

DESCRIPTION

METHOD AND SYSTEM FOR TREATING GROUNDWATER

TECHNICAL FIELD

[0001]

The present invention relates to a method and system for treating groundwater, and more particularly, to a method and system for treating groundwater that can easily and efficiently neutralize alkaline groundwater having a high pH by effectively utilizing carbon dioxide that is not desired to be released into the atmosphere.

BACKGROUND ART

[0002]

In land near water areas where mineral waste is buried, alkaline groundwater with a high pH may be retained in the ground. If such land is left unattended without any measures taken, the alkaline groundwater may flow into the water areas. Conventionally, when modifying such land, alkaline soil mixed with mineral waste is excavated. Then, an air lift using a pumping pipe and an air blower is used to pump the alkaline groundwater to the surface (see, for example, Patent Document 1).

[0003]

The pumped alkaline groundwater cannot be discharged into public water areas or sewers as is. Therefore, conventionally, the pumped alkaline groundwater has been neutralized by adding a neutralizing agent. Since a large amount of groundwater is pumped during land modification work, the neutralization of the groundwater after pumping requires a relatively large amount of cost and time. Also, alkaline soil cannot be backfilled into the excavation site as is. Therefore, conventionally,

alkaline soil is often disposed of by landfill, etc., at waste disposal sites, and the treatment of alkaline soil also requires a relatively large amount of cost.

[0004]

In the construction industry, it is an issue to reduce the emission of carbon dioxide (CO₂), which is considered to be the cause of global warming in construction, and to effectively utilize carbon dioxide contained in the exhaust of power generators, construction machinery, etc. Therefore, it would be very beneficial if carbon dioxide that is not desired to be released into the atmosphere, which is generated at construction sites, etc., could be effectively utilized for the modification of alkaline land, and the carbon dioxide could be fixed in groundwater and the ground.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005]

Patent Document 1: Japanese Patent Application Kokai Publication No. 2005-307575

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006]

An object of the present invention is to provide a method and system for treating groundwater that can easily and efficiently neutralize alkaline groundwater having a high pH by effectively utilizing carbon dioxide that is not desired to be released into the atmosphere.

MEANS FOR SOLVING THE PROBLEM

[0007]

In order to achieve the above object, the groundwater

treatment method of the present invention includes inserting a pumping pipe into a ground where alkaline groundwater having a pH of 9 or higher is present, and injecting a gas having a higher volume ratio of carbon dioxide than an air at a construction site from an injection port provided at a lower part of the pumping pipe into the pipe of the pumping pipe by an air blower so that a large number of bubbles are generated in the pipe of the pumping pipe, raising and pumping the groundwater from the ground where the groundwater is present by a decrease in apparent specific gravity due to the large number of bubbles, and causing a neutralization reaction between the carbon dioxide contained in the bubbles and the alkaline groundwater during or after pumping so that the pH of the groundwater is lowered, wherein the gas contains the carbon dioxide that is not desired to be released into the atmosphere.

[0008]

In order to achieve the above object, the groundwater treatment system of the present invention includes a pumping pipe inserted into a ground where alkaline groundwater having a pH of 9 or higher is present, and an air blower connected to an injection port provided at a lower part of the pumping pipe, wherein the air blower injects a gas having a higher volume ratio of carbon dioxide than an air at a construction site from the injection port into the pipe of the pumping pipe so that a large number of bubbles are generated in the pipe of the pumping pipe, the groundwater is raised and pumped from the ground where the groundwater is present by a decrease in apparent specific gravity due to the large number of bubbles, and a neutralization reaction occurs between the carbon dioxide contained in the bubbles and the alkaline groundwater during or after pumping

so that the pH of the groundwater is lowered, and the gas contains the carbon dioxide that is not desired to be released into the an atmosphere.

EFFECTS OF THE INVENTION

[0009]

According to the present invention, when pumping alkaline groundwater using a pumping pipe, a gas having a high volume ratio of carbon dioxide is injected into the pipe of the pumping pipe so that a large number of bubbles are generated in the pipe of the pumping pipe. Then, the groundwater is raised and pumped by a decrease in apparent specific gravity due to the large number of bubbles, and a neutralization reaction is allowed to occur between the carbon dioxide contained in the bubbles and the alkaline groundwater during or after pumping. Thereby, the pH of the groundwater can be effectively lowered by effectively utilizing carbon dioxide that is not desired to be released into the atmosphere, and the neutralization of alkaline groundwater can be easily and efficiently performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

[Fig. 1] Fig. 1 is an explanatory diagram schematically illustrating an embodiment of the groundwater treatment system of the present invention.

[Fig. 2] Fig. 2 is an explanatory diagram schematically illustrating another embodiment of the groundwater treatment system of the present invention.

MODES FOR CARRYING OUT THE INVENTION

[0011]

Hereinafter, the groundwater treatment method and system of the present invention will be described based on embodiments shown in the drawings.

[0012]

The groundwater treatment method and system of the present invention are a method and system for neutralizing alkaline groundwater having a pH of 9 or higher, which is present

in the ground of land where mineral waste is buried, etc. The neutralization of groundwater referred to in the present invention is not limited to changing the pH of groundwater to completely neutral (pH 7), but means lowering the pH of strongly alkaline groundwater to bring the pH close to weakly alkaline or neutral.

[0013]

As illustrated in Fig. 1, the groundwater treatment system 1 of the present invention includes a pumping pipe 2 inserted into the ground G where alkaline groundwater W having a pH of 9 or higher is present, and an air blower 4 connected to an injection port 2b provided at the lower part of the pumping pipe 2. The treatment system 1 of the present embodiment further includes a high-pressure container (cylinder) 8 connected to the air blower 4, a water storage tank 9 to which a discharge port 2c of the pumping pipe 2 is connected, and a mixing pipe 11 connected to the water storage tank 9.

[0014]

The pumping pipe 2 extends vertically in a state of being inserted into the ground G. An inlet 2a provided at the lower end of the pumping pipe 2 is arranged in an aquifer where the groundwater W is present. An injection port 2b is provided on the side wall of the lower part of the pumping pipe 2, and an air supply pipe 5 is connected to the injection port 2b. The upper part of the pumping pipe 2 is arranged above ground, and a discharge port 2c of the pumping pipe 2 is connected to the water storage tank 9 arranged above ground. The pumping pipe 2 of the present embodiment is bent above ground, and the portion of the pumping pipe 2 arranged above ground extends laterally toward the water storage tank 9. Further, the pumping pipe 2

is bent downward at its downstream end, and the discharge port 2c of the pumping pipe 2 is disposed inside the water storage tank 9. In the present embodiment, an outer pipe 3 is inserted into the ground G, and the portion of the pumping pipe 2 inserted into the ground G and the air supply pipe 5 are arranged inside the outer pipe 3. The outer pipe 3 can be optionally provided as needed.

[0015]

The air blower 4 injects a gas C having a higher volume ratio of carbon dioxide (CO_2) than the air at the construction site into the injection port 2b of the pumping pipe 2. The air blower 4 is, for example, an air compressor. The rear end of the air supply pipe 5 is connected to the air supply port of the air blower 4, and the tip of the air supply pipe 5 is connected to the injection port 2b of the pumping pipe 2.

[0016]

In the present embodiment, a circulation mechanism 7 is provided for supplying the exhaust discharged from the air blower 4 to the air intake port of the air blower 4. The circulation mechanism 7 may be provided with a filter for removing pollutants such as particulate matter (PM), nitrogen oxides (e.g., NO and NO_2), and volatile organic compounds (VOC) contained in the exhaust of the air blower 4. In the present embodiment, a high-pressure container 8 in which carbon dioxide is stored in advance is further connected to the air intake port of the air blower 4. It is preferable that the high-pressure container 8 stores carbon dioxide that is not desired to be released into the atmosphere, such as carbon dioxide generated at other construction sites and carbon dioxide generated at power plants.

[0017]

In the present embodiment, the circulation mechanism 7 supplies the exhaust containing carbon dioxide discharged from the air blower 4 to the air intake port of the air blower 4, and the high-pressure container 8 supplies a gas having a high volume ratio of carbon dioxide to the air intake port of the air blower 4. Thereby, the air blower 4 supplies the gas C having a higher volume ratio of carbon dioxide than the air at the construction site from its air supply port, and the supplied gas C is supplied to the injection port 2b of the pumping pipe 2 via the air supply pipe 5.

[0018]

The volume ratio of carbon dioxide contained in air (atmosphere near the ground surface) varies slightly depending on the altitude of the construction site, etc., but the volume ratio of carbon dioxide in normal air is about 0.03 to 0.04%. The gas C having a higher volume ratio of carbon dioxide than the air at the construction site referred to in the present invention is, for example, a gas C having a volume ratio of carbon dioxide of 0.4% or higher, more preferably 2% or higher, and still more preferably 10% or higher. Alternatively, the gas C has a volume ratio of carbon dioxide that is, for example, 10 times or more, more preferably 50 times or more, and still more preferably 250 times or more the volume ratio of carbon dioxide contained in the air at the construction site. The upper limit of the volume ratio of carbon dioxide contained in the gas C having a higher volume ratio of carbon dioxide is, for example, 99% or less. The volume ratio of carbon dioxide contained in the exhaust of the air blower 4 is, for example, about 1% to 10%.

[0019]

As illustrated in Fig. 1, the water storage tank 9 is provided with an exhaust port 10. The mixing pipe 11 is connected to the downstream side of the water storage tank 9. The mixing pipe 11 is a pipe body used for in-pipe mixing of liquid and gas, and is, for example, an in-line mixer such as a static mixer. In the present embodiment, the rear end of a branch pipe 6 is connected to the middle of the air supply pipe 5, and the tip of the branch pipe 6 is connected to the upstream side of the mixing pipe 11. A part of the gas C having a higher volume ratio of carbon dioxide than the air at the construction site supplied from the air blower 4 to the air supply pipe 5 is supplied to the mixing pipe 11 via the branch pipe 6.

[0020]

A discharge pipe 12 is connected to the downstream side of the mixing pipe 11. The tip side of the discharge pipe 12 is inserted into the ground, and the discharge port of the discharge pipe 12 is arranged in the aquifer where the groundwater W is present.

[0021]

Next, the method for treating the groundwater W using the treatment system 1 will be described.

[0022]

As illustrated in Fig. 1, the pumping pipe 2 is inserted into the ground G where the alkaline groundwater W having a pH of 9 or higher is present. In the present embodiment, the outer pipe 3 is inserted into the ground G, and the soil inside the outer pipe 3 is removed. Then, the pumping pipe 2 and the air supply pipe 5 are installed inside the outer pipe 3. The inlet 2a provided at the lower end of the pumping pipe 2 is arranged

in the aquifer where the groundwater W is present. The discharge port 2c of the pumping pipe 2 is connected to the water storage tank 9 arranged above ground.

[0023]

Then, the air blower 4 is driven to supply the gas C having a higher volume ratio of carbon dioxide than the air at the construction site from the air supply port of the air blower 4 to the air supply pipe 5, and the gas C is injected from the injection port 2b provided at the lower part of the pumping pipe 2 into the pipe of the pumping pipe 2 so that a large number of bubbles are generated in the pipe of the pumping pipe 2. In the present embodiment, the exhaust discharged from the exhaust port of the air blower 4 is supplied to the air intake port of the air blower 4 by the circulation mechanism 7, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 4. Further, the carbon dioxide stored in advance in the high-pressure container 8 is supplied to the air intake port of the air blower 4, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 4.

[0024]

Then, the groundwater W is raised and pumped in the pipe of the pumping pipe 2 by a decrease in apparent specific gravity due to the large number of bubbles generated in the pipe of the pumping pipe 2, and a neutralization reaction is allowed to occur between the carbon dioxide contained in the bubbles (gas C) and the alkaline groundwater W during or after pumping on the downstream side of the inlet 2a of the pumping pipe 2 so that the pH of the groundwater W during or after pumping is lowered. In the present embodiment, the groundwater W flowing

in from the inlet 2a of the pumping pipe 2 undergoes a neutralization reaction while rising in the pipe of the pumping pipe 2 up to the ground (during pumping), and further undergoes a neutralization reaction while passing through the pipe extending above the ground of the pumping pipe 2 (after pumping). The neutralized groundwater NW, whose pH has been lowered by the neutralization reaction in the pipe of the pumping pipe 2, is discharged from the discharge port 2c of the pumping pipe 2.

[0025]

Specifically, for example, in the ground where mineral waste is buried, the groundwater W contains a lot of calcium hydroxide ($\text{Ca}(\text{OH})_2$). Therefore, when the groundwater W and the bubbles come into contact with each other in the pipe of the pumping pipe 2, the carbon dioxide (CO_2) contained in the bubbles and the water (H_2O) contained in the groundwater W chemically react to generate carbonic acid (H_2CO_3) ($\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$). Furthermore, a neutralization reaction occurs in which the generated carbonic acid (H_2CO_3) and the calcium hydroxide ($\text{Ca}(\text{OH})_2$) contained in the groundwater W chemically react to generate calcium carbonate (CaCO_3) ($\text{Ca}(\text{OH})_2 + \text{H}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{H}_2\text{O}$). As a result, in the process of pumping the groundwater W, the pH of the groundwater W is lowered, and the carbon dioxide contained in the bubbles (gas C) is also reduced.

[0026]

In the present embodiment, the neutralized groundwater NW discharged from the discharge port 2c of the pumping pipe 2 and the remaining neutralized gas NC after the neutralization reaction flow into the water storage tank 9, and the groundwater NW stored in the water storage tank 9 sequentially flows into

the mixing pipe 11. The neutralized gas NC is exhausted from the exhaust port 10 provided in the water storage tank 9 to the outside of the water storage tank 9. Since the volume ratio of carbon dioxide in the neutralized gas NC is about the same as that in the air at the construction site, there is no problem in exhausting it as is.

[0027]

In the present embodiment, the gas C having a higher volume ratio of carbon dioxide than the air at the construction site is injected from the air blower 4 into the pipe of the mixing pipe 11 via the branch pipe 6 so that a large number of bubbles are generated in the pipe of the mixing pipe 11 through which the groundwater NW flows. Then, the groundwater NW and the large number of bubbles flow in a swirling manner in the pipe of the mixing pipe 11, and a neutralization reaction occurs between the carbon dioxide contained in the bubbles (gas C) and the groundwater NW in the pipe of the mixing pipe 11. Thereby, the pH of the groundwater NW that has passed through the mixing pipe 11 is further lowered.

[0028]

In the present embodiment, the neutralized groundwater NW that has passed through the mixing pipe 11 is returned to the ground G via the discharge pipe 12. The neutralized groundwater NW is preferably discharged at a position away from the insertion position of the pumping pipe 2. In the present embodiment, the groundwater W is pumped by the treatment system 1, so that the groundwater level near the inlet 2a of the pumping pipe 2 temporarily drops, and the surrounding groundwater W flows into the vicinity of the inlet 2a of the pumping pipe 2 where the groundwater level has dropped. Then, the groundwater

W that has flowed into the vicinity of the inlet 2a of the pumping pipe 2 is pumped by the treatment system 1, neutralized, and then returned to the ground G. By repeating this cycle, the average value of the pH of the groundwater W present in the ground approaches neutral (pH 7).

[0029]

In the present invention, the pH of the neutralized groundwater NW finally discharged from the treatment system 1 is, for example, pH 5.0 or higher and pH 9.0 or lower, more preferably pH 5.8 or higher and pH 8.6 or lower, and still more preferably pH 6.0 or higher and pH 8.0 or lower. In other words, the volume ratio and supply amount of carbon dioxide in the gas C injected into the pumping pipe 2 and the mixing pipe 11, the length of the pumping pipe 2 and the mixing pipe 11, etc. are set so that the pH of the neutralized groundwater NW finally discharged from the treatment system 1 is, for example, pH 5.0 or higher and pH 9.0 or lower, more preferably pH 5.8 or higher and pH 8.6 or lower, and still more preferably pH 6.0 or higher and pH 8.0 or lower.

[0030]

As described above, in the present invention, when pumping the alkaline groundwater W having a pH of 9 or higher using the pumping pipe 2, the gas C having a higher volume ratio of carbon dioxide than the air at the construction site is injected into the pipe of the pumping pipe 2 so that a large number of bubbles are generated in the pipe of the pumping pipe 2. Then, the groundwater W is raised and pumped by lowering the apparent specific gravity by the large number of bubbles, and a neutralization reaction is allowed to occur between the carbon dioxide contained in the bubbles and the alkaline

groundwater W during or after pumping. As a result, the pH of the groundwater NW during or after pumping can be effectively lowered by effectively utilizing carbon dioxide that is not desired to be released into the atmosphere, and the neutralization of the alkaline groundwater W can be easily and efficiently performed. That is, in the present invention, carbon dioxide that is not desired to be released into the atmosphere can be effectively utilized for both pumping and neutralizing the groundwater W. Further, in the present invention, it is not necessary to add a neutralizing agent to the neutralized groundwater NW, or even if a neutralizing agent is added, the amount of the neutralizing agent can be reduced compared to the conventional case. Therefore, the present invention is advantageous for reducing the cost and time required for neutralizing the groundwater W.

[0031]

Furthermore, in the present invention, carbon dioxide, which is a cause of global warming, can be effectively utilized for the neutralization of the alkaline groundwater W. Therefore, the present invention can contribute to the reduction of carbon dioxide, which is very beneficial. As in the present embodiment, when the circulation mechanism 7 is provided so that the gas C supplied from the air blower 4 contains the exhaust discharged from the air blower 4, the carbon dioxide contained in the exhaust of the air blower 4 can be effectively utilized for the neutralization of the groundwater W, and the amount of carbon dioxide discharged in construction can also be reduced.

[0032]

As in the present embodiment, when the carbon dioxide

stored in advance in the high-pressure container 8 or the like is supplied to the air intake port of the air blower 4, the volume ratio of carbon dioxide in the gas C supplied into the pipe of the pumping pipe 2 can be easily increased. Moreover, by storing the carbon dioxide that is not desired to be released into the atmosphere, which is generated outside the construction site, in the high-pressure container 8 or the like, it becomes possible to use the carbon dioxide generated outside the construction site for the neutralization of the groundwater W. In particular, the use of the high-pressure container 8 is very convenient because the carbon dioxide can be easily stored in a stable state, and the amount of carbon dioxide supplied to the air intake port of the air blower 4 can be easily adjusted. [0033]

In the present invention, the method of supplying the gas C having a higher volume ratio of carbon dioxide than the air at the construction site from the air blower 4 is not limited to the case of using the circulation mechanism 7 or the high-pressure container 8, and various other methods can be adopted. Specifically, for example, the exhaust discharged from a machine other than the air blower 4 used at the construction site can be supplied to the air intake port of the air blower 4. Examples of the machines used at the construction site described above include construction machinery, vehicles, and various machines used for construction (e.g., generators). When using carbon dioxide discharged from a machine at the construction site, it is preferable to remove pollutants contained in the exhaust discharged from the machine at the construction site before supplying the exhaust to the air intake port of the air blower 4. That is, in the present invention,

the circulation mechanism 7 and the high-pressure container 8 can be optionally provided as needed. The volume ratio of carbon dioxide contained in the exhaust of construction machinery and vehicles is, for example, about 1% to 10%.

[0034]

The size of the bubbles generated in the pipe of the pumping pipe 2 from the injection port 2b of the pumping pipe 2 is preferably set to, for example, 0.1 mm or more and 5 mm or less. In the process of the bubbles rising in the pipe of the pumping pipe 2, the bubbles gradually shrink due to the neutralization reaction between the carbon dioxide contained in the bubbles and the groundwater W, but by setting the size of the generated bubbles to 0.1 mm or more, the lift effect of raising the groundwater W by the bubbles can be maintained up to the ground, which is advantageous for stable pumping while neutralizing the groundwater W. Further, the larger the size of the generated bubbles is set, the smaller the number of bubbles generated in the pipe of the pumping pipe 2 with respect to the amount of gas supplied becomes, but by setting the size of the bubbles generated from the injection port 2b to 0.5 mm or less, it is possible to prevent the number of bubbles generated in the pipe of the pumping pipe 2 from becoming too small, which is advantageous for stable pumping of the groundwater W.

[0035]

Although not provided in the present embodiment, for example, a porous filter having a large number of minute holes formed therein can be provided at the injection port 2b of the pumping pipe 2. The size of the holes of the porous filter is preferably set to, for example, 0.01 mm or more and 0.1 mm or

less. Providing the porous filter is advantageous for rendering the size of the bubbles generated in the pipe of the pumping pipe 2 uniform. Furthermore, by providing the porous filter, it becomes easy to form a large number of minute bubbles easily.

[0036]

As in the present embodiment, when the neutralized groundwater NW discharged from the discharge port 2c of the pumping pipe 2 is returned to the ground G, the step of pumping and neutralizing the groundwater W by the treatment system 1 and the step of returning the neutralized groundwater NW to the ground G are performed in parallel, so that the average value of the pH of the groundwater W present in the ground G can be efficiently brought closer to neutral. In the present invention, for example, the neutralized groundwater NW discharged from the discharge port 2c of the pumping pipe 2 can be discharged into public water areas or sewers, or the neutralized groundwater NW can be used for other purposes.

[0037]

As in the present embodiment, when the gas C having a higher volume ratio of carbon dioxide than the air at the construction site is injected into the groundwater NW discharged from the discharge port 2c of the pumping pipe 2 so that the groundwater NW and the gas C are mixed, the pH of the groundwater NW can be brought closer to neutral by further neutralizing the groundwater NW after pumping. As in the present embodiment, when the gas C supplied from the air blower 4 is injected into the groundwater NW discharged from the discharge port 2c of the pumping pipe 2, the treatment system 1 that further performs neutralization after pumping can be

configured very simply. As in the present embodiment, when the mixing pipe 11 is used for neutralization after pumping, the groundwater NW and the bubbles flow in a swirling manner in the pipe of the mixing pipe 11, so that the groundwater NW and the bubbles easily come into contact with each other, and the neutralization of the groundwater NW can be performed very efficiently.

[0038]

Next, another embodiment of the treatment system 1 according to the present invention illustrated in Fig. 2 will be described. In the following, the differences from the treatment system 1 of the embodiment illustrated in Fig. 1 will be mainly described.

[0039]

In land near water areas where mineral waste is buried, not only is alkaline groundwater W having a high pH retained in the ground, but the pH of the soil S of the ground G is also mostly high. When modifying (neutralizing) such alkaline land, it is necessary to neutralize not only the groundwater W but also the soil S of the ground G. Therefore, the treatment system 1 of the present embodiment is configured to neutralize the soil S of the ground G along with the neutralization of the groundwater W.

[0040]

As illustrated in Fig. 2, in the present embodiment, a crushing device 14 for crushing the soil S, a barge 15 having a mud pit, and a work vessel 16 equipped with a mud feeding device 18 are used. The barge 15 and the work vessel 16 are, for example, moored in a water area near the land to be modified.

[0041]

In the present embodiment, a shielding plate 13 (e.g., sheet pile) is driven into the ground G, and a part of the ground G is partitioned by the shielding plate 13. Then, the pumping pipe 2 is inserted into the inner region partitioned by the shielding plate 13. In the present embodiment, the mixing pipe 11 is connected to the discharge port 2c of the pumping pipe 2. The discharge pipe 12 is connected to the downstream side of the mixing pipe 11, and the discharge pipe 12 extends to the barge 15. In the present embodiment, the water storage tank 9 of the embodiment illustrated in Fig. 1 is not used.

[0042]

The work vessel 16 is equipped with a backhoe 17, a mud feeding device 18, and an air blower 20. The air blower 20 mounted on the work vessel 16 is provided separately from the air blower 4 connected to the pumping pipe 2. A mud feeding pipe 19 is connected to the downstream side of the mud feeding device 18, and a mud discharge port of the mud feeding pipe 19 is arranged in the inner region partitioned by the shielding plate 13. An enlarged pipe 19a having a larger inner diameter than the pipe diameter of the other portion of the mud feeding pipe 19 is provided in the middle of the mud feeding pipe 19.

[0043]

In the present embodiment, a circulation mechanism 22 is provided for supplying the exhaust discharged from the exhaust port of the air blower 20 to the air intake port of the air blower 20. Further, a high-pressure container 23 in which carbon dioxide is stored in advance is connected to the air intake port of the air blower 20. The other configurations are the same as those of the treatment system 1 of the embodiment illustrated in Fig. 1.

[0044]

In the method for treating the groundwater W using the treatment system 1 of the present embodiment, the shielding plate 13 is driven into the ground G where the alkaline groundwater W having a pH of 9 or higher and the alkaline soil S having a pH of 9 or higher are present, and a part of the ground G is partitioned by the shielding plate 13. Then, the outer pipe 3 and the pumping pipe 2 are inserted into the inner region partitioned by the shielding plate 13.

[0045]

Then, as in the previously illustrated embodiment, the air blower 4 is driven to supply the gas C having a higher volume ratio of carbon dioxide than the air at the construction site from the air supply port of the air blower 4 to the air supply pipe 5, and the gas C is injected from the injection port 2b provided at the lower part of the pumping pipe 2 into the pipe of the pumping pipe 2 so that a large number of bubbles are generated in the pipe of the pumping pipe 2. In the present embodiment, the exhaust discharged from the exhaust port of the air blower 4 is supplied to the air intake port of the air blower 4 by the circulation mechanism 7, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 4. In the present embodiment, the carbon dioxide stored in advance in the high-pressure container 8 is further supplied to the air intake port of the air blower 4, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 4.

[0046]

Then, the groundwater W is raised and pumped by a decrease in apparent specific gravity due to the large number of bubbles

generated in the pipe of the pumping pipe 2, and a neutralization reaction is allowed to occur between the carbon dioxide contained in the bubbles (gas C) and the alkaline groundwater W during or after pumping on the downstream side of the inlet 2a of the pumping pipe 2 so that the pH of the groundwater W during or after pumping is lowered. The pumped neutralized groundwater NW flows into the mixing pipe 11 from the discharge port 2c of the pumping pipe 2.

[0047]

The gas C having a higher volume ratio of carbon dioxide than the air at the construction site is injected from the air blower 4 into the pipe of the mixing pipe 11 via the branch pipe 6 so that a large number of bubbles are generated in the pipe of the mixing pipe 11 through which the groundwater NW flows. Then, the groundwater NW and the large number of bubbles flow in a swirling manner in the pipe of the mixing pipe 11, and a neutralization reaction occurs between the carbon dioxide contained in the bubbles (gas C) and the groundwater NW in the pipe of the mixing pipe 11. As a result, the pH of the groundwater NW that has passed through the mixing pipe 11 is further lowered and approaches neutral. The neutralized groundwater NW that has passed through the mixing pipe 11 is discharged into the mud pit of the barge 15 through the discharge pipe 12.

[0048]

In the present embodiment, the soil S in the inner region partitioned by the shielding plate 13 is excavated in parallel with the step of pumping and neutralizing the groundwater W. The excavation of the soil S is performed using, for example, construction machinery such as a backhoe. The excavated soil

S is transported to the crushing device 14 using a large vehicle or the like, and the soil S is crushed and pulverized by the crushing device 14. The particle size of the crushed soil DS is preferably, for example, 40 mm or less, more preferably 20 mm or less.

[0049]

Then, the crushed soil DS pulverized by the crushing device 14 is transported to the barge 15 using a large vehicle or the like, and the crushed soil DS is charged into the mud pit of the barge 15. As a result, the mud pit of the barge 15 is in a state where the crushed soil DS and the neutralized groundwater NW are stored. In the present embodiment, the backhoe 17 arranged on the work vessel 16 is used to stir and mix the crushed soil DS and the neutralized groundwater NW in the mud pit of the barge 15 to produce slurry-like soil SS. Since the crushed soil DS is alkaline, the slurry-like soil SS is also alkaline. Then, the backhoe 17 is used to charge the slurry-like soil SS produced in the mud pit of the barge 15 into the inlet (hopper) of the mud feeding device 18. The slurry-like soil SS charged into the inlet of the mud feeding device 18 flows into the mud feeding pipe 19.

[0050]

In the present embodiment, the air blower 20 mounted on the work vessel 16 is driven to supply the gas C having a higher volume ratio of carbon dioxide than the air at the construction site from the air supply port of the air blower 20 to the air supply pipe 21, and the gas C is injected into the pipe of the mud feeding pipe 19. In the present embodiment, the exhaust discharged from the exhaust port of the air blower 20 is supplied to the air intake port of the air blower 20 by the circulation

mechanism 22, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 20. In the present embodiment, the carbon dioxide stored in advance in the high-pressure container 23 is further supplied to the air intake port of the air blower 20, thereby increasing the volume ratio of carbon dioxide in the gas C supplied from the air supply port of the air blower 20.

[0051]

As the slurry-like soil SS and the gas C flow into the mud feeding pipe 19, the slurry-like soil SS and the gas C are mixed in the process of passing through the mud feeding pipe 19. Then, in the pipe of the mud feeding pipe 19, the alkaline slurry-like soil SS and the carbon dioxide contained in the gas C undergo a neutralization reaction, so that the pH of the slurry-like soil SS is lowered. In the present embodiment, the slurry-like soil SS and the gas C are particularly effectively mixed in the enlarged pipe 19a provided in the middle of the mud feeding pipe 19, and the neutralization reaction between the slurry-like soil SS and the carbon dioxide contained in the gas C is effectively performed. Then, the neutralized slurry-like soil NS, whose pH has been lowered by the neutralization reaction, flows out from the discharge port of the mud feeding pipe 19 into the inner region partitioned by the shielding plate 13. That is, the neutralized soil NS is fed to the excavation site of the ground G, and the excavation site is backfilled with the neutralized soil NS.

[0052]

In the present invention, the pH of the neutralized soil NS finally discharged from the treatment system 1 is, for example, pH 5.0 or higher and pH 9.0 or lower, more preferably

pH 5.8 or higher and pH 8.6 or lower, and still more preferably pH 6.0 or higher and pH 8.0 or lower. In other words, the volume ratio and supply amount of carbon dioxide in the gas C injected into the mud feeding pipe 19, the length of the mud feeding pipe 19, etc. are set so that the pH of the neutralized soil NS finally discharged from the treatment system 1 is, for example, pH 5.0 or higher and pH 9.0 or lower, more preferably pH 5.8 or higher and pH 8.6 or lower, and still more preferably pH 6.0 or higher and pH 8.0 or lower.

[0053]

As in the present embodiment, the alkaline soil S having a pH of 9 or higher is excavated from the ground G, and the excavated soil S and the groundwater NW whose pH has been lowered are stirred and mixed to produce slurry-like soil SS. Then, the slurry-like soil SS and the gas C having a higher volume ratio of carbon dioxide than the air at the construction site are mixed to cause a neutralization reaction between the carbon dioxide contained in the gas C and the alkaline soil SS. Then, when the neutralized slurry-like soil NS whose pH has been lowered by the neutralization reaction is fed to the excavation site of the ground G and the excavation site is backfilled, the alkaline soil S excavated from the ground G can be easily and efficiently neutralized by effectively utilizing the groundwater NW neutralized by the pumping pipe 2. In other words, the alkaline land having a high pH can be efficiently modified (neutralized) by neutralizing the groundwater W in the ground G and neutralizing the soil S excavated from the ground G and backfilling the excavation site.

[0054]

As in the present embodiment, when the soil S excavated

from the ground G is crushed and pulverized using the crushing device 14 or the like, and the pulverized soil DS after crushing is used to produce the slurry-like soil SS, the excavated soil S is crushed to reduce the size of each particle, so that the surface area of the soil S particles in contact with the gas C increases in the slurry-like soil SS. Therefore, the carbon dioxide contained in the gas C and the alkaline soil SS are more likely to undergo a neutralization reaction, which is advantageous for efficiently neutralizing the alkaline soil SS. Further, by crushing and pulverizing the soil S excavated from the ground G, the risk of the slurry-like soil SS clogging the mud feeding device 18 and the mud feeding pipe 19 is also reduced.

[0055]

As in the present embodiment, when the slurry-like soil SS and the gas C are mixed in the pipe of the mud feeding pipe 19 for feeding the slurry-like soil SS to the excavation site of the ground G, the slurry-like soil SS and the gas C can be efficiently mixed with a simple configuration, and the alkaline soil SS and the carbon dioxide contained in the gas C can be efficiently neutralized. In particular, as in the present embodiment, when the enlarged pipe 19a is provided in the middle of the mud feeding pipe 19, the slurry-like soil SS and the gas C can be efficiently mixed in the enlarged pipe 19a, and the alkaline soil SS and the carbon dioxide contained in the gas C can be efficiently neutralized. The enlarged pipe 19a can be optionally provided.

[0056]

As in the present embodiment, when the carbon dioxide stored in advance in the high-pressure container 23 or the like is supplied to the air intake port of the air blower 20 mounted

on the work vessel 16, the volume ratio of carbon dioxide in the gas C supplied into the pipe of the mud feeding pipe 19 can be easily increased. Furthermore, by storing the carbon dioxide generated outside the construction site in the high-pressure container 23 or the like, it becomes possible to effectively utilize the carbon dioxide generated outside the construction site for the neutralization of the slurry-like soil SS. In particular, the use of the high-pressure container 23 is very convenient because the carbon dioxide can be easily stored in a stable state, and the amount of carbon dioxide supplied to the air intake port of the air blower 20 can be easily adjusted.

[0057]

In the present invention, the method of supplying carbon dioxide to the air intake port of the air blower 20 mounted on the work vessel 16 is not limited to the case of using the circulation mechanism 22 or the high-pressure container 23, and carbon dioxide can be supplied to the air intake port of the air blower 20 by various other methods. Specifically, for example, the exhaust discharged from a machine other than the air blower 20 used at the construction site can be supplied to the air intake port of the air blower 20. Examples of the machines used at the construction site described above include the work vessel 16, the backhoe 17, and various machines used for construction (e.g., generators). When using carbon dioxide discharged from a machine at the construction site, it is preferable to remove pollutants contained in the exhaust discharged from the machine at the construction site before supplying the exhaust to the air intake port of the air blower 20. That is, in the present invention, the circulation

mechanism 22 and the high-pressure container 23 can be optionally provided as needed.

[0058]

As in the present embodiment, when the soil S excavated and crushed from the ground G and the neutralized groundwater NW are stored in the mud pit of the barge 15, it is not necessary to provide a temporary storage area for storing the soil S and the groundwater NW on land, which is advantageous for reducing the cost required for land modification. Further, when the work vessel 16 equipped with the mud feeding device 18 is used, it is not necessary to provide a work area for arranging the mud feeding device 18 and the backhoe 17 on land, which is advantageous for reducing the cost required for land modification.

[0059]

The system for feeding the slurry-like soil SS stored in the mud pit of the work vessel 16 to the excavation site of the ground G is not limited to the configuration of the present embodiment, and various other configurations are possible. For example, the slurry-like soil SS stored in the mud pit of the work vessel 16 can be sucked up by a soil pump and transported to the excavation site of the ground G.

[0060]

Further, in the present invention, for example, a temporary storage area for soil may be provided on land instead of the barge 15. For example, the mud feeding device 18 and the backhoe 17 may be arranged on land. Further, in the present invention, the shape and arrangement of each pipe body (such as the pumping pipe 2 and the air supply pipe 5), the connection position between the pipe bodies, the arrangement of each device

(such as the air blower 4 and the crushing device 14), etc. are not limited to the embodiments illustrated above, and various other configurations are possible depending on the construction conditions. Moreover, the present invention is not limited to the modification of land where mineral waste is buried, and can be adopted for the modification of land where groundwater W and soil S having a high pH due to factors other than mineral waste are present, and other construction works.

EXPLANATION OF REFERENCE NUMERALS

[0061]

- 1 treatment system
- 2 pumping pipe
- 2a inlet
- 2b injection port
- 2c outlet
- 3 outer pipe
- 4 air blower
- 5 air supply pipe
- 6 branch pipe
- 7 circulation mechanism
- 8 high-pressure container
- 9 water storage tank
- 10 exhaust port
- 11 mixing pipe
- 12 discharge pipe
- 13 shielding plate
- 14 crushing device
- 15 barge
- 16 work vessel
- 17 backhoe

18	mud feeding device
19	mud feeding pipe
19a	enlarged pipe
20	air blower
21	air supply pipe
22	circulation mechanism
23	high-pressure container
C	gas (having a higher volume ratio of carbon dioxide than air)
NC	gas after neutralization reaction
W	groundwater
NW	groundwater after neutralization reaction
S	soil of ground
DS	crushed soil
SS	slurry-like soil
NS	soil after neutralization reaction
G	ground

CLAIMS

[Claim 1] A method for treating groundwater, comprising:

- inserting a pumping pipe into a ground where alkaline groundwater having a pH of 9 or higher is present;
- injecting a gas having a higher volume ratio of carbon dioxide than an air at a construction site from an injection port provided at a lower part of the pumping pipe into the pipe of the pumping pipe by an air blower so that a large number of bubbles are generated in the pipe of the pumping pipe;
- raising and pumping the groundwater from the ground where the groundwater is present by a decrease in apparent specific gravity due to the large number of bubbles; and
- causing a neutralization reaction between the carbon dioxide contained in the bubbles and the alkaline groundwater during or after pumping so that the pH of the groundwater is lowered,

Wherein the gas contains the carbon dioxide that is not desired to be released into the atmosphere.

[Claim 2] The method for treating groundwater according to claim 1, wherein the gas contains at least one of carbon dioxide generated at the construction site, carbon dioxide generated at a construction site other than the construction site, and carbon dioxide generated at a power plant.

[Claim 3] The method for treating groundwater according to claim 1 or 2, wherein the groundwater whose pH has been lowered is returned to the ground.

[Claim 4] The method for treating groundwater according to

claim 1 or 2, comprising:

excavating alkaline soil having a pH of 9 or higher from the ground;

stirring and mixing the excavated soil and the groundwater whose pH has been lowered to produce slurry-like soil;

mixing the slurry-like soil and a gas having a higher volume ratio of carbon dioxide than the air at the construction site to cause a neutralization reaction between the carbon dioxide contained in the gas and the alkaline soil; and

feeding the slurry-like soil whose pH has been lowered to an excavation site of the ground and backfilling the excavation site.

[Claim 5] The method for treating groundwater according to claim 4, wherein the soil excavated from the ground is crushed and pulverized, and the pulverized soil is used to produce the slurry-like soil.

[Claim 6] The method for treating groundwater according to claim 4, wherein the slurry-like soil and the gas are mixed in the pipe of a mud feeding pipe for feeding the slurry-like soil to the excavation site.

[Claim 7] A system for treating groundwater, comprising:

a pumping pipe inserted into a ground where alkaline groundwater having a pH of 9 or higher is present; and

an air blower connected to an injection port provided at a lower part of the pumping pipe,

wherein the air blower injects a gas having a higher volume

ratio of carbon dioxide than an air at a construction site from the injection port into the pipe of the pumping pipe so that a large number of bubbles are generated in the pipe of the pumping pipe, the groundwater is raised and pumped from the ground where the groundwater is present by a decrease in apparent specific gravity due to the large number of bubbles, and a neutralization reaction occurs between the carbon dioxide contained in the bubbles and the alkaline groundwater during or after pumping so that the pH of the groundwater is lowered, and

the gas contains the carbon dioxide that is not desired to be released into the an atmosphere.