

SPECIFICATION

TITLE OF THE INVENTION

METHOD AND DEVICE FOR MONITORING ACUTE TOXIN USING SMALL FISH

BACKGROUND OF THE INVENTION

Field of the Invention

[0001]

The present invention relates to a method and a device for monitoring an acute toxin, in which an alert of an acute toxin is issued by constantly supplying water from a water source to a water tank into which small fish are released and by monitoring the small fish.

Description of the Related Art

[0002]

A conventionally known method for monitoring water quality of a water source such as a river, a reservoir, a dam is generally a test method using a chemical reagent or the like. There has been a problem in monitoring the water quality on a daily basis by the above-mentioned method because a toxic substance detected by the reagent is limited and special knowledge is also required in handling the reagent.

[0003]

As for an easier method which detects variety of toxic substances, Bioassay using small fish such as Himedaka (Japanese *Oryzias latipes*) has been drawn attention. In Bioassay, the state of the fish are released into the water tank filled with water obtained from the water source and monitored. Examples of the related art relating to Bioassay are cited in patent literatures below.

In Patent Literatures 1 and 2, the set number of the fish within a monitoring range set in the water tank is monitored and alarm signal is outputted when the number changes.

Citation List

Patent Literature

[0004]

PTL 1: Japanese Unexamined Patent Application Publication No. 2002-257815

PTL 2: Japanese Unexamined Patent Application Publication No. 2003-139764

SUMMARY OF THE INVENTION

Problems to be solved by the Invention

[0005]

In the monitoring methods disclosed in Patent Literatures 1 and 2, when there is a change in water quality by a transferring movement of the fish into a downstream side, an alarm signal is outputted. When the alarm signal is outputted, to what degree the water quality changes is not always clear, therefore there is a need for a skilled staff member to make a final decision after confirming on the spot.

The present invention is proposed in view of the above-mentioned problems. An object of the present invention is to provide a method and a device for monitoring an acute toxin in which an alert especially for an acute toxin is issued at an appropriate timing.

Means of Solving the Problems

[0006]

In the present invention, a method for monitoring an acute toxin is characterized in that raw water is constantly supplied from a water source to a water tank into which a plurality of small fish are released, a vortex flow that circulates in the water tank is generated, and a dead fish collection net is installed in a flow path of the vortex flow; an entire horizontal plane of the water tank is divided into a plurality of detection blocks that are smaller than the small fish and further a setting that designates an installation field of the dead fish collection net as an exclusion block to be excluded from a presence determination processing of the small fish is received; the entire horizontal plane of the water tank is photographed by a camera device

at every predetermined time; presence of the small fish is determined in each of the detection blocks that are not designated as the exclusion block based on a photograph image of the water tank and number of presence detection blocks is accumulated as a monitoring history; and a determination standard of a death rate by the acute toxin is successively calculated based on the monitoring history and an alert of the acute toxin is issued when the number of the presence detection blocks becomes lower than the determination standard.

[0007]

In the present invention, a device for monitoring the acute toxin includes the water tank into which the plurality of small fish are released; a water supply means constantly supplying raw water from the water source to the water tank and generating the vortex flow that circulates in the water tank; the dead fish collection net that is installed in the flow path of the vortex flow; a setting portion dividing the entire horizontal plane of the water tank into the plurality of detection blocks that are smaller than the small fish and further receiving the setting that designates the installation field of the dead fish collection net as the exclusion block to be excluded from the presence determination processing of the small fish; the camera device photographing the water tank at every predetermined time; a monitoring portion determining presence of the small fish in each of the detection blocks that are not designated as the exclusion block based on the photograph image of the water tank and accumulating as the monitoring history the number of presence detection blocks; and an alerting portion successively calculating the determination standard of the death rate by the acute toxin based on the monitoring history and issuing the alert of the acute toxin when the number of the presence detection blocks becomes lower than the determination standard.

Effects of the Invention

[0008]

The present invention is constituted in such a manner that the predetermined period is set, for example, at ninety-six hours and the alert of an acute toxin is issued when the number of the

presence detection blocks decreases equal to or less than half during the predetermined period. In the above-mentioned case, an acute toxin alert is a clear signal showing that water in the water tank contains the acute toxin poisoning the fish by half in the ninety-six hours. Because dimension of the detection blocks is set smaller than the horizontal images of the small fish, the presence of the same small fish is determined in the plurality of detection blocks at the same time. Thereby, the small fish are hardly overlooked and detection errors are suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a block chart illustrating a basic configuration of the device for monitoring the acute toxin as an example of an embodiment.

Fig. 2 is a general perspective view illustrating a concrete example of the device for monitoring the acute toxin.

Fig. 3A is a perspective view illustrating a concrete example of the water tank constituting the device for monitoring the acute toxin. Figs. 3B and 3C are both plane views illustrating a basic action of a water supply means.

Fig. 4A is a plane view illustrating a process for dividing a horizontal plane into a plurality of detection blocks. Figs. 4B and 4C are both plane views illustrating concrete determination examples of the presence of the small fish in the detection blocks.

Fig. 5A is an example of a photograph image of the water tank. Fig. 5B is a plane view illustrating an example of a determination result in which the presence of the small fish is determined based on the photograph image.

Fig. 6 is a graphic chart illustrating an example of a result of monitoring the population of the small fish.

Fig. 7 is a flow chart illustrating an example of basic steps of monitoring the population of the small fish.

Fig. 8A is another example of the photograph image of the water tank. Fig. 8B is a plane

view illustrating an example of a determination result in which entry of the small fish into the detection blocks is determined based on the photograph image.

Fig. 9 is a graphic chart illustrating an example of a result of monitoring an activity amount of the small fish.

Fig. 10 is a flow chart illustrating an example of basic steps of monitoring the activity amount of the small fish.

Fig. 11 is a concrete example of a display screen of the monitoring history.

Fig. 12 is another example of the display screen of the monitoring history.

Fig. 13A is a graphic chart of the population standardized by an alerting standard of the acute toxin. Fig. 13B is a graphic chart of the population standardized by a warning standard of the acute toxin. Fig. 13C is a graphic chart of the activity amount standardized by a warning standard of rapid decrease in the activity amount. Fig. 13D is a graphic chart of the activity amount standardized by rapid increase in the activity amount.

DESCRIPTION OF THE EMBODIMENTS

[0010]

Fig. 1 illustrates a device for monitoring the acute toxin as an example of an embodiment. The device monitors water quality, monitoring the acute toxin in particular, of a water source or a monitor object, for example, a river, a reservoir, a dam, by Bioassay using small fish; small fish such as Himedaka of which length is equal to or more than 2.5 centimeters are used. Himedaka grows up to approximately 2.5 centimeters about one year after birth. In the device for monitoring the acute toxin, about ten to twelve Himedaka as above are used and dead Himedaka are replaced after a lapse of ninety six hours from decease of the Himedaka.

[0011]

First of all, a basic configuration of the device for monitoring the acute toxin is explained below.

A monitoring device 10 includes, as essential elements for monitoring water quality, a water tank 11 to which water is constantly supplied from the water source and into which a plurality

of small fish are released, a setting portion 12 receiving an setting of dividing an entire horizontal plane of the water tank 11 into a plurality of detection blocks that are smaller than horizontal images of the small fish, a camera device 13 photographing the water tank 11 at every predetermined time, a monitoring portion 14 determining presence of the small fish in each of the detection blocks based on a photograph image from the camera device 13 and accumulating as a monitoring history the number of determined presence detection blocks, an alerting portion 15 issuing an alert of the acute toxin when, in reference to the monitoring history, the number of presence detection blocks becomes lower than an alerting standard during a predetermined period, and a display portion 1 displaying the monitoring history. The monitoring device 10 further includes a water supply means 17 supplying water taken from the water source to the water tank 11 by a predetermined amount per hour, an automatically feeding device regularly feeding into the water tank 11, not illustrated, an LED lamp, not illustrated, lighting the water tank 11.

[0012]

If the water tank 11 is a thin type of which dimension is approximately from 20x30 cm to 25x35 cm and depth is approximately from four to five centimeters, the water tank 11 holds approximately seven to fifteen small fish and the camera device 13 easily photographs the entire horizontal plane of the water tank 11 from an upper side.

The setting portion 12 is constituted, for example, by a touch panel, a keyboard, or the like. The setting portion 12 can be constituted so as to load division information of the detection blocks or the other initial setting information by a USB memory stick, a memory card, computer networks, or the like.

The camera device 13 can be a general one using a CMOS sensor or a CCD sensor. The photograph image can be color or monochrome.

The monitoring portion 14 can be constituted, for example, by a computer device such as a personal computer. Thereby, the monitoring history is stored in such as an internal hard disk and stored data can be transferred to the USB memory stick, the memory card, or the like. Connected with a communication terminal in a remote location by computer networks, the

monitoring portion 14 receives a remote setting by the communication terminal or the like or transfers an alert of detection of the acute toxin.

The alerting portion 15 is for informing a staff member of the detection of the acute toxin, and can be constituted, for example, so as to sound an alert by a buzzer or a siren or so as to display the alert by a rotary beacon light. Alternatively, the alerting portion 15 can be constituted so as to transfer the alert to an external device.

The display portion 1 can be constituted by a liquid crystal panel or CRT. Using the touch panel, the display portion 16 is also used as the setting portion 12 and the size of the device is reduced.

The water supply means 17 can be constituted by an electric pump, a solenoid valve, or the like. As for the automatically feeding device and the LED lamp, goods on the market can be used.

[0013]

Fig. 2 is a perspective view illustrating a concrete example of the device for monitoring the acute toxin.

The monitoring device 10 has the basic configuration in which a dark box 20 freely opened or closed by front doors 20a, 20a, or the like houses the water tank 11, the monitoring portion 14, and the like. The monitoring device 10 is provided with the alerting portion 15 made of the rotary beacon light on an upper face of the dark box 20. Specifically, the monitoring portion 14 is housed in an upper shelf of the dark box 20; the water tank 11 is housed in a middle shelf; and a sample water tank 21, a raw water supply pump, and a heat exchanger, not illustrated, are housed in a lower shelf. The camera device 13, the LED lamp, and the automatically feeding device, not illustrated, are arranged at the upper side of the water tank 11. A fan device, not illustrated, blowing a water surface of the water tank 11 when water temperature is high, can further be provided.

The water tank 11 is integrally formed with a settling tank 11a constituting the water supply means 17; and the camera device 13 and the LED lamp are fixed downward to an outer wall face of the settling tank 11a. The monitoring portion 14 includes a numeric keypad

constituting the setting portion 12 in a front face of a chassis, and the touch panel constituting the display portion 16. The camera device 13, the LED lamp, the automatically feeding device, the raw water supply pump, the heat exchanger, or the like are controlled by the monitoring portion 14.

When the monitoring device 10 is entirely housed into the dark box 20 and is internally lit by the LED lamp as mentioned above, only the water tank 11 is lit and the other portions remain dark. Thereby, effects on suppressing generation and growth of algae and phytoplankton are obtained. If the water tank 11 is entirely made of resin of low light reflectivity, the above effects become more excellent. Since the LED lamp generally irradiates with light in one direction, lighting only the water tank 11 is possible and a rise in the water temperature because of irradiation light hardly occurs.

[0014]

Fig. 3A is a perspective view illustrating a concrete example of the water tank. Figs. 3B and 3C are both plane views illustrating a basic action of a water supply means.

As illustrated in Fig. 3A, the water tank 11 is integrated with the settling tank 11a and a waste material tank 11. The settling tank 11a is for eliminating in advance deposited and floating matters from water supply to the water tank 11, and the waste material tank 11b is for moving and storing excrement of small fish in order to keep the water tank 11 clean.

The water tank 11 is communicated with the settling tank 11a through water inlets 11c, 11c provided on one side of two side faces facing each other, and is communicated with the waste material tank 11b by a water outlet 11d provided on the other side of the two side faces. A bottom face of the water tank 11 is gently inclined downward from the water inlets 11c, 11c to the water outlet 11d, and is configured to exhaust excrement by a water stream from the water inlets 11c, 11c to the water outlet 11d. The water outlet 11d can be provided with a net or the like for preventing small fish from going out.

The settling tank 11a is of a four-tank type, an upper portion of a first tank is provided with a water filler 11e, and an upper portion of a fourth tank is provided with a high water level overflow port 11f and a low water level overflow port 11g. The first to fourth tanks are

configured to be communicated with the adjacent tank on a lower end portion or an upper end portion of partition walls. The overflow ports 11f, 11g are respectively connected to the water inlets 11c, 11c by a piping. The piping that connects the low water level overflow port 11g and the water inlet 11c is provided with a solenoid valve 11h.

When the solenoid valve 11h is closed, the settling tank 11a discharges water overflowing from the high water level overflow port 11f through the water inlet 11c, and is able to generate a vortex flow in one side direction within the water tank 11 as illustrated in Fig. 3B. On the other hand, when the solenoid valve 11h is open, the settling tank 11a discharges water overflowing from the low water level overflow port 11g through the water inlet 11c, and is able to generate the vortex flow in opposite direction within the water tank 11 as illustrated in Fig. 3C. The vortex flow in the one side direction only flushes out waste material from half of the bottom face of the water tank 11, but waste material is able to be flushed out from the entire bottom face of the water tank 11 in such a manner that direction of the vortex flow within the water tank 11 is appropriately switched by controlling the solenoid valve.

Four corners of the water tank 11 are curved faces and a vortex flow stabilizing pole 11i is erected at the central part of the water tank 11. Therefore, a stable vortex flow is obtained and water does not stagnate within the water tank 11. Further, a dead fish collection net 11j is stretched between the vortex flow stabilizing pole 11i and a peripheral wall of the water tank 11. The dead fish collection net 11j is configured to have meshes thorough which a small fish is able to swim. Dead fish are collected in such a manner that they are moved by the vortex flow and caught sideways at the dead fish collection net 11j.

The waste material tank 11b is divided into a division close to the water tank 11 and a division distant from the water tank 11 by a partition wall 11m, and drain outlets 11k, 11k are respectively provided for the divisions. The water face of the water tank 11 is defined by height of the drain outlets 11k, 11k. Height of the partition wall 11m is set lower than that of the drain outlets 11k, 11k. The bottom face of the division distant from the water tank 11 is provided with a sample water collecting port 11n that is communicated with a sample water tank 21. A piping connected to the sample water tank 21 is provided with the solenoid

valve or the like. When collecting water of the water tank 11 from the sample water collecting port 11n, such a problem that the water face of the water tank 11 becomes too low does not occur.

[0015]

Next, a basic action of the device for monitoring the acute toxin is explained below.

A method for monitoring the acute toxin by the monitoring device 10 includes steps of constantly supplying water from the water source to the water tank 11 into which the plurality of small fish are released, dividing in advance the entire horizontal plane of the water tank 11 into the plurality of detection blocks that are smaller than horizontal images of the small fish, photographing the entire horizontal plane of the water tank 11 by the camera device 13 at the every predetermined time, determining the presence of the small fish in each of the detection blocks based on the photograph image of the water tank 11 and accumulating as the monitoring history number of the determined presence detection blocks, and issuing the alert of the acute toxin when, in reference to the monitoring history, the number of the presence detection blocks becomes lower than the alerting standard during the predetermined period.

[0016]

For instance, a method of Fish Acute Toxicity Test set by OECD Test Guide Lines 203 shows that effects on the fish when exposed to a chemical substance for a period of the ninety-six hours is determined at concentrations poisoning the fish by half, i.e. half mortality concentration (LC 50).

Therefore, if the predetermined period is set at ninety-six hours and the alert of the acute toxin is configured to be issued when the number of the presence detection blocks decreases to half or to less than half during the predetermined period as a suitable concrete example, the alert of the acute toxin becomes a clear signal indicating that water in the water tank contains the acute toxin poisoning the fish by half in the ninety-six hours. If every small fish is 2 to 3 centimeters in length and an area of each presence detection block is set so as to determine the presence of the same small fish in two to three or two to four adjacent detection blocks at the same time, the small fish are hardly overlooked and detection errors are suppressed.

Determination whether or not the small fish decreases to half or to less than half in the ninety-six hours or not is executed, for instance, by a method in which the alerting standard of the acute toxin is set at fifty percent of a moving average value of the population in ninety-six hours, and the population at the present time is compared with the alerting standard. A modified example can be such that the alerting standard of the acute toxin is set at fifty percent of the population at the time of ninety-six hours earlier than the present time.

[0017]

A process for dividing a horizontal plane into a plurality of detection blocks is executed by the monitoring portion 14 when the setting portion 12 receives a predetermined setting. For instance, an exclusion block NB to be excluded by detection processing is optionally chosen and set in such a manner that photographing direction, magnification, or the like of the camera device 13 is manually adjusted in order that photographing coverage of the camera device 13 corresponds to the entire horizontal plane of the water tank 11, and in such a manner that the predetermined setting is executed in the setting portion 12 while viewing the photograph image of the water tank 11.

[0018]

Fig. 4A is a plane view illustrating the process for dividing a horizontal plane into a plurality of detection blocks. The photographing coverage of the camera device 13 is divided into 24x32 blocks as detection blocks B. When the photographing direction, the magnification, or the like of the camera device 13 is adjusted in such a manner that the photographing coverage of the camera device 13 corresponds to the entire horizontal plane of the water tank 11, the entire horizontal plane of the water tank 11 is divided into a plurality of detection blocks B as illustrated in the figures. By choosing the four corners of the water tank 11, a portion at the vortex flow stabilizing pole 11i, a portion at the dead fish collection net 11j as the exclusion blocks NB, only surviving small fish is able to become an object of presence determination. Namely, the vortex flow stabilizing pole 11i, dead fish, or the like is prevented from being erroneously determined as the small fish. If the dimension of the water tank 11 is 24x32 cm, when the photographing coverage of the camera device 13 is

adjusted so as to correspond to the entire horizontal plane of the water tank, the detection block B becomes 1x1 cm. On the other hand, because the length of the small fish is meant to be equal to or more than 2.5 centimeters, one small fish is detected in two to four detection blocks B at the same time, and detection oversight of the small fish is suppressed.

[0019]

A process for photographing the horizontal face of the water tank 11 by the camera device 13 at the predetermined time can be executed, for instance, at every 0.2 to 2 seconds.

[0020]

The monitoring portion 14 executes a process for determining the presence of the small fish in each of the detection blocks B based on the photograph image of the water tank 11 and accumulating as the monitoring history the number of determined presence detection blocks. By regarding an object of a size equal to or larger than the predetermined value as the small fish, the suspended matters are preferably prevented from being erroneously determined as the small fish.

Specifically, for instance, each of the detection blocks B is constituted by detection points S 5x5. When some object is photographed at equal to or more than thirteen points of the detection points S at the same time, the object is regarded as the small fish and the presence of the small fish can be determined. A concrete determination example of the presence is illustrated in Figs. 4B and 4C.

In a case illustrated in Fig. 4B, part of a small fish F is photographed at fourteen detection points S of the detection points S in five by five that constitute the detection block B. Because such a case satisfies the above conditions for the small fish, the presence of the small fish is determined in the detection block B.

In a case illustrated in Fig. 4C, a suspended matter U is photographed at the eight detection points S of the detection points S in five by five that constitute the detection block B. Because such a case does not satisfy the above conditions for the small fish, the presence of the small fish is not determined in the detection block B. The number of the detection points S that constitutes the detection block B and the conditions for being assumed as the small fish

are explained in the above as one example and not limited to such an aspect.

Figs. 5A and 5B illustrate one example of the photograph image of the water tank and one example of a determination result in which the presence of the small fish is determined based on the photograph image. Fig. 5B illustrates the exclusion block NB with a white frame and a presence detection block EB of the small fish with a hatched frame.

Dead fish DF that are collected in the dead fish collection net 11j are automatically excluded from an object to be detected by the exclusion block NB. Because the number of surviving small fish F is 11 and the number of the determined presence detection blocks is 37, the determined presence detection blocks per one fish becomes about 3.4 pieces.

Because the number of the determined presence detection blocks will vary within a predetermined range at every photograph images even if the number of the small fish F is the same, the determined presence detection blocks is preferably adopted by calculating a moving average value in a short time. Specifically, for instance, the horizontal face of the water tank 11 is photographed at every 0.5 second, the presence of the small fish is determined in each of the detection blocks B based on the photograph image, and a value obtained by calculating a moving average value of the presence detection block EB within one minute is adopted as the number of the presence detection blocks at the present time. The number of the presence detection blocks is not limited to the moving average value of the presence detection block EB within one minute, or can be a moving average value, for instance, within thirty seconds or within three minutes.

The number of the presence detection blocks calculated at the present time can be accumulated as the monitoring history.

[0021]

The monitoring portion 14 and the alerting portion 15 execute a process for issuing the alert of the acute toxin when, in reference to the monitoring history, the number of the presence detection blocks becomes lower than the alerting standard during the predetermined period.

A specific processing can be such that, while calculating the number of the presence detection blocks at the present time as the moving average value within one minute, at the same time a

moving average value of the number of the presence detection blocks in ninety-six hours is calculated; as the alerting standard of the acute toxin is set at fifty percent of the moving average value in ninety-six hours, an acute toxin alert is issued when the number of the presence detection blocks becomes lower than the alerting standard. Even in such a situation that the small fish F dies one after another, the moving average value of the presence detection blocks in ninety-six hours gradually changes. Therefore, even if fifty percent of the moving average value in ninety-six hours is set as the alerting standard of the acute toxin each time, malfunction such as delay of the acute toxin alert does not occur.

On condition that a state in which the number of the presence detection blocks becomes lower than the alerting standard continues, the acute toxin alert can be issued for the predetermined time, for instance, three minutes, from start of time measuring when the number of the presence detection blocks becomes lower than the alerting standard. Needless to say, if the number of the presence detection blocks is recovered to the alerting standard before the predetermined time, issuing of the acute toxin alert is cancelled. Thereby, a false alert is able to be suppressed.

[0022]

Fig. 6 is a graphic chart illustrating a result of monitoring the population of the small fish for seven days, i.e. 168 hours, by the above-mentioned method. An ordinate in a graphic chart G1 represents the number of the presence detection blocks (the population). The initial population of the small fish is set as twelve fish. A period of seven days is shown as one example, and monitoring water quality is generally performed for a long time without stopping.

In the graphic chart G1, a solid line illustrates the number of the presence detection blocks. The number of the presence detection blocks gradually decreases in accordance with decrease of the small fish each time.

A broken line illustrates the moving average value of the number of the presence detection blocks in ninety-six hours and the value gradually after the rapid decrease in the number of the presence detection blocks.

A one dotted chain line illustrates fifty percent of the moving average value in ninety-six hours and is a determination standard of poisoning half of the fish by the acute toxin each time, i.e. an acute toxin alerting standard. The acute toxin alert is issued at which the number of the presence detection blocks becomes lower than the alerting standard. At the above-mentioned time, part of water in the water tank can be moved and stored in the sample water tank.

A two dotted chain line illustrates seventy five percent of the moving average value in ninety-six hours and is a determination standard of poisoning a quarter of the fish by the acute toxin each time, i.e. an acute toxin warning standard. An acute toxin warning is issued at the time in which the number of the presence detection blocks becomes lower than the warning standard. If the acute toxin warning standard is configured to be issued at the time earlier than the acute toxin alert as mentioned above, measures can be taken to deal with the acute toxin with plenty of time.

In the above example, one fish is dead at the twenty-sixth hour and the acute toxin warning is issued when four fish in total are dead at the one hundred eleventh hour. The acute toxin alarm is issued when eight fish in total are dead at the one hundred fortieth hour.

[0023]

Fig. 7 is a flow chart illustrating an example of basic steps of the above mentioned method. Hereinafter, assuming that the process for dividing the entire horizontal plane of the water tank into the plurality of detection blocks has already been executed, a virtual monitoring process is explained below.

Steps 100, 101 are processes for photographing the entire horizontal plane by the camera device at every predetermined time, for instance, 0.5 second.

Steps 102, 103 are processes for determining the presence of the small fish in each of the detection blocks based on the photograph image of the water tank and accumulating as the monitoring history the number of the determined presence detection blocks.

Steps 104 to 108 are processes for issuing the alert of the acute toxin when, in reference to the monitoring history, the number of the presence detection blocks becomes lower than the

alerting standard during the predetermined period.

Specifically, the moving average value of the number of the presence detection block within one minute is calculated in the step 104. By treating the moving average value as the number of the presence detection blocks at the present time, adverse effect by detection dispersion is suppressed.

In the step 105, the moving average value of the number of the presence detection blocks in ninety-six hours is calculated. Fifty percent of the moving average value is set as the alerting standard of the acute toxin, and seventy five percent of the moving average value is set as the warning standard of the acute toxin.

In steps 106, 107, the number of the presence detection blocks at the present time is compared with the alerting standard of the acute toxin and, if the number of the detection blocks is lower than the alerting standard, the acute toxin alarm is issued. The basic steps are finished at the time in which the acute toxin alarm is issued but can be returned to the step 100 without being finished.

In steps 108, 109, the number of the presence detection blocks at the present time is compared with the warning standard of the acute toxin and, if the number of the detection blocks is lower than the warning standard, the acute toxin alarm is issued. After the steps 108, 109, the basic steps are returned to the step 100.

[0024]

Monitoring an activity amount profitably when being executed with monitoring the population of the small fish is explained below. Namely, because the small fish exhibits a property of change in an activity to react to the acute toxin or the like, monitoring the activity amount of the small fish is intended to be utilized for prediction of the acute toxin. For instance, the activity amount of the small fish tends to increase at a stage of starting mixing the acute toxin into water (a frenzy activity). When the concentration of the acute toxin becomes greater, the activity amount of the small fish tends to decrease (an inactive activity). Warning of change in the activity as above greatly contributes to the prediction of the acute toxin. With the date and time when there is change in the activity being recorded, when the

acute toxin poisoning equal to or more than half of the small fish is detected, the date and the time become a helpful clue for analyzing when the acute toxin is beginning to be mixed into water, when the concentration of the acute toxin becomes greater, or the like.

[0025]

A monitoring method of the activity amount is similar to a monitoring method of the population as mentioned above.

Namely, a monitoring method of the activity amount by the monitoring device 10 is configured by the basic steps of photographing the entire horizontal plane of the water tank by the camera device 13 at every predetermined time; determining entry of the small fish into each of the detection blocks B based on the photograph image of the water tank 11; accumulating as the monitoring history the number of entry detection blocks in which the entry is determined; and warning activity disorder when, in reference to the monitoring history, the number of the entry detection blocks reaches the warning standard. The detection block B is able to directly use that for monitoring the population.

[0026]

The monitoring portion 14 executes a process for determining the entry of the small fish into each of the detection blocks B based on a photograph image of a water tank 12 and accumulating as the monitoring history the number of the entry detection blocks in which the entry is determined.

Specifically, the entry of the small fish into the detection blocks B is determined in such a manner that the presence of the small fish is determined respectively in each of the detection blocks B based on two last consecutive photograph images and determination results are compared with each other. In other words, the entry of the small fish can be determined in the detection blocks B in which the presence of the small fish is not previously determined at but is presently determined.

[0027]

Figs. 8A and 8B illustrate one example of the photograph image of the water tank and one example of the determination result in which the entry of the small fish is determined based

on the photograph image.

Fig. 8A illustrates the small fish F of a present photograph image of two last consecutive photograph images with the solid line, and illustrates the small fish F of a previous photograph image with a dotted line. Namely, the small fish that is at a position of the dotted line in the previous photograph image moves to a position of the solid line in the present photograph image.

An entry detection block MB is a block in which the presence of the small fish is not previously determined and is presently determined. As being recognized by comparing the position of the small fish illustrated with the solid line in Fig. 8A and the position of the small fish illustrated with the dotted line in Fig. 8A, the entry detection block MB is illustrated with the hatched frame in Fig. 8B.

In the example, the number of surviving small fish F is eleven in total but the number of the entry detection blocks is fourteen in total. When time difference between previous photographing and the present photographing is small, i.e. moving distance of the small fish F within the time difference becomes shorter (less than the total length of the small fish), the number of the entry detection blocks is assumed to be proportional to an activity amount of the total small fish F. For instance, if 0.5 second is adopted as the time difference, a good detection result is obtained. The moving average value of the number of the entry detection blocks within one minute calculated as above can be treated as a value of the number of the entry detection blocks at the present time.

[0028]

The monitoring portion 14 and the alerting portion 15 execute a process for warning the activity disorder when, in reference to the monitoring history, the number of the entry detection blocks reaches the warning standard.

The warning standard here is not limited in particular and values of the warning standard of rapid increase and decrease in the activity amount can be set based on the moving average value of the activity amount within the predetermined period calculated by the monitoring history.

Specifically, the moving average value within one minute is calculated as the number of the entry detection blocks at the present time and, at the same time, a moving average value of the number of the entry detection blocks in ninety-six hours is calculated. One hundred fifty percent of the moving average value of the number of the entry detection blocks in ninety-six hours is set as the warning standard of the rapid increase in the activity amount, and fifty percent of the moving average value of the number of the entry detection blocks in ninety-six hours is set as the warning standard of the rapid decrease in the activity amount. When the number of the entry detection blocks at the present time exceeds the warning standard of the rapid increase in the activity amount or becomes lower than the warning standard of the rapid decrease in the activity amount, the activity disorder is warned. On condition that a state in which the number of the entry detection blocks exceeds the warning standard of the rapid increase in the activity amount or becomes lower than the warning standard of the rapid decrease in the activity amount continues, an activity disorder warning can be issued for the predetermined time, for instance, three minutes, from start of time measuring when the number of the entry detection blocks exceeds the warning standard of the rapid increase in the activity amount or becomes lower than the warning standard of the rapid decrease in the activity amount. Needless to say, if the number of the entry detection blocks exceeds the alerting standard before the predetermined time, issuing of the activity disorder warning is cancelled. Thereby, the false alert is able to be suppressed.

Because the change in the activity as above occurs when the acute toxin is beginning to be mixed into water or when the concentration of the acute toxin becomes greater, strength of the acute toxin is able to be determined based on transition of the number of the presence detection blocks and of the entry detection blocks. Because time difference between the acute toxin alert and the activity disorder warning (the rapid increase in the activity amount) substantially corresponds to the time for poisoning half of the small fish, the strength of the acute toxin is considered to be estimated based on the time difference. For instance, in such a case in which the activity disorder (the rapid increase in the activity amount) is warned forty eight hours before the alert of the acute toxin is issued, the acute toxin that is substantially

twice as strong as the concentration poisoning the fish by half is assumed to be mixed.

Therefore, the monitoring device 10 can be constituted, at least when the alert of the acute toxin is issued, to estimate the strength of the acute toxin based on the transition of the number of the presence detection blocks and of the entry detection blocks in reference to the monitoring history and to display the estimated strength at the display portion 16.

The change in the activity as above usually occurs not only because of abnormality in the water quality but also when the small fish is surprised at something, for instance, when there is a big sound or when the water tank is quaked, or the like. The change in the activity also occurs when water supply is stopped, water temperature becomes unstable, or the like. Therefore, when a microphone detecting a noise, an acceleration meter detecting a quake, or the like is provided and a sensor such as the microphone and the acceleration meter detects disorder or water supply is stopped, the issuing of the activity disorder warning can be stopped within the predetermined time.

[0029]

Fig. 9 is a graphic chart illustrating the result of monitoring the activity amount of the small fish for seven days, i.e. one hundred sixty eight hours, by the above method of monitoring the activity amount. A vertical axis in a graphic chart G2 illustrates the number of the entry detection blocks.

A solid line in the graphic chart G2 illustrates the number of the entry detection blocks, i.e. the activity amount. The number of the entry detection blocks rapidly increases at the fifteenth hour from the start of monitoring, and returns to the original; thereafter, rapidly decreases at the eighty-fourth hour from the start of monitoring, and returns to the original again. The number of the entry detection blocks greatly changes in actuality but gradual change is illustrated here for brevity.

A broken line illustrates the moving average value of the number of the presence detection blocks in ninety-six hours and gradually decreases after the rapid decrease in the number of the entry detection blocks.

A one-dotted chain line illustrates fifty percent of the moving average value in ninety-six

hours, which is a warning standard of the rapid decrease in the activity amount at each time. When the number of the entry detection blocks becomes lower than the warning standard, a warning of rapid decrease in the activity amount is issued.

A two-dotted chain line illustrates one hundred fifty percent of the moving average value in ninety-six hours, which is a warning standard of the rapid increase in the activity amount at each time. When the number of the entry detection blocks exceeds the warning standard, a warning of rapid increase in the activity amount is issued.

In the above example, the warning of rapid increase in the activity amount is issued at the fifteenth hour. The warning indicates occurrence of abnormality in the water quality such as mixture of the acute toxin into water. The warning of rapid decrease in the activity amount is issued at the eighty-fourth hour. The warning indicates aggravation of abnormality in the water quality.

[0030]

Fig. 10 is a flow chart illustrating an example of basic steps of monitoring the activity amount. Hereinafter, assuming that the process for dividing the entire horizontal plane of the water tank into the plurality of detection blocks has already been executed, a virtual monitoring process is explained below.

Steps 200, 201 are processes for photographing the entire horizontal plane of the water tank 11 by the camera device at every predetermined time, for instance, 0.5 second.

Steps 202, 203 are processes for determining the entry of the small fish in each of the detection blocks based on the photograph image of the water tank and accumulating as the monitoring history the number of the determined entry detection blocks.

Steps 204, 205 are processes for issuing the alert of the acute toxin when, in reference to the monitoring history, the number of the presence detection blocks becomes lower than the alerting standard during the predetermined period.

Specifically, the moving average value of the number of the entry detection blocks within one minute is calculated in the step 204. By treating the moving average value as the number of the entry detection blocks at the present time, adverse effect by detection dispersion is

suppressed.

In the step 205, the moving average value of the number of the entry detection blocks in ninety-six hours is calculated. Fifty percent of the moving average value is set as the warning standard of the rapid decrease in the activity amount, and one hundred fifty percent of the moving average value is set as the warning standard of the rapid increase in the activity amount.

In steps 206, 207, the number of the entry detection blocks at the present time is compared with the warning standard of the rapid increase in the activity amount and, if the number of the entry detection blocks exceeds the warning standard, the warning of rapid increase in the activity amount is issued. The step 200 follows the steps 206, 207.

In steps 208, 209, the number of the entry detection blocks at the present time is compared with the warning standard of the rapid decrease in the activity amount and, if the number of the entry detection blocks is lower than the warning standard, the warning of rapid decrease in the activity amount is issued. The step 200 follows the steps 208, 209.

[0031]

The monitoring device 10 issues the alert of the acute toxin and of the activity disorder of the small fish as mentioned above. During monitoring, the monitoring history can be displayed at the display portion on a real-time basis. A concrete example of displaying the monitoring history is explained below.

[0032]

Fig. 11 is a concrete example of a display screen of the monitoring history.

A display screen W1 is provided with monitoring data displaying column S1 for the population of the small fish, the activity amount, or the like, with a graphic chart displaying column S2 for monitoring data such as the population of the small fish and the activity amount, and with a photograph image displaying column S3 of the water tank 11.

In the monitoring data displaying column S1, the population, the activity amount, and the like at each time can be read out based on the monitoring history and can be numerically displayed.

A time unit is not limited specifically and can be set briefly, for instance, every two hours, every hour, every ten minutes, or every minute. The data in twelve hours of the popularity, the activity amount, the alerts issued, and the warning issued at every one hour are collected in a slot and are displayed in a tabular format. A display range of a table T1 can be set so as to be moved by a scrolling, or the like.

In the graphic chart displaying column S2, the population, the activity amount, and the like at every time is read out based on the monitoring history and are displayed with a graph. A period for displaying with the graph can be set freely, such as seven days, three days, or one day. A display range of the graph can be set so as to be moved by the scrolling, or the like. The population and the activity amount are displayed independently in graphic charts G3, G4. The graphic chart G3 displays the data in seven days from June 4th to June 10th, of the population, the moving average value in ninety-six hours, the alerting standard of the acute toxin (fifty percent of the moving average value in ninety-six hours), the warning standard of the acute toxin (seventy-five percent of the moving average value in ninety-six hours).

The graphic chart G4 displays the data in seven days from June 4th to June 10th, of the activity amount, the moving average value in ninety-six hours, the warning standard of the rapid decrease in the activity amount (fifty percent of the moving average value in ninety-six hours), the warning standard of the rapid increase in the activity amount (one hundred fifty percent of the moving average value in ninety-six hours).

In the photograph image displaying column, a photograph image designated by the predetermined date and the time in the monitoring data displaying column and a photograph image P1 designated by the predetermined date and the time chosen in the graphic chart displaying column are displayed in a switching manner.

With a displaying aspect as the graphs G3, G4, changes in the population and the activity amount of the small fish are able to be grasped. Convenience is enhanced by displaying a date and time designating setting and setting so as to call a monitoring history of a daily report data of the corresponding date and time designated, i.e. one day, in the monitoring data displaying column S1 and the graphic chart displaying column S2.

[0033]

Fig. 12 is another example of the display screen of the monitoring history. A display screen W2 has a different aspect of a graphic chart displayed in the graphic chart displaying column S2 relative to the display screen W illustrated in Fig. 11. Common elements other than the difference are allotted with same reference numerals and explanations for the common elements are omitted.

In a graphic chart G5, the population relative to the alerting standard of the acute toxin, the population relative to the warning standard of the acute toxin, the activity amount relative to the alerting standard of the rapid decrease in the activity amount, the activity amount relative to the warning standard of the rapid increase in the activity amount are illustrated in individual lines; and the individual lines are displayed so as to be laid over in one display screen in such a manner that the alerting standard of the acute toxin, the warning standard of the acute toxin, the alerting standard of the rapid decrease in the activity amount, the warning standard of the rapid increase in the activity amount are located at the same position.

With a displaying aspect as the graphic chart G5, because the corresponding alert and warning are issued when each of the lines becomes lower than the respective standards, i.e. when the rapid increase in the activity amount exceeds the standard, the time or the like when the alert and the warning are issued is able to be predicted just by seeing the graphic chart G5.

[0034]

The graphic chart G1 is explained below more specifically.

Figs. 13 A to 13D illustrate the population relative to the alerting standard of the acute toxin, the population relative to the warning standard of the acute toxin, the activity amount relative to the alerting standard of the rapid decrease in the activity amount, the activity amount relative to the warning standard of the rapid increase in the activity amount.

For instance, in the graphic chart G3 of Fig. 11, when the population is standardized by the alerting standard of the acute toxin, i.e. when the population is divided by the alerting standard of the acute toxin each time, the divided population become a relative value to the alerting standard of the acute toxin. Therefore, when the relative value is illustrated

graphically in such a manner that the alerting standard of the acute toxin becomes a horizontal line, a graphic chart G6 illustrated in Fig. 13A is obtained.

Regarding the population relative to the alerting standard of the acute toxin, the activity amount relative to the alerting standard of the rapid decrease in the activity amount, the activity amount relative to the standard of the rapid increase in the activity, graphic charts G7, G8, G9 as illustrated in Fig. 13B, 13C, 13D are obtained similarly from the graph G3 in Fig. 11.

When the graphic charts G6 to G9 illustrated in Fig. 13A to 13D are laid over in such a manner that the alerting standard of the acute toxin, the warning standard of the acute toxin, the alerting standard of the rapid decrease in the activity amount, the warning standard of the rapid increase in the activity amount are located at the same position, the graphic chart G5 is illustrated in Fig. 12.

[0035]

In the above mentioned method for monitoring the population and the activity amount of the small fish by analyzing the photograph image of the water tank, a normal monitoring result is not able to be obtained if water of the water tank is turbid over a predetermined degree. Therefore, by also monitoring turbidity of water during monitoring the small fish, the issue of the alert and the warning can be terminated during a period in which the turbidity exceeds a predetermined standard.

The turbidity is able to be easily quantified from average brightness or the like of entire photograph image of the water tank. For instance, the average brightness of the entire photograph image of the water tank is measured at every predetermined time and accumulated in the monitoring history; in reference to the monitoring history, when the average brightness at the present time becomes lower than a brightness standard calculated by the predetermined period, high degree of turbidity is determined and the issue of the alert and the warning can be terminated. Thereby, the false alert is greatly suppressed.

Data of the turbidity can be displayed numerically or graphically similar to the population, the

activity amount, or the like of the small fish in the display screen of the monitoring record.

Reference Signs List

[0036]

- 10 monitoring device
- 11 water tank
- 13 camera device
- 12 setting portion
- 14 monitoring portion
- 15 alerting portion
- B detection block
- EB presence detection block
- F small fish
- MB entry detection block

CLAIMS

1. A method for monitoring an acute toxin using small fish, the method comprising:
constantly supplying raw water from a water source to a water tank into which a plurality of small fish are released and generating a vortex flow that circulates in the water tank, and installing a dead fish collection net in a flow path of the vortex flow;
dividing an entire horizontal plane of the water tank into a plurality of detection blocks that are smaller than the small fish and further receiving a setting that designates an installation field of the dead fish collection net as an exclusion block to be excluded from a presence determination processing of the small fish;
photographing the entire horizontal plane of the water tank by a camera device at every predetermined time;
determining presence of the small fish in each of the detection blocks that are not designated as the exclusion block based on a photograph image of the water tank and accumulating as a monitoring history number of presence detection blocks; and
successively calculating a determination standard of a death rate by the acute toxin based on the monitoring history and issuing an alert of the acute toxin when the number of the presence detection blocks becomes lower than the determination standard.
2. The method for monitoring the acute toxin using the small fish as set forth in claim 1, wherein the determination standard of the death rate by the acute toxin is decided based on an average value of the number of the presence detection blocks during the predetermined time.
3. The method for monitoring the acute toxin using the small fish as set forth in claim 2, wherein the determination standard of the death rate by the acute toxin is fifty percent of a moving average value of the number of the presence detection blocks in ninety-six hours.
4. The method for monitoring the acute toxin using the small fish as set forth in claim 1, wherein the determination standard of the death rate by the acute toxin is fifty percent of a value of the number of the presence detection blocks ninety-six hours earlier.
5. The method for monitoring the acute toxin using the small fish as set forth in any one of claims 1 to 4, the monitoring method further comprising:
determining entry of the small fish into the detection blocks in each of the detection blocks and further accumulating number of entry detection blocks as a monitoring history; and
successively calculating determination standards of rapid increase and of rapid decrease in an

activity amount based on the monitoring history in a predetermined period and warning activity disorder when the number of the entry detection blocks exceeds the determination standard of the rapid increase in the activity amount or becomes lower than the determination standard of the rapid decrease.

6. The method for monitoring the acute toxin using the small fish as set forth in claim 5, wherein the determination standards of the rapid increase and of the rapid decrease in the activity amount are both decided based on an average value of the number of the entry detection blocks during a predetermined time.

7. The method for monitoring the acute toxin using the small fish as set forth in claim 6, wherein the determination standards of the rapid increase and of the rapid decrease in the activity amount are one hundred fifty percent and fifty percent of a moving average value of the number of the entry detection blocks in ninety-six hours.

8. The method for monitoring the acute toxin using the small fish as set forth in any one of claims 5 to 7, wherein strength of the acute toxin is estimated and displayed based on time difference between at which activity disorder is warned and at which the alert of the acute toxin is issued thereafter.

9. The method for monitoring the acute toxin using the small fish as set forth in any one of claims 1 to 8,
wherein each of the detection blocks is arranged with a predetermined number of detection points,
and
wherein the presence of the small fish in each of the detection blocks is determined based on the number of the detection points detecting the small fish in the blocks.

10. The method for monitoring the acute toxin using the small fish as set forth in any one of claims 1 to 9,
wherein turbidity of raw water is determined based on the photograph image of the water tank and issue of the alert of the acute toxin is terminated during a period in which the turbidity exceeds a standard.

11. The method for monitoring the acute toxin using the small fish as set forth in any one of claims 5 to 7,
wherein a graph illustrating a history of the number of the presence detection blocks relative to a

determination standard line of the death rate by the acute toxin, a graph illustrating a history of the number of the entry detection blocks relative to a determination standard line of the rapid increase in the activity amount, and a graph illustrating a history of the number of the entry detection blocks relative to a determination standard line of the rapid decrease in the activity amount are displayed so as to be laid over in one display screen in such a manner that the determination standard lines of the death rate by the acute toxin, of the rapid increase, and of the rapid decrease in the activity amount become a same straight line.

12. The method for monitoring the acute toxin as set forth in any one of claims 1 to 11, wherein a monitoring history of one day of a corresponding date is displayed as a daily report after receiving a date designation setting.

13. A device for monitoring an acute toxin, the device comprising:
a water tank into which a plurality of small fish are released;
a water supply means constantly supplying raw water from a water source to the water tank and generating a vortex flow that circulates in the water tank;
a dead fish collection net that is installed in a flow path of the vortex flow;
a setting portion dividing an entire horizontal plane of the water tank into a plurality of detection blocks that are smaller than the small fish and further receiving a setting that designates an installation field of the dead fish collection net as an exclusion block to be excluded from a presence determination processing of the small fish;
a camera device photographing the water tank at every predetermined time;
a monitoring portion determining presence of the small fish in each of the detection blocks that are not designated as the exclusion block based on a photograph image of the water tank and accumulating as a monitoring history number of presence detection blocks; and
an alerting portion successively calculating a determination standard of a death rate by the acute toxin based on the monitoring history and issuing an alert of the acute toxin when the number of the presence detection blocks becomes lower than the determination standard.