NAME: **TOGUE KAMGA FULBERT (2013)**

TITLE : MODELLING, NUMERICAL SIMULATION AND EXPERIMENTAL STUDY OF IRON FILTERS FOR SAFE DRINKING WATER PROVISION

Abstract

Metallic iron-based filters (or Fe0 filters) have a great potential for decentralized safe drinking water provision. Fe0 filters have been demonstrated to be efficient for the removal of both microbial and chemical contaminations. However, the whole literature on metallic iron (Fe0) for water treatment is based on the false premise that Fe0 is a reducing agent. Accordingly, Fe0 oxidation by water has been mistakenly considered as a side reaction. Consequently, the whole effort to estimate the long-term performance of Fe0 filters should be reconsidered.

A Fe0 filter is primarily a porous and permeable system in which water flows in the inter-granular space. Due to the volumetric expansive nature of iron corrosion, the inter-granular space (pore space or porosity) is gradually filled with precipitated iron corrosion products. Eventually this might yield to a clogged system (porosity and permeability loss). Permeability loss is the main negative factor on the sustainability of Fe0 filters.

This thesis develops a mathematical model of Fe0 filter. The porosity loss due to iron oxidation is properly considered for the first time. Admixing Fe0 with an inert or/and non expansive additive (e.g. gravel, pumice, sand) is introduced as a tool to render Fe0 filters sustainable. This contradicts the current approach considering admixture as a tool to save Fe0 costs. The control parameters are the iron proportion, the

volume of sand particles, the height of the filter and the sorption coefficient.

The following results have been obtained:

− The porosity loss with time has been calculated using the rate of formation of corrosion products.

− The time after which the porosity has been reduced to zero indicating a zero flow rate is estimated.

− A mass transport advection-dispersion equation with time dependent coefficients has been derived to predict, through numerical simulation, the spatiotemporal distribution of pollutants and the flow rate in the filter as well as the water quality. The prediction is based on the variation of the pore space within the filter as expansive corrosion proceeds.

− The pollutant removal percentage and the service life of the filter are found to depend on the relative proportions of sand and iron in the filter.

− It is established that any filter must contain less than 52 % Fe0 (vol/vol) as a pure Fe0 filter (100 % Fe0) is not sustainable.

− A concept of community filters (large cylindrical filters or filtration dams) has been developed in the thesis for their application in the derivation of rivers or industrial effluents.

Low-cost iron/sand filters should be manufactured by using the results of this thesis.

Keywords: Iron/sand filters; Mathematical model; Loss of Filter porosity; Advection-diffusion equation; Distribution of pollutants; Filter service life; Community filters; filtration dams.