Use of urine for recycling of phosphorus in the form of soil conditioner

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Abstract: Household wastes and landfill is recently very discussed topic not only in this country but in all European countries. Taking the statistics for waste management in Europe, we find that on average 38% of production goes to landfill. Not so in Sweden, where Eurostat statistics indicate only a percentage. Swedes have perfectly disciplined and sophisticated system of waste separation, recycling and composting could be a good example not only for the Czech Republic.
Currently, it seems that things are starting to move in our country. Examples include projects such as research organizations and companies that are interested in dealing with the issue of waste and recycling and sees potential in them rather than the problem. One example is the project "From waste to materials", which is funded by the support of the National Agency for Agricultural Research. The project aims to recycle materials that are currently considered as waste materials applicable especially in agriculture
Recycling helps save both renewable and non-renewable resources and often can reduce the burden on the environment. EU Directive no. 98/2008 (EC) defines recycling as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery.
This holds even solving the project consortium, which is divided into several work packages. The first is focused on the development of recycling technologies phosphorus soon scarce and essential nutrients. Phosphorus is extracted from treated waste water from other streams rich in phosphorus. There are already a number of technologies that are capable of phosphorus from wastewater recycle predominantly to form of struvite, exceptionally, to form hydroxyapatite. From the activated sludge, phosphorus is most often in the form of fly ash is recycled as fertilizer, sometimes also after acidic hydrolysis to form other fertilizers.
Furthermore, the project aims to optimize the management of yellow waters for the purpose of direct fertilization using them or getting phosphorus soil conditioner. This work, however, is focused on the acquisition of human urine concentrate, which will serve as a source waning and non-renewable phosphorus. For quickly and relatively cheaply preconcentration of urine is used in this case solar energy.

Key-Words: urine, solar energy, struvite, phosphorus, precipitation, nutrients

Introduction

The development of society, whether demographic, economic and technological developments affect not only water consumption, but also the production and composition of waste water, hence the liquid waste.
Successive extraction of phosphate ore as the main source of phosphorus for the production of phosphate fertilizers may lead to a global collapse because darkest scenarios predict that this will happen in the next 20 to 30 years [1] Is mainly to blame completely upset the cycle of phosphorus, which is incorrect management of this element came into surface waters by 75% more phosphorus than they were before the Industrial revolution. [2] A significant proportion of nutrients is carrying wastewater from faeces, urine and biodegradable solids. If these resources are managed (urine, feces, gray water, biodegradable substance) separated, can be recycled 92% nitrogen, 82% phosphorous and 62% potassium of the total flow of chemicals. [3]
Our hypothesis is based on the use of yellow water as an excellent source of nutrients N, P, K. It can be used to produce soil conditioner and applied directly to the soil or to the crystallization of magnesium phosphate-ammon, otherwise known as struvite. This is a highly prized fertilizer. For successful crystallization, as used, for example, a Canadian company Ostara, you must achieve at least a phosphorus concentration of 50 mg / l, (according to Chris Howorth from the company Ostara), yellow water which meets the

listing. The resulting fertilizer Crystal Green® - based struvite then contains 5% nitrogen and 28% phosphorus. Using the technology can be recycled 80% to 90% of dissolved phosphorus from the waste water and 20% ammonia.
There are several extensive review, for example. Morse et al. [2] or de Bashan [3], which are compared in detail how each technology in terms of removal and recycling of view. Currently phosphorus from wastewater frequently removed by precipitation using salts of aluminum or iron and the larger sewage through increased biological phosphorus removal.
Although yellow water comprises less than 1% of the total waste water from households, are the source of almost 80% nitrogen and at least 50% of the total phosphorus amounts of these nutrients occurring in domestic wastewater. [4] Since the nutrients are concentrated in such a small volume for separation is inviting.

Reasons for separation of urine

The main reasons for the separation and purification of yellow plants in European countries:

- Reduction of nutrient with respect to subsequent problems with eutrophization with regard to the costs associated with the removal of their consequences
- Minimize the amount of run-off of nutrients in WW with regard to the economy of clean water, especially reducing the concentration of nitrogen cheaper cleaning process
- Strain the inflow parameter input to the WWTP, which makes it possible to consider other, less economically advanced technologies such as wastewater treatment plants. Domestic wastewater at
- Recycling nutrients contained in urine as fertilizers - phosphorus reserves are falling and the price of phosphate and nitrate fertilizers repeatedly increasing [4]

Urine as a source of raw materials for agriculture

The average person annually produces 50 L of faeces, 500L urine and 100,000L of gray water (depending on local conditions) [5] For specific about the composition of the urine shows the contents of the most widely used in agriculture nutrients contained in urine, relative to the need for these substances necessary for the production of grain weighing 250 kg.

Table 1 Nutrients contained in human feces and their contents in a standard fertilizer needed to produce 250 kg of grain per year. [7]

Most important nutrients	Urine (500 L)	Faeces (50Ll)	Urine + Faeces	Fertilizer for 250kg corn production
N (kg)	5,6	0,09	5,7	5,6
P (kg)	0,4	0,19	0,6	0,7
K (kg)	1,0	0,17	1,2	1,2
N+P+K (kg)	7,6 (94%)	0,45 (6%)	7,5 (100%)	7,5

Material and Methods

In 2013, a project from waste materials taken the first experiments with separation yellow water (urine) and their hygienisation. The next step in this experiment is verify their fertilizing effects in a field experiment and crystallization of phosphorus fertilizers in bioavailable form of struvite and the use of solar energy for decrease the amount of the water and prepare soil conditioner, which is rich to nutrients N,P,K.
Because fresh urine can be a source of various pathogens, depending on the health of producers, or it may be contaminated with feces, is needed before further handling urine hygienization.. The simplest method is the storage for several months. WHO Handbook for disposal of excreta determined period of stabilization for 6 months at 20 ° C. [9]
It was founded by experiment, which was clean urine of male origin, collected in music festival in Brno, Majáles. The volume of urine 10 m3 was stored in tanks and regularly monitored. The key parameters was microbial indicators prescribed by Czech legislation and contents of N, P, K. The results show the following two tables.

Table 2 Microbial indicators monitored in urine during hygienisation

Microbial indicators	**1. month (CFU/100 mL)**	**6. months (CFU/100 mL)**
Enterococus	85	0
Escherischia Coli	0	0
Salmonela	negative	negative
Thermotolerant coliforms	0	0

Table 3 nutrient content in urine after 6 months storage

Parametr	Unit (mg/L)
Total P	180
Kjeldahl Nitrogen	2200
Nitrate nitrogen	< 0,2
Potassium	301
COD_{Cr}	2280

Note: Accuracy 10%

During this simple experiment it was shown that after 6 months storage of urine is sufficiently hygienized and retained and key nutrients and is therefore very suitable for further treatment, eg. Soil conditioner and struvite crystallization. Folloving part will describe, how we conducted in the experiments whit preparing soil conditioner using solar energy. Struvit precipitation will be verified experimentally at the end of the year 2014.

Soil conditioner, urine precontration

The second part of the experiment was designed to concentrate the separated urine and verify the use of solar photovoltaic panels for the production of concentrate and evaporation of the water content of the urine. This is very useful, because in future, when we will have some struvite or soil conditioner factory, will be important also the price per urine transport, so for this reason is necessary to remove water and prepare concentrate rich to N,P,K nutrients.

The experiment was performed with 50 l hygienized urine, which was placed in the storage tank. Urine was heated by a heating cable (75 W), connected to two pieces of photovoltaic solar panels KC120-1 with accessories (battery and elektrical convertor).

During the experiment was continuously recorded temperature in the tank and the outdoor temperature within 1h, using dataloger. The tank was covered with urine rain due to the solar panels and was protected against the entry of dirt with a mesh with diameter of 1 mm. It was also recorded the amount of electrical current supplied by solar panels to the heating cables using electricity meter.

Loss of water compound of the urine in the reservoir was recorded daily. Periodically (once a week) was analyzed concentrate in the tank with respect to the contents of nutrients (N, P, K)

Picture 1 Model devices for urine preconcentration

Conclusion

The choice of solution draining separated urine has a significant influence on the trailing parameters sewage treatment plants, water, energy and the possibility of recycling nutrients. Today there are a large range of separation equipment to enable the separation of powers and minimize dilution. There are also technologies and products to enable the collection, storage and processing of urine. From the economic point of view it seems also important to minimize the amount of nutrients in the outflowing WW and especially input to the WWTP through separation of urine. This reduces the overall energy consumption required for sewage treatment. Due to the decentralized approach, we can also reduce the transport distance of wastewater sewers and minimize transported and pumped volumes of wastewater or sludge weighed and thus save more energy. [8]

Problems with phosphates is closely associated not only with its efficient use of in agriculture, but also his removal from aqueous environment where the increased concentration of undesirable because it causes the formation of algal blooms and deterioration of surface water quality. The threat of depletion of phosphate in the near future, leads to the need for introduction of recycling technologies where the most interesting ways of recycling are the concentrated liquid sources suitable for struvite crystallization which could be subsequently desired commodity among farmers, because it is a slowly dissolving fertilizer.

Struvite is often associated with a blocked duct, which is usually caused by a spontaneous crystallization. Currently is developing a range of technologies for the recycling of waste water right - most of the current sludge water. Crystallization of struvite, control its production and transformation technology from laboratory scale through pilot plant to real plants is an interesting technological challenge.

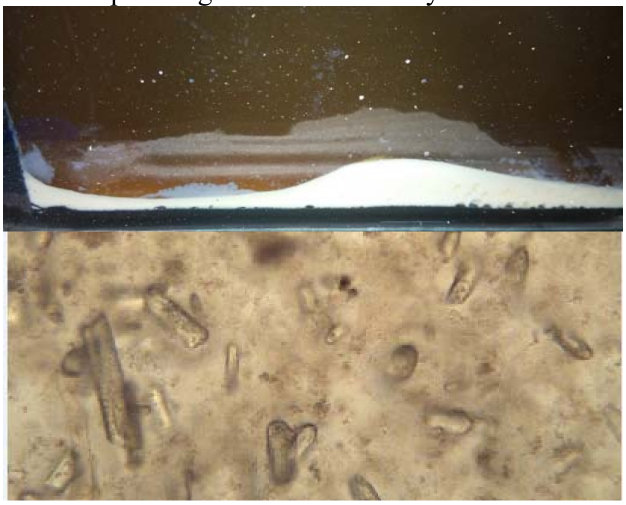
Our experiment shows that the preparation of a concentrated solution of urine realizable. During the experiment were also determined nutrient values in the urine. See the table below.

Table 4 Urine analysis during experiment

Sample	Sampling date	pH	Conductivity mS/m	COD mg/L	P total mg/L	N-NH4 mg/L	N total mg/L
urnie	29.9.2014	9,37	4360	6654	364	7040	7780
urnie	7.10.2014	9,15	5120	6455	389	7800	8500

Already during the first week was recorded decrease in urine volume. Although this was due to less sunny weather, only 10% of the tank volume. However, the value of nutrients is increased, as shown in the table. Since the experiment is not yet finished, it is not possible to present the complete results. However, these existing results seem very promising. The next step is to manage struvite crystallization to the form of commercially salable fertilizer, prepared from urine concentrate.

Picture 2 sediment at the bottom of the urine tank, (second week of the experiment) and below microscopic image of the struvite crystals



The biggest hurdle to this work is public perception of lingering buckets of pee, or the so-called “ick factor.” Urine is actually sterile when it exits the body, save for rare cases of a bladder infection or salmonella poising. So we developed two strategies for eliminating the risk of pathogens, either by solar pasteurization or long-term storage. Both have proven effective.

Second problem are pharmaceuticals that end up in urine. Because it´s difficult to remove hormons, it´s more safty at this stage use only mans separated urine. But even if there is minimal risk to personal or public health, we realizes that only a chosen few will ever be willing to collect their own urine with jugs and funnels. A much more realistic option is urine-diverting toilets.

Acknowledgement

The research has been supported by the project TP 4/2014; Analysis of degradation processes of modern materials used in agricultural technology; financed by IGA AF MENDELU and also from the project: QJ1320234: "From waste materials" which is funded with the support of the National agency for agriculture research NAZV

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