Optimizing Fertilizing Characteristics of Stored Human Urine

Shervin Hashemi*, Mooyoung Han*, Tschungil Kim**

* Department of Environmental Engineering, Seoul National University, Seoul, 151-742, Republic of Korea (E-mail: *myhan@snu.ac.kr*)
** Integrated Research Institute of Construction and Environmental Engineering, Seoul National University, Seoul, 151-742, Republic of Korea

Abstract
Because of the high concentration of nutrients in human urine, its utilization as an organic fertilizer has been notable throughout history. However, the nitrogen compounds in urine are not stable. Therefore, to convert urine into a suitable fertilizer, it is important to stabilize and adjust unstable nitrogen compounds such as ammonia. Because nitrification can influence the nitrogen profile, the use of nitrifying microorganisms can be useful for stabilizing the nitrogen profile of urine. In this study, we investigated the changes in nitrogen compounds in pure urine and examined the effect of adding *Nitrosomonas Europaea* bio-seed solution on these changes. We found that the addition of bio-seed could reduce nitrogen loss as well as the time required to stabilize nitrogen profile. Furthermore, we determined the optimum concentration of bio-seed (6×10^5 *N. Europaea* cells/L) that not only leads to the least nutrient loss but also results in the adequate nitrate : ammonium ratio and regulates the amount of nitrate produced, thereby preventing over-fertilization. At this concentration, no dilution or dewatering is required, thus, minimizing water and energy consumption. Usage of optimum of concentration of bio-seed will also eliminate the need for inorganic chemical additives.

Keywords
Fertilizer; Nitrogen Profile; *Nitrosomonas Europaea*; Resource Oriented Sanitation; Urine

INTRODUCTION

Urine has been collected and used as fertilizer in different parts of the world. This is because in ancient times, people had empirical knowledge of the high concentration of nutrients in urine, such as nitrogen, phosphorus, and potassium compounds, which makes it a good fertilizer. Among the nutrients in urine, the nitrogen profile changes with time, owing to chemical reactions among different compounds such as ammonia, ammonium, nitrite, and nitrate. Therefore, in order to optimize the utilization of urine as a fertilizer, studies of the changes in nitrogen profile in resource oriented sanitation systems are required. Concentration of ammonium and nitrate in urine depends on the chemical reactions involving ammonia. However, because of the high pH of stored urine, ammonia is released as gas; not only is this the main reason of urine odour, but it also suggests loss of nutrients. Although plants absorb nitrogen as either nitrate or ammonium, high concentrations of nitrate in a fertilizer can damage soil and plants. The European Commissions (EC) standards state that the ratio of ammonium (NH_4^+) and nitrate (NO_3^-) in a nitrogen fertilizer should be 1:1 for it to be identified as a standard fertilizer. In this case, nitrifying microorganisms such as Nirosomonas can be utilized, as they can accelerate the changes in nitrogen composition via biochemical reactions such as nitrification. The objectives of this study are as follows: (1) To understand the chemical changes in nitrogen profile and determine the optimum characteristics of pure urine for it to be utilized as fertilizer. (2) To investigate the biochemical enhancement of fertilization properties of urine by using *Nitrosomonas Europaea* bio-seed at different concentrations and to determine the optimum concentration of the bio-seed.

MATERIALS AND METHODS

Pure urine samples were collected from men's waterless urinals designed for research purposes installed in Building No. 35 of Seoul National University. Microbial bio-seed solution containing 6×10^6 *Nitrosomonas Europaea* cells/100 mL was used for the experiments. A 1-L beaker filled with urine was used as an open-batch bioreactor. Pure urine was used immediately for the experiment. Different volumes of bio-seed

solution were added, and the mixture was stirred, but subsequently, no mixing was done throughout the experiment. Total nitrogen, NH_3, NH_4^+, and NO_3^- were quantified using UV/Visible Spectrophotometer Model HS-3300. The nitrogen loss at each time interval was considered as the difference between measured total nitrogen at that interval and that at the previous interval, whereas the difference of total nitrogen compared to the sum of all compounds that are measured separately has been taken as concentration of other nitrogen compounds.

RESULTS AND DISCUSSIONS

Figure 1 shows how the nitrogen profile of pure urine changed with time. The results show about 30% nitrogen loss. Thus, in order to improve the fertilization characteristics, nitrogen loss should be minimized, while maintaining the nitrate : ammonium ratio at approximately 1:1. The nitrogen profile of stabilized urine can meet the nitrate : ammonium ratio requirement, but there is high nitrogen loss, which leads to more smell production; this hinders the utilization of urine as fertilizer. Figure 2 shows the stabilized nitrogen profile in urine by using different concentrations of bio-seed. According to the results, in the sample with 6×10^5 *N. Europaea* cells/L, nitrogen loss was approximately 11%, which means that nutrient reduction and odour production were approximately three times lower than that in urine without added bio-seed. Furthermore, the 1:1 ratio of nitrate : ammonium conforms to the EC standards and regulations for fertilizers.

CONCLUSION

Investigation of the chemical changes in nitrogen compounds in pure urine showed that there is extensive nitrogen loss, implying loss of nutrients and production of odour. Addition of *N. Europaea* bio-seed can influence the nitrogen composition by way of nitrification, which leads to reductions in nitrogen loss and stabilization time. However, adding excess bio-seed leads to higher production of nitrate, which can cause soil pollution. We identified the optimum dosage range of bio-seed of 6×10^5 *N. Europaea* cells/L, which ensures the best fertilization characteristics of urine, according to the EC standards.

ACKNOWLEDGMENT

This research was supported by Korea Ministry of Environment as Eco-Innovation project (413-111-008) and Advanced Industrial Technology Development project (2014000150010).

REFERENCES

Hashemi, S., Han, M., Kim, T. (2016) Optimization of Fertilization Characteristics of Urine by Addition of Nitrosomonas europaea Bio-seed. *Journal of the Science of Food and Agriculture*, **In Press**, doi: 10.1002/jsfa.7652.

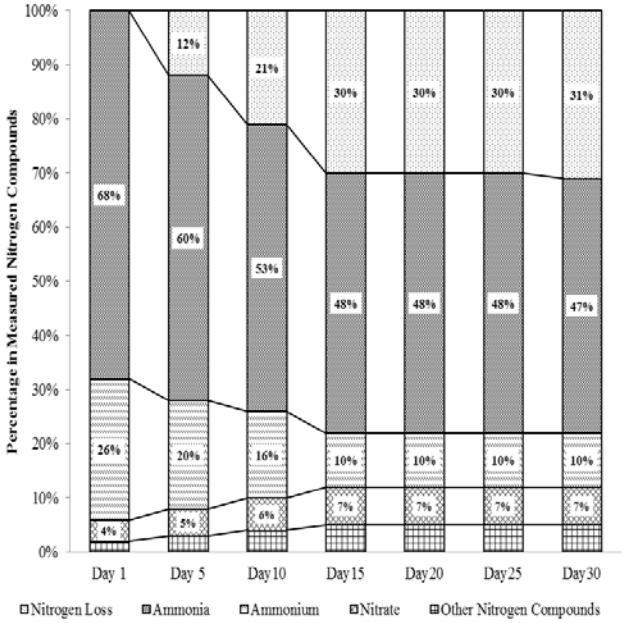

Figure 1. Changes in Nitrogen Profile versus Time in Pure Urine

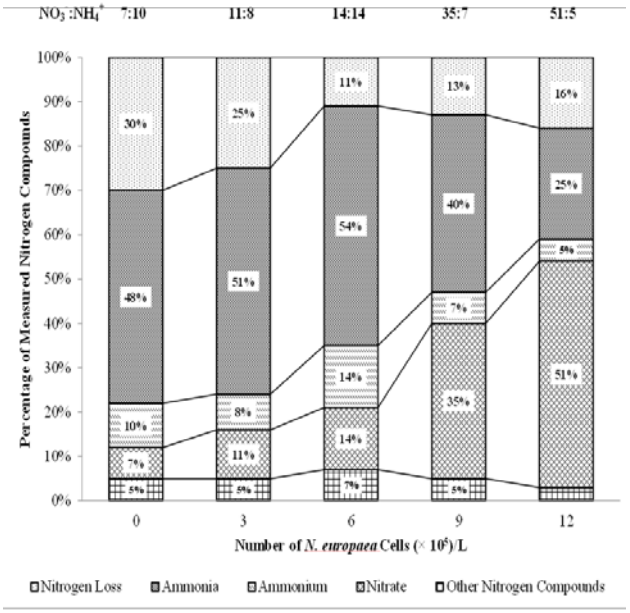

Figure 2. Stabilized Nitrogen Profile after Adding Different Concentrations of *N. europaea* Bio-seed