Sustainable Water and Waste-Water Management:

Energy- and Material-Flow-Management - Quo vadis?

The Example 'Phosphorus-Recycling'

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Preface

When we are talking about sustainable water- and waste-water management we often do not reflect that besides an encompassing treatment to produce high quality water discharges to our natural recipients, the various substances brought into the water by human activities might also be extraordinarily valuable.

The example 'phosphorus' and its salts the 'phosphates' should illustrate this mandatory need to include additional aspects on the way to a more and more sustainable water and waste-water management. Phosphorus is an essential substance for every kind of life on earth. Even the backbone of the DNA is built up of phosphates and sugars. There is no possibility to substitute this element.

Without phosphorus there is no life!

Phosphorus and Sustainability

The majority of phosphorus needed in our economies is used in fertilizers for agricultural production. Since the last 20 years the 'old' industrialized nations have started to slowly reduce their phosphorus consumption while at all emerging and rapidly growing economies the use of artificial fertilizer and thus phosphorus increases dramatically.

How long can we move on that way, how much usable mineral phosphates do we have worldwide? Different resource estimations show different results. Remaining availabilities reach from only 50 up to 150 or even 200 years. But all numbers indicate the very limited mineral resources of phosphorus requesting the need to improve and maximize recycling of this element wherever it is possible.

Currently we mostly are still using phosphorus from mineral resources and 'diluting' it in a way that it is lost forever. It is washed to the rivers and oceans or is incorporated in products with long lifetimes like cement for construction material. We lose phosphorus by shifting it from our annual cycle of naturally fertilizing, food growing, food use and again fertilizing with 'food-residues' into other aquatic or geological cycles out of our reach. This phosphorus is ultimately lost.

Methods of Phosphorus Recycling from Waste-Water

Recycling of phosphorus from waste-water is mandatory in the development process towards a more sustainable society. The technical systems are available. Economically the break-even-point is not yet achieved but is in reach, when considering the price increase of natural phosphates and fertilizers.

The municipal waste-water stream transports about 2 g Phosphorus per capita and day to the treatment plant. State-of-the-art waste-water treatment plants discharge 10 % to the receiving waters. 90 % of the phosphorus can be found in the sludges from sedimentation and biological treatment. Considering this, there is a broad variety of opportunities to recycle either from the water or from the sludge.

According to these varying possibilities, different unit processes can be used to generate a recycled phosphorus product. From the liquid phase usually precipitation-flocculation combined with sedimentation or flotation are preferred processes. Direct crystallization of phosphates at nuclei is another new option.

Using the waste-water sludges as source, the processes often start with re-dilution or extraction of the phosphorus from a solid to the liquid phase. The following processes are mentioned above. Another option is the direct thermal treatment of the sludge or its ashes, and direct production of usable phosphate-complexes.

Numerous technical systems for all options are meanwhile available, some still experiencing at small-scale pilot test level, some with years of experience in large scale units.

Leaving the end of the Pipe

All systems dealing with phosphorus-recycling from waste-water or sludges from treatment have to manage highly diluted phosphorus concentrations due to the fact that water is used as transport medium for flushing the waste on its long way to the treatment plant. There are options to improve this situation when moving from the treatment plant towards the source of the waste-water.

Municipal waste-water usually consists or three major fractions, the so called 'grey-water' from showers, washing machines, dish-washers etc., the 'yellow water' mostly urine and the 'brown water' generated by flushing off faeces.

50 % of the phosphorus contained in the municipal waste water can be found in the 'yellow water' fraction. If we now think at highly innovative dry urine separation toilets, vacuum-systems etc., we will get a highly concentrated solution with 50 % of the phosphates. Treatment options will change dramatically when dealing with these small volumes and high concentrations instead of large volumes with and extremely diluted concentrations.

Economical Aspects

Approaching the economical aspects of phosphorus recycling from waste-water, various methods are used and intensely discussed to determine the cost and benefits. One very illustrative method is based on the fact that, derived from the usage as fertilizer, the phosphorus as well as other agricultural nutrients have a defined market value, which varies with the time. Using this market value and using the cost for recycling of phosphorus from waste-water, the break-even point can be determined.

For Germany the market value of one metric ton of magnesium-ammonium-phosphate (MAP) could e.g. be determined in 2008 to be 763 EUR. Basis was the production of usual fertilizer from natural resources. Calculating the cost of the recycling from waste-water shows that whenever the input concentration of phosphorus in the waste-water exceeds some 200 to 300 mgP/liter this process is already competitive. Phosphorus concentrations in 'Yellow water' from households are in a range of 200 mgP/liter.

Conclusions and Perspectives

Focusing on phosphorus (and other valuable substances) the water and waste-water management has to change its attitude from 'cleaning' to 'recycling'. Goals have to be defined to increase recycling from waste-water and save natural resources.

- Phosphorus is vital and irreplaceable
- Natural phosphorus resources are limited and already running short
- There is no alternative to an encompassing phosphorus recycling
- Recycling of substances from waste-water requires a 100 % material-flow management
- Processes for phosphorus recycling are multiple and technically available
- Further development of sustainable recycling alternatives is the order of the day
- One option for municipal waste-water is to change the 'end-of-the-pipe' treatment
- Cost for phosphorus-fertilizer from recycling are at or close to the threshold of profitability
- Saving the P-resources in waste-water and treatment-sludges is mandatory
- 'Storage' of e.g. ashes from sludge incineration should be considered as option
- Improving flexibility of waste-water systems – collection, transport, treatment, recycling, storage, disposal – is highly recommended

We have to consequently continue the way towards an encompassing material-flow-management for water and waste-water to ensure that the resources in this medium are most widely used to replace non-renewable natural resources. This includes, besides the medium water itself, all nutrients, carbon as well as chemically or physically 'stored' energy.

Further information (German)

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