

1 **Supporting Information**

2 **Enhancing sustainability of household water filters by mixing metallic iron with porous**
3 **materials**

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11 **S1 Suitable porous materials to sustain Fe⁰/sand filters**

12 Natural minerals and rocks are of various porosities [1-8]. For rocks, a certain trend exists For
13 example, volcanic rocs (pumices) are the most porous (up to more than 80 %) while granites
14 are among the less porous. However, compacted pumices with a porosity of only 32 % were
15 reported [9]. Similarly, Morales et al. [6] reported porosity values from 6.29 to 26.43 % for
16 sandstones from several sites in Germany. This work tests the hypothesis, that porous
17 minerals and rocks have the potential to extend iron filter life. Some suitable porous materials
18 are enumerated below.

19 **S1.1 Activated carbon**

20 Activated carbons are the porous carbonaceous materials. Their structure is very complicated
21 and their surface is highly heterogeneous. Generally, they can be made of various raw
22 materials such as coal, lignite, nut-shell, peat, saw dust and synthetic polymers [10]. The form
23 of activated carbons suitable in iron filters is granular which is very popular in commercial
24 uses but could be manufactured locally [11,12].

25 Activated carbon is renowned for its large surface area and tailored pore structure. It is
26 expected that a considerable fraction of porous structure (macro- and mesopores) could be
27 accessible to in-situ generated iron corrosion products. Activated carbon is widely used in

28 many fields, including medical treatment, energy storage, radiation protection and also in the
29 military field. Recently, granular activated carbon (GAC) was mixed with Fe^0 in the frame
30 work of internal electrolysis for wastewater treatment [13,14]. Here, a mixture of iron grains
31 and GAC particles induces numerous microscopic galvanic cells between the particles of iron
32 (anodes) and carbon (cathodes), sustaining iron corrosion and thus contaminant removal.

33 **S1.2 Porous rocks**

34 Various readily available rocks are porous and could be used to sustain iron filter efficiency.
35 The discussion will be limited to sedimentary and volcanic rocks.

36 **S1.2.1 Sedimentary rocks**

37 Sedimentary rocks originate from accumulation of small grains of sand or clay often together
38 with organic material. Sedimentation takes place through the action of wind and water, and
39 leads to a highly porous unconsolidated agglomerate (primary porosity: 50 – 80 %). The
40 sedimentation process is followed by compaction and diagenesis causing the unconsolidated
41 mass to become a consolidated rock by flow of pore filling fluids accompanied by dissolution
42 and other chemical processes [15-17]. The resulting secondary porosity is usually less, but
43 sometimes greater than the primary porosity. Sedimentary rocks are divided into classes such
44 as sandstones or limestones depending upon their composition. Two principal characteristics
45 of sedimentary rocks are: (i) connected porous structure, (ii) porosity ranging from 5 to 25 %.

46 **S1.2.2 Volcanic rocks**

47 In volcanic rocks, porosity, pore shape, tortuosity of pore pathways, and pore size
48 distributions vary during magma ascent and eruption because of bubble growth, coalescence,
49 shear, collapse, and the presence of crystals. The pore structure formed by bubble expansion
50 has a lower permeability (less connectivity) than that formed by bubble collapse at equivalent
51 porosity [18-21].

52 The complexity of pore geometries and the resulting range of permeabilities have led to
53 numerous models of permeability–porosity relationships for volcanic rocks [21]. For

54 simplification, this study assumes that the porosity of volcanic rocks is available as storage
55 room of ICPs. In other words, “fluidic” iron hydroxides should penetrate in all pores, even if
56 when they are not well interconnected. Wright et al. [21] reported on volcanic rocks having
57 porosities varying from less than 20 % to more than 60 %. Pumices are the most porous rocks.
58 Pumice is a light, sponge-like porous volcanic rock that is formed during explosive eruptions
59 [20,21]. It is probably the most uniformly porous rock that exists. It consists of a network of
60 gas bubbles fixed amidst fragile volcanic glass and minerals. Pumice’s pores are irregular in
61 shape and generally not well connected to each other [22]. Like sand, pumice is used as a
62 biofilm support material in water treatment. In many regions of the world, highly porous
63 pumice will be readily available.

64 **S1.3 Natural zeolites**

65 Natural zeolites (e.g. analcime, barrerite, chabazite, clinoptilolite, laumontite, mazzite,
66 mordenite, offretite, paulingite, phillipsite, stilbite) are worldwide occurring hydrated
67 aluminosilicate minerals of a porous structure. They exhibit valuable physicochemical
68 properties including cation exchange, molecular sieving, catalysis and sorption. Application
69 of natural zeolites for water and wastewater treatment has been realized and is still a
70 promising technique in environmental cleaning processes [23,24]. The porosity of natural
71 zeolite is mostly due to their tabular morphology showing an open reticular structure of easy
72 access exhibited by channels up to 0.7 nm in diameter [24,25]. Natural zeolites from various
73 regions show different sorption and ion-exchange behaviour, the difference being mainly
74 caused by different composition of zeolitic tuffs. They are generally characterized by their
75 maximum sorption capacity or their cation exchange capacity (CEC). However because of
76 their worldwide occurrence their porous structure may serve as magazine of iron corrosion
77 products in Fe⁰ filters.

78 **S1.4 Natural manganese oxides (MnO_{1+x})**

79 Manganese oxyhydroxides (MnO_{1+x}) are highly reactive mixed-valent mineral phases of
80 poorly crystalline and porous structure. They are a group of multifunctional materials which
81 are ubiquitous reactive constituents of soils, sediments and aquifer materials and they have the
82 potential to be major contributors to natural attenuation in the subsurface. MnO_{1+x} have been
83 shown to oxidize Cr^{III} , Se^{IV} , As^{III} , Co^{II} , NH_3 , organic-N, and humics, and facilitate
84 degradation of phenols, some chlorinated VOCs, and pesticides [26-28]. Technically, MnO_{1+x}
85 are used as molecular sieves, catalysts, battery materials, and gas sensors [29,30].
86 MnO_{1+x} characteristically have open crystal structures, large surface areas with high negative
87 charges, and exchangeable charge-balancing cations (Na^+ , K^+ , Mg^{2+} , Ca^{2+} , Cu^{2+} , Ni^{2+} , and
88 Mn^{2+}). The basic unit of most Mn oxide minerals is the MnO_6 octahedron, which is generally
89 arranged into either layer structures or chain/tunnel structures. The tunnel structures have
90 single, double, or triple chains of edge-sharing MnO_6 octahedra in which the chains share
91 corners to form tunnels of square or rectangular cross section [29].
92 Recently MnO_{1+x} was discussed as reactive additive to sustain Fe^0 reactivity by virtue of
93 continuous generation of highly reactive iron hydroxides [31-33]. Using the porous structure
94 of MnO_{1+x} as storage room for in situ generated corrosion products will be coupled with the
95 reactivity sustaining properties. Given that MnO_{1+x} has been successfully used to sustain Fe^0
96 reactivity in SONO arsenic filters [34-36], more attention should be paid to the
97 $\text{Fe}^0/\text{MnO}_2/\text{porous rocks}$ system.

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