Supplementary Material

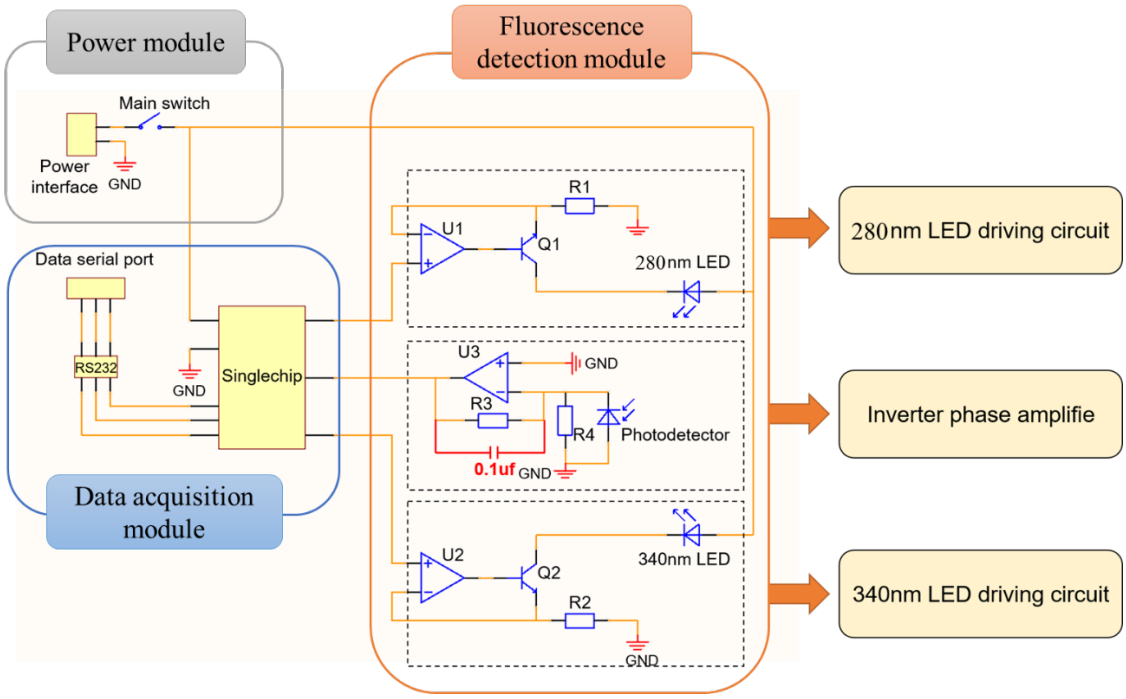


Fig. S1 The portable LED fluorescence instrument design.

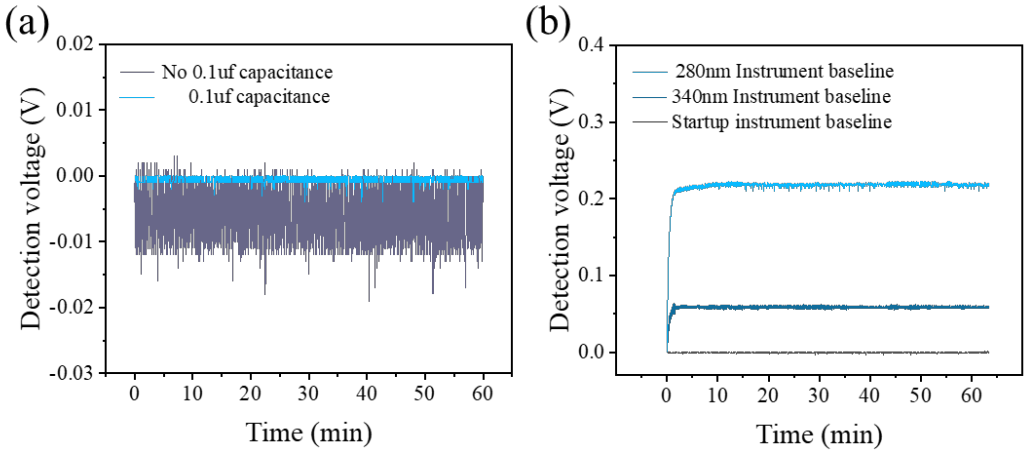


Fig. S2 Instrument stability test: (a) Baseline stability test with capacitance and without capacitance; (b) Instrument output stability test.

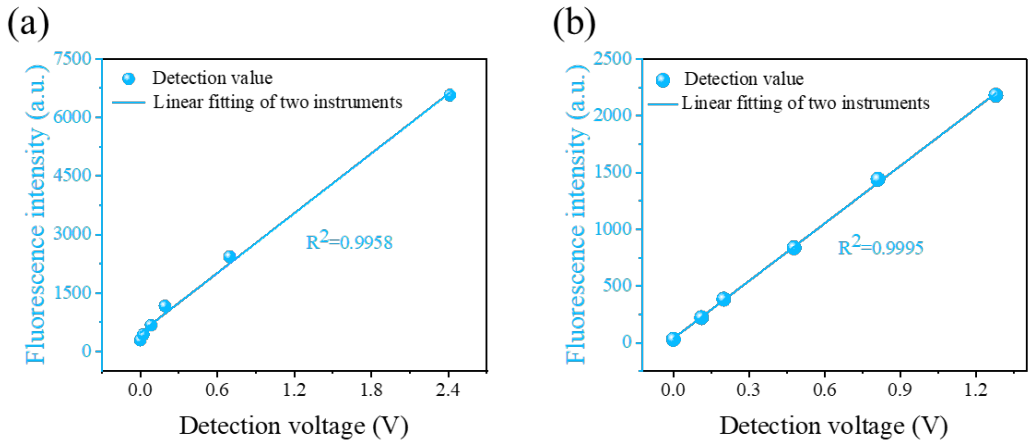


Fig. S3 Fluorescence spectrophotometer and portable instrument contrast test: (a) T-peak test results with two instruments; (b) C-peak test results with two instruments.

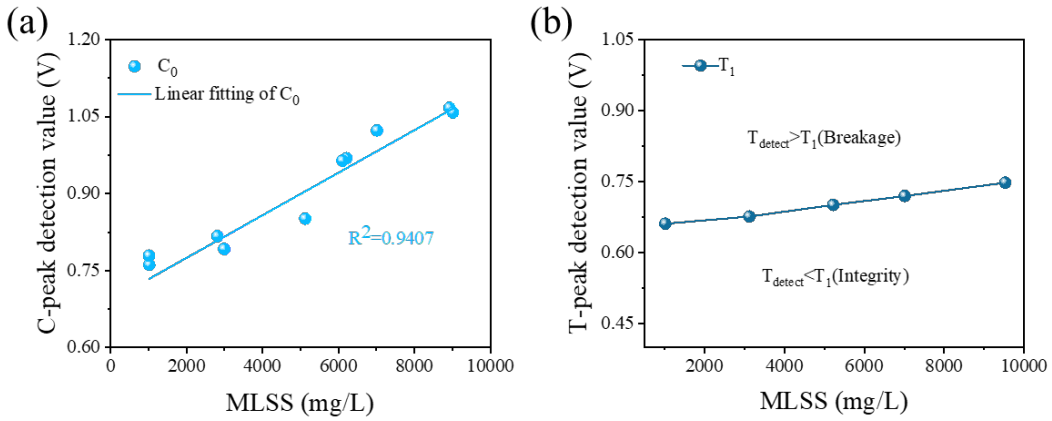


Fig. S4 Portable instrument detection results: (a) C-peak detection results of supernatants with different MLSS; (b) T-peak detection results of BM-Permeate with different MLSS.

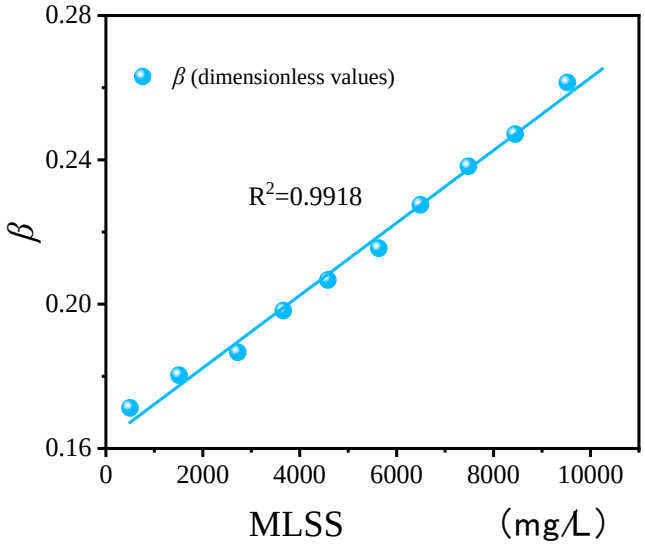


Fig. S5 Relationship between β and MLSS.

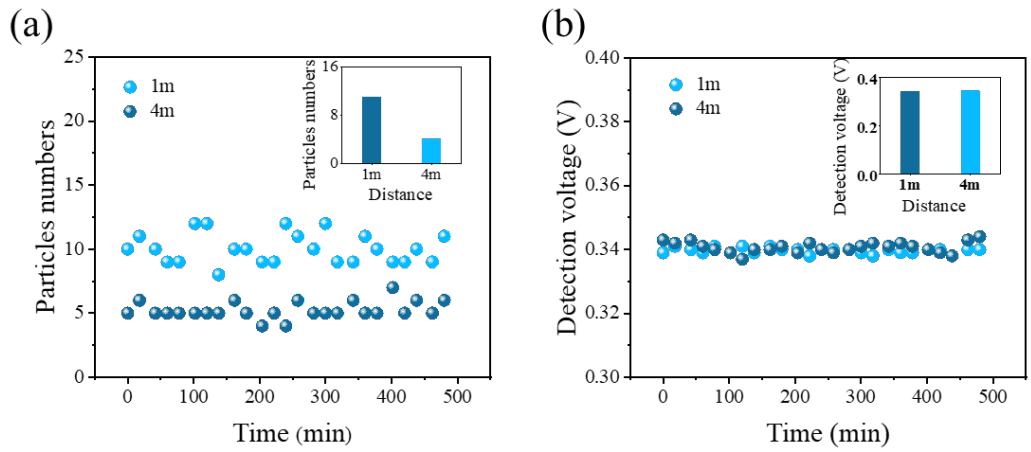
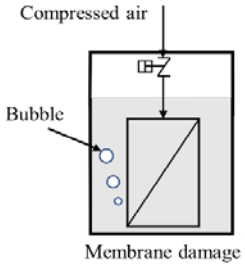
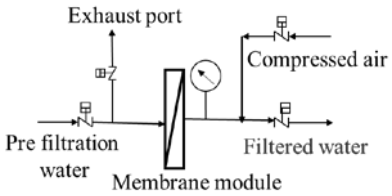
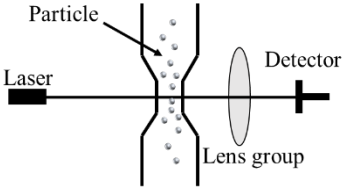


Fig. S6 Membrane integrity detection at different distances between peristaltic pump and instruments: (a) particle counter; (b) portable instrument.

Table S1 Membrane integrity detection methods.

Integrity tests	Advantages	Disadvantages	Schematic diagram	Sensitivity (LRV)
Bubble point test	High sensitivity, The membrane breakage location can be located	Off-line test, Low automation degree		6.0
Pressure decay test	High sensitivity, Simultaneous detection multiple sets of membranes	Off-line test, Discontinuous		4.5─5.0
Diffusive air flow	High automation degree, Do not rely on the raw water, High sensitivity, No destructive	Off-line operation, Sensitive to temperature		6.5─7.0
Particle counting	Online operation	Low sensitivity, High cost, Susceptible to bubbles		3.5

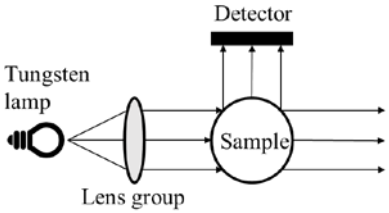
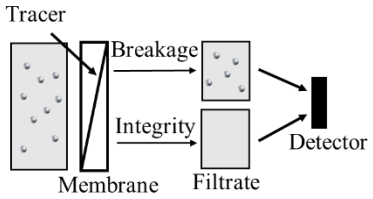
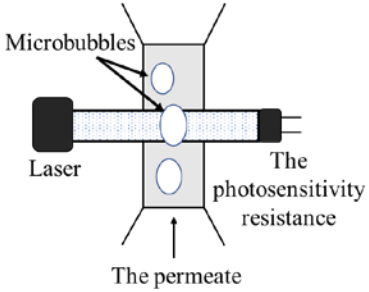
Turbidity monitoring	Online operation, Low cost	Low sensitivity, Affected by feed water quality		＜0.3
Surrogate challenge tests	Online operation, High sensitivity	Safety problem		5.0─6.0
Micro-bubbles test	Continuous online detection, Easy operation	Restricted by aeration		3.0─4.0

Table S2 The MBR operation parameters.

MBR number	Sludge concentration (mg/L)
MBR-1	1021±412
MBR-2	3122±187
MBR-3	5221±322
MBR-4	7012±282
MBR-5	9128±382

Table S3 The synthetic municipal wastewater treatment efficiency.

Index	Sewage	Effluent	Removal rate（%）
COD	552.8±35.0 mg/L	21.0±9.0 mg/L	96.1±1.8
NH_4^+-N	35.6±0.6 mg/L	1.9±0.1 mg/L	92.1±0.5
TP	3.82±0.4 mg/L	1.2±0.1 mg/L	68.5±0.6
TDS	503.0±8.0	349.0±5.0	30.6±0.5
pH	7.1±0.2	7.2±0.2	–