Upflow limestone contactor for soft and desalinated water

Based on calcite dissolution kinetics and PHREEQC built-in Excel models

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Abstract

Desalinated or demineralised water or even soft water is characteristically low in hardness, alkalinity and pH. Thus, these kinds of water need to be re-conditioned (re-mineralized) before distributing for usage as drinking water. The produced water is expected to satisfy the following requirements: safe quality for human health, no quality change during distribution and no demolishing of the distribution infrastructure (no corrosion or excessive scaling). In order to achieve both targets, the water alkalinity, pH and calcium saturation level must be considered as the three main parameters in re-mineralization process. In general, limestone contactors are frequently used for increasing these three parameters before the water can be distributed. This technology should be considered as one of the most popular conditioning techniques used in drinking water treatment field nowadays. Typical examples are limestone contactors of Ashkelon Desalination plant in Israel, Larnaka sea water reversed osmosis (SWRO) plant in Cyprus and Barcelona SWRO plant in Spain.

In fact, the determining factor for remineralized water quality is the kinetics of limestone dissolution. There are several theoretical models (PWP, Chou) as well as practical models (Dreybrodt) to describe the calcite dissolution kinetics. However, the theoretical models tend to idealize the real kinetics in practice while the empirical models are not systematic and constituent to be widely applied. Consequently, this study would mainly focus on developing the two popular theoretical kinetics models (PWP and Chou) to a practical model with theoretical basis that could fully capture the practical calcite dissolution kinetics. On top of that, a layer model concept would be introduced as the base for further developing the downflow and upflow limestone contactor model. Subsequently, simulated results indicate that upflow model is technically more superior to downflow hence providing more economical benefits as well. Vosbeck, Anderlohr’s experiments as well as the marble filtration recorded data at Hoenderloo pumping station of Vitens (Netherlands) would be utilized for building and verifying models throughout this research. In the end, an optimal design would be introduced for the remineralizing process at Hoenderloo marble filtration with the aim to increase the filtering capacity, effluent quality and reducing the operational costs at the same time.

In addition to the technical research, a computer based program was built in Excel application with PHREEQC embedded, which includes all of the developed kinetics models for calcite dissolution. The program is developed in order to assist the users as an accurate yet handy tool for quickly predicting or simulating certain calcite dissolution kinetics.