SANIRESCH

## Research Project SanitaryRecycling Eschborn (SANIRESCH)

# Project component: Quality of the Products / Storage of Urine

## 1. Background

Though the agricultural use of urine and faecal matter as fertiliser has a long tradition, the knowledge about their infectious potential, the introduction of water flushed toilets and modern wastewater treatment relocated nutrients and pathogens to treatment plants and made urine and faeces unattractive for direct use. Additionally, the amount of excreted pharmaceuticals in human urine and faeces excludes them from direct use in Germany and many other countries today. The precipitation of nutrients from urine (nitrogen and phosphorus) as struvite makes it an interesting source for phosphorus and nitrogen recovery. Many research projects dealing with pharmaceuticals in urine and faeces under environmental aspects have been undertaken.

Separating the different wastewater streams into brown-, yellow- and greywater is an approved method for water reuse. The utilisation of the different treated flows and products is a well appreciated source for nutrients as well as for water for toilet flushing or irrigation for example. The aim of this subproject was to analyse the behaviour of pharmaceuticals and bacteria during storage, precipitation and treatment in all three wastewater streams and in the precipitated product struvite.

## 2. Practical approach

Urine was separately collected and stored and the amount of pharmaceuticals analysed prior to the further experiments. Seven different pharmaceuticals have been detected in the original urine at GIZ and were included in different experiments. One active agent (chloroquine) was added under the aspect of the application of struvite as fertiliser in tropical regions where chloroquine is a well known and cheap medicament against malaria though chloroquine resistances exist.

Prior to direct use the storage of urine for six months is recommended by the World Health Organisation (WHO, 2006) to reduce the number of infectious bacteria. In the framework of the project urine was stored for six months in a dark place at 20°C adding 100 µg $l^{-1}$ of different active agents and adjusting pH to 3, 6.5, 8.5, 9.5 and 11 respectively. The elimination of the added pharmaceuticals was measured via liquid chromatography and mass spectrometric detection.

Before the use of struvite as fertiliser the product must be dried and proof its applicability for usage as fertiliser concerning the content of nutrients and hazardous substances. Experiments were carried out drying struvite of the urine precipitation plant of GIZ at different temperatures and measuring the content of medicaments and some chemical elements.

Analyses of the influent and effluent of all pilot plants, MAP (Magnesium-Ammonium-Phosphate = struvite) precipitation reactor as well as membrane bioreactors (MBR) for grey- and brownwater treatment were undertaken to detect the concentration of pharmaceuticals and surface active agents, the hygienic quality as well as the toxic effect of the greywater effluent on *Daphnia magna*.

## 3. Results and discussion

The storage experiments with spiked urine at different pH-values proved that the adjustment of urine to a certain pH-value has no effect on all the tested agents of the different pharmaceuticals that might be detected in the urine of a variety of different people. A high elimination rate of more than 90% resulted from the effect of a very low or very high pH-value on some chemicals (pH 3: diclofenac, pH11: sulfadimidine). Storing the urine for six months without any pH adaptation showed an elimination effect of 60 to 80% for carbamazepine, chloroquine and sulfadimidine only (see Figure 1).

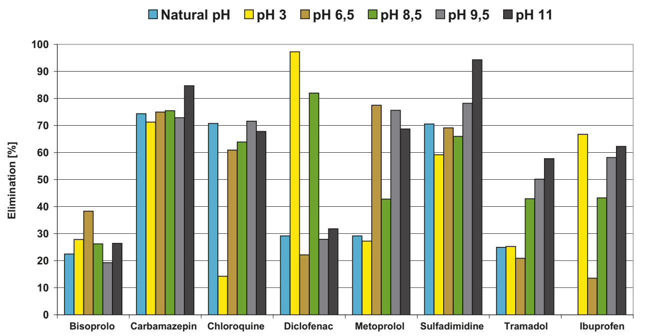


Figure 1: Elimination rate of the pharmaceuticals during storage at different pH-values.

After precipitation of struvite the fertilizer must be dried to allow a safe and hygienic application in agriculture. Comparing the concentration of the struvite ingredients nitrogen (N),



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phosphorus (P) and magnesium (Mg) after drying at 30, 50, 70 and 105°C showed a significant loss of N at 50°C of about 50% while at lower temperatures the molar ratio of N, P and Mg stays stable. The concentration of the tested pharmaceuticals in struvite produced from urine collected in an office building is below the limit of quantification of 1 µg $l^{-1}$ of the applied analytical method (LC-MS) after washing the struvite in a saturated struvite solution and the dried product is free of faecal bacteria as well. The bacteria reduction results from the drying process as the dehydrating effect of the dried mineral on the bacteria causes a disinfection of the fertiliser concerning the analysed bacterial species E. coli and intestinal enterococci.

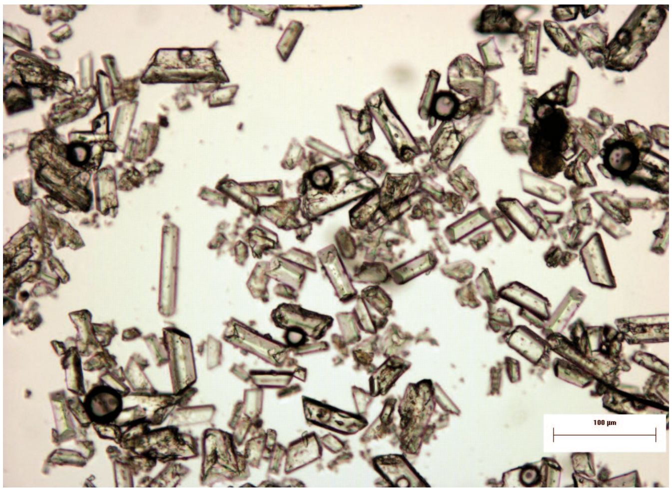

Figure 2: Struvite crystals (indication of size: 100 $\mu$m).

In the framework of the project greywater and blackwater were treated biologically in membrane bioreactors. Prior to reuse the effluent of the treatment plants must at least show a suitable microbiological quality falling below the limits of the EU bathing water directive indicating 200 cfu 100 $ml^{-1}$ for intestinal enterococci and 500 cfu 100 $ml^{-1}$ for E. Coli in bathing water of excellent quality. All results of the greywater treatment plant hit these requirements in the effluent of the MBR as well as in the storage tank for the cleaned water. Due to a re-infection of the effluent tube from environmental effects and as to difficulties in sampling the blackwater effluent showed varying results. Normally the effluent of a blackwater treatment plant with membranes hits the hygienic requirements of the bathing directive as well and may be reused in a similar way like treated greywater.

Medicaments could only be detected in the effluent of the blackwater treatment plant. One sampling showed bisoprolol in the influent and in the effluent of the treatment plant when the bisoprolol concentration was very high in a parallel urine sample as well. Ibuprofen was detected twice in the effluent of the blackwater treatment plant. The concentration of all other analysed pharmaceuticals was below the limit of quantification of 1 µg $l^{-1}$. As only hand wash basins, dishwashers and no showers were connected to the greywater treatment plant just surfactants and caffeine were detected here. Caffeine was completely degraded in the treatment plant and the concentration of tensides was reduced by 90% during the treatment process. As many different cleaning agents are used in the office building it was not possible to specify and identify the sources of the different chromatographic peaks.

The effluents of the greywater as well as of the blackwater treatment plant had no inhibiting effect on *Daphnia magna* (test procedure: DIN 38412 Part 30).

## 4. Outlook

Separation of different wastewater streams is a reasonable and sustainable approach to save water and to protect natural resources by recycling phosphorus and nitrogen. The technology of precipitation of natural urine leads to a product that is free of medicaments and has no harmful effects when used as fertilizer. The treatment of the other wastewater streams greywater and blackwater via membrane technology generates an effluent of water that forms an interesting alternative for usage as service water for toilet flushing, garden watering, industrial use and even the washing of laundry. Prior to use in nature all treatment products that have been received should pass the relevant toxicity tests in future to avoid acute and chronic toxicity effects on the food chain.

## 5. Major references

World Health Organisation (WHO), 2006: The Use of Excreta and Greywater in Agriculture, Vol. 4, World Health Organsisation, Geneva, Switzerland.

## 6. Acknowledgements

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Authors: Bettina Schürmann, David Montag

Responsible partner: Institute for Environmental Engineering
RWTH Aachen University
Mies-van-der-Rohe-Str. 1
52074 Aachen, Germany

Publisher: Coordination by Deutsche Gesellschaft
für Internationale Zusammenarbeit GmbH
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany

I: www.saniresch.de/en
E: saniresch@giz.de

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