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*Editorial*

# Editorial for the Special Issue: Filters in Drinking Water Treatment

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Received: 1 March 2019; Accepted: 12 March 2019; Published: 13 March 2019

**Abstract:** Slow sand filters were first used for safe drinking water provision during the 19th century. The technology has been gradually improved and utilized at several scales. Based on their intrinsic limitations other filtration systems have been developed, including membrane technologies. The universal applicability of filtration in drinking water supply makes filters a device of choice to facilitate the achievement of the UN Sustainable Development Goals ('drinking water for all by 2030'). Available strategies to rationally design efficient and sustainable water filters are scattered in the literature and are difficult to access and evaluate by starting researchers. The present Special Issue summarizes knowledge on two key filtration systems for drinking water supply: (i) membrane technology and (ii) metallic iron based filters. The five (5) accepted articles are being briefly presented herein.

**Keywords:** biosand filter; decentralized water supply; membrane filtration; slow sand filter; water treatment; zero-valent iron

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This Special Issue was conceived to accelerate the achievement of the United Nations Sustainable Development Goals (SDGs) for universal access to safe drinking water [1]. The intention was to critically review the available literature on all relevant aspects of water filtration as applicable in a decentralized manner. The key idea was that the century-old slow sand filtration is universally applicable, but its efficiency can be optimized by several approaches. This optimization effort is equally not new, but available data have been mostly gathered on a pragmatic basis, making any scientific progress challenging. The Special Issue seeks to provide a foundation for further investigations which could enable the achievement of the UN SDG on universal access to clean drinking water within the remaining decade up to 2030. Accordingly, the goal was not to provide any new data but to systematically review available information and present a roadmap for the design of the next-generation water filters for decentralized safe drinking water provision.

From the five received papers, four deal with using metallic iron ($Fe^0$) in filters, and provided a current state-of-the-art on the existing knowledge. During the preparation of the Special Issue, it was realized that a critical review focused on using $Fe^0$ for water treatment in a decentralized manner is lacking. Existing literature mostly compare $Fe^0$-based systems to other systems, for example, in the context of arsenic removal [2] or compare the efficiency of $Fe^0$ filters constructed with various materials [3]. The major shortcoming of this approach is that the most intrinsic property of iron corrosion is not really addressed: The volumetric expansion of iron on corrosion, which is key to contaminant removal and loss of porosity in the long-term. On the other hand, the long-term kinetics of the generation of contaminant scavengers (iron corrosion products) is yet to be properly addressed. This knowledge gap will soon be filled, and a roadmap to achieve this was presented in Nanseu-Njiki et al. [4].

A paper on "Functional channel membranes for drinking water production" was gratefully accepted, wherein Gonzalez-Perez and colleagues [5] addressed the pivotal role of new bioinspired materials in the development of more efficient and environmentally friendly membrane solutions for safe drinking water (and clean environment). The global market for polymer-based membrane separation technologies for water treatment is discussed. The key role of new strategies for embedding ion-channels or water-channels into the next generation of membrane filters, as functional motifs to purify water, is comprehensively presented. The core idea of this contribution is a summary of the different strategies for developing new, advanced membranes with a wide variety of functional motifs and their possible impact on drinking water applications.

It was very gratifying to receive a paper on “Progress in understanding the mechanism of $Cr^{VI}$ removal in $Fe^0$-based filtration systems” [6], wherein the author presented an extensive and useful review on the technology of using metallic iron ($Fe^0$) for water treatment and environmental remediation. The contribution is focused on Cr removal, but the state-of-the-art mechanistic discussion recalls that $Fe^0$ is a generator of contaminant scavengers in the form of iron corrosion products, whose formation is accompanied by volumetric expansion. Dr. Gheju recalled that systems designed for single contaminants underestimate the huge potential of $Fe^0$ for water treatment. Based on this demonstration, new routes to investigate $Fe^0/H_2O$ systems are suggested while insisting on long-lasting column experiments and extending the admixing materials to include manganese oxides ($MnO_x$). $MnO_x$ has the potential to sustain iron corrosion and overcome the commonly claimed ‘reactivity loss’ for $Fe^0$ filters widely reported in the literature [7–9].

Hu et al. [10] draws attention to the scientific history of the $Fe^0/H_2O$ system and demonstrate that regarding $Fe^0$ as a reducing agent under environmental conditions in the 1990s was an avoidable mistake. A review of existing literature at that time could have addressed some of the perpetuated flaws in the literature on $Fe^0$ [11–13]: (i) Misconception that $Fe^0$ is directly involved in the reductive transformation of contaminants, and (ii) failure to account for the volumetric expansive nature of $Fe^0$ in the design process. The incidence of this thinking mistake on the $Fe^0$ technology is discussed together with some consequences for its further development. The key role of characterizing the intrinsic reactivity of $Fe^0$ materials in future research is emphasized.

Nanseu-Njiki et al. [4] is a timely paper focusing on decentralized safe drinking water provision using $Fe^0$-based systems. The authors excellently resolved the prevailing confusion that has strongly hampered the design of efficient and sustainable $Fe^0$ filters for drinking water. The rationale for the success of two existing designs is given: (i) The SONO arsenic filter used at household scale [14], and (ii) the IITB arsenic filter (community scale) [15]. Particularly, ways are given to optimize the IITB arsenic filter. The same tools should be used to optimize amended biosand filters [3]. A time-line for systematic investigations is given, which application would surely enable universal safe drinking water within one decade.

The last paper by Ndé-Tchoupé and colleagues [16] is an extensive piece of work that has involved an impressive range of collaborators from various backgrounds and countries. Ndé-Tchoupé et al. [16] presented a roadmap for the implementation of the newly discussed Kilimanjaro Concept [17] in Tanzania. Specifically, the authors highlight how affordable water filters based on $Fe^0$/biochar can be integrated into rainwater harvesting (RWH) systems to provide fluoride-free drinking water to Tanzanians and the population of the whole great East African Rift Valley. It is, thus, about defeating fluorosis on a long-term, self-reliant basis. The authors are expecting African engineers and scientists to take the lead in translating this concept into reality for the benefit of public health. Although the paper focuses on Africa, the concept may also be applicable in other regions with problems of high fluoride (and even arsenic) in groundwater sources.

Managing to secure more papers on well-known available, affordable technologies (including conventional slow sand filters) for safe drinking water production was not possible within the time frame of the call. Even for the $Fe^0$ based technology, there remains a requirement for a critical systematic review. Nevertheless, the excellent paper of Nanseu-Njiki et al. [4] has largely considered the main cause of failures. The needed up-to-date review in this area would benefit from available three-decades-field experience on the vertical flow multi-soil-layering technology (MSL) for domestic wastewater treatment [18–20]. MSL systems use reactive beds containing 10 % $Fe^0$ and have never experienced clogging. To sum up, this Special Issue is clearly filling a gap in knowledge on the $Fe^0/H_2O$ system, but no papers were received for other important affordable technologies largely reported in the literature. There is, thus, scope for at least another Special Issue on these decentralized technologies in the near future.

Finally, special thanks are due to all the authors for accepting the call and to the publishers for their professional assistance at all stages.

**Funding:** This research received no external funding.

**Acknowledgments:** The manuscript was improved thanks to the insightful comments of anonymous reviewers from Water. The author acknowledges the support by the German Research Foundation and the Open Access Publication Funds of the Göttingen University.

**Conflicts of Interest:** The authors declare no conflict of interest.

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