OPTIMISATION OF NUTRIENT RECOVERY PROCESS FROM HUMAN URINE – AN ECOSAN APPROACH

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JULY 2016

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by

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Submitted

in fulfillment of the requirements of the degree of Doctor Of Philosophy

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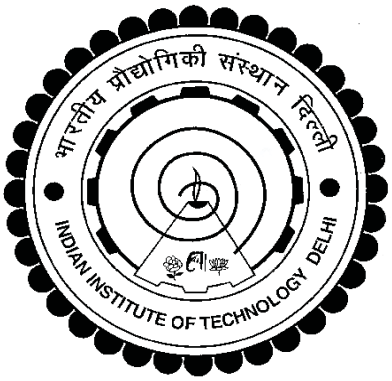

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CERTIFICATE

This is to certify that "**Optimisation of Nutrient recovery Process from Human Urine-An Ecosan Approach"** being submitted by **Md Azizur Rahman** to the Indian Institute of Technology Delhi for the award of **Doctor of Philosophy** is a record of original bonafide research work carried out by him under my guidance and supervision. In my opinion, the thesis has reached the standard of fulfilling the requirements of all the regulations related to the degree. The research report and results presented in this thesis have not been submitted, in part or in full, to any other university or institution for the award of any degree or diploma. I certify that he has pursued the prescribed course of research.

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ACKNOWLEDGMENTS

I wish to express my heartiest gratitude and sincere regards to my respected supervisor, Dr Vijayaraghavan M Chariar for his constant inspiration, encouragement, invaluable guidance and help that he bestowed on me right from the inception to the successful completion of this endeavor.

I am very grateful to my SRC members, Prof Arunachalam Ramanan, Prof Kamal K Pant, and Dr Anushree Malik for their constructive criticism and valuable suggestions.

I would like to express my sincere thanks to Prof Satyawati Sharma, Head, Centre for Rural Development and Technology, Indian Institute of Technology Delhi, for her kind support in sanctioning funds required for my research and for access to facilities in the centre and institute.

I would like to express my thanks and gratitude to all my friends and colleagues for their direct and indirect help. I am especially thankful to Dr S Ramesh Sakthivel for the many discussions in the formative stages of this work and the small suggestions throughout the course of this research. His vast experience in the field of sanitation has helped me in enriching my research. I am immensely grateful to Ms Nalini Srinivasan, Research Scholar, CRDT, IIT Delhi for her constant support and encouragement during the difficult phases of my PhD.

I extend my grateful thanks to the senior members of our "Design for Sustainability Group" - Dr Chandra Shekhar Verma, Dr Sutapa Pati, and Dr Ganesh Prabhu V for their constant support and motivation during this journey.

My heart-felt gratitude to Mr Naresh Kumar Sharma and Ms Mona Chhabra Anand, both senior Research Scholars at CRDT for the invaluable assistance and suggestions they provided for my research work.

I would also like to acknowledge the support received from Mr Satyendra Singh, Research Scholar, Department of Biochemical Engineering and Biotechnology, IIT Delhi, Ms Uzma Anjum, Research Scholar, Department of Chemical Engineering, IIT Delhi, Mr Ejaz Ahmad, M.Tech Student, Department of Chemical Engineering, IIT Delhi, Mr Somnath Sarkar and Mr Gaurav Sharma, Research Scholars, Department of NMR, All India Institute of Medical Sciences, Delhi for support in completing experimentation, discussions regarding analysis and for motivating me in my quest for clarity.

I offer my sincere gratitude to Mr Arun Shanker, Project Associate of our Research Group at CRDT, IIT Delhi for his immense support in preparing the illustrations and in formatting my thesis and research papers. I sincerely acknowledge the logistics support of Rohan Kumar, Project Attendant which was invaluable in completion stages of my research.

I would also like to acknowledge Ms Kausalya Chariar for constant motivation, support and guidance during the period and continuously having belief in me for my success.

I gratefully acknowledge the unconditional support and cooperation of my parents and brother Md Hafizur Rahman throughout my entire study years.

Finally, thanks to 'ALMIGHTY ALLAH' for HIS impeccable guidance and support, which helped me to remain focused in entire period of my journey and I humbly seek His continued benevolence and blessings.

Md Azizur Rahman

ABSTRACT

The liquid fraction of anthropogenic human waste - human urine - has for some time now been recognized as a potential nutrient source. Various methods have been developed for recovering and reusing nutrients present in human urine. Processes such as direct urine application to recovering nutrients in the form of struvite have been reported and practiced around the world. The concept of using urine in agriculture or for recovering nutrients India is still to gain wide acceptability. Except for a few research reports on direct application of urine in agriculture and some studies on a continuous flow reactor for struvite precipitation from urine, there are limited reports on end users' perception, acceptability of urine in liquid form or in salt precipitate etc.

Any idea for implementation of technology which is to be adopted by the society, it is important to analyze and take into consideration the societal, the technological and the scientific aspects of the technology. At present there is no guideline to help local governments, be they are rural or urban – to choose which nutrient recovery technology is most suitable for a particular context. Recovery of nutrients from human urine is an important aspect of environmental sanitation systems which will result in better health of water bodies as well as reduced energy consumption on wastewater treatment. This thesis aims in the connecting the dots between societal, technological and scientific approach in developing and addressing the nutrient recovery process from human urine. A survey conducted among farmers countywide throws some light on which options

may be preferred by the potential end users of human urine or nutrients recovered from human urine. The study on comparison and evaluation of various nutrient recovery technologies based on a net-scoring method carried out by researchers recommends options for various scenarios helps in looking on to the options for nutrient recovery process as an business option. This research concludes that choice of nutrient recovery technology is governed by economic factors such as fixed cost, operational cost and value of the end product and by technological fit with the setting. Following the evaluation of different processes of nutrient recovery, a process for maximal nutrient recovery (namely N, P and K) from human urine has been explored. It was concluded that desorption of ammonia from hydrolyzed urine followed by struvite precipitation can offer an encouraging option for nutrient recovery. This research opens up some new possibilities - social, scientific and technological - in visualizing urine not as waste but as a potential resource.

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LIST OF ABBREVIATIONS

%	Percent
µm	Micrometer
ºC	Degree Celcius
ANNAMOX	ANaerobic AMMonium Oxidation
APHA	American Public Health Association
CFU	Colony Forming Unit
CPCB	Central Pollution Control Board
CSTR	Continuous Stirred Tank Reactor
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
Fig.	Figure
g	Gram
g/h	Gram per Hour
g/l	Gram per Liter
g/m^2	Gram per Meter square
g/m^3	Gram per cubic meter
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German Federal Enterprise for International Cooperation)
GNP	Gross National Product
Hrs	Hours
Kg/Ha	Kilogram per Hectare
L/min.	Liter per minute
M	Molar/Meter
m^2/m^3	Meter square per meter cube
m^3	Cubic Meter
m^3/h	Cubic meter per Hour
mgL^{-1}	Milligram per Liter
MLD	Million liters per day
mlL^{-1}	Milliliter per Liter
Mm	Millimeter
N	Normal (Strength of Solution)
NH_4-N/L	Ammonia Nitrogen per Liter
NPK	Nitrogen Phosphorus and Potassium
Ppm	Parts per million
r.p.m	Rotation per minute
UNDP	United Nations Development Program
US EPA	United States Environmental Protection Agency