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Interactive comment

Interactive comment on "Riverbank filtration for treatment of highly turbid Colombian rivers" *by* Juan Pablo Gutiérrez et al.

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Many thanks to the reviewer for the comments to improve the manuscript. All the suggestions have been addressed, and the changes were applied in the manuscript as follows:

- P4, 4 Please explain the role of the schmutzdecke layer in biological treatment? R/ "In the first centimeters of the riverbed a fine sediments' layer is formed, also known as cake layer. The cake layer is called schmutzdecke if a highly active biological layer is involved (Hiscock and Grischek, 2002; Unger and Collins, 2006). A certain degree of clogging in the riverbed is preferred since it can be favorable for water quality improvement (Ray and Prommer, 2006), due to the augmentation of traveling times, particulate removal and the richness of processes occurring in the schmutzdecke (Hiscock and

Grischek, 2002; Schmidt et al., 2003; Unger and Collins, 2006). Jüttner (1995) determined e.g. that the schmutzdecke and upper layers were responsible for most of the elimination of volatile organic carbon, and Dizer et al. (2004) concluded that this layer is extremely efficient in eliminating viruses. Maeng et al. (2008) found that the 50% of the total dissolved organic matter removal in a simulated RBF system occurred in the first few centimeters of infiltration surface due to the biological activity in the developed biomass. In the schmutzdecke layer, the removal of organic matter, pathogens and chemicals occurs by predation, scavenging and metabolic breakdown mechanisms (Haig et al., 2011). A cake layer, mainly composed of organic and/or clay constituents, may also enhance the sorption of pollutants onto its surface (Li et al., 2003)."

- Section 4: Please highlight the potential challenges in the application of RBF in conventional surface water treatment plants in Colombia. With regards to construction, maintenance and operational costs, would the use of RBF as pretreatment be cost-effective over a long term? What is the competitiveness of RBF to slow sand filtration (SSF)? Please highlight the limitations of the current systems used in treatment of surface water and suggest which treatment steps RBF can replace (or eliminate) if incorporated in the current water purification plants. What would be the willingness (acceptance) of surface water treatment plants to incorporate RBF in their current treatment chain taking into account cost-effectiveness and amount of space required compared to membrane bioreactor (MBR)? R/ Two subheading were added. One subheading was focused in the comparison of water treatment technologies, whilst the other subheading was addressed to discuss the challenges of applying RBF in conventional WTPs. The information included reads as follows:

4.1 Comparative assessment of water treatment technologies In Colombia, nowadays, conventional surface water treatment plants (coagulation-flocculation-sedimentation-filtration-chlorination) are used for supplying drinking water. As stated by Gutiérrez et al. (2016), in Colombian WTPs the operation and maintenance and sludge disposal are the main processes leading to costly water production. The costs are linked to chemical usage, sludge production and its treatment. A brief comparison of robust drinking water technologies in removal of turbidity, pathogens and the chemical contaminants discussed during this review is realized based on the analysis conducted by Hubbs et al. (2003) and Ray and Jain (2011). Slow sand filtration, with pre-treatment, is mainly suitable for small to medium sized communities, whereas RBF and conventional WTP can be suitable for small to very large communities (Ray and Jain, 2011). RBF is suitable for highly contaminated rivers, able to match conventional treatments including advanced technologies such as ozone, ultraviolet light or granular activated carbon for pesticides' removal. Although using a conventional train such as coagulation – sedimentation – filtration – activated carbon filtration – disinfection (O3/UV/H2O2/Cl2) and an alternative train such as RBF – aeration – filtration – activated carbon filtration – disinfection (O3/UV/H2O2/Cl2) may produce similar water qualities, there are differences in the production costs. The use of RBF leads to savings of chemical dosing, sludge handling and filter backwashing. As reported by Sharma and Amy (2009), the conversion from a conventional WTP to a process including a RBF system may reduce the operational costs up to 50%. Moreover, the sedimentation step may be skipped, and advanced removal of pathogens is no longer needed. As reported by Dusseldorp (2013), after anaerobic river bank filtrate is extracted in a WTP train in the Netherlands, water is pre-treated with reverse osmosis prior to conventional treatment steps of sand filtration, granular activated carbon and UV disinfection, in order to use in combination with membrane filtration avoiding ultrafiltration and biofouling. RBF has the advantage over the other assessed technologies of dampening shock loads and peaks, which is a need in rivers with extreme variable water qualities such as the Colombian rivers (e.g. Cauca River, Figure 2).

4.2 Potential challenges in the application of RBF in conventional surface water treatment plants in Colombia

RBF as an alternative pre-treatment step may provide an important reduction of chemicals' consumption, considerably simplifying the operation of the existing treatment processes. It is expected that employing RBF in communities where the conditions are appropriate for its implementation (e.g. located in an alluvial formation and close to a river,) will lead to considerable improvements in source water quality. Mainly, improvements due to the removal of turbidity, and pathogens, and to a lesser extent inorganics, organic matter and micro-pollutants are expected. Furthermore, in Colombia, shock loads of pollutants commonly lead to shutdowns of water treatment plants until the peak has passed (Gutiérrez et al., 2016; Pérez-Vidal et al., 2012). RBF has the potential to mitigate shock loads (Schmidt et al., 2003) thus leading to the prevention of shutdowns of water treatment plants.

During the application of RBF in conventional surface WTPs in Colombia, many of the treatment processes currently employed could be varied or even removed completely, leading to simpler plant operation and control. In the specific case of the Puerto Mallarino WTP in Cali, Colombia, RBF would replace all current pre-treatment process steps occurring in the grit chamber, rapid mix chamber, and the flocculation and settling clarifiers (Gutiérrez et al., 2016). Chemical doses could be reduced in all remaining processes, but an additional requirement for aeration directly after well extraction may be needed. However, this would only be necessary in the instance that the RBF filtrate had become anaerobic during soil passage. Because of the process changes a stable inflow quality (turbidity, temperature, pH and electrical conductivity) means that the plant will operate under more stable conditions, thereby increasing plant efficiency and effluent quality. RBF well operation and control is much simpler than the existing treatment steps, which currently require continual adjustment to ensure smooth plant operation according to any changes in raw water quality. Additionally, a complete reduction in the sludge produced by the grit chambers and clarifiers would be achieved.

Please also note the supplement to this comment:
http://www.drink-water-eng-sci-discuss.net/dwes-2017-10/dwes-2017-10-AC2-supplement.pdf

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