


Editorial

Special Issue on Planning, Designing and Managing Decentralized Drinking Water Supply System—Editorial

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Abstract: The growing demands for affordable and applicable technologies for decentralized safe drinking water provision have instigated technical innovations in the water filtration industry. Adsorptive filtration appears to be the most affordable, resilient, and socially acceptable solution for households and small communities worldwide. However, water filtration devices have not yet been widely implemented due to lack of awareness for the efficiency of such systems using locally available materials. Water filtration has the potential to secure universal access to safe drinking water by 2030. This special issue has elucidated the applicability, benefits, constraints, effectiveness, and limitations of metallic iron as filter material for safe drinking water provision. Tools to make rainwater a primary water source are also presented together with ways to transform existing centralized water management systems into decentralized ones (sectorization). The knowledge is applicable to a wide variety of situations on a global scale.



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The sixth United Nations Sustainable Development Goals (SDGs) strives to “ensure availability and sustainable management of water and sanitation for all” by 2030. This further attempt by the international community to improve the quality of life of about 2.2 billion of people in the world will only be successful if affordable, efficient, and scalable technologies are made available for scattered small communities all over the world [1,2]. Recently, Hering et al. [1] called for the “synthesis of water research to achieve the Sustainable Development Goals by 2030.” The present Special Issue was an answer to this call. The objective was to summarize the state-of-the-art knowledge on various available technologies to the point where researchers can directly go for pilot testing such that the remaining nine to ten years will be enough to achieve Goal 6 of the SDGs. It is a great pleasure and a pride to state that this goal could be achieved for the metallic iron (Fe⁰)-based technology for decentralized safe drinking water provision.

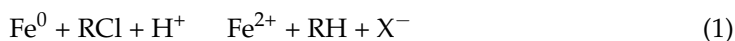
The Special Issue comprises 13 articles [3–15], co-authored by 32 scientists from 10 countries on 4 continents: Cameroon, Tanzania, and Zimbabwe in Africa; Mexico in the Americas; China, Pakistan, Taiwan, and Vietnam in Asia; and Germany and Spain in Europe. Topically, the articles covered the broad range of water management comprising safe drinking water supply [4,5], wastewater management [4,6], groundwater recharge [6], and system design [4,7]. The remaining 8 publications are on the technology of treating water using Fe⁰ materials, with two critical review articles [9,10]. The 13 accepted articles are briefly presented below.

A paper on tools to support the design of decentralized water management systems via “distribution network sectorization” was gratefully accepted, wherein Vegas-Niño and colleagues [15] recalled that centralized water management systems face difficulties to adapt to dynamic changes (e.g., city extension). They present two different sectorization approaches to decentralize existing water distribution networks. The idea of converting centralized systems to decentralized ones is very original. Vegas-Niño et al. [15] used two complementary methodologies for water supply system decentralization by distribution network sectorization and implemented them in a software decision support tool freely available on Internet. Vegas-Niño et al. [15] is regarded as an important instrument for city planners both in the developed and in the developing worlds. The debate should no longer be “to centralize or not” but rather how to efficiently decentralize. A major feature of sectorization is that it allows localized treatment of wastewater generated in each sector, and its reuse. This aspect can be considered first in efforts to decentralize existing city-wide water management systems. Environmental sustainability is increased throughout the water cycle, and the network can more easily adapt to future changes.

It was very gratifying to receive a paper on “Rainwater Harvesting Potential and Utilization for Artificial Recharge of Groundwater Using Recharge Wells” [4]. Hussain et al. [4] investigated harvesting rainwater runoff for groundwater recharge in Lahore city (Pakistan). The local recharge well technique was used with the double advantage of (i) avoiding mixing rainwater with municipal sewerage, and (ii) mitigating urban flooding. It was demonstrated that half of the volume of rainfall can be recharged using this approach. The infiltration system involves filtration through granular media, and Fe⁰ has been suggested as one of the most suitable filter media for such systems [16]. The key message from this study is that extensive RWH and partial infiltration using recharge wells should be considered, everywhere rain falls, to sustain freshwater supply. Considering the decentralization approach of Vegas-Niño et al. [15], RHW can be used in the sectorization of the water supply network for the sustainable development of any city.

Guan et al. [12] used the emergy analysis theory to establish a reservoir water supply benefits evaluation model, taking Hekoucun (Henan Province, China) reservoir as an example. Emergy is a scientific concept and measurement scale developed from system ecology and ecological economics [17]. Emergy converts the material flow, the water resource values of different water users, and the water supply situation of the reservoir into a unified standard, which is convenient for quantitative analysis and assessment of development sustainability [12,17]. Their results showed that the trend of water resource values well reflected the contribution and utility of water resources in different sectors (e.g., industrial, agricultural, domestic, ecological). Guan et al. [17] have emphasized the benefit of emergy analysis for the interannual regulation function of reservoirs for sustainable water management and reservoir water supply. Considering rainwater harvesting and partial infiltration [4] and the sectorization of the distribution systems [15] will certainly improve the application of emergy analysis in decentralized water management.

The remaining 10 papers are on “using Fe⁰ for water treatment,” a century old technology [18] that has been independently rediscovered some three decades ago and used both for safe drinking water provision and environmental remediation [18]. In the 1990s, Fe⁰ was introduced as a reducing agent for selected halogenated hydrocarbons (RX) (Equation (1)). However, the knowledge is very old that, under environmental conditions, Fe⁰ is oxidized by protons (H⁺) and by protons only (Equation (2)) [18]. It follows that when a dissolved species (e.g., RX) is reduced in the presence of Fe⁰, relevant reducing agents are Fe²⁺ (Equation (3)), H₂, and further iron corrosion products like green rust or magnetite (Fe₃O₄).



Comparing Equations (1) and (3), it is clear that the stoichiometry of reduction reactions has been wrongly considered for the past three decades [3]. The two review articles [3,10] have clarified this key issue while depicting the origin of the mistake and demonstrating the consequences on the development of the technology. The eight other articles insist on the rationale for: (i) Fe⁰ selection [5,7], (ii) understanding the operating mode of Fe⁰-based systems [8,11,14], (iii) designing pilot-scale and field scale filtration systems [6], and (iv) pilot-testing Fe⁰-based filters [6,9,13]. In particular, Cao et al. [11] and Xiao et al. [10] demonstrate the efficiency of the methylene blue discoloration method (MB method) for the characterization of the operating mode of Fe⁰/MnO₂ and Fe⁰/FeS₂, respectively. The eight articles are regarded as the cornerstone on which the Fe⁰-based water treatment technology will enable the achievement of Goal 6 of the UN SDGs. All that is needed are well-designed experiments using well-characterized materials, lasting for more than one year.

Tepong-Tsindé et al.'s [6] article is suggested as a good starting point to design Fe⁰-based filtration systems for both households and small communities. Design rules have been known for more than 100 years [9]. Fe⁰ materials have been selected using the method presented in Hu et al. [5]. Reactive additives like FeS₂ [8,10] and MnO₂ [11] were tested in long term experiments to improve the efficiency of Fe⁰ filters. The overall water treatment train can be designed after the flexible scheme presented by Aqueous Solutions (www.aqsolutions.org; Access on 22 May 2021). Aqueous Solutions is a non-governmental organization (NGO) based in Thailand and the USA. This NGO and Dr. Josh Kearns (North Carolina State University) have been advocating for “the science of self-reliance” in safe drinking water provision for the past 15 years, mainly based on using biochar for the removal of chemicals and pathogens [19]. Similar decentralized systems for wastewater treatment are known and have been tested under various climatic conditions [16]. Well-designed decentralized systems will soon be implemented in a self-reliant manner to accelerate the achievement of SDG 6 [1].

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