Supporting Information

Removal of Lead Phosphate Nanoparticles from Drinking Water by Hydrogen Peroxide Photolysis Combined with Point-of-Use Filtration

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Text S1 Calculation of the UV dosage in the UV/H_2O_2 system

To quantify the UV intensity of the UV system in this study, the atrazine degradation experiment was conducted. 3.5 L of atrazine solution (10 mg/L) was exposed in UV light for 10 min with other conditions same as the nano-Pb-PO_4 exposure experiment. 2 mL of the solution was collected at different time points (0, 1, 2, 4, 6, 8 and 10 minutes), and measured for atrazine concentration. Atrazine actinometry was based on the degradation kinetics of atrazine:

$$-\frac{dC}{dt} = 2.303 \cdot \emptyset_{atr} \cdot \varepsilon_{atr} \cdot I_0 \cdot C_{atr} \cdot t$$

$$-\frac{\ln(\frac{C}{C_0})}{t} = 2.303 \cdot \emptyset_{atr} \cdot \varepsilon_{atr} \cdot I_0$$

$$I_0 = \frac{-\frac{\ln(\frac{C}{C_0})}{t}}{2.303 \cdot \emptyset_{atr} \cdot \varepsilon_{atr}}$$

From atrazine degradation data in Figure S1: $-\frac{\ln(\frac{C}{C_0})}{t} = 0.00247$ s^{-1} (R^2= 0.999)

I_0 is photon fluence rate (unit: $einstein\ m^{-2}s^{-1}$)

From literature (at 253.7 nm):

$$\emptyset_{atr} = 0.046\ mol \cdot einstein^{-1}$$

$$\varepsilon_{atr} = 3860\ m^2 mol^{-1}$$

$$I_0 = \frac{-\frac{\ln(\frac{C}{C_0})}{t}}{2.303 \cdot \emptyset_{atr} \cdot \varepsilon_{atr}} = \frac{0.00247}{2.303 \times 0.046 \times 3860} = 6.05 \times 10^{-6} einstein\ m^{-2}s^{-1}$$

$$E = h\nu = \frac{hc}{\lambda}$$

$h = 6.626 \times 10^{-34} J \cdot s$, $c = 3 \times 10^{8} m \cdot s^{-1}$, $\lambda = 253.7 \times 10^{-9} m$

$$E = h\nu = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{253.7 \times 10^{-9}} = 7.835 \times 10^{-19} J$$

Avogadro Constant: 6.022×10^{23}

Molar photon energy (*Einstein*) $= E \times N_A = 7.835 \times 10^{-19} \times 6.022 \times 10^{23} = 471823.7\ J$

$$Photon\ Flux = \frac{6.05 \times 10^{-6} \times 471823.7 \times 1000}{100^2} = 0.285\ mJ/(cm^2 \cdot s)$$

For 10 mins of UV irradiation, the UV intensity is $0.285 \times 60 \times 10 = 170\ mJ/cm^2$

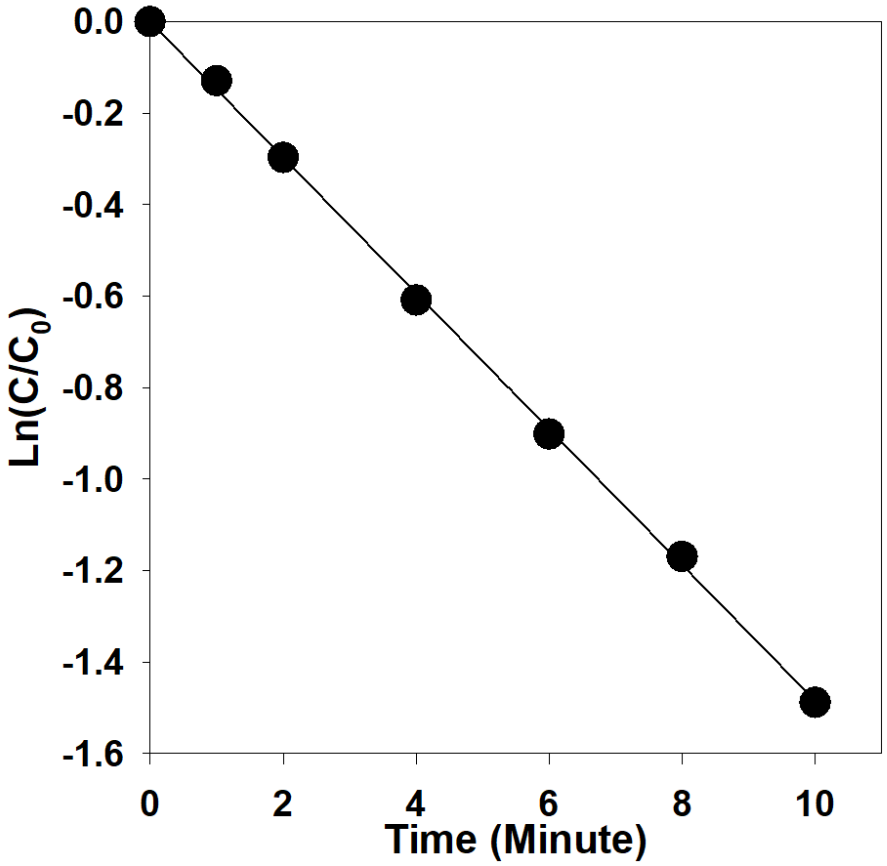

Figure S1 Atrazine degradation (10 mg/L) under direct photolysis in DI water at pH 7.

Text S2 Detection of Lead Dioxide (PbO_2) in Drinking Water

The mechanism to quantify PbO_2 is that PbO_2 can oxidize iodide to form triiodide (I_3^-) in the excess of iodide which can be quantified through the UV absorbance. Specifically, 0.4 g KI was added to 10 mL water with PbO_2. The pH was adjusted to 2 with HCl, and then the suspension was stirred for 1 h at 700 rpm to fully develop the color. The UV absorbance of the final sample was measured at the wavelength of 351 nm to quantify the PbO_2 concentration.

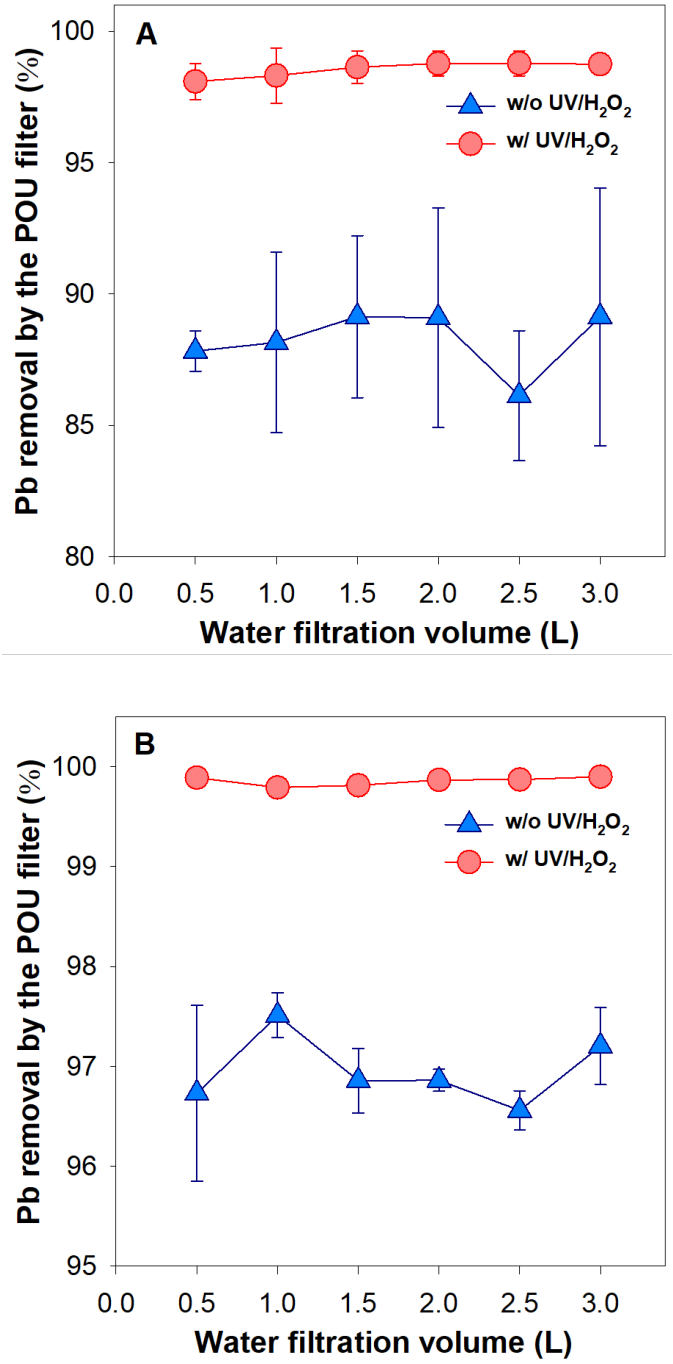

Figure S2 Percentages of Pb removal after POU faucet filtration with and without UV/H_2O_2 treatment in synthetic drinking water with 2 mM $NaClO_4$ at pH 7. (A): [Nano-Pb-$PO_{4(s)}$]=0.1 mg Pb/L and [H_2O_2]=0.5 mg/L; and (B): [Nano-Pb-$PO_{4(s)}$]=1 mg/L and [H_2O_2]=5 mg/L.

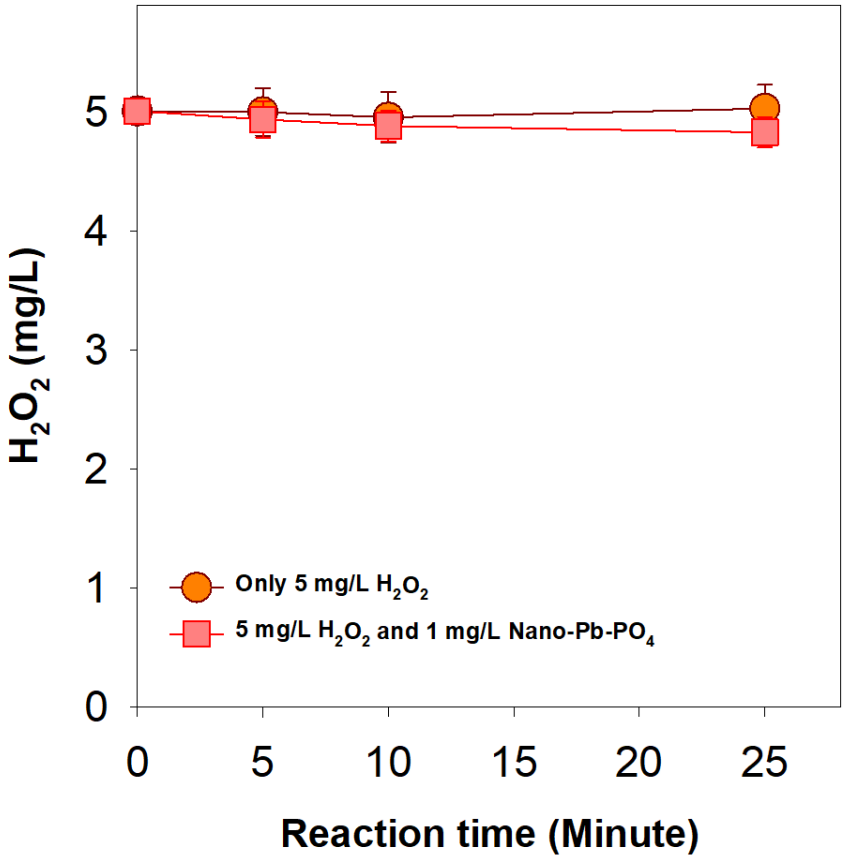

Figure S3 H_2O_2 concentrations with and without 1 mg/L Nano-Pb-PO_4 in synthetic drinking water with 2 mM $NaClO_4$ at pH 7.

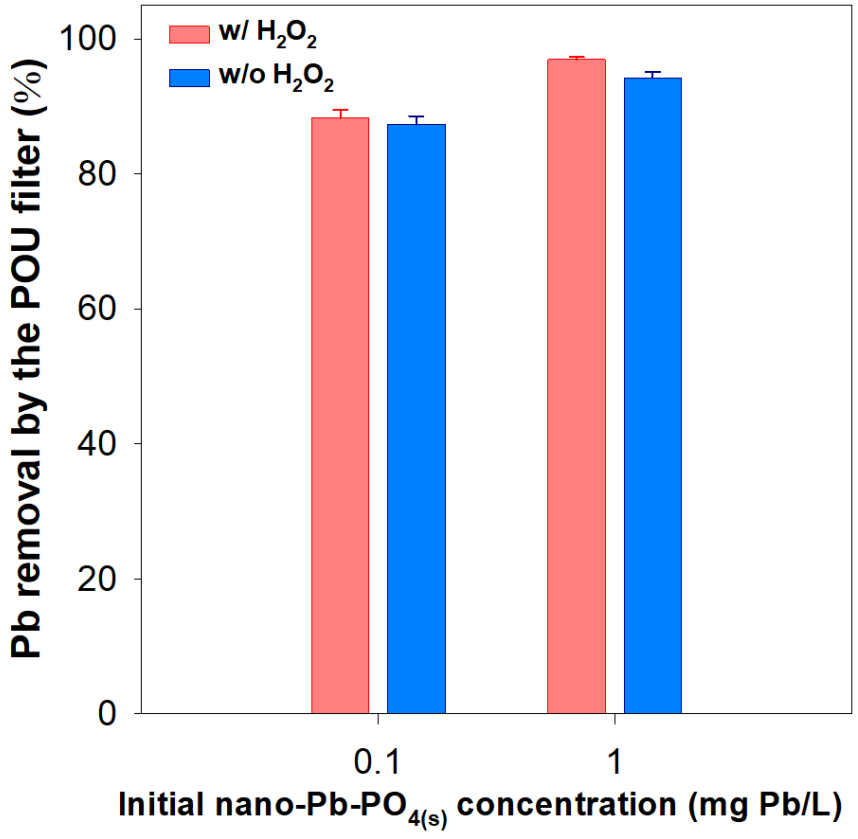

Figure S4 Percentages of Pb removal after POU faucet filtration with and without H_2O_2 in synthetic drinking water at pH 7. Treatment received no UV exposure. ([Nano-Pb-$PO_{4(s)}$]=0.1 mg Pb/L and [H_2O_2]=0.5 mg/L; and [Nano-Pb-$PO_{4(s)}$]=1 mg/L and [H_2O_2]=5 mg/L).

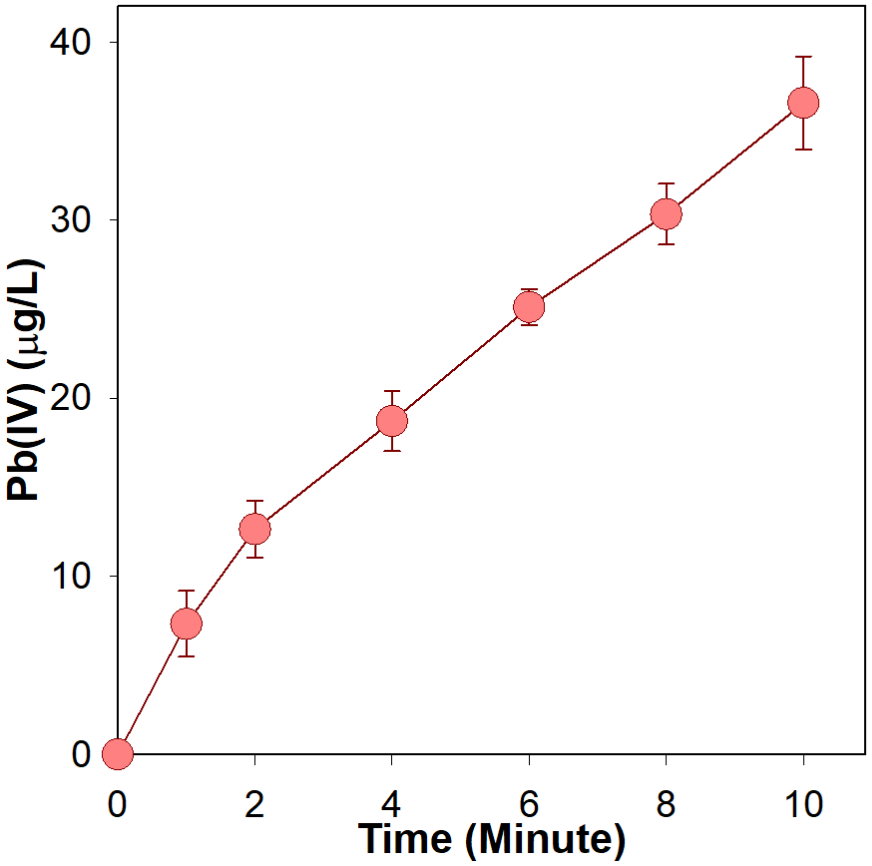

Figure S5 The formation of Pb(IV) due to the oxidation of nano-Pb-PO_4 under the UV/H_2O_2 in synthetic drinking water at pH 7. [Nano-Pb-PO_4]=1 mg Pb/L and [H_2O_2]=5 mg/L.

Text S3 Calculation of the formation rate constant of $PbO_{2(s)}$

The steady state concentration of $HO^{\bullet}$ was calculated based on the nitrobenzene degradation (Figure S5) and the reaction rate constant between $HO^{\bullet}$ and nitrobenzene (4.7×10^{9} $M^{-1}\cdot s^{-1}$): $[HO^{\bullet}]_{ss}$=(0.1164 min^{-1})(slope of Figure S5)×(1/60 min/s)/(4.7×10^{9} $M^{-1}\cdot s^{-1}$)= 4.13×10^{-13} M

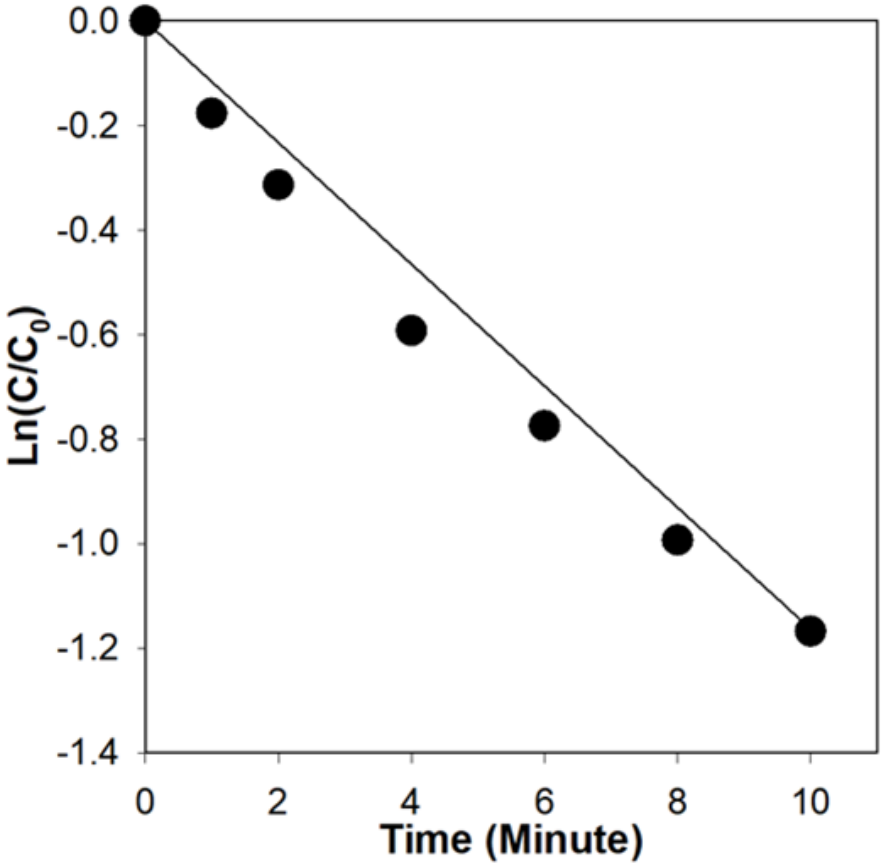

Figure S6 Nitrobenzene (1 mg/L) degradation under the UV-H_2O_2 with 5 mg/L of H_2O_2 at pH 7.

The formation rate constant of $PbO_{2(s)}$ was calculated based on the steady state concentration of $HO^{\bullet}$ and the oxidation kinetics of Pb(II) to Pb(IV) (Figure S6):

$k_{Pb(VI)}$=(0.004 min^{-1})(slope of Figure S6)×(1/60 min/s)/(4.13×10^{-13} mol/L)=1.61×10^{8} $M^{-1}\cdot s^{-1}$

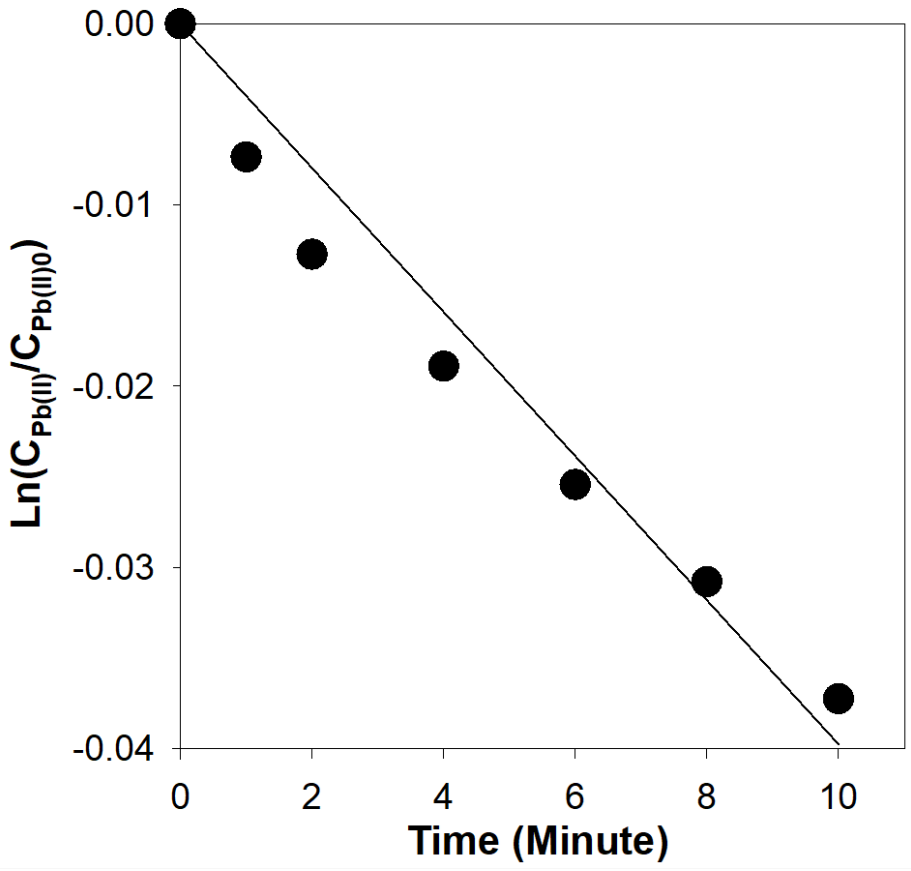

Figure S7 Oxidation kinetics of Pb(II) to Pb(IV) under the UV/H_2O_2. [Nano-Pb-PO_4]=1 mg Pb/L and [H_2O_2]=5 mg/L.

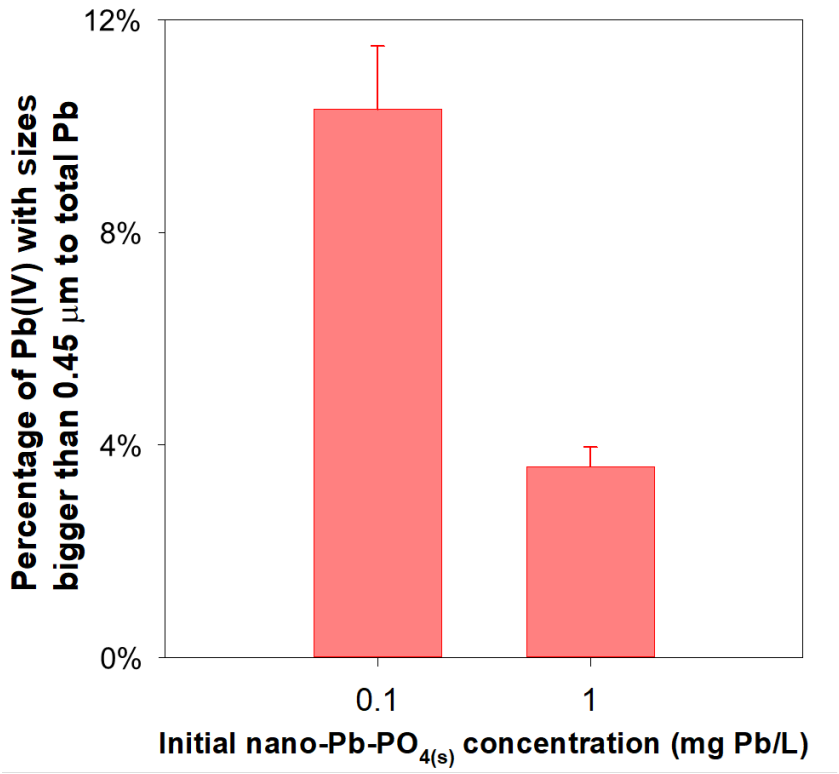

Figure S8 The percentage of Pb(IV) with sizes bigger than 0.45 μm to total Pb particles after the UV/H_2O_2 in synthetic drinking water with 2 mM $NaClO_4$ at pH 7. [Nano-Pb-PO_4]=0.1 mg Pb/L and [H_2O_2]=0.5 mg/L, and [Nano-Pb-PO_4]=1 mg/L and [H_2O_2]=5 mg/L.

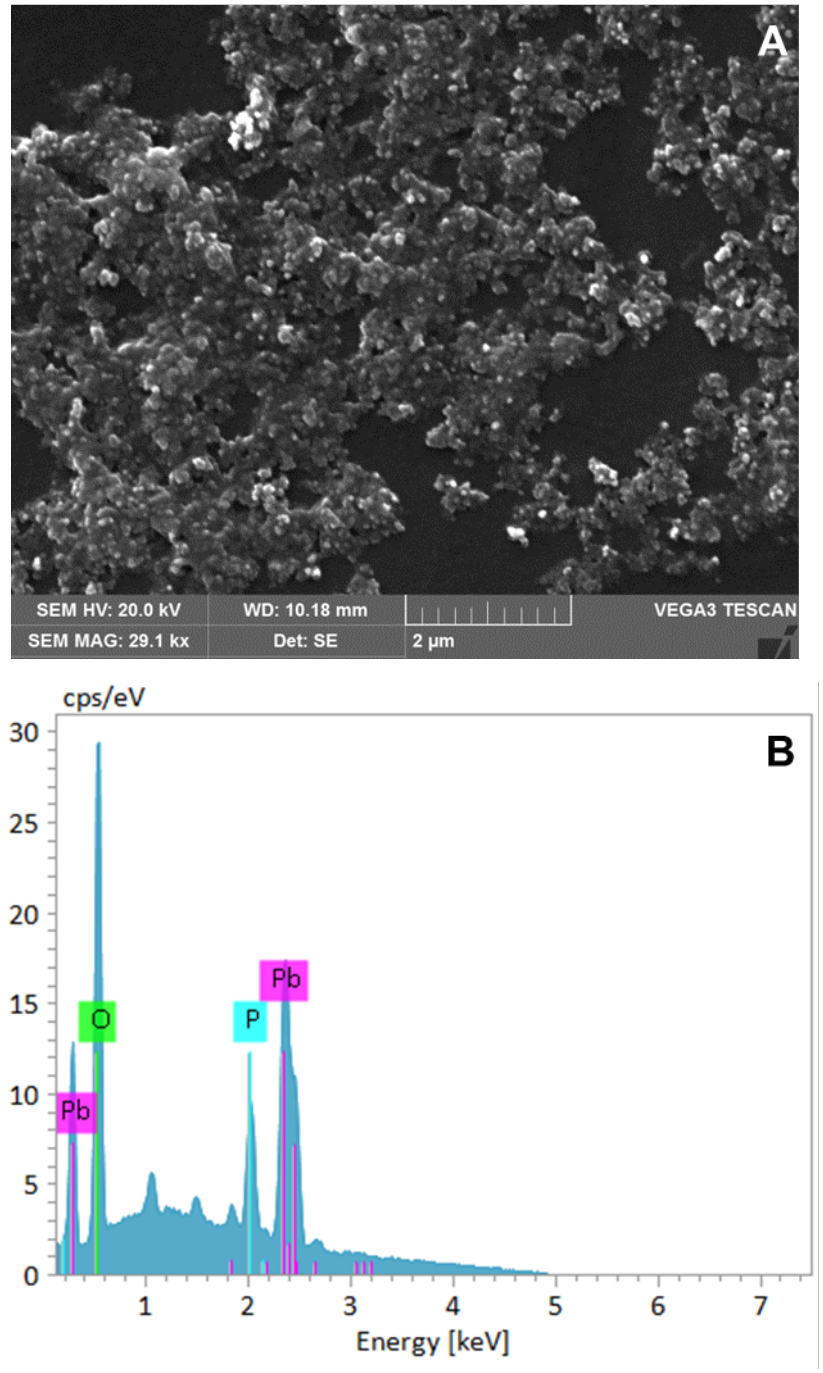

Figure S9 Characterization of 1 mg Pb/L of nano-Pb-PO_4 before the UV/H_2O_2. (A): SEM image; and (B): elemental composition of the Pb particles.

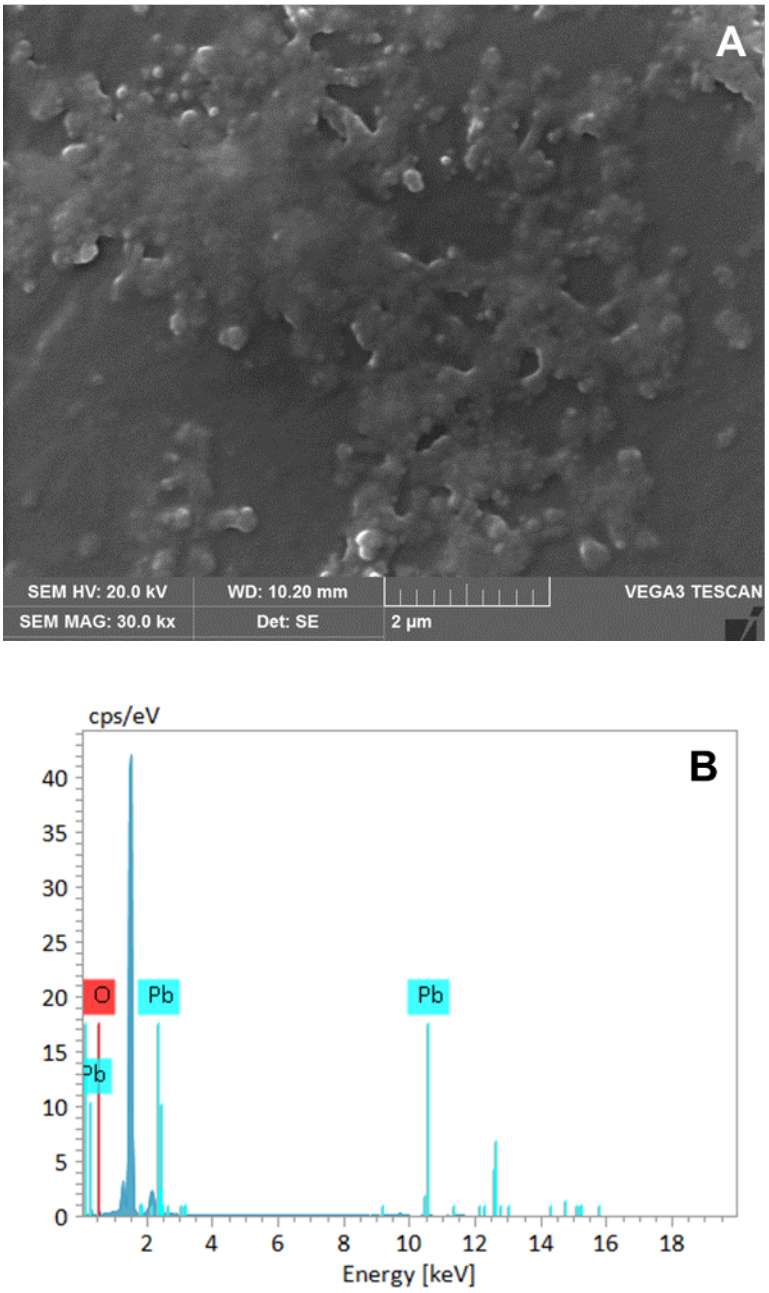

Figure S10 Characterization of 1 mg Pb/L of nano-Pb-PO_4 after the UV/H_2O_2. (A): SEM image; and (B): elemental composition of the Pb particles.