

Biological P-removal – Its basic requirements and difficulties in small wastewater treatment plants

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Research works, inter alia,

- Investigations on the biological elimination of phosphorus in waste water treatment process
- Elimination of phosphorus and nitrogen in small waste water treatment plants

Phosphorus is the most effective nutrient for algal bloom in lakes and rivers. 1 g of phosphorus in the water can result in more than 100 g of biological dried algae substances being responsible for eutrophication. Today it is state of the art to reduce the concentration of phosphorus in any outlet of big wastewater treatment plants. Recently small wastewater plants for <50 PE appeared on the European market with extremely high P-elimination rates of 80 to 97%. Is that possible?

During every biological process of wastewater treatment 35% of the incoming P-load is integrated in the bacterial mass of activated sludge or biofilms. This would result in a concentration of 6,5 mg/l in the outlet presuming a concentration of 10 mg/l in the incoming water. This would not be enough in big treatment plants according to the EU Urban Wastewater Treatment Directive (2024) postulating for bigger plants 0,4 mg/l in the future.

There are different mechanisms to achieve satisfying P-concentrations in the treated wastewater. In most cases phosphorus elimination is done via addition of ferrous or aluminous precipitants and sometimes an additional filtration of the effluent. This is the most common way to eliminate phosphorus in small wastewater treatment plants for up to 50 PE too. The additional amount of sludge containing the precipitated phosphorus salts of Fe and Al is removed via the desludging process of the plant.

The biological elimination of phosphorus is another possibility to reduce the amount of phosphorus in the effluent of wastewater treatment plants. Here phosphorus accumulating bacteria (PAB) are responsible for the extraction of P from the liquid phase. These bacteria must be exposed to alternating anaerobic phases with high acetic acid concentration and following aerobic phases to result in a “luxury uptake” of phosphorus. These processes have to be very well controlled and in big treatment plants different measuring and controlling means are installed to keep phosphorus removal via PABs stable. In the end phosphorus reduction is achieved by the desludging process of the treatment plant. Nevertheless, in most cases an additional precipitation and filtration is installed to keep the P-concentration stable in the outlet.

But how can biological P-elimination be achieved in small wastewater treatment plants? Biological phosphorus removal may happen but is neither standard nor routine. Having achieved biological P-elimination during the testing phase according EN 12566-3 (2013) does not guarantee this under onsite conditions at all. Here treatment parameters often differ extremely from testing conditions, e.g. quality and quantity of wastewater, BOD₅ load, temperature, sludge loading rate and especially the concentration of phosphorus in the incoming water.

During the process of development of the European testing standard EN 12566-3 an adaptation of some parameters took place. The available and actually binding version for testing has been published in September 2013. In the normative annex B the relevant range of concentration of the incoming wastewater is given in B.3.2 with: Total-P: 5 mg/l to 20 mg/l.

As more than 75 % of phosphorus in wastewater results from human excrements and as the concentration of only 5 mg/l in the inlet may lead to a decrease of bacterial growth in the sludge and as additionally the number of analysed inlet samples had grown in all testing notified bodies for small wastewater treatment plants it was decided to ask for another range of P-concentration in the new version of the standard. All experts agreed in the range of 10 to 20 mg/l. Due to the problems with the European Construction Products Regulation it is up till now not possible to publish the new harmonized version of the European standard EN 12566-3 prepared for publication in 2018 where this range forms part of the testing conditions.

Really stable biological P-elimination rates can only be achieved by an additional installation of monitoring and regulating systems. These systems are available on the market but would certainly raise the price of the small treatment plant. But nevertheless, only the installation of an additional technical system for P-elimination via precipitation leads to sustainable results and is already being offered as additional device in small plants by manufacturers on the European market.

The stability of high elimination rates must be controlled regularly when these plants are installed in the field. As formerly laid down in the technical approvals being used in Germany for small wastewater treatment plants P eliminating plants must be maintained three times per year to guarantee stable effluent concentrations. Nevertheless, these measurements stay snapshots.

If the published EU-declaration of conformity or performance results lead to doubtful conclusions, the water authorities should not hesitate to contact the manufacturer and the responsible Notified Body to clarify the situation concerning P-concentration in the incoming wastewater during testing as well as the measured concentrations in the cleaned wastewater.