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INNOVATIONS

URINE DIVERTING TOILETS IN EUROPE: NUTRIENT RECOVERY AND USE IN BUILDING

C. PIMENTEL-RODRIGUES
LAS VEGAS, USA, 2017



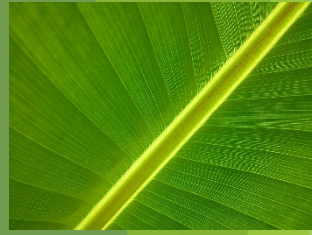
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2. Present

- ▶ The exponential growth of the world's population and, above all, the current model of economic development based on increasing consumption of resources, has made environmental sustainability one of the main issues of the future.
- ▶ In addition to water and energy, there are other critical resources today, and the toilet can make important contributions to sustainability in relation to these resources, especially in the urban environment, where it is expected to locate 2/3 of the world population in 2050.

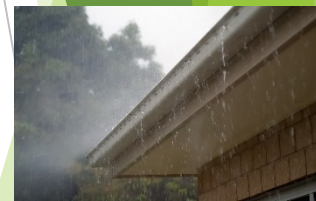
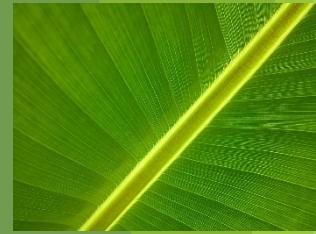


1. Past

- ▶ The toilet has an old history... More than two thousand years ago there were already open seats, situated on above a continuous stream of water.



<http://www.localhistories.org/toilets.html>

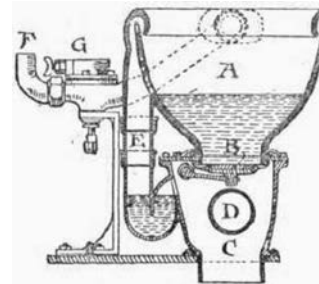


1. Past

- ▶ In 1585, Sir John Harington invented a first model of toilet, although it does not appear to have had immediate applications.
- ▶ In 1778, Joseph Bramah designed a toilet with an improved flushing system. The toilet seat was invented by Frank J in 1912.



<http://www.historic-uk.com/CultureUK/The-Throne-of-Sir-John-Harington/>

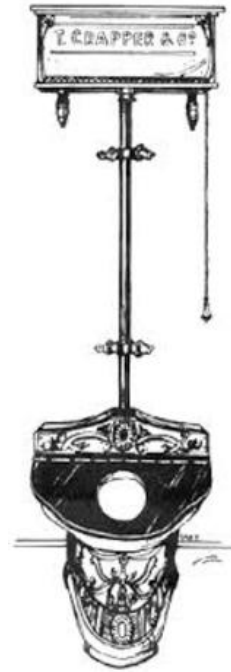


<http://www.hydraulicsonline.com/history-of-hydraulics>



1. Past

- But it was throughout the twentieth century that its development and dissemination were more significant, benefiting from the appearing of the siphon in the late nineteenth century, making it possible to have the bathroom inside the house.



<http://content.time.com/time/health/article/0,8599,1940525,00.html>

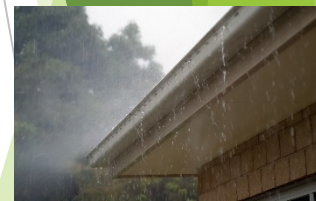
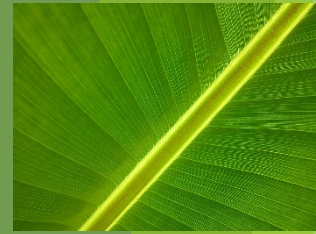


1. Past

- ▶ Until the end of the World War II there was no evolution in the design of the toilets, whose design and functions remained very conservative. From that date, the population growth and the increased consumerism led to the emergence of more elaborate toilets, incorporating bidet valences and seeking essentially to increase comfort and hygiene in use.

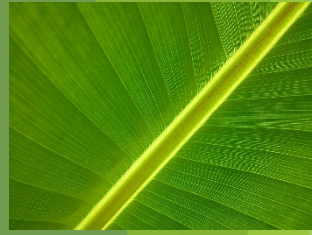


TOTO catalog



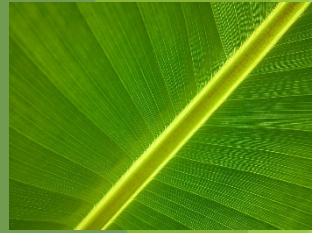
1. Past

- ▶ Concerns about sustainability and resource efficiency have also led to some innovations. Regarding water efficiency in the toilets, the evolution was towards the reduction of discharge volumes and the appearance, for example, of dual flush mechanisms and interruptible (or discontinuous) discharge.
- ▶ These solutions for the reduction of the volumes of discharge had great acceptance in the countries of central and northern Europe.



2. Present

- ▶ As a glance of the main innovations introduced during the last years in the toilets operating with gravitational discharge (thus excluding other systems), a summary of features is presented in the next Table (not exhaustive).
- ▶ As can be seen, most of these innovations concern **hygiene and comfort**, with **sustainability** concerns being reduced only to dual-discharge and interrupted discharge solutions.





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2. Present

FEATURES	Function		
	Comfort	Hygiene	Sustainability
Dual flush	-	-	✓
Discontinuous flush	-	-	✓
Touchless flush button	-	✓	-
Tornado flush	-	✓	-
Rimless pan design	-	✓	-
Motion-activated, auto open/close seat	✓	✓	-
Soft close seat	✓	-	-
Heated seat	✓	-	-
Adjustable seat temperature	✓	-	-
Air purifier-deodorisation	✓	✓	-
Self-cleaning nozzle	-	✓	-
UV sanitising nozzle	-	✓	-
Removable nozzle	-	✓	-
Rear cleaning nozzle	-	✓	-
Adjustable jet position	✓	✓	-
Oscillating jet	✓	✓	-
Adjustable water pressure	✓	✓	-
Adjustable water temperature	✓	-	-
Air dryer	✓	✓	-
Adjustable dryer temperature	✓	-	-
Hands-free stylish remote control	✓	✓	-
Touch-screen remote control	✓	-	-
Ambient lighting	✓	-	-
More than one profile saved preferences	✓	-	-
Built-in speakers play (radio, music, etc.)	✓	-	-
Emergency flushing system during power outages	-	✓	-
Built-in sensors that alert you to possible tank leaks	✓	-	-
Chair-height seating	✓	-	-

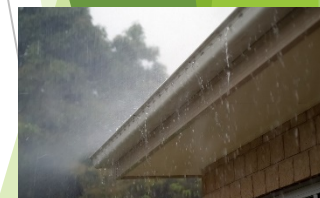
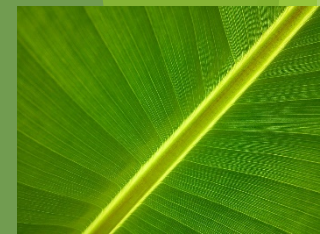
2. Present

- ▶ A resource that is becoming scarce is phosphorus and the toilets can give an important contribution to their efficient recovery.
- ▶ Phosphorus it is a unique non-renewable resource and an essential chemical element for food production and it has been estimated that today's recoverable reserves will be depleted within the next 30-40 years to 300-400 years. Population increase and the intensification of global agriculture will place increasing pressure on the **finite supply** of this resource.



2. Present

- ▶ Its uniqueness therefore makes it urgent to develop new technological solutions to enable the recovery and its reuse in the value chain, especially in urban areas, where there are the greatest losses of this resource.
- ▶ On the other hand, the rejection of domestic and industrial effluents rich in P and other nutrients into water bodies is the major cause of their eutrophication, which reinforces the importance of phosphorus recovery.



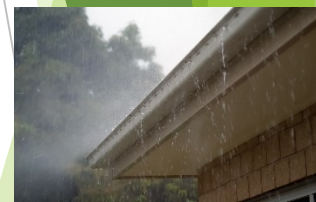
2. Present

- ▶ The toilets are mainly responsible for the loss of phosphorus in the environment and in the value chain, through the discharges of urine.
- ▶ An average adult excretes about 1 g of phosphorus per day through urine and there are no feasible systems in current operation for its recovery from water bodies or in urban wastewater treatment plants. However, the recovery at source, i.e., in buildings, is possible and will have numerous advantages.



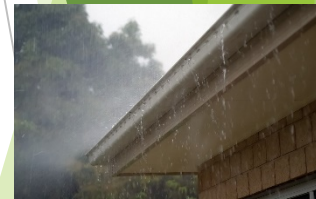
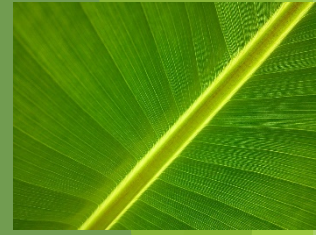
2. Present

- ▶ Some solutions to solve this problem aiming to recover the urine for later use as fertilizer in agriculture are now available in the market, but are relatively simple (diverting toilets) and directed to a rural environment.
- ▶ Contrary to current trends in toilet development, with added hygiene and comfort valances, the existing diverting toilets are designed without concerns of great hygiene and comfort, with a design that only seeks collect urine directly (without dilution or mixing with feces).



2. Present

- ▶ The use of urine directly for agricultural purposes has already been the subject of projects in South Africa, China, Germany and Sweden, for example, using urine separation toilets.
- ▶ But, in urban environment, there is also potential for using urine or nutrients in the buildings themselves, on green roofs or urban agriculture, thereby boosting these two trends, which are now recognized as being of great importance in terms of sustainability policies in cities.



2. Present

- ▶ A revolution is needed at this level, developing “urban” toilets that, in addition to the recent innovations of comfort and hygiene, can also contribute to environmental sustainability, adding the possibility of recovering urine for later use (after maturation), as a fertilizer in urban (or rural) environment.
- ▶ This recovery will also be an important contribution to reduce the pollution of the water bodies which are the final destination of urban effluents.



2. Present

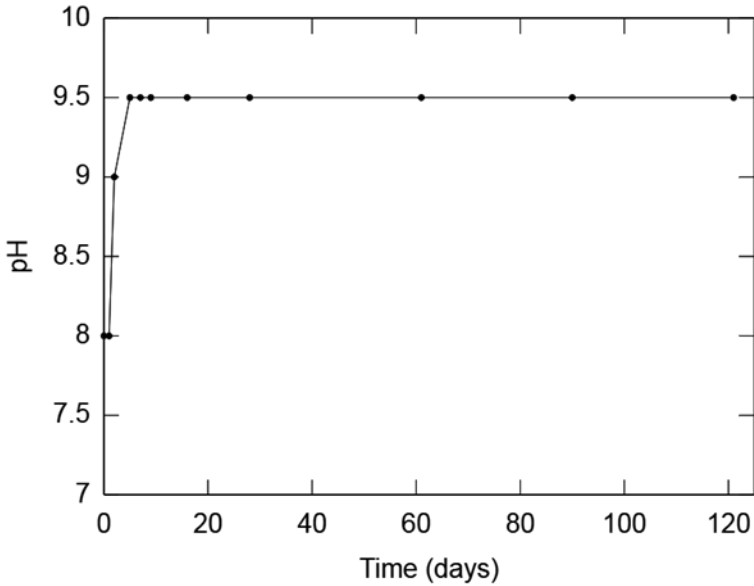
- ▶ In Portugal, an innovative urine-diverting sanitation solution is currently under development (*Project Washone*), trying combine comfort, hygiene and sustainability solutions.
- ▶ However, the solution implies the dilution of urine in the bowl with a small water volume before extraction, and so studies on the maturation process of the urine effluent collected under these conditions are required to assess the efficiency of this new urine diverting system and the feasibility of the later use of the matured urine effluent as a fertilizer.



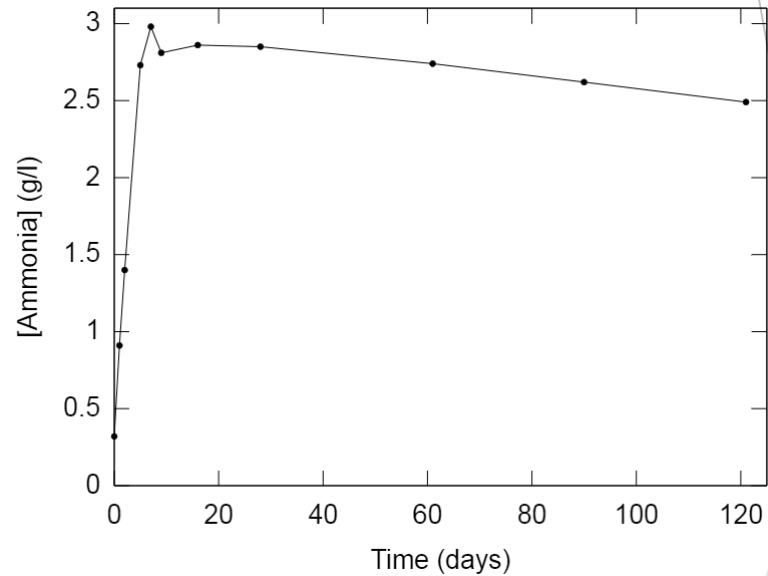
2. Present

- ▶ This presentation focuses on the results of ongoing studies on the maturation process. Some results already obtained at this stage suggest the viability of the solution.
- ▶ Results obtained during the first 120 days of urine effluent storage clearly show that urine maturation process initiated shortly after collection and continued throughout the storage time (Figures 1 and 2). As expected, the total microorganisms' content exhibited a significant decrease within the first 30 days after collection (Figure 3).

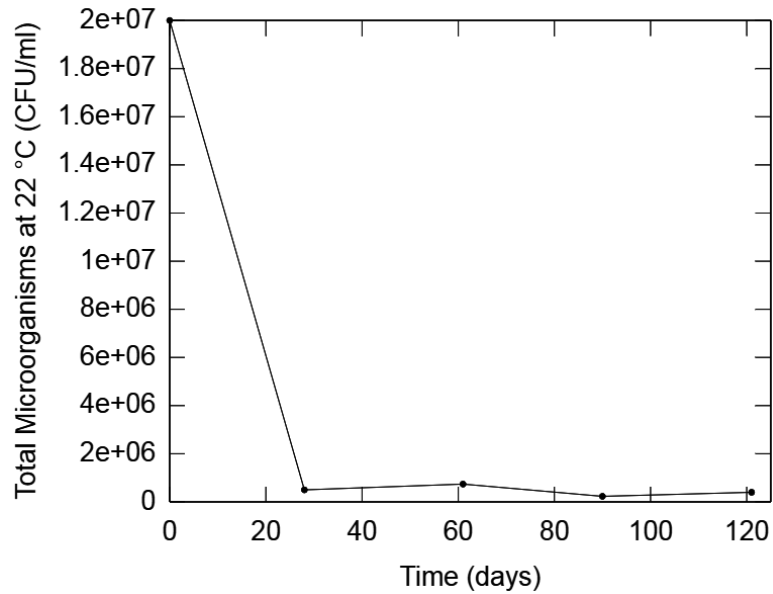




Evolution over time
of the pH of urine effluent
stored at 23°C



Evolution over time
of the ammonia content of urine effluent
stored at 23°C.

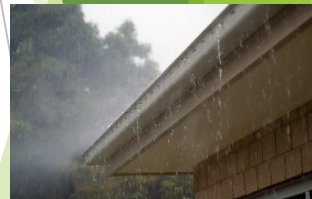
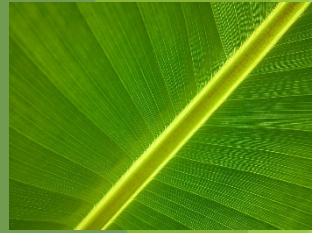


Evolution over time of microorganisms' content of urine effluent stored at 23°C.



3. Future trends and final remarks

- ▶ The efficient use of resources becomes imperative today in the face of the demographic growth, economic development and climate change. Policies of sustainability in all sectors and at all levels, including cities and buildings are increasingly important.
- ▶ In buildings, the bathroom can make a very important contribution by allowing a more efficient use of water, the recovery of some critical resources, such as phosphorus, and significant energy savings through the water-energy nexus.



3. Future trends and final remarks

- ▶ The innovation at the level of the toilets should seek to incorporate these valences, combining the current trends to develop very sophisticated and "urban" toilets, in terms of comfort and hygiene, with more simple and "rural" toilets, oriented to the recovery of urine/phosphorus.
- ▶ In fact, the development of toilets seems to have reached a saturation point in terms of additional features of comfort and hygiene, being necessary that in the coming years, the research, the design, and the technological development are directed toward solutions of sustainability.



Thank you very much for your
attention!

C. Pimentel-Rodrigues

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