Supporting Information (SI) on

Real-Time Smartphone-Based Multi-Parameter Detection of Nitrite, Ammonia nitrogen, and Phosphorus in Water

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Section1. Tables of contents

Section2. Figures of content

the operation interface)

SI-Fig 4 Color sampling points and color comparison

SI-Fig 5 Color complementation principle, and color corresponding wavelength

SI-Fig 6 G channel signal value obtained from different smartphone shooting processing analysis (a for nitrite, b for ammonia nitrogen, c for the total phosphorous)

SI-Fig7 Field in situ determination process

SI-Table 1 Smartphone hardware parameters

Smartphone model	System	Pixel (mp)	Aperture	Shutter (s)	ISO	Exp
iPhone 12	IOS 17.5.1	1200	f/1.6 f/2.4	1/200	200	-3.0~3.0 Automatic adjustment
iPhone 13	IOS 17.5.1	1200	f/1.6 f/2.4	1/200	200	-3.0~3.0 Automatic adjustment
HONOR Magic 4	Android	5000	f/1.6 f/2.2	1/250	50	Automatic adjustment
Vivo iQOO 10	Android	500	f/1.88 f/1.98 f/2.2	1/150	100	Automatic adjustment
Red Rice K50	Android	4800	f/1.6	1/200	100	Automatic adjustment
OPPO A92s	Android	4800	f/1.8	1/150	100	Automatic adjustment
XiaoMi 12	Android	5000	f/1.7	1/200	100	Automatic adjustment

SI-Table 2 Characteristic wavelengths of each product by the EPA method

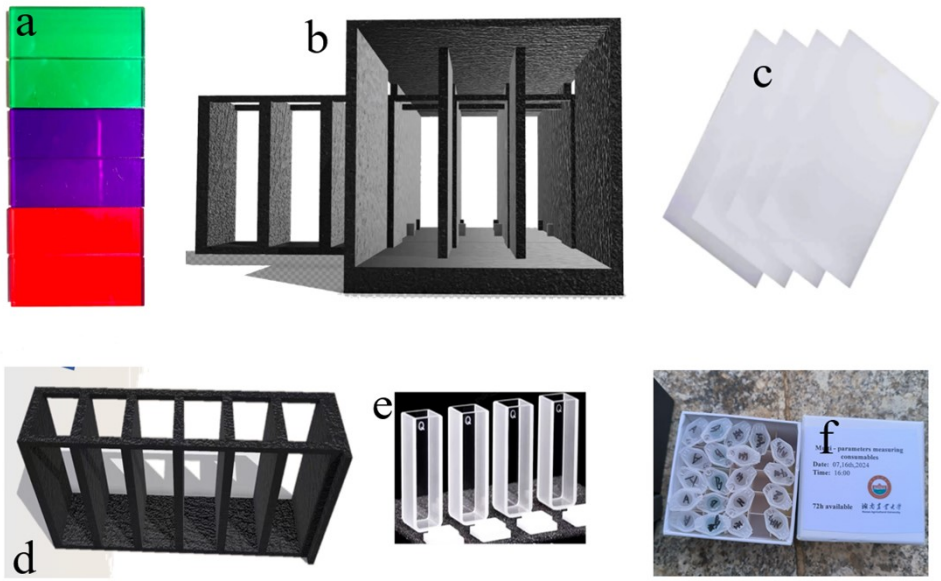
Target substance	EPA Reference method	Color reaction system	characteristic wavelength
Nitrite	EPA 353.2	Sulfonamine-nedd azo dye	540 nm
Ammonia nitrogen	EPA 350.1	Nessler's reagent method (yellowish-brown)	425 nm
Total phosphorus	EPA 365.3	Molybdenum blue method (blue complex)	680 nm

52 **SI-Table 3 Results of on-site measurement (n=3)** Unit:mg/L

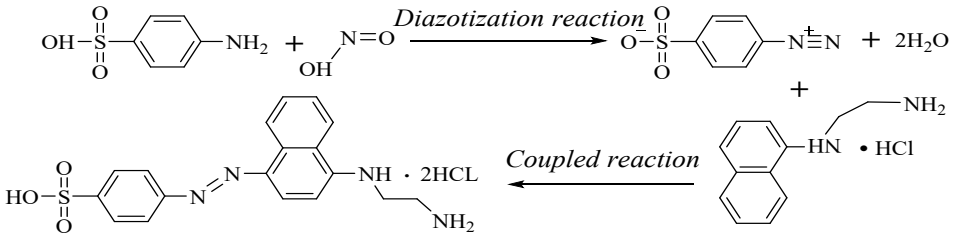
Material	Nitrite	Ammonia nitrogen	Total phosphorus
Reference value of QC sample	0.405±0.025	0.256±0.019	1.500±0.050
Detected results of QC sample	0.404±0.001	0.258±0.002	1.483±0.021
Recovery rate (%)	99.7	100.8	98.9
RSDs (%)	0.2	4.8	1.4
Detected results of real water sample	0.212±0.001	N.D.	0.335±0.005
Detected results of real water sample（spiked 0.5mg/L standard substance）	0.708±0.002	0.495±0.001	0.840±0.008
Recovery efficiency of spiked samples (%)	99.4	99.0	100.6

53 **N.D. means that the detected result is lower than LOD of this method**

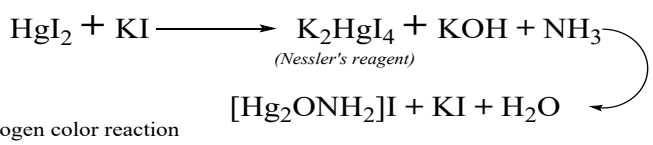
SI-Fig.1 Materials a. colored glasses, b.3D printed black nylon, c. diffuser boards, d. Cupola placement tank, e. cuvette, f. light proof test tube box



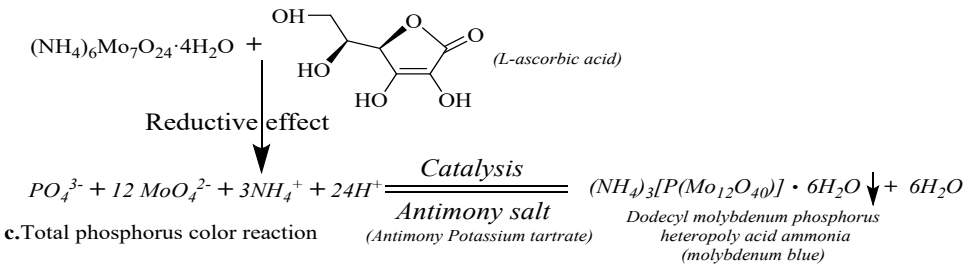
SI-Fig.2 Chemical Reaction schematic diagram (a for nitrite, b for ammonia nitrogen, c for the total phosphorous)



a.Nitrite color reaction(Griess)

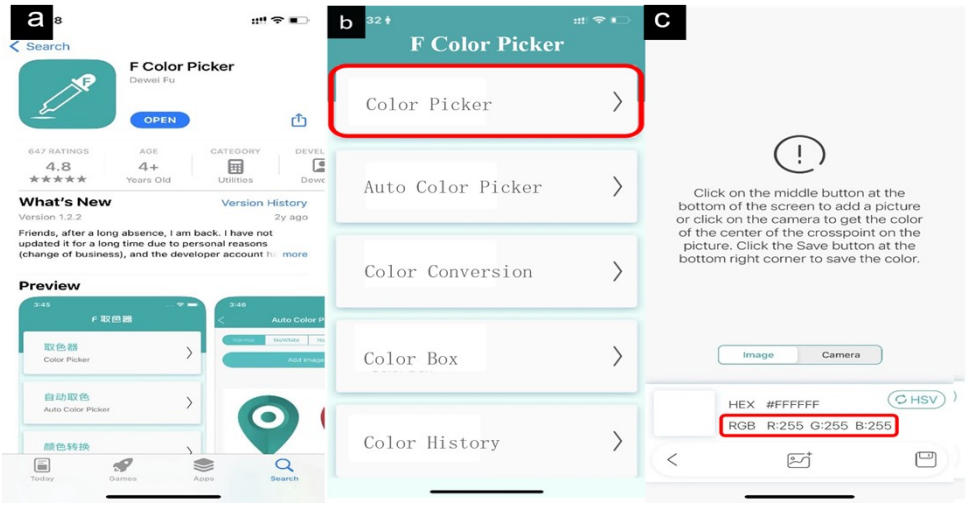


b.Ammonia nitrogen color reaction

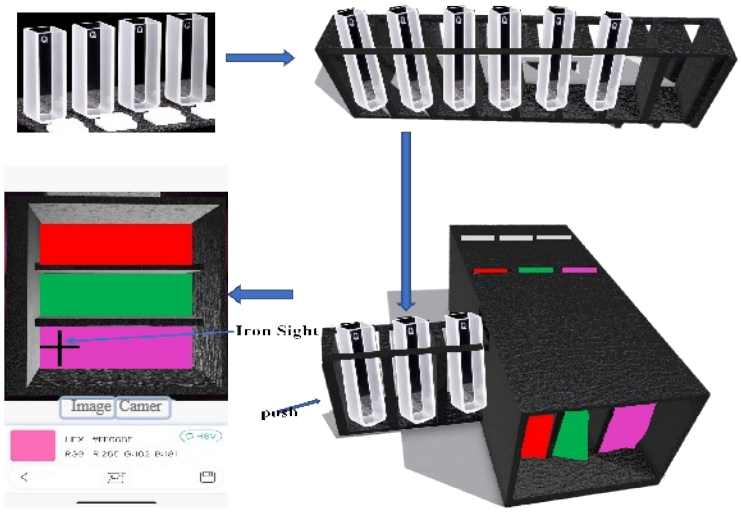


c.Total phosphorus color reaction

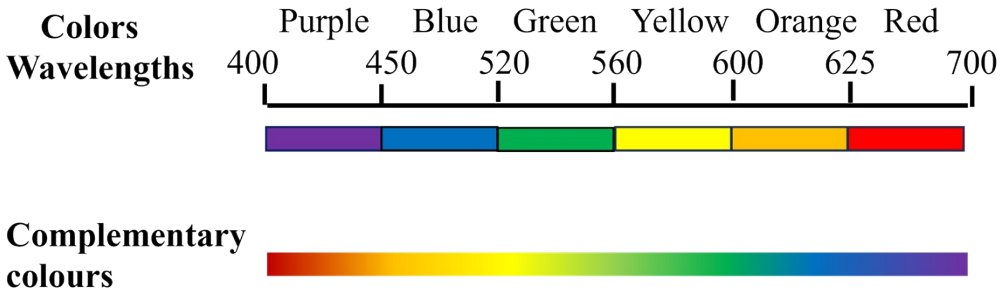
SI-Fig.3 Smartphone measurement process (a is the download interface, b and c are the operation interface)



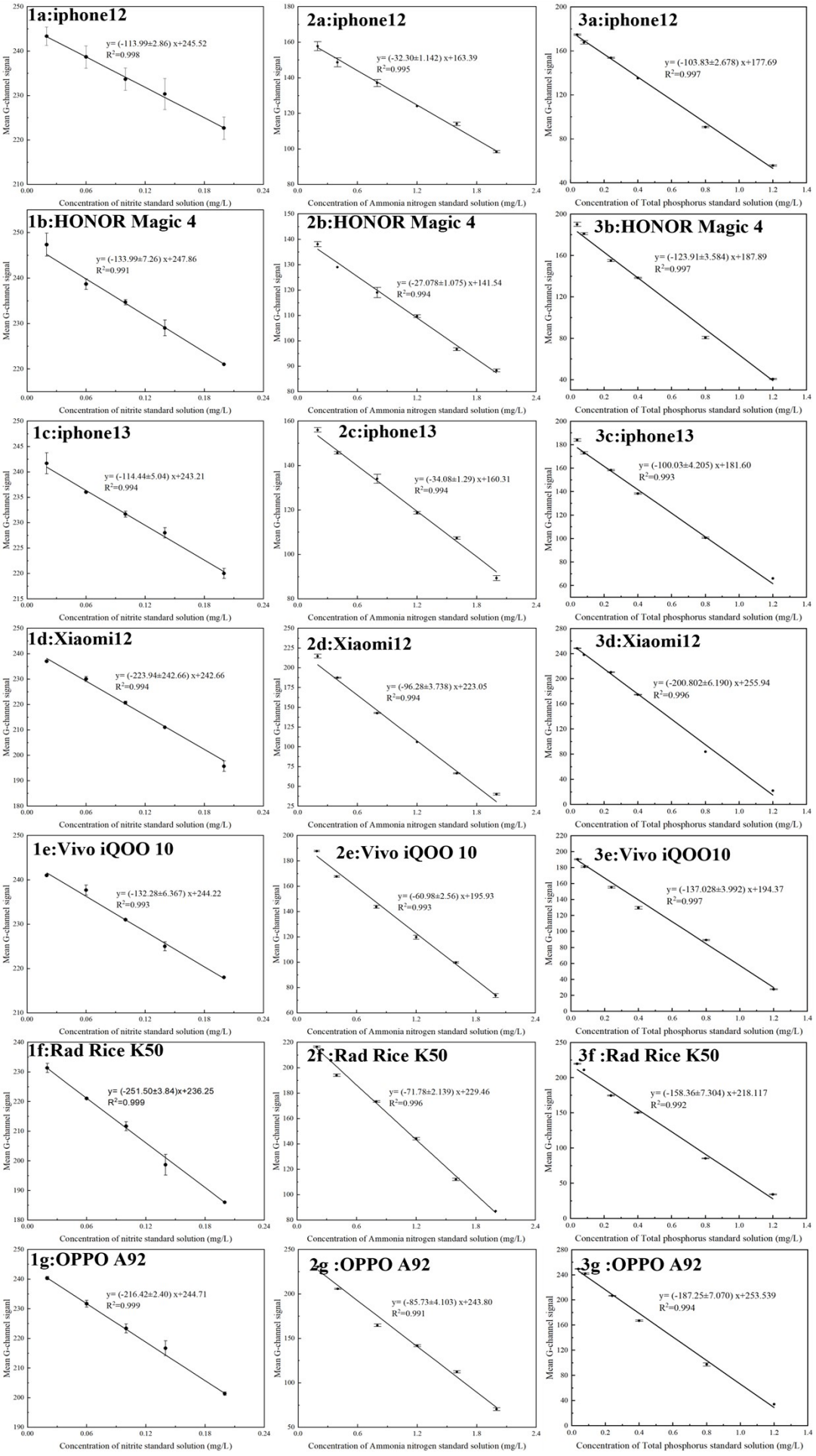
SI-Fig.4 Color sampling points and color comparison



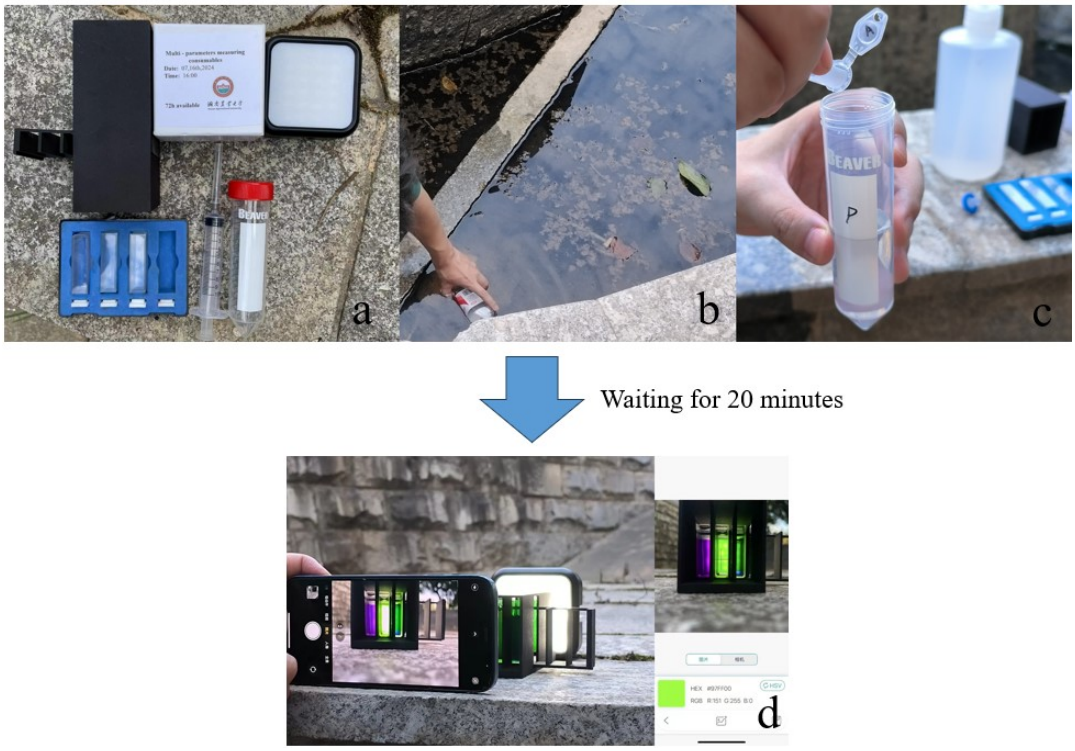
SI-Fig.5 Color complementation principle, and color corresponding wavelength



SI-Fig.6 G channel signal value obtained from different smartphone shooting processing analysis (a for nitrite, b for ammonia nitrogen, c for the total phosphorous)(n=3)


1a:iphone12
y= (-113.99±2.86) x+245.52
R²=0.998
2a:iphone12
y= (-32.30±1.142) x+163.39
R²=0.995
3a:iphone12
y= (-103.83±2.678) x+177.69
R²=0.997
1b:HONOR Magic 4
y= (-133.99±7.26) x+247.86
R²=0.991
2b:HONOR Magic 4
y= (-27.078±1.075) x+141.54
R²=0.994
3b:HONOR Magic 4
y= (-123.91±3.584) x+187.89
R²=0.997
1c:iphone13
y= (-114.44±5.04) x+243.21
R²=0.994
2c:iphone13
y= (-34.08±1.29) x+160.31
R²=0.994
3c:iphone13
y= (-100.03±4.205) x+181.60
R²=0.993
1d:Xiaomi12
y= (-223.94±242.66) x+242.66
R²=0.994
2d:Xiaomi12
y= (-96.28±3.738) x+223.05
R²=0.994
3d:Xiaomi12
y= (-200.802±6.190) x+255.94
R²=0.996
1e:Vivo iQOO 10
y= (-132.28±6.367) x+244.22
R²=0.993
2e:Vivo iQOO 10
y= (-60.98±2.56) x+195.93
R²=0.993
3e:Vivo iQOO10
y= (-137.028±3.992) x+194.37
R²=0.997
1f:Rad Rice K50
y= (-251.50±3.84)x+236.25
R²=0.999
2f :Rad Rice K50
y= (-71.78±2.139) x+229.46
R²=0.996
3f :Rad Rice K50
y= (-158.36±7.304) x+218.117
R²=0.992
1g:OPPO A92
y= (-216.42±2.40) x+244.71
R²=0.999
2g :OPPO A92
y= (-85.73±4.103) x+243.80
R²=0.991
3g :OPPO A92
y= (-187.25±7.070) x+253.539
R²=0.994
Mean G-channel signal
Concentration of nitrite standard solution (mg/L)
Concentration of Ammonia nitrogen standard solution (mg/L)
Concentration of Total phosphorus standard solution (mg/L)

SI-Fig.7 Field in situ determination process (a for carrying consumables and devices, b collecting water samples, c for adding color developing agent, d for multiparameter determination)



Section3. Some Pretreatment Steps

3.1 Water sample filtration operation based on microporous membrane：0.22 -μm MCE/GF Membrane Filtration for Water Sample Purification

First, select the appropriate 0.22-μm pore-sized membranes made of mixed cellulose ester (MCE) or glass fiber (GF). Install these membranes correctly into syringe filters, ensuring that the membranes are flat, firmly attached, and free of any looseness or wrinkles to prevent impairment of the filtration efficiency. Subsequently, use a clean syringe to draw a specific volume of water samples, taking care to avoid introducing additional impurities during the sampling process. Connect the syringe tightly to the syringe filter equipped with the membrane, and then push the plunger of the syringe slowly and evenly to drive the water sample through the membrane under pressure. Given the fine pore size of MCE and GF membranes, suspended particles and other turbidity-causing substances in the water sample can be effectively intercepted. As a result, the filtered water sample flows into the collection container from the other end of the syringe filter, achieving the filtration process and removing the vast majority of suspended solids.

3.2 Pretreatment of water samples for determining total phosphorus content: digestion based on potassium persulfate

A suitable amount of water sample was collected in clean containers. If the sample was turbid or contained suspended matter, it was homogenized by stirring or ultrasonic treatment. If necessary, it could be filtered through a 0.22-micron membrane filter (which had been pre-tested to be free of phosphorus to avoid contamination), and then the filtration operation was carried out. Subsequently, a solution of potassium peroxodisulfate ($K_2S_2O_8$) was added to the pre-treated sample, and the pH was adjusted to the neutral or slightly alkaline range (pH 6-8) using sulfuric acid (H_2SO_4) or sodium hydroxide (NaOH). Then, the mixture was transferred to a high-pressure-resistant glass digestion tube or a polytetrafluoroethylene (PTFE) digestion container, and sealed digestion was performed at 120-124℃ and a pressure of 1.1-1.3 kilograms per square centimeter in a portable multi-functional rapid digestion instrument for 30 minutes to ensure that all

organic and polymeric phosphorus was completely converted into orthophosphate. After digestion, the heat source was turned off, and the system was allowed to cool naturally to room temperature. Before opening the container, the pressure was slowly released, and the digestion solution was diluted to its original volume (except in cases where evaporation occurred during digestion) using ultra-pure water. If necessary, a blank control group was prepared, that is, using ultra-pure water instead of the sample while keeping all other operation steps exactly the same to eliminate the influence of reagent background interference.

On-site neutralization procedure:

A 5 mL aliquot of the water sample was transferred to an appropriate dis solving tube, followed by the addition of pre-packaged potassium persulfate sol ution. Digestion was subsequently performed at a constant temperature of 120 ° C for 30 minutes using a portable multifunctional digestion instrument. After cooling to ambient temperature, the pH of the digested solution was adjusted t o the neutral to slightly alkaline range.

Section4. On-site applicability technology

4.1 Power management specifications

a. A self-powered white light source lamp

This system is equipped with a 3.7V/2000mAh lithium battery. It can support continuous operation for 2 to 10 hours in outdoor environments, with a brightness of up to 800 LUX at 0.5 meters and a color temperature ranging from 2500K to 9000K. It is equipped with a charging module and can be used in conjunction with a portable power bank or a fixed power source.

b. Portable multi-functional rapid digestion instrument

This system is equipped with a 24V/12Ah lithium iron phosphate battery and a compatible inverter (150W pure sine wave), featuring short circuit protection, over-temperature cooling and dehumidification protection. In an outdoor environment (at 25℃), it can operate continuously for approximately 2 hours. It can be used together with portable power sources or fixed power supplies. Based on the actual situation on

site, choose "battery power supply" or "power supply".

4.2 Environmental operating ranges

Operational temperature range: 10℃ to 45℃;

Humidity tolerance: 10-90% RH (non-condensing);

Operating pressure: atmospheric pressure；

Identify applicable bodies of water for the project: surface water, groundwater and other natural water bodies, domestic sewage, rainwater, etc;

Weather (Interference from External Light Sources): Suitable for on-site measurement outside (external light source interference can be disregarded).

4.3 Sample handling procedures

The sample processing needs to be carried out according to the EPA standards or the Chinese national standards as follows for the pre-treatment: Filtration: See details in SI3-1; Resolution: See details in SI3.2; Dilute (if necessary); Color development: See details in 2.4; Determination: See details in 2.4.

Note: It is necessary to pay attention to the environmental parameters such as volume, time, concentration, and sampling depth provided in each of the above sections.

4.4 Data collection protocols

The data acquisition protocol employs smartphone-based image capture to extract colorimetric information, which is automatically processed by a self-developed algorithm to quantify target analyte concentrations. This integrated system incorporates quality control modules and delivers intuitively visualized results through a user interface specifically designed for simplified operation under field conditions.