**Supplementary File for:**

# Spatial variation of loose deposits characteristics in a 40 km long operational drinking water distribution system

Xu Ma[a], Guiwei Li[b,c], Ying Yu[b,c], Ruya Chen[b,c], Yao Zhang[b], Hui Tao[d], Guangming Zhang[a*], Baoyou Shi[b,c*]

[a]School of Environment & Natural Resource, Renmin University of China, Beijing, 100872, China.

[b]Key Laboratory of Drinking Water Science and Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China.

[c]University of Chinese Academy of Sciences, Beijing 100049, China

[d]College of Environmental Science and Engineering, Hohai University, Nanjing 210098, China

# CONTENTS

Table S1

Treated water quality parameters

| Parameters | Treated water |
|---|---|
| T (°C, average) | 24.6 |
| pH | 7.44 |
| Turbidity (NTU) | 0.14 |
| Chlorine (mg/L as $Cl_2$) | 0.57 |
| Alkalinity (mg/L $CaCO_3$) | 53.2 |
| Hardness (mg/L $CaCO_3$) | 92.9 |
| Chloride (mg/L) | 11.3 |
| Nitrate (mg/L) | 1.41 |
| Sulfate (mg/L) | 24.5 |
| $COD_{mn}$ (mg/L) | 0.87 |
| Fe (mg/L) | <0.05 |
| Mn (mg/L) | <0.03 |
| Al (mg/L) | 0.054 |

$COD_{mn}$: Chemical Oxygen Demand

Table S2

Location, type and manufacturers of each flow meter

| | Location | Type | Manufacturers |
|---|---|---|---|
| 1 | Within the water treatment plant | FXE4000 | Shanghai ABB Engineering Co., Ltd. |
| 2 | site a | IFC050W | Shanghai Guanghua·Altometer Instruments Co.,Ltd. |
| 3 | The front of site 3 | IFC100W | Shanghai Guanghua·Altometer Instruments Co.,Ltd. |
| 4 | site b | FXE4000 | Shanghai ABB Engineering Co., Ltd. |
| 5 | site c | FXE4000 | Shanghai ABB Engineering Co., Ltd. |
| 6 | site d | FEP | Shanghai ABB Engineering Co., Ltd. |
| 7 | site e | 7ME5033 | Siemens Ltd., China |

Table S3

Elemental composition (weight %) of the pipe deposits collected along the pipeline

| El | **0** | **1-1** | **1-2** | **2-1** | **2-2** | **3-1** | **3-2** | **4-1** | **4-2** | **5-1** | **6-1** | **6-2** | **7-1** | **7-2** | **8-1** | **8-2** | **Mean** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Si | 6.91 | 4.49 | 4.84 | 29.02 | 31.46 | 8.02 | 13.13 | 26.63 | 25.64 | 25.21 | 30.15 | 27.75 | 27.9 | 29.21 | 23.0 | 26.84 | 21.57 |
| Al | 13.01 | 13.10 | 12.62 | 7.76 | 8.63 | 14.04 | 11.81 | 10.65 | 8.07 | 9.81 | 7.73 | 8.34 | 8.33 | 7.82 | 9.28 | 8.23 | 10.32 |
| Mn | 13.83 | 20.88 | 22.48 | 0.91 | 1.48 | 13.81 | 9.61 | 1.08 | 0.69 | 2.1 | 0.7 | 0.46 | 0.47 | 0.24 | 2.52 | 0.58 | 5.57 |
| Fe | 6.13 | 1.27 | 1.79 | 5.39 | 4.58 | 2.68 | 3.49 | 8.57 | 6.48 | 4.58 | 4.64 | 6.24 | 5.58 | 5.27 | 4.84 | 6.64 | 4.68 |
| K | 0.48 | 0.28 | 0.3 | 2.09 | 2.21 | 0.58 | 0.84 | 2.33 | 0.06 | 2.01 | 2.18 | 2.04 | 2.61 | 2.12 | 1.77 | 2.24 | 1.51 |
| Ca | 1.88 | 1.50 | 1.63 | 1.41 | 1.33 | 1.43 | 1.37 | 1.73 | 1.36 | 1.24 | 1.33 | 1.16 | 1.43 | 1.26 | 1.28 | 1.22 | 1.41 |
| Ti | 0.985 | 0.0909 | 0.127 | 0.722 | 0.865 | 0.208 | 0.349 | 0.916 | 0.676 | 0.694 | 0.654 | 0.87 | 0.779 | 0.748 | 0.738 | 0.836 | 0.6199 |
| Mg | 0.70 | 0.50 | 0.64 | 0.57 | 0.47 | 0.45 | 0.4 | 0.89 | 0.70 | 0.6 | 0.62 | 0.54 | 0.69 | 0.61 | 0.52 | 0.64 | 0.6 |
| Na | 0.16 | 0.10 | - | 0.45 | 0.38 | 0.22 | 0.03 | 0.21 | 0.25 | 0.34 | 0.48 | 0.23 | 0.63 | 0.3 | 0.24 | 0.24 | 0.27 |
| Cl | 0.741 | 0.256 | 0.104 | 0.132 | 0.0977 | 0.419 | 0.164 | 0.025 | 0.021 | 0.181 | 0.0632 | - | 0.273 | - | 0.237 | - | 0.2126 |
| S | 0.239 | 0.205 | 0.226 | 0.0821 | 0.0771 | 0.174 | 0.128 | 0.115 | 0.0878 | 0.0717 | 0.0291 | - | 0.0377 | 0.0138 | 0.132 | 0.0155 | 0.1209 |
| P | 0.104 | 0.115 | 0.0895 | 0.0662 | 0.12 | 0.143 | 0.143 | 0.126 | 0.0865 | 0.116 | 0.0703 | 0.0479 | 0.0915 | 0.0658 | 0.181 | 0.0847 | 0.1158 |
| Zn | 0.121 | 0.139 | 0.138 | 0.038 | 0.036 | 0.202 | 0.156 | 0.112 | 0.069 | 0.059 | 0.038 | 0.051 | 0.028 | 0.040 | 0.12 | 0.073 | 0.085 |
| Cu | 0.047 | 0.074 | 0.059 | - | - | 0.079 | 0.038 | - | - | 0.01 | 0.003 | - | - | - | - | - | 0.044 |
| Ni | 0.061 | 0.089 | 0.08 | 0.007 | - | 0.09 | 0.055 | - | - | 0.015 | 0.008 | - | 0.008 | - | 0.006 | - | 0.038 |
| La | - | 0.0096 | 0.0149 | 0.0229 | 0.064 | 0.0132 | 0.046 | 0.0660 | 0.047 | 0.0136 | - | - | 0.0344 | - | 0.046 | - | 0.0344 |
| Zr | - | - | 0.0038 | 0.0334 | 0.0409 | 0.0058 | - | 0.0275 | 0.0269 | - | 0.0219 | 0.067 | - | 0.039 | 0.0272 | 0.0419 | 0.028 |
| Sm | - | 0.018 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.018 |
| Cr | - | - | - | 0.0960 | 0.0066 | 0.0016 | - | 0.0205 | 0.0118 | 0.0079 | 0.0068 | 0.017 | 0.0096 | 0.0096 | 0.0093 | 0.0103 | 0.0156 |
| Sr | - | 0.012 | 0.016 | 0.017 | 0.018 | 0.011 | 0.011 | - | 0.017 | 0.011 | 0.017 | - | 0.018 | 0.022 | 0.014 | 0.022 | 0.015 |
| V | - | 0.013 | 0.017 | 0.011 | 0.014 | 0.011 | 0.015 | 0.018 | 0.013 | 0.012 | 0.011 | 0.023 | 0.015 | 0.016 | 0.017 | 0.019 | 0.014 |
| Co | - | 0.014 | 0.013 | - | - | 0.012 | 0.006 | - | - | 0.002 | - | - | - | - | - | - | 0.009 |
| Ga | - | 0.0042 | - | 0.0049 | - | 0.0026 | - | 0.0167 | - | 0.0032 | 0.0051 | - | 0.0044 | - | 0.0049 | 0.0143 | 0.0063 |
| Y | - | - | - | 0.0039 | - | - | - | - | - | 0.003 | 0.0029 | - | - | - | - | - | 0.0033 |

-: The element was not detected in this sample.

Table S4

The normal flow rates at different flushing sites

| Flushing sites | Pipe diameter | Flow rate ($m^3/h$) |
|---|---|---|
| 1 | DN 800 | 1400 |
| 2 | DN 600 | 800 |
| 3 | DN 500 | 200 |
| 4 | DN 600 | 800 |
| 5 | DN 600 | 500 |
| 6 | DN 600 | 250 |
| 7 | DN 400 | 250 |
| 8 | DN 400 | 250 |

Table S5

Concentration of heavy metals in flush water collected from different locations

| Element (μg/L) | Drinking water sandard (μg/L) | Flushing water samples | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1-1 | 1-2 | 2-1 | 2-2 | 3-1 | 3-2 | 3-3 | 4-1 | 4-2 | 5-1 | 5-2 | 6-1 | 6-2 | 7-1 | 7-2 | 8-1 | 8-2 |
| Zn | 1000 | 458.7 | 151.8 | 57.8 | 25.1 | 393.9 | 93.6 | 8.6 | 57.1 | 35.5 | 246.4 | 97.3 | 321.4 | 46.3 | 60.8 | 64.2 | 81.0 | 74.9 |
| Cu | 1000 | 242.9 | 64.4 | 0.0 | 0.0 | 153.1 | 22.9 | 0.0 | 0.0 | 0.0 | 42.1 | 0.0 | 22.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ni | 20 | 294.0 | 87.8 | 10.4 | 0.0 | 175.5 | 32.7 | 1.4 | 0.0 | 0.0 | 60.5 | 3.6 | 67.7 | 0.0 | 17.6 | 0.0 | 4.3 | 0.0 |
| Cr | 50 | 0.0 | 0.0 | 146.9 | 4.6 | 3.1 | 0.0 | 0.3 | 10.5 | 6.1 | 32.9 | 7.1 | 58.3 | 15.6 | 20.6 | 15.5 | 6.3 | 10.5 |

“red numbers” means that they exceed the Drinking water standard

Table S6

The bacterial community diversities of the samples collected from flush water or tap water

| Sample | OTU | Shannon | Simpson | Ace | Chao | Coverage |
|---|---|---|---|---|---|---|
| a-1 | 209 | 1.35 | 0.50 | 268.76 | 265 | 0.9972 |
| b-1 | 175 | 2.01 | 0.24 | 384.29 | 272 | 0.9964 |
| c-1 | 335 | 2.88 | 0.12 | 504.67 | 496 | 0.9943 |
| d-1 | 230 | 2.97 | 0.14 | 235.08 | 240 | 0.9994 |
| e-1 | 600 | 4.63 | 0.04 | 643.58 | 641 | 0.9967 |
| 1-2 | 515 | 3.32 | 0.09 | 631.11 | 634 | 0.9939 |
| 2-1 | 2011 | 5.81 | 0.05 | 2232.29 | 2241 | 0.9837 |
| 2-2 | 654 | 3.67 | 0.07 | 712.05 | 719 | 0.9952 |
| 3-1 | 708 | 3.11 | 0.14 | 1127.17 | 1025 | 0.9866 |
| 3-2 | 690 | 4.28 | 0.06 | 1144.14 | 1027 | 0.9899 |
| 4-1 | 1835 | 5.97 | 0.01 | 2238.28 | 2239 | 0.9790 |
| 4-2 | 2004 | 6.27 | 0.01 | 2420.10 | 2408 | 0.9778 |
| 5-1 | 920 | 1.89 | 0.40 | 1629.89 | 1482 | 0.9794 |
| 5-2 | 1304 | 5.31 | 0.02 | 1749.90 | 1735 | 0.9818 |
| 6-1 | 1206 | 2.71 | 0.27 | 1850.86 | 1789 | 0.9773 |
| 6-2 | 1186 | 3.58 | 0.12 | 1657.19 | 1550 | 0.9811 |
| 7-1 | 1230 | 3.60 | 0.14 | 1826.18 | 1795 | 0.9781 |
| 7-2 | 1428 | 3.66 | 0.17 | 2065.22 | 2070 | 0.9755 |
| 8-1 | 726 | 3.92 | 0.07 | 1309.91 | 1084 | 0.9879 |
| 8-2 | 1231 | 4.27 | 0.08 | 1849.28 | 1761 | 0.9789 |
| a-2 | 277 | 1.80 | 0.44 | 374.15 | 361 | 0.9960 |
| b-2 | 203 | 1.58 | 0.54 | 225.24 | 233 | 0.9984 |
| c-2 | 188 | 1.58 | 0.47 | 208.02 | 205 | 0.9985 |
| d-2 | 273 | 2.00 | 0.38 | 289.61 | 293 | 0.9984 |
| e-2 | 574 | 3.44 | 0.12 | 720.58 | 739 | 0.9930 |

Table S7
ANOSIM statistics for flush water samples

| Method | Statistic | P value | Permutation_number |
|---|---|---|---|
| ANOSIM | 0.5743 | 0.003 | 999 |

Table S8

Relative abundance of opportunistic pathogen-containing genera collected from flushed water and tap water samples

| | a | b | c | d | e | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mycobacterium* | 0.04 | 0.01 | 0.01 | 0.03 | 0.01 | 0.61 | 0.13 | 0.39 | 0.71 | 0.01 | 0.04 | 0.07 | 0.03 |
| *Legionella* | 0.04 | 0.01 | 0.02 | 0.19 | 0.25 | 0.78 | 0.01 | 0.27 | 0.27 | 0.01 | 0.03 | 0.03 | 0.06 |
| *Pseudomonas* | 0.19 | 0.07 | 0.05 | 0.1 | 0.57 | 0.41 | 0.14 | 0.18 | 1.39 | 0.02 | 0.03 | 0.89 | 1.01 |

Table S9

The quality parameters of treated water and tap water (before and after flushing)

| | Turbidity (NTU) | residual chlorine (mg/L as $Cl_2$) | Hardness (mg/L) | $COD_{mn}$ (mg/L) | $F^-$ (mg/L) | $Cl^-$ (mg/L) | $NO_3^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | HPC (CFU/ml) |
|---|---|---|---|---|---|---|---|---|---|
| TW-1 | 0.06 | 0.31 | 96.09 | 1.68 | 0.24 | 8.73 | 5.62 | 31.69 | 0 |
| a-1 | 0.08 | 0.27 | 108.10 | 1.68 | 0.26 | 9.05 | 5.57 | 32.35 | 0 |
| b-1 | 0.10 | 0.06 | 92.08 | 1.12 | 0.25 | 8.31 | 5.56 | 31.77 | 15 |
| c-1 | 0.06 | 0.05 | 88.08 | 1.12 | 0.25 | 8.41 | 5.64 | 32.23 | 25 |
| d-1 | 0.20 | 0.01 | 94.08 | 0.88 | 0.24 | 8.52 | 5.68 | 32.65 | 86 |
| e-1 | 0.25 | 0.00 | 94.08 | 1.12 | 0.23 | 8.64 | 5.78 | 32.31 | 152 |
| TW-2 | 0.08 | 0.34 | 92.08 | 1.04 | 0.24 | 8.32 | 5.36 | 33.60 | 0 |
| a-2 | 0.10 | 0.3 | 94.08 | 1.04 | 0.24 | 9.03 | 5.67 | 37.03 | 0 |
| b-2 | 0.11 | 0.27 | 100.09 | 0.8 | 0.25 | 9.94 | 5.89 | 35.19 | 0 |
| c-2 | 0.10 | 0.12 | 134.12 | 0.96 | 0.36 | 9.32 | 5.68 | 35.91 | 2 |
| d-2 | 0.25 | 0.11 | 102.09 | 1.04 | 0.27 | 9.56 | 5.68 | 36.14 | 1 |
| e-2 | 0.28 | 0.00 | 100.09 | 1.04 | 0.36 | 8.80 | 5.63 | 35.74 | 15 |

$COD_{mn}$: Chemical Oxygen Demand, “-1” means before flushing, “-2” means after flushing

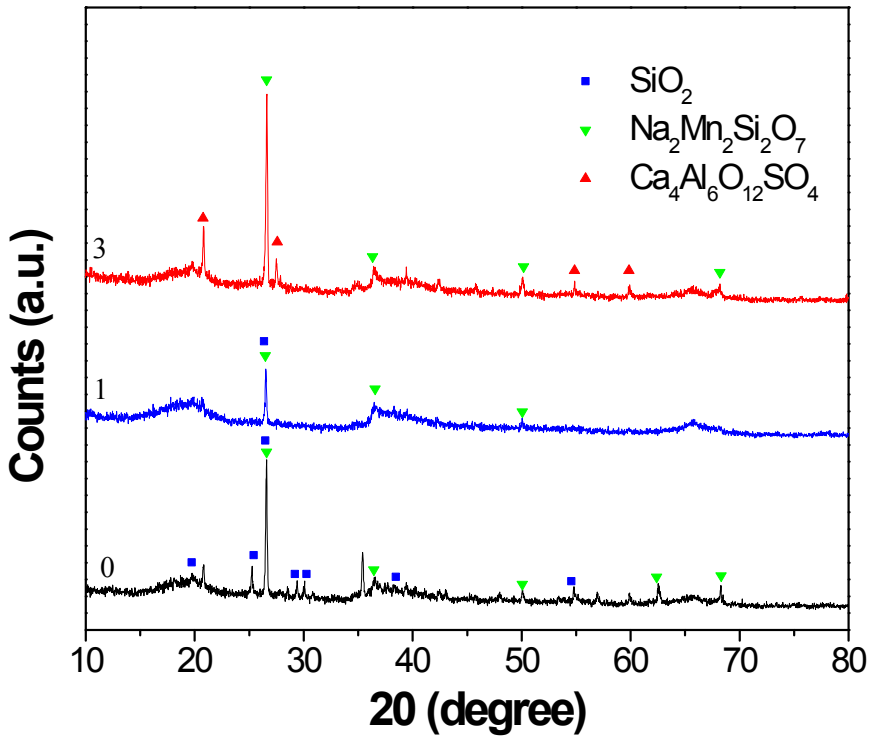
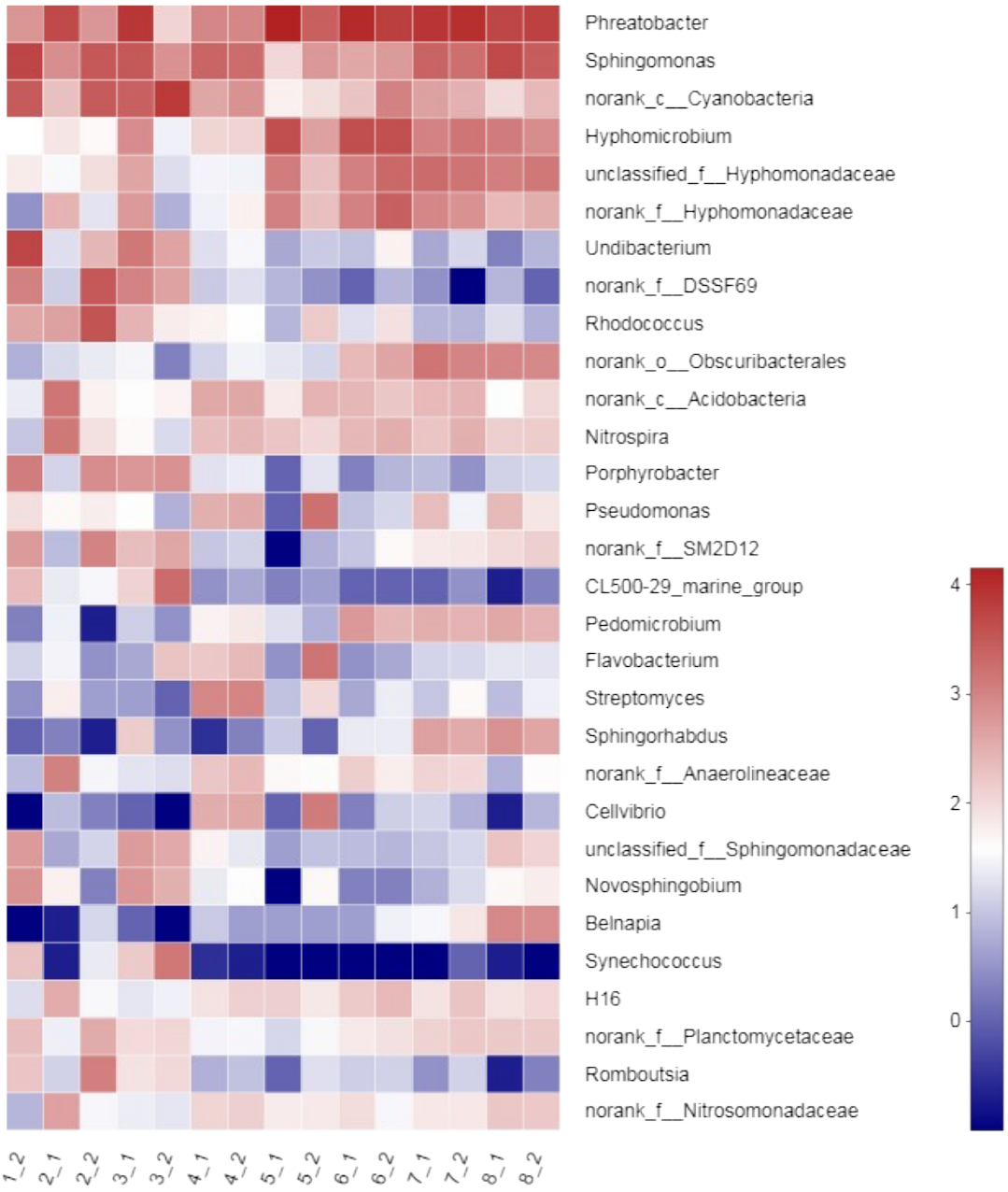
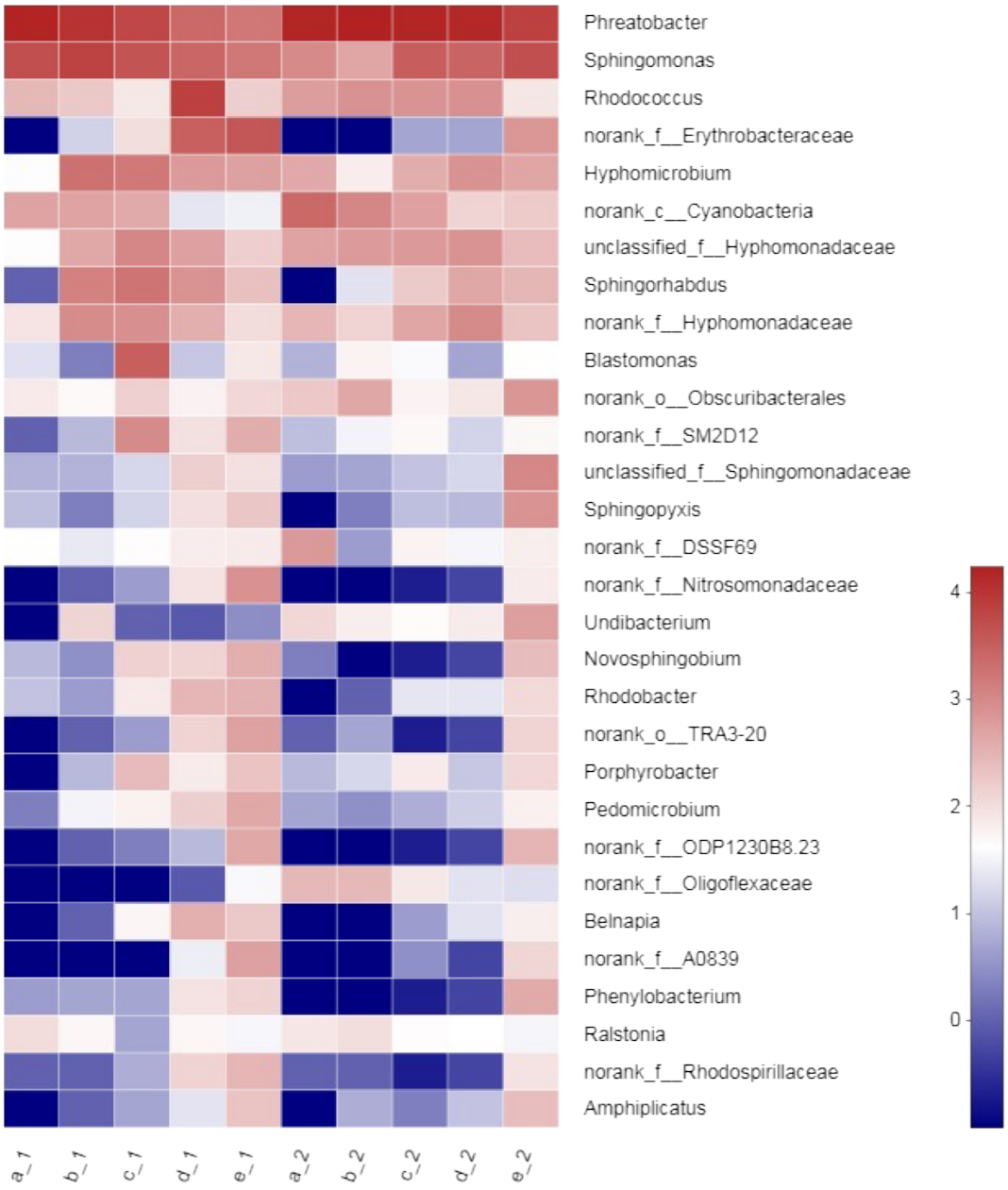



Fig. S1. XRD patterns of three typical deposits samples 0, 1 and 3 collected during the flushing process.



(a) flushed water




(b) tap water

Fig. S2. Heatmaps showing the percentages of the top 30 abundant species at genus level for (a) flushed water and (b) tap water samples

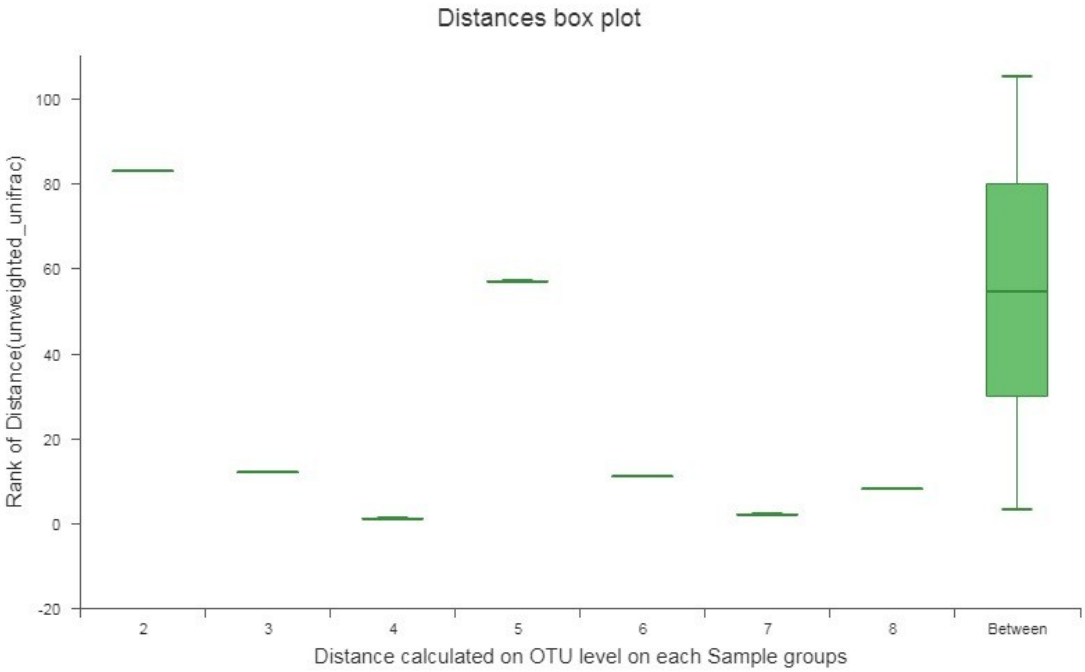



Fig. S3. Distance calculated on genus level on each flush water sample group

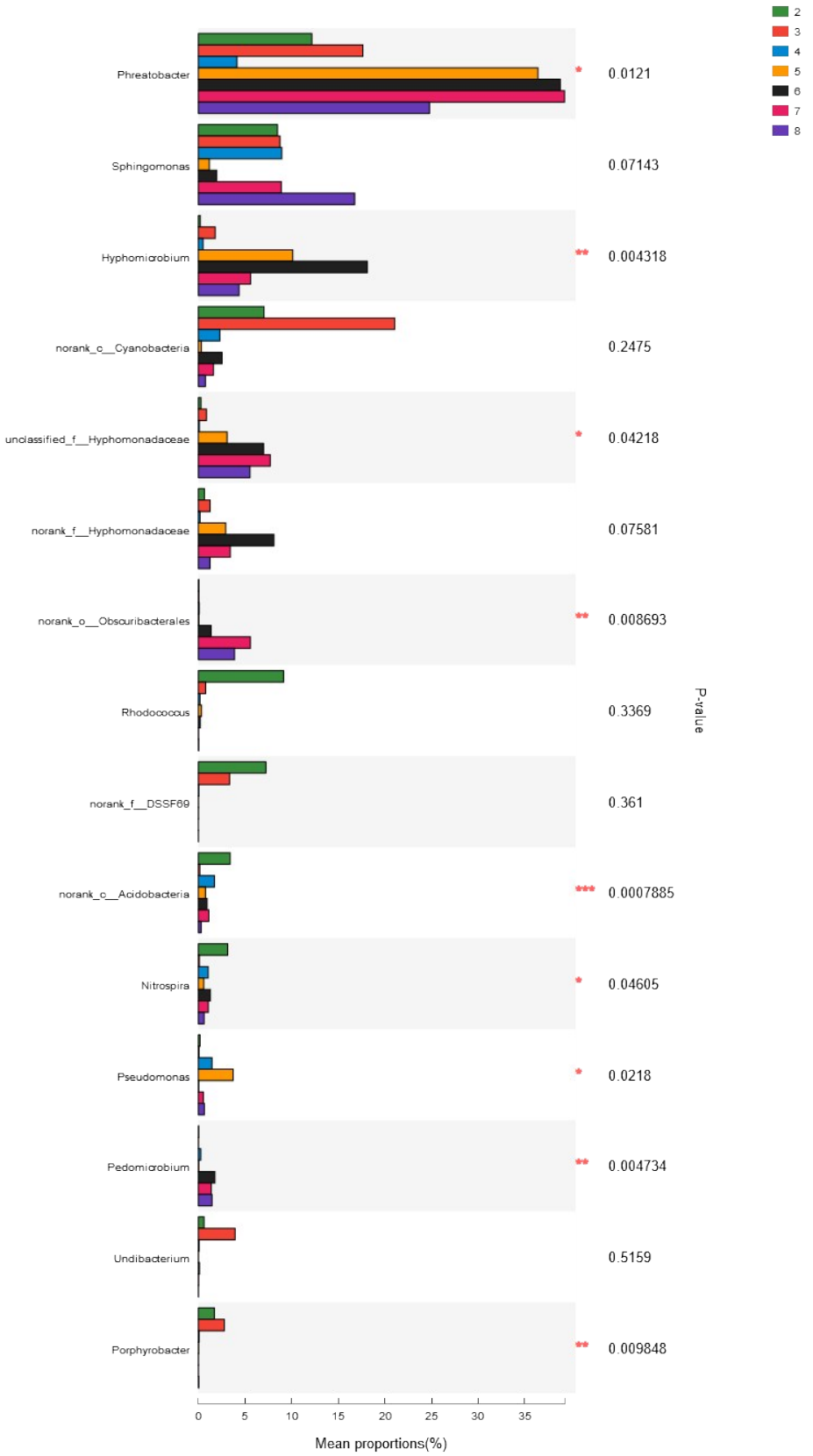



Fig. S4. Microbial species with significant differences in the different flushed water samples

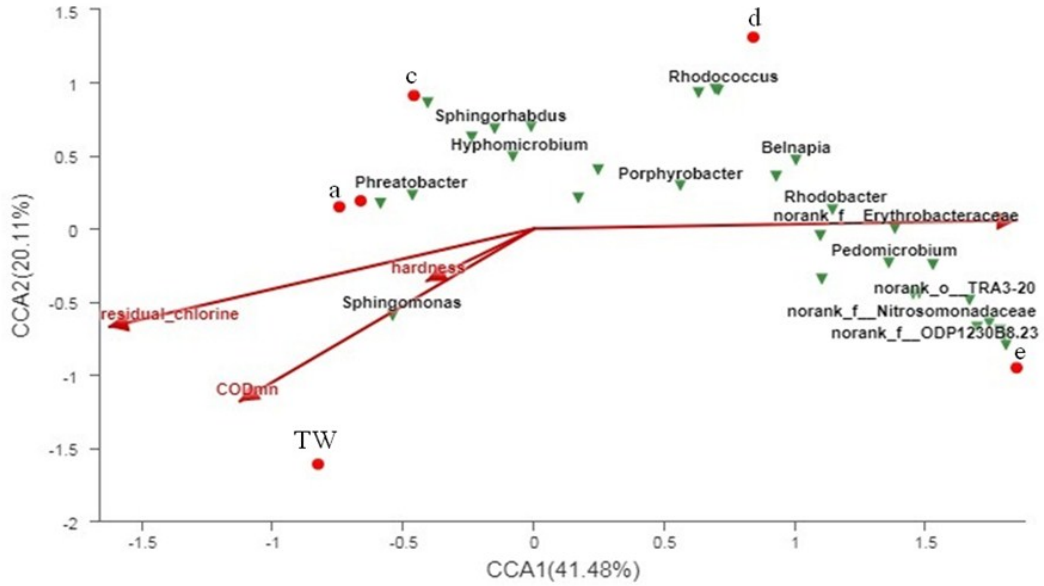



Fig. S5. Canonical Correlation Analysis (CCA) of bacteria community with tap water quality

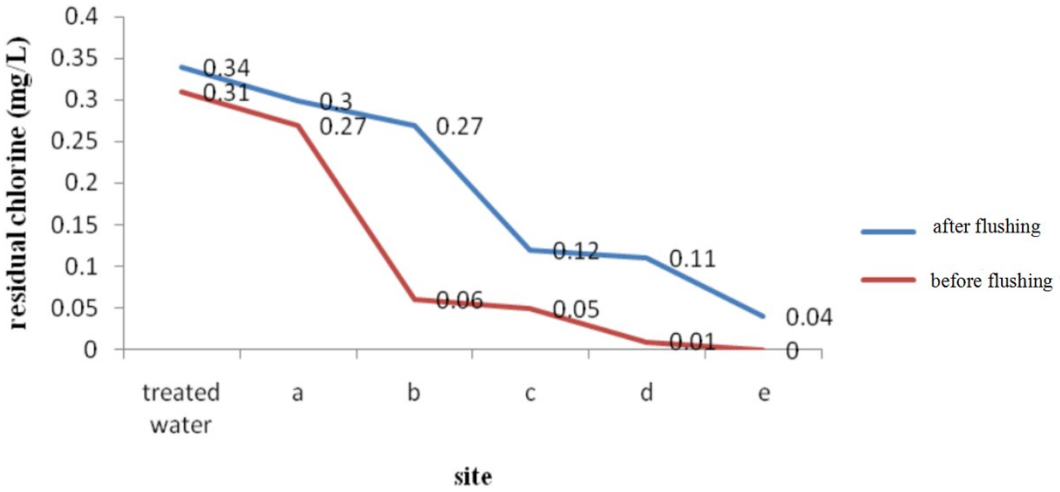



Fig. S6. The residual chlorine values of treated water and 5 sites tap water