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Research Article

Valorization of Human Urine: A Sustainable Strategy for Nutrient Recycling, Sanitation Improvement, and Energy Production

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Abstract

Human urine is a valuable resource for nutrient recycling and energy generation, yet it is often discarded unscientifically. Conventional disposal methods in schools and public places across India involve direct release into drains, leading to water body pollution and health risks. This study investigated repurposing human urine into valuable products across 60 sites in Maharashtra, India. Chemical analysis confirmed its rich nutrient content. A field experiment demonstrated that urine application significantly enhanced the growth, branching, and flowering of rose plants, validating its efficacy as a potent organic fertilizer. The study also explored the feasibility of extracting hydrogen and nitrogen gases from urine via electrolysis for energy applications. The findings advocate for a paradigm shift in sanitation, promoting urine valorization as a sustainable, cost-effective solution for improving waste management, agriculture, and energy production, thereby enhancing public health and environmental conservation.

INTRODUCTION

The safe and scientific management of human waste is a cornerstone of public health and environmental protection. In many developing nations, including India, inadequate sanitation infrastructure remains a pervasive challenge. Toilets in schools, colleges, and public spaces are frequently connected to septic tanks or, worse, directly discharge untreated urine into open drains. Without proper sewage treatment, this effluent ultimately contaminates rivers and groundwater, jeopardizing aquatic life and community health by facilitating the transmission of waterborne diseases such as cholera, typhoid, and hepatitis.

The World Health Organization (WHO) estimates that 2.2 million annual deaths are attributable to diarrheal diseases, largely linked to improper excreta management. This problem is exacerbated by rapid urbanization and the financial constraints faced by local municipalities in implementing high-cost, high-maintenance sewage treatment systems. However, human urine, which constitutes the majority of nutrient load in domestic wastewater, is not a waste but a valuable resource. It is rich in nitrogen, phosphorus, potassium, and other essential plant nutrients.

This study posits that a paradigm shift from disposal to resource recovery is imperative. By scientifically managing and repurposing human urine into agricultural fertilizer and a source for energy production (hydrogen and nitrogen gas), we can address multiple objectives simultaneously: improving sanitation, enhancing agricultural productivity, generating renewable energy, and protecting the environment. This research investigates the composition of human urine, its efficacy as a liquid fertilizer, and its potential for electrochemical conversion into useful gases.

MATERIALS AND METHODS

2.1 Study Area and Data Collection: The investigation was carried out in 60 schools, colleges, and public places across Maharashtra, India. Data on existing urine disposal practices were gathered through physical observation, structured questionnaires ("Clean India" initiative), and interviews with principals, headmasters, and facility managers.

2.2 Urine Collection and Analysis: Urine was collected separately in dedicated 15-liter plastic containers. Samples were transported to the laboratory of the Department of Environmental Science, North Maharashtra University, Jalgaon, for chemical analysis. Standard methods were used to quantify macro-nutrients and physicochemical parameters.

2.3 Field Experiment: A controlled experiment was designed to evaluate urine's fertilizer potential. Two adjacent plots (2m × 1.5m) with identical soil structure and climatic conditions were established. Each plot was planted with three rose saplings of the same variety. The treatment plot received application of stored human urine, while the control plot received only compost. Both plots received a baseline application of 500g of compost to maintain soil moisture. Plant growth parameters (height, number of branches, number of flowers) were monitored and recorded.

2.4 Energy Potential Assessment: The technical feasibility of extracting hydrogen and nitrogen from urine via electrolysis was researched based on established scientific principles. The energy output was calculated based on volume data collected from a case study at St. Joseph's School, Jalgaon.

RESULT AND DISCUSSION

3.1 Urine Composition and Volume: Chemical analysis confirmed that human urine is a concentrated aqueous solution of nutrients. Key constituents included Urea (9.3 g/L), Chloride (1.87 g/L), Sodium (1.17 g/L), Potassium (0.75 g/L), and Creatinine (0.67 g/L), among other ions (Table 1 in original document). The case study revealed that a large school with over 3000 students can produce 2,500–3,000 liters of urine daily, which is typically wasted and pollutes local water bodies.

3.2 Efficacy as Liquid Fertilizer: The field experiment yielded significant results. Rose plants fertilized with urine showed markedly superior growth compared to the control group (Table 1 in original document). The average plant height, number of branches, and number of flowers were substantially higher in the treatment plot (e.g., heights of 85-95 cm vs. 60-71 cm in control). This demonstrates that urine is a complete and readily available fertilizer, with a nutrient value comparable to commercial NPK blends (e.g., 18:2:5).

3.3 Potential for Energy and Gas Production: The study highlighted the electrochemical potential of urine. The urea molecule in urine requires less energy to split for hydrogen production (0.37V) compared to breaking down water (1.23V), making it a cheaper feedstock for hydrogen gas generation. This hydrogen can be used in fuel cells for electricity. Furthermore, nitrogen gas, a valuable industrial commodity, can be simultaneously captured at the anode during electrolysis.

3.4 Sanitation and Health Benefits: Proper collection and valorization of urine prevent its discharge into the environment, thereby interrupting the pathway for pathogen transmission and reducing the incidence of associated diseases. This creates a closed-loop system that protects community health and water resources.

Table 1: Composition of Urine in g/l Material Concentration

Material	Concentration
Urea	25
Criatine	1.1
Soy Broth	10
KCL	1.6
$KH_2\ PO_4$	2.9
NH_4Cl	1
$NaSO_4$	2.3
NaCl	4.7
$MgCl_2.6H_2O$	0.651
$CaO_2.2H_2O$	0.651
pH	5.8

Table 2: Effect of urine fertilizers application on growth of rose plant

Treatment	Plant number	Plant height (cm)	Number of Branches	Number of flowers
Urine fertilizer	1.1	85.0	8	7
	1.2	95.3	8	7
	1.3	92.8	9	6
Control	2.1	60.7	5	3
	2.2	67.1	7	3
	2.3	71,2	5	1

Graph 1: Shows diagrammatic representation of Plant height, number of branches and flowers

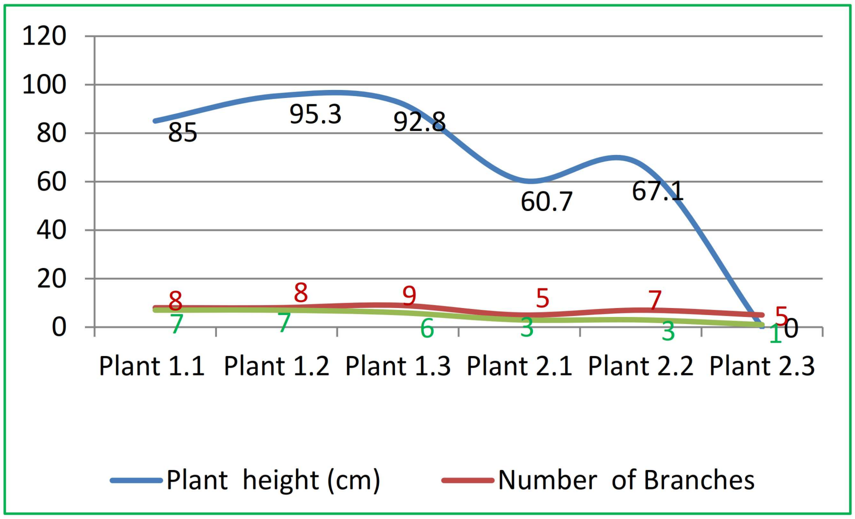

Table 2: Showing summary of volume for urine per day average

Day	Morning	First Interval	Sec. Interval	After school	Total Collection per day
1	600	840	990	530	2960 L.
2	430	820	570	300	2120 L.
3	550	930	630	435	2545 L.
4	260	1120	580	350	2310 L.
5	435	1055	560	500	2550 L.
6	550	880	600	700	2730 L.
Average collection urine per day					2535.8 liters

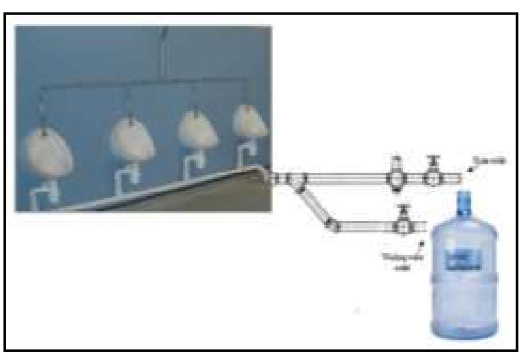

Fig.1. Modified urine washroom showing urinal outlet and washing water outlet.

CONCLUSION

This study conclusively demonstrates that human urine is a valuable resource, not a waste product. The traditional practice of indiscriminate disposal into drains is unsustainable and harmful. The research validates two primary valorization pathways:

Agricultural Application: Human urine is an effective, nutrient-rich liquid fertilizer that can enhance plant growth and reduce dependence on synthetic fertilizers.

Energy Recovery: Urine presents a technically feasible and economically advantageous feedstock for producing hydrogen fuel and nitrogen gas through electrolysis.

Implementing source-separation toilets and creating systems for the collection and treatment of urine at schools, bus stands, and other public places can transform a sanitation problem into an economic opportunity. This approach offers a sustainable, cost-effective strategy for improving community health, protecting the environment, and contributing to energy and food security. Future work should focus on pilot-scale implementation, optimizing electrochemical processes, and developing business models for community-based urine recycling programs.

References

Esrey SA, Potash JB, Roberts L, Shiff C. 1991. Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and tracoma. *Bulletin of the World Health Organization*, **69**, 609–621.

Hotta S, Funamizu N. 2007. Biodegradability of fecal nitrogen in composting process. *Bioresource Technology,* **98**(17): 3412-3414.

Jonsson H, Vinneras B. 2007. Experiences and suggestions for collection systems for source-separated urine and faeces. *Water Science and Technology,* **56**(5): 71-6.

Jonsson H, Vinneras B, Hoglund C, Stenstrom TA, Dalhammar G, Kirchmann H, 2000. Kallsorterad humanurin I kretslopp. VA-FORSK, Report 1.

Kirchman H, Pettersson S. 1995. Human urine-chemical composition and fertilizer use efficiency. *Fertilizer research* **40**, 149-154.

Kirchmann H. 1998. Phosphorus flows in Swedish society. *KSLA Tidskr*. **137** (7): 145-156.

Kirchmann H, Pettersson S. 1995. Human urine-chemical composition and fertilizer use efficiency. *Fertilizer Reseach* **40**, 1949-154.

Kone D, Cofie OO, Nelson K. 2010. Low-Cost Options for Pathogen Reduction and NutrientRecovery from Faecal Sludge. In: Drechsel, P., Scott, C. A., Raschid-Sally, L., Redwood, M. and Akiça Bahri (Ed.) *Waste water Irrigation and Health - Assessing and Mitigating Risk in Low-Income Countries*. pp. 171-188.

Lind BB, Ban Z, Byden S. 2000. Nutrient recovery from human urine by struvite crystallization with ammonia adsorption on zeolite and wollastonite, *Bioresource Technol,* **73**, 169-174.

Lindén B. 1997. Human urine as a nitrogen fertilizer applied during crop growth to winter wheat and oats in organic farming. Department of Agricultural Reseach Skara, Sweden. Report 1, Series B Crops and soils.

Murray CJL, Lopez AD. 1999a. On the comparable quantification of health risks: lessons from Global Burden of Disease study. *Epidemiology,* **10**(5): 594-605.

Rahman MA. 2004. Plantation Crops and Organic Farming: Research Articles Series-1 Some Environment Related Problems and Their Solutions. Touhid Publication, Dhaka, Bangladesh. Pp. 9-43.

Rahman MA. 2005. Plantation Crops and Organic Farming: The Principle of Organic Farming, Touhid Publication, Dhaka, Bangladesh. Pp 80.

Talukder A, Islam N, Klemm R, Blocm M. 1993. Home Gardening in South Asia, The Complete Handbook, Helen Keller International. *In* Training Manual on Plant Propagation and Nursery Management, Horticulture Research Development Project (FAO/UNDP/AsDB Project: (BGD/87/025) in collaboration with Department of Agricultural Extension, Bangladesh Agricultural Development Corporation, Dhaka, 1995 pp 155-156.

Winker M, Vinneras B, Muskolus A, Arnold U, Clemens J. 2009. Fertiliser products from new sanitation systems: Their potential values and risks. *Bioresource Technology* **100** (18): 4090-4096.

Winker DM, Vaughan MA, Omar A, Hu Y, Powell KA, Liu Z, Hunt WH, Young SA. 2009. Overview of the CALIPSO mission and CALIOP data processing algorithms, J. Atmos. Oceanic Technol., 26, 2310-2323, doi:10.1175/2009JTECHA1281

Jonsson H, Stinzing AR, Vinneras B, Salomon E. 2004. *Guidelines on the Use of Urine and Faeces in Crop Production- Report 2004-2*.

Kvarnstrom EK, Emilsson AR, Stintzing M, Johansson H, Jonsson E, Petersens C, Schonning J, Christensen D, Hellstrom L, Qvarnstrom P, Ridderstolpe, Drangert JO. 2006. *Urine Diversion: One Step Towards Sustainable Sanitation*.

Lawton G. 2006. "Pee-cycling." *New Scientist* Issue 2583, 20 Dec 2006.

Manandhar DR, Shiwakoti N, Kafley S. 2004. *Piloting Ecological Sanitation Toilets in Peri-Urban Community of Nepal.*