Electronic Supplementary Material (ESI) for Analytical Methods.

Electronic Supplementary Information

Underwater determination of calcium and strontium as scaling ions in oilfield produced water by Laser-Induced Breakdown Spectroscopy (LIBS)

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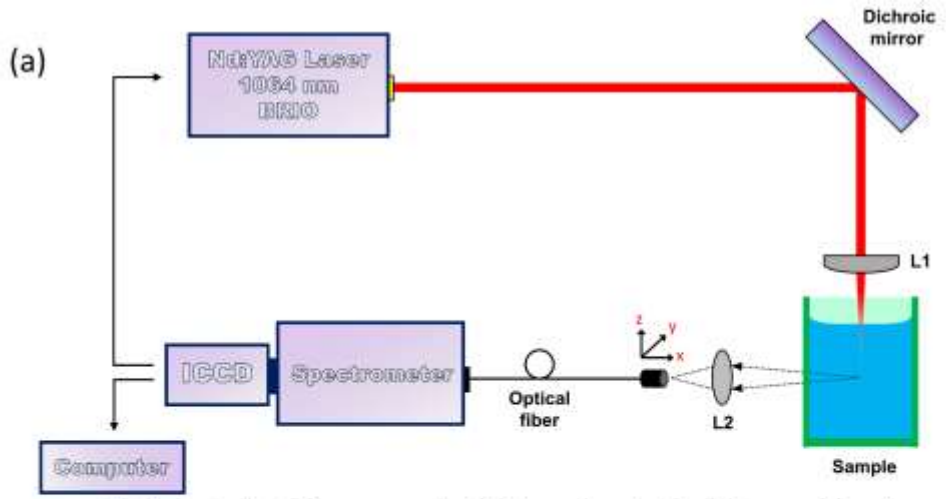
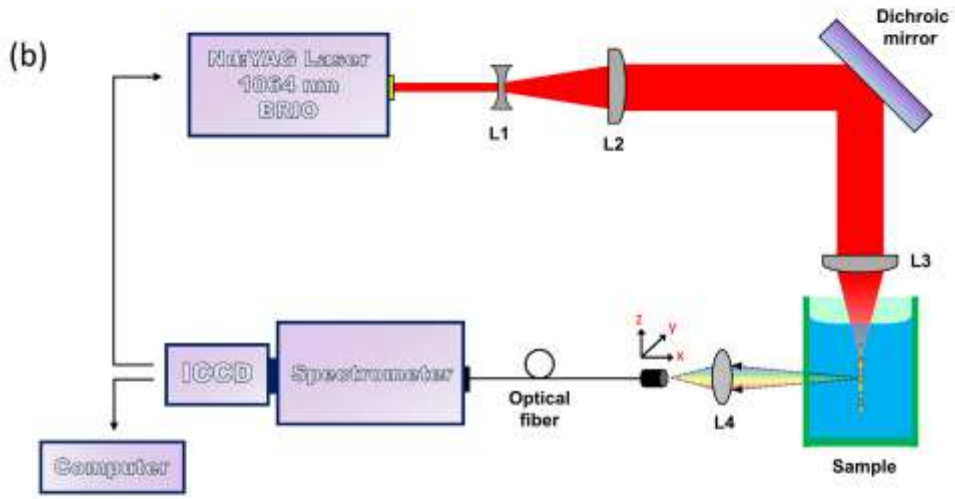
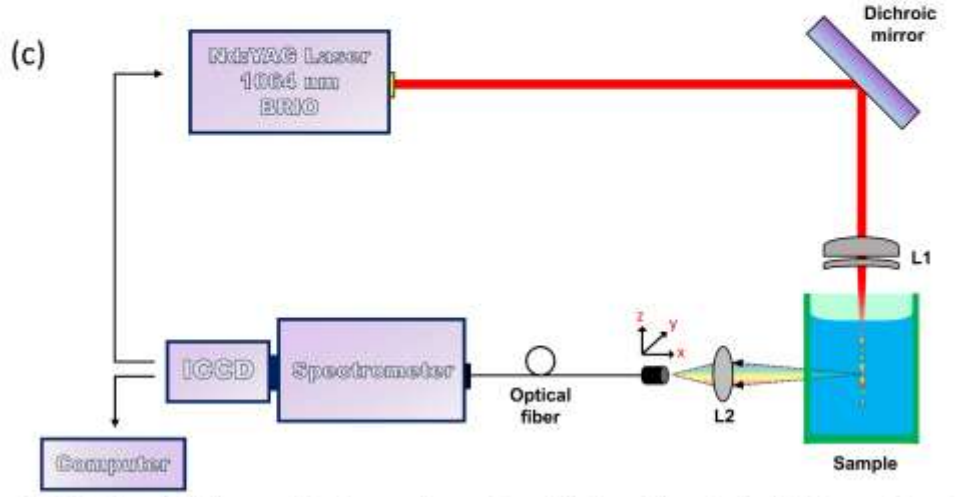


Optical setup 1: L1 plano-convex lens (25.4 mm diameter, focal distance = 30 mm), L2 biconvex lens (5 mm diameter, focal distance = 40 mm)



Optical setup 2: L1 plano-concave lens (12.7 mm diameter, focal distance = -25 mm), L2 plano-convex lens (25.4 mm diameter, focal distance = 150 mm), L3 plano-convex lens (25.4 mm diameter, focal distance = 30 mm), L4 biconvex lens (5 mm diameter, focal distance = 40 mm)



Optical setup 3: L1 lens combinations, achromatic lens (25.4 mm diameter, focal distance = 60 mm) and meniscus lens (25.4 mm diameter, focal distance = 100 mm), L2 biconvex lens (5 mm diameter, focal distance = 40 mm)

Fig. S1 Schematic diagram of the different optical setups for underwater measurements: setup 1 (a), setup 2 (b) and setup 3 (c).

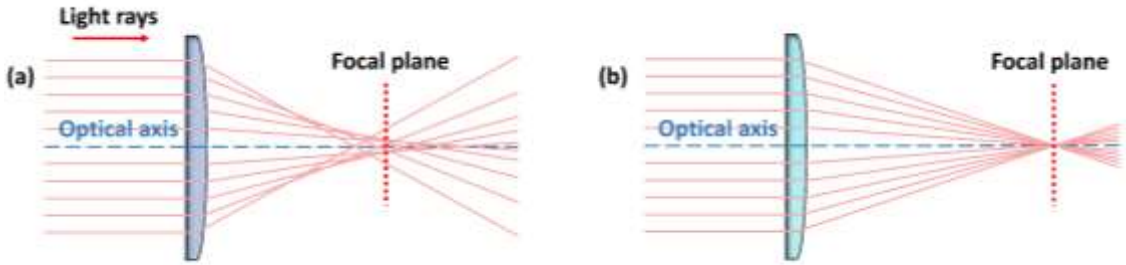


Fig. S2 lens with spherical aberration (a) and lens without spherical aberration (b).

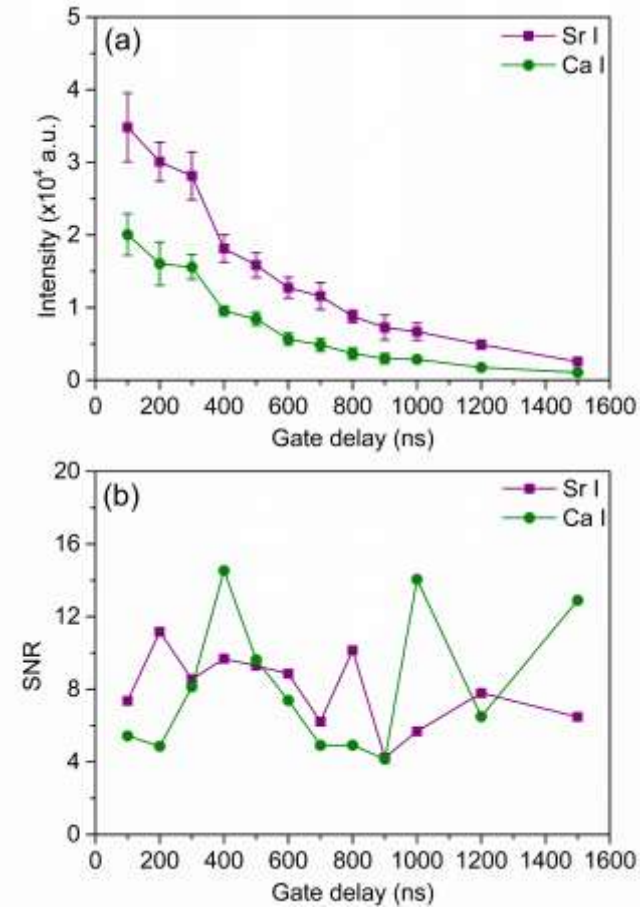


Fig. S3 Emission intensity (a) and SNR values (b) as a function of the gate delay (laser pulse energy: 25 mJ, gate width: 3.0 µs, integration of 100 laser pulses, repetition rate: 10 Hz, 200 mg L^{-1} Ca(II) and 400 mg L^{-1} Sr(II), n = 5).

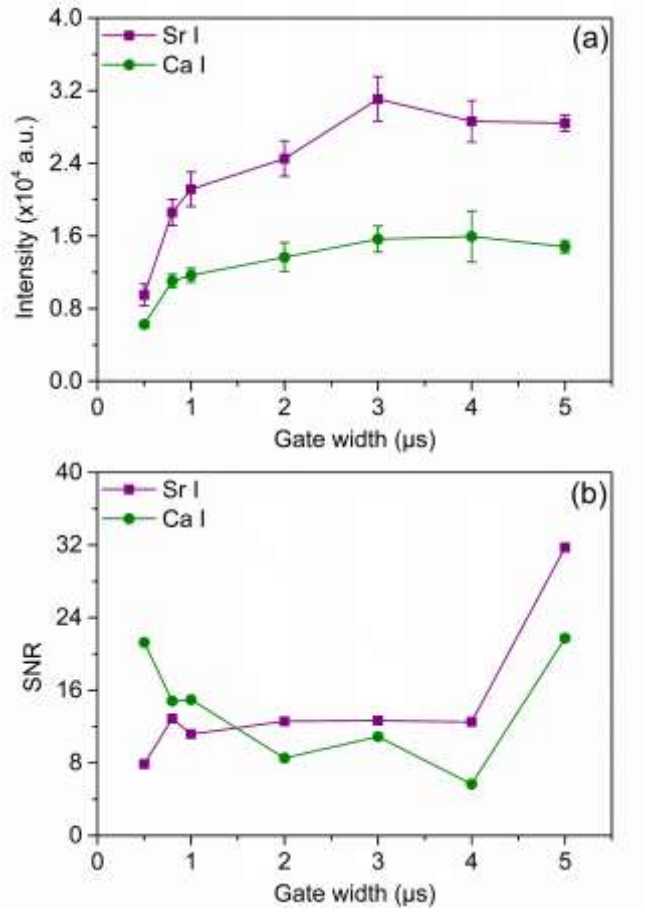


Fig. S4 Emission intensity (a) and SNR values (b) as a function of the gate width (laser pulse energy: 31 mJ, gate delay: 300 ns, integration of 100 laser pulses, repetition rate: 10 Hz, 200 mg L^{-1} Ca(II) and 400 mg L^{-1} Sr(II), n = 5).

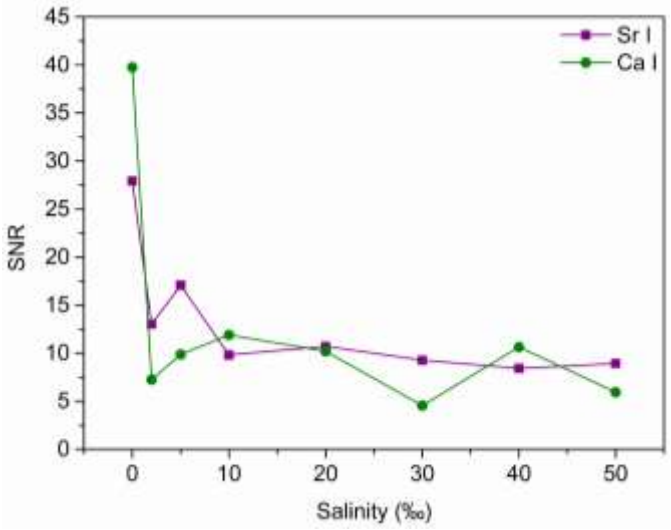


Fig. S5 Effect of salinity on SNR values (laser pulse energy: 31 mJ, gate delay: 300 ns, gate width: 5.0 μs, integration of 100 laser pulses, repetition rate: 10 Hz, 200 mg L^{-1} Ca(II) and 400 mg L^{-1} Sr(II), n = 5).

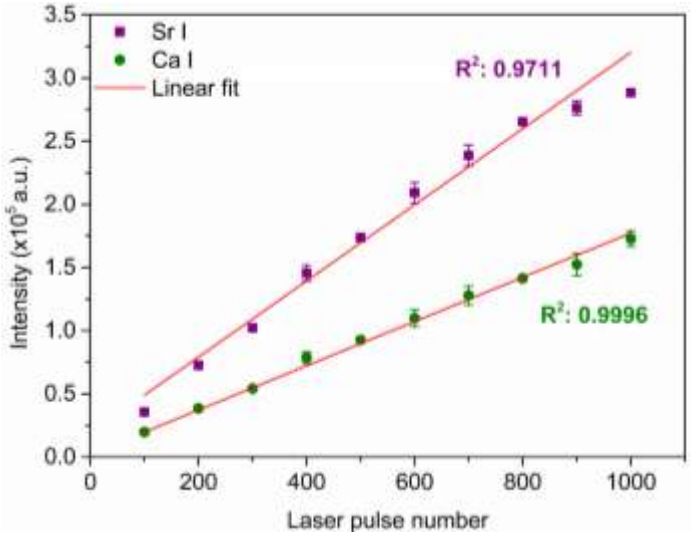


Fig. S6 Emission intensity as a function of the number of laser pulses employed in a single measurement (laser pulse energy: 31 mJ, gate delay: 300 ns, gate width: 5.0 µs, repetition rate: 10 Hz, 200 mg L^{-1} Ca(II) and 400 mg L^{-1} Sr(II), n = 5).

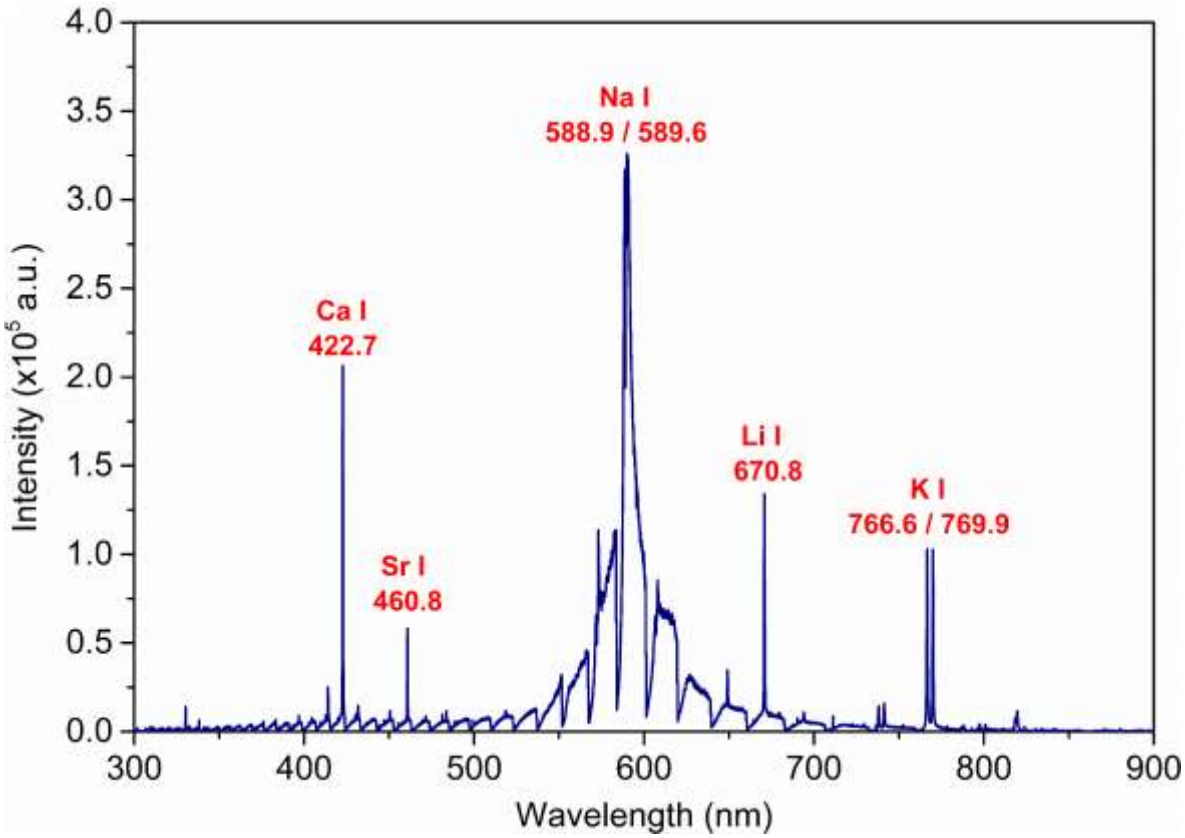


Fig. S7 LIBS spectrum of produced water sample (laser pulse energy: 31 mJ, gate delay: 300 ns, gate width: 5.0 µs, integration of 500 laser pulses, repetition rate: 10 Hz, average of five spectra).