

## Description

Title of Invention: Dilution Apparatus for Water Quality  
Measurement and Dilution Method

Technical Field

[0001]

The present invention relates to a dilution apparatus for water quality measurement, and particularly relates to a dilution apparatus for water quality measurement for diluting a raw solution to perform water quality measurement. The present invention also relates to a dilution method using the dilution apparatus for water quality measurement.

Background Art

[0002]

As a technique for automatically measuring residual chlorine concentration in water, a batch-type automatic continuous residual chlorine concentration measuring apparatus is known, which measures the residual chlorine concentration in water by an absorptiometric method using an N,N-diethyl-1,4-phenylenediamine reagent (DPD reagent). The residual chlorine concentration measurable by the apparatus is 8 mg/L or less. Therefore, the apparatus is not suitable for measurement in a high concentration region exceeding 8 mg/L.

[0003]

As a dilution apparatus for water quality measurement capable of quantifying high-concentration residual chlorine, Patent Literature 1 discloses a water quality measurement apparatus including: a dilution devices for preparing sample water including raw water and dilution water; and a residual chlorine concentration measuring

apparatus for measuring the residual chlorine concentration of the sample water, wherein the dilution apparatus includes: a container in which the sample water is stored; a first water level detection unit for detecting a first water level in the container; a second water level detection unit for detecting a second water level in the container; a raw water injection unit for injecting the raw water into the container until the first water level detection unit detects the first water level; and a dilution water injection unit for injecting the dilution water into the container until the second water level detection unit detects the second water level and diluting the raw water.

[0004]

In the dilution apparatus for water quality measurement of Patent Literature 1, the dilution apparatus dilutes the raw water and, if necessary, re-dilutes the raw water to prepare sample water, and the sample water is transferred to the residual chlorine concentration measuring apparatus via a sample water storage unit, whereby the residual chlorine concentration is measured. In this water quality measurement apparatus, dilution of the raw water is performed once or two or more times. By performing dilution two or more times, high-concentration raw water can be sufficiently diluted.

Citation List

Patent Literature

[0005]

Patent Literature 1: JP 2023-87160 A

Summary of Invention

Technical Problem

[0006]

In the dilution apparatus for water quality measurement of Patent Literature 1, when a capacitance sensor or an optical sensor is used as the water level detection unit, an error may occur in water level detection due to contamination of the dilution container or water droplets running along the wall surface of the dilution container, and the dilution concentration may fluctuate.

[0007]

Patent Literature 1 also describes that a pressure-type water level sensor may be used for water level detection. However, in Patent Literature 1, when measuring the raw water, the raw water in the raw water tank is injected into the container from above until the water level detection unit detects the water level.

[0008]

When the raw water is supplied from above in this manner, the water surface in the container fluctuates due to the raw water falling inside the container. When the water surface fluctuates in this manner, pressure fluctuations occur, and therefore an error occurs in the detected water level even when the pressure-type water level sensor is used in Patent Literature 1.

[0009]

An object of the present invention is to provide a dilution apparatus for water quality measurement and a dilution method capable of controlling a dilution ratio with high accuracy.

Solution to Problem

[0010]

A dilution apparatus for water quality measurement

according to the present invention is a dilution apparatus for water quality measurement for preparing sample water by diluting a raw solution with dilution water, the apparatus comprising:

- a container;

- a raw solution supply unit for supplying the raw solution to the container;

- a dilution water supply unit for supplying dilution water to the container;

- a circulation unit for circulating the water in the container;

- an outflow unit for allowing the water in the container to flow out; and

- a pressure sensor for detecting a water level in the container,

wherein the outflow unit includes a pump, and the water is caused to flow out from the container by gravity in a state where the pump is stopped.

[0011]

In one aspect of the present invention, the circulation unit performs circulating water by the pump of the outflow unit.

[0012]

A dilution method of the present invention is a dilution method for preparing sample water by diluting a raw solution with dilution water using the dilution apparatus for water quality measurement according to the present invention, the method comprising:

- a raw solution introduction step of introducing a first predetermined amount of the raw solution into the container;

a dilution water introduction step of introducing a second predetermined amount of dilution water into the container;

a stirring step of stirring by circulating the water in the container; and

a taking-out step of taking out the water thus diluted from the container,

wherein the raw solution introduction step includes:

a step of introducing into the container an excessive amount of the raw solution more than the first predetermined amount;

a pump discharge step of discharging a part of the excessive amount of the raw solution from the container by operating the pump; and

a gravity discharge step of stopping the pump and allowing the raw solution in the container to flow out by gravity so that the amount of the raw solution in the container detected by the pressure sensor becomes the first predetermined amount.

[0013]

In one aspect of the dilution method of the present invention, after performing the raw solution introduction step, the residual water in the circulation unit is discharged to outside the dilution apparatus for water quality measurement, and thereafter the dilution water introduction step is performed.

[0014]

In one aspect of the dilution method of the present invention, after performing the raw solution introduction step, the dilution water introduction step, and the stirring step, a water discharge step is performed in which

the water is discharged so that the amount of the water in the container becomes the first predetermined amount, and thereafter a second dilution step comprising introducing dilution water into the container is performed.

[0015]

In one aspect of the dilution method of the present invention, after the water discharge step and before introducing the dilution water, residual water is discharged from the circulation unit.

Advantageous Effects of Invention

[0016]

According to the dilution apparatus for water quality measurement and the dilution method of the present invention, when preparing diluted sample water by mixing a predetermined amount of a raw solution and dilution water in the container, the amount of water in the container is detected by a pressure sensor. In the dilution method of the present invention, after introducing into the container an excessive amount of the raw solution more than the predetermined amount, most of the excessive amount is first discharged by a pump, and thereafter the remaining portion of the excessive amount is allowed to flow out by gravity so that the predetermined amount of the raw solution is stored in the container.

[0017]

When the excessive amount is allowed to flow out by gravity in this manner, fluctuation of the water surface in the container caused by pump vibrations does not occur, and the water level is accurately detected by the pressure sensor. Therefore, the predetermined amount of the raw solution can be stored in the container with high accuracy.

Accordingly, the raw solution can be diluted at a highly accurate dilution ratio.

[0018]

Further, since most of the excessive amount is discharged by the pump, the discharge time is shortened compared with a case where the entire excessive amount is discharged by gravity.

#### Brief Description of the Drawings

[0019]

[Fig. 1] Fig. 1 is a configuration diagram of a dilution apparatus for water quality measurement according to an embodiment.

[Fig. 2] Fig. 2 is an explanatory diagram of a water quality measurement process in the dilution apparatus for water quality measurement of Fig. 1.

[Fig. 3] Fig. 3 is an explanatory diagram of a water quality measurement process in the dilution apparatus for water quality measurement of Fig. 1.

[Fig. 4] Fig. 4 is an explanatory diagram of a water quality measurement process in the dilution apparatus for water quality measurement of Fig. 1.

[Fig. 5] Fig. 5 is an explanatory diagram of a water quality measurement process in the dilution apparatus for water quality measurement of Fig. 1.

#### Description of Embodiments

[0020]

Hereinafter, embodiments will be described with reference to the drawings. Fig. 1 is a configuration diagram of a dilution apparatus for water quality measurement according to an embodiment.

[0021]

A raw solution supply unit including a pipe 1, a solenoid valve 2, and a pipe 3 is connected to an upper portion of a container 10 so as to supply a raw solution into the container 10. Further, a dilution water supply unit including a pipe 4, a solenoid valve 5, and a pipe 6 is connected to the upper portion of the container 10 so as to supply dilution water into the container 10.

[0022]

A communication port (not shown) for communicating the inside of the container 10 with the atmosphere is provided at the top portion of the container 10. When water is supplied to or discharged from the container 10, air in the container 10 moves in and out through the communication port.

[0023]

A pressure sensor 9 for detecting the water level in the container 10 is provided at a lower portion (in this embodiment, the bottom portion) of the container 10.

[0024]

An outflow unit including a pipe 11, a solenoid valve 12, a pipe 13, a pump 14, and a pipe 15 is connected to the bottom portion of the container 10 in order to discharge or circulate the water in the container 10.

[0025]

The pump 14 has a configuration in which water is supplied from the pipe 13 to the pipe 15 during operation and the pipe 13 and the pipe 15 communicate with each other (so that water can flow) during stoppage of the pump.

[0026]

The end of the pipe 15 branches into pipes 16, 20, and 23. The pipe 16 constitutes a circulation unit and is

connected to the upper portion of the container 10 via a solenoid valve 17 and a pipe 18, thereby returning the water in the container 10 to the upper portion to circulate the water.

[0027]

The pipe 20 is connected to a pipe 22 via a solenoid valve 21, thereby constituting a take-out unit for taking out diluted sample water for analysis.

[0028]

The pipe 23 is connected to a pipe 25 via a solenoid valve 24, thereby constituting a discharge unit for discharging the water in the container 10 or in each pipe to outside the system.

[0029]

Each step for preparing diluted sample water using the dilution apparatus for water quality measurement configured as described above will be described below.

[0030]

[Initial Water Discharge Step]

First, residual water remaining in the dilution apparatus for water quality measurement from a previous dilution operation or the like is discharged. In order to discharge this residual water, the solenoid valves 12 and 24 are opened, the other solenoid valves are closed, and the pump 14 is operated (hereinafter sometimes referred to as ON). As a result, the residual water in the container 10 and between the pipes 11 to 15 is discharged through the pipes 23 and 25.

[0031]

Next, the pump 14 is stopped (hereinafter sometimes referred to as OFF), the solenoid valves 17 and 24 are

opened, and the other solenoid valves are closed, whereby the residual water between the pipes 18 to 16 is discharged through the pipes 23 and 25.

[0032]

[Raw solution Introduction Step]

In order to prepare sample water by diluting the raw solution with dilution water at a predetermined ratio, first, the raw solution is stored in the container 10 so that the water level becomes H1. The amount of water at the water level H1 is hereinafter sometimes referred to as a first predetermined amount.

[0033]

In this case, the solenoid valve 2 is opened, the other solenoid valves are closed, and the pump 14 is set to OFF. The solenoid valve 2 is opened for a predetermined time so that the water level in the container 10 becomes higher than H1, thereby introducing the raw solution. Next, the solenoid valves 12 and 24 are opened, the other solenoid valves are closed, and the pump 14 is set to ON so that the water level in the container 10 is lowered to near H1, and thereafter the pump 14 is set to OFF. At this time, the solenoid valves 12 and 24 are kept open. As a result, the water flows out from the container 10 by gravity. In this case, since the pump 14 is OFF, the container 10 does not vibrate and no fluctuation occurs in the water surface in the container 10.

[0034]

When the water level detected by the pressure sensor 9 becomes H1, the solenoid valve 12 is closed. As a result, the raw solution is accurately stored in the container 10 at the water level H1 (Fig. 2).

[0035]

As described above, the pump 14 is ON to perform pump discharge until the water level becomes close to H1, and thereafter the pump 14 is turned OFF and gravity discharge is performed in which the water flows out from the container 10 by gravity. In this manner, until the water level becomes close to H1, the water is caused to flow out from the container 10 by the pump 14, whereby water discharge is accelerated. During the gravity discharge, there is no fluctuation of the water surface in the container 10 due to vibration transmission from the pump 14, and the water level detected by the pressure sensor 9 becomes highly accurate.

[0036]

The outflow rate during gravity discharge is lower than that during pump discharge when the pump 14 is ON, and therefore the water level in the container 10 decreases more slowly. Therefore, when the water level in the container 10 decreases to H1, the solenoid valve 12 can be reliably closed.

[0037]

[Discharge of Water Circulation Piping]

After the above-described raw solution introduction step, the solenoid valves 17 and 24 are opened, the other solenoid valves are closed, and the pump 14 is kept OFF, whereby the water between the pipes 18 to 16 is discharged through the pipes 23 and 25.

[0038]

[Dilution Step]

Thereafter, the solenoid valve 5 is opened, the other solenoid valves are closed, and the pump 14 is kept OFF,

and dilution water is introduced into the container 10 until the water level reaches H2 (Fig. 3). Next, the solenoid valves 12 and 17 are opened, the other solenoid valves are closed, and the pump 14 is set to ON, and the water in the container 10 is circulated through the pipes 11, 13, 15, 16, and 18 to perform stirring (Fig. 4).

[0039]

When the volume of the raw solution introduced into the container 10 is denoted as V1 and the volume of dilution water (a second predetermined amount) introduced into the container 10 is denoted as V2, the sample water (hereinafter sometimes referred to as first diluted sample water) obtained by diluting the raw solution by  $(V2+V1)/V1$  times is prepared by the above dilution step (first dilution step).

[0040]

In the case where the first diluted sample water is a 10-fold dilution of the raw solution, by performing a similar second 10-fold dilution step (second dilution step), the second diluted sample water being diluted 100 times is prepared, and by performing a similar third 10-fold dilution step (third dilution step) on the second diluted sample water, the third diluted sample water being diluted 1,000 times is prepared.

[0041]

When the second, third, or further dilution step (hereinafter sometimes referred to as an n-th dilution step) is performed, a discharge step is performed in which the (n-1)-th diluted sample water prepared in the (n-1)-th dilution step and remaining in the container 10 is discharged to the water level H1 by pump discharge and

subsequent gravity discharge.

[0042]

Also in this discharge step, first, the solenoid valves 12 and 24 are opened, the other solenoid valves are closed, and the pump 14 is set to ON to perform pump discharge. When the water level approaches H1, the pump 14 is set to OFF while keeping the solenoid valves 12 and 24 open, and gravity discharge is performed in which the water in the container 10 is discharged by gravity. Also in this gravity discharge, since the water surface in the container 10 does not fluctuate, the residual water amount at the water level H1 can be obtained with high accuracy.

[0043]

After the water level of the (n-1)-th diluted sample water in the container 10 is lowered to H1 as described above, the solenoid valves 17 and 24 are opened, the other solenoid valves are closed, and the pump 14 is set to OFF, and the residual (n-1)-th diluted sample water between the pipes 18 to 16 is discharged through the pipes 23 and 25. Thereafter, dilution water is introduced into the container 10 until the water level reaches H2, and circulation stirring is performed to obtain the n-th diluted sample water.

[0044]

[Take-out Step]

In order to take out the diluted sample water in the container 10 after the above dilution step, the solenoid valves 12 and 21 are opened, the other solenoid valves are closed, and the pump 14 is set to ON, and the diluted sample water is taken out through the pipes 11, 13, 15, 20, and 22 (Fig. 5).

[0045]

<Raw solution, Dilution Water>

The present invention is suitable as a dilution apparatus for measuring a residual chlorine concentration in a raw solution. The raw solution is not particularly limited, but examples thereof include a CIP cleaning liquid in a beverage or food manufacturing plant, a food sterilization liquid, and a cooking utensil sterilization liquid, and the like. The dilution apparatus for water quality measurement of the present invention can also be used as a dilution apparatus for measuring components other than residual chlorine.

[0046]

As the dilution water, water obtained by treating tap water with activated carbon, pure water, ultrapure water, or the like may be used, but the dilution water is not limited thereto.

[0047]

<Container>

The container preferably has a cylindrical shape, but a rectangular tubular shape may also be used. In the case of a cylindrical shape, the height of the container is preferably 3 to 30 times, particularly about 5 to 10 times, the diameter of the bottom of the container.

[0048]

<Pressure Sensor>

The pressure sensor is not particularly limited as long as it can detect the water level in the container 10, and various commercially available products can be used.

[0049]

Although the present invention has been described in

detail using specific embodiments, it will be apparent to those skilled in the art that various modifications can be made without departing from the spirit and scope of the present invention.

The present application is based on Japanese Patent Application No. 2023-191016 filed on November 8, 2023, the entire contents of which are hereby incorporated by reference.

#### Reference Signs List

[0050]

2, 5, 12, 17, 21, 24: Solenoid valves

9: Pressure sensor

10: Container

14: Pump

## CLAIMS

## [Claim 1]

A dilution apparatus for water quality measurement for preparing sample water by diluting a raw solution with dilution water, the apparatus comprising:

a container;

a raw solution supply unit for supplying the raw solution to the container;

a dilution water supply unit for supplying dilution water to the container;

a circulation unit for circulating the water in the container;

an outflow unit for allowing the water in the container to flow out; and

a pressure sensor for detecting a water level in the container,

wherein the outflow unit includes a pump, and the water is caused to flow out from the container by gravity in a state where the pump is stopped.

## [Claim 2]

The dilution apparatus for water quality measurement according to claim 1,

wherein the circulation unit performs circulating water by the pump of the outflow unit.

## [Claim 3]

A dilution method for preparing sample water by diluting a raw solution with dilution water using the dilution apparatus for water quality measurement according to claim 1 or 2, the method comprising:

a raw solution introduction step of introducing a first predetermined amount of the raw solution into the

container;

a dilution water introduction step of introducing a second predetermined amount of dilution water into the container;

a stirring step of stirring by circulating the water in the container; and

a taking-out step of taking out the water thus diluted from the container,

wherein the raw solution introduction step includes:

a step of introducing into the container an excessive amount of the raw solution more than the first predetermined amount;

a pump discharge step of discharging a part of the excessive amount of the raw solution from the container by operating the pump; and

a gravity discharge step of stopping the pump and allowing the raw solution in the container to flow out by gravity so that the amount of the raw solution in the container detected by the pressure sensor becomes the first predetermined amount.

[Claim 4]

The dilution method according to claim 3,

wherein after performing the raw solution introduction step, the residual water in the circulation unit is discharged to outside the dilution apparatus for water quality measurement, and thereafter the dilution water introduction step is performed.

[Claim 5]

The dilution method according to claim 4,

wherein after performing the raw solution introduction step, the dilution water introduction step,

and the stirring step, a water discharge step is performed in which the water is discharged so that the amount of the water in the container becomes the first predetermined amount, and thereafter a second dilution step comprising introducing dilution water into the container is performed.

[Claim 6]

The dilution method according to claim 5,  
wherein after the water discharge step and before introducing the dilution water, residual water is discharged from the circulation unit.