VIDEO ARTICLE

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Removal of Bacteria and Chemicals from Water: Filtration by Granulated Micelle-clay Complexes and Modeling, Biocidal Effects of Free Cations and Regeneration by Microwaves

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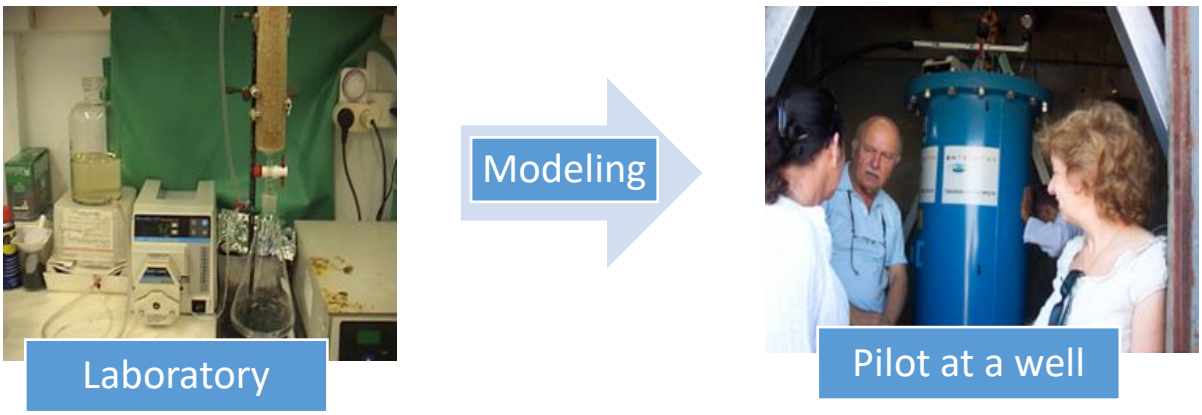
Graphical Abstract



Abstract

Filtration by granulated micelle-clay complexes removes efficiently pathogenic microorganisms (bacteria, viruses, cryptosporidium) and residues of pesticides, and pharmaceuticals in treatment of drinking water and greywater [**1-4**]. Bacteria removed from water by filtration include (**a**) *Escherichia coli*; (**b**) Total bacteria count (TBC); and (**c**) Cyanobacteria [**3**] (*Microyistis* and *Aphanizomenon)*. The (ordinarily) positively charged complexes have a relatively large surface area, and large hydrophobic fractions. Recently it has been shown that optimal removal of particular pollutants from water can be achieved by changing the ratios between the organic cation octadecyl-trimethyl ammonium (ODTMA) and the clay bentonite, which form the micelle-clay complex. A model which considers convection, adsorption, and desorption simulated the filtration results and yielded predictions [**1-4**]. Regeneration of the used filter material was demonstrated to enhance its capacity 2-fold [**2**] at least by: (**i**) passing a dilute solution of NaOCl, or HCl, or by (**ii**) heating in a furnace at 105^0 C. Recently we have established a regeneration procedure based on microwave (MW) heating, which reduced 20- and 5-fold the energy and time required, in comparison with ordinary oven [**5**]. The current approach for removal of microorganisms from water intends to utilize both **filtration** and biocidal/biostatic activity of **free cations** [**2-4**]. Consequently, a granulated micelle-clay complex enriched by adding 15% more ODTMA than in the ordinary complex during preparation yielded a significant increase in removal of bacteria from water, due to a small increase in released ODTMA. Concentrations of released ODTMA in water were determined by using LC-MS/MS; labeled ODTMA-D_3 was used as an internal standard [**2**]. Placing a layer of activated carbon after the micelle-clay filter reduced the released cations to about 1 µg/L. Another type of change in the complex composition was the production of a neutral complex, which yielded increased capacity in removal of the hydrophobic herbicide metolachlor from water by filtration, while saving 1/3 of the amount of needed ODTMA, which is the expensive part in the complex. A collaboration of technologies is illustrated by 2 examples 1. [**3-4**]. A 10-fold reduction in cyanobacteria cell numbers in water was achieved by a first step of coagulation followed by sedimentation by means of a polymer. Consequently, the calculated capacity [**4**] to purify water to drinking standards by a 1 m long filter (flow velocity 6 m/h), which includes 10^6 *Microcystis* cells per mL was increased to 22 m^3/ kg of complex. 2. Purification of greywater by (**i**) a moving bed reactor which reduced the concentration of organic material followed by (**ii**) a filter including a granulated micelle-clay composite. This combination enabled an order of magnitude increase in filter capacity and reduction in frequency of replacements [**4**].

Keywords: Bacterial removal, removal of cyanobacteria toxins, granulated micelle-clay, filtration modeling, regeneration by microwave.

Acknowledgment

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Biography of Presenting Author

Shlomo Nir is Professor Emeritus at The Hebrew University of Jerusalem (HUJI) and chief scientist of En Gibton, a Company for water purification. 1969 Ph.D-Theoretical Physics. Thesis on Atomic Spectroscopy; calculations of energy levels. 1970 Fellow, Inst. Life Sciences, HUJI. 1970-1980. RPMI, Buffalo NY. Cancer Research Scientist I-IV, and Assoc. Prof. Biophysics; University of NY, Buffalo. 1980 Assoc. Prof. HUJI; Dept Soil and water Sciences.1985 Professor. 2003 Emeritus. Recent research mainly on Water Purification; teaches a graduate course. Developed models for: 1. Simultaneous adsorption of several cations to surfaces, by accounting for electrostatic equations and specific binding in a closed system. The model has been applied to artificial and biological membranes and to clay-minerals, for which it was extended to adsorption of organic cations. 2. Particle aggregation, extent and kinetics. 3. Membrane fusion and endocytosis 4. Pore formation by peptides. 5. Kinetics of filtration for a solution with several pollutants. The model has yielded simulations and predictions for removal of chemicals and bacteria for laboratory and pilot scales. 6. Filtration and degradation. The model, which predicts steady sate phenomena was recently applied in (i) removal from fish ponds of off flavor compounds and (ii) removal of bacteria. Designed complexes between organic cations and a clay-mineral or clay, which have been efficient in removal of chemicals and microorganisms, such as bacteria, viruses and a parasyte, Cryptosporidium. Guided 12 Ph.D and 15 M.Sc. students.1989- 2005 Chairman of Israeli Clay Society. 2009. Became honorary member of Spanish Clay Society. Published 257 articles in peer reviewed scientific Journals and books, 4 books, 6 patents; h-index 84.

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