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Tang, Camilla; Rosshaug, P. S.; Kristensen, J. B.; Rygaard, Martin; Albrechtsen, Hans-Jørgen

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By-product reuse in drinking water softening: influence of operating conditions on calcium carbonate pellet characteristics

Authors & affiliations:

C. Tang[*1,3], *P. S. Rosshaug*[2], *J. B. Kristensen*[3], *M. Rygaard*[1] *& H.-J. Albrechtsen*[1]
[1]*Technical University of Denmark, Denmark;* [2]*HOFOR, Greater Copenhagen Utility, Denmark;*
[3]*NIRAS A/S, Denmark*
catang@env.dtu.dk

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Water utilities are becoming increasingly aware of the environmental sustainability of drinking water production and distribution, while still producing water meeting regulatory guidelines in a cost-effective manner. In areas with high water hardness, central drinking water softening can provide both socio-economic and environmental benefits. However, optimal implementation of softening requires a holistic approach including e.g. possibilities for by-product reuse. A pellet reactor is one widely used softening technology that may produce up to 350 kg calcium carbonate pellets per 1000 m^3 softened water. As of yet, no overview exists of how the physical and chemical properties of pellets are affected by operating conditions, such as placement in the water treatment train and which seeding material is used (quartz sand or calcium carbonate). The aim of this study was to characterize pellets formed under different operating conditions in pilot scale experiments at 8 Danish water treatment plants softening 16 water types. Results showed that iron concentrations, measured with ICP-MS, varied from 19 to 9,200 mg/kg and manganese varied from 0.5 to 980 mg/kg. The concentrations depended on both the raw water quality and the location of softening in the treatment train. Despite differences in chemical dosage, chemical composition of influent water, and seeding material, XRD analyzes showed that all pellets crystallized as calcite and have a relatively low reactivity of 7.4 to 26 % measured by the Sauerbeck & Rietz method. Our study showed that some pellet characteristics, e.g. the concentrations of iron and manganese, can be controlled in the design of the softening process. This allows for optimization of pellets with respect to environmentally sustainable reuse and ensure a pellet composition with high market value e.g. in markets such as glass or chemical industries. Our results assist the circular economy thinking in drinking water production.