# Final Report

## Project acronym: *TANDEM*

## Project number*: 4155*

## M-ERA.NET Call *2016*

**Period covered: 14/06/2017 to 30/06/2020**

## Publishable project summary

Layer-by-layer nano-assembled films (organosilica interfaces with tethered lipopoly-saccharide-molecularly imprinted bactericidal layers) and monodisperse clay-based microparticles (functionalized *via* organosilica interfaces with bactericidal polycationic brushes bearing quaternary ammonium salts) were developed to work in tandem for the retention and inactivation of Gram-negative bacteria (GNB) and Gram-positive bacteria (GPB), respectively. The innovative and competitive materials were synthesised using original methodologies for the chemical grafting of the bactericidal hybrid surfaces. In the first step, a 500 mL tandem bio-tank (TRL 4), having *smart tools* as building blocks was constructed followed by upscaling to a 5 L biotank (TRL 6).

TANDEM project promoted originality and innovativeness through the conceptual developments, feasible designs and novel implementations, which included original aspects concerning (*i*) the synthesis methods beyond the state of art for obtaining two new types of bactericidal surfaces (for GNB and GPB, respectively), (*ii*) the know-how solutions for reconditioning of proposed bactericidal surfaces, (*iii*) the new knowledge of the two bactericidal surfaces transposed into building blocks (named *smart tools*) for prototyping the bio-tank, and (*iv*) the maximized tandem effort of these *smart tools* for developing more efficient wastewater purification strategies. All these original approaches further conveyed to qualitative and quantitative results as follows: *(i)* two novel synthesis technologies for bactericidal hybrid surfaces (protected by two patent claims), *(ii)* know-how for designing and constructing the two tandem bio-tanks, and *(iii)* a sustainable purification technology, in dinamic conditions, for domestic wastewater and source-separated grey- water.

The specific output of the project led to several outcomes during project implementation (mid-term scenario: 5 publication in specific ISI journals - *2 publication in journals having Impact Factor over 3 and other 3 in journals with 1.5 Impact Factor*, 2 RO patent claims registered at OSIM, 6 communications at prestigious Symposia, Congresses and 3 Workshops/Round Tables) and transferable knowledge to lead-users to fabricate the bio-tanks and new patented technologies to for preparing the two types of surfaces.

The nano-assembled hybrid films for GNB inactivation were prepared by sol-gel techniques and deposited on glass/plexiglass substrates. Hybrid films were characterized morpho-structurally with the use of FTIR, TG / DTA, Cryo-TEM/SEM and AFM analysis. Clay particles functionalized with QAS groups were prepared and characterized physico-chemically using appropriate techniques and equipment, such as: FTIR, TG / DTG, XRD, XPS and solid state C-NMR / Si-NMR. Bacterilogical test were performed using real water samples collected from water basins. The methods employed for determining the bactericidal efficiency of materials refered to conventional Agar plates and PCR. The pilot laboratory reactor of small capacity (V = 500 ml) was initially designed and tested in the laboratory in static and dynamic operation mode. The "tandem" tests led to (i) a decrease in the total coliform bacteria content by 58% in static regime and 65% in dynamic regime (ii) decrease in organic content and nitrites (CCO, NO2, NO2-N) and the number of C. perfringens, with 47% in static regime and 66% in dynamic regime. Thereafter, ultimate design of bio-tank with a capacity of ~ 5 liters and a detachable lid was constructed to be used both in the laboratory and in the field. The results of testing the 5 L pilot bio-tank, before and after reconditioning the assembled components, were similar to those obtained after testing the small capacity bio-tank. All bacteriological indicators analyzed when using the films and particles before the reconditioning procedures showed a considerable decrease compared to the materials tested after reconditioning. Both types of tandem bio-tanks, having layer-by-layer nano-assembled films and monodisperse clay-based microparticles, have demonstrated effectiveness for inactivating bacteria in various contaminated water streams.