



**BUSITEMA  
UNIVERSITY**  
*Pursuing Excellence*

## **FACULTY OF ENGINEERING**

**DEPARTMENT OF WATER RESOURCES ENGINEERING**

### **FINAL YEAR PROJECT REPORT**

**REDESIGN AND CONSTRUCTION OF AN AUTOMATED WATER SAVING PUBLIC  
FLUSH TOILET**

**(CASE STUDY: TORORO TAXI PARK)**

**By**

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## **ABSTRACT**

In today's life, the water borne toilets have a problem of poor sanitation and high spread of UTIs. This are attributed to clogging due to low water pressure, dirty surfaces, continued use of toilets without water, damage of facets due to manual operation. This project aims at improving sanitation through solving the clogging issue by increasing the water pressure, cleaning the toilet pan and also improving the water use efficiency through avoiding multiple flushes.

Automation of the system using Arduino helps to prevent the direct contact of the user with the toilet and the spoilage of the system. The low water pressure in the system is boosted by use of the compressor and this solves the clogging issues and saves water.

There is therefore need for the redesign and construction of an automated water saving public flush toilet with a compressor to help solve the low water pressure, a self-cleansing mechanism for the toilet seat and an exhaust pipe to suck out the bad smell during the toilet use at a relatively low expense.

The results revealed that the amount of water saved is 1314 units of water, water bills saved is 4,955,094UGX and Money saved on medication is 48000000UGX for five years. The longer the time of cleaning of the toilet seat, the larger the area cleaned and the efficiency of cleaning and the same applies to the drying efficiency. That is; at one minute of cleaning, the area cleaned is 20cm<sup>2</sup> and the cleaning efficiency is 12% and for 10 minutes, the area cleaned is 60cm<sup>2</sup>, the cleaning efficiency is 64% which is higher than for one minute.

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Thanks so much may the Lord Almighty bless you all.

**APPROVAL**

This report on Redesign and Construction of an Automated Water Saving Public Flush Toilet

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**DECLARATION**

I Namulondo Annet, BU/UP/2018/3802, declare that all the material portrayed in this project proposal report is original and has never been submitted in for award of any Degree, certificate, or diploma to any university or institution of higher learning

Signature: ..... *CA* ..... Date: *20<sup>th</sup> 01/2023*

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## **List of Abbreviation**

DEO	District Education Officer
FAWEU	Forum for African Women Educationalist Uganda
UV	Ultra Violet
LED	Light Emitting Diodes
NPV	Net Present Value
PI	Profitability Index
PW	Present Worth
CF	Cash Flows
PVF	Present Value Factor

# **CHAPTER ONE**

## **1.0 INTRODUCTION**

### **1.1 Background**

Throughout the history, toilet has been an important part of human life. Toilets vary from one land to the other from one century to the other. Many are used for hygiene now but in ancient Roman public toilets were where people socialized as well (States et al., 2009). Archaeological excavations surfaced a lot of evidence on ancient cleaning habits and also on toilets. Slowly, after the invention of toilets, people-built sewer, drainage systems, and water channels to dispose of the waste and increase hygiene (Jaglarz, 2020).

Throughout the history many civilizations find ways to dispose of human waste. All these civilizations developed different methods. Cultural differences, beliefs, necessities, hygiene shaped the toilet design. Thus, there have been many different types of toilets around the world including flushed toilets and squat toilets (Shaikh et al., 2019).

In Uganda, pit latrines are considered to be the standard for managing human excreta in rural areas. While pit latrines are a significant improvement over alternatives such as open defecation, they often provide a smelly, fly-infested environment that is uncomfortable, potentially unsafe, and possibly harmful to the environment (Shedafa & Johnston, 2013).

According to the most recent Demographic and Health Survey, only 18.7% of the population use flush toilets and these are majorly found in urban schools, restaurants, hospitals, supermarkets and in other public buildings(Zhu et al., 2017). and therefore, it's safe to say everyone is using public toilets during their daily life.

However, these facilities (water born toilets) have problems like poor sanitation and high spread of UTIs which is contributed by dirty toilet seat and surfaces which disgust the users .Some of the users who are germophobic leave without flushing which worsens the situation(Reddy et al., 2019). Manual operation of the faucets leads to their damage when the users always turn strongly to open or close the tap or flushing lever(Jaglarz, 2020).

Clogging also contributes to poor sanitation and it comes as a result of the low water pressure in the cistern hence making the flushing process to nearly impossible. (Shuaeb & Han, 2017). This

## REFERENCES

- Esther, B. (2021). *No Title. SELF CLEANSING MECHANISM.*
- Jaglarz, A. (2020). Ergonomic Criteria for Bathroom and Toilet Design with Consideration to Potential Health and Hygiene Hazards for Users. *Technical Transactions*, 1–18. <https://doi.org/10.37705/techtrans/e2020041>
- Manvita Asnodkar. (2020). Futuristic Technologies for Smart Toilets in Smart Cities. *International Journal of Engineering Research And*, V9(07). <https://doi.org/10.17577/ijertv9is070690>
- ngotoah joel mark. (2017). *No Title.*
- Reddy, Y. M., Raghavan, S., & Vedala, S. C. (2019). A Narrative Exposition on Public Toilet Usage by Women: A Study from Warangal. *Indian Journal of Gender Studies*, 26(1–2), 108–137. <https://doi.org/10.1177/0971521518808100>
- Sablik, M. J., Rios, S., Landgraf, F. J. G., Yonamine, T., De Campos, M. F., Kim, J. H., Semiatin, S. L., Lee, C. S., Babu, J., Dutta, A., ABNT, Asm, A. N., Publication, I., Huang, J. C., Barnes, J. E., Williams, J., Blue, C. A., Peter, B., Asaadi, E., ... Foram, Q. (2012). No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析Title. *Acta Materialia*, 33(10), 348–352. <http://dx.doi.org/10.1016/j.actamat.2015.12.003> [https://inis.iaea.org/collection/NCLCollectionStore/\\_Public/30/027/30027298.pdf?r=1&r=1](https://inis.iaea.org/collection/NCLCollectionStore/_Public/30/027/30027298.pdf?r=1&r=1) <http://dx.doi.org/10.1016/j.jmrt.2015.04.004>
- Shaikh, F., Sayed, K., Shaikh, F., Mittha, N., & Khan, N. (2019). Smart toilet based on IoT. *Proceedings of the 3rd International Conference on Computing Methodologies and Communication, ICCMC 2019, Iccmc*, 248–250. <https://doi.org/10.1109/ICCMC.2019.8819606>
- Shedafa, M. H., & Johnston, R. (2013). *36th WEDC International Conference , Nakuru , Kenya , 2013 DELIVERING WATER , SANITATION AND HYGIENE SERVICES IN AN UNCERTAIN ENVIRONMENT Groundwater vulnerability to geogenic contaminants : a case study , Tanzania. 2008*, 1–6.

- States, U., Pollard, E. L., Lee, P. D., Lippman, L. H., Moore, K. A., McIntosh, H., Australian Institute of Health and Welfare; Australian Research Alliance for Children & Youth, Pogge, T., Harvard, T., Dyk, T. Van, Coetzee, M., Camfield, L., Skevington, S. M., Núñez Domínguez, R., Samuelson, P. A., Nordhaus, W. D., Kula, M. C., Panday, P., Mantia, K., ... (NPC), N. P. C. (2009). No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析Title. *Journal of Human Development*, 6(1), 1–22. [http://www.keepeek.com/Digital-Asset-Management/oecd/development/the-world-economy\\_9789264022621-en#.WQjA\\_1Xyu70%23page3%0Ahttp://www.sciencemag.org/cgi/doi/10.1126/science.1191273%0Ahttps://greatergood.berkeley.edu/images/application\\_uploads/Diener-Subje](http://www.keepeek.com/Digital-Asset-Management/oecd/development/the-world-economy_9789264022621-en#.WQjA_1Xyu70%23page3%0Ahttp://www.sciencemag.org/cgi/doi/10.1126/science.1191273%0Ahttps://greatergood.berkeley.edu/images/application_uploads/Diener-Subje)
- Still, D., & Louton, B. (2012). *PILOTING AND TESTING THE POUR FLUSH LATRINE TECHNOLOGY* by. 1887.
- Wiseman, ^ Yair. (2020). Adjustable and Automatic Flush Toilet. *International Journal of Control and Automation*, 13(4), 1–10. <http://dx.doi.org/10.33832/ijca.2020.13.4.01>
- Zhu, B. W., Zhang, J. R., Tzeng, G. H., Huang, S. L., & Xiong, L. (2017). Public open space development for elderly people by using the DANP-V model to establish continuous improvement strategies towards a sustainable and healthy aging society. *Sustainability (Switzerland)*, 9(3), 1–29. <https://doi.org/10.3390/su9030420>