Sustainable use of crushed autoclaved aerated concrete (CAAC) as a filter medium in wastewater purification

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The presentation

- Introduction – general motivation of research
- The secret of autoclaved aerated concrete for wastewater purification
- Experiment – evidence for its successful use as a filter medium
- Discussion and conclusion
Water purification
aiming at
and preventing eutrophication

After V. Cucarella
Autoclaved aerated concrete (AAC)

High-class building material made of simple or even waste ingredients (sand and/or fly ash) with a limited amount of mineral binders (lime, cement)

Global production: 100 Mm³ / yr
Density: 275-750 kg/m³

Filter material, 2-4 mm
Spec. surface area: 30-40 m²/g
By-product use in water/wastewater treatment

We demonstrate the potential of CAAC as a filter material, promoting the sustainable use of scrap material from AAC production or from demolition of houses built with AAC

• Suitable product also for soil remediation

• Several competing materials on the market, e.g. Leca Filtralite (Weber), blast furnace slag (SSAB, Merox), Polonite (Bioptech AB)
By-products as bed filter materials

Bed filters using reactive materials are an emerging technology for on-site wastewater treatment. The reactive bed filter technology has several advantages, the most important of which are:

- Purification is achieved by treatment in materials of natural origin or by-products from industry
- Used solid filter materials or sludge from filtration and sedimentation of domestic wastewater are replaced regularly and returned to agriculture as P fertilisers and soil amendments
- Minor or no use of electricity, since pumps and other energy-consuming devices are not needed at all or only to a minor extent in the system
- A robust system in terms of function, control and management.
Phosphorus removal by alkaline filter materials

Dominating P species in wastewater

$\text{HPO}_4^{2-}$

Filter material
Phosphorus removal by alkaline filter materials

Dominating P species in wastewater

\[ \text{HPO}_4^{2-} \]

High pH of the material is essential

The material must release calcium ions

Filtermaterial
CAAC – The chemical structure

Mineralogy

• 11Å-Tobermorite, $\text{Ca}_5\text{Si}_6\text{O}_{16}$(OH)2 x 4$\text{H}_2\text{O}$
• Calcium silicate hydrate (C-S-H)
X-ray diffraction (XRPD) spectrum of the CAAC sample

Q: quartz
T: tobermorite
Laboratory & field experiments with CAAC

Bench-scale study: horizontal flow box system

Filter for landfill leachate or wastewater treatment

P-Filter for agricultural run-off
Phosphorus sorption capacity of the 2-4 mm CAAC studied. Calculated values from triplicate samples, mean values ± SD.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>P sorption capacity (g kg(^{-1}))</th>
<th>Calculated</th>
<th>Langmuir model</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-site wastewater (P=10 mg L(^{-1}))</td>
<td>28 ±4</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Solution (P=10 mg L(^{-1}))</td>
<td>57 ±2</td>
<td></td>
<td>70.9</td>
</tr>
</tbody>
</table>

P content (determined by means of ICP) was about 40 g kg\(^{-1}\) dry matter
Long-term box experiment – saturated horizontal flow system
Potential barriers to by-product reuse

- Possibility of environmental contamination via the un-intentional release of toxic elements, contaminants or radionuclides

- Public opinion that materials designated as waste or by-products are inherently unsafe

- Selection of methods for assessing toxicity and recovery potential
New product for water filtration prepared from autoclaved aerated concrete

Sorbulite – manufactured by Bioptech AB, Sweden

Application:
- Know-how to decision-makers, SMEs
- Business and collaborators
Conclusions

• Scrap material from AAC production can particularly be used in small-scale wastewater treatment

• The P reaction kinetics proved to be slow for CAAC, implying that bed filter treatment systems should be constructed with long hydraulic retention time (24 hrs)

• The formation of calcium phosphates is suggested to be connected to the dissolution of CSH compounds (tobermorite)

• Exhausted CAAC after wastewater filtration has a high content of total P (4% w/w) a is a possible material for recycling to agriculture