water

MDPI

Supplementary Materials

Threshold Recognition of Water Turbidity for Clogging Prevention during Groundwater Recharge Using Secondary Effluent from Wastewater Treatment Plant

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Table S1. Threshold values of suspended solids concentration and turbidity for reclaimed water quality standards in different regions.

Standards/requirements of reclaimed water	area	Turbidity (NTU)	SS (mg/L)
Standards of reclaimed water quality (SL368-2006)	China	5.00	n
Water quality standard for groundwater recharge (GB/T19772-2005)	China	5.00	n
Reclaimed water quality and treatment requirements for 2012	Florida	n	5.00
Guidelines for water reuse (US EPA/600/R-12/618)	Massachusetts	2.00	5.00
(Nonpotable aquifer recharge)	Washington	2.00~5.00	5.00
(Potable aquifer recharge)	Washington	0.1~0.5	5.00
Australian guidelines for water recycling (managed aquifer recharge)	Australia	1.00	10.0
Standards for drinking water quality (GB 5749– 2006)	China	1.00	n
Drinking water guideline [1]	Spanish	1.00	n
Water quality standard for groundwater recharge [2]	Japan	n	2.00

References

1. Camprovin, P.; Hernandez, M.; Fernandez, S.; Martin-Alonso, J.; Galofre, B.; Mesa, J. Evaluation of Clogging during Sand-Filtered Surface Water Injection for Aquifer Storage and Recovery (ASR): Pilot Experiment in the Llobregat Delta (Barcelona, Spain). Water 2017, 9, doi:10.3390/w9040263.
2. Okubo, T.; Matsumoto, J. Bological clogging of sand and changes of organic-constituents during artificail recharge. Water Research 1983, 17, 813-821, doi:10.1016/0043-1354(83)90077-5.

Table S2. The main water quality parameters of secondary wastewater.

Parameter	Values	Parameter	Values
SS	16.5 ± 0.440	Total organic carbon	7.69 ± 0.030
NTU	1.88 ± 0.050	Chemical oxygen demand	14.6 ± 1.15
pH	7.53 ± 0.060	Biological oxygen demand	0.600 ± 0.010
K^+	14.8 ±0.030	Total nitrogen	5.12 ± 0.440
Na^+	70.5 ± 0.010	Total phosphorus	0.050 ± 0.000
NH^{4+}	0.400 ± 0.010	Total bacterial count (cells/mL)	0.000
Ca^{2+}	109 ± 0.370	Polysaccharide	1.10 ± 0.260
Mg^{2+}	10.4 ± 0.040	Protein	13.5 ± 0.630
Al^{3+}	0.210 ± 0.070	Zeta potential (mv)	–20.2 ± 0.500
NO^{3-}	10.6 ± 0.010	Conductivity (mS/cm)	0.890 ± 0.000
NO^{2-}	0.050 ± 0.000	Salinity	0.480 ± 0.000
Cl^-	96.3 ± 0.160	UV_{254}	0.110 ± 0.000
HCO^{3-}	184 ± 0.210	Residual chlorine	> 0.500
Fe^{2+}	0.180 ± 0.030		

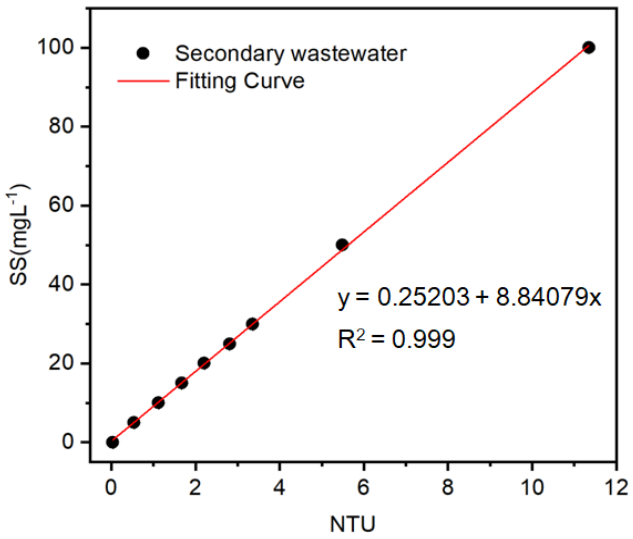

Figure S1. Linear calibration curves of NTU and SS for suspended particles.

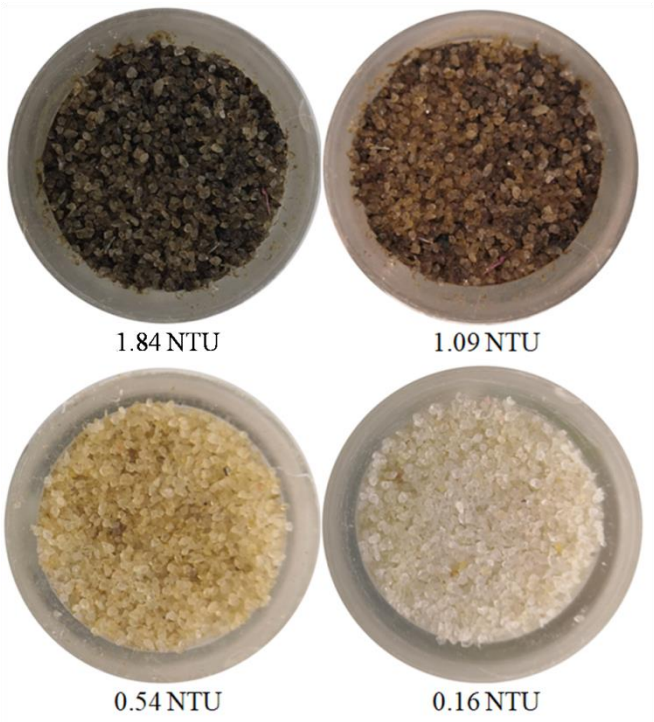

Figure S2. The pictures of the surface of porous medium at the end of the experiments.

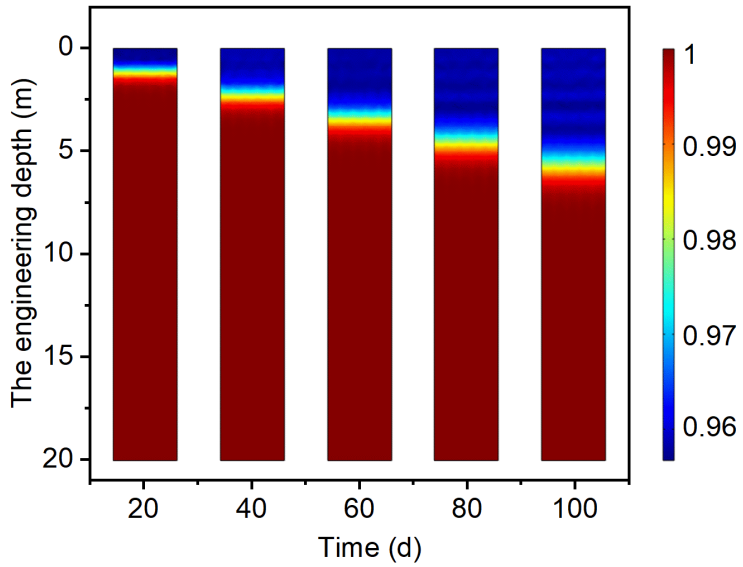

Figure S3. Clogging of infiltration safety threshold recharge water at large-scale site.

Text S1. Formulae for calculating Φ_{VDW} and Φ_{EDL}.

The ordinate of the DLVO potential energy diagram corresponds to the interaction energy between the suspended and collected particles, while the abscissa represents the separation distance between them. The Φ_{VDW} is calculated from the following equation:

$$\Phi VDW = -\frac{Ar}{6(1+14h/\lambda)} \quad (1)$$

where A is the Hamaker constant for organic (6.50×10^{-21} J)and inorganic particles (1.00×10^{-20} J) [3], r is the radius of suspended particles, h is the separation distance between the surfaces of suspended particles and quartz sands, and λ is the characteristic wavelength of suspended particles (λ=100 nm) [4].

The Φ_{EDL} can be calculated as:

$$\Phi_{\mathrm{dl}} = \pi\varepsilon_0\varepsilon_r\left\{2\Psi_1\Psi_2\ln\left[\frac{1+\exp(-\kappa y)}{1-\exp(-\kappa y)}\right] + (\Psi_1{}^2 + \Psi_2{}^2)ln[1-\exp(-2\kappa y)]\right\} \quad (2)$$

where ε_0 is the vacuum permittivity (8.85×10^{-12} C J^{-1} m^{-1}), ε_r is the relative dielectric permittivity of water (82.1), φ_1 and φ_2 are the surface potentials of suspended particles and quartz sands, respectively, and κ is the Debye reciprocal length.

References

3. Redman, J.A.; Walker, S.L.; Elimelech, M. Bacterial adhesion and transport in porous media: Role of the secondary energy minimum. Environmental Science & Technology 2004, 38, 1777-1785, doi:10.1021/es034887l.
4. Fan, W.; Jiang, X.H.; Yang, W.; Geng, Z.; Huo, M.X.; Liu, Z.M.; Zhou, H. Transport of graphene oxide in saturated porous media: Effect of cation composition in mixed Na-Ca electrolyte systems. Science of the Total Environment 2015, 511, 509-515, doi:10.1016/j.scitotenv.2014.12.099.