Selected Article

Development of the U-50 Series Multi-Parameter Water Quality Checker

Yuichiro Komatsu, Katsunobu Ehara, Katsuaki Ogura

Multi-parameter water quality checker named U-50 capable of simultaneously measuring turbidity, dissolved oxygen, conductivity, pH, oxidation-reduction potential (ORP), water depth, and temperature was developed. This series equipped with the high-sensitivity turbidity meter compliant with EPA Method 180.1, and the easy-to-maintain dissolved oxygen electrode. The dissolved oxygen electrode and conductivity features an expanded measurement range for high concentrations. Compared to the earlier model U-20, usability improvements were made to the GPS function, simultaneous display of all parameters, and data storage function. The U-50 series is expected to provide a new measurement application which was not able to be handled by the U-20.
Keywords: Water quality checker, U-50, EPA

Introduction

Measurements of water properties such as water temperature, conductivity, pH, dissolved oxygen, turbidity, etc. are important to perform environmental water monitoring, maintenance and control of supply and sewage water, and wastewater inspections at construction sites and factories. However, using separate instruments for each measurement can be cumbersome. Thus, a multi-parameter water quality checkers such as U-20 are often used to perform these measurements.

A multi-parameter water quality checker integrates all the sensors for measuring turbidity, dissolved oxygen, pH, conductivity, ORP, water depth, and temperature in a single handheld unit. However, few multi-parameter water quality checkers are equipped with a turbidity meter which requires an optical sensor. The turbidity sensors are influenced by air bubbles and dirt, resulting in unstable measurements. In addition, the replacement of sensor film on the dissolved oxygen sensor tends to be difficult.

In this study, new multi-parameter water quality checker which can figure out the former U-20 drawback was developed.

Instrument Overview

Figure 1 shows the appearance and display screen of the multi-parameter water quality checker U-50. The display unit and sensor probe each weigh approximately 0.8 kg and 1.8 kg, respectively. These components are connected via a cable with a maximum length of 30 m. The sensor probe is deployed into the measurement water, and can

Figure 1 Appearance and Display of U-50

measure to a depth of 30 m or less.
On models U-52G and U-53G, the controller has a GPS function for logging position data with measurement data. The display screen provides operating guidance in addition to a display of all measurement parameters.
Figure 2 shows the sensors in the sensor probe. The seven sensors for measuring turbidity, dissolved oxygen (DO), pH, conductivity, ORP, water depth, and temperature is embedded into 10-cm diameter probe base. The sensors for turbidity, DO, pH, and ORP are removable and easy to replace.

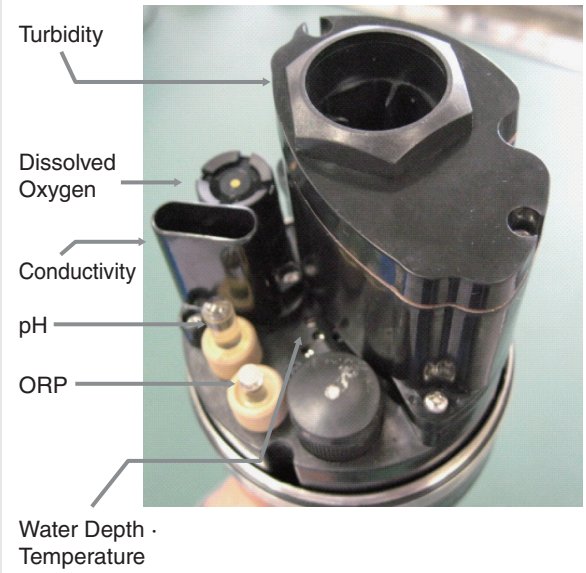

Figure 2 Sensors Housed in Sensor Probe

Comparison of the U-20 and U-50

Table 1 compares the specifications of the U-20 and newly developed U-50 series. As shown in the table, improvements were also made to each measurement parameter. Significant improvements were made particularly in the turbidity meter and dissolved oxygen electrode. The turbidity meter in the U-20 uses an LED as the light source with a 30 degree scattering method. Meanwhile, the U-50 series model U-53 uses a tungsten lamp as the light source with a 90 degree scattering method. This method complies with the US EPA Method 180.1, and is strong against chromaticity differences while being highly sensitive to small particles. Prior to the measurement, the wiper can clean the sensor window to reduce the influences of air bubbles and dirt.
The dissolved oxygen sensor on the U-50 is based on the polarographic method, whereas on the U-20 the galvanic battery system. This means the electrode can be lead-free, making it exempt of restrictions imposed by the European RoHS regulation. As shown in Figure 3, the oxygen isolation film is shaped like a cap. This allows the customer to replace the film simply by tightening the film cap. Additionally, the measurement range was expanded.

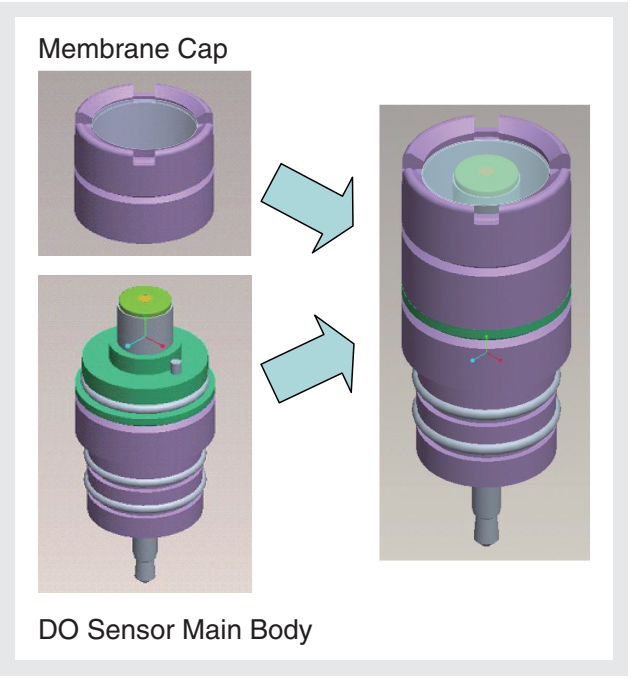

Figure 3 Structure of DO Sensor

Table 2 shows potential new measuring applications for the U-50 series afforded by these improvements. The improved turbidity measuring accuracy enables measurement and control of ground water, environmental water, and plant water with low turbidity. Turbidity sensors in previous multi-parameter water quality checkers are not capable of measuring low turbidity concentrations. Users who accustomed to measuring turbidity separately will appreciate the simplified and simultaneous measurement. The expanded measuring range for dissolved oxygen enables measurement and control of high concentrations of oxygenated water such as oxygen enriched drinking-water and the photosynthetically-activated environment water. The expanded measuring range for conductivity enables measurement of high salinity samples such as seasonings solution in the food making industry.

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Table 1 Specifications and Improved Points of U-20 and U-50 Series

Parts name	Item	U-20 Series	U-50 Series	Improved Points
Sensor Probe	Measurement temperature	0~55 °C	-5~55 °C	Measurable low temperature sample
Control Unit	LCD	Custum (monochrome) 1 parameter listed on Screen	Backlighting Graphic LC (monochrome) 11 parameter listed on Screen Magnified view of display value	Multiple parameters listed on Screen Equipped with backlighting
	Data memory	2880	10000	1 day's data acquisition at intervals of 10 seconds
	communication	RS232	USB (peripheral)	speeding up of data movement to PC
pH	Measurement principle	Glass electrode method		Lowering running cost by chipping pH and Reference Sensor
	Range	pH 0 to 14		
	Resolution	0.01 pH		
	Repeatability	±0.05 pH		
	Accuracy	±0.1 pH		
Oxidation Reduciton Potential (ORP)	Measurement principle	Platinum electrode method		Lowering running cost by chipping ORP Sensor calibration by ORP Standard Solution
	Range	-2000 mV to +2000 mV		
	Resolution	1 mV		
	Repeatability	±5 mV		
	Accuracy	±15 mV		
Dissolved Oxygen (DO)	Measurement principle	Galvanic method	Polarographic method	Safety inner Solution (KCl solution) Easy maintenance by DO membrane Cap Lead-free component mesurable saturated oxygen solution
	Range	0 to 19.99 mg/L	0 to 50.00 mg/L	
	Resolution	0.01 mg/L		
	Repeatability	±0.1 mg/L		
	Accuracy	0.2 mg/L	0~20 mg/L : ±0.2 mg/L 20~50 mg/L : ±0.5 mg/L	
Conductivity (COND)	Measurement principle	4 AC electrode method		Accuracy improvement by 4 point calibration
	Range	0 to 9.99 S/m	0 to 10 S/m	
	Resolution	0.1%F.S.		
	Repeatability	±1%F.S.	±0.5%F.S.	
	Accuracy	±3%F.S.	±1%F.S.	
Salinity	Measurement principle	Conductivity coversion		Measurable doubled general seawater Salinity
	Range	0 to 4%	0 to 70 PPT	
	Resolution	0.1 PPT (0.01%)		
	Repeatability	±1 PPT (0.1%)		
	Accuracy	±3 PPT (0.3%)		
Total Dissolved Solid (TDS)	Measurement principle	Conductivity coversion		
	Range	0 to 100 g/L		
	Resolution	0.1%F.S.		
	Repeatability	±2 g/L		
	Accuracy	±5 g/L		
Seawater specific gravity σ_t, σ_0, σ_{15}	Measurement principle	Conductivity coversion		
	Range	0 to 50 σt		
	Resolution	0.1 σt		
	Repeatability	±2 σt		
	Accuracy	±5 σt		
Temperature	Measurement principle	Thermistor method		Repeatability improvement
	Range	0 to 55 °C	-5 to 55 °C	
	Resolution	0.01 °C		
	Repeatability	±0.3 °C	±0.1 °C (at calibration point)	
Turbidity (TURB)	Measurement principle	LED light source Scattering Method	Tungsten lamp source 90° scattering method (U-53)	The wiper can clean the sensor window to reduce the influences of air bubbles and dirt. U-53 uses a tungsten lamp as the light source with a 90 degree scattering method. This method complies with the US EPA Method 180.1.
	Range	0 to 800 NTU	0 to 1000 NTU	
	Resolution	0.1 NTU	0.01 NTU	
	Repeatability	±3%F.S.	±3% (Reading) or ±0.1 NTU whichever is greater	
	Accuracy	±5%F.S.	0 to 10 NTU : ±0.5 NTU 10 to 1000 NTU : ±3% (Reading) or ±1 NTU whichever is greater	
Water Depth	Measurement principle	Pressure method		Accuracy improvement by New pressure sensor
	Range	0 to 100 m	0 to 30 m	
	Resolution	0.1 m	0.05 m	
	Repeatability	±3%F.S.	±1%F.S.	
	Accuracy	±5%F.S.	±0.3 m	

Table 2 New Applications Possible with the U-50 Series

Features of the U-50	New applications
Improved turbidity accuracy	Measurement and control of low turbidity ground water, environmental water, supply water, and plant water.
Expanded measurement range for dissolved oxygen	Control of high concentrations of oxygenated water (beverages, envirionment water)
Expanded measurement range for conductivity	High salinity concentrations (seasonings, factory wastewater, etc.)

Measurement Examples

The changes in turbidity and dissolved oxygen as measured continuously over 12 days in Inba-pond, Chiba prefecture is shown in Figure 4. When we began measuring on May 28, the turbidity was 20.5 NTU and the COD value was 10.0 ppm. The turbidity and COD value dropped during the measurement period and became 5.89 NTU and 8.8 ppm, respectively, on the last day of June 9. This result suggests decrease in organic matter. The dissolved oxygen (DO) concentration increased from the morning to the afternoon, and decreased from the evening to the following morning. This is the result of oxygen generated by photosynthesis in the afternoon, and oxygen consumed by breathing during the night.Although traces of organic matter were found on the measurement unit after 12 days of continuous measurement, the wiper kept the cell window on the turbidity meter in a clean state.

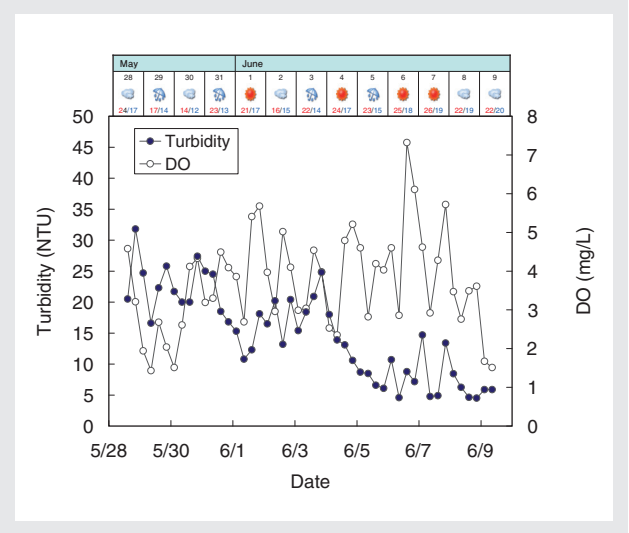

Figure 4 Continuous Test Data of Turbidity and DO in Lake Imba

Figure 5 shows the measurement results for pH and ORP. On sunny days during the continuous testing period, the pH values shifted to alkaline. This result suggests that photosynthesis of plants caused the carbon dioxide gas and organic matter in the lake to drop. On the other hand, the ORP shifted to the reducing side, suggesting that the effects of water purification induced by photosynthesis.

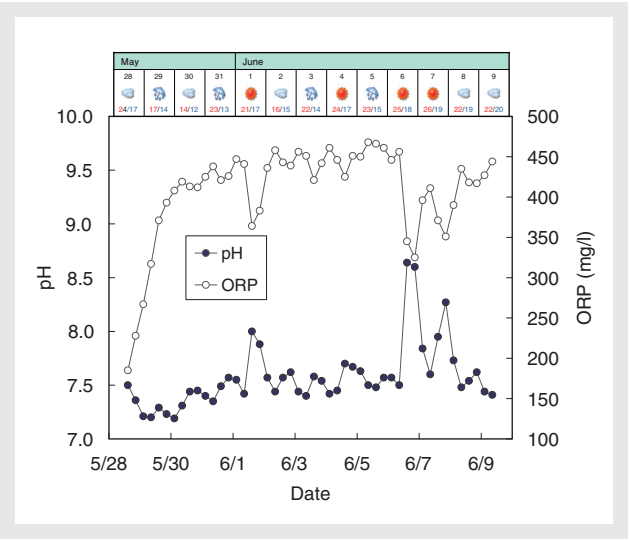

Figure 5 Continuous Test Data of pH and ORP in Lake Imba

Figure 6 shows the results of measurements in Motosu Lake, Yamanashi prefecture. In this measurement, the same test was performed using the turbidity meter on the former model U-20 (30-degree transmission scattering method), which does not have a wiper. On the U-20 turbidity meter, the measurement in the immersion direction changed over a range of 0.0 NTU to 1.0 NTU. Measuring in the retraction direction from 20 m to 10 m showed a significant change from 0.0 NTU to 5.0 NTU, revealing a discrepancy with the measurement in the immersion direction. This suggests that air bubbles occurred on the measuring unit due to decompression and temperature rise. On the other hand, the U-53 turbidity meter, equipped with a wiper, showed consistent results between 0.3 NTU and 0.8 NTU, in both immersion and retraction directions. This result indicates that the wiper on the new turbidity meter effectively cancels the effects of air bubbles.

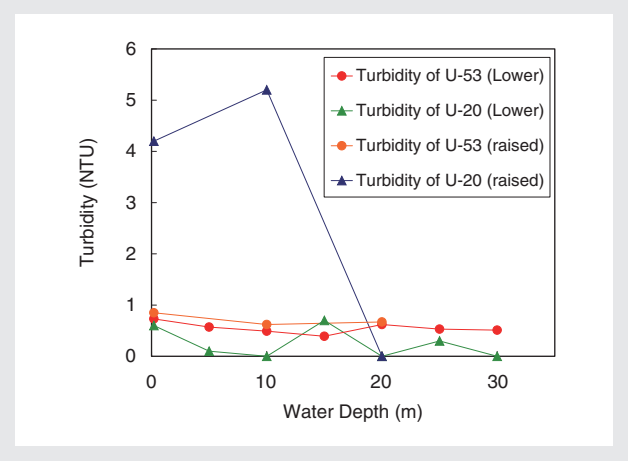

Figure 6 Turbidity immersion test in Lake Motosu

Conclusion

The newly developed U-50 features EPA Method 180.1 compliant turbidity sensor, expanded measurement ranges and greater ease of handling. These features can expand the scope of an existing multi-parameter water quality checker.

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