes with membrane technology in order to effectively separate organics through metabolic activity and reduce the likelihood of fouling. Because there is an opportunity to increase the recovery percentage, the thesis does not address the possibility of advancing the project.

## V. FUTURE WORKS

In order to research the recovery percentage and the volume of rejected urine and permeate urine, reverse osmosis performance in this thesis is confined to the use of 200 psi output pressure. This should be carried out with output pressure up to 1000 psi and appropriately replace suitable RO membrane.

Reverse osmosis performance depends upon the following parameter: - Feed pressure Permeate pressure Temperature Permeate conductivity.

The impact of temperature variation has to be the focus of attention because it is an important design element. A few of the variables that affect it are the solubility of the permeate, the pressure requirements of the feed pumps, and the hydraulic flow between these two. Thus, it is advised that every component influencing temperature be thoroughly examined. Generally speaking, every 10 degrees Fahrenheit drop in feed temperature results in a 15% increase in feed pump pressure requirements. (Kuntke et al., 2012)

Variation in pH can also effect the rejection of ions and needs detailed study.

Further study on membrane technology is needed, with an emphasis on potential membrane fouling at low cost. ROM Membrane fouling reduces the productivity of nutrient restoration by impairing membrane efficiency and shortening membrane life. Strong separation procedures are therefore required to recover nutrients from difficult wastewater streams.

To improve the applicability of membrane filtration technology and thus reduce the number of membrane fouling situations, we also need to incorporate another biological technique. (Kuntke et al., 2012).

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