SOURCE SEPARATION FOR A MORE SUSTAINABLE ENVIRONMENT

Sibel BAŞAKÇILARDAN KABAKCI*

A.Nursen IPEKOĞLU**

Ilhan TALINLI***

*Yalova University, Energy Systems Engineering Department

**Istanbul Technical University, Chemical Engineering Department

***Istanbul Technical University, Environmental Engineering Department

SOURCE SEPARATION FOR A MORE SUSTAINABLE ENVIRONMENT

* Aim of the study
* Sustainable water system
* How to obtain more sustainable wastewater treatment system
* Separating Household wastewater
* Urine separation: benefits, disadvantages and risks
* What has been done up to now to overcome the disadvantages and risks
* Conclusions

Aim of this presentation:

* To introduce the source separation of domestic wastewater
* To discuss urine separation (yellow water separation) as a more sustainable wastewater management option
* To summarize what has been done to overcome the disadvantages and risks

WASTEWATER TREATMENT

Traditional aim →to enable wastewater to be disposed safely, without being a danger to public health and without polluting watercourses or causing other nuisance.

More?

To recover **energy**, **nutrients**, **water**, and other **valuable resources** from wastewater.

Is it possible?

Yes/No

Wastewater treatment

→conventional centralized systems

→decentralized systems

Why do we want to recover energy, nutrients, water?

SUSTAINABLE DEVELOPMENT

World Commission on Environment and Development (1987): "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs".

All individuals have equal rights, whether living today or in future.

Sustainable Development:

economy, **environment** and **well-being** can no longer be separated.

3 main character of sustainability: economic, environmental and social-cultural

Let's come back to WWTSs
How can we compare WWTSs in terms of sustainability?

* ECONOMICAL INDICATORS: Costs, labour
* ENVIRONMENTAL INDICATORS: Resource utilization-reuse(?), Sludge/waste production, use of chemicals, accumulation, biodiversity, land area required, emissions, pathogen removal, lifetime of the system …
* SOCIAL-CULTURAL INDICATORS: Acceptance, local development, participation…

SUSTAINABLE WATER SYSTEM (=SMART SYSTEM)

- ENERGY (GENERATION, RECOVERY)
- NUTRIENT (RECOVERY)
- WATER (RE-USE)

How can we obtain a more sustainable wastewater treatment?

* Clean water (flush water) is lowered,
* Nutrients are recovered with higher efficiency,
* Cost of the technology is lowered,
* The technology used for treating and recovering the wastewater has a long lifetime,
* The amount of sludge is reduced,
* The amount of by-products such as biogas, biomass, compost etc. is maximized.

A more sustainable wastewater treatment system

A system that minimizes cost, energy consumption, land area while maximizing performance.

Small decentralized systems with different kinds of treatment

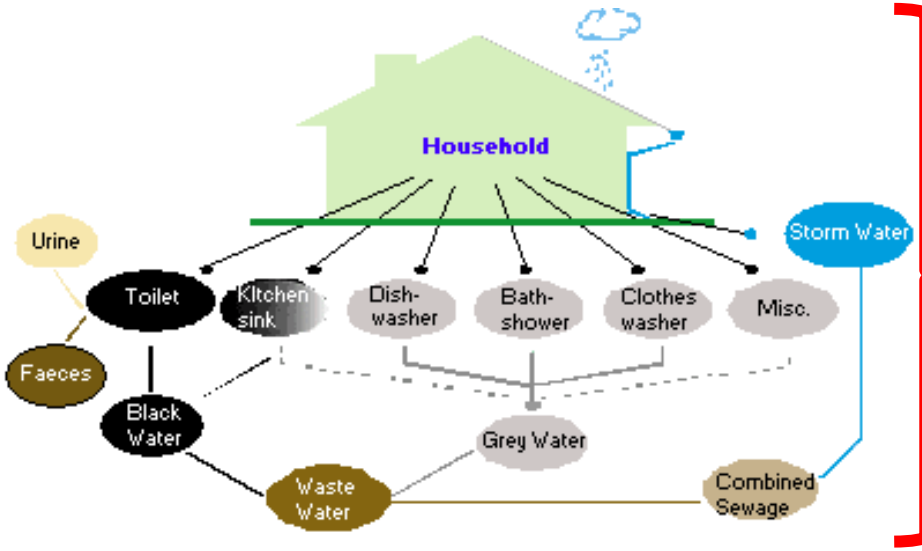


Figure 1: A range of possible sources of household wastewater showing wastewater from toilet, kitchen, bathroom, laundry and others
http://www.unep.or.jp/ietc/publications/freshwater/sb_summary/2.asp

Separating the streams of household wastewater and processing the streams separately has many advantages:

- it reduces eutrophication,
- it decreases the production of mineral fertilizers by increasing nutrient recycling,
- it decreases the amount of fresh water used for flushing,
- and saves energy.

Why urine separation?

Urine

* Human urine is the largest contributor of nutrients to household wastewater. 80% of N and 50% of P from domestic wastewater at treatment plants is contained in urine
* The major ingredient of urine is water (nearly 95%), the rest is urea, sodium, potassium, phosphates, sulfates, creatinine, uric acid, calcium and magnesium
* Pathogenic bacteria content is low in urine when compared with faeces.

Faeces

* The second largest contributor of nitrogen and phosphorus to household wastewater is faeces.
* 17% of faecal nitrogen is contained in the bacterial fraction.
* About 10% is found as ammonia from the degradation of urea, peptides and amino acids.
* The remaining part is found in different organic compounds such as uric acid and different enzymes.
* But only the 50% of nutrients are water soluble or in other words plant available.
* The major part of the heavy metals excreted in the faeces.

How do we separate urine from the household water and collect?

* Example: Sweden research studies

  →Unlike classical toilets, a separating toilet separates the urine and faeces in the toilet itself.

  →After the urine is separated in toilets, it passes through a separate pipe system to a holding tank which is connected to one or more households.

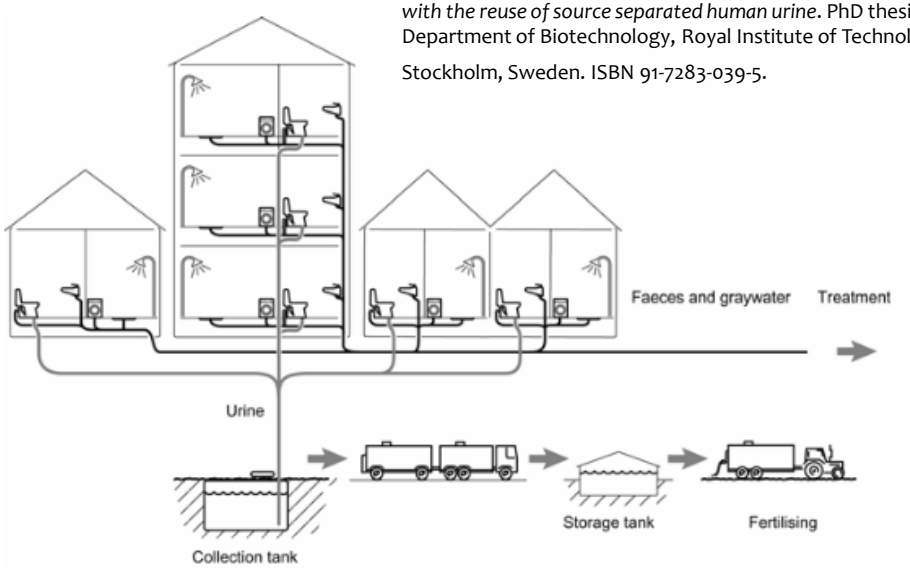
  →The urine is collected and transported by a tank truck or suction truck to storage tanks which are often located deep in the ground.

* Example: Swiss research studies

→ Many researchers proposed to use the existing pipeline for transporting the stored urine to a treatment unit. Urine is intended to be transported at nights.

Figure 3. *Urine-separating toilets originating from Sweden. (a) Model DS from Wost Man Ecology AB; (b) Dubbletten™ from BB Innovation & Co AB; (c) Nordic 393U from Gustavsberg.*

Höglund, C. (2001). *Evaluation of microbial health risks associated with the reuse of source separated human urine*. PhD thesis, Department of Biotechnology, Royal Institute of Technology, Stockholm, Sweden. ISBN 91-7283-039-5.



http://www.who.int/water_sanitation_health/wastewater/urineguidelines.pdf

Any difficulties?

The difficulties and risks are:

* difficulties in using the toilets,
* difficulties in storage,
* difficulties in transportation,
* difficulties in farmland application,
* risk of pathogenic bacteria transmission,
* risk of pharmaceutical and hormonal residues transmission.

What has been done to overcome the obstacles?

* To reduce the volume of urine → freezing

Nearly 80% of both nitrogen and phosphorus was concentrated in 25% of the volume.

* To recover nitrogen →evaporation of nonhydrolyzed urine

78 °C, 200mbar, viscous solution of 10%N

* To reduce the ammonia evaporation →acidification (sulphuric acid, acetic acid, hydrochloric acid)

Ammonia evaporation was reduced. Acidification was found to be a useful method where sulphuric acid was more efficient than acetic acid. Urea in urine samples stored either frozen or frozen after addition of thymol or hydrochloric acid was stable for 7 days.

* To reduce the risks (infection from rotavirus) related to the reuse of source separated urine →storing at low temperature (4°C)

Risks related to the reuse of source separated human urine were low except for possible infections from rotavirus when the urine is either unstored or stored at low temperature (4°C).

* To recover P and N in source separated urine → precipitation of MgNH3PO4.6H2O

Nearly 98% of PO_4^{3-}-P and 40% of NH_3-N was recovered by this method. Optimum reaction pH was found as 9,5.

* To eliminate the contamination of separated human urine with faeces and to lower the flush water (clean water) consumption →designing different toilets

With the new designs 50% of the flush water was saved when compared with conventional toilets.

* To understand the precipitation potential of urine in pipes during transportation → simulation program (to simulate precipitation)

What has been done to overcome the obstacles?

* To recover NH_3-N → stripping (with air)and absorption (in sulphuric acid) to obtain ammonium sulphate.
* To transport urine → studies on existing sewer network
* To recover urea in urine →precipitation of isobutylaldehyde-di-urea (fertilizer)
* To recover N → $MgNH_3PO_4$ precipitation together with adsorption onto wollastonite and zeolite.

65-80% nitrogen recovery

* To investigate the different uses of separately collected human urine → culturing of green algae.

It was possible to culture algae and zooplankton to feed fish larvae.

* To investigate the social acceptance of a "urine based fertilizer" →survey

The whole concept of urine separation is accepted only if the comfort of living and the expenses of new technology are same as conventional ones.

* To evaluate the potential use of urine in aquaculture systems → toxicological tests (with *Daphnia magna*)

It was concluded that fresh and stored urine are highly toxic for *Daphnia magna*. High pH and high ammonia concentration are reported to be the main reasons for the toxicity. Same study also revealed that, urine which was remained after struvite precipitation and zeolite adsorption was highly toxic for *Daphnia magna*.

What has been done to overcome the obstacles?

* To investigate the benefits and the drawbacks of urine separation systems → simulation program ORWARE
* To apply the source separation system → urine separation was applied in an ecological village.
* To understand the possible interaction of tetracycline with struvite → adsorption and co-precipitation of tetracycline

Approximately 17 to 22% of the tetracycline was precipitated from the magnesium ammonium hexahydrate solution containing tetracycline.

* To compare the wastewater treatment and urine separation → Life cycle assessment of centralized wastewater treatment and urine source separation with struvite precipitation
* To understand the public acceptance→ surveys were done in different countries

Conclusions

* Urine source separation is still very immature
* Suitability of different approaches should be investigated.

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Thank you for listening

Sibel BASAKCILARDAN KABAKCI
sibel.kabakci@yalova.edu.tr