Thermal treatment as a method to reduce storage volume and inhibit decomposition of urea in human urine

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Abstract

It is suggested by the World Health Organization (WHO) that urine should be stored for at least six months at 20℃ before applying to the agricultural fields in order to reduce the potential health risks from pathogenic organisms. However, such a storage condition requires large space, longer period of time, and neglects the risk of losses of nitrogen. In this study, thermal treatment was investigated for human urine storage, including undiluted urine and diluted urine. Firstly, The urine samples diluted at a ratio of 2 were stored under ambient temperature, 60℃ and 70 ℃ for several days, respectively in order to find out the optimal thermal treatment condition, and then the selected storage condition were tested for undiluted and diluted urine samples storage for continuous monitoring. During the storage, pH, ammonia concentration, total coliforms, fecal coliforms and E. coli were detected. It has been demonstrated that diluted urine stored under the temperature of 70 ℃ could be hygienized and stabilized within 7 days. The comparative investigation for undiluted and diluted urine showed that the population of total coliform, fecal coliforms, E.coli could be estimated to not detectable level within 2 days. Meanwhile, the changes of pH and ammonia concentration showed that the stored urine could be stabilized within 7 days. Thus, a 7-day storage with a temperature of 70 ℃ is suggested to be the optimal storage condition for human urine. However, thermal treatment is much more suitable for undiluted urine storage in terms of energy consumption and stabilization process.

Keywords:

Source separated urine, thermal treatment, urine disinfection, urea hydrolysis

INTRODUCTION

Source-separation presents many advantages, and the immediate benefit is to recover available and valuable nutrients for agriculture, thus the concept of source-separated human feces and urine collection has been gaining more and more attention in recent decades to promote the sustainable sanitation solutions from local to global level (O'Neal et al.,2013, Yongha Boh et al.,2013). Urine contains the available nutrients for plants growth, including nitrogen, phosphorous and potassium (Karak et al.,2011, Lind et al.,2001a), therefore, it is proved to be good source of green fertilizer (Akpan-Idiok et al.,2012). However, proper storage/hygienization and treatment are essential before safe application to the agricultural fields due to the health risk through transmission of infectious diseases by pathogens, and it was also previously found that urine can be contaminated by various pathogens through fecal-cross-contamination and human infections (Höglund et al.,2002, Levett,1993, Schönning et al.,2002). Urine stored at ambient temperature prior to application is considered a viable treatment option, but the storage time should be depended on temperature and the contamination level as well as the target crops (Richert et al.,2010). Based on estimated pathogen content and recommended crop for large system, the recommended minimum urine storage times by World Health Organization (WHO) are one and six months under 4 °C and 20 °C, respectively (WHO,2006). However, there are problems related to re-collection and transportation of the large volumes of treated urine after the one or six month's storage, moreover, nitrogen loss by volatilization of ammonia due to urea hydrolysis is another issue which should be addressed during urine storage process (Udert et al.,2006). Therefore, it is required to optimize the storage process by shortening the storage time and preventing urea decomposition.

This study aims to investigate the thermal effect of 60℃ and 70℃ on the source-separated human urine storage process. Two objectives should be addressed 1) the reduction of microorganism and urea hydrolysis inhibition in diluted urine; and 2) the technical and economic analysis in treating undiluted and diluted source-separated urine based on the recommended storage condition.

1 MATERIAL AND METHODS

1.1 Experimental set-up

The overall objective of the study was to investigate the thermal effect on urine storage process under two temperatures, and the inactivation of fecal coliform as well as the decomposition of urea were analyzed in the experiments. Fresh urines were stored in glass bottles separately with a volume of 2L for each. Each experimental period was up to several days under 60 and 70℃ respectively, and fecal coliform, pH, urea and ammonia in urine samples were measured accordingly. The storage temperatures were control by using a water bath, then, the urine samples were cooled down to ambient temperature after a reasonable storage time and kept for one week monitoring.

1.2 Urine samples

The fresh urine used for the tests was taken from the male toilet without flushing water

in the Civil and Environmental School of the University of Science and Technology Beijing (USTB), China. The urine was collected in a plastic bucket and then stored immediately.

1.3 Sample analysis

A handheld pH meter (Hanna HI9125N, Italy) was used to measure the pH and ammonia were analyzed colorimetrically with a DR/600 spectrophotometer (HACH, Co., USA). The standard membrane filter method was used for fecal coliform, E.coli and total coliforms analysis (APHA, 2012) . The microorganisms' concentration of the urine were analyzed every day at the same sampling time in the early period, and the interval of sampling was adjusted in the later period of the storage time. All the samples were diluted to a suitable concentration for further measurement, and results were expressed in CFUs/L. For chemical analysis, 1 mL of urine sample was removed from each replicate. For pH analysis, 3mL of urine sample from each replicate were transferred to a glass tube and measured immediately after sampling. All assays were performed in triplicates and presented in average value.

2 RESULTS AND DISCUSSION

2.1 Disinfection efficiency of the diluted urine during the storage period

The inactivation of fecal coliforms and E.coli were presented in Fig.1, It can be seen that diluted urine stored under the temperature of 70℃ could be hygienized and stabilized within 7 days.

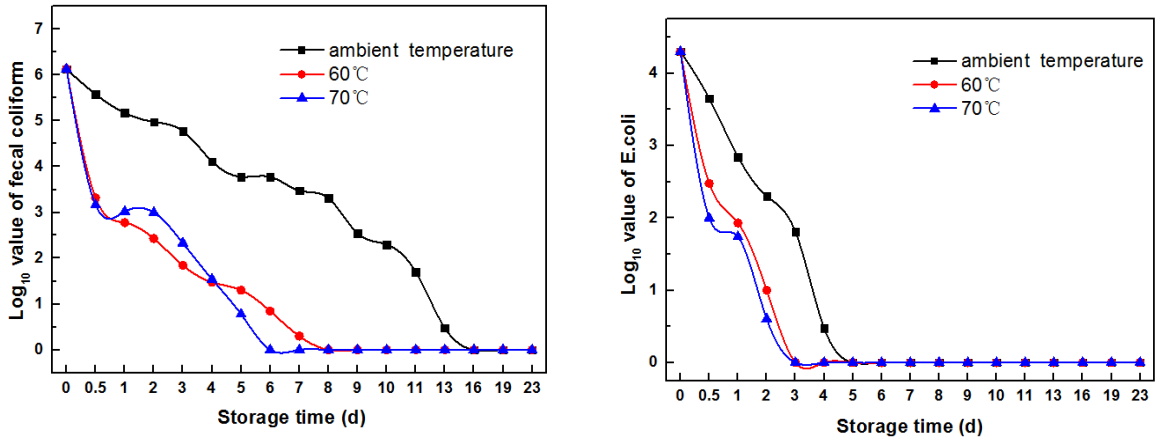

Fig. 1 The inactivation of fecal coliforms and E.coli in the diluted urine

2.2 Technical and economic analysis for undiluted and diluted source-separated urine storage

The comparative investigation for undiluted and diluted urine were presented in Fig. 2. It showed that the population of total coliform could be estimated to not detectable level within 2 days. Meanwhile, the changes of pH and ammonia concentration in Fig.3 showed that the stored urine could be stabilized within 7 days. Thus, a 7-day storage with a temperature of 70 ℃ is suggested to be the optimal storage condition for human urine. However, thermal treatment is much more suitable for undiluted urine storage in terms of energy consumption and stabilization process.

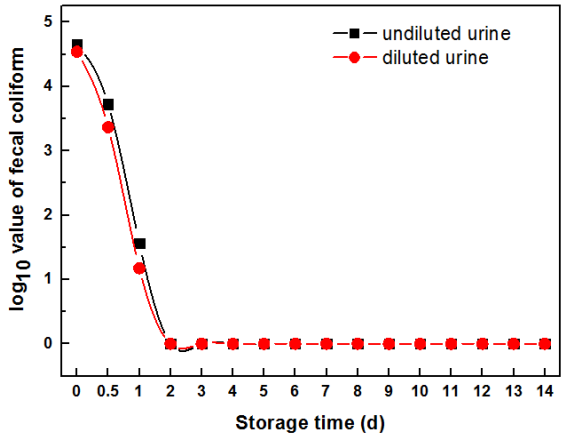

Fig. 2 Fecal coliforms inactivation in the two urine samples

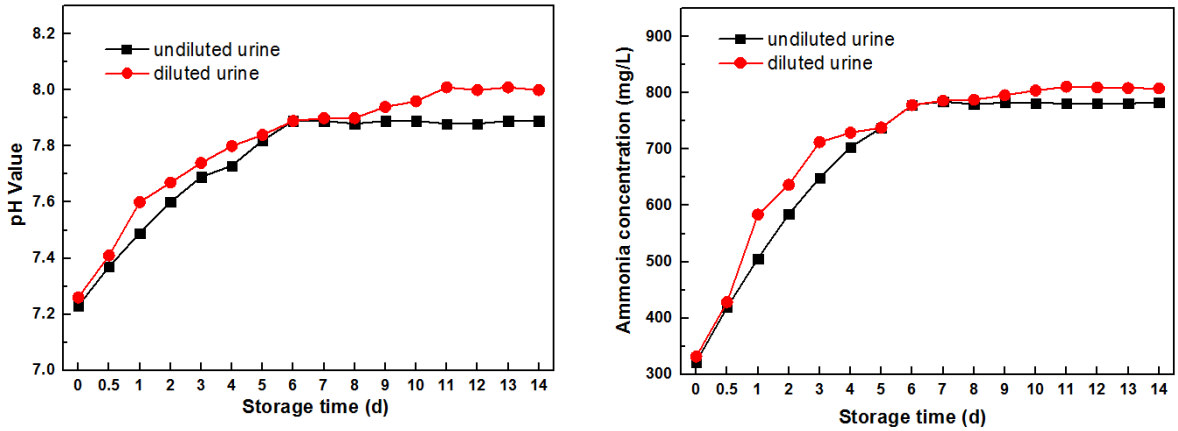

Fig.3 pH and ammonia value in the two urine samples

CONCLUSIONS

Thermal disinfection could be effective for both undiluted source-separated urine and diluted source separated urine, 7 days storage time with a storage temperature of 70℃ is recommended for thermal storage. However, the suggested storage condition is more effective for undiluted urine in terms of technical and economic analysis.

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